## 博士論文

Integrated Assessment of Co－benefits from Methane Recovering－based
CDM Projects：Case Studies in Thailand
（メタン回収型 CDM における統合的コベネフィット評価：タイにおける事例からの分析）

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by

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#### Abstract

Clean Development Mechanism (CDM) for greenhouse gases emission reduction has allowed developed countries with emission reduction commitment to earn emission reduction credits from where it makes the investment worthwhile (mostly in developing countries). Together with earned credits, local sustainability benefits, called co-benefits, have been also expected to achieve in invested host countries. In recent years, comprehensive analysis for project prioritization to invest CDM projects by integrating local benefits rather than only CDM financial study has been challenging for decision making process. This study aims to develop methodologies to valuate co-benefits on improved water quality by implementing methane recovery CDM project to non-aerobic open lagoon treatment system. Competitive two factories (i.e., ethanol and crude palm oil plants in Ayutthaya and Krabi provinces in Thailand) were chosen as studied sites to develop an valuation model in terms of financial, environmental and societal valuation metrics.

In terms of CDM business, financial assessment is basically required for allocating investment funds with functions of certified emission reductions (CERs) and electricity revenues. Both studied sites were estimated low transaction costs of 12.36-35.87 $\mathrm{USD} / \mathrm{tCO}_{2} \mathrm{e}$ compared with averaged carbon price of carbon taxation scheme, 35 USD/ $\mathrm{tCO}_{2} \mathrm{e}$. Ayutthaya site produced more CERs than Krabi site in a certain crediting period, however, it costed the higher CER generating cost from a higher investment cost and less operating days. Although, the methane recovery CDM projects had been proven to not be "business-as-usual" projects but electricity sale was a major revenue. Krabi site was more attractive for investors in terms of internal rate of return (IRR) and net profit percentage by more electricity produced, $29.57 \%$ and $191.84 \%$, respectively with 20 -year CER crediting period. Investors should be induced to invest gas generators at full coverage of produced biogas for increasing profitability and viability of projects.


Apart from CDM financial assessment, the indicators for co-benefits from CDM projects by assessing environmental impacts from high-strength wastewater operation in ethanol and crude palm oil plants, point-source pollutants originated from a factory and infiltrated pollutants from an open lagoon, received wastewater from a factory were separately
valuated. The valuation of point-source is chosen to be a co-benefits indicator of environmental impact due to the purposes to expand its applicability by simple assessment and give direct relation to the societal valuation from a view of cleaner public water. From the results of the point-source pollutant valuation, Ayutthaya site resulted a higher environmental alleviation from the methane recovery CDM than Krabi site. Ayutthaya site costed 75,134 USD/y over the cost of Krabi site, 66,250 USD/y because a larger UASB size required in Ayutthaya site. The cost of UASB treatment was the determining factor to differentiate the costs of environmental impact and define environmental alleviation from methane recovery CDM project. As for the valuation of infiltrated pollutants, it estimated the cost of 16,384 and 11,044 USD/y for Ayutthaya and Krabi sites, respectively. The results of pollutants removal cost showed that cost to treat nitrate rather than cost of oxygen supplement by assuming that nitrified ammonium is all nitrified under lagoons, was the most valuable contaminant and differentiated environmental impacts between project sites.

In order to integrate social involvement to co-benefits assessment, a part of this study framework analyzed the spacial scales of water quality perception to examine how stakeholders at different administrative scales attached on different preference values between the studied sites. Questionnaire survey was used to elicit willingness-to-pay (WTP) using 3 different starting bid values of 20, 50 and 100 THB per household/month for sub-samples of local respondents (Ayutthaya and Krabi residents) and national respondents (Bangkok residents) with closed-end double-bounded question for one step improvement in rivers' water quality from status quo. Water quality perception showed $79 \%$ of respondent agreed to pay with different mean WTPs, varied across sub-samples. As for local respondents, households in Ayutthaya gave the higher WTP than Krabi at an average of 77.9 THB per household/month (28.8 USD per household/y). Whereas, Bangkok residents gave the higher WTP, of 75.3 THB per household/month (27.8 USD per household/y), for improved water quality in Krabi than Ayutthaya. By analysis of censored regression model, in general perspective of water quality services, the most endogenous variables for Ayutthaya's rivers associated with the WTP were household income and members. Nevertheless, for Krabi's rivers, education and attitude factors became more considerate by the reason of acknowledged public benefits in terms of land use in the province. From the reasons mentioned, it is suggested to consider the
importance of spacial scale in water quality perception to be measured and compared separately for the analysis of co-benefits assessment.

Due to simplified methodologies of financial, environmental, societal assessment for cobenefits CDM prioritization, it could give an ease to widen utilization or application in CDM wastewater works. This method could be used in a comparison basis between projects as supporting informations for allocating CDM finance with co-benefits integration. To compare values of environmental impacts between projects, the methodologies of point-source pollutants valuation for environmental impact applied with the studied sites. They gave low financial barrier for assessing the benefit values from the CDM projects without instrument investment to assess environmental impact which increase transaction cost to burden the CDM by its simplicity of methodologies. The infiltrated pollutants valuation could not estimate an actual benefit value, unless, the comparison of costs on environmental impact before and after CDM implementation is assessed. In order to compare values of social preferences between projects, it could be applied to studied sites with contingent valuation method regarding their preferences for improvement of river water quality from status quo in current situations in each site. Nevertheless, questionnaire survey was the most time-consuming for this study because it requires a credible number of samples and explanation of the hypothetical market for river quality.

In the integrated valuation study, Multi-criteria Decision Analysis (MCDA) for comparing and ranking different project/site alternatives by monetary indicators from financial, environmental, and social assessments was elaborated with outranking method (pair-wise comparisons). The key indicators were illustrated in the value tree for making decision matrix and separated into different models of CDM investment. This method was proven to express comparative quantifiable scores with the concerns in "profitability", "transparency" and "community participation" for discussions on individual indicator and the absolute results. In partial ranking, Ayutthaya site competed over Krabi site in the indicators of total produced CERs, environmental impacts, and local WTP except the indicators of IRR, net profit, and national WTP. The discrete preference scales between positive and negative preference flows resulted for all indicators except CER generating cost which is opened to be the justifiable indicator in decision making process. In complete ranking, Ayutthaya site competed over Krabi site for scenario A and B\&C from
viewpoints of CDM subsidizers and investors, which are benefited from lower cost of CER investment and co-benefits recognition. Co-benefits indicators have significant effects on the change of ordered preference scores and differentiated comparative score with the score of 0.038 (or $3.8 \%$ in difference). From the all pair-wise results of preference choices in equal weighting approach, the UASB investment is more preferred for Ayutthaya and Krabi sites than the investment of UASB coupling with gas generators. Whilst, by considering incremental GHGs reduction in the scheme of electricity sale, Ayutthaya site obviously became the best-fit site for the both investments of only UASB and UASB coupling with gas generators by importance of lower CER generating cost in scenario $B \& C$. This comparative method provided a guideline or a starting point for what will be developed or expanded to applicability of the co-benefits CDM approach in voluntary assessment by project developers or even in the international mechanism integrated with price premium, rather than a present checklist approach based on "Do no harm" and "Scoring" practice. From that reason, researches on improving the framework is required, considering on the reduction of uncertainties, expanding of the types of CDM implementation and criteria pollutants for environmental and economic impacts assessment, indicating a boundary of impacts/benefits, and justification of MCDA in decision-making process.

## TABLE OF CONTENTS

## Chapter Title

Page
$\begin{array}{lr}\text { Title Page } & \text { i } \\ \text { Acknowledgements }\end{array}$
Abstract iii-vi
Table of Contents vii-x
List of Tables xi-xii
List of Figures xiii-xvi
List of Abbreviations and Nomenclatures xvii-xix
List of Conversion Factors xix
Glossary xx-xxiii
1 Introduction 1
1.1 Background 1
1.2 Rationale of the research 3
1.3 Objectives of study 4
1.4 Structure of the dissertation 5

2 Literature review 7
2.1 Clean development mechanism 7
2.1.1 Background 7
2.1.2 Clean Development Mechanism in post 20129
2.2 Methane recovering based CDM project 17
2.2.1 Business-as-usual practice for distillery slop treatment 17
2.2.2 Market share for methane recovery CDM project 19
2.2.3 Methane recovery and renewable energy project for 21 open lagoon wastewater treatment
2.3 Economical analysis of CDM project 22
2.4 Co-benefits of methane recovering based CDM 24
2.4.1 Beneficiaries and benefits from methane recovery project 26
2.4.2 Development of co-benefits assessment 27
2.4.3 Principles of Superfund site 28
2.4.4 Ecosystem valuation: TEEB conceptual framework 28
2.5 Environmental assessment of anaerobic open lagoon 30
2.5.1 Pollutant inventory 31
2.5.2 Groundwater contamination 32
2.6 Socio-economic assessment for methane recovery CDM 37
2.6.1 Welfare theory in environmental markets 37
2.6.2 Valuing the externalities 38
2.6.3 Contingent valuation studies 42
2.7 Decision-making analysis 46
2.7.1 Environmental, economic, and social integrity 46
2.7.2 Modified total economic value (TEV) and aggregation 47
concept
2.7.3 Multi-criteria decision analysis (MCDA) 49

3 Methodology, background information, and scenarios 54
3.1 Research methodology 54

## TABLE OF CONTENTS (continued)

Chapter Title Page
3.2 Site selection and contaminant assessment ..... 55
3.2.1 Site selection ..... 55
3.2.2 Estimation of greenhouse gases emission reduction ..... 58
3.2.3 Contaminant assessment ..... 62
3.2.4 Evaluation of leaked nitrate in groundwater ..... 65
3.3 Scenarios establishment for financial assessment of CDM ..... 66 project
3.3.1 CDM investment scheme ..... 66
3.3.2 Scenarios and conditions of financial analysis ..... 67
3.4 Decision criteria on project investment ..... 69
4 Financial assessment of methane recovery CDM project ..... 71
4.1 Introduction and objectives ..... 71
4.1.1 Sources of information for financial analysis ..... 72
4.1.2 CER investment of methane recovery CDM project ..... 73
4.1.3 Profitability of methane recovery CDM project ..... 74
4.1.4 Viability of methane recovery CDM project ..... 75
4.2 Study of activities and parameters ..... 77
4.2.1 Cost investment for CDM project activity ..... 77
4.2.2 Estimation of CERs and electricity sales ..... 77
4.2.3 Extended appraisal for entities of investment ..... 78
4.3 Results and discussion ..... 80
4.3.1 CER generating cost ..... 82
4.3.2 The internal rate of return ..... 84
4.3.3 Net profit percentage and net profit margin ..... 86
4.3.4 Break-even point of electricity production for Feed-in ..... 89 tariffs regulation
4.3.5 Decline rate on profitability and viability of project ..... 90
4.4 Conclusions ..... 92
5 Assessment of environmental impacts for co-benefits indicators ..... 96
5.1 Introduction and objectives ..... 96
5.2 Contaminated pollutants for co-benefits valuation ..... 98
5.2.1 Point-source pollutants ..... 98
5.2.2 Infiltrated pollutants from open lagoon ..... 98
5.3 Methodologies ..... 103
5.3.1 Procedure to valuate point-source carbon and nitrogen ..... 103 contamination
5.3.1.1 Mass of point-source carbon and nitrogen ..... 104 contamination
5.3.1.2 Selection of hypothetical wastewater treatment ..... 104 system
5.3.1.3 Valuation of point-source carbon and nitrogen ..... 107 ..... 107
5.3.2 Procedure to valuate infiltrated carbon and nitrogen ..... 112
5.3.2.1 Mass of infiltrated carbon and nitrogen ..... 113 contamination

TABLE OF CONTENTS (continued)
Chapter Title Page
5.3.2.2 Valuation of nitrate contamination in infiltrated ..... 116 wastewater
5.4 Results and discussion ..... 118
5.4.1 Valuation of point-source pollutants ..... 118
5.4.2 Valuation of infiltrated pollutants ..... 122
5.4.2.1 Estimation of wetting front depth ..... 123
5.4.2.2 Estimation of depth to groundwater table ..... 123
5.4.2.3 Infiltration rate to soil sediment under lagoons ..... 125
5.4.2.4 Mass of infiltrated organic carbon and nitrate ..... 127
5.4.2.5 Cost of air supply and nitrate treatment ..... 128
5.4.3 Utilization of point-source pollutant and infiltrated ..... 130pollutant valuation
5.5 Conclusions ..... 133
6 Social preference for co-benefits indicators ..... 135
6.1 Introduction and objectives ..... 135
6.2 Methodologies ..... 137
6.2.1 Potential CDM project and benefits to water environment ..... 137
6.2.2 Framework of co-benefits valuation in host country ..... 138 provinces
6.2.3 Societal benefits valuation by contingent valuation method ..... 140
6.3 Results and discussion ..... 146
6.3.1 Acceptance rate to WTP on water quality perception ..... 146
6.3.2 Mean and median WTP ..... 149
6.3.3 Regression analysis of WTP ..... 151
6.4 Conclusions ..... 154
7 Integrated valuation of CDM financial and co-benefits ..... 157
7.1 Introduction and objectives ..... 157
7.2 Methodologies ..... 157
7.2.1 Assessment of sustainability benefits from methane ..... 158 recovery CDM project
7.2.2 MCDA with pairwise outranking method ..... 159
7.3 Results and discussion ..... 163
7.3.1 Cost functions of decision indicators ..... 163
7.3.2 Data acquisition of decision-making process ..... 165
7.3.3 Analysis of Decision matrix ..... 166
7.3.4 Partial ranking of MCDA ..... 169
7.3.4 Complete ranking of MCDA ..... 171
7.3.5 Utilization of the methodologies and relevant stakeholders ..... 173
7.4 Conclusions ..... 175
8 Conclusions and recommendations ..... 178
8.1 Conclusions ..... 178
8.2 Recommendations ..... 182

## TABLE OF CONTENTS (continued)

Chapter Title Page
REFERENCES ..... 186
APPENDIX I Calculation of greenhouse gas emission reduction ..... 206
APPENDIX II Estimation of electricity generation from captured ..... 218biogas by UASB system
APPENDIX III Analysis for CER generating cost, IRR, and net ..... 219
profit percentage/margin APPENDIX IV Analysis for incline rate of CER generating cost, ..... 266
IRR, and net profit percentage/marginAPPENDIX V Comparative cost for nitrate removal by ion268
exchange treatment process
APPENDIX VI Estimation of groundwater table (or depth L) in the ..... 269
Green-Ampt approximation
APPENDIX VII Relationship of willingness-to-pay and cumulative ..... 271
probability of bidding
APPENDIX VIII Lifereg analysis of SAS program ..... 272
APPENDIX IX Samples of questionnaire for Ayutthaya and Krabi ..... 277 respondents (in Thai)

## LIST OF TABLES

Table Title Page
2.1 List of responses on premium for CERs with sustainability benefits ..... 15
2.2 Example of sustainable development matrix ..... 16
2.3 The project types and categories of methane recovery based CDM project
2.4 The difference of internal rate of return between the CDM and co- benefit CDM
2.5 Benefit, beneficiaries and funding mechanism of improved water quality
2.6 Possible selected list of projects using the co-benefits approach in water quality improvement category
2.7 The estimation of treatment costs based on appropriate technology ..... 36 for various nitrate levels
2.8 Comparison of critical elements, strengths, and weaknesses of ..... 51 several advanced MCDA methods: MAUT, AHP, and outranking
3.1 Wastewater characteristic of ethanol and palm oil factory in ..... 56
Thailand
3.2 Description of the sources and greenhouse gases included in the project boundary of methane recovery CDM project in palm oil factory, Krabi
3.3 Potential environmental impacts from winery and/or distillery ..... 64 wastes and by-products
3.4 Financial indicators and conditions in different CDM models ..... 69
4.1 Summary of data resources and value estimation for methane ..... 79 recovery CDM project activity with one electricity generator unit (in 2008 value)
4.2 Financial conditions for methane recovery CDM project activity ..... 80 (recondition of tax, depreciation etc.)
5.1 Averaged wastewater characteristics from annual plant data of ..... 104 Ayutthaya and Krabi factories' effluent
5.2 Hypothetical treatment systems for different carbon and nitrogen ..... 105 concentrations
5.3 Estimated construction, operation and maintenance cost of ..... 109 conventional activated sludge on flow
5.4 Averaged construction, operation and maintenance cost of the ..... 111 Modified Ludzack-Ettinger (MLE) retrofit on flow
5.5 Case studies' wastewater characteristics and hypothetical treatment ..... 119 system for baseline and project scenarios

## LIST OF TABLES (continued)

Table Title Page
5.6 Comparison of point-source pollutant treatment costs between ..... 121 Ayutthaya and Krabi sites in baseline and project scenarios
5.7 The valuation of environmental alleviation from methane recovery ..... 122 CDM project for Ayutthaya and Krabi sites
5.8 Infiltration rate and infiltration volume of Ayutthaya and Krabi sites ..... 126 from the Green-Ampt approximation
5.9 Infiltrated carbon and nitrogen under the open lagoons in a mass ..... 128 basis
5.10 Comparison of pollutant treatment costs under the lagoons between ..... 129 Ayutthaya site and Krabi site
5.11 Advantages and disadvantages between point-source pollutant ..... 131 valuation and infiltrated pollutant valuation
5.12 Comparison of point-source pollutant valuation and infiltrated ..... 132 pollutant valuation in baseline scenario
6.1 Independent variable (socio-economic status) of willingness-to-pay ..... 146 logistic model
6.2 Respond rate of WTP in Ayutthaya and Krabi ..... 147
6.3 Parameters of mean and median WTP by log-likelihood function ..... 149
6.4 Coefficient and P.value of willingness-to-pay regression model for ..... 152 national respondents
6.5 Coefficient and P.value of willingness-to-pay regression model for ..... 153 local respondents
7.1 Cost functions of financial and co-benefit indicators ..... 164
7.2 Selection of data for decision-making process ..... 165
7.3 The decision matrix of financial decision for site selection ..... 167
7.4 The decision matrix of co-benefits decision for site selection ..... 168
7.5 Preference scores of outranking method for selection of CDM site ..... 169 locations: Financial conditions
7.6 Preference scores of outranking method for selection of CDM site ..... 170 locations: Co-benefits conditions
7.7 Preference scores of outranking method for selection of CDM site ..... 172 locations: Complete ranking
7.8 Weighted comparative scores of finanacial and co-benefit ..... 173 indicators in each dimension concern: Complete ranking

## LIST OF FIGURES

Figure Title Page
1.1 Projected annual financing need for CDM project and current finance
1.2 Structure of dissertation ..... 5
2.1 Schematic of Clean Development Mechanisms (CDM) ..... 8
2.2 Schematic arrangement of the two-track CDM ..... 14
2.3 Classification of wastewater treatment systems for ethanol ..... 19 industry in Thailand
2.4 CDM crediting by project type, 2005-2013 ..... 20
2.5 Sectoral distribution of global GHG emission and NAMAs ..... 20
2.6 "Before and after" activities of methane recovering CDM project ..... 22
2.7 Concept of co-benefits for CDM project ..... 25
2.8 The Economics of Ecosystems and Biodiversity (TEEB) conceptual ..... 29 framework
2.9 Practical use and impacts of high strength wastewater open lagoon ..... 31
2.10 Horizontal configuration of organic matter and nitrogen pollutant ..... 33 attenuation
2.11 Vertical distribution of $\mathrm{NH}_{4}{ }^{+}-\mathrm{N}$ concentrations in the sediment at ..... 34 three different locations underneath the waste lagoon and the waste channel
2.12 Vertical distribution of (a) $\mathrm{NO}_{3}{ }^{-}-\mathrm{N}$ concentrations in porewater from ..... 35 the vadose zone beneath the waste channel and the waste channel margins, (b) sediment water content profiles under the channel and its margins
2.13 Monetary valuation methods and techniques ..... 39
2.14 Compensating Variation (CV) and Equivalent Variation (EV) ..... 44
2.15 Total environmental economic value ..... 46
2.16 Modification of total economic value model for water environment ..... 47
2.17 Methodologies of decision analysis ..... 50
3.1 Overall methodology of the research ..... 54
3.2 Project boundary with CDM implementation for ethanol factory in ..... 59 Ayutthaya province, Thailand
3.3 Project boundary without CDM implementation for palm oil factory ..... 59 in Krabi province, Thailand
3.4 Indicators of water environment contamination ..... 62

## LIST OF FIGURES (continued)

Figure Title Page
3.5 Concept of project prioritization and total benefit value ..... 70
4.1 Study process for the financial assessment ..... 72
4.2 CDM project boundary of GHGs reduction and electricity revenue ..... 81 between the schemes of electricity sale and internal electricity use
4.3 Relationship of CER investment and CERs margin against the number of biogas generators with different CER crediting periods: the scheme of electricity sale
4.4 Relationship of CER generating cost and CERs margin against the number of biogas generators with different CER crediting periods: the scheme of internal electricity use
4.5 Relationship of internal rate of return and CERs margin against the ..... 85 number of biogas generators with different project CER crediting periods
4.6 Comparison on internal rate of return against the number of biogas ..... 86 generators in 20-year CER crediting period with no loan and loan condition
4.7 Relationship of profit percentage and CERs margin against the number of biogas generators with different project CER crediting periods
4.8 Relationship of profit margin and CERs margin against the number ..... 88 of biogas generators with different project CER crediting periods
4.9 "Break-even point" of biogas-generated electricity production for ..... 89 Feed-in tariff program in Ayutthaya site and Krabi site
4.10 Relationship between incline rate of IRR and electricity generation with different CER crediting periods
4.11 Relationship between incline rate of profit percentage and electricity ..... 91 generation with different CER crediting periods
4.12 Relationship between incline rate of profit margin and electricity ..... 92 generation with different CER crediting periods
5.1 Schematic of point-source pollutant valuation and infiltrated ..... 97 pollutant valuation
5.2 Carbon and nitrogen cycle of open lagoon operation in the studied ..... 99 sites
5.3 Processes for scoping infiltrated pollutants from earthen-lining open ..... 100 lagoon and treated pollutants from UASB system
5.4 Conceptual schematic of single-stage UASB system and two-stage ..... 107 UASB system

## LIST OF FIGURES (continued)

Figure Title Page
5.5 Schematic diagram for valuating carbon and nitrogen contamination ..... 108 from factory wastewater
5.6 Relationship between construction cost and design flow rate ( $\mathrm{m}^{3} / \mathrm{d}$ ) ..... 109 by using conventional activated sludge treatment system
5.7 Relationship between annualized operation and maintenance costs ..... 110 and operational flow rate ( $\mathrm{m}^{3} / \mathrm{d}$ ) by using conventional activated sludge treatment system
5.8 Relationship between averaged construction and O\&M costs, and flow rate ( $\mathrm{m}^{3} / \mathrm{d}$ ) for small system: Retrofit
5.9 Schematic diagram for valuating infiltrated carbon and nitrogen ..... 113 from open lagoon operation
5.10 Schematic of pollutants contamination from open lagoon operation ..... 114 with the Green-Ampt approximation of infiltration rate under lagoon
5.11 Relationship between average annualized combined cost and nitrate ..... 117 removal by using conventional ion exchange
5.12 Schematic of hypothetical treatment system in baseline scenario (a) ..... 119 three-stage upflow anaerobic sludge blanket (UASB) followed by activated sludge treatment system (AS) for Ayutthaya site (b) two- stage UASB followed by AS for Krabi site
5.13 Schematic of hypothetical treatment system in project scenario (a) ..... 120 two-stage upflow anaerobic sludge blanket (UASB) followed by activated sludge treatment system (AS) for Ayutthaya site (b) single- stage UASB followed by AS for Krabi site
5.14 Infiltration condition of wetting zone in a range of depth $L$ at steady ..... 123 state of open lagoon operation
5.15 "Trifills" performance to estimate groundwater contours in ..... 124 Ayutthaya site
5.16 "Trifills" performance to estimate groundwater contours in Krabi ..... 124 site
5.17 Altitude profile to estimate wetting front depth in the Green-Ampt ..... 125 equation for Ayutthaya site
5.18 Altitude profile to estimate wetting front depth in the Green-Ampt ..... 125 equation for Krabi site
6.1 Study process for social assessment ..... 137
6.2 Framework of co-benefits valuation for methane recovery CDM ..... 139 project
6.3 Positions of host Ayutthaya and Krabi province for methane ..... 139 recovery CDM investment in Thailand

## LIST OF FIGURES (continued)

Figure Title Page
6.4 Survey procedure for contingent valuation method ..... 141
6.5 Respond rate between local and national level of target provinces ..... 148 (Ayutthaya and Krabi) to willingness-to-pay
6.6 Relationships between cumulative probabilities of WTP and local ..... 150 and national level of target provinces (Ayutthaya and Krabi) to willingness-to-pay
7.1 Value tree of key indicators on financial and co-benefits assessment ..... 158
7.2 Guideline of pair-wise scoring in the outranking method ..... 166
7.3 Partial ranking of outranking method for selection of CDM site ..... 170 locations
7.4 Proposed mechanism for the integrated assessment method of co- ..... 174 benefit CDM projects: mechanism procedure and responsibilities of relevant stakeholders

## LIST OF ABBREVIATIONS AND NOMENCLATURES

| Symbol | Description |
| :---: | :--- |
| ABM | Averting behavior method |
| AWWA | The American Water Works Association |
| AWG-KP | Ad Hoc Working Group on Further Commitments for Annex I Parties |
|  | under the Kyoto Protocol |
| AWG- LCA | Ad Hoc Working Group on Long-term Cooperative Action under the |
|  | Convention |
| BOD | Biochemical oxygen demand |
| BNR | Biological nitrogen removal |
| CAS | Conventional activated sludge |
| CBA | Cost-benefit analysis |
| CDCF | The World Bank's Community Development Carbon Fund |
| CDF | Compensated demand function |
| CDM | Clean development mechanism |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability |
|  | Act |
| CER | Certified emission reduction |
| CMP | The Meeting of the Parties |
| COD | Chemical oxygen demand |
| COI | Cost of illness method |
| COP | The Conference of the Parties serving as Meeting of the Parties to the |
|  | Kyoto Protocol |
| CPO | Crude palm oil |
| CSM | Complaint assessment method |
| CV | Compensating variation |
| CVM | Contingent valuation method |
| DBDC | Double-bounded dichotomous choice |
| DOC | Dissolved organic carbon |
| DOE | The designated operating entities |
| EB | The Executive Board |
| EIRR | Economic internal rate of return |
| EPA | Environmental Protection Agency |
| EPS | Extracellular polymeric substances |
| ERPA | Emission reduction purchase agreements |
| EV | Equivalent variation |
| FDI | Foreign direct investment |
| FFB | Fresh fruit branch |
| FIRR | Financial internal rate of return |
| Feed-in Tariffs |  |

## LIST OF ABBREVIATIONS AND NOMENCLATURES (continued)

| Symbol | Description |
| :---: | :--- |
| GHG | Greenhouse Gas |
| HCFC | Hydrochlorofluorocarbon |
| HPF | Health production function |
| HPM | Hedonic price method |
| IGES | Institute for Global Environmental Strategies |
| IRR | Internal rate of return |
| KP | The Kyoto Protocol |
| MAP | Magnesium ammonium phosphate |
| MARR | Minimum attractive rate of return |
| MAUT | Multi-attribute Utility Theory |
| MCDA | Multi-criteria Decision Analysis |
| MCL | Maximum concentration level |
| MLE | Maximum Likelihood Estimation |
| MLE | the Modified Ludzack-Ettinger |
| MOEJ | Ministry of Environment, Japan |
| MRV | Measurable, reportable and verifiable |
| NAMA | National appropriate mitigation action |
| NPL | National priorities list |
| O\&M | Operation and maintenance |
| ODA | Official development assistance |
| OOF | Other official flows |
| PCB | Polychlorinated biphenyls |
| PCF | Prototype Carbon Fund |
| PDD | Project development document |
| PEA | Provincial Electricity Authority |
| PW | Present worth method |
| REDP | A renewable energy development plan |
| SAS | Statistical analysis software |
| SD | Sustainable development |
| TCM | Travel cost method |
| TEEB | The economics of ecosystems and biodiversity |
| TEV | Total economic value |
| UASB | Up-flow anaerobic sludge blanket |
| UNFCCC | United Nations Framework Convention on Climate Change |
| VERs | Voluntary emission reductions |
| VSPP | Very small power producer |
| WTA | Willingness to accept |
|  |  |

# LIST OF ABBREVIATIONS AND NOMENCLATURES (continued) 

| Symbol | Description |
| :---: | :--- |
| WTP | Willingness to pay |
| WWF | The Worldwide Fund for Nature |

## LIST OF CONVERSION FACTORS

## Notes

Units used are metric units, unless otherwise stated

## Length:

$1 \mathrm{ft}=0.3048 \mathrm{~m}$
Mass:
$1 \mathrm{lb}=0.4536 \mathrm{~kg}$
Volume:
$1 \mathrm{gal}=0.0045 \mathrm{~m}^{3}$
Energy:
$1 \mathrm{hp}=0.746 \mathrm{~kW}$
$1 \mathrm{kcal}=4.1868 \mathrm{~kJ}$
$1 \mathrm{kWh}=3.6 \mathrm{MJ}$
Exchange rate used: (BOT 2006)
$1 \mathrm{JPY}=0.36 \mathrm{THB}$
$1 \mathrm{USD}=37.88 \mathrm{THB}$
Exchange rate used: (conversion value in CDM PDD, 2008)
1 USD $=35.86$ THB
Exchange rate used: (BOT 2012)

$$
1 \mathrm{JPY}=0.39 \mathrm{THB}
$$

1 USD $=31.08 \mathrm{THB}$
Exchange rate used: (BOT 2014)
$1 \mathrm{JPY}=0.31 \mathrm{THB}$
$1 \mathrm{USD}=32.48 \mathrm{THB}$
Year:A.D. $=$ B.E. -543

## GLOSSARY

Terms Definitions (UNFCCC 2009b, EERE 2013, unless otherwise stated)
Activated An active population of microorganisms used to treat wastewater, or the sludge (AS) process in which the organisms are employed.
Additionality The effect of the CDM project activity or CPA to reduce anthropogenic GHG emissions below the level that would have occurred in the absence of the CDM project activity or CPA.
Anaerobic A device for optimizing the anaerobic digestion of biomass and/or digester

Anaerobic A holding pond for livestock manure that is designed to anaerobically open lagoon stabilize manure, and may be designed to capture biogas, with the use of an impermeable, floating cover.
Annex I A Party that is included in Annex I to the Convention or a Party that has Party
Baseline The scenario for a CDM project activity or CPA that reasonably scenario represents the anthropogenic emissions by sources of GHG that would occur in the absence of the proposed CDM project activity or CPA.

Biogas A combustible gas created by anaerobic decomposition of organic material, composed primarily of methane, carbon dioxide, and hydrogen sulfide.
Capital cost The amount of money needed to purchase equipment, buildings, tools, and other manufactured goods that can be used in production.
CDM project A measure, operation or action that aims to reduce GHG emissions, activity
Certified A unit issued for emission reductions from CDM project activities in Emission accordance with the CDM rules and requirements, which is equal to Reduction (CER)

CFCs Chlorofluorocarbons, chemicals which result in a depletion of the ozone layer in the upper atmosphere.
Clean A mechanism under the Kyoto Protocol, the purpose of which, in Development accordance with Article 12 of the Kyoto Protocol, is to assist Parties not Mechanism (CDM) included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3 of the Kyoto Protocol.
The period in which verified and certified GHG emission reductions to

Crediting a CDM project activity or CPA, as applicable, can result in the issuance period

Designated The body granted responsibility by a Party, among other things and National Authority (DNA)
Designated An entity designated by the CMP, based on a recommendation by the Operational Board, as qualified to validate proposed CDM project activities and Entity (DOE)

Efficiency Under the First Law of Thermodynamics, efficiency is the ratio of work or energy output to work or energy input, and cannot exceed 100 percent. Efficiency under the Second Law of Thermodynamics is determined by the ratio of the theoretical minimum energy that is required to accomplish a task relative to the energy actually consumed to accomplish the task. Generally, the measured efficiency of a device, as defined by the First Law, will be higher than that defined by the Second Law.

Electricity The process of producing electricity by transforming other forms or generation sources of energy into electrical energy; measured in kilowatt-hours.
Electricity A common term referring to an electricity transmission and distribution grid

Emission factor system.
A measure of the average amount of a specified pollutant or material emitted for a specific type of fuel or process.
Externality The environmental, social, and economic impacts of producing a good or service that are not directly reflected in the market price of the good or service.
Heating The amount of heat produced from the complete combustion of a unit Value of fuel. The higher (or gross) heating value is that when all products of combustion are cooled to the pre-combustion temperature, water vapor formed during combustion is condensed, and necessary corrections have been made. Lower (or net) heating value is obtained by subtracting from the gross heating value the latent heat of vaporization of the water vapor formed by the combustion of the hydrogen in the fuel.

Host country A Party involved not included in Annex I to the UNFCCC on whose /party

Infiltration The movement of water from the surface of the land through the unsaturated zone and into the groundwater. This occurs during and
$\left.\begin{array}{ll}\text { Terms } & \begin{array}{l}\text { Definitions (UNFCCC 2009b, EERE 2013, unless otherwise stated) }\end{array} \\ & \begin{array}{l}\text { immediately after precipitation events. It can also occur at the bottom } \\ \text { of lakes and rivers. }\end{array} \\ \text { Ion exchange }\end{array} \quad \begin{array}{l}\text { An adsorption process in which one ion is exchanged for another ion of } \\ \text { like charge. There is an equivalence of exchanged charge. }\end{array}\right]$
engineered in wastewater treatment systems. The purpose of nitrification in wastewater treatment systems is a reduction in the oxygen demand resulting from the ammonia.
Non-Annex I Parties to the Convention that are not included in Annex I to the Parties Convention.

To modify existing industrial, commercial and residential facilities,
Retrofit automobiles, energy conversion systems etc., which are already in service using new, improved or more efficient parts and equipment developed or made available after the time of original manufacture or installation of the facility, automobiles, energy conversion systems etc., in accordance with any guidance from the Board on the lifetime of parts and equipment.

Stakeholders The public, including individuals, groups or communities affected, or likely to be affected, by the proposed CDM project activity or PoA, or actions leading to the implementation of such an activity.
Site The process of cleaning up a hazardous waste disposal site that has remediation either been abandoned or that those responsible either refuse to cleanup or are financially unable to cleanup.
Verification The periodic independent evaluation and ex post determination by a DOE of monitored reductions in anthropogenic emissions by sources of GHG that have occurred as a result of a registered CDM project activity or PoA.

## Chapter 1

## Introduction

### 1.1 Background

The Clean Development Mechanism (CDM) is a cooperative mechanism established under the Kyoto Protocol (KP) to the United Nation Framework Convention on Climate Change (UNFCCC), which allows emission reduction projects in developing countries from industrialized countries, by supporting finance and providing a tool of technology transfer, for e.g. clean technologies. Under this mechanism, donor countries to implement emission reduction projects in host countries with low-cost abatement opportunities and in return the donor countries or investors receive "Certified Emission Reductions" (CERs) as on joint agreement for the emission reduction units. In the CDM, the donor country is an industrialized or developed country or Annex I country having emissions targets by achieving emission reduction, while the host country or developing country or non-Annex I country has no greenhouse gases (GHG) emission restrictions. In post 2012, CDM has urged to assist the host country in achieving sustainable development (SD) (Article 12.2 of KP) through technology transfer. In addition, under the Kyoto Protocol the CDM should be integrated with National Appropriate Mitigation Actions (NAMAs) that are specific to the host country (Article 3.4 of KP). Therefore, the need of achieving GHG emission reductions from CDM project should be balanced with the aim of SD contributed in the host countries which is called "co-benefits" (Miyatsuka and Zusman, 2010; Netherlands Environmental Assessment Agency, 2009).

The current financial schemes are initiated for the CDM under the UNFCCC and the others (about 20 other bilateral and multilateral climate funds). Figure 1.1 exhibits that the funding for adaptation and mitigation was 9 billion USD a year in 2008 -2012. However, the projection indicated that adaptation and mitigation funds for developing countries in 2030 with adaptation investments ranging from 28 billion USD to 100 billion USD a year, mitigation costs ranging from 139 billion USD to 175 billion USD a year to control global atmospheric temperature (World Bank, 2010). In
recent years, CDM has been intended to provide financial resources for investment in clean technologies in purpose of contributing to their SD priorities in developing countries. Some of the funding organizations, e.g., The Worldwide Fund for Nature (WWF), The World Bank's Community Development Carbon Fund (CDCF) and CoolEarth Partnership by Japan, offer subsidies and loans which differs in the CERs approach for evaluating project activities that will result in benefits such as environment conservation.


Source: World Bank (2010)
Figure 1.1 Projected annual financing need for CDM project and current finance

The system to evaluate co-benefits from CDM projects addressed three dimensions of human well-being recognition including local environmental improvement, economical development and sustainable social development. In the CDM under the UNFCCC and some funds to support co-benefits, evaluations have been given under the methodology that assigns a score rating to meet certain standards by expert judgement (Sterk et al, 2009). Regarding methodology to evaluate co-benefits for achievement of SD in the formulation of NAMAs for developing countries, the cobenefits approach is also being regarded as voluntary climate change activities in development plans, and that activities based on national action plans should be in measurable, reportable and verifiable (MRV) manners. Therefore, the outcomes of cobenefits approach are being important to establish a method for quantitative evaluation as well as estimation of GHG emission reduction from the project (Cerqueira et al., 2012; UNFCCC, 2013).

In Thailand, Designated National Authority (DNA) issued Letter of Approval (LoA) for 191 CDM projects and has expected average annual CERs as 11.1 million tons of carbon dioxide. Around $56 \%$ of LoA received CDM projects in Thailand was being registered from methane recovery CDM projects, mostly from electricity and/or thermal generation by biogas emitted from anaerobic degradation in wastewater treatment system (TGO, 2012). with this methane recovery CDM project, however, a general concern is that it focuses primarily on emission reductions. As the concept of co-benefits, It also contributes to SD properties for improving water quality and controlling odors by closed-structure anaerobic treatment system. While considering amount of wastewater generated per product and practical wastewater management, food and beverage industries with non-aerobic storage wastewater treatment lagoon are considered as examples of high potential for implementing methane recovery CDM project and also has a high possibility to achieve tangible benefits for local environmental improvement. At present, the scoring method by expert judgement, providing positive or negative scores were considered in SD criteria including natural resources, environment, social, technology and economic for Thailand LoA approval.

In order to improve present evaluation methodology under the CDM framework and NAMAs, an ample scope of studies used a comprehensive approach to evaluate cobenefits quantitatively in MRV manners with simplicity of methods, to unify into monetary valuation for universal judgement and CDM integrity, and to develop a comparative decision method for site comparison and judgement in different financial schemes.

### 1.2 Rationale of the research

So far, the SD assessment from CDM projects has been left to the host countries so that how to ensure the sustainable benefits are really achieved from subjective views is quite a problem in the accord. Bottom-up processing to evaluate co-benefits by host country has an opportunity to ensure some local benefits at the approval stage of the CDM project, but practically the resources, expertise on this SD assessment are not on their priority.

At current situation, SD matrix has been used for CDM gold standard (CDM-GS) but
there is also a certain degree of subjectivity involved in the matrix assessment by expert judgement through Analytic Hierarchy Process (AHP). From the above reasons, this study aims to input a comprehensive approach in an example to host governments, developers and professionals on SD assessment tools to enable them to conduct co-benefit assessment with MRV manners into feasible SD indicators and to suggest further suggestions to the projects in sustainability criteria, before approval is granted.

### 1.3 Objectives of study

This study aims to assess co-benefits of methane recovering based CDM project as a new criteria to allocate financing of CDM investment with the purpose of GHGs emission reduction along with water quality improvement in developing countries The study results can be used to engage and inform stakeholders of the CDM investment in the host country, and to support the decision makers for selection of project/site implementation. Specific objectives are the following:

1. To assess and compare financial status of the methane recovery CDM projects from case studies in Thailand with different stakeholders of CDM businesses;
2. To develop co-benefits valuation methods for the dimension of environmental impact from alleviation of carbon and nitrogen contamination by additional closed structured anaerobic system from a methane recovery CDM project, and compare values between sites with different valuation methods;
3. To develop a co-benefits valuation method for the dimension of social preference from expectation of cleaner public surface water by methane recovery CDM project, and compare values between sites with different administrative scales;
4. To examine applicability of the co-benefits valuation methods, developed from CDM implemented site and applying to another unimplemented site;
5. To develop an integrated valuation method with CDM financial and cobenefits indicators for methane recovery CDM project as supporting tool for decision making process on preferential site selection to allocate financing of CDM investment.

### 1.4 Structure of the dissertation

Overall structure of dissertation is shown in Figure 1.2. This dissertation consists of 8 chapters summarized as follows: Chapter 1 provides the background information and objectives of this study and also includes the structure of this dissertation.


Figure 1.2 Structure of dissertation

Chapter 2 presents CDM situation in the post 2012 and a reform due to the integrity of SD benefits in host countries. The SD assessment for the CDM, in the present, is cited and a concept of expanding the co-benefits assessment in MRV manners is suggested and investigated.

Chapter 3 presents the overall methodological framework of the research. Then, background information is presented and the selected study sites with anaerobic open lagoon treatment system for methane recovery CDM project are explained. This chapter focuses on the methodology of GHG reduction estimation, pollutant inventory setup, scenarios establishment for financial analysis, and decision criteria.

Chapter 4 describes financial assessment of methane recovery CDM project. This section shows the comparison results of financial returns in terms of CER revenue and electricity sale from the methane recovery CDM project to compare between studied sites. CERs investment and profitability/viability of methane recovery CDM project are separately discussed in terms of different CDM investment scenarios.

On the other hand, the co-benefits assessment is conducted in the dimensions of environmental impacts and social preference. Due to advantage of carbon and nitrogen alleviation by the methane recovery CDM project, it can benefit to water environment and society.

Chapter 5 focuses on environmental impact study in project boundary based on the principle of Superfund Act, which is considered as a cost of environmental impact to pay for environmental lost by a site owner. This chapter uses biophysical approaches to assess a cost to treat carbon and nitrogen pollutants with different frameworks of point-source and infiltrated pollutants valuations including procedures to estimate pollutants mass, valuation of pollutants, and utilization of the valuation methods.

Chapter 6 presents social preference estimation for study sites in terms of expectation to provide cleaner public surface water by the CDM project with different administrative scales by using Contingent Valuation Methods (CVM). The concept and survey instrument are discussed, and the analysis of results from respondents in the study are discussed in terms of Willingness to Pay (WTP) and factors influencing WTP.

In Chapter 7, reports the indicators from co-benefits-typed CDM investment are selected and integrated from the results that examined in financial feasibility study based on Chapter 4, environmental impact assessment based on Chapter 5, and social preference based on Chapter 6. The financial and co-benefits decision matrices are developed by using pairwise outranking technique for an example of project prioritization.

The final chapter, Chapter 8 is the overall conclusions of the present study and recommendations for further works.

## Chapter 2

## Literature review

In this part, comprehensive contents and related issues on the co-benefits from methane recovering-based CDM project, in terms of marketability and sustainability integrity, are reviewed. It emphasizes the present and on-going co-benefits assessment methods. Also, co-benefits evaluation framework is structured.

### 2.1 Clean Development Mechanism

### 2.1.1 Background

Over the past decade carbon finance has emerged as an important tool for supporting climate change mitigation. The main emitted gas is carbon dioxide $\left(\mathrm{CO}_{2}\right)$ which is anthropogenic gas by burning fossil fuels. Carbon trading has grown continuously since the Kyoto Protocol was ratified. Under United Nation Framework on Convention on Climate Change (UNFCCC), most transactions have occurred within the European Union Emission Trading Scheme (EU ETS). However, the system of globally-linked emission reduction investments goes under the Article 12 of the Kyoto Protocol, the Clean Development Mechanism (CDM), which has the purpose of contributing to meet the emission with a purpose of cost effectiveness, while assisting developing countries to achieve sustainable development (SD). In figure 2.1, under this "Market-based" mechanisms of the Kyoto Protocol, each developed country (Annex I country) has been allocated a target level of greenhouse gas (GHG) emissions, and the country would then allocate permits to emitters that allow emission up to the target. Emitters could use these permits on their own, and/or augment their permits with purchases and/or investments for additional permits from other emitters. Until September 2012, international trading on GHG markets has totally issued Certified Emission Reduction units (CERs) for CDM projects as 648 million CERs (UNFCCC, 2012). The main advantage of international tradable permits system is that it would provide opportunities for market forces to work on a global level. In general, the comprehensive market-based approaches could allow considerable flexibility
which can help countries achieve a prescribed level of GHG abatement at the lowest costs. This is in contrast to "command-and-control" pollution strategies which are typical rigid and more expensive, e.g., carbon taxation scheme.


Figure 2.1 Schematic of Clean Development Mechanisms (CDM) Source: Institute for Global Environmental Strategies (IGES), http://enviroscope.iges.or.jp/modules/envirolib/upload/835/attach/charts.pdf

Under the contribution to the ultimate objective of Article 12 of the Kyoto Protocol (UNFCCC, 1998), for developing countries which are not listed in Annex I and not subject to emission reduction commitments, the goal of the article is to help them achieve SD. Since definition of SD has not been clearly stated and is subject to be interpreted and prioritized with the respect of host countries, however, It is, like other projects, used as criterion as an instrument to invest the CDM project without curiosity from society. Generally SD include three pillars, i.e., environment, economic and social development (Olsen, 2007). The latter goal rather than contributing SD is to help developing countries transition to a low-carbon development path, with the ultimate objective of decreasing global GHG reductions in the range of $50-85 \%$ relative to 2000 levels (Metz et al., 2007). Such a transition has induced clean technology investments from Annex I countries to structure funding institutions and invest infrastructures, e.g., the Prototype Carbon Fund (PCF), and renewable energy and energy-efficient production facilities in developing countries. In order to
supporting the goal of the Convention, the Kyoto Protocol stipulate that Annex I countries should transfer financial and technological resources as well as capacity building to support developing countries to achieve development with low-carbon pathway. (UNFCCC, 1992; UNFCCC, 1998).

### 2.1.2 Clean Development Mechanisms in post 2012

The second commitment of the Kyoto Protocol began in 2013 and will end in 2020. The negotiation of country ratification under UNFCCC reached less than only 15 percent of global emission, and still be structured for new agreement with a larger number of countries under Ad Hoc Working Group on the Durban Platform (Seligsohn, 2011). However, the adaptation to the climate change in developing countries has continuously been proceeded for the post-2012 CDM with the expectation that investments of environmentally friendly technologies to developing countries induce mitigation and adaptation to climate change with different stakeholders such as governments, private sector entities, financial institutions, NGOs, research and education institutions (Sterk et al., 2009).

## - Overviews and sustainability development concerns

The active promotion of CDM projects is expected to produce more than 1.4 billion CERs by the end of 2012 (MOEJ, 2009) and the projections from the current CDM pipeline, it will be issued no less than 7.4 billion CERs by 2020 (Olsen and Fenhann, 2008). As market-based approaches of CDM include the system to allow developed countries with emission reduction commitments to play a role as sponsors to implement any emission reduction projects in developing countries and receiving CERs (which converted into CERs that each equivalent to 1 ton of carbon dioxide) in return of clean technologies investment. These CERs, however, do not always contribute economic and social development needs but only GHG emission reduction, despite the fact that these needs are often a high concern in developing countries. The imbalance in the distribution of CDM project types, are due to hydrofluorocarbon-23 (HFC-23) and nitrogen dioxide $\left(\mathrm{N}_{2} \mathrm{O}\right)$ projects from adipic acid plants which contributed to almost $40 \%$ of all CERs (Wara, 2007), but it has been declined due to international regulations (UNEP RISOE, 2010). Another problem is regional
imbalances in distribution of CDM project which have encouraged to increase fresh flows of carbon finance to Asia' Least Developed Countries (LDCs) (Miyatsuka and Wakiyama., 2012). Since the CDM continues growing rapidly, there are many criticisms on aforementioned problems especially its contribution to SD. Against this problem, on the further development of the project-based CDM within the future climate regime, the focuses are on how to couple the CDM's quality and its contribution to SD in developing countries, with the environmental integrity in quantitative aspect.

## - The current status of the negotiations on sustainability integrity

The future of the CDM is being discussed under both the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG- LCA) and the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP). The purpose of improving the environmental integrity and contribution to SD of the CDM that have been negotiated under the AWG-KP. A comprehensive picture of all the proposals of SD integrity have been discussed since the decisions of the negotiations in April 2008 in Bangkok (AWG-KP 5.1) to the recent negotiations in November 2012 in Doha (AWG-KP 17.2), and it is also presented on a version from April 2009 in Bonn that contained additional proposals that are introduced about the positive or negative lists and making in achievement of co-benefits mandatory for registration under the CDM (UNFCCC, 2009a).

The improvement of the environmental integrity and contribution to SD of the project-based CDM was proposed in various ways. The current negotiations under the UNFCCC are mainly on defining standardized baselines, including benchmarks and parameters, in project types for demonstration of additionality (a project would not be occurred as usual), and addressing SD integrity or co-benefits. The discussions on the co-benefits still do not reach any decision on the issues so far but there is a flavored request to implement measures to enhance "visibility" of co-benefits and measures to promote co-benefits to some extent (Sterk et al., 2009). The issues on reforming the CDM regarding with SD are described as follows;

- Project additionality screening principles

Basically, testing on additionality is project-based, but the performance standard has urged to implement for more accuracy by establishing a generic baseline scenarios against all projects or given type of project in an industrial sector and country by establishing parameters, including benchmarks, and procedure on the basis of top-bottom process, it requires comprehensive data collection, verification and a regular update, and may be feasible for certain industries, but it may thus reduce cost and administrative burden for the CDM (SEI, 2011). Additionally, positive and negative lists are set up for an ease to additionality test. established a lists of project types mean these project types have been assumed to be nearly always additional from business-as-usual, thus there is no need to undergo project-by-project basis. A lists of negative projects would restrain some specific project types which assumed to nearly always be non-additional from their eligibilities (Sterk et al., 2009). From the perspective of SD integrity, based on benchmark test, it could not simply assume that a specific type of project is always contribute SD. Viability of a project should be differently discussed with a purpose of SD which depends on the specific circumstance in a country.

- Co-benefits principles

The co-benefits approach is a new project-based approach to address SD integrity. Japan, for example, has launched the co-benefits CDM in 2006. The objective of the co-benefit approach aims win-win situation to help developing countries address their economic and social development needs and achieve target of GHG emission reduction by developed countries (MOEJ, 2009). Under UNFCCC framework, registered co-benefits projects would receive promotions by following advantages, e.g., postponement of fees, expedited registration, and application of simplified modalities and procedures (SEI, 2011). A fundamental criterion of co-benefits approach in the negotiation text suggested that projects would be required to declare for specific co-benefits as a requirement for project registration. Unless, projects could not be registered as co-benefits CDM.

In order to specify co-benefits from CDM projects, in current negotiation under the KWG-KP, the list of co-benefits is discussed in very generic point of views. Economic growth from particular aspect would probably apply to all types of CDM projects. Therefore, the co-benefits would need to be more elaborated. In particular, either the Conference of the Parties serving as Meeting of the Parties to the Kyoto Protocol (COP) or the Executive Board (EB) would need to organize to define specific indicators to measure whether a project achieves co-benefits (Sterk et al., 2009).

## - Multiplication and Discount Factors

With the objective to compensate for CDM market imperfections (e.g., testing on additionality, imbalanced distribution by region and project type, and SD contribution), Many options of differentiation have been proposed. The option of multiplication and discount factors, that is, factors to increase or decrease the number of issued CERs (normally one CER used to offset one ton of emission reduction), could be applied and adjusted to the most of market imperfections with windfall profits than other methods so that they could offset to underrepresented countries in the market and the project which strongly contribute to SD (Bakker et al., 2011). The drawbacks of this approach is that discounting possibility create a mechanism that result in net global emission reduction, if the non-additional project is lower than the application of discounting rate. Another drawback is that applying discount rate may reduce CERs issued from the truly additional projects, which actually depend on the CER revenue to become viable. By contrast, non-additional projects could still be not screened out and brought forward. Therefore, discounting is considered to not be an instrument for additionality test. Nevertheless, with this approach, the trade-off in the interest of SD integrity seem acceptable by multiplying /discounting to augment/limit environmental contributions, although, additional project do not achieve a net atmospheric benefit (Sterk et al., 2009). It has been demonstrated a conflict between additionality and expected SD benefits (Alexeew et al., 2010)

## - Integrity of sustainability development to market-based mechanisms

Olsen \& Fenhann (2008) pointed out that 296 CDM projects, out of total 744 projects, submitted with expected SD benefits till May 2006. The methods to assess SD allowed projects to be ranked from a number of potential sustainability benefits. Thus, actual realized SD is needed to compare with expected SD in the present assessment and need to be in addition of national criteria. Since the assessment of actual SD increase transaction cost to the CDM, international carbon markets, so far, do not attribute a price premium to this SD (Nussbaumer, 2009; Olsen, 2007; Sutter and Parreño, 2007).

Nevertheless, the assessment of SD depend on how SD is defined. The choice of SD parameters is subjective by their nature in each host country, and is complied with different number of the criteria in same CDM project type. From that reasons, there is competitive choices to investor for implementing lower cost projects with larger CDM revenues and potentially lower risks because it is potentially the result of a "race to bottom" in a country which has less stringent SD criteria (Schneider, 2007). In order to make a pricing of sustainability benefits into the carbon market, standardizing SD criteria in some CDM project type is required because the assessment vary between CDM host countries. Otherwise, investors will prefer cheap projects rather than sustainable CDM projects with price premium.

Since SD faces problems of quantifiable measurement and market practice, Torvanger (2013) suggested that a "Two-track CDM mechanisms" should be applied into the market as shown in Figure 2.2. In the track of SD-CERs, a project developer must indicate the extents of the SD criteria and method to measure the performance in the project development stage. The SD performance should be graded rather than subjective scoring or check-list as in the case of normal CERs. Then, the grades from the assessment would be indicated in the project development document with international justification by comparing expected and actual sustainability impacts. Once the project is under the process and claimed for sustainability benefits, the Designated Operating Entities (DOEs), as independent auditors, would evaluate the projects' performances and also assign grades to various expected SD impacts vis-àvis the grades assigned to them by the project developer.


Figure 2.2 Schematic arrangement of the two-track CDM
Source: modified from Torvanger (2012)

These grades, linked to a price premium, would be mandated for developed countries to buy a certain quota of SD-CERs which are correspond to over-achievement, inrange achievement and under-achievement against the expected performance.

In the present, willingness to pay for sustainability benefits from the CDM existed. Due to the report's interview on 19 answers at a particular CDM symposium from Kollmuss, et al. (2008), $32 \%$ of 55 respondents have their preferences to pay for SDCERs. A premium price of $5-25 \%$ from CERs price is possible as shown in Table 2.1. A premium varies widely depended on specific project type and location. The higher premium occurred when sustainability benefits perceived in smaller projects than large industry projects. The relative premium for Voluntary Emission Reductions (VERs) is distinctly higher about 70-100\%, however, the absolute price is much lower than the CER price because of the lower requirements in the voluntary market.

As aforementioned reasons, the set of modalities and procedures which would be more sophisticated to safeguard enhanced SD benefits and improve the environmental impact of the CDM projects has been asserted. Quantifiable measurement including criteria and indicators for assessing the environmental, economic, and social impacts of a project, as well as detailed requirements for stakeholder involvement is required. Without reforming sustainability assessment, SD integrity of the CDM is clearly superior to vague qualitative judgement, as provided by most host countries. Many of concerns to ask on positive benefits from a project in qualitative manner would be the same result as when asking whether it has negative impacts in "Do no harm approach".

Table 2.1 List of responses on premium for CERs with sustainability benefits (about $11.4 €$ at the average 2008 exchange rate)

| Premium on CER Certificates - List of Estimations by |
| :--- |
| Buyers in Absolute and Relative Terms |$|$| Response 1: CERs: ca. $1 €$ or $8 \%$ premium |
| :--- |
| Response 2: CERs: premium between $1-2 €$ for larger <br> projects, $5 €$ for small volumes |
| Response 3: CERs: premium of around $2 €$; VERs: <br> premium of around $4 €$ <br> Response 4: CERs: $3 €$ or $25 \%$ premium <br> Response 5: CERs: $3-7 €$${ }^{2}$R |

Source: Kollmuss et al. (2008)

## - Criteria and Indicators for environmental, economic, and social impacts

The assessment of the CDM Gold Standard (CDM-GS) has been used as a wellknown example to point out that whether the effectiveness of the Gold Standard assessment work well with sustainable projects. There are two main methods for CDM GS assessment as follows;

- Do no Harm Safeguards

The CDM process should ensure that technology transfer do not cause harms or negative consequences to people and the environment. In other words, intention to address one problem should not make new harms and problems because it is a duty of the international community which created the CDM to prevent unacceptable harms to host countries (Johl and Lador, 2012). Therefore, the EB of the CDM should adapt international safeguard criteria and indicators for their assessment and comply with project developers to submit a description in criterion related to the CDM activity. Like other project investments, description should be prepared for gravity of the expected risks and appropriate measures to cope with negative impacts. Nevertheless, many of the questions to be asked on whether a project has positive benefits would
be the same as when asking whether it has negative impacts (Sterk et al., 2009)

- Sustainable development matrix (voluntary assessment)

Apart from "Do no harm approach" to prevent negative impacts, the assessment of a positive contribution to SD , a SD matrix approach with verifiable indicators is required. To be registered as CDM-GS, project developers must demonstrate that the project activities give total positive externalities - projects with non-positive and negative sub total score are not eligible for the GS (the gold standard, 2006). Project developers need to assess their projects against lists of criteria including environmental, economic, and social impacts, for an example in Table 2.2. Its application is no obligation to quantify impacts, but only scoring by experts and qualitative explanation, to avoid incremental cost of the CDM-GS and not required to assess criteria that has obviously no effects. The most important methods to assure the quality of the CDM GS are a "bottom-up review process", which is closely monitored by experts and "verification process" which is subjected to be checked by independent auditors.

Table 2.2 Example of sustainable development matrix

| Environment | Social development | Economic and technological <br> development |
| :--- | :--- | :--- |
| Air quality | Quality of employment | Quantitative employment and <br> income generation |
| Water quality and quantity | Livelihood of the poor |  |
| Soil condition | Access to affordable and <br> clean energy services | Balance of payments and <br> investment |
| Other pollutants | Human and institutional <br> capacity | Technology transfer and <br> technological self-reliance |
| Biodiversity |  |  |

Source: Ecofys et al. (2008)

On this basis, although verification process is obligated, it is clear that there is a certain degree of subjectivity involved in the matrix assessment. There is
evidently shown a trade-off between the objective of SD integrity and increasing transaction costs. Assessment by quantitative analysis of project impacts would increase project transaction cost, and thus make projects unattractive. However, we could not deny that quantifiable sustainability benefits make a difference of actual co-benefits attached in CDM projects, whether it will include into the pricing mechanism.

### 2.2 Methane recovering based CDM project

The CDM methodologies required for alleviation of methane gas emission for anaerobic open lagoon are new technologies to be transferred. The project activities fall under the following types and categories in Table 2.3.

Table 2.3 The project types and categories of methane recovery based CDM project

| Type/ Category | Description | References |
| :---: | :---: | :---: |
| Type (iii):Other project activities/ <br> AMS-III.H. Methane Recovery in Wastewater Treatment | This category covers the biogas recovery component of the project by '(vi) introduction of a sequential stage of wastewater treatment with biogas recovery and combustion, with or without sludge treatment, to an existing anaerobic wastewater treatment system without biogas recovery. Measures are limited to those that result in aggregate emission reductions of less than or equal to $60,000 \mathrm{tCO}_{2}$ equivalent annually. | IPCC Version 10, Scope 13 , in effect as of Oct. 10, 2008 |
| Type (i): Renewable energy projects/ <br> AMS-I.D. Grid Connected Renewable Electricity Generation | This category comprises renewable energy generation units, such as photovoltaics, hydro, tidal/wave, wind, geothermal and renewable biomass, that supply electricity to and/or displace electricity from an electricity distribution system that is or would have been supplied by at least one fossil fuel fired generating unit. The added capacity shall be not exceed 15MW. | IPCC Version 13 , Scope 1, in effect as of Dec. 14, 2007 |

Source: IPCC (2006)

### 2.2.1 Business-as-usual practice for distillery slop treatment

An ethanol factory in Thailand is selected as a case study for co-benefits approach because this kind of factory, in nature of business practices, has high potential for implementing methane recovery CDM project and also has possibility that the waste
from the factory contaminate water resources from unlined construction of wastewater treatment system. Thailand produces ethanol mainly from molasses and some produced from cassava. Main waste of ethanol factory is wastewater, $44.8-99.3 \%$ of total wastewater, from distillation process that is called "stillage" or "slop". In year 2012, Thailand has 19 large-scale ethanol factories with $1.8-1.9$ million liter/day in $99.5 \%$ ethanol production rate capacity and tends to increase every year because mixing use with gasoline for increasing demand of fossil fuel substitution especially in Thailand, where ethanol represent $10 \%$ and $20 \%$ of the alternative biofuel blend (Preechajarn, 2011).

Distillery slop that is the main wastewater from ethanol factory contain very high organic and inorganic matters from concentrated ethanol wastes after fermentation and distillation processes. All constituents of distillery slop contain substances which are used as additions to the fermenter (e.g. less fermentable sugar, yeast metabolites and yeast cell contents). Therefore, with characteristic of distillery slop, it becomes a valuable resource for using as fertilizer, animal feed, or by-product methane gas, while it can also be a serious source of water contamination. From Figure 2.3, commonly, in Thailand ethanol factories are located adjacent to surface water because of the nature of business to economically use water resources. So, it is needed to handle wastewater properly. Although, the selecting the most appropriate slop management is a matter of trade-offs between energy, economic and environmental consideration, most of distillery slop still remain from the slop reuse due to high wastewater amount per production rate. Consequently, open lagoons have been increasingly built in purpose to stabilize and store distillery slop in their factory land. From the data of wastewater treatment systems category by production rate in year 2006 Thailand, almost all of ethanol factories have handled remaining distillery slop with open lagoons and around $37.5 \%$ of ethanol production, open lagoons have been solely used for wastewater treatment as shown in Figure 2.3. Therefore, it is assumed that at least methane recovery CDM project could be implemented to this business-asusual practices and could also be expected for alleviating local water quality related (DIW, 2009).


Figure 2.3 Classification of wastewater treatment systems for ethanol industry in Thailand

### 2.2.2 Market share for methane recovery CDM project

## - Global market trend

In the past, CERs has been mostly issued towards industrial gas disposal projects (e.g., hydrofluorocarbons emitted as a by-product of hydrochlorofluorocarbon (HCFC) production, and nitrous oxide emitted from adipic and nitric acid production). About 75 percent of issued CERs had allocated to these projects since the commencement of the CDM. Renewable energy projects, latterly, have a substantial and growing share and it has become to overtake industrial gas projects since 2013 (see in Figure 2.4).

The predominance of industrial gas projects was driven by the very low cost and high volumes of CERs in these projects (Wara, 2006) because these types of projects was implemented by pre-existing technologies and relatively easy and straightforward methodologies rather than other project types, as well as, proven to be additionality for these projects. However, increasing CERs of industrial gas projects has declined by international regulation for HCFC projects in 2011.


Figure 2.4 CDM crediting by project type, 2005-2013
Source: modified from Australia Government Climate change authority 2014, based on UNFCCC (2014)

Although emissions from waste account for a small share of global GHG emissions, there has been a lot of interest in NAMAs in this sector. This underscores the importance attached by developing countries to the waste sector for their SD as shown in Figure 2.5 (Lorenzo, 2014). In Thailand, as a case country of this research, Designated National Authority (DNA) issued Letter of Approval (LoA) for 191 CDM projects and has expected average annual CERs as 11.1 million ton of carbon dioxide. Around $56 \%$ of LoA received CDM projects was being registered from methane recovery CDM projects, mostly from electricity and/or thermal generation by biogas emitted from anaerobic degradation in wastewater treatment system (TGO, 2012).


Figure 2.5 Sectoral distribution of global GHG emission and NAMAs
Source: modified from Lorenzo (2014)

## - Thailand market trend

From the past year, several model co-benefits projects (i.e. Methane recovery from wastewater treatment in Thailand) are already underway in Asia. Cost saving from incorporating co-benefits seem to be particularly significant in Asia. Thai government policy has addressed that global warming is a key component influencing future national development in $11^{\text {th }}$ the national economic and social development plan (2012-2016). This plan has focused on approaches to enhance efficiency in energy conservation, expansion of biomass energy, and adaptation to climate change. In 2000, Energy sector is a main sector of total national GHGs emission (69.57\% of 210 million ton of $\mathrm{CO}_{2}$ ). A renewable energy development plan (REDP) has been proposed with intention to promote renewable energy at a share of $20.4 \%$ of the total energy supply in 2022 (Weerathaworn, 2009). Since community cohesion is a major indicator caused a drop of social development in Thailand, co-benefits approach to ease surrounding environment is a mechanism to achieve sustainable economic and social development according with present Thailand national development plan. Until March 2010, 100 CDM projects had approved with $\mathrm{CO}_{2}$ reduction potential equivalent to 6.3 million ton per year (most projects dealt with biogas and biomass energy projects) which are consistent with the criteria of the CDM and SD criteria of Thailand. Nevertheless, no systematic research studies have been conducted to introduce techniques for preparing socio-economic scenarios or NAMAs corresponding with financial flows from the CDM mechanism in Thailand.

### 2.2.3 Methane recovery and renewable energy project for open lagoon wastewater treatment

In business-as-usual practice of wastewater treatment system for ethanol plant, wastewater discharged from factory is treated in series of non-aerobic storage lagoons without discharge to public water sources. CDM activity process is shown in Figure 2.6. It is designed to treat the wastewater in a closed-structured anaerobic processing system prior to existing the series of lagoons, practically Up-flow Anaerobic Sludge Blanket (UASB) installed, to partially capture methane gas and reduce organic carbon to open lagoons, so as to restrict the atmospheric emission of methane gas from the lagoons. Meanwhile, the captured methane gas from closed-structure treatment tank is
recovered (without leakage to atmosphere) to utilize for power generation by gas engine. The generated electricity is subject to sell to grid under Very Small Power Producer (VSPP) scheme or utilize as internal electricity use. The emission reduction is counted from the reduction of national fossil fuel consumption for generating power supply equivalency and through the combustion of surplus methane gas, in case of emergency, by a flare stack.


Figure 2.6 "Before and after" activities of methane recovering CDM project

### 2.3 Economical analysis of CDM project

CDM project is assigned to firstly demonstrate additionality of CDM projects as the requirement by the financial analysis test, mainly the internal rate of return (IRR) analysis, published by UNFCCC CDM Executive Board. The developing project has to be determined whether the project activity can be invested by their own with economical and financial sound or not. The CDM project have to be not attractive for investment without the revenue from the sale of CERs.

One of the measures of worth of an investment we treat involve the use of a compound interest rate. The interest rate used is variously referred to as a minimum attractive rate of return (MARR), required rate of return, return on investment, or discount rate. Various methods exist for determining the value of the interest rate to use; e.g. present worth method (PW), annual worth method, future worth method,
internal rate of return method (IRR), payback period method, etc. (Block and Hirt 1994). In developing of method and criteria for measuring the worth of investment, IRR method determines the interest rate that yields a present worth (or future worth or annual worth) of zero.

The calculated IRR without CER revenue from methane recovery CDM is usually below $0 \%$, which means not attractive investment, and become an realization with CER revenue with average IRR of $15-17 \%$ in Thailand between year 2004 and 2011 (Siteur, 2012) and with median $\Delta I R R$ of $17 \%$ (CDM investment additionality by difference of IRR without CER revenue and with CER revenue) from a sample of 222 world-wide registered CDM projects in year 2005-2008 with $\Delta I R R$ in a range of 2$19.4 \%$ of all different project types (Yong, 2009)

In terms of economic assessment for the CDM project, financial indicators such as IRR will be chosen appropriately to make a decision for investment. If methane recovery CDM projects are assumed to actually deliver benefits to local environment improvement, the choices of GHGs mitigation, considered as alternatives for comparable remediation costs, would be counted as cost of pollution prevention. As for cost of prevention, CERs are related to reduction of pollutants somehow when it has a certain relationship between reduction of GHGs and reduction of pollutants as equation below (Junjie and Can, 2011).

Relationship between reduction of greenhouse gases and pollutants:

$$
r_{C O D, T N, T P}=\delta r_{C O_{2}}
$$

Relationship between carbon credits and reduction of pollutants:

$$
r_{C O D, T N, T P}=\delta p c_{C O_{2}}
$$

Where: $r_{C O D, T, T P}$ is Reduction of COD, total nitrogen and total phosphorus
$r_{C O 2}$ is Reduction of carbon dioxide - equivalent
$c_{C O 2}$ is Value of carbon credits
$\delta$ is Regression coefficient
$p$ is Unknown parameter (if the project is awarded more than what it actually reduces, then $p<1$. If $\mathrm{p}=1$, then carbon credit issuance is fair. If $\mathrm{p}>1$, it means that the emission baseline is too conservative)

In order to promote co-benefits CDM projects, the feasibility of the project implementation with sustainability benefits should be accurately determined. To promote and differentiate projects which have the high sustainability benefits, the values of benefits should be taken into consideration for financial analysis. There is a theoretical suggestion that the IRR of co-benefit project should be included ways to calculate the co-benefit effects, environmental benefits, from improving environment condition including water, air, waste issues, and so on from status quo. In order to differentiate IRR for feasibility study and co-benefits analysis of CDM projects, table 2.4 describes that financial internal rate of return (FIRR) is measured by monetary value of revenues and expenditures including CERs revenues as income of projects. For co-benefits projects, on the other hand, analysis of economic internal rate of return (EIRR) is the IRR by concerning additional monetary value from actual benefits which varies by different conditions in the country (MOEJ, 2009).

Table 2.4 The difference of internal rate of return between the CDM and co-benefit CDM

|  | Type | Outflow | Inflow | Type of return | Evaluation criteria |
| :--- | :--- | :--- | :--- | :--- | :--- |
| FIRR <br> (Financial <br> internal rate <br> of return) | With cash <br> revenue | Expenditure | Revenue | Cash | Compare with <br> interest rate levels <br> in the region <br> concerned |
| EIRR <br> (Economic <br> internal rate <br> of return) | Without cash | revenue | Cost | Benefit | Tangible and <br> intangible <br> benefit |
| Example: 4\% for <br> Japan, 12\% for <br> developing country |  |  |  |  |  |

### 2.4 Co-benefits of methane recovering based CDM

Nevertheless, the purpose of CDM, as defined by Article 12 of the Kyoto Protocol, is not only intended to achieve reduction of GHG impact in global aspect but also expected to help developing countries achieve SD (MOEJ, 2009). With expectation to benefit from project activities resulting in CERs, Figure 2.7 presents that the cobenefits approach was established as a new project-based approach to address climate change concerns while also improving the local environment for developing countries according with local development goals with sustainable manner, which resulting
from socioeconomic growth within developing countries is accompanied by deteriorating environmental problems, such as water and air pollution and waste management, and it is becoming more serious. And as part of development needs, addressing such environmental problems by pollution control is now more prioritized to protect human health and more efficient socioeconomic productivity. However, the capacity of developing countries to address the increasingly difficult problem of environmental pollution is limited, due to the shortage of financial and technological resources and management experiences, and support in these areas is essential for meeting these nations' development needs. For example, by promoting the implementation of methane recovering projects, both water quality improvement and GHG emissions reduction can be achieved, which gives developing countries a strong incentive to promote effective climate change mitigation.


Figure 2.7 Concept of co-benefits for CDM project
Source: modified from MOEJ (2009)

Industrial wastewater discharge or leakage may cause public water contamination, if treatment system not properly treated or operated. If wastewater is treated with unstable conventional method, high contents of organic wastewater in the system release methane, and has potentially water contamination and odors to the surrounding communities. Proper treatment technologies and equipment will offer cobenefits and control these problems. With this methane recovery CDM project, however, a general concern is that it focuses primarily on emission reductions. As the concept of co-benefits, it also contributes to SD properties for improving water
quality and controlling odors. When considering amount of wastewater generated per product and practical wastewater management, ethanol factory is one case study that has high potential for implementing methane recovery CDM project and also has possibility to achieve tangible benefits for local environmental improvement.

### 2.4.1 Beneficiaries and benefits from methane recovery project

An examples of methane recovery CDM project showing how importance of watershed management actions create benefits. For example, an upgrade by installing UASB which improves the wastewater treatment performance of existing operation, and these results in improving the quality of treated effluent and/or reduce frequency of untreated wastewater bypass. The broad benefits from water quality improvement are shown in Table 2.5.

Table 2.5 Benefit, beneficiaries and funding mechanism of improved water quality

| Benefit | Beneficiary | Funding mechanism |
| :--- | :--- | :--- |
| Improved municipal <br> water supply | Urban water supply customers <br> (enjoy better quality, quantity, safety, <br> lower cost) | Municipal water bill or property <br> taxes (if customers are not billed <br> separately) |
| Improved assimilative <br> capacity for municipal <br> wastewater effluent | Urban water supply customers <br> (benefit from treatment cost saving) | Municipal water bill or property <br> taxes if customers are not billed <br> separately |
| Improved water quality <br> and quantity for private <br> water and wastewater <br> systems | Industry, farms, rural residents | Large users - volumetric charges <br> attached to water taking permits or <br> to certificates of approval for <br> effluent discharges, property taxes <br> if user charge are not feasible <br> Small users - charges for |

Source: Fortin and Dofonsu (2001)

The expected benefits experienced by water supply and wastewater systems, recreational experience, agricultural, commercial, industrial operations and non-use benefits. The use of a "beneficiary pay" principle or "polluter pay" principle are different by a purpose of uses. In terms of fairness, enforcement of "beneficiary pay" principle is quite not suitable to apply because benefit valuation of water resources contain with high uncertainty and also many nuisances, in contrast with "polluter pay" principle, which can be established by laws and regulations (Mauerhofer et al., 2013). In beneficiary pay basis for funding decision, the values of benefits could be used to make an information for decisions, regarding the cost allocation among beneficiary groups.

### 2.4.2 Development of co-benefits assessment

In recent years, CDM has been intended to provide developing countries with additional financial resources for investment in clean technologies while contributing to their SD priorities. Co-benefits funding organizations, for example, The Worldwide Fund for Nature (WWF), The World Bank's Community Development Carbon Fund (CDCF) and CoolEarth Partnership by Japan, offer funds or loans which differs in the approaches for evaluating project activities and environmental benefits (Aditi, 2009 and Ministry of Foreign Affair, Japan, 2007).

This system commonly evaluates the SD contributions to CDM projects using three criteria, i.e, local environmental improvement, economical/technical development and social development. Some co-benefits funds has been given under the methodology that assigns a score rating to meet certain standards. Regarding methods to evaluate co-benefits in host countries, the co-benefits approach is correspond with an important concept in national development plans which should be based on "measurable, reportable and verifiable" (MRV) manners, then the outcomes of co-benefits approach and the national plan should be identified with the same basis. Therefore, it has been important to develop methods for quantitative evaluation of co-benefit project outcomes.

At present, the scoring method by experts is also used in SD criteria including natural resources, environment, social, technology and economic for Thailand LoA approval.

In order to improve evaluation methodology according with national action plans, four aspects which should be taken into consideration are to evaluate benefits quantitatively, to simplify evaluation method, to create techniques for preparing socioeconomic indicators consisting with climate change in the country and to unify to economic evaluation indicators.

### 2.4.3 Principles of Superfund site

The situation on hazardous waste contamination in the late 1970s, the United States Congress established the Superfund program under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. Under that program, some of the most contaminated site by waste and waste byproducts in the country has been chosen by the Environmental Protection Agency (EPA) and placed on the National Priorities List (NPL). The funds have supported to cleanup the sites which could not be recovered by a responsible party. By 2007, only around 1,500 sites out of more than 47,000 hazardous waste sites has been placed on the NPL because the cleanups of the Superfund sites are not that cheap. Even before the budget crisis in Washington, for making decision of site selection, an evaluation of costs and benefits is needed for allocating the budget, and the latter necessitating a non-market valuation exercises (Greenstone and Gallagher, 2008; Timmin, 2010) The open lagoon operation is on the same situation, although, the effluent of the lagoons do not directly discharge to public water resources. Eventually, the sites operated for a long time is also needed for cleanup, maybe not from hazardous waste but high concentrated organic matters and so on accumulated in the soil under the lagoon. In current situation, the open lagoons have been increasingly builded in purpose to stabilize and store high strength wastewater. Therefore, the assessment of cost and the impacts from the lagoon operation is necessary for allocating co-benefit funds and comparing between sites.

### 2.4.4 Ecosystem valuation: TEEB conceptual framework

In any defined ecosystem unit, The Economics of Ecosystems and Biodiversity (TEEB) conceptual framework starts with ecosystem structure, processes and their functions. The building block of ecosystem functions is the complex interactions
between structure and processes of nature, which may be physical (e.g. infiltration of water, sediment properties), chemical (e.g. oxidation, reduction) or biological (e.g. degradation, nitrification), disturbed by human activities and directly/indirectly also affected to them, as shown in Figure 2.8 (Fisher and Christie, 2010).


Figure 2.8 The Economics of Ecosystems and Biodiversity (TEEB) conceptual framework

Source: modified from Fisher and Christie (2010)

The changes of ecosystem services from direct and external drivers would give positive/negative externalities to human well-being in economic (welfare), social (well-being) and ecological (sustainability) aspects. Regarding project details and site characteristics, benefits of human well-being could be accessed as follows;

## - Environmental benefits by biophysical approach

Measures of value by biophysical approach are important indicators to determine thresholds and minimum requirements for maintaining a given ecological state, or critical amount of non-substitutable natural capital being preserved (ecologically stable environment) (Fisher and Christie, 2010). These values are physical capital (measuring in weight, area, or energy) in "strong sustainability" concept which should be distinguished from social capital in
"weak sustainability" concept by preference-based approach because although physical values also contribute to welfare, but social value should be taken into account in the expression of individual preferences for sustainability analysis (Wackernagel et al., 2001). Valuation of biophysical approach from the lagoon operation use a "cost of waste management" as "cost of production" to derive values from measurements of the physical costs (e.g., in terms of labor, land requirement, energy or material inputs) for producing a good or service.

- Economic and socio-cultural benefits by preference-based approach

In contrast to biophysical approach, preference-based approach in environmental issues bases on models of human behavior to natural resources which rest on the assumption that values arise from the subjective preferences of individuals (Fisher and Christie, 2010). Stating values by individual preference could capture all values from given ecosystem service because ecosystem services are important to humans for many reasons. In economic terms, values from this approach contributes to various components of "Total Economic Value" (TEV), comprising both use values (including direct use , e.g., water consumption, recreation, and indirect use, e.g., water productive use) and non-use values, e.g. the value from people thinking for protecting nature for future use, which called "option values" or for ethical reasons, which called "bequest and existence values" (Kontoleon et al., 2002). The preference-based approach for water environment simulates a hypothetical market and demand for water use by means of surveys on changes from any implementation in the provision of water services. With no actual market or product exists, the extracted value of water service could be deduced and depended on an asserted hypothetical market in current water situation.

### 2.5 Environmental assessment of anaerobic open lagoon

High strength wastewater effluent is produced from factory in large volumes in regions throughout the year. In Thailand, effluent with high nutrients has been partially used as fertilizers, activators and animal feeds for agriculture, land and
aquatic animal livestock. Anyhow, most of effluent has still remained and increased in open lagoons, as a result of increasing numbers of effluent receiving lagoons in sets of two or more in series constructed by the factory owner (It is noted that approximately $4,000 \mathrm{~m}^{2}$ of land is required to treat 100,000 liter of distillery effluent with minimum retention time of 20 days). In addition, there are likely to be odor problems (Sheehan and Greenfield, 1980), occasional surface and ground water contamination as shown in Figure 2.9. Consequently, because of its characteristics, it has negative effects on human activities and aesthetic appeal of the environment.

The impact assessment is specific for each site judgement because different wastewater characteristics, open lagoon construction and operation and site characteristics dependently affect to site owner and nearby communities.


Figure 2.9 Practical use and impacts of high strength wastewater open lagoon

### 2.5.1 Pollutant inventory

The type of CDM project activities would be, somehow, representative of the cobenefits approach. Suggestion for biophysical indicators can be specified from the cobenefits expected directly from that activities. As for ethanol and palm oil industries, evaluation methodologies and indicators of the co-benefits approach in the water
quality improvement are subject to reducing pollutants (e.g. COD, odors, nitrogen, phosphorus and hazardous substances) as shown in Table 2.6 (Magnussen and Bergland, 1996).

Table 2.6 Possible selected list of projects using the co-benefits approach in water quality improvement category

| Description of project | Co-benefits indicator | Co-Benefit effect | Projects registered as CDM projects |
| :---: | :---: | :---: | :---: |
| 1. Methane emissions reduction and/or capturing (for flaring or electricity generation purpose) by changing the treatment process for high strength organic wastewater <br> - Capture methane by closed-structure anaerobic treatment system <br> - Change to be more efficient anaerobic treatment processes and capture methane - Reduce methane emissions by changing to be more efficient aerobic treatment process that make less released methane than inefficient one <br> 2. Wastewater use for energy or as a raw material <br> - Recover alcohol from blackstrap molasses and use for electricity generation purpose | COD <br> Odors <br> Nitrogen <br> Phosphorus <br> Heavy metals | - Reduce emissions of water pollutants by enhancing efficiency of wastewater treatment - Reduce emissions of odors (hydrogen sulfide) generated from wastewater - Use resources effectively by reusing wastewater | AM0013: avoided methane emissions from organic wastewater treatment AM0039: methane emission reduction from organic wastewater and bio-organic solid waste cocomposting AMS-III.H: <br> Methane recovery in wastewater treatment AMS-III.I: <br> Avoidance of methane production in wastewater treatment through replacement of anaerobic systems by aerobic systems |

### 2.5.2 Groundwater contamination

The high strength effluent is stored in large open lagoons, which were unlined for a long term retention. In case that characteristic of the soil being red sandy loam, the effluents percolate into the soil under lagoons contaminating soil itself and groundwater. contamination of groundwater has emerged as a severe environmental issue in the locality due to spreadability to nearby field and percolation of effluent from lagoon to the groundwater. This has affected the prospectus of agriculture, health and environment in that region. Consequent to use of polluted groundwater for irrigation farmers are incurring heavy losses in agriculture due to use of polluted groundwater (Yoshida et al., 2003; Carvella et al., 2005; Varuni, 2006).

## - Boundary of organic matter and nitrogen pollutant estimation in open lagoon sediment

In Figure 2.10, upper shallow sediment under lagoons (Oxic unsaturated zone) is considered as an important organic mineralization pathway to dominate in different conditions of saturated zone (in this study, it assumes that percolated organic matters and nitrogen species below unsaturated zone have a potential to contaminate water resources). Availability and vertical distribution of oxygen and organic carbon load determine the thickness of the oxic zone, which vary from less than 1 millimeter to a few centimeter in the upper sediment (Zilius, 2011).


Figure 2.10 Horizontal configuration of organic matter and nitrogen pollutant attenuation

Source: modified from Zilius (2011)

Such a high organic matter input infiltrating into the sediment could result in the progressive depletion of oxygen as consumption rates and inhibit nitrification process, when exceed diffusion in soil profile than oxygen yield. These could ultimately affect oxygen concentration in near-bottom waters. A subsequently developing hypoxia has numerous feedbacks to biogeochemistry of sediments, which could lead eutrophication (Rivett et al., 2008).

## - Infiltration mechanism under waste Lagoon

Baram, 2012 studied on the fate of ammonium and nitrate in unsaturated zone below earthen-clay dairy farm waste lagoons with unlined condition. The waste lagoons are commonly used to store liquid wastes from concentrated operations. The unsaturated zone was monitored from 0.5 to 30 m below land surface. Unsaturated conditions appear below depth of 1.5 cm . With slow flux, $2.4 \mathrm{~mm} \mathrm{~d}^{-1}$. They pointed out that the reduction of hydraulic conductivity in the top section of sediment below the lagoon is attributed to seal formation from earthen lining of pond bottom.

In Figure 2.11, $\mathrm{NH}_{4}{ }^{+}-\mathrm{N}$ concentrations in the sediment under the lagoon and the channel decreased dramatically in the upper shallow cross section, from 2,700 to $4,200 \mathrm{mg} \mathrm{kg}^{-1}$ dry sediment at 0.05 m to $\sim 10 \mathrm{mg} \mathrm{kg}^{-1}$ dry sediment at a depth of 0.45 m . Aerobic conditions are explained by development of unsaturated zone and welldeveloped desiccation-crack networks at the banks which enhance aeration of unsaturated zone.


Figure 2.11 Vertical distribution of $\mathrm{NH}_{4}{ }^{+}-\mathrm{N}$ concentrations in the sediment at three different locations underneath the waste lagoon and the waste channel (Baram, 2012)

In Figure $2.12, \mathrm{NO}_{3}{ }^{-}-\mathrm{N}$ was the only N form found in the groundwater under the lagoon ( $71 \pm 19 \mathrm{mg} / \mathrm{L}$ ). The average concentration under the lagoon was 3.5 times higher than the average concentration in the regional groundwater ( $\sim 20.2 \mathrm{mg} / \mathrm{L}$ ). $\mathrm{NO}_{3}{ }^{-}$ -N in unsaturated zone under the waste lagoon was similar to concentrations measured in the upper groundwater, indicating that leachate from the waste lagoon have reached the groundwater.


Figure 2.12 Vertical distribution of (a) $\mathrm{NO}_{3}^{-}-\mathrm{N}$ concentrations in porewater from the vadose zone beneath the waste channel and the waste channel margins, (b) sediment water content profiles under the channel and its margins (Baram, 2012)

The water content determining formation of desiccation cracks enhanced unsaturated zone aeration and hence aerobic processes. Consequently, organic -N and $\mathrm{NH}_{4}{ }^{+}-\mathrm{N}$ were completely oxidized in the upper 0.5 m of the sediment below the lagoon, channel, and their banks. $\mathrm{NH}_{4}^{+}-\mathrm{N}$ oxidation was coupled with $\mathrm{NO}_{3}-{ }^{-}-\mathrm{N}$ increase in upper shallow sediment.

## - Cost of nitrate treatment in shallow groundwater

Implication to extract nitrate treatment cost in groundwater is assumed to be comparable with treating nitrate in tap water works. Honeycutt et al. (2012) conducted a survey to observe the costs by the application of nitrate treatment with facilities, currently treating for nitrate and/or in design for future treatment. This survey was conducted for assessment of nitrate treatment alternatives for the American Water Works Association (AWWA) in US. In a part of their studies, Ion exchange and reverse osmosis systems were studied for the interference of treatment cost by the level of nitrate and water quality parameters. Table 2.7 lists costs by system types and sizes with increasing nitrate levels, 1 time (1X) to 3 times (3X) of maximum concentration level (MCL) in raw wastewater concentration. The data of combined cost ranges is specific for application from estimation of operation and maintenance (O\&M) increases as the increasing nitrate concentration from $\sim 1 \mathrm{X} \mathrm{MCL}, 10 \mathrm{mg} / \mathrm{l}$, to 3X MCL, but quite restrict to actual cost which varying by various factors. It should be noted that difference in a design of system (e.g., more or larger vessels, in series/in
parallel, different bypass ratios, etc.) is not included in this table.

Table 2.7 The estimation of treatment costs based on ion exchange technology for various nitrate levels.

| System size <br> (people) | Raw nitrate <br> level* | O\&M cost range (Average) <br> $\$ / 1000$ gallons | Annualized cost range (Average) <br> $\$ / 1000$ gallons |
| :---: | :---: | :---: | :---: |
| Very small <br> $(25-500)$ | 1X MCL | $0.28-3.81(1.22)$ | $0.62-4.60(1.97)$ |
|  | 2X MCL | $0.35-10.48(2.13)$ | $0.69-11.27(2.88)$ |
|  | 3 X MCL | $0.42-17.15(3.05)$ | $0.76-17.94(3.80)$ |
|  | 1X MCL | $0.15-2.53(0.87)$ | $0.34-2.73(1.05)$ |
|  | 2X MCL | $0.19-7.23(1.52)$ | $0.38-7.33(1.70)$ |
| Medium <br> $(3,301-10,000)$ | 3X MCL | $0.23-11.84(2.18)$ | $0.42-11.94(2.36)$ |
|  | 2X MCL | $0.12-1.69(0.84)$ | $0.36-2.04(1.06)$ |
|  | 3X MCL | $0.15-4.65(1.47)$ | $0.39-5.00(1.60)$ |
| Large <br> $(10,001-100,000)$ | 1X MCL | $0.18-7.61(2.10)$ | $0.42-7.96(2.32)$ |
|  | 2X MCL | $0.13-1.39(0.66)$ | $0.22-1.81(0.97)$ |
|  | 3X MCL | $0.20-6.26(1.65)$ | $0.25-4.24(1.46)$ |

Remarks: *indicated as increasing level of maximum concentration level (MCL) in
1X MCL, 2X MCL, 3X MCL, MCL $=10 \mathrm{mg} / \mathrm{l}$
Source: modified from Honeycutt et al. (2012)

Availability of cost data for groundwater recovery is limited for carbon and nitrogen contamination. Nevertheless, US EPA documented full-scale remediation projects to treat hazardous wastes in the Superfund sites with groundwater pump-and-treat technologies. Contaminated sites ( 1 completed cleanup and 2 on-going cleanups) were remediated total petroleum hydrocarbons (TPH). The completed site used In situ density-driven groundwater sparging and soil vapor extraction, which costed 156,950 USD for capital cost and 62,750 USD for annual operating costs in year 1992-1993. The 2 on-going sites used groundwater extraction following granular activated carbon (GAC) and In situ air sparging of saturated zone. The one site of them, with data of treated quantity, costed 672,000 USD for 5-year operating capital cost (297,000 USD for groundwater extraction and GAC, 375,000_USD for air sparging) and 475,000 USD for annual operating costs to treat 775 Mil.gallons of groundwater in 5 years (year 1988-1993) (USEPA, 1995a). The annual combined cost per wastewater volume for cleanup is estimated to $0.72 \mathrm{USD} / \mathrm{m}^{3}$ groundwater. Data of quantity treated for all cases are not available.

### 2.6 Socio-economic assessment for methane recovery CDM

In sustainability concept, the most challenge is to decide what kinds of new investment and how much of change, the community could adapt to live without compromising the day-to-day quality of life. The CDM projects, which is a new channel of funds from developed countries, is also unavoidably questioned. The example of indicators used to measure the potential socio-economic impacts from an investment includes changes in community demographics, housing and land markets, demand of public services, employment and income levels, and the aesthetic quality (Edwards, n.d.).

Quantitative measurement for such indicators is an important element of the socioeconomic impact assessment. More importantly, the perceptions of people on how much a new investment affect their lives is a critical part of the assessment. More than community involvement with their opinions, this social value should contribute to decision criterion for project feasibility and/or selection. Moreover, the understanding about how people place the values and their concerns is an better step in conducting a socio-economic impact assessment.

### 2.6.1 Welfare theory in environmental markets

Environmental economists have developed a method to make the change of environmental quality measurable in term of utility function. Customer who gain benefits from improvement of environmental quality consumes two market products, for example $x_{1}$ and $x_{2}$, and also consumes these two products with the same environmental quality ( $s$ ). By the concept of maximum utility with restricted budget $(M)$ and limited quality and quantity of environment $\left(s^{0}\right)$ that would lead to the equations as below.

$$
\operatorname{Max} U\left(x_{1}, x_{2}, s\right)
$$

In conditions of

$$
\begin{equation*}
p_{1} x_{1}+p_{2} x_{2} \leq M \text { and } s=s^{0} \tag{1}
\end{equation*}
$$

Demand functions of product $x_{1}$ and $x_{2}$ are:

$$
\begin{align*}
& x_{1}=x\left(p_{1}, p_{2}, M, s\right) \text { and } \\
& x_{2}=x\left(p_{1}, p_{2}, M, s\right) \tag{2}
\end{align*}
$$

According to the relationship between demand functions of two products which depends on the price of product, the prices of composite products, income and quantity/quality of environment. When replacing equation (1) by equation (2), indirect utility function (v) would be leaded as equation below.

$$
\begin{equation*}
U=v=u\left(p_{1}, p_{2}, M, s\right) \tag{3}
\end{equation*}
$$

In equation (3), variables that define utility from commodity consumption and environment are functioned by $p_{1}, p_{2}, M$ and $s$. The utility would be increased when decreasing product price and increasing income and quantity or quality of environment.

### 2.6.2 Valuing the externalities

Several techniques for monetary valuation for externalities to communities have been developed by economists. Apart from the subjective method by expert judgement and assessment which assign values to indicators, most of the quantitative methods rely on economic welfare theory that individuals place their preferences for introducing better a particular environmental good with no actual price in the existing market. Eshet et al. (2005) studied the classification of the valuation methods, the categories of the methods are presented in Figure 2.13 and the all techniques are described briefly as follows.


Figure 2.13 Monetary valuation methods and techniques
Source: modified from Eshet et al. (2005)

## - Dose response function (DRF)

This measurement is used scientific data to establish the relationship between a unit of pollutant concentration and its impact on affected people or receptors (Tellus, 1992; Rabl et al., 1998).

## - Direct methods (stated preference or preference-based method)

This methods measure perceptive value with an assumption that the consumers have their the best judge for their best interests, and that they can perceive realistic choices based on their preferences without making any behavioral changes (Adamowicz et al., 1994; Shechter 1995).

- Contingent valuation method (CVM) is a survey approach that directly ask people about how much they are willing to pay for a perceived benefit or for avoidance, on contrary, they may be asked their willingness to accept to forego a benefit or tolerate, regarding proposed investment or policy (Pearce and Howarth, 2000; Rahmatian, 2005).
- Choice modeling method is survey approach that directly ask people to choose or rank alternatives. The key of this method is to monetarize utility of different attribute levels (Pearce and Howart, 2000).


## - Indirect methods (revealed preference)

In this methods, preference value for externalities are indirectly revealed by implicitly using an existing market goods and services with purchase prices related to complements or substitutes of environmental good (Shechter, 1995; EC, 2000).

- Hedonic price method (HPM) focuses on the market value of house and/or land price which differentiate by distances away from the contaminated site, for example, demand for places in proximity of the waste lagoons decrease than other places far from the lagoons (Shechter, 1995; Pearce and Howarth, 2000; Segeron 2001).
- Averting behavior method (ABM) assumes that people make choice for maximize their level of well-being when face a problem of life quality, thus, their expenditure for maintaining their well-being is equal to value of environmental impact. For example, the purchase of bottled water or filters provide estimate of a problem of drinking water contamination (ODPM, 2004).
- Cost of illness method (COI) values the human health effects by using the external changes of private and public expenditures on medical goods and lost due to day-off caused by illness related to an environmental problem (Shechter, 1995; Navrud, 2001).
- Health production function (HPF) depicts the relationship between health and health inputs (i.e., the environmental factor). Health status such as mortality rate is used as health output for this estimation (Pearce and Howarth, 2000).
- Travel cost method (TCM) assumes that value of the recreational site or value of changing its quality come from costs of traveling trips, entry fees, on-site expenditures and time to that recreational site or other nearby creational sites (in case that deteriorated quality of that recreational site) which could be used as a proxy to estimate the use value (Shechter, 1995; Pearce and Howarth, 2000; ODPM, 2003).
- Complaint assessment method (CAM) estimates by actual cases of legal suits against facilities which cause related environmental problems. All expenditures engaged in the suits are assumed to be equal to that environmental problem (Bellof et al., 2000).


## - Experts' assessment of damage costs

Damages or impacts of environmental changes are usually judged from experts by their own knowledge and experience. The intuition and knowledge of professionals in particular fields is used to estimate the costs of abatement or restoration from impacts, or the costs of replacement in contaminated assets.

- Control cost method imply that the costs for implementing regulations to abate pollution, for avoiding damages, estimate to the social value that is attributed to that pollutants (Tellus, 1992; EC, 2000).
- Clean-up cost method infers that when the damage or contamination to environment from pollutants is done, the costs of rehabilitation to achieve the pre-damage situation are assumed as a minimum or a proxy of economic value for the damage occurrence (EC, 2000). This method is applied to be principle of The Superfund site program.
- Replacement cost method assumes that proxy value of damage is equal to the cost of replacing or restoring a damaged asset to its status quo (Pearce and Howarth, 2000).


## - Benefit transfer (BT) or environmental value transfer

This method is an econometric tool by using existing data of non-market values to transfer from a site or many sites (primary sites with studied values) to a new different site (secondary site with a proposed implementation). This combination and comparison of existing data in BT method potentially benefit to conduct a new studies with time and money constrains. Despite some flaws, the BT method offers an efficient way towards study extensions of the economic valuation for the externalities

### 2.6.3 Contingent valuation studies

Contingent Valuation Method (CVM) is a one of direct methods for economic analysis that helps to ascertain whether the populations who will be the beneficiaries or recipients of a public service value that service enough to justify its cost. CVM is the most applied valuation method in recent years, and it has been developed mainly in the context of environmental valuation (Rahmatian, 2005). The word "contingent" come from a reason that the valuation of environmental resources is contingent on the hypothetical scenario proposed to respondents. The function is to provide responses to analyses of changes in the level of provision and/or quality of public goods, which have the characteristics of non-rivalry, non-excludability, and non-divisibility, unlike normal market goods. Thus, the problem of CVM is to state and clarify hypothetical questions which should be in amenity of respondents, Unlikely, the indirect methods exploit actual data on observation and behavior from respondents. Nevertheless, the CVM has an advantage over indirect methods that can capture all types of values including use and non-use values from environmental goods over indirect methods, whereas, the indirect methods can not capture the non-use values (Torgler et al., 2010). In the CVM, respondents directly answer willingness to pay (WTP) or willing to accept (WTA) questions for estimating monetary values of environmental utility changes.

CVM with the WTP is now only example of a study of public risk perception in the context of sediment remediation assessment. It has found that the choices of valuation end-point, such as health risk and changes in recreational fishing days, that are closer to respondents involves the burden to achieve information placed on the respondents, by the researcher, regarding respondent's knowledge on risk perception and their behavior, thus, amenity to environment should be considered and well adjusted by the researcher (Magnussen and Bergland, 1996). CVM has effects of remediation scope, substitution and ordering, depending on sample and type of WTP question. David et al., 2010 also studied CVM to estimate the total non-market benefits of accelerated removal of dietary health advisories from water contamination in the Grenland fjords in Norway, and compare them along with remediation costs from impacts of
commercial fishing and property values. This study showed that extracting values by the WTP contain methodological and communication challenges, before the respondents are accepted to pay in total values as same as remediation costs. Regression tests showing validity and reliability of WTP resulted in the WTP is affected with "distance decay" from contaminated source but is not sensitive to the scope and/or speed of removing advisories, and partial sensitive to mixed results with WTP showing 'distance decay', but not sensitivity to the availability of substitute recreational sites.

WTP studies in Bangkok Province in Thailand expressed WTP for better water quality in a range of 45.00-163.68 THB per household/month. Their WTPs are different according to money value in year conducting a study, hypothetical market on boundary of water quality improvement, and technique of elicitation method. Tapvong and Kruavan (1999) reported 100.81 and 115.03 THB per household/month for mean WTP of better fish conservation and human swimming water in "Chao Phraya" river, respectively. The highest WTP was expressed from the study of Mungchan (2009), that WTP of sewage treatment charge for canal "San Sab" in Bangkok Province was estimated to 163.68 and 113.77 THB per household/month for mean and median, respectively.

## - Costumer's surplus in CVM

The change of customer utility on market product can be measured from customer's surplus or the change of area in the original demand curve. In the case of environmental goods, it could not be valued by the change of area in the original demand curve because there is non-market product with no actual demand curve for environmental goods. However economists have tried to valuate non-market goods by Compensated Demand Function (CMF) for measuring value to keep satisfaction at the same level when quantity or quality of environment is changed.

In order to measure the value of environmental goods, it would be considered from Compensating Variation (CV) or Equivalent Variation (EV) which reflect customer satisfaction or welfare to be better off or worse off. From Figure 2.14, when environment is improved it will change the budget line from BA to BB that make
costumer's utility better off because actual income increase. If the budget line is stabilized to the same level, income or composite commodity in monetary term should be deducted to maintain the original satisfaction or indifferent curve $\left(I_{0}\right)$.


Figure 2.14 Compensating Variation (CV) and Equivalent Variation (EV) Source: modified from Wainwright, 2008

So, compensating variation is maximum value to pay (or WTP) as equal as BC on axis-y that assume to be other values except quantity or quality of environment on axis-x. On the contrary, equivalent variation is maximum value to accept (or WTA) to achieve the new satisfaction or indifferent curve $\left(I_{l}\right)$ as equal as MB on axis-y.

## - Classification of environmental economic value

Classification of Total Economic Value (TEV), as illustrated in Figure 2.15, provides a conventional framework for organizing the different classes and types of value associated with water resource. TEV is the sum of all benefit values extracted from beneficiaries from a public water resource (Brander et al., 2010).

$$
\text { TEV }=\text { Use Value }+ \text { Option Value }+ \text { Bequest Value }+ \text { Existence Value }
$$

## - Use values

Use values derive from benefits from actual use of the water resource. Water used as
direct or indirect exposure, e.g., swimming, angling, boating, and used as an input for any production, e.g., food, drinking water, electricity and so on, which is a process involving the combination with other constituents for production. The kinds of the use values can be further separated into;

- Commercial value, where water is a combination with other constituents for making products and outputs are marketable (e.g., foods, drinking water, electricity) ;
- In situ use value, where the water resource are direct services (e.g., swimming) or indirect services (e.g., angling, boating) to users, and the utility itself is not marketable;
- Option value is a non-use value where respondents or firms pay for the right for their safety to use the resource after in someday, although they intend to not use in the present day. Option value is upon their thinking which is not related to current use but it is typically measuring value attached to future use opportunities;
- Quasi-option value is a non-use value in terms of the welfare gain or lost regarding a delay of decision from uncertainty about the payoffs of alternative choices, with at least one choice has an irreversible change of resource use. Quasi-option value is not a value attached to the changes in the environmental sources, but it is value of information attached by delaying an irreversible decision (Freeman, 1993);


## - Non-use values

These are independent perceptive values from individuals' opinions about present and future use of resources. They are variously classified as "existence value", which is the value from knowing that a particular environmental assets exists (e.g., endangered species); and "bequest value", which is the value arising from the desire to bequeath certain resources to one's heirs or future generations (e.g., habitat preservation).


Figure 2.15 Total environmental economic value
Source: modified from Brander et al. (2010)

### 2.7 Decision-making Analysis

Decision making is defined as the study of identifying and selecting alternatives based on the values and preferences from the assessments or decision makers. Making a decision implies that all selected alternatives taken into consideration, but it is impossible to identify as many of these alternatives feasible in a particular condition, but in such that case the best-fit alternative should be selected with indicated goals, objectives, desires, values, and so on (Harris, 1980).

### 2.7.1 Environmental, economic, and social integrity

There is no universal definition of SD. the three major dimensions, i.e, environmental, economic, social aspects are evolved for encompassment. Each dimension answers to a domain with its own driving forces and objectives. The environmental dimension aims to protect the integration and resiliency of ecological systems. The economy dimension focuses on improving human welfare by increasing the production of goods and services. The social dimension emphasizes the enrichment of human
relationships, achievement of individual and group aspirations, and strengthening of values and institutions (Munasinghe, 2007). Though comparison of different sites applying CDM, we can indicate how differences in SD matrix of decision after proposing CDM, the financial situation with CDM revenues, environmental impacts, economic impact, and social perception are balanced to achieve goal of choosing best site alternative of the methane recovery project.

### 2.7.2 Modified total economic value (TEV) and aggregation concept

## - Modification of TEV model for water environment

In Figure 2.16, the TEV model was modified to account for the specific nature of water. In particular, values for water can be largely considered instrumental values, in that water is valued for the goods and services it helps to provide, and not so much as a good in itself.


Figure 2.16 Modification of total economic value model for water environment
Source: modified from Gomez-Baggethun and De Groot (2010); Rolls (2011)

The existence value of water, and the indirect use value of water both then are valuing the contribution water makes to the ongoing existence of ecosystems, and indirect use
value was excluded to avoid double counting. existence value, bequest value and altruistic value were reduced to existence value only, as the distinction between these values is too fine to allow for accurate measurement (in fact, very few studies identifying these values separately exist in the literature). Option value was also excluded due to measurement difficulties.

## - Aggregation concept

The TEV model has been in existence for some time but few actual applications exist. The majority of studies focus on only one or two individual value components, such as recreation and existence values. Bringing together individual values estimated using different methodologies into a TEV estimate therefore it has a particular complication. There is a significant risk that due to the different methodologies used, some of the value components actually incorporate elements of other values. In order to combine values or preferences from two different conceptual approaches, it could be noticed that the assessment by biophysical and the preference-based approaches generated from different axiomatic frameworks and valuation theories with different view points of responsibilities, therefore, their values fall to be not generally comparable without clarifying complexity of ecosystem functions of a particular environmental service. There is still an ongoing debate about the need to use multiple units of measurement and notions of value in environmental valuation (Brander et al., 2010).

Controversies remain concerning the extent to which values from different axiomatic dimensions could be combined into a single rod for making decision. GeorgescuRoegen (1979) criticized against monistic theories in combining values, either preference-based or biophysical approach, to be single unit in terms of reductionism. Martínez-Alier (2002), similarity, pointed out that even in monetary values, valuation of natural resources still deal with a variety of conflicting taxonomies of valuation techniques (e.g., environment, economic, ecological, aesthetic, and spiritual). It should not be reduced into a single rod because this values inherit weak comparability and incommensurability with each other. (O'Neill, 1993; Martínez-Alier et al., 1998). According to this arguments, supporting tools for decision making should allow for the integration of incommensurable values. Multi-criteria decision analysis (MCDA)
makes a possibility for the formal integrated multiple values with assigned relative weights (Munda, 2004).

### 2.7.3 Multi-criteria decision analysis (MCDA)

The environmental alternative with low cost, while minimum human health and environmental risks, should be identified by the rational criteria (Driscoll et al., 2002). However, the best choice is not outstanding and there is not only one dimension to consider. Results of Cost-benefit analysis (CBA) and MCDA are totally different. CBA, conducted by experts, could fulfill transparency and inclusiveness to some extent but it is not entire inclusiveness especially non-monetized values. Both methods have been applied for various environmental issues, however, MCDA achieved increasing acceptance by using both objective assessment and judgement method (Bhagtani, 2008). Consequently, a decision matrix with all concerned criteria for MCDA is created to assess the performances of available alternatives. In the CDM, the UNFCCC explicitly put the need of MCDA on some cases, when sustainability criteria could not be conduced with CBA, or could not be quantified and monetized (UNFCCC, 2002). MCDA is regarded as evaluation method able to consider multiple objectives and criteria, especially to integrate stakeholders' preferences into the constructive and systematic process for decision making.

A multi-criteria perspective has been employed for the analysis focusing on environmental, economic, and social sustainability dimensions. Hence, developing a sustainability assessment technique is able for reliably screening the different alternatives or locations in decision making for all stakeholders in the country. In order to quantitatively prioritize the importance of qualitative criterion from ranking and scoring method by expert judgement with different skills and experiences is subjective especially in non-monetary benefits of environmental aspect. For example, the USEPA National Priorities List through the Superfund cleanup process. Grelk (1997), Grelk et al. (1998), and Parnell et al. (2001) have used a Multiattribute Utility Theory (MAUT) to express alternatives performance with non-monetary number and determine weights associated with each individual alternative.

In Figure 2.17, among various methodologies of decision analysis show similar steps of organization in the construction of the decision matrix, but alternative selection technique including problem and stakeholder identification, alternatives and criteria establishment, performance elicitation. MCDA techniques are differentiated by different means to organize the matrix information and ranks the alternatives. Different techniques create diverse types of scoring by various optimization algorithms (Yoe, 2002). The selection of techniques depend on purposes of use, e.g., ranking options, identifying a single optimal alternative, providing an incomplete ranking, and differentiating between acceptable and unacceptable alternatives. Moreover, MCDA methods, meanwhile, provide a similar concept in organization but, somehow, purport different stakeholder involvement in details. An analysis of the theoretical foundations of MCDA methods and their comparative strengths and weaknesses is reported in Belton and Stewart (2002) and Figueira et al. (2004) as shown in Table 2.8.


Figure 2.17 Methodologies of decision analysis

Table 2.8 Comparison of critical elements, strengths, and weaknesses of several advanced MCDA methods: MAUT, AHP, and Outranking

| Method | Important Elements | Strengths | Weaknesses |
| :---: | :---: | :---: | :---: |
| Multiattribute utility theory | - expression of overall performance of an alternative in a single, nonmonetary number representing the utility of that alternative <br> - Criteria weights often obtained by directly surveying stakeholders | - Easier to compare alternatives whose overall scores are expressed as single numbers <br> - Choice of an alternative can be transparent if highest scoring alternative is chosen <br> - Theoretically sound based on utilitarian philosophy <br> - Many people prefer to express net utility in nonmonetary terms | - Maximization of utility may not be important to decision makers <br> - Criteria weights obtained through less rigorous stakeholder surveys may not accurately reflect stakeholders' true preferences <br> - Rigorous stakeholder preference elicitations are expensive |
| Analytical hierarchy process | - Criteria weights and scores are based on pair-wise comparisons of criteria and alternatives, respectively | - Surveying pair-wise comparisons is easy to implement | - The weights obtained from pair-wise comparison are strongly criticized for not reflecting people's true preferences <br> - Mathematical procedures can yield illogical results; for example, rankings developed through AHP are sometimes not transitive |
| Outranking | - One option outranks another if: <br> 1) "it outperforms the other on enough criteria of sufficient importance (as reflected by the sum of criteria weights)" and <br> 2) it "is not outperformed by the other in the sense of recording a significantly inferior performance on any one criterion" <br> - Allows options to be classified as "incomparable" | - Does not require the reduction of all criteria to a single unit <br> - Explicit consideration of possibility that very poor performance on a single criterion may eliminate an alternative from consideration, even if that criterion's performance is compensated for by very good performance on other criteria | - Does not always take into account whether overperformance on one criterion can make up for underperformance on another <br> - The algorithms used in outranking are often relatively complex and not well understood by decision makers |

Source: ODPM (2004), Larichev and Olson (2001)

## - Multi-attribute utility theory (MAUT) and analytical hierarchy process (AHP)

MAUT and AHP are complex methods using optimization algorithms, whereas outranking method uses a dominance approach. The optimization approaches rescale numerical value on some performances to $0-1$ scale ( 0 representing the worst, and 1 representing the best) to deliver comparative merit of each alternative on a single scale. Aggregated scale of an alternative is simply a sum or average of all score from individual criteria, or a weighting mechanism could be used in flavored conditions of some criteria than others by stakeholders. The purpose of MAUT is to rank ordered alternatives with individual's or stakeholders' preference by a single net expression of a decision.

AHP is a competitor to MAUT for ranking ordered alternatives because MAUT define decision problem by aggregating from a single optimization function known as the objective function. The theory of AHP is to select the alternative through pair-wise comparison between alternatives with respect to individual criteria, and rely on the judgements of experts to give preference scale, which called "compensatory optimization approach". Unlike MAUT, the comparisons from AHP are elicited to absolute scale for judgement with repeating processes for improving consistency (Saaty, 2008).

## - Pair-wise outranking assessment

Unlike MAUT and AHP, outranking method is, somehow, like combination of MAUT and AHP by using pair-wise comparison of performances and normalized into 0-1 scale. The principle of this method is based on that one alternative may have a quantitative degree of dominance over another which is preferred (Kangas et al., 2001). Dominance occurs when one option performs better than another on at least one criterion and no worse than the other on all criteria (ODPM, 2004) and it is better to apply when criteria metrics are not easily aggregated, measurement scales vary over wide ranges, and performance units are incommensurate or incomparable (Linkov et al., 2004). The distinctive point of outranking technique is to not suppose that the single best alternative can be identified. Process of pair-wise comparisons begins with coupling performance in each alternative and criteria to other all
performance within the same criteria which give a vector of superior and inferior dominance to each scale, then, aggregating comparative scale across all relevant criteria. With this process, outranking method can evidently find out the strength of evident favoring selection of alternative over another. Superior dominance scales may entail favoring the alternative with the greater number of criteria, however, inferior dominance scale is not strongly rejected and is allowed to be compensated by comparative scales of other criteria.

## Chapter 3

## Methodology, background information and scenarios

### 3.1 Research methodology

The discussion of this research is a comprehensive approach on the co-benefits valuation of methane recovery CDM project to anaerobic open lagoon. Overall methodology of the research is proposed in Figure 3.1 and models of the core studies are explained as following:


Figure 3.1 Overall methodology of the research

Firstly in this chapter, background information for the data of study sites are gathered including greenhouse gases (GHGs) estimation from methane recovery CDM project implementing to existing anaerobic open lagoon, wastewater characteristics, open lagoon construction and operation, factory location, land use data, soil characteristics and groundwater contaminants in factory vicinity for impact assessment prerequisite for co-benefits assessment. Then, different impacts from existing open lagoons in the study sites in Thailand are evaluated using all possible dimensions and indicators in the next steps.

To implement methane recovery technology with high investment and operation cost, financial assessment is important because of the limited financial resource to select a project site. So, to determine whether the alternative is feasible, total CERs production and CER generating cost, internal rate of return (IRR), and net profit for as a justification filters are applied in Chapter 4. Chapter 4 consists of the evaluation of CER investment and project profitability/viability with different scenarios of CDM investment, e.g., unilateral, bilateral and multilateral frameworks.

On the environmental impact in Chapter 5, Guidance of Superfund act/CERCLA and valuation techniques is developed to evaluate impacts from wastewater treated in earthen lining lagoon. The costs to treat carbon and nitrogen in wastewater from factory and in infiltrated wastewater in shallow groundwater under the lagoons are estimated with different frameworks for environmental impacts in project boundary for each site location.

In Chapter 6, social preference of the co-benefits to better water environment from the investment of methane recovery CDM project is evaluated with contingent valuation method (CVM). Survey results from respondents' perception, including willingness to pay (WTP) to compare between sites. In Chapter 7, integrated evaluation with the SD concept is estimated from the indicators taken from financial, environmental, and social criteria, previously examined. Multi-criteria decision analysis (MCDA) and panel weighting approach are used to compute for selecting best-fit site location.

### 3.2 Site selection and contaminant assessment

In this part, a description of the study sites and an assessment of potential contamination to water resources are presented.

### 3.2.1 Site selection

The study sites selected for comprehensive monetary comparison with co-benefits were based on same businesses-as-usual practice on wastewater treatment system, i.e, operating non-aerobic open lagoon, with high organic wastewater characteristic. In
table 3.1 shows wastewater characteristics of selected industries, which are ethanol and palm oil factories in Thailand.

Table 3.1 Wastewater characteristic of ethanol and palm oil factory in Thailand

| Parameters | Ethanol factory* | Palm oil factory** |
| :--- | :---: | :---: |
| Temperature, ${ }^{\circ} \mathrm{C}$ | $42-104$ | $80-90$ |
| pH | 4.57 | 4.81 |
| $\mathrm{BOD}, \mathrm{mg} / \mathrm{l}$ | 58,198 | 46,500 |
| $\mathrm{COD}, \mathrm{mg} / \mathrm{l}$ | 151,355 | 51,000 |
| SS, $\mathrm{mg} / \mathrm{l}$ | 34,774 | 34,600 |
| Oil and Grease, $\mathrm{mg} / \mathrm{l}$ | $\mathrm{N} / \mathrm{A}$ | 6,200 |
| TKN, $\mathrm{mg} / \mathrm{l}$ | $\mathrm{N} / \mathrm{A}$ | 1,100 |
| TP, $\mathrm{mg} / \mathrm{l}$ | $\mathrm{N} / \mathrm{A}$ | 47 |

Source: * DIW (2006), Average value of the 16 studied factories in Thailand year 2006
** Chavalparit, 2006 (Average value of the 5 studied factories in Thailand, 2002)

## - Ethanol factory

The first factory was selected from an implemented example in action of co-benefits CDM approach supported by Ministry of Environment, Japan (MOEJ). The purpose of project is to treat wastewater discharged from an ethanol factory by introducing closed structure anaerobic digester (practically install Up-flow Anaerobic Sludge Blanket, UASB). Before the implementation of project, wastewater was treated in a unlined non-aerobic open lagoon. The UASB will introduce methane capturing system to collect methane and reduce atmospheric GHG emission, and thereby alleviate environmental pollution by improving the quality of wastewater and preventing the release of odors. The collected biogas also can be utilized to generate electricity and sell it to the local power company or supply it for internal use. Consequently, it can reduce the consumption of national fossil fuels used for power generation. As a result, the project would help reduce GHG emission along with improving water quality, and controlling odors which realized as co-benefits of the project. Furthermore, this type of project has high replicability to industries in many countries because the non-aerobic open lagoon treatment method is prevalent.

The ethanol factory is located in Ayutthaya province, Thailand. Due to the demand of
the ethanol transportation fuel under the government policy, the dehydration unit has been added to the ethanol factory with the purity $99.5 \%$ ethanol from year 2004 to until now, and at this moment, the ethanol factory is in full operation. the CDM project site is located on the factory site. In general, the capacity of the ethanol factory is $31.25 \mathrm{~m}^{3} /$ day in volume using molasses as the raw material and $323 \mathrm{~m}^{3}$ as industrial water with COD, 0.145 ton $/ \mathrm{m}^{3}$ (Factory data in Project Development Document, PDD). Molasses, which is waste of sugar canes, are being procured from the sugar factories in districts about 70 km far from the ethanol factory with the long term raw material purchasing agreement.

## - Palm oil factory

A palm oil factory was selected as a competitive factory to comprehensively compare with the ethanol factory because at present, non-aerobic open lagoon is practically used to treat palm oil mill effluent (POME) in general and the wastewater characteristic contain the high organic, high solid, acidic content and a high temperature as same as ethanol factor's effluent. In terms of economic demand side, the world palm oil production has increased since 1982 and become the second important oil in the world's oil and fat trade, after soybean oil. Palm oil has became a major traded oil in 2001 which is accounting for $40 \%$ worldwide. Highly increasing world consumption with 7.7 million ton per year from 11.4 million ton to 21.8 million ton per year from 1991 to 2000 (MPOB, 2004).

The selected palm oil factory in this study is located in Krabi province, Thailand and started its operation with wet processing mill for crude palm oil (CPO) extraction process from year 2004 until now. In general, the capacity of the palm oil factory is nominal 60 ton/hour in weight using fresh fruit branch (FFB) as the raw material and $464 \mathrm{~m}^{3}$ as industrial water with COD, $0.089 \mathrm{ton} / \mathrm{m}^{3}$. The process to extract oil from FFB requires high consumption of water, then large amounts of wastewater are generated. (water required about one ton of water to process one ton of FFB). Ratio COD/BOD is lower in average than ethanol factory's wastewater in Table 3.1 because the process does not require any chemical aids (Chavalparit, 2006). However, wastewater from this industry is originated from only the FFB residues but with high
concentrated organic wastewater and large amount of wastewater, it has high potential to create water and air pollution to environment from the open lagoon treatment system ( $64 \%$ of palm oil mills use anaerobic and facultative ponds in series) because it has obviously seen that it is unable to treat this concentrated wastewater to meet the effluent standard under anaerobic lagoon system. It possibly poses threats to the water and air environment, especially with the lagoon located close to communities, unless proper pollution prevention measures are taken (Chavalparit, 2006).

### 3.2.2 Estimation of greenhouse gases emission reduction

From Project Design Document (PPD) of ethanol factory in Ayutthaya province, the project was designed to treat the wastewater in an anaerobic processing system (or UASB). Emission reductions are generated by two different schemes. First one is from biogas capturing system so as to restrict the atmospheric emission from methane gas. Secondly, the methane gas is recovered without leak to the atmosphere and utilized for power generation by gas generator with gross output $1,095 \mathrm{kWe}$. The generated electricity generated is subjected to sell to grid Provincial Electricity Authority (PEA) under Very Small Power Producer (VSPP) as shown in Figure 3.2 or use as internal electricity consumption. Through biogas capturing system by means of flare stack combustion, and electricity production by means of limiting national fossil fuel use for grid power supply equivalency, this CDM type makes reductions of GHG emission in global aspect.

The proposed CDM project activity in the ethanol factory resulted in emission reductions from the avoidance of methane emissions from the anaerobic open lagoon, the avoidance of carbon dioxide emissions and from the displacement of grid sourced electricity which includes fossil fuel based electricity generation. The estimated emission reductions are 25,467 tons of $\mathrm{CO}_{2}$ e per year. AMS-III.H. The project activity falls under Methane Recovery in Wastewater Treatment AMS-I.D. and Grid Connected Renewable Electricity Generation (refer in Chapter 2).


Figure 3.2 Project boundary with CDM implementation for ethanol factory in Ayutthaya province, Thailand

GHGs emission reductions of methane recovery CDM project for palm oil factory in Krabi was estimated based on the same condition of CDM project activities as the ethanol factory in Ayutthaya. In Figure 3.3,


Figure 3.3. Project boundary without CDM implementation for palm oil factory in Krabi province, Thailand
at present time, palm oil plant treat wastewater by the series of anaerobic open lagoons without CDM implementation. The in-plan proposed CDM project activity involves the installation of a UASB digester in between the existing sump pit and anaerobic lagoon. The UASB consists of concrete reinforced lagoons which are covered with a biogas storage dome made from PVC sheeting. The UASB digester is expected to remove around $70 \%$ of the COD content of the wastewater. The treated wastewater leaves the UASB digester at the top of the lagoon, and will flow into the existing anaerobic lagoon. No wastewater will be discharged to public water sources. Biogas with a high concentration of methane is produced as a by product of the wastewater treatment in the UASB digester and will be captured in the biogas storage dome. The biogas will be utilized for both heat and electricity generation.

The proposed CDM project activity in Krabi resulted in emission reductions from the avoidance of methane emissions from the anaerobic open lagoon, the avoidance of carbon dioxide emissions and from the displacement of grid sourced electricity which includes fossil fuel based electricity generation. The estimated emission reductions are 24,202 tons of $\mathrm{CO}_{2}$ e per year (refer in Chapter 2). The sources and gases included in project boundary are described in Table 3.2 ( $\mathrm{N}_{2} \mathrm{O}$ emission is excluded for simplification from a reason that this is conservative in IPCC methodology and/or emission is assumed to be very small).

Table 3.2 Description of the sources and greenhouse gases included in the project boundary of methane recovery CDM project in palm oil factory, Krabi

|  | Source | Gas | Included | Justification/explanation |
| :---: | :---: | :---: | :---: | :---: |
|  | Wastewater treatment processes | $\mathrm{CO}_{2}$ | Excluded | $\mathrm{CO}_{2}$ emissions from the organic waste decomposition are not accounted for |
|  |  | $\mathrm{CH}_{4}$ | Included | The major source of GHG emissions in the baseline scenario is from open lagoons |
|  | Electricity consumption | $\mathrm{CO}_{2}$ | Included | Electricity consumed for the wastewater treatment system operation in the baseline scenario (pumping wastewater to the open lagoons) is supplied from the Thai national grid |
|  |  | $\mathrm{CH}_{4}$ | Excluded | Excluded for simplification of CDM calculation |
|  | Electricity generation | $\mathrm{CO}_{2}$ | Included | Electricity is generated with biogas generator under the proposed project activity and will reduce electricity generation from the grid |
|  |  | $\mathrm{CH}_{4}$ | Excluded | Excluded for simplification of CDM calculation |
|  | Wastewater treatment processes | $\mathrm{CO}_{2}$ | Excluded | $\mathrm{CO}_{2}$ emissions from the organic waste decomposition are not accounted for |
|  |  | $\mathrm{CH}_{4}$ | Included | The treatment of wastewater under the proposed project activity will lead to the following emissions: <br> 1. Methane emissions of degradable organic carbon in treated wastewater <br> 2. Physical leakage of methane from the gas capturing system <br> 3. Methane emissions from flare stack |
|  | On site electricity use | $\mathrm{CO}_{2}$ | Included | Electricity consumed for the operation of the proposed project activity (UASB system and open lagoons) will be supplied from the Thai national grid |
|  |  | $\mathrm{CH}_{4}$ | Excluded | Excluded for simplification of CDM calculation. (assumed to be very small) |
|  | On site fossil fuel consumption | $\mathrm{CO}_{2}$ | Excluded | The proposed project activity does not use fossil fuels |
|  |  | $\mathrm{CH}_{4}$ | Excluded | The proposed project activity does not use fossil fuels |

### 3.2.3 Contaminant assessment

In view point of contaminant assessment in broad perspective, general types of contaminants is observed from the various kinds of factory wastewater including organic pollutants, inorganic pollutants, nutrients, pathogens, suspended solid and sediment, dyes and pigments, thermal pollutants, and radio active pollutants. In case that pollutants contaminate to a water resource, the economical impacts from pollutant state of environment impacts are assessed in described indicators in Figure 3.4.

| Environmental impacts |  | Economical impacts |
| :---: | :---: | :---: |
| Indicator: |  | Indicator: |
| - Organic pollutants |  | - Pollutant state impacts |
| a) Oxygen demanding waste |  | a) Human health |
| b) Synthetic organic |  | - Food safety |
| compounds* | Services | - Health risk swimmer <br> b) Agriculture production |
| c) Oil \& grease |  | b) Agriculture production <br> c) Drinking water |
| - Inorganic pollutants <br> a) Mineral acids |  | production |
| b) Inorganic salts |  | - Ecological state impacts |
| c) Inorganic Fertilizers |  | a) Aquatic animal production <br> b) Recreation |
| d) Heavy metals |  | b) Recreation <br> c) Non-use value |
| - Nutrients |  | Biodiversity |
| - Pathogens |  | d) Bequest value clean wa |
| - Suspended solid and sediments |  | f) Living comfort |
| - Dyes and pigments |  |  |
| - Thermal pollutants |  |  |
| - Radio actives pollutants |  |  |

[^0]Figure 3.4 Indicators of water environment contamination

The contaminant assessment in the study sites follow the EPA guideline of wineries and distilleries wastewater monitoring programs (EPA, 2004) and applied for ethanol and palm oil industries which generate high strength organic wastewater. The information in this program provide information that who undertakes the activity which has potential to pollute water, soil, air and noise from wineries and distilleries in order to take reasonable measures to minimize environmental threats and also guide
them to develop an monitoring program in accordance with the EPA and relevant Environment Protection Policies.

Distilleries have potential to cause the environmental impacts associated with, for example, pollution of water; change of soil properties; damages to plantation from liquid and solid waste disposal practices; odors and air emissions resulting from the management of wastewater, solid and semi-solid by-products from the production process. Some of the potential effects on the environment from the suspicious constituents of liquid and solid waste by-products from the distillery production are summarized in the table 3.3 below.

Apart from monitoring of factory effluent pollutants, in order to identify whether the impacts from wastewater storage lagoons actually occur, groundwater in the vicinity of lagoons must be monitored. The mandatory provisions for wastewater lagoon construction and reconstruction are outlined in Clause 18 of the Water Quality Policy and the EPA Guideline Wastewater Lagoon Construction, 2003. Qualified groundwater professionals or experienced and/or trained operators are mandated to sampling and monitor groundwater once in every six months for parameters, e.g, TOC, $\mathrm{pH}, \mathrm{EC}$, oxidized nitrogen (nitrite and nitrate) and ammonia nitrogen. The contaminant assessment in case of wastewater storage lagoons in the studied sites is applied to estimate the parameters listed in monitoring groundwater well parameters because only infiltrated pollutants are concerned from open lagoon system which has no directly discharge treated wastewater to public water sources.

Table 3.3 Potential environmental impacts from winery and/or distillery wastes and by-products


### 3.2.4 Evaluation of leaked nitrate in groundwater

Nitrate is considered to not form insoluble compound. It is more mobilization and readily leach from soil to groundwater than other ionic substances (Baram, 2012) and is subject to potentiality of shallow groundwater contamination because nitrates attenuate very slowly and can persist for years or decades in groundwater plume under the lagoon, and without sufficient dilution, nitrate possibly move down-gradient more than 300 feet from the source (MPCA, 1999), and in order to improve the water quality in groundwater channel becomes physically impossible and expensive which is not in a practical way (Nolan et al., 1997). From that reason, nitrate is considered to be a major pollutants to be evaluated, and natural attenuation in groundwater plume is not counted for environmental impact assessment.

A mass balance model (refer in chapter 5) that can be used to estimate concentration of nitrate-nitrogen entering groundwater per storage lagoon. Simplistic of this models benefit to a wide range of users can utilize this model with ease. Mass balance models was adapted from the study on assessment of potential impact to groundwater from septic systems (Taylor, 2003). This mass balance application has been used increasingly with simplicity but it still has shown good correlation between calculated and measured nitrate concentrations in groundwater. Assumptions of this study regarding the nitrate and groundwater interactions are following;

- Infiltration volume is calculated as year based at steady state of groundwater infiltration;
- There is uniform and complete mixing of wastewater in the lagoon system and the infiltrated rainwater toward groundwater;
- All nitrogen leaking from the lagoon system is completely nitrified to nitrates and has a potential to contaminate the shallow groundwater;
- The model does not consider dispersion, diffusion or adsorption are generally assumed to be absent; and
- Dilution and denitrification accounts for reduction of nitrate concentration are generally assumed to be absent for comparative assessment.


### 3.3 Scenarios establishment for financial feasibility of CDM project

In this part, the different scenarios of CDM investment models are established to identify financial indicators for decision making of CDM implementation.

### 3.3.1 CDM investment scheme

In post 2012, establishment of interested parties for CDM investment has been clarified how to operate the CDM, especially in organization of CDM investment function. So far, these investment models are not rigidly defined but it is obviously seen that parties have their own preferences to invest for different models in developing country (Yamin, 2015). From that reasons, indicators and stakeholders for CDM investment can be clustered in accordance with investment models by different business entities and investment purposes as follows;

## - Bilateral CDM model

The bilateral CDM model has firstly gathered momentum and has been flavored for many developed countries in the global GHG emission reduction trade since 1997 (the year which the Kyoto Protocol was signed). Under this model, it emphasizes the needs of developed country investor and the interests of private sector in developing country on project-by-project basis. It is all duty for a company in developed country to develop, finance and implement the CDM project by concerning own benefits and risks. Contract are agreed between partners on a project by in-advance purchase agreement before CERs issued. Under this approach, CDM is designed to make incentives to corporations in industrialized countries with maximum flexibility and minimum bureaucratic interference. This process only needs mechanism incorporated between investors and interested hosts to reduce transaction costs and independent certification process to generate sustainable benefits and business confidence.

## - Multilateral CDM model

Multilateral CDM is the approach in which investment from a mutual fund to projects in host countries. The reasons of this approach are to reduce a host country's risk from direct buying and selling of CERs, and partially reduce a investors' risk of individual project failure. Fund is managed by finance institutions such as the World Bank's Prototype Carbon Fund (PCF), consequently, Investors are not directly involved in project financing and development but buy CERs from the project itself (or portfolio of project). Then, it allows developing countries to offer the project with sustainable development to obtain a better deal or higher price in the contract agreement than in the bilateral model.

According to the initial barrier of a bilateral CDM model, several Annex I countries have initiated their own national credit buying schemes which share some characteristics with the multilateral approach as described above to get wider coverage of projects with sustainable development integrity.

## - Unilateral CDM model

Regarding to host country's risks induced from economical and political situation, and a preference to use home-grown technologies, the unilateral model is the approach which project development, financing and risks entirely bonded with the host country investment. Certified credits accrue to the host country, they have choices to sell or keep a part of the credits from their carbon account. Unilateral CDM is attractive to host countries with lower transaction cost and better integration of sustainable development strategy compared with other models. Although, This model do not involve technology transfer from Foreign Direct Investment (FDI) but capacity building services could be supported from the other models before CERs accrue (Jahn and Michaelowa, 2003).

### 3.3.2 Scenarios and conditions of financial analysis

In terms of business, not only the exchange between methane recovery technology investment and CERs is concerned but electricity sale is also another profit from the
project by selling to national grid or utilizing for internal electricity use. From that reason, indicators and decision maker who design in final decision to invest the project would be different in case of limited financial source as shown in Table 3.4.

In scenario A (bilateral CDM model), numerous financial sources from government/public sectors provide a financial support to private companies in developing countries for the CDM project implementation because initial cost is a major barrier to the realization of projects. To support private entities, for example, Japan government has established and implemented financial systems to subsidy a partial initial investment, which includes foreign direct investment (FDI), as well as subsidies and allocation of funds from Official Development Assistance (ODA) and Other Official Flows (OOF). In view point of subsidizer to give an $50 \%$ of initial fund to invest methane recovering technology, UASB, regardless of electricity income, only CERs or carbon credits are expected as a return from giving an initial fund to be an criteria for site comparison with Emission Reduction Purchase Agreements (ERPAs).

In scenario B (bilateral or multilateral CDM model), financial flow from Annex I countries through a mutual fund of the World Bank are contributed toward CDM project activities. Under this model, Entities of capital investment (either Annex I entities or host country entities or entities from both the host and Annex I countries) owns a project with share of benefits and risks. In project developing stage, it is carried out by the developers and the World Bank together, so called "Prototype Carbon Fund (PCF)" model. Finally the returns give to its investors by an amount proportional to their capital contributions. In view point of the PCF model, entities of capital investment expect not only issued CERs or carbon credit but also electricity sale income to decide for site consideration and/or comparison.

In scenario C (unilateral CDM model), because foreign investors are unwilling to invest in where projects contain with perceived high country-specific risks and high transaction costs, many proposed CDM projects are usually designed by local investors. So far, the unilateral model has been defined by the condition that the actors in the host country develop, finance, and implement a project on their own with/without CERs purchase agreement (Baumert, 2000). After the project is
successful to certify CERs production, selling the issued CERs on an open market in one option with Direct Purchase Agreement (DPA). Another option is that the host countries, especially economic-in-transition countries, would like to end the project with no purchase agreement either would like to keep the CERs for future sale or use in future commitment periods or wishes to wait for particular reasons. In view point of local investors, they bear their own risk for methane recovery CDM investment, on the other hand, returns from CERs and electricity sale would be account for this model.

Table 3.4 Financial indicators and conditions in different CDM models

|  | Scenario A <br> (Bilateral CDM) | Scenario B <br> (Bilateral/Multilateral <br> CDM) | Scenario C <br> (Unilateral CDM) |
| :--- | :--- | :--- | :--- |
| Financing <br> channel | Only FDI* <br> (UASB investment) | Partly FDI/Partly PCF** <br> (UASB+GEN investment) | Only domestic <br> investment |
| Subsidy | $50 \%$ of initial <br> investment | 50\% of initial investment | none |
| Loans <br> responsibility | Foreign investor | Domestic investor | Domestic investor |
| Income source | $50 \%$ or more of CERs | $50 \%$ or more of CERs, <br> electricity | CERs/VERs, <br> electricity |
| CERs contract | ERPA*** | ERPA | DPA**** or <br> No agreement |
| Income <br> beneficiary | Foreign investor | Foreign investor <br> Domestic investor | Domestic investor |
| Decision maker | Subsidizer <br> Foreign investor | Foreign investor <br> Domestic investor | Domestic investor |
| Indicator | Total CERs, <br> CERs generating cost | Total CERs, <br> CERs generating cost <br> IRR, net profit | Total CERs, <br> CERs generating cost <br> IRR, net profit |

## Remarks:

FDI* $=$ Foreign Direct Investment, PCF** $=$ Prototype Carbon Fund
ERPA*** $=$ Emission Reduction Purchase Agreement
DPA ${ }^{* * * *}=$ Direct Purchase Agreement (open market)

### 3.4 Decision criteria on project investment

In Figure 3.5, project prioritization of CDM candidates is decided by financial returns and co-benefits from the project, which include all dimensions of finance,
environment, and society. Financial indicators represent economical status of methane recovery CDM investment with CERs and electricity revenues. As for environmental criteria, the cost of pollutants alleviation from the project, e.g. UASB installment, is regarded as local benefit to environment for a host country. Social criteria is assessed in terms of potentiality or expectation that the project may help public surface water cleaner from pollutants alleviation of the project without a prove of contamination. From that reason, social values are subjects to use only for comparison basis in terms of community perception, and could not be referred as a value from the project. Due to necessity of social involvement, decision on project prioritization is conducted with overall dimensions by MCDA perspective, which is different from total benefit value from the project. Regarding total benefits value, apart from this study, cost-benefit analysis (CBA) is suggested to conduct with different frameworks. Financial CBA is measured by the concept of FIRR with revenues and expenditures of the project. While, economic CBA is considered all tangible benefit values. The values of community perception to importance of improved surface water quality is distinctive from other criteria. It should be considered separately to be a total benefit value with intangible benefits from CVM method.


Figure 3.5 Concept of project prioritization and total benefit value

## Chapter 4

## Financial assessment of methane recovery CDM project

### 4.1 Introduction and objectives

The CDM is a flexible market mechanism that make GHG emission reduction tradable by clean technology investment in developing countries from developed country investors. The fundamental criteria of CDM project registration is that the emissions reductions achieved in developing countries should be "additional" or "not economical attractive", which mean that the project could not be built without having extra money support because if the project happens in "business-as-usual" or "selffinance", it would not create actual emission reduction (Yong, 2009). Ensuring additionality in CDM projects protect the mechanism to not increase global GHG emission reduction relative to level agreement of emissions in the Kyoto Protocol from issuing CERs to non-additional project (Trexler et al., 2006).

In order to demonstrate additionality, project appraisal must be established at least one of the following criteria: the project cannot be self-finance within reasonable timeframe; the project requires knowledge or skills rather than commercial provider in the host country; the project is perceived some costs or risks than expected benefits (UNFCCC, 2008). However, the most objective and the only measurable test is the financial criteria of project investment barrier. The additionality is proven when the project is demonstrated to not be economically feasible, without the revenue generated from CERs and it became feasible with CER revenue. Under CDM mechanism, this appraisal is mostly judged from the internal rate of return (IRR) of a CDM project comparing with and without revenues of CERs. If calculated IRR without CER revenue is below a certain benchmark in host country, the project achieves the additionality proven (UNFCCC, 2000).

If CDM projects having been successfully passed additionality tests. CERs revenue would help to increase economic benefits of CDM projects, thereby increasing its investing attractiveness. From the view point of investors, the choice of the CDM
project investment requires a comparison of all costs and benefits involved. So, costbenefit analysis provides a method for making the direct comparisons among alternative projects. Even when goals other than economic efficiency are important, it can serves as yardstick that can be used to provide information about the relative efficiency of alternatives (Boardman et al. 2001). In this chapter, CER investment, in particular with the CER generating cost, and project profitability, with respect to IRR and net profit from the application of methane recovering technology incorporated into the anaerobic lagoon wastewater treatment system in Thailand are studied in terms of different business models. Figure 4.1 shows the steps performed for the financial assessment in this chapter from collection of CDM transaction cost and revenues information, key indicators and then parameters and alternative analysis.


Figure 4.1 Study process for the financial assessment

### 4.1.1 Sources of information for financial analysis

In order to study on the financial comprehensive evaluation of the methane recovery projects between two CDM studied cases in Ayutthaya province and Krabi province, Thailand. Economic assessment by applying the CDM from a financial point of view, the CDM investment, IRR and net profit of the projects with CDM revenue were extracted from financial data of Project Design Document (PDD) from Ayutthaya site (a methane recovery CDM project was already implemented) and factory data from Krabi site (no CDM project is implemented), used to relatively estimate costs with the same basis as Ayutthaya PDD to grasp the financial conditions efficiently in terms of
project profitability and viability and to make judgments on the project's financial position level.

### 4.1.2 CER investment of methane recovery CDM project

Although the transaction cost variation among types of CDM projects, there is no one best project type for the lowest cost CER investment of reducing GHG emissions in the developing countries because another profit such as electricity production somewhat gives significant change in terms of profitability, but the average CER investment for specific project types provides a useful proxy for the dollars spent per issued CER to compare in each project type. For examples, estimated CER investment widely varies from 0.79 USD/ton for $\mathrm{N}_{2} \mathrm{O}$ projects to $391 \mathrm{USD} /$ ton for solar, and methane recovery projects to around 10 USD/ton. The averages are over 25 USD/ton across all project types (Gillenwater and Seres, 2011).

The formula for the CDM investment or CER generating cost is to divide capital cost investment for CDM project by ton $\mathrm{CO}_{2}$ equivalent reduction expressed in equation (1).

CER generating cost (USD/tonCO $\left.{ }_{2} e\right)=$ capital cost investment/reduced tonCO $\mathrm{CO}_{2} e \quad$ (1)

Another hindrance for implementing CDM project is CDM mechanism cost which is relative to costs for putting the project through the CDM registration process including costs of document preparation, validation, verification, registration, and new method development. The ability to seek for lower cost investment of CDM project is a remarkable feature in the CDM, then the international offset from the administrative and other cost rather than mitigation cost should be low, otherwise, this cost can possibly outweigh the gains from CDM project (Gillenwater and Seres, 2011). Anyway, the transaction cost for CDM registration process was proven to be relatively small from some studies. Wetzelaer, et al. (2007) reviewed that the transaction costs per ton from CDM projects in pipeline were small in the range of 0.05-3.5 percent of the CER price, 0.01-0.70 USD per CER. It also resulted in similar conclusions from Antinori and Sathaye (2007), Transaction costs for CDM projects is in range of 0.03 USD per CER (for large projects) to 4.05 USD per CER (for smaller
projects), with a weighted average of 0.36 USD for all projects. Moreover, roughly 0.02-1.2 USD per CER is suggested for the administration process from World Bank (2009).

### 4.1.3 Profitability of methane recovery CDM project

One of the measures for worth of an investment to profit gains involves the use of an interest rate. The interest rate is used variously referred to as a hurdle rate, cutoff rate, benchmark rate, and minimum attractive rate of return (MARR) which all imply to a reasonable rate of return established for evaluation or selection of alternatives. The measures of investment worth are referred to as discounted cash flow (DCF) measures when using compound interest, and the methods used to compute the values of investment worth are called discounted cash flow methods.

Various methods exist for determining the value of the interest rate to use, e.g., present worth method (PW), annual worth method, future worth method, internal rate of return method (IRR), payback period method, etc. (Block and Hirt 1994). In developing of method and criteria for measuring the worth of investment, IRR has increasingly been used as financial indicator since the 1950s, and it is still widely used so far. IRR method determines the interest rate that yields a present worth (or future worth or annual worth) of zero. IRR is used in capital budgeting and investment analysis to assess the return over time from an investment made. The implementation of CDM methane recovering technology is also depended on financial feasibility. It is essential for investors to evaluate their expected profitability on the investment. In order to justify the feasible alternative, IRR is also used to compare with minimum attractive rate of return (MARR).

Letting IRR, $i^{*}$, is the interest rate that equates the net present value (NPV) or present worth ( $P W$ ) of its cash flows to zero as expressed in Equation (2) and (3).

$$
\begin{align*}
& 0=N P V=P W_{\text {cash inflow }}-P W_{\text {cash ouffow }}  \tag{2}\\
& i^{*}=\{i \mid " P W(i) "=0\} \tag{3}
\end{align*}
$$

Where: $P W_{\text {cash inflow }}$ is total sales (CERs and electricity sales) and $P W_{\text {cash outfow }}$ is all costs
of operation and depreciation with income taxes and interest cost recognized. Decision Rules;

$$
\begin{aligned}
& \text { if } i^{*}>M A R R \text {, accept the project } \\
& \text { if } i^{*}<M A R R \text {, reject the project } \\
& \text { if } i^{*}=M A R R \text {, indifferent }
\end{aligned}
$$

where: $M A R R$ is the minimum attractive rate of return that investors will accept.

In general for the private investors as CDM investment from developed country parties and private companies in a host country, no public project should be undertaken that would generate a rate of return less than "the rate of return that would have been experienced on the privates uses of funds" that would be unacceptable by the financing of the public project (through taxes or bonds) (Howe, 1971). However, White et al. (1998) suggested that a rate of perhaps $10-15 \%$ is more appropriate for the early 2000s. In the UK, the rate of $6 \%$ is used as addressed by Grout (2003).

### 4.1.4 Viability of methane recovery CDM project

The net profit ratio and profit margin are the ratios of after-tax profits to cost price and net sales. The net profit is one of the best measures to capture the overall financial status of a firm or a project over a period of time, by meaning that how its capital works to generate income. Apart from IRR which is discount rate to be profitable, This measure is not based on discount rate and benchmark setup, but it is usually reported on a trend line of business growth, to judge performance over time and also used to compare the results of a business with its competitors as company's income statement (Dilipkumaran, 2013).

## - Net profit ratio/percentage

Net profit ratio/percentage or profit-to-investment ratio has been initiated by Seba (1987). This ratio is calculated by dividing either the net operating income or the net cash flow from a project (with/without discount rate) by the sum of the investments. Then, the results could be specified either undiscounted net profit ratio or discounted net profit ratio, in which discount rate is applied or not. The net profit ratio should be
in a range of $15-20 \%$ for minimum requirement, and possibly over the minimum, closer to $40-50 \%$ for more endurance of investment (Stefan, n.d.)

In the implementation of CDM methane recovery technology, the net profit ratio/percentage is an accounting measure which is calculated based on time period of investment expressed in equation (4) (Zions business resources center, 2012). Net profit is not an indicator of purely cash flows, since cash flow data for net profit calculation incorporates with a number of non-cash expenses, such as accrued expenses, amortization, and depreciation cost.

$$
\begin{equation*}
\text { Net profit ratio }=\left(P W_{\text {cash inflow }}-P W_{\text {cash outfow }}\right) / \text { capital cost } \tag{4}
\end{equation*}
$$

Where $P W_{\text {cash inflow }}$ is total sales (CERs and electricity sales) and $P W_{\text {cash ouflow }}$ is costs of operation and with income taxes and interest cost recognized.

## - Net profit margin

Net profit margin is used as an accounting measure to compare economic status in a project or between projects in similar industry. A higher net profit margin means that company has more efficiency to convert sales to actual profit. Net profit margin is calculated by dividing net profit (after tax) with all sale revenues taken as base times 100. There are different purpose to utilize net profit percentage and net profit margin because companies calculate net profit percentage for "Markup" based on cost investment to turn into profit, whereas net profit margin looks for the percentage of selling price of products turned into the profit.

The formula of net profit margin is used to specify how much in revenues of company's products are kept as net cash flow. It is calculated based upon one year or time period consideration expressed as percentage in equation (5) (Zions business resources center, 2012).

$$
\begin{equation*}
\text { Net profit margin }=\left(P W_{\text {cash inflow }}-P W_{\text {cash ouffow }}\right) / \text { sales revenue } * 100 \tag{5}
\end{equation*}
$$

Where $P W_{\text {cash inflow }}$ is total sales (CERs and electricity sales) and $P W_{\text {cash ouflow }}$ is costs of
operation and with income taxes and interest cost recognized.

### 4.2 Study activities and parameters

### 4.2.1 Cost investment of methane recovery CDM project activity

In comparison between the project sites, for Ayutthaya site, capital investment cost ,and system operation and maintenance costs of methane recovery management system including an upflow anaerobic sludge blanket (UASB) treatment system and gas generation units were acquired from expert judgement in the PDD document. For Krabi site, the factory data of wastewater characteristics was used to relatively estimate capital investment cost, and operational and maintenance cost for UASB investment with fixed volumetric COD loading as same as Ayutthaya's by adjusting a reactor size to estimate combined cost investment of an UASB and gas generators.

Practically, These CDM processes are composed of anaerobic fermentation reactor or UASB to capture biogas for power generation. The GHG emission reductions for the both studied sites were estimated by the same UNFCCC methodologies of methane recovery in wastewater treatment, and grid connected renewable electricity generation. Electricity outputs for two studied cases were calculated based on produced biogas from capturing system and gas generators with same specification.

### 4.2.2 Estimation of CERs and electricity sales

As for the case study in Ayutthaya site, a CER evaluation report was prepared in December 2008 with the aim to estimate the CERs in tons of carbon dioxide equivalent $\left(\mathrm{tCO}_{2} \mathrm{e}\right)$ for 7-years project period. CERs are a measure of carbon credits associated with CDM projects, and each CER represents $1 \mathrm{tCO}_{2} \mathrm{e}$ mitigated. According to CDM project activities AMS-III.H. (Methane recovery in wastewater treatment) type (iii): other project activities and AMS-I.D. (Grid Connected Renewable Electricity Generation) type (i): renewable energy project, profiles of expected CERs and electricity generation per year CER crediting period of the project were $22,500 \mathrm{tCO}_{2} \mathrm{e}$ from AMS-III.H. and $2,967 \mathrm{tCO}_{2} \mathrm{e}$ from AMS-I.D. (or produced electricity of $5,817 \mathrm{kWh}$ ). The another case study in Krabi site, CDM unimplemented
site, was estimated from factory data for CERs and electricity generation under the same basis as the Ayutthaya PDD. The different results of CERs and electricity production were mainly based on different wastewater characteristics and baseline wastewater treatment process, which generated 21,645 $\mathrm{tCO}_{2} \mathrm{e}$ from AMS-III.H. And 3,243 $\mathrm{tCO}_{2} \mathrm{e}$ from AMS-I.D. (refer in Appendix I).

### 4.2.3 Extended appraisal for entities of investment

Some of CDM projects has been implemented independently by host country project participants and the CERs directly sold to an Annex I purchaser with no further involvement of the purchaser in the project. A company investor could develop this project framework, called an unilateral CDM project, based on its own financial arrangements without no need for Annex I investment and sell CERs discretely to one or more CER purchaser through forward contracts (Jahn and Michaelowa, 2003). Despite the Annex I investment, a host country company has to consider economical feasibility with more limited fund to invest to a project activities than Annex I country. An extended appraisal is made by considering factors of CDM crediting period and electricity generating capacity to gain a choice with different profitability and viability of methane recovery project in terms of CERs and electricity sales.

A design of biogas management system for the two study sites were prepared, and gas generation and CER calculations were made, together with a financial model to assess the financial status of the project as shown in Table 4.1. The projects were calculated to have CER investment and IRR for a a 10 -year CDM crediting period (a single contract without a renewal), a 14 -year period ( $7+7$ years, i.e., a 7 -year crediting period with one renewal), and for a 20 -year period ( $10+10$ years, i.e., a $10-$ year crediting period with one renewal) schemes. Another concerned parameter is electricity generation capacity which varied numbers of electricity generator set with the same specification (a genset generator with electricity output $=1,063 \mathrm{kWe}$ per unit). Maximum generated electricity from captured biogas by UASB for Ayutthaya and Krabi sites are 28,107 and 27,095 MWh per year, respectively (refer in Appendix II), which is applied for varying the number of gas generators from 0 to 4 units (a generator produces electricity of 5,817 and 6,359 MWh per year for Ayutthaya and Krabi sites, respectively). The resources assumptions and financial conditions (tax and
depreciation conditions) for two sites are summarized in Table 4.2.

Table 4.1 Summary of data resources and value estimation for methane recovery CDM project activity with one electricity generator unit (in 2008 value)

| Items | Ayutthaya <br> value | Source/Reference | Krabi <br> value | Source/Reference |
| :--- | ---: | :--- | ---: | :--- |
| COD (ton $/ \mathrm{m}^{3}$ ) | 0.145 | PDD (plant data) | 0.089 | Estimated plant data |
| Volume of wastewater (m $\left.\mathrm{m}^{3} / \mathrm{y}\right)$ | 323 | PDD (plant data) | 464 | Estimated plant data |
| Operating day | 268 | PDD (plant data) | 293 | The annual average <br> value of the factory <br> data |
| Comparing ratio of reactor <br> volume | 1.00 | Assumed to be 1 | 0.88 | Adjusted from <br> Ayutthaya PDD by <br> volumetric COD <br> loading |
| Capital investment* (Mil.USD) | 6.57 | PDD (estimated by <br> expert) | 5.85 | Adjusted cost from <br> comparing ratio of |
| Manpower cost in the year <br> (Mil.USD) | 0.020 | PDD (estimated by <br> expert) | 0.018 | volume |

Remarks: * Capital investment cost includes adjustable price of anaerobic fermentation system by size and adjustable price of gas generation system by number of generator unit ( 1 unit costs 0.5 Mil.USD)
** Not included GHG emission reduction from grid connected renewable electricity generation
*** Equivalent to $2,967 \mathrm{tCO}_{2} \mathrm{e}$ and $3,243 \mathrm{tCO}_{2} \mathrm{e}$ for Ayutthaya site and Krabi site, respectively in the scheme of internal electricity use
**** Calculated estimation plant data: Operation condition No. of set x Generator output (1063 $\mathrm{kWe}) \mathrm{x}$ Operation hour x Operation day x Accident factor (0.95) x Transmission loss (0.995) x Internal demand (0.9)

Table 4.2 Financial conditions for methane recovery CDM project activity (recondition of tax, depreciation etc.)

| Items | Value | Unit | Remarks |
| :---: | :---: | :---: | :---: |
| Corporation tax | 30 | \% | Tax rate of Thailand (8 years tax holiday) |
| Interest, Borrowing condition | $0 \%$ and $50 \%$ loan | USD | Analyze with 2 conditions; In case of on loan, It assumes that implementation fund is on hand completely, it isn't considered assetliability for the IRR calculation, <br> or $50 \%$ loan of capital investment for domestic investors |
| Payment start time | 2010 | year | - |
| Depreciation taxable | $90 \%$ of capital investment | USD | Equipment cost and design expense |
| Depreciation period | 10 | year | Least 5 years |
| Depreciation method and rate | fixed installment method, $10 \%$ | - | Fixed installment method is general in Thailand. |
| Salvage value | 0 | \% | Salvage value is zero. |
| Price inflation rate | 0 | \% | It isn't considered for the IRR calculation. |
| Exchange rate in 2008 (THB $\Leftrightarrow$ USD) | 35.86 | THB/USD | - |

### 4.3 Results and discussion

The financial status of the CDM project was assessed in terms of CER investment and profitability/viability. CER generating cost represented the condition of CER investment, while, the IRR and net profit percentage/margin were used to grasp the conditions of profitability/viability. The analysis was performed by varying the
numbers of gas generators and CER crediting period. For pure speculation of methane recovery CDM investment, the efficiency due to different generator sizing and the overhaul cost for prolongation of all assets after depreciation period were not regarded in this assessment.

The investment of methane recovery CDM is analyzed by separating the schemes of electricity sale and internal electricity use as shown in Figure 4.2. Produced electricity from captured biogas propose distinct results in terms of GHG emission reduction and financial returns. As for the purpose of GHG emission reduction in the scheme of internal electricity use, additional on-site GHG reduction (calculated from AMS-I.D.) is considered as energy saving from neutral emission of biofuel in the project boundary, in which electricity demand of factory is larger than produced electricity in the scheme of internal electricity use. This additional GHG reduction from generating electricity augments the GHG reduction by UASB (calculated from AMS-III.H.).


Figure 4.2 CDM project boundary of GHGs reduction and electricity revenue between the schemes of electricity sale and internal electricity use

Generated CERs by on-site energy saving are equal to 2,967 and $3,243 \mathrm{tCO}_{2} \mathrm{e} /$ unit generator for Ayutthaya site and Krabi site, respectively (referred in Appendix I) by assuming that those emission reductions are equal to different GHG emissions between baseline and project scenarios of electricity use. As for the purpose of
electricity sale/saving, revenue is estimated from fully export/internal use amount of produced electricity without data of a balance of electricity import and export from factories.

### 4.3.1 CER generating cost

Figures 4.3 and 4.4 show CER generating costs and CER margins in the form of vertical bars for the study sites and each project sampled. The different color lines correspond to varied CER crediting periods for each project sampled and CER margins for the two study sites. This graph format shows the comparison of CER generating costs with varied the number of gas generators ( $0-4$ units) for different choices of investment from Annex I country and investment entities/host country investors.

For both sites, CER generating costs are in a range of 12.36-35.87 USD/tCO ${ }_{2}$ e which are acceptable in carbon taxation schemes, which the prices vary between countries, and the majority of prices in existing systems are below 35 USD/ $/ \mathrm{CO}_{2} \mathrm{e}$ (World bank, 2014). Comparing between the two sites, Krabi site provides cheaper CER investment than Ayutthaya site in any same varied conditions because Krabi site has lower initial cost investment to CERs than Ayutthaya site by a lower COD loading per day of factory wastewater influent. The cheapest CER investment costs are 13.49 and 12.36 $\mathrm{USD} / \mathrm{tCO}_{2} \mathrm{e}$ with no generator investment for Ayutthaya site and Krabi site, respectively (refer in Appendix III). For each site's condition varied, increasing CER crediting period give cheaper CERs investment with decreasing rates because there is no additional capital cost required for increasing project crediting period to produce CERs. In practical way, produced electricity is proportionally used either for sale or internal use. In case of all electricity sold as shown in Figure 4.3, more capital investment by increasing the number of biogas generators give more expensive CER investment with constant rates because initial investment capital increased with increasing electricity generation in a purpose of more electricity revenue, while total CERs are counted in the same amount and no additional CER generated from energy saving scheme in the project boundary. In case of internally using produced electricity internally as shown in Figure 4.4, it contrarily induces less CER generating costs because of the reduction of fossil fuel consumption, instead of grid import, in a
project scale rather than the offset to revenue of electricity sale.

As noticed in Figures 4.3 and 4.4, Difference on increasing/decreasing rates in each CER crediting period is originated from more CER production of higher CER crediting period with a constant increase of capital cost for UASB and generators for every CER crediting projects. In Figure 4.4, more difference on decreasing rate for higher CER crediting period is distinctive from lower ratio of CER production of gas generators and UASB. Values of CER generating cost between Ayutthaya site and Krabi site are tend to give lower difference with increasing CER crediting period because the function of CER crediting period for Ayutthaya site has more decreasing rate on CER generating cost than Krabi site. In both schemes of electricity sale and internal electricity use, GHGs reductions from electricity generation are not significant difference in terms of total GHGs emissions because GHGs are mostly emitted from decomposition of anaerobic open lagoons.


Figure 4.3 Relationship of CER generating cost and CERs margin against the number of biogas generators with different CER crediting periods: the scheme of electricity sale


Figure 4.4 Relationship of CER generating cost and CERs margin against the number of biogas generators with different CER crediting periods: the scheme of internal electricity use

Therefore, the increasing CER generation from the scheme of internal electricity use mainly causes by GHGs reduction of energy saving, instead of grid electricity import. Nevertheless, in the scheme of electricity sale, Feed-in Tariff (FIT) policies, notably in Europe and widely in many countries, would help stabilize electricity rate, from which incremental return could lower the investment cost and minimize transaction costs of overall project. In addition, considering GHG emissions for the both schemes of electricity sale and internal electricity use are neutral for national electricity production, it could be noted that the results of CER generating costs in the scheme of electricity sale in Figure 4.3 should be similar to the results of CER generating costs in the scheme of internal electricity use in Figure 4.4 because there is the same amount of the additional GHG reduction from energy saving by assuming that electricity demand for factory is larger than produced electricity from captured biogas.

### 4.3.2 The internal rate of return

The internal rates of return (IRR) from CDM scenarios were assessed as summarized in Figure 4.5. This graph format shows the levels of profitability of different project varied and also the improvement in profitability expected through the increases of electricity production from 0 to 4 units of gas generators and the increases of CER
crediting period for consideration of investment entities in host countries.

For all conditions varied, IRRs are in a range of $-10.06 \%$ to $29.57 \%$ (refer in Appendix III). Investors need to install gas generator more than 1 unit to receive an acceptable rate of profitability gain in Thailand year 2008 (IRR $=5.59$ ), except 20 year CER crediting period which 1 unit of generator is sufficient for Ayutthaya site, and 14-year and 20-year CER crediting period with 1 generator investment for Krabi site. Comparing between the two sites, Krabi site gives higher IRR than Ayutthaya site in any conditions with the same CER crediting period and electricity generation because Krabi site has higher total income (CERs and electricity sales) due to higher produced electricity per capital originated from captured biogas and higher operational days per year.


Figure 4.5 Relationship of internal rate of return and CERs margin against the number of biogas generators with different project CER crediting periods

Increasing CER crediting period induce higher IRR with decreasing rate because total incomes increase with increasing CER crediting period, while initial investment capital is the same. Increasing electricity generation give higher IRR in any CER crediting periods with decreasing rate because increasing the number of biogas generators result in higher benefits to total incomes in terms of electricity sale than investment cost of gas generators. The logarithmical function of IRR with constant
increasing rate of income per year and the constant incomes from UASB give the decreasing rate. The decreasing rate of IRR with increasing electricity generation is obviously noticed at higher CER crediting period because electricity sale is a major income from the projects, then, income of UASB become less effective in different CER crediting period when increasing electricity generation.

In Figure 4.6, under circumstance that entities of the CDM investment or host countries seek a loan option for $50 \%$ of capital cost, in which remaining cost from Annex I subsidizer takes part. In the condition of $50 \%$ capital investment loan with interest cost of $10 \%$ (after paid-up balance) for the CDM investment with 20-year CER crediting period, interest cost has no effect on changing IRR decreasing rates but give lower values of IRR because total income deducted by interest cost still make constant value of decreasing rate but lower value, which give lower IRR value in the same CER crediting period and electricity generation. In this condition, the investment with 1 gas generator may has a risk to not be registered as the CDM project due to the IRR value is lower than the expect IRR in the country.


Figure 4.6 Comparison on internal rate of return against the number of biogas generators in 20-year CER crediting period with no loan and loan condition

### 4.3.3 Net profit percentage and net profit margin

The net profit percentage and net profit margin from CDM scenarios are assessed as
summarized in Figure 4.7 and 4.8. These graph formats show the levels of variability of different conditions varied and also the improvement in variability expected through the increases of electricity generation and CER crediting period for consideration of investment entities in host countries.

In Figure 4.6, All projects could not make a profit without generator investment (Net profit percentage $<0 \%$ ), and they become profitable by at least 1 unit of generator investment (except Ayutthaya site with 10 -year CER crediting period), with net profit percentage in a range of $12.21 \%$ to $191.84 \%$. The minimum requirement in terms of net profit percentage, which should be more than $15 \%$, starts from 14 -year CER crediting period with 1 generator investment for both Ayutthaya site and Krabi site, corresponding to the results of IRR. Comparing between the two study sites, Krabi site provides higher net profit percentage than Ayutthaya site in any conditions of the same CER crediting period and electricity generation from a reason that Krabi site has higher net profit (which related to functions of CERs and electricity sales, depreciation cost, operating cost, interest cost, corporation tax, tax holiday) and lower total cost investment. The highest net profit percentage are $156.58 \%$ and $191.84 \%$ with 4 generators investment for Ayutthaya site and Krabi site, respectively.


Figure 4.7 Relationship of profit percentage and CERs margin against the number of biogas generators with different project CER crediting periods

Increasing CER crediting period express higher net profit percentage with increasing rate because total net profit increased with increasing CER crediting period is higher than the increase of total cost investment capital from maintenance cost of prolonging gas engine use. Increasing electricity generation show higher net profit percentage in any CER crediting periods with decreasing rate because increasing the number of biogas generators make more net profit in terms of increasing electricity sale comparing with total combined costs of biogas generator operation. Although, total cost investment capital increases with a constant value but net profit increased with decline rate from reasons of different corporation tax and holiday tax in each year.

In comparison of the net profit margin between the two studied sites as shown in Figure 4.8, Krabi site gives higher profit margin than Ayutthaya site in any same CER crediting period and electricity generation because The operation of Krabi site result in higher net profit to total sales comparing with Ayutthaya site. The highest net profit margin are $52.48 \%$ and $56.24 \%$ with 4 generators investment for Ayutthaya site and Krabi site, respectively. Increasing CER crediting period give higher net profit margin with decreasing rate because total net profit increase with increasing crediting period, higher than the increase of total sales.


Figure 4.8 Relationship of profit margin and CERs margin against the number of biogas generators with different project CER crediting periods

### 4.3.4 Break-even point of electricity production for Feed-in tariffs regulation

Feed-in tariffs (FIT) has been the most widely used to support renewable energy producers for expanding productivity with security of investment. This program put technology-specific renewable premium price on the top of electricity normal price to on-site power production (Greacen, 2007). In the concept of methane recovery CDM investment, CER mostly generated from avoidance of methane emission in wastewater treatment system. However, CER revenue of producing electricity from captured biogas should be taken into consideration in terms of FIT optimization. In Figure 4.9, electricity export prices to the national grid are varied from 2.96 Baht $/ \mathrm{kWh}$ to $\pm 15 \%$ and $\pm 30 \%$. The electricity incomes for Ayutthaya and Krabi sites (with 20-year CER crediting period and 4 generators investment) are projected by a increase of electricity export price comparing with the baseline of electricity cost from imported electricity rate of $3.6 \mathrm{THB} / \mathrm{kWh}$ with the same amount of produced electricity from the CDM project. Without FIT applied to the case studies, selling electricity in the grid may not be a good choice than utilizing it internally because the cost of electricity import is higher than the export.


Figure 4.9 "Break-even point" of biogas-generated electricity production for Feed-in tariff program in Ayutthaya site and Krabi site

Increased profits from CER revenue by generating electricity would help to minimize the break-even point of renewable tariff from $3.6 \mathrm{THB} / \mathrm{kWh}$ to $3.4 \mathrm{Baht} / \mathrm{kWh}$ for both studied sites. In Thailand, a policy for biogas plants gives a new FIT of 4.5 $\mathrm{THB} / \mathrm{kWh}$, which apply to biogas system smaller than 1MW in size (GIZ, 2014). The CERs counted in this estimation cause a saving of $0.2 \mathrm{THB} / \mathrm{kWh}$ from the normal tariff and a profit of $0.9 \mathrm{THB} / \mathrm{kWh}$ from a new tariff scheme. The saving costs from CER account are equal to 2.60 and 2.84 Mil.USD for Ayutthaya and Krabi, respectively.

### 4.3.5 Decline rate on profitability and viability of the projects

The three figures below express linearization of different decline rate for profitability and viability in form of vertical bars. The horizontal bars corresponds to electricity generation per year which increased from the right side to the left side of the bars ,varied from 5,817 to 25,437 MWh per year.

From overall results of the financial assessment, the increase of electricity generation perform different incline rate of increasing IRR, net profit percentage and net profit margin to the project investment as shown in Figures 4.10, 4.11 and 4.12, respectively. The coefficient in the linear models can be interpreted that, for Ayutthaya site, a $1 \%$ increase in $1 / \mathrm{kWh}$ in electricity generation leads to a $9.6-15.4 \%$ in IRR, a $65.6-99.8 \%$ in net profit percentage, and a $48.7-93.5 \%$ in net profit margin (refer in Appendix IV). The function of electricity generation has more effect on a change of net profit percentage than net profit margin and IRR, respectively. On the other hand, there is no effect on the incline rate of CER generating cost by biogas generator investment (see in Figure 4.3, 4.4). Electricity generation induce the most difference of decline rates between Ayutthaya site and Krabi site for net profit percentage with the highest rates of change (coefficient values) from the linear equations as shown in Figure 4.11. In addition, increasing CER crediting period created decline rate of increasing IRR and net profit margin, but performed increasing rate of increasing net profit percentage. The function of CER crediting period has more effect on profit margin with higher difference of coefficient values (see in Figure 4.12) than profit percentage and IRR, respectively.

Ayuthaya (10y crediting period) $\quad$ Ayuthaya (14y crediting period) $\longrightarrow$ Ayutthaya (20y crediting period)

Figure 4.10 Relationship between incline rate of IRR and electricity generation with different CER crediting periods


Figure 4.11 Relationship between incline rate of profit percentage and electricity generation with different CER crediting periods


Figure 4.12 Relationship between incline rate of profit margin and electricity generation with different CER crediting periods

On account of methane recovery CDM investment, it summarily results in the CER generating costs have constant incline rates, but the IRR and the net profit have a change of incline rates with increasing electricity generation. Consequently, The investment in a purpose of achieving the lowest CER generating cost should be selected from 20-year CER crediting period with the lowest investment of biogas generator ( 1 unit of gas generator for the IRR beyond the expected IRR). On the contrary, in consideration of IRR, there are decreasing incline rates varied with different electricity generation and CER crediting period, which should be considered to invest with capital availability. The results of the effect on the decline rates of IRR and net profit over CER generating cost means that this consideration would be more concerned for host country investors or CDM investment entities in order to make projects profitable from electricity sale, which is the major revenue of the biogas projects rather than CER sale.

### 4.4 Conclusions

Due to various barriers facing methane recovery technology in developing countries (i.e., technological, financial, social, institutional and operational barriers), this
potential can hardly be tapped. However, there is relatively large potential for methane recovery CDM investment to anaerobic lagoon treatment by using closed structure anaerobic digester technology. The results from the case studies in Ayutthaya and Krabi provinces showed that there is a promising future for applying the methane recovery technology to ethanol and palm oil industries with acceptable CER generating costs (12.36-35.87 USD/ $/ \mathrm{CO}_{2} \mathrm{e}$ ), especially if demands of productions are increased to guarantee adequate availability of waste. For both Ayutthaya and Krabi methane recovery projects, the financial analysis also resulted in that the profitability and viability of the projects with carbon revenues can be acceptable in term of Thailand business basis. It was estimated that the global annual potential for 20-year crediting GHG mitigation from Ayutthaya site and Krabi site are 450,000 and 432,900 $\mathrm{tCO}_{2} \mathrm{e}$ (with the scheme of electricity sale), respectively. When all of these emission reductions are realized through a CDM approach, the approximate annual value of the CERs generated would be approximately 4.50 and 4.33 Mil.USD for Ayutthaya site and Krabi site, respectively. This incremental value would of course be additional to annual revenues from power export to the grid and savings linked to power import avoidance, which are estimated at 9.6 and 10.5 Mil.USD per an unit of gas generator for Ayutthaya site and Krabi site, respectively.

CER investment cost is considered alone for Annex I countries as project subsidizers, for fund allocation, while not only CER investment but also the IRR and net profit are considered for host country investors and business entities to cooperate all revenues of CDM project activities. In order to compare financial feasibility between two case studies, the main issues for project comparison in the implementation of the methane recovery CDM projects have been the functions of electricity generation, CER crediting period and complexity of the CDM calculation process and methodologies. The summaries and lessons learnt from the projects include:

- Ayutthaya and Krabi sites were estimated lower the cost of mitigation, 12.36 35.87 USD/ $/ \mathrm{CO}_{2} \mathrm{e}$, to combating the climate change with average carbon price of carbon tax pricing instrument, 35 USD/ $/ \mathrm{CO}_{2} \mathrm{e}$;
- Krabi site costed lower CER investment than Ayutthaya site, but need to separately consider emission trading scheme of methane reduction from electricity sale and internal electricity reduction, and also FIT applied for
electricity export in a host country;
- Although the projects were proven to not be business-as-usual, electricity sales were considered as major revenues for this type of CDM project;
- IRR and net profit showed rate to achieve a profit and overall profit over time from investment which Krabi site competed a higher values in this study conditions;
- Krabi site was more attractive for private investment. Host country investors should be induced to install electricity generator at full coverage of biogas produced to gain economical profitability and viability, However, in case of limited fund, at least 1 unit of gas generator should be invested to make a project visible with the acceptable IRR. The IRR value should be particularly considered through depreciation cost and loan-debt condition;
- CER revenues from generating biogas-based electricity gave a more profit to the projects of $0.2 \mathrm{THB} / \mathrm{kWh}$ from a scheme with electricity tariff of 3.6 $\mathrm{THB} / \mathrm{kWh}$, and totally $1.1 \mathrm{THB} / \mathrm{kWh}$ from a scheme with a new FIT of 4.5 THB/kWh;
- Increasing electricity generation gave constant incline rate on the change of CER generating cost, but gave lower incline rate on increasing IRR, net profit percentage, and net profit margin; and
- Increasing CER crediting period had a lower incline rate on decreasing CER generating cost and increasing IRR/net profit margin of the projects, but had a higher incline rate on increasing net profit percentage.

Regarding host country investment for methane recovery CDM project, project developers and investors could take advantage of the pilot methane recovery plant implemented in Ayutthaya in gaining experience to implement the technology in other areas. Small scale methane recovery CDM projects (e.g., Ayutthaya and Krabi sites) offer an opportunity to demonstrate the role of sectoral approaches in self-financing GHG reduction projects from major income of electricity sale. Methane recovery CDM projects could be developed using a sectoral approach in order to overcome the financing, technological and other barriers faced by CDM projects implemented on an ad-hoc, project-by-project basis. A sectoral policy based approach is a government-
driven mechanism that allows developing countries to set policy and programs that lower GHG emissions in a specific sector. The carbon savings will be compensated directly to the host government by an investor. The government may then pass on these benefits to the relevant sectors affected by the measures in the form of tax incentives, subsidies, concessional finance, etc. These approaches provide an innovative tool for government to finance climate friendly policy measures.

## Chapter 5

## Assessment of environmental impact for co-benefits indicators

Apart from GHGs emission reduction, which is the main issue of methane recovery CDM investment, the environmental impact of high-strength wastewater treatment process is assessed for project comparison in the expectation of alleviating pollutants to environment, considered as "co-benefits" from the investment of a methane recovery CDM project. The results for assessment and valuation of environment impact from factory's point-source pollutants and open lagoon's infiltrated pollutants are separately discussed with different characteristics of wastewater and site conditions.

### 5.1 Introduction and objectives

Continued and regional growth of high strength wastewater industries such as ethanol and crude palm oil industries have contributed an potential to pollute surface water and groundwater, and cause noxious odors by releasing to public water sources, and enriching carbon and nutrients in wastewater treatment system. Furthermore, recent studies indicated volatilization of ammonia to the atmosphere from concentrated wastewater in storage lagoons (Viney et al., 1999). As a result of these inborn problems, adaptation of technologies and management practices has been encouraged to cope with high strength wastewater for factory owners and operators.

According to Wolmarans and Villiers (2002) and Orendain (2006), both efficiency and cost effective treatments was opted to treat stillage or ethanol factory's effluent starting by anaerobic treatments for high biochemical oxygen demand (BOD), chemical oxygen demand (COD) and total solid content. Even after the anaerobic treatment, some organic compounds in the wastewater cause dark color and it is removed to some extent by aerobic digestion with biological and/or physico-chemical treatments and it needs further treatments for public water release. In terms of
environmental impact, treatment in earthen lining open lagoon should be considered as same as consequence of stillage, used in land application, the underground and surface water quality depends on land characters such as slope, soil depth, clay content and hydraulic properties and stillage properties like chemical composition, time and rate of application and depth of groundwater table (Jain et al., 2005). High EC, potassium, chloride, sulphate and melanoidine as colorant are potential components in stillage to cause the pollution (Kumar and Gopal, 2001; Filho, 1996). Studies in many countries concluded for factory management practices of stillage caused the underground water pollution (Schoor, 2004). Indiscriminate application in agriculture to the areas of shallow water table $(<15 \mathrm{~m})$ associated with sandy soils of high infiltration rate are highly prone to pollution and that could not be recommended.

From the reason of contamination potentiality, the objective of this chapter is to assess and compare costs of environmental impact between sites by different valuation methods. In Figure 5.1, point-source pollutants from a factory (in baseline and project scenarios) and infiltrated pollutants from an open lagoon (in baseline scenario before implementing the CDM project) are separately discussed on pollutants estimation and valuation methods. Point-source pollutants valuation is applied in a purpose to simplify a valuation method to achieve a benefit value of the CDM project by using hypothetical treatment systems to treat wastewater in baseline and project scenarios and assuming efficiency of the CDM system without consideration of site conditions.


Figure 5.1 Schematic of point-source pollutant valuation and infiltrated pollutant valuation

Infiltrated pollutants valuation is conducted with consideration of site conditions to achieve an actual cost of environmental impact for each site, however, it could not estimate an actual benefit value for feasibility study from unknown conditions of site conditions after CDM implementation. Pollutant movement from open lagoon receiving factories effluent to shallow groundwater buffered by upper sediment is considered as site conditions for contamination of groundwater pollutants, in order to assess the influences from wastewater characteristics of factory effluent, and biological/hydrologic factors of lagoon site conditions on nitrate movement into a groundwater. The calculations of both valuations are assessed and valued into monetary term to compare between project sites.

### 5.2 Contaminated pollutants for co-benefits valuation

Pollutants for environmental impact assessment are separately valuated from concerned types of pollutant, originated from the studied factories and potentially contaminating in shallow groundwater.

### 5.2.1 Point-source pollutants

High strength wastewater which has very high COD concentration (60,000-200,000 $\mathrm{mg} / \mathrm{l}$ ) and BOD concentration ( $25,000-75,000 \mathrm{mg} / \mathrm{l}$ ), and also contains nutrients (mostly nitrogen) such as stillage, the substances from manufacturing process including high concentrations of carbohydrates, reducing sugars, dissolved lignin, proteins, alcohols, waxes, etc. conveys high organic and nitrogen substances to wastewater and lead to oxygen depletion and eutrophication of water bodies (Satyawali and Balakrishnan, 2008). Therefore, carbon and nitrogen species are concerned as common threats to water environment from high strength wastewater treatment process, and considered to be valuated as point-source pollutants for a basis of project comparison.

### 5.2.2 Infiltrated pollutants from open lagoon

Amongst various treatment processes suggested for the treatment of high strength
wastewater, anaerobic microbial digestion is found to be most promising in Southeast Asia (Chaudhari et al., 2008). Open lagoon has been mostly used as compromising of treatment and storage capability in a wasteland or unusable land. In practical way of open lagoon operation as shown in Figure 5.2, when high strength carbon wastewater is treated in open lagoon system with high amount of nutrients in their waste, under acidic condition and no free oxygen, ammonia volatilization and nitrification should not happen in the lagoons. Predominant substances in the lagoons would be considered only remaining organic carbon and ammonium-nitrogen. Ammonium lost to groundwater plume in form of nitrate through oxic condition under lagoons. The sharp oxic condition is originated from desiccation-crack network and seal formation which driven by clogging process of clay sediment pore and organic matter, controlling hydraulic condition over underlying sediment (Baram, 2012).


Figure 5.2 Carbon and nitrogen cycle of open lagoon operation in the studied sites

In order to scope types of valuating pollutants from groundwater contamination, Figure 5.3 shows step-by-step processes to screen out pollutants which are reduced pollutants from upflow anaerobic sludge blanket (UASB) system, benefitting to environment from CDM project, and a potentiality to contaminate in shallow groundwater sources under the lagoons. Remaining pollutants after attenuation process in subsurface sediment are assessed from remaining pollutants in the lagoons with site specific conditions. Specific mechanisms of substance degradation and attenuation in the lagoons and shallow sediment under lagoons of studied sites are explained to scope valuating substances as follows;


Figure 5.3 Processes for scoping infiltrated pollutants from earthen-lining open lagoon and treated pollutants from UASB system

## - Organic carbon

In an anaerobic treatment system, specialized bacteria will develop to use organic matter as a source of carbon for fermentative metabolic processes. Methane and carbon dioxide are the main end products of the fermentation. Fermentation is a biological conversion process by reducing complex organic matter into methane and carbon dioxide which can be divided into four steps: hydrolysis, acidification, acetogenesis and methanogenesis (Gujer and Zehnder, 1983). Therefore, applying closed structure to anaerobic treatment system would help to reduce organic carbon in supernatant going to existing open lagoons.

In unlined open lagoon, dissolved organic carbon (DOC) in treated wastewater of open lagoon infiltrates through the unsaturated zone under the lagoons and is usually oxidized before it reaches the groundwater table. DOC persistence under unsaturated conditions suggest that moisture content may be a major controlling factor in biodegradation because it makes less oxygen availability in soil. The role of unsaturated condition in reducing the concentration of organic matter by biodegradation, volatilization or sorption are still in debate. In most cases, it was shown that up to $99 \%$ of organic matter is removed, whilst other studies demonstrated that organics are not removed while passing soil column (Abraham et al, 1990). It suggests that there is different observation while wastewater effluent is forced to flow through saturated porous media, and under unsaturated conditions, from topsoil to the water table.

## - Nutrients

When treating wastewater in anaerobic system, it is usually stated that the ratio of COD:N:P in the wastewater to be treated should be approximately 250:5:1 (Maier, 1999; Metcalf and Eddy, 1991; USEPA, 1995b). For anaerobic treatment system or UASB, it lowers nutrient concentration in wastewater by required nitrogen and phosphorous for microbial growth which is lower than the case for aerobic treatment because anaerobic system naturally produces only $20 \%$ sludge compared to sludge production of aerobic system.

Although nitrogen and phosphorus are important elements for agricultural and industrial development, but their excess release at high concentration to public water sources are the main causes of eutrophication. Anaerobic digestion or UASB is capable to reduce nutrients but still yields effluents rich in ammonium and phosphate, thereby making it less suitable for biological nitrogen and phosphorus removal by stand-alone system. In addition to enhance nitrogen and phosphorus removal, this requires changes or coupling technologies with UASB, both changes in wastewater treatment technologies and implementation of new processes. In this contribution, the combination of an ureolytic MAP (magnesium ammonium phosphate) precipitation with UASB, ammonia stripping, and Anammox technology in anoxic condition are described (Othman et al., 2010; Strous et al., 1997).

In operation of unlined open lagoon, dense earthen lining and desiccation crack network underneath the lagoon has ability to augment an oxic zone (vadose zone) for nitrification process which is concerned as nitrate leaching risk to groundwater (Baram, 2012). Both infiltrated anionic forms from unlined open lagoon $\left(\mathrm{NO}_{2}^{-}, \mathrm{NO}_{3}^{-}\right.$ and $\mathrm{H}_{2} \mathrm{PO}_{4}^{-}, \mathrm{HPO}_{4}{ }^{2-}$ ) are not subject to retention by cation exchange reactions. However, phosphate anions are low solubility because of its inorganic compounds and strongly immobilized by binding with chiefly iron, calcium, aluminum and by adsorption to soil particles. However, nitrate anions are very soluble and do not form insoluble compounds with metals or soil particles and therefore readily leach from soil into surface and groundwater (Lew, 2015).

## - Heavy metals

In distillery industry, heavy metals from metal equipment with high pressure and temperature process such as cadmium, chromium, cobalt, copper, nickel, lead, zinc, mercury are associated to potential environmental impacts in "Wastewater monitoring program" in EPA guideline (USEPA, 2004). The presence of heavy metals in wastewater is concerned because of their known toxic effects to human health with acute and chronic exposure. Human may be contaminated by organic and inorganic pollutants associated to aquatic systems by consumption of contaminated fish and other aquatic foods from this environment.

In biological wastewater treatment process, the UASB and lagoon would reduce heavy metals by a reason that heavy metals are mainly bounded to sludge. The study pointed out that extracellular polymeric substances (EPS) actively involve in the biosorption activity of metals by sludge. EPS, which are secreted in part by microorganisms during growth. Therefore, heavy metals can either be trapped or precipitated within EPS but importantly, functional groups of EPS play an essential role on mechanisms based on exchange reactions, complexation with negatively charged groups, adsorption, and precipitation to sink types of heavy metals (Liu and Fang, 2002; Hao et al., 2013).

Regarding mechanisms under lagoon, the research conducted the amounts of metals in the soils from sludge application on confined crop land to study heavy metals seepage. It concluded that heavy metals largely accumulated within top-soil profile for very long-term period and it showed negligible movement downward. Amounts of DTPA-extractable $\mathrm{Cd}, \mathrm{Cu}, \mathrm{Ni}$, and Zn were determined in soil samples of depth 85 cm from the control and the 210 Mg sludge $\mathrm{ha}^{-1}$ treatment to measure downward movement through soil profile. The DTPA-extractable $\mathrm{Cd}, \mathrm{Ni}$, and Zn within the soil profile of various types of soils (e.g. silty loam, clay loam and loamy sand) indicated no downward metal movement 1.5, 1.7, and 1.8 years after sludge application, respectively. Only DTPA-extractable Cu showed a little downward movement only in the silt loam soil (Rappaport et al., 1988).

## - Pathogens

In distilleries, with high temperature process, pathogens are not considered as considerable amount and not mentioned in EPA guideline to monitor wastewater. Regardless of high temperature process, the soil profile under lagoons is functioned as the detention and elimination barrier to pathogen contamination of groundwater because as these pathogenic organisms are subject to naturally occurring attenuation processes which are mainly from filtration process with soil surface clogging, sorption process especially with high clay and/or humus content and biological process by biofilm active layer (or "Schmutzdecke"). Moreover, in aerobic environments of soil, usually aerated by soil fauna which create biologically active ecosystems, pathogens could be removed by grazing, predation and even die-off with long retention time. Also, in most soils the relatively there are helminth parasites and large size of most protozoan and metazoan pathogens to act like predators to other pathogen organisms (Lapworth et al., 2007).

### 5.3 Methodologies

From potentiality of public water contamination, carbon and nitrogen species are major concern to be treated into certain consent levels, and used for project comparison in terms of environmental impacts. Other pollutants originated from the studied factories (i.e., pathogens and heavy metals) are considered as not considerable amounts of public water contamination due to open lagoon operation. Pollutant valuation is separately discussed on comparative costs of point-source pollutant treatment and infiltrated pollutant treatment.

### 5.3.1 Procedure to valuate point-source carbon and nitrogen contamination

As for point-source pollutant valuation, carbon and nitrogen in wastewater is comparatively converted into values with particular hypothetical carbon and nitrogen reducing treatment systems, in order to achieve relative average cost functions of reducing parameters from factory effluent for project comparison. The cost functions for point-source pollutant valuation represent the relationship between the equivalent annual cost (including capital, operational and maintenance expenditures), and
reducing the level COD, ammonium, nitrates and other pollutant loads of these wastewater treatment systems.

### 5.3.1.1 Mass of point-source carbon and nitrogen contamination

Mass of carbon and nitrogen contamination for point-source pollutants valuation is obtained from annual wastewater characteristics of effluent from factories as shown in Table 5.1. The data of Ayutthaya ethanol plant was collected in year 2006-2007 (two years before the methane recovery CDM implemented) and the data of Krabi palm oil plant was collected in year 2012 for comparatively analysis in this study. The data from two sites is used to differentiate pollutant mass and volume for competitive comparison on treatment costs with the same in a base year. Data of wastewater flows, and COD and TKN concentrations are used as elements to represent volume and pollutants to be treated in an individual parameter, i.e., cost per flow and load removed of COD, ammonium, respectively.

Table 5.1 Averaged wastewater characteristics from annual plant data of Ayutthaya and Krabi factories' effluent

| Item | Ayutthaya factory's <br> effluent | Krabi factory's <br> effluent |
| :--- | :---: | :---: |
| COD $(\mathrm{mg} / \mathrm{l})$ | 145,000 | 89,000 |
| TKN $(\mathrm{mg} / \mathrm{l})$ | 120 | 53 |
| Wastewater volume <br> $\left(\mathrm{m}^{3} / \mathrm{d}\right)$ | 323 | 464 |
| Operating day $(\mathrm{d} / \mathrm{y})$ | 268 | 293 |

### 5.3.1.2 Selection of hypothetical wastewater treatment systems

In Table 5.2, it shows a hypothetical model for point-source wastewater differentiable treatment systems by influent COD concentrations. The hypothetical model encompasses coupling of wastewater treatment systems for different ranges of influent COD concentrations, in order to estimate the costs in baseline and project scenarios (before and after CDM implementation). The conventional activated sludge system (CAS) is set up to be capable to treat influent COD concentrations ranging from 120 to maximum 10,000 mg/l (ACRP, 2013; Egloso et al., 2015; Grady, 2011),
and achieve effluent COD concentration of $<120 \mathrm{mg} /$, which is consent level of industrial effluent to public surface water in Thailand (PCD, 2010). The single-stage UASB system is designed to treat COD concentrations in a range of 10,001-33,333 $\mathrm{mg} / \mathrm{l}$, while, the two-stage and three-stage UASB systems are designed for treating COD $\geq 33,334 \mathrm{mg} / 1$ by assumption that efficiency of COD removal for each UASB reactor is $70 \%$ for high strength wastewater operation (COD $>10,000 \mathrm{mg} / \mathrm{l}$ ) (Ghangrekar et al., 2003), which is consistent with assumed efficiency of UASB in UNFCCC methodology (in Chapter 4). The Modified Ludzack-Ettinger (MLE) is required to include in the selected hypothetical treatment system when nitrogen is excess than microbial growth requirement as shown in the equations of Table 5.2, determining by $\mathrm{C}: \mathrm{N}$ ratios, 100:5 (or 1:0.05) for aerobic treatment process or CAS and 250:5 (or 1:0.02) for anaerobic treatment process or UASB (Metcalf and Eddy, 1991; USEPA, 1995b; Henze et al., 1997; Henze and Harremoes, 1983).

Table 5.2 Hypothetical treatment systems for different carbon and nitrogen concentrations

| COD |  | TKN |  | Hypothetical treatment system |
| :---: | :---: | :---: | :---: | :---: |
| Level | Range (mg/l) | Level | Range (mg/l) |  |
| Very high | >111,110 | High | $>(\mathrm{COD} * 0.02)+\left(0.3^{3} \mathrm{COD} * 0.05\right)$ | Three-stage UASB + CAS + MLE |
|  |  | Low | $\leq\left(\mathrm{COD}^{*} 0.02\right)+\left(0.3^{3} \mathrm{COD} * 0.05\right)$ | Three-stage UASB + CAS |
| High | 33,334-111,110 | High | $>(\mathrm{COD} * 0.02)+\left(0.3^{2} \mathrm{COD} * 0.05\right)$ | Two-stage UASB + CAS + MLE |
|  |  | Low | $\leq(\mathrm{COD} * 0.02)+\left(0.3^{2} \mathrm{COD}^{*} 0.05\right)$ | Two-stage UASB + CAS |
| Moderate | 10,001-33,333 | High | $>(\mathrm{COD} * 0.02)+\left(0.3 \mathrm{COD}^{*} 0.05\right)$ | Single-stage UASB + CAS + MLE |
|  |  | Low | $\leq\left(\mathrm{COD}^{*} 0.02\right)+\left(0.3 \mathrm{COD}^{*} 0.05\right)$ | Single-stage UASB + CAS |
| Low | 120-10,000 | High | $>\left(0.3 \mathrm{COD}^{*} 0.05\right)$ | CAS + MLE |
|  |  | Low | $\leq\left(0.3 \mathrm{COD}^{*} 0.05\right)$ | CAS |
| None | $<120$ | High | >100 | MLE |
|  |  | Low | $\leq 100$ | Treatment system is not required |

[^1]In Table 5.2, the following hypothetical treatment systems are differentiable by influent COD and TKN concentrations. The levels of influent concentrations express in "None" to "Very high" for COD, and "Low" and "High" for TKN, coverage in any carbon and nitrogen_concentration ranges for baseline and project scenarios. The level "high" for influent TKN determines the requirement of the MLE retrofit. In case of nitrogen deficiency, a cost of nutrient supplement is not considered as a benefit value from the CDM project.

As for UASB systems, the single-stage UASB reactor is designed by volumetric COD loading of 16 kg COD $/ \mathrm{m}^{3}$ for treating influent COD to achieve $70 \%$ COD removal efficiency with HRT in a range of $5 \mathrm{~h}-15.25 \mathrm{~d}$ (Ghangrekar et al., 2003; Matsuo et al., 2001). The conceptual two-stage UASB system consists of two identical single-stage UASB reactors in series as shown in Figure 5.4. The effluent from the first UASB is conducted to the second UASB by gravity through a pipe connecting the reactors. The first UASB is for partial hydrolysis, conversion of soluble compounds, and retention of particulate organic matter. The second UASB is for completely conversion of soluble compounds and ones formed in the first UASB. With well operating conditions, COD removal efficiency is assumed to be $70 \%$ for the single-stage UASB system and totally $91 \%$ for the two-stage UASB system by doubling hydraulic retention time with constant influent concentration. Regardless increased removal efficiency by phase separation of acidogenesis and methanogenesis from the twostage UASB, lowering COD removal efficiency is determined in order to simplify a design of the system with same volumetric loading rate and conserve system efficiency with uncertain phase separation from different influent characteristics. In addition, three-stage UASB and recirculation of system effluent to the first UASB and alkali adjustment are possibly applied for increasing organic loading rate in case of very high COD concentration ( $>111,110 \mathrm{mg} / \mathrm{l}$ ) or decreasing hydraulic retention time in semi-continuous process. Construction cost of the UASB system is decided by designed reactor size. It assumes that two-stage and three-stage UASB cost twice and triple as single-stage UASB (connecting pipe between reactors is neglected to not be considerable amount). Operation and maintenance (O\&M) costs are assumed to be $3.5 \%$ of capital cost for anaerobic treatment process since only pumping cost is incurred in anaerobic treatment process (Campbell, et al., 1997; Moser and Mattocks, 2000; USEPA, 1997).


Figure 5.4 Conceptual schematic of single-stage UASB system and two-stage UASB system

### 5.3.1.3 Valuation of point-source carbon and nitrogen

In case of high-strength wastewater operation (COD $>10,000 \mathrm{mg} / \mathrm{l}$ ) with TKN level "high", valuation of carbon and nitrogen pollutants is determined by comparative costs of UASB system followed by a CAS system retrofitted with the MLE system as a post treatment in order to reduce both carbon and nitrogen concentration to nonpolluting level. In Figure 5.5, firstly, wastewater characteristics of the studied factories are used to differentiate designed reactor sizes of UASB with constant volumetric COD loading and relatively compare to the annual combined costs between sites. Effluent COD from the UASB system is assumed to reach achievable effluent COD concentration of $\leq 10,000 \mathrm{mg} / 1$ with an acceptable hydraulic retention times. The construction cost for the UASB system is annualized for achievable COD before treating by aerobic treatment. Then, the annual combined cost of CAS retrofitted with the MLE to treat COD of $120-10,000 \mathrm{mg} / \mathrm{l}$ and excess TKN than microbial need (in Table 5.2) is added up with an UASB cost to be the total costs for carbon and nitrogen treatment. The UASB system has been chosen for anaerobic digestion to treat industrial wastewater including distillery stillage with high dissolved organic concentration because its high treatment capacity compared with other systems (España-Gamboa et al., 2011). It is operated with a wide range of retention time from 5 h to 15.25 d (Matsuo et al., 2001) and reached optimal organic loading rate up to $19 \mathrm{~kg} \mathrm{COD} / \mathrm{m}^{3} \mathrm{~d}$ with a retention time of 7.5 d (España-Gamboa et al., 2012).


* Cost functions of AS/MLE treatment process depend on flow, with achievable COD $\leq 10,000 \mathrm{mg} / 1$ from the UASB system and excess TKN than microbial need (in Table 5.2) from the UASB and CAS systems

Figure 5.5 Schematic diagram for valuating carbon and nitrogen contamination from factory wastewater

In this study, the cost is determined by a designed reactor size, related to organic loading from factories. A_volumetric organic loading rate of 16 kg COD $/ \mathrm{m}^{3} \mathrm{~d}$ to treat sugar industrial wastewater between $27-39^{\circ} \mathrm{C}$ (Hampannavar and Shivayogimath, 2010) and average COD removal efficiency of $70 \%$ is selected as design criteria for high COD concentration of $>10,000 \mathrm{mg} / 1$ (Ghangrekar et al., 2003). In the case studied sites, designed working volumes of UASB are $2,927 \mathrm{~m}^{3}$ with retention time of 9.1 d for Ayutthaya site and $2,581 \mathrm{~m}^{3}$ with retention time of 5.6 d for Krabi site to reduce influent COD to $\leq 10,000 \mathrm{mg} / \mathrm{l}$. Vieira and Souza (1986) reported that the UASB costs involved in installing a system, labor fee and materials was about 647 USD $/ \mathrm{m}^{3}$ reactor (2012 value, adjusted with fixed inflation rate $3 \%$ per year from 300 $\mathrm{USD} / \mathrm{m}^{3}$ in 1986). The O\&M costs are assumed to be $3.5 \%$ of capital cost for anaerobic treatment process since only pumping cost is incurred. The annual combined cost is calculated from annualized construction cost within 30-year lifetime operation with no salvage value, and combined with annual O\&M costs.

As for aerobic treatment, the construction cost of CAS is a fixed cost with design capacity in flow rate. Construction cost is adjusted to annual capital cost from the relationship of economic scale with design flow in Figure 5.6, as given data in Table
5.3 for treating wastewater of 420 and $603 \mathrm{~m}^{3} / \mathrm{d}$ ( $30 \%$ increased from actual flow) for Ayutthaya site and Krabi site, respectively, within 30-years lifetime operation and no salvage value. The annual O\&M costs is decided by actual unit of flow ( $\mathrm{m}^{3} / \mathrm{d}$ ), in which small flow data show the higher O\&M costs per $\mathrm{m}^{3}$ as shown in Figure 5.7. In terms of widen applicability of valuation method for high-strength industrial wastewater, the UASB system is applied to cope with high COD influent to be treated for CAS receiving influent COD concentration of $\leq 10,000 \mathrm{mg} / 1$ to the consent of $<120 \mathrm{mg} / \mathrm{l}$ for public water release.

Table 5.3 Estimated construction, operation and maintenance cost of conventional activated sludge on flow

|  | 2012 financial cost (Mil.USD)* |  |  |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 38 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 379 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 1,895 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 3,785 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 9,460 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 18,925 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 37,854 <br> $\mathrm{~m}^{3} / \mathrm{d}$ |
|  | 0.142 | 0.682 | $\mathrm{~N} / \mathrm{A}$ | 3.276 | $\mathrm{~N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ | 16.380 |
| Operation and <br> maintenance costs <br> (annual costs) | N/A | 0.048 | 0.127 | 0.192 | 0.335 | 0.510 | N/A |

Source: Modified from Wang et al. (2009)
Remark: * Financial cost is updated from 2008 USD to 2012 USD with fixed inflation rate of $3 \%$ per year
** Included all relevant costs, except sludge treatment cost


Figure 5.6 Relationship between construction cost and design flow rate ( $\mathrm{m}^{3} / \mathrm{d}$ ) by using conventional activated sludge treatment system


Figure 5.7 Relationship between annualized operation and maintenance costs and operational flow rate ( $\mathrm{m}^{3} / \mathrm{d}$ ) by using conventional activated sludge treatment system

The treatment process configuration of the MLE retrofit, able to cope with TKN concentration which exceed than microbial need after the UASB and CAS systems, is determined by cost effectiveness to achieve designed TKN limit of $<100 \mathrm{mg} / \mathrm{l}$ for public water release from industrial purpose in Thailand (PCD, 2012). Foess et al. (1998) summarized average biological nutrient removal (BNR) costs for small systems including construction and O\&M costs in US. In purpose of TN removal, the Modified Ludzack-Ettinger (MLE) process is feasible in terms of the most costeffective configuration among others to reduce TN to achievable effluent of $10 \mathrm{mg} / \mathrm{l}$. Moreover, the MLE process can be retrofitted to conventional activated sludge system by adding an anoxic basin upstream of the existing influent point and adding recirculation pumping from the existing aeration basin to the new anoxic basin.

The valuation of nitrogen pollutants is comparable to annual combined cost of a retrofit opportunity of the MLE configuration to represent practical way for nitrogen removal rather than installing a new plant. Cost information from Maryland Department of the Environment and Connecticut Department of Environmental Protection for 29 MLE facilities is used for plotting the cost functions between average cost of anoxic tank basin and recirculation pump, and wastewater flow with economies of scale (the cost per flow generally decrease as the size of the plant increases) as shown in Table 5.4. In Figure 5.8, an annual capital cost is calculated from the averaged construction cost with design flow rate of 420 and $603 \mathrm{~m}^{3} / \mathrm{d}$ for Ayutthaya site and Krabi site, respectively and divided by 30-year life time operation
and no salvage value as the same basis as the comparative cost of conventional activated sludge. An annual O\&M cost is directly calculated from actual flow rate from the studied factories without applying dilution factor due to TN concentration of influent acceptable for the MLE treatment process.

Table 5.4 Averaged construction, operation and maintenance cost of the Modified Ludzack-Ettinger (MLE) retrofit on flow

| Averaged cost/flow | 2012 financial cost (USD)* |  |  |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  | 15.14 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 37.85 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 94.63 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 189.25 <br> $\mathrm{~m}^{3} / \mathrm{d}$ | 378.50 <br> $\mathrm{~m}^{3} / \mathrm{d}$ |
|  | 33,506 | 38,292 | 62,225 | 90,945 | 95,520 |
| Operation and maintenance <br> costs (annual cost) | 17,709 | 18,441 | 19,611 | 27,368 | 25,193 |

Source: Modified from Foess, et al. (1998).
Remarks: * Financial cost is updated from 2006 USD to 2012 USD with fixed inflation rate of $3 \%$ per year
**The construction costs include only an additional anoxic tank and circulating pumps, O\&M costs include labor, electricity, maintenance and repair materials, solids handling and disposal, administration labor, laboratory analytical requirements, and chemical costs for retrofit to reduce TN to $10 \mathrm{mg} / 1$


Figure 5.8 Relationship between averaged construction and O\&M costs, and flow rate $\left(\mathrm{m}^{3} / \mathrm{d}\right)$ for small system: Retrofit

### 5.3.2 Procedure to valuate infiltrated carbon and nitrogen

As for infiltrated pollutants valuation, Figure 5.9 shows the procedure to valuate carbon and nitrogen substances potentially contaminating into shallow groundwater. In the first step, open lagoons are checked for oxygen depletion and acidic condition to estimate nitrate-nitrogen and ammonia-nitrogen formation and then calculate remaining carbon and ammonium-nitrogen in the lagoons. The next step is to estimate the depth of lagoons bottom to groundwater table in order to estimate infiltration rate under lagoons by the Green-Ampt method. Either measuring depths from monitoring wells around the lagoons in case they are presence in 20-meter proximity of lagoons, or estimating the groundwater depth from the "Trifills" method by using hydraulic conditions of three groundwater wells around the lagoons for drawing the groundwater contour lines can be applied. Then, using the infiltration rate by the Green-Ampt approximation method to estimate the mass of carbon and nitrogen infiltration under lagoons.

Oxygen availability in soil under the lagoons is checked to compare with baseline oxygen contents in order to monitor in order whether oxygen amount is sufficient for carbon degradation and nitrification in upper shallow sediment under the lagoons. In the case of insufficient oxygen in soil, air supply budget is added in valuation process. Finally, nitrate formation in unsaturation zone is calculated by assuming all ammonium species are nitrified in shallow sediment of lagoons. The sum of costs from additional air supply and nitrate treatment is considered as total value of environmental impact from open lagoon operation.


Figure 5.9 Schematic diagram for valuating infiltrated carbon and nitrogen from open lagoon operation

### 5.3.2.1 Mass of infiltrated carbon and nitrogen contamination

In comparison basis between two studied sites, valuation is separately discussed on different sources of pollutants. In Figure 5.11, as for point-source valuation, mass of carbon and nitrogen originated from factory and discharging to the open lagoon ( $\mathrm{TC}_{\text {lagoon }}$ and $\mathrm{TN}_{\text {lagoon }}$ ) are comparatively valuated from wastewater treatment works. As for groundwater nitrate valuation, mass of nitrate $\left(\mathrm{TN}_{\text {groundwater }}\right)$ is comparatively valuated from water treatment works by assumptions on estimating infiltrated carbon and nitrogen as follows; infiltration volume is calculated as year-based at steady state of groundwater infiltration; there is uniform and complete mixing of wastewater in lagoon toward groundwater; all carbon and ammonium-nitrogen leaving the bottom of lagoon is completely oxidized to nitrate and reach groundwater; nitrate in groundwater does not consider dispersion and adsorption; dilution and denitrification are assumed to be absent.

In Figure 5.10, water infiltration to soil typically is not steady state. Water content will all change with soil depth. The basic assumption behind the Green-ampt equation is that water infiltrates into (relatively) dry soil as a sharp wetting front. The variation in
moisture content with depth below the soil surface, at a point in time when the front has progressed a distance L (wetting front depth). The passage of this front causes the moisture content to increase from an initial value to a saturated value. At position of the wetting front, saturated hydraulic conductivity and average suction head which are used to represent overall unsaturated condition under the lagoon.


Figure 5.10 Schematic of pollutants contamination from open lagoon operation with the Green-Ampt approximation of infiltration rate under lagoon

Mass of infiltrated carbon and nitrogen under the lagoons is estimated from remaining carbon and nitrogen after degradation process in the lagoons by assuming that there is $50 \%$ BOD removal efficiency in each pond of lagoon series, and no ammonium removal by assuming there is no nitrification process in the lagoons by no free oxygen condition. As for the studied sites, wastewater effluent from factories is treated in series of lagoons without directly discharge treated wastewater out of the system, and after a long retention time, the treated wastewater flow into evaporation ponds. Only the pollutants in lagoons are considered as seepage by assumption that there is uniform and complete mixing of wastewater in lagoon toward groundwater, and there is no seepage from evaporation ponds. Mass of infiltrated carbon and nitrogen is estimated on a yearly basis from the equations as follows;

## Estimation of infiltrated carbon and nitrogen from open lagoon

Mass of infiltrated carbon $\left(T C_{\text {groundwater }}\right)=\sum_{i}^{n}\left[f \cdot A_{i} \cdot\left(0.5^{i} \cdot B O D_{\text {inf }}\right)\right]$

Mass of infiltrated nitrogen $\left(T N_{\text {groundwater }}\right)=\sum_{i}^{n}\left[f \cdot A_{i} \cdot T K N_{\text {inf }}\right]$

Where: $T C_{\text {groundwater }}=$ total infiltrated $\operatorname{BOD}(\mathrm{kg} / \mathrm{y}), T N_{\text {groundwater }}=$ total infiltrated TKN $(\mathrm{kg} / \mathrm{y}), f=$ averaged infiltration velocity under lagoon ( $\mathrm{m} / \mathrm{y}$ ), $A_{i}=$ area of pond $i$ in the lagoon series $\left(\mathrm{m}^{2}\right), B O D_{i n f}=\mathrm{BOD}$ concentration of factory effluent $\left(\mathrm{kg} / \mathrm{m}^{3}\right), T K N_{\text {inf }}=$ $T K N$ concentration of factory effluent $\left(\mathrm{kg} / \mathrm{m}^{3}\right), i=$ order number of pond, $n=$ total numbers of ponds

## Estimation of infiltration rate under lagoon

The Green-Ampt Approximation

$$
f(t)=K_{s a t}\left[\frac{L+h_{w f}}{L}\right]
$$

Where $f(t)=$ the infiltration rate at time $t(\mathrm{~L} / \mathrm{t}), K_{\text {sat }}=$ saturated hydraulic conductivity (L/t), $L=$ depth of the wetting front below the bottom of the pond, approximate to depth of groundwater table from the bottom of ponds when infiltrated water reach steady state (depth of pond $=\mathrm{H}_{0}$ ), and $h_{w f}=$ average suction head at the wetting front $(L)$, approximately equal to the air entry pressure or bubbling pressure ( $K_{\text {sat }}$ and $h_{w f}$ obtained from literatures for earthen-lining waste lagoon and type of soil).

In order to estimate mass of carbon and nitrogen contamination into groundwater, upper shallow sediment (oxic unsaturated zone) is considered as an important organic mineralization pathway to dominate in different conditions of saturated zone (assuming that organic matter and nitrogen species below unsaturated zone have a potentiality to contaminate water resources). Availability and vertical distribution of oxygen and organic carbon load mainly determine the thickness of the oxic zone, which vary from less than 1 millimeter to a few centimeter in the upper sediment. Amount of organic matter input can result in the progressive depletion of oxygen as consumption rates exceed water diffusion rate in soil profile. This can ultimately affect oxygen concentration in near-bottom waters. A subsequently oxygen content has numerous feedbacks to biogeochemistry of sediments, which could lead
eutrophication by nitrate release.

In countries where is no scarcity of lands, a cost-effective practice to treat high strength wastewater is to treat by open lagoons without secondary treatment and without discharge the treated out of the lagoons. It usually requires more land to storage increasing wastewater than volatilization and infiltration rate. Therefore, hypothetical treatment processes are solely applied into pollutants discharging into open lagoons, differently assessed for treatment cost of point-source pollutants and infiltrated pollutants into shallow groundwater, which give difference in mass of pollutants, and cost functions of reducing the level carbon and nitrogen. In order to compare environmental impacts between studied sites, costs to treat carbon and nitrogen into certain consent levels of public water release are used as comparison basis.

### 5.3.2.2 Valuation of nitrate contamination in infiltrated wastewater

Baseline oxygen contents of upper sediment in the studied sites are estimated by using a sediment oxygen uptake (TOU) for eutrophic freshwater system because wastewater storage lagoons or open lagoons are usually located near public water sources (e.g. river, canal). Zilius M. (2011) studied oxygen exchange at the sediment-water interface in the eutrophic lagoon (Baltic sea). Sediment aerobic mineralization in coastal and estuarine sediments are comparable to eutrophic freshwater system such as lakes and streams (Jensen et al., 1993; Stief and De Beer, 2006). Measured total sediment oxygen uptake (TOU) for eutrophic freshwater area varied between measuring points and sampling periods, with a minimum of $6.48 \mathrm{mmol} \mathrm{m}^{-2} \mathrm{~d}^{-1}$, and a maximum of $51.36 \mathrm{mmol} \mathrm{m}^{-2} \mathrm{~d}^{-1}$. Sediment level of collected cores was adjusted to 20 cm were measured in situ at each station and on every sampling occasionally by means of an YSI 460 multiple probe.

Oxygen supply for biological wastewater treatment is used as comparative amount for oxygen requirement in sediment in this study. Basically, the active sludge require oxygen for the reaction of cell synthesis together with taking soluble carbon (BOD) out of solution. It requires about 0.5 to $0.6 \mathrm{~kg} \mathrm{O}_{2} / \mathrm{kg}$ BOD for this carbon conversion process. In case of oxidizing the cell or stabilizing the cell, oxygen is needed for
continuous supply to the system, in which requires additional 0.8 to $0.9 \mathrm{~kg} \mathrm{O}_{2} / \mathrm{kg}$ BOD for endogenous respiration. Therefore, total oxygen requirement for carbonaceous phase in biological treatment system can be in a range of $0.7 \mathrm{~kg} \mathrm{O}_{2} / \mathrm{kg}$ BOD for high rate operation with low sludge age, and possibly to $1.5 \mathrm{~kg} \mathrm{O}_{2} / \mathrm{kg}$ BOD for extended aeration with long sludge retention time because as for nitrification process, additional oxygen demand must be added for extended aeration at temperatures above $5-10^{\circ} \mathrm{C}$ (Environmental Dynamic International, 2005). In lagoon sediment condition, oxygen availability in vadose zone is assumed to be sufficient for organic matter biodegradation and nitrification process from the basis of project comparison. Therefore, when considering infiltrated organic carbon and nitrogen in valuation of infiltrated liquid waste, if oxygen requirement is insufficient to referred oxygen level in sediment, the price of compensated oxygen is used to add up into the cost of environmental impacts.

By assumption that ammonium is all nitrified through sharp oxic condition in upper sediment under lagoons, cost to treat nitrate is comparatively estimated from ion exchange process. In Figure 5.11, a linear relationship of treatment cost and increased level of nitrate mass in source water by using conventional ion exchange is made to achieve relative cost to remove nitrate in shallow groundwater under the lagoons.


Figure 5.11 Relationship between average annualized combined cost and nitrate removal by using conventional ion exchange

Available data were specifically applicable to estimation of construction cost and O\&M costs increase as the nitrate concentration increase from $\sim 1 \mathrm{X}$ the nitrate
maximum concentration level (MCL), $45 \mathrm{mg} / \mathrm{l}$, to 2 X the MCL. To extrapolate the exercise further, the same percent increase was used to predict the O\&M increase from 2X the MCL to 3X the MCL (refer in Appendix V). The cost function to treat nitrate is determined as $3.48 \mathrm{USD} / \mathrm{kg}$ nitrate (Honeycutt et al., 2012).

### 5.4 Results and discussion

The results of environmental impacts for the co-benefits indicator are separately discussed between point-source pollutants and infiltrated pollutants. The point-source pollutants are valuated from different wastewater characteristics of factories' effluent without consideration of lagoon site conditions. The infiltrated pollutants are valuated from remaining pollutants after degradation process in open lagoons and upper sediment attenuation.

### 5.4.1 Valuation of point-source pollutants

In order to estimate cost for treating pollutant contamination in terms of point-source valuation, the cost of environmental alleviation by CDM project is estimated from difference on the costs of environmental impact between baseline scenario (before CDM implementation) and project scenario (after CDM implementation). Table 5.5 shows hypothetical treatment systems differentiable by influent COD and TKN concentrations in baseline and project scenarios for the studied sites. In baseline scenario, three-stage and two-stage UASB system coupling with CAS are applied to COD concentration range "very high" and "high" for Ayutthaya and Krabi sites, respectively and the MLE is not required for nitrogen removal since nitrogen containing in wastewater is insufficient and used up as a source of anaerobic microbial growth. In project scenario, by implementing UASB from CDM project, it assumes that a UASB system from the methane recovery CDM is theoretically identical with single-stage UASB system in the hypothetical model with the same design and efficiency. Therefore, expected influent COD concentration after the UASB from CDM become the level "high" and "moderate" in Table 5.2, then the hypothetical two-stage and single-stage UASB system coupling with CAS is applied for Ayutthaya and Krabi sites, respectively to treat such a COD level to non-polluting concentration.

Table 5.5 Case studies' wastewater characteristics and hypothetical treatment systems for baseline and project scenarios

| Project <br> site | Baseline scenario |  | Project scenario |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  | COD and TKN <br> concentration <br> (mg/l) | Hypothetical <br> treatment system | COD and TKN <br> concentration <br> (mg/l) | Hypothetical <br> treatment system |  |
| COD concentration |  |  |  |  |  |
| Ayutthaya <br> site | 145,000 | Three-stage UASB <br> + CAS | $33,334-111,110$ | Two-stage UASB + <br> CAS |  |
| Krabi site | 89,000 | Two-stage UASB <br> + CAS | $10,001-33,333$ | Single-stage UASB <br> + CAS |  |
| TKN concentration | Not required | 0 | Not required |  |  |
| Ayutthaya <br> site | 120 | Not required | 0 | Not required |  |
| Krabi site | 53 |  |  |  |  |

Remarks: UASB = Upflow anaerobic sludge blanket, CAS = Conventional activated sludge Additional TN requirement for microbial growth $=3,553 \mathrm{mg} / 1$ (for Ayutthaya site), $2,181 \mathrm{mg} / 1$ (for Krabi)

The schematics of treatment systems for baseline and project scenarios are illustrated as shown in Figure 5.12 and 5.13 for Ayutthaya site and Krabi site, respectively. In project scenario, the UASB system from the methane recovery CDM is not priced in terms of local environmental impacts because it concerns as foreign investment in an exchange for carbon credits to Annex I country.

(a) hypothetical treatment system for Ayutthaya site

(b) hypothetical treatment system for Krabi site

Figure 5.12 Schematic of hypothetical treatment system in baseline scenario (a) threestage upflow anaerobic sludge blanket (UASB) followed by activated sludge treatment system (CAS) for Ayutthaya site (b) two-stage UASB followed by AS for Krabi site

(a) hypothetical treatment system for Ayutthaya site

(b) hypothetical treatment system for Krabi site

Figure 5.13 Schematic of hypothetical treatment system in project scenario (a) twostage upflow anaerobic sludge blanket (UASB) followed by activated sludge treatment system (CAS) for Ayutthaya site (b) single-stage UASB followed by AS for Krabi site

For both scenarios, the CAS system is designed for treating influent COD concentration of $\leq 10,000 \mathrm{mg} / \mathrm{l}$, with changing annual combined cost with economic of scale by flow rate, to achieve effluent COD concentration of $<120 \mathrm{mg} / \mathrm{l}$. In Table 5.6, before treating in the CAS, the UASB is applied to reduce COD concentration of high strength wastewater to acceptable concentration for the CAS. Annual combined costs of the UASB with a fixed cost per reactor volume, $647 \mathrm{USD} / \mathrm{m}^{3}$ (2012 values of $75,134 \mathrm{USD} / \mathrm{y}$ and $66,250 \mathrm{USD} / \mathrm{y}$ per an unit of the UASB for Ayutthaya site and Krabi site, respectively) are obtained from the cost function of designed reactor size to construction and O\&M costs, annualized with 30-year life time of civil works. The annual combined cost of the CAS mainly depends on flows. The design and actual flows of Ayutthaya and Krabi sites applied to the cost functions of the CAS in order to separately estimate annualized construction and O\&M costs (2012 values of 116,503 USD/y and 122,405 USD/y for total costs of CAS in Ayutthaya site and Krabi site, respectively). Costs for nitrogen supplement and sludge treatment are considered to be equal in baseline and project scenarios for each site, and taken with responsibility by factory owner, which is not included in the CDM benefit value.

From the results of cost estimation for environmental alleviation from the methane recovery CDM in Table 5.7, by assuming that the UASB system from the CDM is identical with the hypothetical single-stage UASB, Ayutthaya site is valued higher than Krabi site. The total costs to treat pollutants of Ayutthaya site ( 341,905 and $266,771 \mathrm{USD} / \mathrm{y}$ for baseline and project scenarios, respectively) is higher than the costs of Krabi site ( 254,905 and 188,655 USD/y for baseline and project scenarios,
respectively).

Table 5.6 Comparison of point-source pollutant treatment costs between Ayutthaya and Krabi sites in baseline and project scenarios

| Wastewater treatment system | Cost in 2012 (USD/y)* |  | Cost function** | Reference/ Justification |
| :---: | :---: | :---: | :---: | :---: |
|  | Ayutthaya site | Krabi site |  |  |
| Baseline scenario |  |  |  |  |
| UASB*** <br> - Annual combined costs | $\begin{array}{r} \mathbf{2 2 5 , 4 0 2} \\ \text { (3-stage UASB) } \end{array}$ | $\begin{array}{r} \mathbf{1 3 2 , 5 0 0} \\ \text { (2-stage UASB) } \end{array}$ | $669.65 x$ (for single-stage UASB) | Vieira and Souza (1986) |
| CAS <br> - Annual construction cost <br> - Annual O\&M costs <br> - Annual combined costs |  |  | $\begin{array}{r} 415.22 \mathrm{Q}_{\mathrm{d}}+754398 \\ 23.89 \mathrm{Q}_{\mathrm{a}}+77827 \end{array}$ | Wang, et al. (2009) |
| MLE (retrofitted to AS) <br> - Annual construction cost <br> - Annual O\&M costs <br> - Annual combined costs | - | - | $\begin{array}{r} 175.82 \mathrm{Q}_{\mathrm{d}}+38942 \\ 23.34 \mathrm{Q}_{\mathrm{a}}+18325 \end{array}$ | Foess, et al. (1998) |
| Cost summary | 341,905 | 254,905 |  |  |
| Project scenario |  |  |  |  |
| UASB*** <br> - Annual combined costs | $\begin{array}{r} \mathbf{1 5 0 , 2 6 8} \\ \text { (2-stage UASB) } \end{array}$ | $\begin{array}{r} \mathbf{6 6 , 2 5 0} \\ \text { (single-stage UASB) } \end{array}$ | $669.65 x$ (for single-stage UASB) | Vieira and Souza (1986) |
| CAS <br> - Annual construction cost <br> - Annual O\&M costs <br> - Annual combined costs |  |  | $\begin{array}{r} 415.22 \mathrm{Q}_{\mathrm{d}}+754398 \\ 23.89 \mathrm{Q}_{\mathrm{a}}+77827 \end{array}$ | Wang, et al. (2009) |
| MLE (retrofitted to AS) <br> - Annual construction cost <br> - Annual O\&M costs <br> - Annual combined costs | - | - | $\begin{array}{r} 175.82 \mathrm{Q}_{\mathrm{d}}+38942 \\ 23.34 \mathrm{Q}_{\mathrm{a}}+18325 \end{array}$ | Foess, et al. (1998) |
| Cost summary | 266,771 | 188,655 |  |  |

Remarks:

* Value calculation based on present value in 2012 USD (with fixed inflation rate of 3\% per year)
** Annual combined costs of UASB are calculated from designed reactor size ( $x$ ) with safety factor, $15 \%$ of working volume, and O\&M costs (assumed $3.5 \%$ of construction cost) in 30-year lifetime, annual combined costs of AS and MLE are calculated from design flow $\left(\mathrm{Q}_{\mathrm{d}}\right)$ for construction cost with 30-year lifetime, and actual flow $\left(Q_{a}\right)$ for $O \& M$ costs, $x=3,366 \mathrm{~m}^{3}, \mathrm{Q}_{\mathrm{d}}=420 \mathrm{~m}^{3} / \mathrm{d}, \mathrm{Q}_{\mathrm{a}}=323 \mathrm{~m}^{3} / \mathrm{d}$ (for Ayutthaya site), and $x=2,968 \mathrm{~m}^{3}, \mathrm{Q}_{\mathrm{d}}=603 \mathrm{~m}^{3} / \mathrm{d}, \mathrm{Q}_{\mathrm{a}}=464 \mathrm{~m}^{3} / \mathrm{d}$ (for Krabi site)
*** Total costs of two-stage and three-stage UASB are assumed to be double and triple as single-stage UASB, respectively. Designed working volume of single-stage UASB digesters are $2,927 \mathrm{~m}^{3}$ with retention time of 9.1 d for Ayutthaya site, $2,581 \mathrm{~m}^{3}$ with retention time of 5.6 d for Krabi site

Whilst, the treatment cost of the CAS in Table 5.6 for Krabi site, 122,405 USD/y, is higher than Ayutthaya site, 116,503 USD/y because of higher influent flow. Nevertheless, the unit cost of UASB treatment system ( 75,134 USD/y for Ayutthaya site and 66,250 USD/y for Krabi site) is the determining factor to differentiate the costs of environmental impact and define environmental alleviation between sites from the methane recovery CDM because the UASB operation of constant volumetric COD loading for Ayutthaya and Krabi sites, Ayutthaya site operating higher COD loading rate requires a larger size of UASB unit, from which anaerobic-aerobic treatment is the practical way to treat high concentrated wastewater in terms of cost effectiveness and energy recovery. Nevertheless, in practical way, these costs of UASB could be decreased and differentiated with a concern of energy recovery compensations, i.e., Feed-in tariff scheme and carbon credit.

Table 5.7 The valuation of environmental alleviation from methane recovery CDM project for Ayutthaya and Krabi sites

| Project site | Environmental impact <br> in baseline scenario, <br> $\boldsymbol{B E} \boldsymbol{E}_{\boldsymbol{y}}$ (USD) | Environmental impact <br> in project scenario, <br> $\boldsymbol{P E} \boldsymbol{E}_{\boldsymbol{y}}$ (USD) | Environmental <br> alleviation, <br> $\boldsymbol{E R _ { \boldsymbol { y } }}$ (USD) |
| :--- | ---: | ---: | ---: |
| Ayutthaya | 341,905 | 266,771 | 75,134 |
| Krabi | 254,905 | 188,655 | 66,250 |

Remarks: assuming UASB investment from CDM project is identical same as the one of UASB in hypothetical UASB treatment system and costs of sludge treatment from the hypothetical system are assumed to be the same in baseline and project scenarios for each site $E R_{y}=B E_{y}-P E_{y}$
$B E_{y}=$ Annual combined costs of hypothetical treatment system in baseline scenario
$P E_{y}=$ Annual combined costs of hypothetical treatment system in project scenario

### 5.4.2 Valuation of infiltrated pollutants

As for valuation of infiltrated pollutants in unsaturated zone, with the information of contaminated pollutants in shallow groundwater, oxygen consumption in lagoon sediment, mass of infiltrated carbon and nitrogen calculation, and treatment cost to treat nitrate from each studied site, the activities and processes of analysis for each studied site are presented step-by-step.

### 5.4.2.1 Estimation of the wetting front depth

In Figure 5.14, at steady state of groundwater infiltration under lagoons, it is assumed that the condition of wetting zone approach more saturated condition $\left(\theta_{s}\right)$ and get close to groundwater table, then the depth to groundwater table is approximate to the depth of wetting front $(L)$ in the Green-Ampt equation. Mass of nitrate passing to unsaturated condition under lagoon is considered to have a potentiality to contaminate groundwater.


Figure 5.14 Infiltration condition of wetting zone in a range of depth $L$ at steady state of open lagoon operation

### 5.4.2.2 Estimation of depth to groundwater table

The Groundwater Contour Applet (TriFills) performs linear and non-linear twodimensional interpolation on triangles. This enables a way to rendering or drawing groundwater contour maps using measured groundwater level at various observation tubes (piezometers) or groundwater wells. The estimated contour lines can then be used to derive groundwater depth of any position in a triangle shape. The depths of groundwater table in studied sites are estimated by using three groundwater wells in vicinity of the lagoons. The hydraulic heads of three groundwater wells and distance between wells are used to estimate the groundwater contour as shown in Figure 5.15 for Ayutthaya site and Figure 5.16 for Krabi site. The equipotential lines in the figures represent the groundwater contour lines which trace lines of equal groundwater attitude. The drawing red-colored lines represent the widest part of lagoons with different depth L estimates.


Figure 5.15 "Trifills" performance to estimate groundwater contours in Ayutthaya site


Figure 5.16 "Trifills" performance to estimate groundwater contours in Krabi site

Estimation of depth from the bottom of lagoons to groundwater table is estimated by cross-sectional attitude profile in Figure 5.17 for Ayutthaya and Figure 5.18 for Krabi. The red-colored lines represent the widest part of lagoons with different groundwater table altitude from equipotential lines, which refer to mean sea level altitude of 0 meter. The length in between pond bottom altitude and groundwater table altitude is estimated to depth L. Average depth L for Ayutthaya site is 12.18 m and average depth L for Krabi site is 43 m (refer in Appendix VI).


Figure 5.17 Altitude profile to estimate wetting front depth in the Green-Ampt equation for Ayutthaya site


Figure 5.18 Altitude profile to estimate wetting front depth in the Green-Ampt equation for Krabi site

### 5.4.2.3 Infiltration rate to soil sediment under the lagoons

The infiltration rate under lagoon from the Green-Ampt approximation depends on saturated hydraulic condition, average capillary suction head, and wetting front depth. As for hydraulic condition under the lagoon, infiltration rate is highly dependent on seal hydraulic conductivity and minimally dependent on sediment hydraulic
conductivity. Cihan et al. (2006) developed a model for describing the sealing process in dairy and swine waste lagoons with time. After a stable seal formation develops, the model predicts that the seal properties, and not the sediment properties, are responsible for limiting infiltration. It was recommended that the saturated hydraulic conductivity coefficient $\left(K_{s a t}\right)$ of the earthen lining would be less than a prescribed level, $10^{-6} \mathrm{~cm} / \mathrm{s}$, as indicated in Table 5.8 ( $K$ U.S. states) (SCS, 1997). Hence, during the construction of the waste lagoon, clay is typically mixed with local sediment and compacted to form an earth liner along its bottom and banks. Following the introduction of wastewater into the lagoon, the hydraulic conductivity of the earth lining will most likely be reduced by at least an order of magnitude due to physical, chemical, and biological processes, commonly termed seal formation (Cihan et al., 2006; SCS, 1997; Sher et al., 2012, Tyner et al., 2004).

Table 5.8 Infiltration rate and infiltration volume of Ayutthaya and Krabi sites from the Green-Ampt approximation

| Parameters | Ayutthaya <br> site | Krabi <br> site | Justification/Reference |
| :--- | ---: | ---: | :--- |
| Average depth L, $L(\mathrm{~m})$ | 12.18 | 43.0 | Estimation value from site <br> specification |
| Area of open lagoons, $A\left(\mathrm{~m}^{2}\right)$ | 30,841 | 42,337 | Plant data |
| Infiltration velocity, $f(\mathrm{~m} / \mathrm{y})$ | 0.3229 | 0.3175 | Calculation from the Green- <br> Ampt approximation in <br> Heading 5.3.2.1 |
| Infiltration volume $\left(\mathrm{m}^{3} / \mathrm{y}\right)$ | 9,959 | 13,442 | Calculation from multiplying <br> infiltration velocity by area <br> of open lagoons |
| Saturated hydraulic <br> conductivity, $K_{\text {sat }}(\mathrm{cm} / \mathrm{h})$ | 0.0036 | 0.0036 | Constant value for earthen <br> lining waste lagoon (should <br> be less than 10-6 $\mathrm{cm} / \mathrm{s})$, <br> USDA-SCS,1997 |
| Average suction head, $h_{w f}(\mathrm{~cm})$ | -29.22 | -29.2 | constant value for silty clay |

In Table 5.8, both studied sites have same conditions of soil and hydraulic conductivity by seal formation influencing infiltration rate under lagoons. However, they give different infiltration rate and volume because of different values of wetting front depth and the area of lagoons. Ayutthaya site has a higher infiltration rate, $0.3229 \mathrm{~m} / \mathrm{y}$, than Krabi site's infiltration rate, $0.3175 \mathrm{~m} / \mathrm{y}$ but Krabi site has a much
higher in infiltration volume than Krabi site because Krabi site has a larger area of all lagoons.

### 5.4.2.4 Mass of infiltrated organic carbon and nitrogen

Organic carbons, ionic nitrogen, ionic phosphorus species and heavy metals in the wastewater non-aerobic lagoons are mainly retained by sorption, precipitation, coprecipitation, and biological uptake process. Biological processes can transform organic carbons, nitrogen and phosphorus species to insoluble matters retained in the lagoons. The nitrogen and phosphorous removals of the anaerobic lagoons are only a small fraction and conservative for calculation in mass basis.

Because of long sludge retention time of wastewater storage lagoons more than 100 days, ionic nitrogen species (dominantly $\mathrm{NH}_{4}{ }^{+}$) can release from sludge to lagoons' wastewater supernatant on a mass basis directly related to infiltration losses through earthen-lining bottom of lagoons. Reduction of organic carbons and nitrogen passaging through the lagoons are considered because of attenuation mechanisms in upper shallow sediment. Mass of organic carbon and nitrogen passaging to shallow groundwater is determined by wastewater characteristics from the factory and infiltration rate by assuming that each lagoon has $50 \%$ BOD removal efficiency and no nitrification in the lagoons. Table 5.9 shows infiltrated carbon and nitrogen in series of open lagoon system. Influent BOD concentrations to open lagoons for Ayutthaya and Krabi sites are $55.75 \mathrm{~kg} / \mathrm{m}^{3}$ and $24.47 \mathrm{~kg} / \mathrm{m}^{3}$, which are converted by BOD/COD ratios of 0.38 and 0.27 from wastewater characteristics of ethanol and palm oil factories in Thailand (DIW, 2006 and Chavalparit, 2006). Influent TKN to open lagoons for Ayutthaya and Krabi sites are $0.12 \mathrm{~kg} / \mathrm{m}^{3}$ and $0.053 \mathrm{~kg} / \mathrm{m}^{3}$. Mass of infiltrated pollutants are calculated by infiltration volume from each pond and concentration of reduced BOD in series of ponds and TKN. Ayutthaya site has a higher mass of infiltrated carbon than Krabi site ( 42,332 and $41,419 \mathrm{kgBOD} / \mathrm{y}$ for Ayutthaya site and Krabi site, respectively), although the area of lagoons in Krabi site is larger. It means the wastewater characteristics and the order of pond size influenced the infiltrated substances. The higher infiltrated TKN for Ayutthaya site ( 1,195 $\mathrm{kgTKN} / \mathrm{y}$ ) is higher than Krabi site ( $712.4 \mathrm{kgTKN} / \mathrm{y}$ ), which solely depends on the TKN influent concentration and total pond area.

Table 5.9 Infiltrated carbon and nitrogen under the open lagoons in a mass basis

| Number of pond | Area of pond ( $\mathrm{m}^{2}$ ) |  | Infiltrated pollutants (kg/y) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Infiltrated carbon* |  | Infiltrated nitrogen** |  |
|  | Ayutthaya site | Krabi site | Ayutthaya site | Krabi site | Ayutthaya site | Krabi site |
| 1 | 2,305 | 5,200 | 20,004.0 | 20,200.0 | 89.31 | 87.5 |
| 2 | 1,360 | 5,200 | 5,901.4 | 10,100.0 | 87.5 | 52.7 |
| 3 | 2,499 | 5,200 | 5,422.0 | 5,050.0 | 96.8 | 87.5 |
| 4 | 3,965 | 6,762 | 4,301.3 | 3,283.5 | 153.6 | 113.8 |
| 5 | 6,758 | 7,350 | 3,665.6 | 1,784.5 | 261.9 | 123.7 |
| 6 | 8,447 | 5,625 | 2,290.9 | 682.9 | 327.3 | 94.7 |
| 7 | 5,507 | 3,500 | 746.8 | 212.4 | 213.4 | 58.9 |
| 8 | - | 3,500 | - | 106.2 |  | 58.9 |
| Summary | 30,841 | 42,337 | 42,332.0 | 41,419.0 | 1,195.0 | 712.4 |

Remarks: * Measured as BOD, ** Measured as TKN

### 5.4.2.5 Cost of air supply and nitrate treatment

In order to estimate cost for treating pollutant contamination in the principle of Superfund Act, by assuming that all infiltrated ammonium-nitrogen is nitrified through sharp oxic condition under the lagoons induced by the seal formation, it needs a cost to cleanup contaminants. Before estimating treatment cost for nitrate removal, baseline oxygen yields of upper soil in studied sites were indicated. Sediment oxygen uptake rate, $51.36 \mathrm{mmol} \mathrm{m}^{-2} \mathrm{~d}^{-1}$ is acquired from the study of Zilius (2011), from which was measured total oxygen uptake rate (TOU) by in situ micro-electrode within $<1 \mathrm{~mm}$ of lagoon sediments. In Table 5.10, Ayutthaya site requires additional oxygen in sediment for degradation of infiltrated carbon and nitrification, $28,065.2 \mathrm{kgO}_{2} / \mathrm{y}$ and $5,461.3 \mathrm{kgO}_{2} / \mathrm{y}$, respectively (converted by ratio of $1.1 \mathrm{kgO}_{2} / \mathrm{kgBOD}$ ). The baseline oxygen content in upper sediment, $18,500 \mathrm{kgO}_{2} / \mathrm{y}$, is not sufficient for organic carbon degradation. Therefore, the cost to supply oxygen is required as additional budget for site treatment. Comparatively, Krabi site required oxygen for organic carbon degradation and nitrification, $20,164.3 \mathrm{kgO}_{2} / \mathrm{y}$ and $3,255.8 \mathrm{kgO}_{2} / \mathrm{y}$, respectively. The baseline oxygen content in upper sediment, $25,397 \mathrm{kgO}_{2} / \mathrm{y}$, is also not sufficient. The costs of oxygen supply are calculated by a basis of infiltrated wastewater volume comparing with the average cost of energy consumption for extended aeration of
activated sludge treatment system for carbon and nitrogen removal.

Table 5.10 Comparison of pollutant treatment costs under the lagoons between Ayutthaya site and Krabi site

| Index | Substance |  | Cost (USD/y)** |  | Unit price | Reference |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Ayutthaya site | Krabi site | Ayutthay a site | Krabi site |  |  |
| Oxygen requirements |  |  |  |  |  |  |
| - Infiltrated wastewater to add oxygen supply for carbon degradation and nitrification ( $\mathrm{m}^{3} / \mathrm{y}$ ) | $\begin{array}{r} 9,959 \\ (\mathrm{BOD}= \\ 2,500 \mathrm{mg} / \mathrm{l})^{*} \end{array}$ | $\begin{array}{r} 13,442 \\ (\mathrm{BOD}= \\ 1,364 \mathrm{mg} / \mathrm{l})^{*} \end{array}$ | 5,972 | 4,836 | $\begin{aligned} & 0.06^{* * *} \\ & \text { USD } / \mathrm{m}^{3} \end{aligned}$ | $\begin{aligned} & \text { EPRI, } \\ & 1996 \end{aligned}$ |
| $\mathrm{NO}_{3}{ }^{-}$treatment <br> - $\mathrm{NO}_{3}{ }^{-}$treatment in upper sediment $\left(\mathrm{kgNO}_{3} / \mathrm{y}\right)$ | 2,992 | 1,784 | 10,412 | 6,208 | $\begin{gathered} 3.48 \\ \text { USD/kg } \end{gathered}$ | Honeycutt, $2012$ |
| Cost Summary |  |  | 16,384 | 11,044 |  |  |

Remarks:

* Remaining BOD concentration after degradation by baseline oxygen in upper sediment, calculated from mass of BOD after oxidation and infiltration volume in each site
$\mathrm{O}_{2}$ required $1.1 \mathrm{~kg} / \mathrm{kgBOD}, \mathrm{O}_{2}$ required $4.57 \mathrm{~kg} / \mathrm{kgTKN}$, Sediment $\mathrm{O}_{2}$ uptake rate 51.36 mmol $\mathrm{m}^{-2} \mathrm{~d}^{-1}$, Estimated $\mathrm{O}_{2}$ in upper sediment of study area (calculated from sediment oxygen uptake rate multiplied by area of the lagoon) $=18,500 \mathrm{kgO}_{2} / \mathrm{y}$ (Ayutthaya site), $25,397 \mathrm{kgO}_{2} / \mathrm{y}$ (Krabi site), Total area of lagoon ponds $=30,841 \mathrm{~m}^{2}$ (Ayutthaya site), $42,337 \mathrm{~m}^{2}$ (Krabi site) ** Value calculation based on present value in 2012 dollar (with fixed inflation rate of 3\% per year and current exchange rate of 31.08 and $32.48 \mathrm{THB} / \mathrm{USD}$ in 2012 and 2014, respectively) (BOT, 2012; BOT, 2014)
*** Energy consumption of extended aeration in activated sludge $=0.773 \mathrm{kWh} / \mathrm{m}^{3}($ EPRI, 1996), assuming $70 \%$ of total energy used on aeration system, electricity price in Thailand for industry $=3.6 \mathrm{THB} / \mathrm{kWh}$ in 2014

The dilution of wastewater theoretically applied to achieve proper influent BOD concentration of $250 \mathrm{mg} / \mathrm{l}$ to the system by using relative air supply cost of 0.541 $\mathrm{kWh} / \mathrm{m}^{3}$. Infiltrated wastewater under the lagoon of $9,959 \mathrm{~m}^{3} / \mathrm{y}$ with $\mathrm{O}_{2}$-insufficient
$2,500 \mathrm{mgBOD} / 1$ in Ayutthaya site, and $13,442 \mathrm{~m}^{3} / \mathrm{y}$ with $\mathrm{O}_{2}$-insufficient 1,364 $\mathrm{mgBOD} / 1$ in Krabi site are used to estimated the air supply costs. From the results of cost estimation in Table 5.7, the relative cost of air supply under the lagoons is higher in Ayutthaya site (5,972 USD/y) than Krabi site (4,836 USD/y). Infiltrated TKN is assumed to all nitrified under the lagoons. The cost function of nitrate treatment, 3.48 USD/kg, is used to estimate the cost between sites. Ayutthaya site obtains the higher total costs then Krabi site with 16,384 and 11,044 USD/y, respectively (56 and 64 percent of cost difference originated from cost of nitrate treatment in shallow groundwater). In comparison of environment impacts between the two studied sites, the CDM investment should prioritize Ayutthaya site than Krabi site in terms of higher potentiality of groundwater contamination.

### 5.4.3 Utilization of point-source pollutant and infiltrated pollutant valuation

The values, achieved in this valuation methods of this study, were conducted in project boundary based on the principle of Superfund Act, which is considered as a minimum value of the impact/benefit to water environment. Advantages and disadvantages of point-source pollutant valuation and infiltrated pollutant valuation are presented in Table 5.12. The valuation of point-source pollutants is chosen to be a co-benefits indicator of environmental impacts for integrated evaluation (in Chapter 7) due to the purposes to expand its applicability by corresponding simply and quickly to assessment method for an achievable benefit value and give direct relation to pollutant alleviation of the methane recovery CDM projects for cleaner public surface water, from which the social perception is valuated (in Chapter 6). Nevertheless it should be regarded that the simplicity of this point-source pollutant valuation lead overestimation of the costs on environmental impact in scenarios because all pollutants originated from factory are concerned as contaminated pollutants to be treated to non-polluting level. Values from infiltrated pollutant valuation are highly possible to propose in the non-UNFCCC CDM platform, e.g., Joint Crediting Mechanism (JCM)/ Bilateral Offset Crediting Mechanism (BOCM), because a development/revise on methodologies could be decided with agreement of joint committee comprised of government/private officials of partner countries without supervision of UNFCCC executive board (Global CCS Institute, 2013). However, with regard to UNFCCC methodologies, the valuation of infiltrated pollutants is
another choice with integrity of site conditions, corresponding to the methodology under UNFCCC mechanism which calculates based on pollutant removal in lagoons converted into GHGs emission (IGES, 2014). It would provide some kind of consistency and accountable measures to international community. However, it could not estimate a benefit value by this valuation method, unless, a comparison between costs of environmental impact by different site conditions before and after CDM implementation is assessed.

Table 5.11 Advantages and disadvantages between point-source pollutant valuation and infiltrated pollutant valuation

| Valuation source | Advantage | Disadvantage |
| :--- | :--- | :--- |
| Point-source pollutant | - Applicable for any point <br> sources and wastewater <br> strengths | - Cause overestimation of cost on <br> environmental impact |
|  | - Cost estimate is more <br> accurate due to less <br> assumptions <br> - More simply and quickly <br> - Do not consider site-specific <br> conditions of treatment system <br> assessment by using only <br> characteristics of wastewater <br> - Directly relate to the purpose <br> of cleaner public water | - UNFCCC integrity is <br> questionable due to incongruity of <br> CDM methodology |
| Infiltrated pollutant | - Integrate site-specific <br> conditions of wastewater <br> treatment system for achieve <br> an actual cost of environmental <br> impact | - Benefit cost of the CDM project <br> sould not be achieved in feasibility <br> study before project <br> implementation |
|  | - Integrate site-specific <br> conditions of wastewater <br> treatment system <br> - UNFCCC integrity is <br> possible due to correspondence <br> of CDM methodology | - Applicable only for earthen-lining <br> open lagoon operation <br> - High uncertainty of cost estimate <br> due to assumptions of degradation <br> process in lagoons and upper <br> sediment |

The valuation of environmental impacts resulted in different values for baseline scenario between point-source pollutant valuation and infiltrated pollutant valuation.

The value of point-source pollutants costed higher than the value of infiltrated pollutants as shown in Table 5.13 because reducing pollutants by degradation processes of the open lagoons and upper sediment were not take part. In baseline scenario, as for point-source pollutant valuation, the total treatment costs for Ayutthaya site cost higher than Krabi site due to larger designed UASB for three-stage UASB in Ayutthaya site. The treatment cost per wastewater volume for Ayutthaya site, 2.26 USD $/ \mathrm{m}^{3}$, is higher than Krabi site, 1.51 USD $/ \mathrm{m}^{3}$ because of economic scale by lower flow operation for the CAS system and the larger UASB reactor in Ayutthaya site. Cost of industrial wastewater treatment is typically varying between $0.5-5 \mathrm{USD} / \mathrm{m}^{3}$ (Saariaho, 2013). The costs per wastewater volume of CAS in this study ( 0.99 and $0.72 \mathrm{USD} / \mathrm{m}^{3}$ for Ayutthaya site and Krabi site, respectively) are quite high compared with treatment costs for reuse quality by conventional activated sludge followed by tertiary treatment, estimated at a cost ranging from 0.10 to $0.70 \mathrm{USD} / \mathrm{m}^{3}$ (Missimer, 2014), but lower than costs of biological treatment followed by pressured filtration, $2 \mathrm{USD} / \mathrm{m}^{3}$, and desalination, $2.7 \mathrm{USD} / \mathrm{m}^{3}$ (Aswathanarayana, 2012). These high costs are possibly caused by small-scale plant, conservative degrees in assumptions, and different costs regarding locations and countries.

Table 5.12 Comparison of point-source pollutant valuation and infiltrated pollutant valuation in baseline scenario

| Valuation method | 2012 value |  |
| :--- | ---: | ---: |
|  | Ayutthaya site | Krabi site |
| Point-source pollutant valuation |  |  |
| - Total annual costs (USD/y) | 341,905 | 254,905 |
| - Cost per volume (USD/m $\left.\mathrm{m}^{3}\right)^{*}$ | 2.90 | 1.51 |
| CAS cost (USD $\mathrm{m}^{3}$ ) | 0.99 | 0.72 |
| UASB cost (USD $/ \mathrm{m}^{3}$ ) | 1.91 | 0.78 |
| Infiltrated pollutant valuation |  |  |
| - Total annual costs (USD/y) | 16,384 | 11,044 |
| - Cost per volume (USD $\left./ \mathrm{m}^{3}\right)^{* *}$ | 1.65 | 0.82 |

Remarks: * Calculated from wastewater volume from factories, volume $=323^{*} 365 \mathrm{~m}^{3} / \mathrm{y}$ (for Ayuthaya site), and $464 * 365 \mathrm{~m}^{3} / \mathrm{y}$ (for Krabi site)
** Calculated from infiltrated wastewater volume from lagoons, volume $=9,959 \mathrm{~m}^{3} / \mathrm{y}$ (for Ayutthaya site), and 13,442 m³/y (for Krabi site)

The UASB costs per reactor ( 0.64 and 0.39 USD per $\mathrm{m}^{3}$ for Ayutthaya site and Krabi
site, respectively) are comparable to the study of Sandy (2010), indicating a cost range of 0.36 to 0.42 USD per $\mathrm{m}^{3}$ for UASB treating $4,000 \mathrm{~m}^{3} / \mathrm{d}$. As for infiltrated pollutant valuation, the total costs for Ayutthaya site costs higher than Krabi site. Ayutthaya site also has a higher treatment cost per volume than Krabi site (1.65 and $0.82 \mathrm{USD} / \mathrm{m}^{3}$ for Ayutthaya site and Krabi site, respectively) because of higher mass of nitrate in infiltrated wastewater.

### 5.5 Conclusions

The pollutants valuation method of high-strength wastewater operation in this study could be applied with study sites treating high-strength wastewater. It gives low financial barrier without instrument investment for assessing the benefit value, which increase transaction cost in the CDM mechanism with sustainability integrity approach. Then, it could provide an opportunity to valuate pollutants removal cost as well as a benefit value from the methane recovery CDM project, and also provides a starting point for what will be an expansion of applicability for co-benefits CDM approach. In valuation methods, the value of point-source pollutants costed higher than the value of infiltrated pollutants because reducing pollutants of site conditions, in infiltrated pollutant valuation, were not take part. The valuation of point-source is chosen to be a co-benefits indicator of environmental impacts for integrated evaluation (in Chapter 7) due to the purposes to expand its applicability by simple assessment and give direct relation to the societal valuation from a view of cleaner public water. Moreover, it could be assessed the benefit value by assumption of carbon and nitrogen efficiency from a CDM treatment system before project implementation, while infiltrated pollutants valuation could only estimate impact value in feasibility study. Nevertheless, benefit value, in practical way, would be more accurate with consideration of degradation process from the lagoons by using infiltrated pollutant valuation from the baseline scenario in this study and the project scenario after CDM implementation.

From the results of this valuation methods, Ayutthaya site resulted a higher environmental alleviation from the methane recovery CDM than Krabi site by pointsource pollutant valuation. Ayutthaya site costed 75,134 USD/y over the cost of

66,250 USD/y for Krabi site. The cost of UASB treatment was the determining factor to differentiate the costs of environmental impact and define environmental alleviation from the methane recovery CDM project, by the reactor size of UASB units required to reduce COD concentration to an acceptable range for CAS influent. As for the valuation of infiltrated pollutants, from a potentiality of groundwater contamination by the Green-Ampt approximation in terms of values, it estimated the cost of 16,384 and 11,044 USD/y for Ayutthaya and Krabi sites, respectively. The results of pollutants removal cost showed that cost to treat nitrate, by assuming that nitrified ammonium is all nitrified under lagoons, was the most valuable contaminant and differentiated environmental impacts between project sites. Most of total values from environmental impact assessment were originated from the cost to treat nitrate in shallow groundwater rather than the cost of additional oxygen supply. In the estimation method, for mass of infiltrated BOD, the factor of wastewater characteristic from factories, area and order of waste lagoons are influenced because the calculation of infiltrated pollutants was calculated in each lagoon pond with reducing BOD concentration in order, which eventually caused quite same mass of infiltrated BOD between two sites, although, Krabi site has a lower BOD concentration of influent to the lagoons than Ayutthaya's. While, the factor of wastewater characteristic from the factories became an only influencing factor to estimate the mass of infiltrated ammonium by assumption that there is no nitrification process in the lagoons from oxygen depletion condition with high strength wastewater operation.

## Chapter 6

## Social preference for co-benefits indicators

### 6.1 Introduction

The CDM, considered as the most emission-saving scheme in present, involves the purchase of carbon credits by interests in Annex I countries (i.e., industrialized countries) by partially financing, through a marketable carbon credit projects in nonAnnex I countries (i.e., developing countries). About 7,664 CDM projects, that have been expectedly issued 4,732 million certified emission reductions (CERs) by the end of 2015, have already been registered with the CDM committee as of August 2015 (UNFCCC, 2015). However, since the CDM is not so successful in its applicability there is a need for serious reform.

As the literature points out, much attention is paid to the sustainable development (SD) criterion in developing countries and much more to maximizing a project's CERs (Alexander, 2012). Since there is no common definition for SD, the SD integrity of CDM is at the present time superior to vague qualitative guidelines without concrete indicators, provided by most host countries. Many of the questions to be asked on whether a project has positive benefits would be the same as when asking whether it has negative impacts (do no harm approach) (Sterk et al., 2009). At the $19^{\text {th }}$ annual session of the Conference of Parties (COP 19) and the $9^{\text {th }}$ Meeting of the Parties (CMP 9) in Warsaw, the final outcome in the decision (FCCC/KP/CMP/2013/L.10) urged the Executive Board to expedite evaluating the use of the voluntary SD tool and develop guiding tools to monitor SD benefits of CDM activities (IISD, 2013). There are now ongoing processes to develop a top-down standard tool for SD evaluation of CDM projects by creating a draft voluntary tool to report on the SD co-benefits of CDM projects (Greiner, 2013). Following its consideration of the concept note at the meeting, the Executive Board requested the secretariat to develop a checklist approach based on the best practices of SD which is flexible to include the voluntary tool in existing CDM documents and workflows (UNFCCC, 2012). Moreover, many of the proposals for CDM reform suggest
methods to include co-benefits into the price mechanism which could be more reflected on cost effectiveness in terms of investment. Torvanger et al. (2013) suggested that co-benefits of CDM should deliver a price premium as a by-product of CERs and should have a compulsory purchase agreement. More importantly, for assessing co-benefits, criteria of co-benefits should be acceptable with respect to measurement, reporting and verification (MRV).

In recent years, the co-benefits have faced a problem of quantification measurement and CDM has been intended to provide additional financial resources and initiate Joint Crediting Mechanism (JCM) for investment in a CDM project contributing to SD priorities in developing countries (Kill et al., 2010). Although the completed cobenefit projects has been described successful, but concerning profitability, transparency and community participation of the co-benefit projects, additional set of scientific modalities and procedures which would enhance SD benefits on how valuable are these projects to the stakeholders are needed. From above perspective, an evaluation method to assess societal preference, especially in monetary term for comparing projects to select which project implementation is better for SD contribution coupled with financial indication of carbon market as supporting tool for decision making process. The purpose of improved water environment from methane recovery CDM project is assessed in terms of perceptive values with different administrative scales of beneficiaries for project comparison.

To assess societal preference as the co-benefits from methane recovery CDM projects, information from the communities are required as social involvement of project investment because public participation is a principle for effective climate policy in Article 6 of UNFCCC, which in present provided technical guidelines of SD benefits by the Designated National authorities (DNA) (Dong et al., 2014), and contamination risk from lagoon operation (Cavella et al., 2005; EPA, 2004; Varuni et al., 2006; Yoshida et al., 2003), and also the benefit perception of CDM system (i.e., UASB) to reduce carbon and nitrogen pollutant to environment. Societal preference is assessed in terms of potentiality to make surface public water cleaner, from which could be only used as comparison basis. Figure 6.1 shows the steps performed for the socioeconomic study from collection of required information, using of the survey instrument, and analysis. The surveys are started after the findings from respondent
grouping and the focus group analysis are well understood. A hypothetical market for surface water quality improvement in a target site are prepared to extract values from water users of different institutional scales by contingent valuation method (CVM).


Remarks: * Respondents in administrative province which co-benefits of CDM expected
** Respondents in nation which co-benefits of CDM expected (Bangkok residents representing national respondents in this study)
Figure 6.1 Study process for social assessment

### 6.2 Methodologies

Some CDM projects assist the developing host country by making a certain contribution to promote SD. Although SD criteria are widely incorporated into many aspects, there are many existing and developing indicators that vary widely between type and size of project. Nevertheless, a separate framework which is specific for water environment benefits is needed to be adopted in the present study example and apply it to the CDM approval process.

### 6.2.1 Potential CDM project and benefits to water environment

methane recovery CDM was chosen as an example CDM type which benefits to water environment. Although CDM in the pipeline methane recovery projects represent a relatively small share of 516 registered projects or $11.6 \%$ of all projects (Fenhann et al, 2009). While biogas was relatively unattractive for investors in the past, many highly profitable projects like biomass fuel-, wind- and hydropower plants were realized. But since the potential in these sectors has been diminished and the cobenefits has been considered, the relative attractiveness for investments in methane
recovery projects has been increased in the future.

In Thailand, around $56 \%$ of Letter of approval (LoA) received CERs was being registered from methane recovery CDM projects (TGO, 2012). Methane recovery projects are situated on the main emission reduction takes place due to switch in those cases where biogas is used for energy generation. By installing the closed structured treatment unit the wastewater that was previously deposited in an anaerobic open lagoon in the baseline scenario is fermented in the biogas digester and the methane emission is avoided. Two competitive factories with anaerobic open lagoon treatment system located in Ayutthaya and Krabi provinces, Thailand were selected as case studies to assess different co-benefits. As anaerobic open lagoons of the case studies are operated as earth-lining wastewater storage without discharge wastewater out of the system, the main advantages to water environment from this kind of project are to reduce odor from opened treatment system and reduce infiltrated substances (alleviating water pollutants) (MOEJ, 2009), especially nitrogen pollutants from existing lagoons to underground water resource by the construction of closed structure anaerobic system with improved treatment efficiency caused a decrease in the nitrogen load in the existing lagoon (Nakamura, 2014). It consequently reduces the contamination by nitrate- and nitrite-nitrogen in groundwater which is due to human activities (Miyagi, 2013)

### 6.2.2 Framework of co-benefits valuation in the host country provinces

Since the functioning of water resources and their services affect so many aspects of human welfare, a broad set of indicators can and should be used to measure the value of their impacts. The three main types of benefits (well-being aspects) and related values are introduced as environmental, economic and societal values in Figure 6.2. In order to assess benefits and value of perception on water quality improvement of provincial water environment (e.g. rivers), we considered institutional scales as local/provincial and national beneficiaries because of the manner in which they influence economic and social issues.


Figure 6.2 Framework of co-benefits valuation for methane recovery CDM project

Two factories with anaerobic open lagoon treatment systems located in Ayutthaya and Krabi provinces in Thailand were selected as case studies to assess different cobenefits. The location of the Ayutthaya and Krabi provinces are shown in Figure 6.3. Ayutthaya and Krabi are representative local/provincial respondents for methane recovery CDM investment in this study.


Figure 6.3 Positions of host Ayutthaya and Krabi province for methane recovery CDM investment in Thailand (Modified from Modified from d-maps, n.d.)

In 2008, the Ministry of the Environment, Japan, subsidized a private sector company, an ethanol factory in Ayutthaya Province, to implement a promising biogas model CDM (MOEJ, 2009). In Krabi Province, the palm oil industry is considered to be a potential candidate for CDM investment because it has increased its production since 2009 (Dallinger, 2011) Additionally, a palm oil factory also has much potential for water quality improvement from the high volume of highly concentrated wastewater
from the factory. Contribution to water quality improvement by proposing a methane recovery project may not be so significant in the target areas, however, as outcomes of the project are widely applied from the purpose of co-benefits project, it eventually yields better water quality. Therefore, the objective of improving water quality in these two provinces would make a difference in terms of perception on water use and benefits related to different land uses of the provinces, i.e., Ayutthaya representing a historical and industrial region and Krabi representing a natural conservation region.

### 6.2.3 Societal benefits valuation by contingent valuation method

The stated preference approach has usually been used to simulate a market and demand for water services, by means of surveys of hypothetical changes in provisions of water quality improvement plan. Stated preference methods can capture both use and non-use values to calculate the total economic value (TEV) using the CVM.

## - Sampling and method of social preference valuation

River water is considered as the most tangible water quality perception from communities, and improved river water quality would benefit all societies in a CDM host country. For sampling, 224 respondents in the host provinces (120 and 104 samples from Ayutthaya's and Krabi's residents, respectively) were selected to represent beneficiaries in the local scale. A total of 824 respondents in the capital province, Bangkok ( 415 and 409 samples of Bangkok residents separately benefited from Ayutthaya's and Krabi's rivers, respectively), were chosen to represent beneficiaries in the national scale by consideration of cost effectiveness involving money and time. The respondents were selected by their convenience to answer questionnaires as household representatives. The surveys were conducted at different places and times per week in both Bangkok and the host province for representing provincial water users from July 2013 to April 2014. The interviews were carried out from a household perspective by face-to-face interviews with a knowledgeable member as family representative. A hypothetical market was designed for a question regarding their preferences for a one-step improvement of river water quality, compared to the status quo by improving the host province's rivers for more purposes of use such as boating, fishing and swimming.

Figure 6.4 shows the overall process of survey procedure for designing questionnaire and conducting the survey (refer in Appendix IX). The questionnaire was designed with three sections. The first section consisted of questions regarding information about the respondents and the household. The questions in the second part focused on household knowledge and attitude about water quality. These two sections were designed to extract information about household socio-economic status and their attitude towards environmental problems both at the national level and at the local level. The third section sought information about household willingness-to-pay (WTP) for improved river water quality. This was accomplished by providing information about WTP to the respondents and then inquiring about their maximum WTP amount. However, taking into account the advantages of CVM, double-bounded dichotomous choice (DBDC) was used to measure the amount of WTP, a method proposed by Hanemann et al. (1991). This model requires determination and selection of a higher offer in comparison with the primary bidding price. The higher offer is referred to as the "Yes" and the lower offer is referred to as the "No" answer. The offers were designed in two steps. In this section three proposed prices of 20, 50 and 100 THB per month were put forward in order to test the significance on different starting bid prices. The proposed prices were selected on the basis of a pre-test. The command "Proc Lifereg" of Statistical Analysis Software (SAS), version 9.4 was used to estimate the mean WTP (SAS Institute Inc., 2013). Wording in questions and strategies for creating amenity to each respondent group in the survey come from the focus groups.


Figure 6.4 Survey procedure for contingent valuation method

## - Analysis of willingness to pay (WTP) for water quality improvement

The actual WTP from the double-bounded format is a value in the range of upper and lower bound on their acceptable prices. Probabilities of the WTP are distributed continuously with any numerical value or interval scale. Cameron (1988) developed regression analysis for CVM coupled with double-bounded questions. In individual WTP, the value depends on different vectors of independent variables, and different functions of probability distribution in equation (1). The mean of willingness is statistically estimated by maximum likelihood estimation (MLE),

$$
\begin{equation*}
W T P=\beta x+\mu \tag{1}
\end{equation*}
$$

where $W T P$ is the vector of actual willingness to pay, $\beta$ is the vector of unknown coefficient, $x$ is the vector of explanatory variable which indicates WTP, and $\mu$ is the vector of random error term from normal distribution with zero mean and variance equal to $\sigma^{2}$.

A choice question model is simply dichotomous answer by "yes" or "no" to a proposed bidding price. A person answers "yes" when his WTP is greater than a bidding price $t$. Probability of acceptance to pay in condition of explanatory $x$ is shown in equation (2).
$\operatorname{Pr}(I=1 \mid x)=\operatorname{Pr}(W T P \geq t \mid x)$

Where $I$ is the vector of variables on the probability of actual WTP. The value equals to $1(I=1)$ if actual WTP is greater than or equal to the bidding price $t$ as shown in equation (2), but the value equals to $0(I=0)$ if actual WTP is less than the bidding price $t$.

Substitute the value $\beta x+\mu$ into the equation (2) as shown in equation (3).

$$
\begin{equation*}
\operatorname{Pr}(W T P \geq t \mid x)=\operatorname{Pr}(\beta x+\mu \geq t)=\operatorname{Pr}(\mu \geq t-\beta x) \tag{3}
\end{equation*}
$$

Following standard normal distribution function, the mean and variance of random error term are considered to be zero and constant, respectively. It is assumed that $\mu \sim$ $N\left(0, \sigma^{2}\right)$. Standardize term $\operatorname{Pr}(\mu \geq t-\beta x)$ in equation (3) to make $\mu$ to be $Z$ score as shown in equation (4).
$\operatorname{Pr}(W T P \geq t \mid x)=\operatorname{Pr}[Z \geq(t-\beta x) / \sigma]$

Where $Z$ is equal to $\mu / \sigma$ by zero mean of random error term $\mu$
From equation (4), use $\Phi($.$) as function of value on probability from Z$ score in normal accumulative distribution, then probability of $Z$ which equal or more than $(t-\beta x) / \sigma$ can be written as equation (5) for the answer "yes" in bidding price and equation (6), which probability of Z is less than $(t-\beta x) / \sigma$ for the answer "no" in a bidding price.
$\operatorname{Pr}(W T P \geq t \mid x)=1-\Phi[(t-\beta x) / \sigma]$
$\operatorname{Pr}(W T P<t \mid \mathrm{x})=\Phi[(t-\beta x) / \sigma]$

In case each person answering independently gives individual probability of WTP from equation (5) and (6), estimation with the maximum likelihood function is done as shown in equation (7) with the vector $I$. Probabilities of closed-end doublebounded format will give four probabilities of bidding, then, all the probability functions are multiplied to be a joint density function as shown in equation (8).
$\operatorname{Ln} L=\Sigma[\operatorname{In}\{1-\Phi[(t-\beta x) / \sigma]\}+(1-I) \ln \{\Phi[(t-\beta x) / \sigma]\}]$
$L=\operatorname{Pr}(y e s, y e s) \operatorname{Pr}($ yes,no $) \operatorname{Pr}($ no, yes $) \operatorname{Pr}(n o, n o)$

Where first "yes" or "no" is an answer for primary bidding price and second "yes" or "no" is an answer for secondary bidding price. In case of answering "yes", biding price increase twice as primary bidding price, while answering "no", bidding price decrease a half as primary bidding price.

Using a log-likelihood function in equation (8) for each function of probability in equation (7) will result in equation (9).

$$
\begin{equation*}
\ln L=\Sigma\left[I_{Y Y} \ln \{\operatorname{Pr}(\text { yes, yes })\}+I_{Y N} \ln \{\operatorname{Pr}(\text { yes, no })\}+I_{N Y} \ln \{\operatorname{Pr}(\text { no, yes })\}+I_{N N} \ln \{\operatorname{Pr}(\text { no,no })\}\right] \tag{9}
\end{equation*}
$$

When estimating by MLE using the program SAS, the choice of distribution function may influence the results. Which distribution to choose depends on the data being analyzed. The true WTP is unobservable, but we know how the respondents are distributed according to the different bid ranges. The cumulative distribution curve of WTP is categorized into three types, viz. log-normal, Weibull and log-logistic distributions. Parameters $\beta$ and $\sigma$, which are values of intercept and scale, respectively, will be obtained from data processing to calculate the mean and median of WTP. The mean and median WTP can be calculated as different formulas based on each distribution function. In regression analysis, inputs are independent variables (socio-economic status) influencing WTP in the function of MLE (Nunes, 1998).

When estimating by Maximum Likelihood Estimation (MLE) with program SAS, parameters $\beta$ and $\sigma$ will be obtained to calculate mean and median of WTP. Cumulative distribution curve of WTP is categorized to 3 types such as Lognormal, Weibull and Loglogistic distribution. Parameters $\beta$ and $\sigma$ obtained from computer processing to calculate mean and median of WTP are values of intercept and scale respectively. In case of Lognormal distribution, the mean and median can be calculated as formulas below.

```
Mean of WTP \(=e \wedge\left(\beta+0.5 \sigma^{2}\right)\)
Median of WTP \(=e \wedge \beta\)
CI of Mean WTP \(=\) Mean WTP \(\pm 1.96(\) SD of Mean WTP)
CI of Median WTP \(=\) Mean WTP \(\pm 1.96(\) SD of Median WTP)
Pseudo \(\mathrm{R}^{2}=1-\left(\ln \mathrm{L}_{1} / \operatorname{Ln} \mathrm{L}_{0}\right)\)
```

Where: CI is Confidence of Interval at $95 \%$ confidence level, $L_{1}$ is coefficient of loglikelihood of independent variables to WTP, $\mathrm{L}_{0}$ is coefficient of log-likelihood of Lognormal distribution

In case of Weibull distribution, the mean and median can be calculated as formulas below.

Mean of WTP $=e^{\beta} \gamma(1+\sigma)$
Median of WTP $=e^{\beta}(\ln 2) \sigma$
CI of Mean WTP $=$ Mean WTP $\pm 1.96$ (SD of Mean WTP)
CI of Median WTP $=$ Mean WTP $\pm 1.96($ SD of Median WTP)
Pseudo $\mathrm{R}^{2}=1-\left(\ln \mathrm{L}_{1} / \operatorname{Ln} \mathrm{L}_{0}\right)$

In case of Log-logistic distribution, the mean and median can be calculated as formulas below.

Mean of WTP $=e^{-\alpha / \beta}[(\boldsymbol{\Phi} / \beta) / \sin (-\Phi / \beta)]$
Median of WTP $=e^{-\alpha / \beta}$
CI of Mean WTP $=$ Mean WTP $\pm 1.96$ (SD of Mean WTP)
CI of Median WTP $=$ Mean WTP $\pm 1.96($ SD of Median WTP)
Pseudo $\mathrm{R}^{2}=1-\left(\ln \mathrm{L}_{1} / \operatorname{Ln} \mathrm{L}_{0}\right)$

Life regression model in SAS program for the case study

| Starting bid | Probability | Lower bound | Upper bound |
| :---: | :---: | :---: | :---: |
| Bid 1 (20 THB) | Yes, Yes | 40 | $\infty$ (or max WTP) |
|  | Yes, No | 20 | 40 |
|  | No, Yes | 10 | 20 |
|  | No, No | 0 | 10 |
| Bid 2 (50 THB) | Yes, Yes | 100 | $\infty$ (or max WTP) |
|  | Yes, No | 50 | 100 |
|  | No, Yes | 25 | 50 |
|  | No, No | 0 | 25 |
| Bid 3 (100 THB) | Yes, Yes | 200 | $\infty$ (or max WTP) |
|  | Yes, No | 100 | 200 |
|  | No, Yes | 50 | 100 |
|  | No, No | 0 | 50 |

Maximum Likelihood Estimation (MLE) is used to determine suitable cumulative distribution curve which gives maximum log-likelihood. This estimate can be determined with independent variables or without independent variables.

Model $\left(\right.$ Lower $_{\mathrm{i}}$, Upper $\left._{\mathrm{i}}\right)=/$ Distribution function

$$
\text { Model }\left(\text { Lower }_{\mathrm{i}}, \text { Upper }_{\mathrm{i}}\right)=\mathrm{F}\left(\mathrm{X}_{\mathrm{i}}\right) / \text { Distribution function }
$$

In regression analysis, inputs are independent variables (in Table 6.1) influencing WTP in the function of MLE.

$$
\begin{aligned}
& \text { Model }\left(\text { Lower }_{i}, \text { Upper }_{i}\right)=\beta_{0}+\beta_{1} \text { Start }_{i}+\beta_{2} \text { Age }_{i}+\beta_{3} \text { Sex }_{i}+\beta_{4} \text { Income }_{i}+ \\
& \beta_{5} \text { Edu }_{i}+\beta_{6} \text { Occup }_{i}+\beta_{7} \text { Time }_{i}+\beta_{8} \text { Know }_{i}+\beta_{9} \text { Mem }_{i}+\beta_{10} \text { Emplo }_{i}+\beta_{11} \text { Been }_{i}+ \\
& \beta_{12} \text { Attwq }_{i}+\beta_{13} \text { Attimp }_{i} / \text { Distribution function }^{2}
\end{aligned}
$$

Table 6.1 Independent variable (socio-economic status) of willingness-to-pay logistic model

| Variable | Description | Quantitative <br> value | Fixed <br> value |
| :--- | :--- | :--- | :--- |
| Starting bid price | Starting price proposed to <br> respondent |  | $20,50,100$ <br> Baht |
| Gender | Respondent's gender |  | Male, Female |
| Educational level | Numeric years of study period | Year |  |
| Occupation | Respondent's occupation |  | Occupational <br> type |
| Residential years | Residential years in the province | Year |  |
| Household members | Members of household | Person |  |
| Employed members | Employed members of household | Percent |  |
| Household Income | Disposable income of household | Baht |  |
| Visits | Have been to host province |  | Yes, No |
| Attitude on water <br> quality | Respondent's perception on river <br> quality in host province |  | Score (low to <br> high quality) |
| Attitude on impacts <br> from water quality | Respondent's perception on impact <br> from water quality in host province |  | Score (low to <br> high impact) |

### 6.3 Results and discussion

### 6.3.1 Acceptance rate to WTP on water quality perception

In Table 6.2, In both local and national level, most reason of not willingness to pay in Krabi and Ayutthaya was that it is duty of government sector to use money from normal tax system and respond to the problem. Ayutthaya gave $25.8 \%$ and $29.9 \%$ for
local and national respondents. Krabi gave $46.7 \%$ and $23.1 \%$ for local and national respondents.

In national level, compared with Ayutthaya, Krabi respondents have increasing number to answer that "Do not think it has effects on daily life" ( $19.5 \%$ for Krabi and $13 \%$ for Ayutthaya) and . Whereas, they had decreasing number to answer that "It is duty of all beneficial people in target province to respond to the problem" $(7.7 \%$ for Krabi and $11 \%$ for Ayutthaya) and "Industrial sector should pay and respond to the problem" ( $1.8 \%$ for Krabi and $10.4 \%$ for Ayutthaya).

Table 6.2 Respond rate of WTP in Ayutthaya and Krabi

| Starting bid | Number of respondents in Ayutthaya |  |  | Number of respondents in Krabi |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | WTP | non-WTP | Sum. | WTP | non-WTP | Sum. |
| Local level (Ayutthaya and Krabi) |  |  |  |  |  |  |
| $20 \mathrm{THB} /$ month | 28 (71.8\%) | 11 (28.2\%) | 39 | 26 (76.5\%) | 8 (23.5\%) | 34 |
| $50 \mathrm{THB} /$ month | 30 (73.2\%) | 11 (26.8\%) | 41 | 27 (75.0\%) | 9 (25.0\%) | 36 |
| 100 THB/month | 31 (77.5\%) | 9 (22.5\%) | 40 | 21 (61.8\%) | 13 (38.2\%) | 34 |
| Total | 89 (74.2\%) | 31 (25.8\%) | 120 | 74 (71.2\%) | 30 (28.8\%) | 104 |
| National level (Bangkok) |  |  |  |  |  |  |
| $20 \mathrm{THB} /$ month | 97 (69.8\%) | 42 (30.2\%) | 139 | 89 (65.4\%) | 47 (34.6\%) | 136 |
| $50 \mathrm{THB} /$ month | 85 (62.0\%) | 52 (38.0\%) | 137 | 78 (59.1\%) | 54 (40.9\%) | 132 |
| $100 \mathrm{THB} / \mathrm{month}$ | 79 (56.8\%) | 60 (43.2\%) | 139 | 73 (51.8\%) | 68 (48.2\%) | 141 |
| Total | 261 (62.9\%) | 154 (37.1\%) | 415 | 240 (58.7\%) | 169 (41.3\%) | 409 |

Survey response rates to willingness-to-pay (WTP) were calculated from a total of 1,048 completed survey questionnaires. This includes a total of 535 questionnaires for beneficiaries from the rivers of Ayutthaya Province and 513 questionnaires for beneficiaries from the rivers of Krabi Province. Response rates for each beneficiary group were separated into local household and national household respondents. Ayutthaya and Krabi residents represent local respondents who receive benefits from improved river quality, while Bangkok residents represent national respondents. Throughout this section, results will be discussed for all four sub-samples, viz., Ayutthaya (local) - Ayutthaya residents benefitting from the rivers of Ayutthaya Province; Ayutthaya (national) - Bangkok residents benefitting from the rivers of Ayutthaya Province; Krabi (local) - Krabi residents benefitting from the rivers of

Krabi Province; and Krabi (national) - Bangkok residents benefitting from the rivers of Krabi Province, compared with different bid prices of 20, 50 and 100 THB per month as shown in Figure 6.5.


Figure 6.5 Respond rate between local and national level of target provinces (Ayutthaya and Krabi) to willingness-to-pay

The overall response rate was approximately $78 \%$ for Ayutthaya Province's rivers and $80 \%$ for Krabi Province's rivers (regardless of different bid prices). The response rate is quite similar to contingent valuation (CV) response rate for water quality improvement in Neuse River, US, and Mula, Mutha and Pavana rivers, India, where about $71 \%$ and $78 \%$, respectively, replied positively to WTP (Whitehead, 2003; Imandoust and Gadam, 2007). Some broad suggestions were presented for water quality improvement and most of the respondents agreed with the suggestions.

For the same bid price, the response rates of local respondents were higher than national respondents for both Ayutthaya and Krabi Province's rivers. The response rate of local respondents were about $74 \%$ for Ayutthaya and $71 \%$ for Krabi, while the response rate of national respondents were about $63 \%$ for Ayutthaya and $59 \%$ for Krabi on the average. Typically, it showed the relationship between scale and stakeholders for a range of institutional scales of ecosystem services (Hein et al., 2006). As this study considers the case of river resources that provide benefits to local stakeholders rather than national stakeholders for recreational purposes, increasing the
bid price resulted in a decrease of response rates except from Ayutthaya (local). It shows that the frequency of WTP responses decreases as the bid gets higher in Fig. 3. This was also noted in other studies where it is implied that the likelihood of respondents answering "no-no" or "no willingness-to-pay" in DBDC questions increased with the size of the first bid (Loureiro et al., 2006 and Mungchan, 2009). However, the response rate to WTP for Ayutthaya (local) increased with increased bid price. This could be attributed to the strong anchoring effect of starting price influence due to perceived poor river water quality in Ayutthaya by local residents, that they accepted the bids were reasonable. It was similar to the findings of Frykblom and Shogren (2000), that the acceptance to pay increased with the higher bid price when using a dichotomous format.

### 6.3.2 Mean and median WTP

Approximately one-fourth of the respondents opposed or remained neutral and would not participate in the river water recovery plan. The distribution of all WTP data from respondents was in support of the water quality improvement plan and had a lognormal distribution with maximum log-likelihood values (refer in Appendix VIII). For all respondents, monthly mean monetary response values ranged from 70.6 to 77.9 THB per month (in Table 6.3).

Table 6.3 Parameters of mean and median WTP by log-likelihood function

| Statistical data* | Upper bound for "Yes,Yes" |  |  |  |
| :--- | ---: | ---: | ---: | ---: |
|  | Ayutthaya <br> (national) | Ayutthaya <br> (local) | Krabi <br> (national) | Krabi <br> (local) |
| Max $\left(\mathrm{L}_{\mathrm{n}} \mathrm{L}_{0}\right)$ | -363.3 | -115.9 | -311.8 | -77.5 |
| Max $\left(\mathrm{L}_{\mathrm{n}} \mathrm{L}_{1}\right)$ | -164.3 | -66.8 | -49.0 | -29.2 |
| Intercept $(\beta)$ | 4.0 | 4.1 | 4.1 | 4.1 |
| Scale $(\sigma)$ | 0.7 | 0.7 | 0.7 | 0.5 |
| Mean WTP** <br> (THB/household/month) | 73.1 | 77.9 | 75.3 | 70.6 |
| Median WTP <br> (THB/household/month) | 55.3 | 60.8 | 59.8 | 61.4 |
| Pseudo R ${ }^{2}(\%)$ | 54.8 | 42.4 | 84.3 | 62.3 |

Remarks: *Mean WTPs are 2.25, 2.39, 2.32, 2.17 USD/household/month (1USD=32.48THB) (BOT, 2014). Probabilities of WTPs distribute as log-normal. Mean of WTP $=e^{\left(\beta+0.5 \sigma^{\prime}\right)}$, Median of WTP $=e^{\beta}$, Pseudo $R^{2}=1-\left[L_{n} L_{1} / L_{n} L_{0}\right]$

In local scale, the monthly mean monetary response value for water quality improvement of Ayutthaya is higher than Krabi, i.e. 77.9 and 70.6 THB per month,
respectively. However, in national scale, higher value was expressed from Krabi than Ayutthaya, i.e. 75.3 and 73.1 THB per month, respectively. This means WTP were lower than the WTP to improve Bangkok river water quality for recreational purposes, 100.8 THB (Tapvong and Kruavan, 1999). The possible reasons were the worse water quality situation and more perceivable benefits from rivers in Bangkok.

The cumulative probability distribution curves in Fig. 6.6 show that the range of acceptable WTP varies between 10 and 200 THB per month with high concentration at the lower end and greater than 200 THB , where the bid values are associated with a probability value that is close to zero (refer in appendix VII). It shows in Table 6.3 that the highest mean payment is WTP 77.9 THB for Ayutthaya (local) and the next highest mean payment is WTP 75.3 THB for Krabi (national). The difference of WTP is related to the expectation that WTP should be increasing in the scale or magnitude of what is being valued. In the present study, scenarios of improvements in water quality for both host provinces were quite similar and we did not specify a geographic extent to the hypothetical water quality improvement. Therefore, these differences particularly determine whether WTP for water quality improvement increases with the severity of concern related to their own uses/benefits, experiences and awareness of water quality (Otsuka et al., 2011).


Figure 6.6 Relationships between cumulative probabilities of WTP and local and national level of target provinces (Ayutthaya and Krabi) to willingness-to-pay

### 6.3.3 Regression analysis of WTP

The explanatory variables in the regression model are dummy variables for gender, occupation, visits, attitude on water quality and attitude on impact of water quality. Demographic variables such as educational level and household income among others were collected as part of the survey (see in Table 6.1). The reason for comparison of attitude parameters is to evaluate the respondents who perceived river water quality in the host provinces and how they indicated whether water quality had impact on their behavior. Thus, respondents who thought that water quality is bad and were concerned that their living conditions depended on water quality, tended to give a higher WTP. Results of explanatory variables to WTP from the regression analysis are given in Table 6.4 for national respondents and Table 6.5 for local respondents. All parameters which have the sign * (or **) were significant at the $90 \%$ (or $99 \%$ ) confidence level.

The first significant parameter was the variable "starting bid price", which had significance at $99 \%$ confidence level for all four sub-samples. It was examined whether the size of the first bid had any influence on WTP. The variable should turn out to be non-significant because the WTP should be independent of the first bid. However, the parameter turned out to be positive indicating that a higher first bid resulted in respondents expressing a higher WTP than the average. An explanation is the anchoring effect. This effect is widely discussed in the literature and covers the effect that the respondents do not know their true WTP and think that the bid offered is the correct WTP (Herriges and Shogren, 1996; Mitchell and Carson, 2005; Banerjee and Shogren, 2014). This means that the likelihood for a respondent answering "no willingness-to-pay" was quite equal for all starting bids in Figure 6.5 of sub-sample Ayutthaya (local). In order to avoid this, a number of randomly assigned bid values must be provided to reduce the anchoring effect that arises under DBDC format and it is recommended to test the accuracy of DC question format in eliciting WTP.

The negative correlation coefficient of variable "gender" indicated that female respondents had more WTP than males at national level. This result was consistent with previous studies that females gave a higher WTP for water quality improvement from nutrient reductions of agricultural non-point sources in Mississipi, US (Hite et al., 2002) and for tap water quality improvement to meet drinking water standards in

Maun, Botsawana (Moffat et al., 2012). Significance of gender to WTP, actually, may not be comparable to surveys in other geographic regions, however, the onus of domestic households about water quality in most cases falls on female gender than male. For this reason, from the general perspective of water quality benefits, females are probably more sensible in relation to water-related health issues, and also more worried about conditions for future generations. On the other hand, there is no difference between genders at the local scale from the view point of direct use benefits. However, gender was not a key factor for selecting the CDM host provinces because the two case studies had significance to WTP for both provinces at the national scale, which made no difference to gender influencing the decision.

Table 6.4 Coefficient and P.value of willingness-to-pay regression model for national respondents

| Variable | Ayutthaya |  | Krabi |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Coefficient | P.Value | Coefficient | P.Value |
| Starting bid price | 0.017 | $<0.001^{* *}$ | 0.001 | $<0.001^{* *}$ |
| Gender | -0.155 | $0.009^{* *}$ | -0.166 | $0.070^{*}$ |
| Educational level | -0.002 | 0.903 | 0.062 | $0.011^{*}$ |
| Occupation | -0.009 | 0.666 | -0.031 | 0.307 |
| Staying time | -0.006 | $0.017^{*}$ | -0.003 | 0.584 |
| Household member | 0.002 | 0.930 | -0.028 | 0.421 |
| Employed member | -0.046 | 0.740 | -0.141 | 0.488 |
| Household Income | 0.035 | $0.000^{* *}$ | -0.019 | 0.252 |
| Visit | 0.132 | 0.295 | 0.042 | 0.661 |
| Attitude on water <br> quality | -0.010 | $0.037^{*}$ | -0.038 | 0.391 |
| Attitude on impact of <br> water quality | 0.040 | 0.176 | -0.050 | $0.096^{*}$ |
| Number of <br> observations | 261 |  |  | 240 |
| Log-likelihood | -164.27 |  | -191.57 |  |
| AIC | 356.54 |  |  | 415.15 |
| BIC |  |  |  |  |
| ** indicates significance at 99\% confidence level, * indicates significance at 90\% |  |  |  |  |
| confidence level |  |  |  |  |

The variable "household income" had a positive correlation to WTP which has
significance at $99 \%$ confidence level for Ayutthaya (national). Such an effect is quite reasonable and agrees with Mungchan (2009), that the larger the income, the less limited is the person to choose any desirable value. Those who chose to pay seemed to be receptive to a possible river water recovery project. With different family characteristics, at local scale the variable "household member" showed negative significance to WTP. Respondents with more family members in the household had a lower WTP than the average. Lower WTP amounts may indicate that more family members are quite sensitive how it will affect their disposable income (Kamaludin and Rahim, 2013).

Table 6.5 Coefficient and P.value of willingness-to-pay regression model for local respondents

| Variable | Ayutthaya |  | Krabi |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Coefficient | P.Value | Coefficient | P.Value |
| Starting bid price | 0.016 | $<0.001^{* *}$ | 0.013 | $<0.001^{* *}$ |
| Gender | -0.134 | 0.192 | -0.066 | 0.445 |
| Educational level | -0.012 | 0.532 | 0.023 | 0.135 |
| Occupation | -0.035 | 0.238 | 0.033 | 0.185 |
| Staying time | -0.001 | 0.862 | 0.002 | 0.585 |
| Household member | -0.106 | $0.005^{* *}$ | -0.059 | $0.062^{*}$ |
| Employed member | 0.194 | 0.329 | -0.110 | 0.527 |
| Household Income | 0.023 | 0.219 | 0.006 | 0.669 |
| Attitude on water <br> quality | 0.022 | 0.801 | -0.174 | $0.003^{* *}$ |
| Attitude on impact of <br> water quality | 0.144 | $0.032^{*}$ | 0.145 | $0.025^{*}$ |
| Number of <br> observations | 89 |  |  | 74 |
| Log-likelihood | -66.76 |  | 345.55 |  |
| AIC | 599.32 |  | 378.03 |  |
| BIC | 604.3 |  |  |  |

** indicates significance at $99 \%$ confidence level, * indicates significance at $90 \%$ confidence level

Another reason behind this may be that compared to Bangkok, people in Ayutthaya
and Krabi households depend on each other by blood relationships to share their income and expenses. Correspondingly, when considering the variable "employed members" (percent of employed household members), its relationship was positive to WTP which means the more unemployed persons there are in a household, the less they are willing to pay.

The "attitude on water quality" parameter had a negative correlation to WTP for Ayutthaya (national) and Krabi (local) which means that people who perceived bad river quality tend to have higher WTP than the average. Respondents in the aforementioned sub-samples were willing to pay for river water quality recovery, recognizing the contribution water quality makes towards maintaining a healthy ecosystem. In general, such benefits from better quality of water resources from upstream river and better water environment for future generations would be expected. Meanwhile, since Krabi is specified as a tourism and natural conservation region, maintaining the ecosystem would be more profitable for local people. Therefore, these sub-samples focused on overall water quality rather than direct use value/impacts. Lastly, the variable "attitude on impacts from water quality" had a positive correlation to WTP for Ayutthaya (local and national) and Krabi (local). It means that respondents who thought water quality was very important in their behavior would express a higher WTP than the average. Respondents in all subsamples except Krabi (national) were willing to pay for river water recovery by reason that they were more concerned about direct use of rivers, such as recreational and productive use, than indirect benefits. This agreed with the result corresponding to positive significance of recreational activities on creek water quality (Benson, 2006). Accordingly, the more tangible benefits they expected to achieve in a host province, reflected significant correlation in WTP.

### 6.4 Conclusions

Due to concerns in profitability, transparency and community participation of cobenefits CDM investments, these case studies provide an opportunity to quantify societal preference, to compare different water quality perceptions between host provinces, and also to provide a starting point for what will be an expansion of applicability for co-benefits CDM approach, rather than using the present checklist
approach based on "do no harm" and "scoring" practices.

Keeping this in mind the valuation method was designed with a CVM survey for the households regarding their preference for an improved river water quality from the status quo to compare different co-benefits between projects. This value could not referred as a value from the project. As for societal preference results with different WTP in sub-samples, it could not compare between local/provincial and national scale in terms of total value. Therefore, WTP per household for water quality improvement in each local and national scale should be measured and compared separately, for example, local people in Ayutthaya province gave the WTP of 77.9 THB/household/month (28.8 USD/household/year) on water quality improvement than WTP of 70.6 THB/month (26.1 USD/household/year) from local people in Krabi province, while in national scale they considered Krabi's rivers as more important to improve by giving the higher WTP of 75.3 THB/month (27.8 USD/household/year) than $73.1 \mathrm{THB} /$ month ( $27.0 \mathrm{USD} /$ household/year) for Ayutthaya's rivers. From the results of regression analysis, the disposable income of a respondent seems to be a considerable factor to select CDM project location but it is explained differently in terms of household income at the national scale for Ayutthaya respondents, with $p$ value of 0.007 , and household members, which considered as a hindrance to WTP, at the local scale for both provinces' respondents with p-value of 0.0053 and 0.0616 , respectively. Remarkably, the income factor would be less important compared to education and attitude factors at local and national scale when investment proposed in the province provides tangible benefits from water quality improvement. People perceived that compared to the rivers in Ayutthaya Province, rivers in Krabi Province provided more economic incentives from tourism and existing values from maintaining the ecosystem, which are more related to respondents' knowledge and attitudes on benefits, especially on indirect benefits from water quality improvement.

Local WTP and national WTP were separately discussed regarding distance and types of perceived benefits to be different values. Therefore, we suggested assessing the local and national WTP in separation of the societal indicators for the co-benefits to cooperate with other indicators of environmental and economic dimensions. Nevertheless, these values could not be concluded in terms of total societal benefits from the project, unless, the geographical boundary of improved water quality could
be justified in sustainability aspects.

## Chapter 7

## Integrated valuation of CDM financial and co-benefits

### 7.1 Introduction and objective

The co-benefit CDM has the twin aims of GHG emission reduction and SD benefit delivery. Thus, the analysis has two main strands which are the sustainability benefit assessment and the GHG reduction accounting. As for methane recovery CDM project, values of project stand for trade-offs in water resources and project revenues from CERs and electricity increased economic benefits of projects, thereby increasing its investing attractiveness. As for the analysis of the benefits associated with the project, multi criteria decision analysis (MCDA) has been used for the assessment of the project. The criteria for the analysis were based on the SD framework which was discussed and developed into the formation of illustrated value tree. This approach can be applied to most community-based projects and has been tested on the case study methane recovery projects in Thailand. Simplification and flexibility of the MCDA method in this study is proposed to support decision making process without the need to purchase software.

The modalities for the decision-making of the finance and co-benefits from the methane recovery project are presented in this chapter. The study has addressed issues of simplification of procedures for the co-benefits integration of small-scale methane recovery projects to input to the simplified modalities for project investment prioritization and a bilateral/international procedure. A comparison with existing and proposed projects has revealed in different areas where this project can input to improve current advice on the original CDM mechanism.

### 7.2 Methodologies

Our approach analyzes the methane recovery CDM project in Ayutthaya province, Thailand that was already implemented, and SD assessment was carried out via site visits. It could be a template for methane recovery CDM projects because information
in the past year before the CDM implementation has therefore been generated and approved on actual benefits being delivered in practical ways. Then, the another site in Krabi province, Thailand where the methane recovery CDM project is proposed was assessed by using the previous case in Ayutthaya province as the example case.

### 7.2.1 Assessment of Sustainability Benefits from methane recovery CDM project

The MCDA is used to assess the study projects in Thailand. The starting point for generating the values associates with the appraisal of The Economics of Ecosystems and Biodiversity (TEEB) conceptual framework (refer in Chapter 2). After inspecting the project, the TEEB framework led to the formulation of the value tree illustrated in Figure 7.1. Financial analysis is used to grasp the financial conditions ,which separately discuss on dimensions of CDM investment and profitability/viability of project (with CERs revenues), by these 4 indicators (i.e., total CERs, CER generating cost, IRR, and net profit percentage) it makes judgment on the project's financial position level. Co-benefits analysis is used to grasp the co-benefits conditions originated from the CDM project, which separately discuss on dimensions of environmental impact and social preference to judge a level of sustainability benefits from the project by 3 indicators of cost to treat carbon and nitrogen, local WTP, and national WTP.


Figure 7.1 Value tree of key indicators on financial and co-benefits assessment

Then, each level's importance of indicator is established by determining their weights based on the degree of importance, and make a comprehensive matrix analysis. At last, the absolute results can be reached with a particular condition in this study.

A matrix is made to combine all the indicators together according to the importance levels or magnitudes ordered the figure above. Typically, in a conventional MCDA, the overall performance of different alternatives would be totally compared and the alternative with the highest expected score, total weighted sum of scores on relative preference scales over all the criteria, would be chosen as the best choice for further investigation (Begg, 2003). In site comparison for CDM implementation of this study, the MCDA assessment could not refer to how benefits the project delivers from the baseline situation or benchmark. Therefore, It is an assessment of selecting project site or that one project site is better than another site judged by the difference of the same indicator from expected financial status of investment after CDM implementation, and from selected co-benefit indicators in actual and perceptive values in same conditions of status quo. However, MCDA results are finally relative and dependent on the specific project circumstances in terms of how the project was implemented under particular funding criteria. Therefore, the suggestions from the results should be discussed about a range of benefits provided with the additional options which can improve project options.

### 7.2.2 MCDA with pairwise outranking assessment

In order to aggregate values of financial status of CDM project, environmental impacts and social preference from different valuation framework, rather than Costbenefit analysis (CBA), Multi-attribute method with outranking technique was selected based on the pairwise comparison and compromising preference concept that one alternative may have a degree of dominance over other alternatives (Kangas et al., 2001). The principle of outranking method is that dominance occurs when one option performs better than another on at least one criterion and no worse than the other on all criteria. It means the worse performance is not strongly rejected but it is still acceptable or compensable with other criteria (ODPM, 2004). Moreover, outranking technique is appropriate when performances in each criteria are not easily aggregated, performance scales vary in wide ranges, and units of performances are
incommensurate or incomparable (Linkov, 2006).

## - Outranking method (PROMETHEE method)

The PROMETHEE method is a multi-criteria decision method developed by Bran and Vincke (1985). In the MCDA, The ranking method is quite simple in a concept of alternative selection and application compared to other methods. It is well adapted to cope with a selection problem where a finite number of alternative actions $a_{i}$ are to be ranked considering several criteria $f_{j}$.

|  | $f_{l}()$. | $f_{2}()$. | $\ldots$ | $f_{j}()$. | $\ldots$ | $f_{q}()$. |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $a$ | $f_{l}(a)$ | $f_{2}(a)$ | $\ldots$ | $f_{i}(a)$ | $\ldots$ | $f_{q}(a)$ |
| $b$ | $f_{l}(b)$ | $f_{2}(b)$ | $\ldots$ | $f_{i}(b)$ | $\ldots$ | $f_{q}(b)$ |
| $\ldots$ | $\ldots$ | $\ldots$ | $\ldots$ | $\ldots$ | $\ldots$ | $\ldots$ |
| $a_{i}$ | $f_{l}\left(a_{i}\right)$ | $f_{2}\left(a_{i}\right)$ | $\ldots$ | $f_{j}\left(a_{i}\right)$ | $\ldots$ | $f_{q}\left(a_{i}\right)$ |
| $b_{i}$ | $f_{l}\left(b_{i}\right)$ | $f_{2}\left(b_{i}\right)$ | $\ldots$ | $f_{j}\left(b_{i}\right)$ | $\ldots$ | $f_{q}\left(b_{i}\right)$ |

The PROMETHEE method is set up to treat the multi-criteria problem by selecting maximum of preference functions in alternatives as a basic principle:
$f_{q}\left(a_{i}\right)=\max \left\{f_{l}\left(a_{i}\right), \ldots, f_{j}\left(a_{i}\right) \mid A\right\}$,

Where: $A$ is a finite set of possible alternatives, and $f_{q}(a)$ are performances of $f_{l}$ to $f_{j}$ criteria to be maximized. For each alternative, $f_{j}(a)$ is a performance of each alternative and criteria. When comparing two alternatives $(a, b \mid A)$, these comparisons of performances are expressed in terms of preference score, therefore, consider a preference function $P$ :

$$
P_{k}(a, b)=P_{k}(x)=P_{k}\left[f_{j}\left(a_{i}\right)-f_{j}\left(b_{i}\right)\right], \quad 0 \leq P_{k}(a, b) \leq 1
$$

$P_{k}(x)$ is a positive non-decreasing preference function, $P(x)=0$ for $x \leq 0$, and $0 \leq P(x)$ $\leq 1$ for $x>0$. The linear uni-criterion preference function is often used in practice for quantitative criteria:
$P_{k}(x) \begin{cases}0, & \text { if } x \leq q_{k} \\ \frac{x-q_{k}}{p_{k}-q_{k}}, & \text { if } q_{k}<x \leq p_{k} \\ 1, & \text { if } x>p_{k}\end{cases}$

Where: $q_{k}$ and $p_{k}$ are the indifference and preference thresholds, respectively. The meaning of these parameters is the following: when the difference of performances is equal or lower than the indifference threshold, uni-criterion preference score is equal to 0 because it is considered as indifference for decision process. When the difference of performances is equal or higher than preference threshold, the preference score is equal to 1 (maximum score) because it is considered to be significant by the decision maker. In case that the difference of performances is in between the two thresholds, an intermediate value is calculated for the preference score by using a linear interpolation.

Each preference function has been associated to weighting criterion by the decision makers, weighting can apply to all pairs of performances for all the criteria. A multicriteria preference score is then calculated to globally compare every couple of actions:

$$
\pi(a, b)=\sum_{k=1}^{q} P_{k}(a, b) \cdot w_{k}
$$

Where $W_{k}$ represents the weight of criteria $f$. It is assumed that $W_{k}>0$ and $\Sigma W_{k}=1$.

In order to position every pairwise score with respect to all the other pairwise scores, positive and negative preference scores are separately calculated:
$\phi^{+}(a)=\frac{1}{n-1} \sum_{x \in A} \pi(a, x)$
$\phi^{-}(a)=\frac{1}{n-1} \sum_{x \in A} \pi(x, a)$

The positive preference flow $\Phi^{+}\left(a_{i}\right)$ quantifies $a_{i}$ how a given pairwise score is outranking to all the other pairwise scores (representing the power) while the negative preference flow $\Phi^{-}\left(a_{i}\right)$ quantifies $a_{i}$ how a given pairwise score is outranked by all the other pairwise scores (representing the weakness). The value of preference flow is non-decreasing value between 0 to 1 . Discussion of outranking method can be separated into the Promethee I (partial ranking) and the Promethee II (complete ranking). The partial ranking means pairwise score $a_{i}$ is preferred when positive preference flow is equal or higher than other scores, and negative preference flow is equal or lower than other score (expect the positive and negative flows are same in each flow which means indifference). Some couples of pairwise scores are not comparable which is used as information for decision making. The complete ranking is requested by decision makers to avoid any incomparable by using net preference flow, then the alternative with the highest pairwise score can be considered as the best -fit alternative (Baker et al., 2002).

The Promethee I (partial ranking) is defined as the compromising of these two preference flows. As a consequence, an action $a_{i}$ will be as good as another action, if:
$\phi^{-}\left(a_{i}\right) \geq \phi^{-}\left(a_{j}\right)$
$\phi^{-}\left(a_{i}\right) \leq \phi^{-}\left(a_{j}\right)$

The Promethee II (complete ranking) is defined as the positive and negative preference flows are aggregated into the net preference flow:
$\phi(a)=\phi^{+}(a)-\phi^{-}(a)$

According to the definition of the multi-criteria preference degree, the multi-criteria net flow can be disaggregated to the equations as follows:
$\phi\left(a_{i}\right)=\sum_{k=1}^{q} \phi_{k}\left(a_{i}\right) \cdot w_{k}$
and
$\phi_{k}\left(a_{i}\right)=\frac{1}{n-1} \sum_{a_{j} \in A}\left\{P_{k}\left(a_{i}, a_{j}\right)-P_{k}\left(a_{j}, a_{i}\right)\right\}$

This equation is the uni-criterion net flow, which has the same interpretation as the multi-criteria net flow but is limited to one single criterion. Any action can be characterized by a vector in a dimensional space.

### 7.3 Results and discussion

Analysis in this part is to rescale performances/values of individual criteria in each chapter to be $0-1$ in order to make ordered comparative preference scores from decision indicators in the value tree. The performances/values are monetized to compare in each dimension, and used to determine the results of preference by optimization algorithms.

### 7.3.1 Cost functions of decision indicators

The cost functions, in Table 7.1, are indicated in each key indicator to individual criteria. The performances and values are obtained from the all previous chapters in this study.

Although, the result sets of financial and co-benefit matrix decision are calculated based on all monetary values for comparing in each criteria with universal standard, the outranking method is applied because although, even in monetary values, value aggregation in terms of cost-benefit analysis is going to be difficult because the valuation still deal with conflicting taxonomies of valuation techniques (i.e., environment, economic, and social).

Table 7.1 Cost functions of financial and co-benefit indicators

| Scope | Criteria | Key indicator | Cost function | Reference |
| :---: | :---: | :---: | :---: | :---: |
| Finance of CDM project | CER investment | Total CERs | $\begin{array}{r} \mathrm{BE}_{\mathrm{y}}-\mathrm{PE}_{\mathrm{y}} \\ \left(\mathrm{BE}_{\mathrm{y}}+\mathrm{BE}_{\text {grid }}\right)-\mathrm{PE} \end{array}$ | IPCC <br> methodology <br> Type (iii): Other project activities AMS-III.H. <br> Type (i): <br> Renewable energy projects AMS-I.D. |
|  |  | CER generating cost | Capital cost/ produced CERs | Michaelowa and Jotzo (2003) |
|  | Project profitability with CER revenue | IRR | $0=\Sigma\left(\mathrm{C}_{\mathrm{n}} /(1+\mathrm{r})^{\mathrm{n}}\right)$ | Schmidt (2013) |
|  | Project viability with CER revenue | Net profit percentage | Net profit/total cost investment * 100 | $\begin{aligned} & \text { COMPUSTAT } \\ & (2000) \end{aligned}$ |
| Co-benefits from CDM project | Environmental impact alleviation | Treatment cost of UASB | $647 x+22.65 x$ <br> (for combined cost) | Vieira and Souza (1986) |
|  |  | Treatment cost of CAS | $\begin{array}{r} 415.22 \mathrm{Q}_{\mathrm{d}}+754398 \\ \text { (for construction cost) } \\ 23.89 \mathrm{Q}_{\mathrm{a}}+77827 \\ \text { (for } \mathrm{O} \& \mathrm{M} \text { costs) } \end{array}$ | Wang, et al. (2009) |
|  |  | Treatment cost of MLE | $175.82 \mathrm{Q}_{\mathrm{d}}+38942$ <br> (for construction cost) $23.34 \mathrm{Q}_{\mathrm{a}}+18325$ $\text { (for } \mathrm{O} \& \mathrm{M} \text { costs) }$ | Foess, et al. (1998) |
|  | Social | Local WTP | N/A | Refer to Chapter 6 |
|  | preference | National WTP | N/A | Refer to Chapter 6 |

Remarks:
$\mathrm{BE}_{\mathrm{y}}=$ Baseline emission in the year $\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$\mathrm{BE}_{\text {grid }}=$ Emission of electricity produced in the year $\left(\mathrm{CO}_{2} \mathrm{e}\right)$
$\mathrm{PE}_{\mathrm{y}}=$ Emission of project activity in the year $\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$\mathrm{C}_{\mathrm{n}}=$ Cash flow in each period n (USD)
$\mathrm{r}=$ Internal rate of return (\%)
$x=$ designed digester volume $\left(\mathrm{m}^{3}\right)$
$\mathrm{Q}_{\mathrm{d}}=$ design flow rate of factory effluent $\left(\mathrm{m}^{3} / \mathrm{d}\right), \mathrm{Q}_{\mathrm{a}}=$ actual flow rate of factory effluent $\left(\mathrm{m}^{3} / \mathrm{d}\right)$
UASB $=$ Upflow anaerobic sludge blanket
CAS $=$ Conventional activated sludge system
MLE = the Modified Ludzack-Ettinger

### 7.3.2 Data acquisition of decision-making process

The data acquisition for MCDA process is selected from the results of assessments in all chapters of financial and co-benefits of the methane recovery CDM projects. In Table 7.2, as for financial indicators, the values of the two studied sites are decided with the same investment basis, i.e., the investment with 20 -year CER crediting period in the scheme of electricity sale to the grid, giving site-specific values of the study sites and scenarios. CER generating costs, from the scheme of internal electricity use, are not considered because IRRs and net profit percentage are respect to income/cash-flow majorly associated with electricity export. As for co-benefit indicators, the difference of values is based on the conditions of project site and community, and there is no different values between scenarios.

Table 7.2 Selection of data for decision-making process

| Num <br> -ber | Indicator | Unit | Value |  |  |  | Acquisition |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Scenario A* |  | Scenario B\&C** |  |  |
|  |  |  | Ayutthay <br> a site | Krabi site | Ayutthaya site | Krabi site |  |
| Financial indicators |  |  |  |  |  |  |  |
| i1 | Total CERs | $\mathrm{tCO}_{2} \mathrm{e}$ | 450,000 | 432,900 | 450,000 | 432,900 | Chapter 4 |
| i2 | CER generating cost | $\begin{aligned} & \mathrm{USD} \\ & / \mathrm{tCO}_{2} \mathrm{e} \end{aligned}$ | 13.49 | 12.36 | $\begin{array}{r} 17.93 \\ (11.74)^{* * * *} \end{array}$ | $\begin{array}{r} 16.98 \\ (10.62)^{* * * * *} \end{array}$ | Chapter 4 |
| i3 | IRR*** | \% | - | - | 24.32 | 29.57 | Chapter 4 |
| i4 | Net profit percentage*** | \% | - | - | 156.58 | 191.84 | Chapter 4 |
| Co-benefit indicators |  |  |  |  |  |  |  |
| i5 | Treatment cost of C\&N | USD/y | 75,134 | 66,250 | 75,134 | 66,250 | Chapter 5 |
| i6 | Local WTP | USD/household/y | 28.8 | 26.1 | 28.8 | 26.1 | Chapter 6 |
| i7 | National WTP | USD/household/y | 27.0 | 27.8 | 27.0 | 27.8 | Chapter 6 |

Remarks:
Financial indicators based on the CDM investment with a 20 -year crediting period

* Values from the investment with no gas generator invested for the lowest CER investment
** Values from the investment with 4 gas generators invested for the higher IRR
*** Not considered in scenario A because these indicators purpose for entities of investment, not for Annex I subsidizers/donors
**** Values for considering neutral GHGs emission in the scheme of electricity sale (CER generated in case of selling produced renewable energy to the grid)


### 7.3.3 Analysis of Decision matrix

The results of Pair-wise comparisons on performances/values are utilized from an average of preference scores from all pairings in an individual indicator. In a decision matrix, site locations are given to be alternatives preferably selected by criterion with different performances in each scenario. In Figure 7.2, for example, the preference score of site 1 in scenario $A$ in a decision of indicator $i$ is determined by a average score of preference functions of $P_{1}, P_{2}$, and $P_{3}$, which are pairings of performances scenarios and site locations (i.e., $X_{I}$ paired with $X_{2}, X_{I}$ paired with $Y_{l}$, and $X_{I}$ paired with $Y_{2}$ ). In each preference function $\left(P_{n}\right)$, it is normalized into scale $0-1$ by means of indicated thresholds and linear interpolation.

|  |  | Site 1 | Site 2 |
| :---: | :---: | :---: | :---: |
|  |  | Indicator ${ }_{P 2}$ | Indicator $\boldsymbol{i}$ |
| Scenario A |  | X1 | Y1 |
| Scenario B and C |  | X2 | Y2 |
| Site 1 | 11 | $\frac{P(X 1, X 2)}{P(X 2, X 1)} P 1$ | $P(Y 1, X 1), P(Y 1, X 2)$ $P(Y 2, X 1), P(Y 2, X 2)$ |
|  | i2 |  |  |
|  | i3 |  |  |
|  | 14 | P2 P3 |  |
| Site 2 | $i 1$ | $\begin{aligned} & P(X 1, Y 1), R(X 1, Y 2) \\ & P(X 2, Y 1), P(X 2, Y 2) \end{aligned}$ | $\begin{aligned} & P(Y 1, Y 2) \\ & P(Y 2, Y 1) \end{aligned}$ |
|  | i2 |  |  |
|  | i3 |  |  |
|  | 14 |  |  |

Figure 7.2 Guideline of pair-wise scoring in the outranking method

In decision matrix of financial decision, CDM investment models are distinguished to scenario A , and scenario B and C in purpose of deciding a site location with different decision makers of CDM investment (refer into Table 3.4, Chapter 3). Scenario A means the methane recovery CDM project contracted in 20-year CERs crediting period with no electricity generator investment in order to minimize the cost for
producing CERs because initial investment is a major barrier for developing countries to invest a project, thus, in a view point of subsidizers to invest UASB to recover releasing methane, CERs sale without a revenue of electricity sale is only concerning criteria to make a site selection. Whereas, scenario B and C are considered as the CDM investment from entities of capital share. According to maximize profitability and viability of project, the CDM project binding with 20-year CERs crediting period with 4 generators investment in the study projects (or full capacity of produced biogas) was chosen. Therefore, additional criteria (i.e., IRR and net profit percentage) are also included into the decision matrix for site comparison.

In Table 7.3, the performances and comparative scores of scenario A , and B and C shown in blue and green colors, respectively. All scores are dominance-based, which adjusted negative effect of values/performances on decision to all positive scores. Through comparisons, after applying CDM with additional CERs revenue from normal project investment, the IRRs for both studied sites, $24.32 \%$ and $29.57 \%$, are greatly higher than the expected IRR in Thailand year 2008, 5.6\%.

Table 7.3 The decision matrix of financial decision for site selection

|  |  | Ayutthaya |  |  |  | Krabi |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | 11 | i2 | i3 | 14 | i1 | i2 | i3 | 14 |
| Performance for Scenario A |  | 450,000 | 13.49 | - | - | 432,900 | 12.36 | - | - |
| Performance for Scenario B and C |  | 450,000 | 17.93 (11.74) | 24.32 | 156.58 | 432,900 | 16.98 (10.62) | 29.57 | 191.84 |
| Ayutthaya | i1 | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ |  |  |  | $\begin{aligned} & \hline-0.073,-0.073 \\ & -0.073,-0.073 \end{aligned}$ |  |  |  |
|  | i2 |  | $\begin{aligned} & 0.189(-0.074) \\ & -0.189(0.074) \end{aligned}$ |  |  |  | $\begin{gathered} 0.048,0.237(-0.026) \\ -0.148(0.122), \\ 0.040(0.048) \end{gathered}$ |  |  |
|  | i3 |  |  | 0 |  |  |  | 0.132 |  |
|  | 14 |  |  |  | 0 |  |  |  | 0.138 |
| Krabi | $i 1$ | $\begin{aligned} & 0.073,0.073 \\ & 0.073,0.073 \end{aligned}$ |  |  |  | 0 |  |  |  |
|  | i2 |  | $\begin{gathered} -0.048,0.148(-0.122) \\ -0.237(0.026), \\ -0.040(-0.048) \end{gathered}$ |  |  |  | $\begin{aligned} & 0.197(-0.074) \\ & -0.197(0.074) \end{aligned}$ |  |  |
|  | i3 |  |  | -0.132 |  |  |  | 0 |  |
|  | i4 |  |  |  | -0.138 |  |  |  | 0 |

[^2]As for the purpose of CER investment, Ayutthaya site clearly produced more CERs for both scenarios, but, in the scheme of electricity sale, it shows the lower CER generating costs in scenario $A$ then scenario $B$ and $C$ except the performances considering the case that neutral emission for the scheme of electricity sale. The CER generating costs for scenario B and $\mathrm{C}(11.74$ and 10.62 USD/tCO 2 e for Ayutthaya site and Krabi site, respectively) become lower than for scenario A (13.49 and 12.36 USD/ $\mathrm{tCO}_{2} \mathrm{e}$ for Ayutthaya site and Krabi site, respectively). In the purpose of profitability and viability of projects, Krabi site dominates over Ayutthaya site for all indicators of IRR and net profit percentage. The 0-1 non-decreasing scales of preference scores show normalized quantitative difference of paired performances (e.g., $0<x \leq 1$ indicating dominance over others, $0>x \geq-1$ indicating dominance under others, 0 indicating indifference).

According to values of co-benefits assessment, it can come to the sustainability decision matrix as shown in Table 7.4. Since the performances of co-benefits are originated from sustainability benefits or impacts to a specific site location, there is no separated scenarios in the matrix. Regardless comparing the magnitudes of comparative scores between indicators, Ayutthaya site dominates over Krabi site for all indicators except the indicator of national WTP (i8). The comparative scores on dominance of Ayutthaya site result in 0.006 ( $11.8 \%$ in difference) for an indicator of environmental impacts (i5) and 0.094 (9.4\% in difference) for an indicator of local WTP (i6), while, Krabi site scores dominance of 0.029 ( $2.9 \%$ of difference) for the indicator of national WTP (i7) over Ayutthaya site.

Table 7.4 Decision matrix of co-benefits decision for site selection

|  |  | Ayutthaya |  |  | Krabi |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | i5 | 16 | i7 | i5 | $i 6$ | 17 |
| Scenario A 20y crediting period no generator |  | 75,134 | 28.8 | 27.0 | 66,250 | 26.1 | 27.8 |
| Scenario B and C 20y crediting period 4 generators |  | 75,134 | 28.8 | 27.0 | 66,250 | 26.1 | 27.8 |
| Ayutthaya | i5 | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ |  |  | $\begin{aligned} & \hline-0.118 \\ & -0.118 \end{aligned}$ |  |  |
|  | 16 |  | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ |  |  | $\begin{aligned} & -0.094 \\ & -0.094 \end{aligned}$ |  |
|  | $i 7$ |  |  | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ |  |  | $\begin{aligned} & 0.029 \\ & 0.029 \end{aligned}$ |
| Krabi | i5 | $\begin{aligned} & 0.118 \\ & 0.118 \end{aligned}$ |  |  | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ |  |  |
|  | $i 6$ |  | $\begin{aligned} & 0.094 \\ & 0.094 \end{aligned}$ |  |  | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ |  |
|  | 17 |  |  | $\begin{aligned} & -0.029 \\ & -0.029 \end{aligned}$ |  |  | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ |

Remarks: Value $+=$ dominance , value $-=$ submission
$\mathrm{i} 5=$ indicator of environmental impacts (USD/y), $\mathrm{q}_{\mathrm{k}}=0$ USD/y, $\mathrm{p}_{\mathrm{k}}=75,134$ USD/y
i6 = indicator of local WTP (USD/household/y), $\mathrm{q}_{\mathrm{k}}=0$ USD/household/y, $\mathrm{p}_{\mathrm{k}}=28.8$ USD/household/y
i7 = indicator of national WTP (USD/household/y), $\mathrm{q}_{\mathrm{k}}=0$ USD/household $/ \mathrm{y}, \mathrm{p}_{\mathrm{k}}=27.8$
USD/household/y

### 7.3.4 Partial ranking of MCDA

The outranking method provides an opportunity of partial ranking in order to not give up an importance of inferior dominance. Table 7.5 and Table 7.6 show the preference scores in each indicator with positive flows/dominance-over and negative flows /dominance-under in given alternative sites. Consequently, the ranking in Figure 7.3 results in all indicators, except the indicators of CER generating cost, show discrete differences of preference flows between Ayutthaya site and Krabi site. Regardless of CER generating costs and weighting consideration to indicators, in scenario A, Ayutthaya site is dominant over Krabi site for the indicators of total produced CERs (i1), environmental impact (i5) and local WTP (i6), except the indicator of national WTP (i7). Whereas, in scenario B and C, Krabi site become dominant over Ayutthaya site from the indicators of IRR and net profit percentage.

Table 7.5 Preference scores of outranking method for selection of CDM site locations: Financial conditions

| Alternative | i1 |  | i2 |  | i3 |  | i4 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\Phi^{+}$ | $\Phi$ | $\Phi^{+}$ | $\Phi$ | $\Phi^{+}$ | $\Phi$ | $\Phi^{+}$ | $\Phi$ |
| Scenario A |  |  |  |  |  |  |  |  |
| Ayutthaya site | 0.049 | - | $\begin{array}{r} 0.169 \\ (-) \end{array}$ | $\begin{array}{r} 0.048 \\ (0.081) \end{array}$ | N/A | N/A | N/A | N/A |
| Krabi site | - | 0.049 | $\begin{array}{r} 0.161 \\ (0.048) \end{array}$ | $(0.050)$ | N/A | N/A | N/A | N/A |
| Scenario B and C |  |  |  |  |  |  |  |  |
| Ayutthaya site | 0.049 | - | $(0.050)^{-}$ | $\begin{array}{r} 0.155 \\ (0.048) \end{array}$ | - | 0.132 | - | 0.138 |
| Krabi site | - | 0.049 | $\begin{array}{r} 0.040 \\ (0.081) \end{array}$ | $\begin{array}{r} 0.173 \\ (-) \end{array}$ | 0.132 | - | 0.138 | - |

Remarks: $\Phi^{+}=$positive preference flow,$\Phi^{-}=$negative preference flow
$\mathrm{i} 1=$ indicator of total produced CERs, $\mathrm{i} 2=$ indicator of CER generating cost, $\mathrm{i} 3=$ indicator of IRR,
$\mathrm{i} 4=$ indicator of net profit percentage, values in the blankets $=$ averaged preference scores for CER generating costs by considering incremental GHG reduction from electricity sale

Table 7.6 Preference scores of outranking method for selection of CDM site locations: Co-benefits conditions

| Alternative | i 5 |  | i 6 |  | i 7 |  |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: |
|  | $\Phi^{+}$ | $\Phi^{-}$ | $\Phi^{+}$ | $\Phi^{-}$ | $\Phi^{+}$ | $\Phi^{-}$ |
| Ayutthaya site | 0.118 | - | 0.094 | - | - | 0.029 |
| Krabi site | - | 0.118 | - | 0.094 | 0.029 | - |

Remarks: $\Phi^{+}=$positive preference flow,$\Phi^{-}=$negative preference flow
i5 = indicator of environmental impacts, i6 = indicator of local willingness-to-pay,
i7 $=$ indicator of national willingness-to-pay


* Comparative scores of performances on CER generating cost for not considering incremental GHG reduction from produced electricity, exporting to the grid
** Comparative scores of performances on CER generating cost for considering incremental GHG reduction from produced electricity, exporting to the grid

Figure 7.3 Partial ranking of outranking method for selection of CDM site locations

From that reasons, it can be concluded that different objectives of CDM investment could be decided by considering quantitative flows in a concerned indicator. In a view point of CER investment (or scenario A), Ayutthaya site is dominant for total generated CERs and local people's perceptions, but the indicator of CER generating cost is opened to be widely justifiable with negative preference flows. Ayutthaya site, moreover, is dominant in achieving better co-benefits contribution, for alleviating
environmental impacts and local people's perceptions. Nevertheless, in terms of profitability and viability of the project (or scenario B and C), it is clearly shown that investors should select Krabi site by focussing on investment of electricity production by capturing biogas from the UASB implementation.

### 7.3.5 Complete ranking of MCDA

In order to achieve ordered preferential choices from the outranking method with a particular condition, complete ranking was made as an example for project prioritization by aggregating positive and negative preference flows to net preference flows in each indicator as shown in Table 7.7. Maximization of preference function is used for selection criteria. The selection is induced with a condition by assuming equal weighting, 0.25 , to each dimension and applied to all pairing scores, then, the sum of all weighted pairing scores comes to a final answer. As noticed by this condition, from the viewpoint of CER investment by subsidizer, Ayutthaya site is selected for a best-fit alternative in the scenario A with quantitative comparative scores of 0.080 and ( 0.030 ) over Krabi site with comparative scores of -0.010 and (0.049 ). This preference outcome in the scenario A is mainly influenced by the indicator of total CERs production (i1) with the difference magnitude of 0.049 and the indicator of environmental impacts with the difference magnitude of 0.118 . As for the investment in scenario B and C, Ayutthaya site is also more attractive for investors than Krabi site. The comparative scores of Ayutthaya site, 0.004 and ( 0.031 ), is preferred than the comparative scores of Ayutthaya site, -0.009 and ( 0.010 ), mainly from the indicator of environmental impacts. However, Krabi site becomes more competitive from the indicators of profitability and viability (i3 and i4) by the difference magnitudes of 0.132 and 0.138 , respectively, which originated from all revenues including CERs and electricity expected as returns from the project. The consideration of incremental GHGs reduction in the scheme of electricity sale has no a significant change for the ordered alternatives in each scenario.

From the all pair-wise results of preference choices in equal weighting approach, the UASB investment seems to be more preferred for Ayutthaya and Krabi sites than the investment of UASB coupling with gas generators. By considering incremental GHGs reduction in the scheme of electricity sale, Ayutthaya site obviously becomes the best-
fit site for the both investments of only UASB and UASB coupling with gas generators by importance of lower CER generating cost in scenario B and C , and higher CER generating cost in scenario A. As for an CDM investment in Krabi site, an investment of UASB coupling with gas generators is prioritized than only UASB investment in favor of counting GHGs reduction in the scheme of electricity sale.

Table 7.7 Preference scores of outranking method for selection of CDM site locations: Complete ranking

| Scenario |  | Finance of CDM project |  |  |  | Co-benefits of CDM project |  |  | Total score |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\mathrm{CDM}$ <br> investment |  | Project profitability and viability |  | Environmental impacts |  | ial ence |  |
|  | Panel weighting | 0.125 | 0.125 | 0.125 | 0.125 | 0.250 | 0.125 | 0.125 | 1.00 |
|  | Site location | i1 | i2 | i3 | i4 | i5 | i6 | i7 |  |
| A | Ayutthaya | 0.049 | $\begin{array}{r} 0.121 \\ (-0.081) \end{array}$ | - | - | 0.118 | 0.094 | -0.029 | $\begin{array}{r} 0.081 \\ (0.030) \end{array}$ |
|  | Krabi | -0.049 | $\begin{array}{r} 0.161 \\ (-0.002) \end{array}$ | - | - | -0.118 | -0.094 | 0.029 | $\begin{array}{\|r\|} \hline-0.010 \\ (-0.051) \\ \hline \end{array}$ |
| B\&C | Ayutthaya | 0.049 | $\begin{gathered} -0.155 \\ (0.002) \end{gathered}$ | -0.132 | -0.138 | 0.118 | 0.094 | -0.029 | $\begin{gathered} -0.009 \\ (0.011) \end{gathered}$ |
|  | Krabi | -0.049 | $\begin{gathered} -0.133 \\ (0.081) \end{gathered}$ | 0.132 | 0.138 | -0.118 | -0.094 | 0.029 | $\begin{gathered} -0.027 \\ (0.000) \end{gathered}$ |

Remark: values in the blankets $=$ averaged preference scores and total scores for CER generating costs by considering incremental GHG reduction from electricity sale

In equal weighting condition, Table 7.8 shows weighted comparative scores in each dimension. As noticed, the comparative scores of co-benefits indicators have significant effect on a change of ordered preference choices. Regardless of co-benefits assessment, Ayutthaya site is more attractive for investment in scenario A because of worthy CDM investment. Meanwhile, Krabi site is more interested for investment in scenario B and C due to higher profitability of electricity sale. Nevertheless, with the co-benefits integrated, it differentiates comparative scores to give a high priority to invest in Ayutthaya site by the importance of alleviating environmental impacts and higher local people's perception with increasing comparative score of 0.038 (or 3.8\%
in difference) to the scores of financial indicators.

Table 7.8 Weighted comparative scores of financial and co-benefit indicators in each dimension concern: Complete ranking

| Scenario |  | Finance of CDM project |  |  | Co-benefits of CDM project |  |  | Total score |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | CDM <br> investment | Project profitability and viability | SUM | Environmental impacts | Social preference | SUM |  |
|  | Panel weighting | 0.25 | 0.25 |  | 0.25 | 0.25 |  | 1.00 |
| A | Ayutthaya | $\begin{array}{r} 0.043 \\ (-0.008) \end{array}$ |  | $\begin{array}{r} 0.043 \\ (-\mathbf{0 . 0 0 8 )} \end{array}$ | 0.030 | 0.008 | $\begin{array}{r} 0.038 \\ (0.038) \end{array}$ | $\begin{array}{r} \hline 0.081 \\ (0.030) \end{array}$ |
|  | Krabi | $\begin{array}{r} 0.028 \\ (-0.013) \end{array}$ | - | $\begin{array}{r} 0.028 \\ (-0.013) \end{array}$ | -0.030 | -0.008 | $\begin{array}{r} -0.038 \\ (-0.038) \end{array}$ | $\begin{array}{r} -0.010 \\ (-0.051) \end{array}$ |
| B\&C | Ayutthaya | $\begin{aligned} & -0.013 \\ & (0.006) \end{aligned}$ | -0.034 | $\begin{array}{r} -0.047 \\ (-0.027) \end{array}$ | 0.030 | 0.008 | $\begin{array}{r} 0.038 \\ (0.038) \end{array}$ | $\begin{aligned} & \hline-0.009 \\ & (0.011) \end{aligned}$ |
|  | Krabi | $\begin{aligned} & -0.023 \\ & (0.004) \end{aligned}$ | 0.034 | $\begin{array}{r} \hline 0.011 \\ (0.038) \end{array}$ | -0.030 | -0.008 | $\begin{array}{r\|} \hline-0.038 \\ (-0.038) \end{array}$ | $\begin{array}{r} -0.027 \\ \mathbf{( 0 . 0 0 0 )} \end{array}$ |

Remark: values in the blankets $=$ weighted preference scores and total scores for CER generating costs by considering incremental GHG reduction from electricity sale

### 7.3.6 Utilization of the methodology and relevant stakeholders

These integrated assessment methods and comparative technique provided a balance between finance of the international-organized CDM and local sustainability in CDM host countries. The simplicity of these methodologies could be useful for stakeholders related to CDM investments to utilize it with ease and compromise decision. Although all indicators are expressed in monetary values but it just shows how much difference in quantitative score between sites and scenarios. The score could not be comparable with the other criteria and it should be considered in each indicator and dimension individually. For example, CDM subsidizer should consider preference scores in concerned indicators in scenario A, but in a view point of all entities of project investment, it should make decision by using scenario B\&C and giving different weights to each dimension in decision-making process.

Normally, the CDM investment mostly is initiated by project participants from collaboration of a private and/or public entities from an investing country (AnnexI
country) and a host country (non-AnnexI country). In project development process, the project development document (PDD) is prepared by a host country's company, responsible for project execution with an assent of a factory owner. After either the PDD document is evaluated and registered under the UNFCC framework, or the PDD is agreed in Joint Crediting Mechanism (JCM), an implementation of cleaner technology would be proceeded by an investing country's company or a public sector for managing and contacting entities of the project (including a project donor), then assign a contractor for installation, operation and maintenance of technology under long-term agreement of CER procurement. An urge of using valuation techniques with co-benefits integrated for site preference would benefit a project donor for allocating fund with local sustainability consideration and community involvement, and it would be applied in the PDD preparation stage in terms of co-benefit assessment by project developers as the mechanism shown in Figure 7.4.


Figure 7.4 Proposed mechanism for the integrated assessment method of co-benefit CDM projects: mechanism procedure and responsibilities of relevant stakeholders

The integration of co-benefit assessment in the proposed mechanism would induce the changes of duty for project preparation and decision process for project prioritization by particular stakeholders as follows;

## - CDM project developer

In order to support information for decision-making process of project prioritization, project developer would set up the co-benefit indicators, corresponding with SD guiding tool for specific type of the CDM (under developing process in present for UNFCCC mechanism), or an agreement of investment entities and evaluators under the JCM. Data collection and assessment for proposing comparative performances of additional finance status (i.e., CER generating cost and IRR with CER revenue) and co-benefit indicators from a CDM project should be initiated by a project developer on a track of defining standardized baseline including benchmark and indicators of co-benefits in each project type for developing top-bottom process. The performances of co-benefits are recommended to be also evaluated and monitored by an independent entity as same as CER production to validate and ensure visibility of cobenefits, especially co-benefits applicable to pricing mechanism.

## - CDM project donor

In order to allocate funds to a best-fit project in particular conditions, CDM donor and/or investment entities could apply the proposed method with MCDA outranking technique for project prioritization with different purposes of the CDM investment. In the proposed methodology, the highest comparative score should be basically selected by a function of preference maximization. Justification, however, could be applied for each concerned indicator by integrating other decision-making methods, i.e., expert judgement, analytic hierarchy process (AHP), and panel weighting approach into this ranking technique. It is suggestion that project donor especially for the JCM should initially provide an example of expected benefits of the CDM to coverage all CDM project types, which, somehow, help to give a direction of co-benefit assessment for project developers, then, standardization of co-benefits indicators is expected to develop for site selection on comparison basis.

### 7.4 Conclusions

Through all concerned indicators including financial and co-benefits indicators from the assessments of the previous chapters. A multi-criteria decision analysis (MCDA)
which combine valuation techniques and pair-wise comparisons (outranking technique) was elaborated as a supporting tool for selecting CDM site preference. According to the process of outranking method, the analysis was conducted step by step, by selecting and ordering key indicators, eliciting performances of indicators, and creating the matrix for combining these indicators towards different investment objectives. Finally, the results and outcomes has been reached to following conclusions;

- The outranking method as structured approach expressed an comparative analysis of established valuable indicators for selection of site studies with a quantitative sound, which benefits to cooperate into market-based mechanisms of the CDM;
- An financial status in terms of project profitability and net profit percentage for both site, based on costs and all incomes, the IRR and net profit percentage improved into a good state for methane recovery technology investment in Thailand;
- With consideration of the co-benefit indicators, they have significant effects on the change of ordered preference scores and differentiated comparative score with the score of 0.038 (or $3.8 \%$ in difference), nevertheless, objective for site selection is depend;
- Due to CDM investment considered as full or partial foreign financial funds with various beneficiaries, the selection method was proven to be capable of discussion in individual criteria and indicators;
- In partial ranking, the discrete comparative scores between positive and negative preference flows were resulted from all indicators except the indicators of CER generating cost, which can be justifiable in decision process. In all scenarios, Ayutthaya site competed over Krabi site in the indicators of total produced CERs, environmental impacts, and local WTP, except the indicators of national WTP and questionable CER generating cost. Whilst, in scenario B\&C, Krabi site became more competitive by the
indicators of IRR and net profit percentage;
- In equal weighting approach of complete ranking, Ayutthaya site competed over Krabi site for scenario A and $\mathrm{B} \& \mathrm{C}$ from viewpoints of CDM subsidizers and host country, which are benefited from lower cost of CER investment and co-benefits. The indicators of project profitability and viability from biogas generation have no significant effect to make Krabi site competing over Ayutthaya site;
- The UASB investment is more preferred for Ayutthaya and Krabi sites than the investment of UASB coupling with gas generators. Nevertheless, by considering incremental GHGs reduction in the scheme of electricity sale, Ayutthaya site obviously became the best-fit site for the both investments of only UASB and UASB coupling with gas generators by importance of lower CER generating cost in scenario $\mathrm{B} \& \mathrm{C}$;
- The proposed co-benefit integrated mechanism from this study provided more "visibility" of co-benefits from the CDM by introducing the quantifiable scores, and proposing the changes of duty and comparative decision-making process to project developers and project donors.


## Chapter 8

## Conclusions and recommendations

### 8.1 Conclusions

The CDM for GHGs emission reduction has allowed developed countries with emission reduction commitment to earn emission reduction credits from where it makes the investment worthwhile (mostly in developing countries). Together with earned credits, local sustainability benefits, called co-benefits, are also expected to achieve in invested host countries. In recent years, comprehensive analysis for project prioritization to invest a CDM project by integrating local benefits has been challenging for decision making process. This study aims to develop a model to valuate co-benefits on improved water quality by implementing methane recovery CDM project to non-aerobic waste storage lagoons. Competitive two studied sites (ethanol and crude palm oil plants in Ayutthaya and Krabi provinces in Thailand) were chosen to develop an evaluation model in terms of financial, environmental, and societal metrics. The overall conclusions of the assessment on finance and co-benefits CDM projects from the investment of methane recovering technology for project/site preference could be made as follows;

1. In terms of CDM business, financial assessment is basically required for allocating investment funds. The methane recovery projects represented the CDM project implementation to the study sites, Ayutthaya and Krabi, with economical functions of CERs and electricity revenues. Cost investment for both sites were estimated lower transaction costs of 12.36-35.87 USD/tCO $\mathrm{CO}_{2} \mathrm{e}$ for CER production compared with averaged carbon price of carbon taxation scheme, 35 USD/ $/ \mathrm{CO}_{2} \mathrm{e}$. Ayutthaya site produced more CERs than Krabi site in a certain CER crediting period, however, it costed the higher CER generating cost because of larger UASB and less operating days by assuming that biogas is produced without storage. Anyway, CER generating cost could be changed by considering different emission trading schemes of electricity sale and internal electricity use. Although, the methane recovery projects had been proven to not be "business-as-usual" but electricity sale is a major revenue. Krabi site
was more attractive for investors in terms of IRR and net profit percentage, 29.57\% and $191.84 \%$, respectively with 20 -year CER crediting period. The IRR highly depended on the number of generators invested, but it should be particularly considered by business entities with depreciation cost and loan-debt conditions.
2. Apart from financial assessment, the indicators for co-benefits from CDM projects by assessing environmental impacts from high-strength wastewater operation, pointsource pollutants and infiltrated pollutants were separately valuated. The valuation of point-source pollutants is chosen to be a co-benefits indicator of environmental impacts due to the purposes to expand its applicability by simple assessment and give direct relation to the societal valuation from a view of cleaner public water. From the results of the point-source pollutant valuation, Ayutthaya site resulted a higher environmental alleviation from the methane recovery CDM than Krabi site. Ayutthaya site costed 75,134 USD/y over the cost of Krabi site, 66,250 USD/y because a larger UASB size required in Ayutthaya site. The cost of UASB treatment was the determining factor to differentiate the costs of environmental impact and define environmental alleviation from methane recovery CDM project, by the reactor size of UASB units required to reduce COD concentration to an acceptable range for CAS influent. As for the valuation of infiltrated pollutants, it estimated the cost of 16,384 and 11,044 USD/y for Ayutthaya and Krabi sites, respectively. The results of pollutants removal cost showed that cost to treat nitrate rather than cost of oxygen supplement by assuming that nitrified ammonium is all nitrified under lagoons, was the most valuable contaminant and differentiated environmental impacts between project sites.
3. To integrate social involvement to the co-benefits and aid CDM funds by developed countries from unavoidable questions of the investments, valuation of the social preferences were conducted using contingent valuation method (CVM) with willingness-to-pay (WTP) question with 3 different starting bid values of 20, 50 and 100 THB per household/month for sub-samples of local respondents (Ayutthaya and Krabi residents) and national respondents (Bangkok residents) on a purpose of onestep water quality improvement in each Ayutthaya's and Krabi's rivers from status quo. Questionnaire survey was conducted by the hypothetical markets for cleaner surface water appearance and for more recreational activities by face-to-face
interviews with dichotomous choice (closed-end double-bounded technique). The results showed that a higher acceptance rate to pay was from local respondents than national respondents. The social preferences also resulted in significant different mean WTPs in each sub-samples (28.8, 26.1 USD per household/y for local respondents in Ayutthaya and Krabi, respectively, and 27.0, 27.8 USD per household/y for national respondents in Ayutthaya and Krabi, respectively). The economical status of household is a key decision to WTP from an individual site for both institutional scales in Ayutthaya site, but the explanatory variables expressed differently in terms of household income and household members for national and local respondents, respectively. However, the factor of household economical status became less important following by educational level and factors of attitude towards river water quality, when an the investment proposed in Krabi province, at which it was perceived to make more tangible benefits from improved water quality, e.g., economic incentives from tourism and existence values from natural conservation. From the reasons mentioned, we suggest to consider the importance of spacial scale regarding distance and types of perceived benefit on water quality improvement to be measured and compared separately for the analysis of co-benefits assessment.
4. Due to simplified methodologies of financial, environmental, societal assessment for co-benefits CDM prioritization, it could give an ease to widen utilization or application in CDM wastewater works. This method could be used in a comparison basis between projects as supporting informations for allocating CDM finance with co-benefits integration. To compare values of environmental impacts between projects, the methodology of point-source pollutants valuation for environmental impact applied with studied sites. They could apply for any point sources and concentrations of carbon/nitrogen pollutants. They also gave low financial barrier for assessing the benefit values from the CDM projects without instrument investment to assess environmental impact which increase transaction cost to burden the CDM by its simplicity of methodologies. The infiltrated pollutants valuation could not estimate an actual benefit value, unless, the comparison of costs on environmental impact before and after CDM implementation is assessed. To compare values of social preferences between projects, it could be applied to studied sites with CVM regarding their preferences for improvement of river water quality from status quo in current situations in each site. Nevertheless, questionnaire survey was the most time-
consuming task of this study because it required a credible number of samples and explanation of the hypothetical market for river quality.
5. In the integrated valuation study, the MCDA for comparing and ranking different site alternatives that evaluated by monetary indicators from financial, environmental, and social aspects was elaborated with outranking method (pair-wise comparisons). The key indicators were illustrated in the value tree for making decision matrix and separated into different business models of CDM investment. This method was proven to express comparative quantifiable scores with the concerns in "profitability", "transparency" and "community participation" for discussions on individual indicator and the absolute results. In partial ranking, Ayutthaya site competed over Krabi site in the indicators of total produced CERs, environmental impacts, and local WTP except the indicators of IRR, net profit, and national WTP. The discrete preference scales between positive and negative preference flows resulted for all indicators except CER generating cost which is opened to be the justifiable indicator in decision making process. In complete ranking, Ayutthaya site competed over Krabi site for scenario A and $\mathrm{B} \& \mathrm{C}$ from viewpoints of CDM subsidizers and investors, which are benefited from lower cost of CER investment and co-benefits recognition. Co-benefits indicators have significant effects on the change of ordered preference scores and differentiated comparative score with the score of 0.038 (or $3.8 \%$ in difference). From the all pair-wise results of preference choices in equal weighting approach, the UASB investment is more preferred for Ayutthaya and Krabi sites than the investment of UASB coupling with gas generators. Whilst, by considering incremental GHGs reduction in the scheme of electricity sale, Ayutthaya site obviously became the bestfit site for the both investments of only UASB and UASB coupling with gas generators by importance of lower CER generating cost in scenario B\&C. This comparative method provided a guideline or a starting point for what will be developed or expanded to applicability of the co-benefits CDM approach in voluntary assessment by project developers or even in the international mechanism integrated with price premium, rather than a present checklist approach based on "Do no harm" and "Scoring" practice.

### 8.2 Recommendations

Based on the findings, recommendations for consideration of this study by focussing on limitations and framework expansion are presented as follows;

1. The objective of this study is to suitably indicate the indicators of co-benefits from methane recovery CDM project for project prioritization by outranking scores. In this regard, the dimensions of project finance and environmental alleviation from highstrength wastewater operation in open lagoons by methane recovery project, as well as social preference were monetized, but in my study case, these values could not be concluded in terms of total benefit value from the project, unless, the values from financial and environmental dimensions are selected to avoid double counting and summarized into total benefit value in a project lifetime. In case that there is impact outside the project boundary, the value of environmental impact should be conducted with different methods (e.g., travel cost and hedonic price). The value in terms of total economic value with non-use value of the project from social preference could be obtained if the geographical boundary of those reduced pollutants could be justified in sustainability aspects.
2. Basically, the project development document (PDD) is prepared by a consultant to prove "additionality" in terms of unattractive financial status. In financial assessment of this study, the data of the implemented PDD in Ayutthaya site was accessed and adjusted with functions of CER crediting period and a number of electricity generators, whereas, the data input to the analysis of Krabi site was acquired by estimation methods relied on the Ayutthaya's PDD, in which the capital and operating costs varied with the same basis of volumetric COD loading rate. Due to the limitation of data acquisition from private company, it is important to note that the treatment system could be designed differently in details for a change of COD loading rate (e.g., more or larger water pipes, pumps, different bypass ratios, etc.). This analysis of this study would be expected as pure speculation for consideration of methane recovery CDM investments.
3. In financial assessment of methane recovery CDM projects, due to unavailability of disclosed informations from private companies, the data of electricity imports was
limited for estimating GHGs emission and financial returns. The analysis of CER generating cost in the schemes of electricity sale and internal electricity use was made in a case that electricity demand of factory is larger than produced electricity. Ethanol and crude palm oil factories in Thailand mostly apply wet manufacturing process, which require high energy input. From that reason, some industries possibly generating electricity more than electricity import (mostly in dry manufacturing process), could be different from the analysis by forcedly exporting full or partial produced electricity.
4. The financial assessment of CDM investment is highly depend on conditions of marketability on internal CER price and domestic electricity tariff. Moreover, the results would reflex economic fluctuation at that time (e.g., material and labor costs,, interest cost, corporation tax, acceptable IRR, etc.). Thus, minimum requirement for gas generator and CER crediting period could not be referred as absolute answers. Since the fixed size of gas generator is used in this study, efficiency due to different generator sizing is another concern affecting electricity production. In addition, overhaul costs for prolongation of all assets within 20-year CER crediting period should practically be appraised and taken into consideration for optimizing a profit gain.
5. In the assessment of environmental impacts, hypothetical wastewater/water treatment systems were used for estimating the pollutant costs of environmental impacts. Feasible treatment systems were selected based on typicality of simple treatment process, available in developing countries (host countries of CDM investment). Although, applicability of this assessment is versatile due to its simplicity, suitable treatment systems in a particular condition are specific on wastewater characteristics/strengths, system footprint, energy recovery, water reuse, legislation of public water release in a country, etc.
6. The potentiality of nitrate groundwater contamination was used to assess a value of infiltrated pollutants in the context of comparison basis between project sites. Since, mechanisms of denitrification in saturated condition of groundwater plume for reducing nitrate are complex biogeochemical processes (which are relative to the influence of organic carbon, sulphur and iron electron donors, physical restrictions on
microbial activity in dual porosity aquifers, influences of shallow groundwater flow conditions), However, it could not be appropriate to assess attenuation processes in groundwater plume for estimation methods of feasibility study. Nevertheless, monitoring process during project's operation phase for nitrate contamination is suggested for verification of the co-benefits from the CDM.
7. As for the assessment of social preference, local WTP and national WTP were separately discussed regarding distance and types of perceived benefits. Therefore, it is remarkable that local WTP may not be comparable to national WTP in terms of total economic values by multiplying a number of households. However, it is still applicable to express total economic values from CVM in the cost-benefit analysis by using the data of national WTPs.
8. In order to estimate WTP for the co-benefits indicator, the constrains of money and time is a burden for this assessment because face-to-face questionnaire surveys with explanation of hypothetical market about water quality have to be conducted in a host country. In order to fasten the process, the benefit transfer method, by using existing data from similar studied sites to a new site, is recommended. Furthermore, from the result of values attached on the types of land uses, classifying types of land uses and expanding the study to different land use types would benefit for saving money and time in universal application.
9. In decision-making analysis, the magnitudes of preference scores are influenced by the number of data inputs in an indicator. The number of project sites affects the magnitudes of scores in comparison basis. The discrete preference flows was resulted in this study with two studied sites applied. It should be noted that the preference scores could be referred as case-by-case basis in a selection. Basically, a score of individual indicator could not be compensated with others, but they are used for data support for a selection matrix. It still requires another decision process, e.g., analytical hierarchy process, expert judgement, etc., in order to achieve a best-fit choice by relevant stakeholders.
10. In the final decision of CDM investment, each indicator justification could be included in decision-making process. For the sustainable development perspective, it
can be used to support an additional information to CDM investors, and to justify subsidies of relevant mechanisms. Furtherly, it is important that researches on improving the framework is required, considering on the reduction of uncertainties, expanding of the types of CDM implementation and criteria pollutants for environmental and economic impacts assessment, indicating a boundary of impacts/benefits, and justification of MCDA in decision-making process.

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## APPENDIX I

## Calculation of greenhouse gases

 emission reduction
## Calculation of Greenhouse gas emission reductions

The study was concluded using relevant methodology AMS-I.D. and AMS-III.H. under UNFCC methodologies.

AMS-III.H. Methane Recovery in Wastewater Treatment (Version 10, Scope 13, in effect as of Oct. 10, 2008)

AMS-I.D. Grid Connected Renewable Electricity Generation (Version 13, Scope 1, in effect as of Dec. 14, 2007)

## Emission reduction per year (ERy) from AMS-III.H.

$E R_{y}=$ Total Baseline emission $-\left(\right.$ Total PE ${ }_{y}+$ Total Leakage $\left.{ }_{y}\right)$

| Project site | Emission reduction <br> ,ERy (tCO2e) | Total baseline <br> emission $\left(\mathrm{tCO}_{2} \mathrm{e}\right)$ | Total project emission <br> $(\mathrm{tCO} 2 \mathrm{e})$ |
| :--- | ---: | ---: | ---: |
| AMS-III.H. | 22,500 | 41,625 | 19,125 |
| Ayutthaya | 21,645 | 40,126 | 18,481 |
| Krabi | $2,967^{*}$ | - | - |
| AMS-I.D. | $3,243^{*}$ | - | - |
| Ayutthaya | - |  |  |
| Krabi |  |  |  |

Remarks:
total leakage $=0, *$ Emission reductions from AMS-I.D. are account for additional emission reductions to overall calculated emission reductions of AMS-III.H. And AMS-I.D.

## Description of baseline in AMS-III.H.:

$B E_{y}=\left\{B E_{\text {power, }, ~}+B E_{w w, t r e a t m e n t, y}+B E_{s, \text { treatment, } y}+B E_{w v, \text { discharge, }, ~}+B E_{s, f \text { final, },}\right\}$
where :
BEy : Baseline emissions from an existing wastewater treatment in year ( $\mathrm{tCO}_{2} \mathrm{e}$ )
$\mathrm{BE}_{\text {power, } \mathrm{y}} \quad:$ Baseline emissions from electricity or fuel consumption in year ( tCOze )
BEww,treatment,y $\quad$ : Baseline emissions of the wastewater treatment systems affected by the project activity in year ( $\mathrm{tCO}_{2} \mathrm{e}$ )
$\mathrm{BE}_{s, \text { treatment, } \mathrm{y}} \quad$ : Baseline emissions of the sludge treatment systems affected by the project activity in year ( $\mathrm{tCO}_{2} \mathrm{e}$ )
$\mathrm{BE}_{\mathrm{ww}, \text { discharge, } \mathrm{y}} \quad:$ Baseline methane emissions from degradable organic carbon in treated wastewater discharge into lake/lagoon in year ( $\mathrm{tCO}_{2} \mathrm{e}$ )

BEs,final,y $\quad:$ Baseline methane emissions from anaerobic decay of the final sludge produced in year ( $\mathrm{tCO}_{2} \mathrm{e}$ )

## Baseline emissions from electricity or fuel consumption in year (BEpower, )

$B E_{\text {power, }, ~}=E P_{\text {consumed }} * E F_{\text {consumed }}$
$B E_{\text {power }, \text { ( }}($ for Ayutthaya site $)=0\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$B E_{\text {power, },}($ for Krabi site $)=0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya <br> value | Krabi <br> value | Unit | Source/Reference |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Electricity consumption by <br> all equipment/devices in <br> the baseline wastewater and <br> sludge treatment facilities <br> in year | EP consumed | 0 | 0 | MWh | There is no <br> equipment in existing <br> system, therefore, |
| there is no power to |  |  |  |  |  |
| be consumed. |  |  |  |  |  |$|$

Baseline emissions of the wastewater treatment systems affected by the project activity in year (BEww,treatmenty)

$B E_{\text {wn,treatment } y}($ for Ayutthaya site $)=8,325\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$
$B E_{\text {wv, treatmenty }, ~}($ for Krabi site $)=8,025\left(\mathrm{tCO}_{2} \mathrm{e}\right)$

Where:

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Volume of wastewater per day | Qww,i,d | 323 | 464 | $\mathrm{m}^{3} / \mathrm{d}$ | Estimated plant data. |
| Operating days | D | 268 | 293 | Days | The annual average value of the factory results of 2006. |
| Volume of wastewater treated in baseline wastewater treatment system "i" the year " $y$ " | $\mathrm{Qwww}_{\text {w, y }}$ | 86,564 | 135,952 | $\mathrm{m}^{3}$ | $\begin{aligned} & \text { Calculated as } \mathrm{Qww}_{\mathrm{ww}, \mathrm{y}} \\ & =\mathrm{Q}_{\mathrm{www}, \mathrm{~d}} * \mathrm{D} \end{aligned}$ |
| Chemical oxygen demand removed by baseline treatment system " i " in year " $y$ ", measured as the difference between inflow | $\underset{\text { ed, }, \mathrm{i}, \mathrm{y}}{ } \mathrm{CO}$ | 0.029 | 0.018 | $\begin{gathered} \text { tonnes/ } \\ \mathrm{m}^{3} \end{gathered}$ | It is assumed that the existing lagoons are the conventional anaerobic reactor which can remove |


| COD and the outflow COD <br> in system " i " |  |  |  |  | Chemical Oxygen <br> Demand (COD) at <br> 20\% efficiency. |
| :--- | :--- | ---: | ---: | ---: | :--- |
| Methane correction factor <br> for baseline wastewater <br> treatment system " i " | MCF $_{\mathrm{ww}, \mathrm{tr}}$ eatment,BL, | 0.8 | 0.8 | - | IPCC default value, <br> as per AMS-III.H. <br> table III.H.1. |
| Methane producing <br> capacity of the wastewater | $\mathrm{B}_{\mathrm{o}, \mathrm{ww}}$ | 0.21 | 0.21 | $\mathrm{kg} \mathrm{CH} / /$ <br> kg COD | IPCC default value, <br> as per AMS-III.H. |
| Global Warming Potential <br> for methane | GWPCH4 | 21 | 21 | - | AMS-III.H. |
| Model correction factor to <br> account for model <br> uncertainties | UFBL | 0.94 | 0.94 | - | AMS-III.H. |

Remark: * $0.145\left(\mathrm{t} / \mathrm{m}^{3}\right)^{*} 0.2$ for Ayutthaya, $0.089\left(\mathrm{t} / \mathrm{m}^{3}\right)^{*} 0.2$ for Krabi

Baseline emissions of the sludge treatment systems affected by the project activity in year (BEs,treatment,y)

$$
B E_{s, \text { treatment. }}=\Sigma_{j S_{j, B L, ~} *} * M C F_{s, \text { treatment,BL, }} * G W P_{C H 4} * U F_{B L} * D O C_{s} * D O C_{F} * F^{*} 16 / 12
$$

$B E_{s, \text { treatment, }}($ for Ayutthaya site $)=0\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$B E_{s, \text { treatment, },}($ for Krabi site $)=0\left(\mathrm{tCO}_{2} \mathrm{e}\right)$

Where:

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Amount of dry matter in the sludge that would have been treated by the sludge treatment system " j " in the baseline scenario | $\mathrm{S}_{\mathrm{j}, \mathrm{BL}, \mathrm{y}}$ | 0 | 0 | tonne | Sludge is not envisaged for this baseline scenario. |
| Methane correction factor for baseline sludge treatment system " j " | $\underset{\text { ment,BL,i }}{\mathrm{MCF}_{\mathrm{s}, \text { treat }}}$ | 0.8 | 0.8 | - | IPCC default value, as per AMS-III.H. table III.H.1. |
| Global Warming Potential for methane | GWPCH4 | 21 | 21 | - | AMS-III.H. |
| Model correction factor to account for model uncertainties | UFBL | 0.94 | 0.94 | - | AMS-III.H. |
| Degradable organic content of the untreated sludge generated in the year | DOCs | 0.257 | 0.257 | - | AMS-III.H. |
| Fraction of DOC dissimilated to biogas | DOCF | 0.5 | 0.5 | - | IPCC default value, as per AMS-III.H. |
| Fraction of $\mathrm{CH}_{4}$ in biogas | F | 0.5 | 0.5 | - | IPCC default value, as per AMS-III.H. |

## Baseline methane emissions from degradable organic carbon in treated wastewater discharge into lake/lagoon in year ( $\mathrm{BE}_{\mathrm{ww} \text {,discharge, } \mathrm{y}}$ )

$B E_{w w, d i s c h a r g e, y}=Q_{w w, y} * C O D_{w v, d i s c h a r g e, B L, y} * M C F_{w v, B L, d i s c h a r g e} * B_{o, w w} * G W P_{C H 4} * U F_{B L}$
$B E_{w v, d i s c h a r g e, y}($ for Ayutthaya site $)=33,300\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$
$B E_{w w, d i s c h a r g e, y}($ for Krabi site $)=32,101(\mathrm{tCO} 2 \mathrm{e})$

Where :

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Volume of wastewater per day | Qww,i,d | 323 | 464 | $\mathrm{m}^{3} / \mathrm{d}$ | Estimated plant data. |
| Operating days | D | 268 | 293 | Days | The annual average value of the factory results of 2006. |
| Volume of wastewater treated in baseline wastewater treatment system "i" the year " y " | Qwwi, y | 86,564 | 135,952 | $\mathrm{m}^{3}$ | $\text { Calculated as } \mathrm{Qww}_{\mathrm{ww}, \mathrm{i},}$ $=\mathrm{Q}_{\mathrm{ww}, \mathrm{~d}, \mathrm{~d}} * \mathrm{D}$ |
| Chemical oxygen demand of the treated wastewater discharged into lake/lagoon in the baseline situation in the year " $y$ " | $\underset{\text { charge,BL, }, \mathrm{dis}}{\mathrm{COD}_{\text {wis }}}$ | 0.116 | 0.071 | tonnes/ $\mathrm{m}^{3}$ | It is assumed that Chemical Oxygen Demand (COD) is remained $80 \%$ after anaerobically treated prior to discharge to the lagoons. |
| Methane correction factor for baseline wastewater treatment system " $i$ " | $\begin{aligned} & \mathrm{MCF}_{\mathrm{ww}, \mathrm{tr}} \\ & \text { eatment,BL,i} \end{aligned}$ | 0.8 | 0.8 | - | IPCC default value, as per AMS-III.H. table III.H.1. |
| Methane producing capacity of the wastewater | Bo,ww | 0.21 | 0.21 | $\begin{aligned} & \operatorname{kg~CH}_{4} / \\ & \mathrm{kg} \mathrm{COD} \end{aligned}$ | IPCC default value, as per AMS-III.H. |
| Global Warming Potential for methane | GWPch4 | 21 | 21 | - | AMS-III.H. |
| Model correction factor to account for model uncertainties | UFbi | 0.94 | 0.94 | - | AMS-III.H. |

## Baseline methane emissions from anaerobic decay of the final sludge produced in year

 (BEs,finaly)$B E_{s, f \text { final, }, y}=S_{f n a l, B L, y} * M C F_{s, B L, f \text { fnal }} * G W P_{C H} * U F_{B L} * D O C_{s} * D O C_{F} * F^{*} 16 / 12$
$B E_{s, \text { final, } y}($ for Ayutthaya site $)=0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$
$B E_{s, f \text { final, }, y}($ for Krabi site $)=0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya <br> value | Krabi <br> value | Unit | Source/Reference |
| :--- | ---: | ---: | ---: | ---: | :--- |
| Amount of dry matter in <br> final sludge generated by <br> the baseline wastewater <br> treatment <br> year "ystems in the | Sfinal,BL,y | 0 | 0 | tonne | Sludge is not <br> envisaged for this <br> baseline scenario. |
| Methane correction factor <br> of the disposal site that <br> receives the final sludge in <br> the baseline situation | MCF $_{\text {s,BL,f }}$ <br> inal | 0 | 0 | - | AMS-III.G |
| Global Warming Potential <br> for methane | GWPCH4 | 21 | 21 | - | AMS-III.H. |
| Model correction factor to <br> account for model <br> uncertainties | UFBL | 0.94 | 0.94 | - | AMS-III.H. |
| Degradable organic content <br> of the untreated sludge <br> generated in the year | DOC |  | 0.257 | 0.257 | - |
| Fraction of DOC <br> dissimilated to biogas | DOCF | 0.5 | 0.5 | - | AMS-III.H. |
| Fraction of CH in biogas | F | 0.5 | 0.5 | - | IPCC default value, <br> as per AMS-III.H. |

## Description of baseline in AMS-I.D.:

## Baseline electricity generation emissions in the year (BEgrid)

$B E_{\text {power, }, ~}=E P_{\text {consumed }} * E F_{\text {consumed }}$
$B E_{\text {power, },}($ for Ayutthaya site $)=2,967\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$B E_{\text {power }, y}($ for Krabi site $)=3,243\left(\mathrm{tCO}_{2} \mathrm{e}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya <br> value | Krabi <br> value | Unit | Source/Reference |
| :--- | :---: | :---: | :---: | :---: | :--- |
| Electricity produced by the <br> biogas generator unit for <br> grid electricity replacement <br> in the year | EРвіо | 5,817 | 6,359 | MWh | Calculated <br> estimation plant data <br> $1($ set) * 1,063 (kWe) <br> $* 24(\mathrm{~h}) * \mathrm{D}$ <br> (Operating Days)* <br> $0.95 * 0.995 * 0.9$ |


|  |  |  |  |  | lost:0.5\% <br> Internal demand: <br> $10 \%$ |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Emission factor of <br> electricity consumed | EF consumed |  |  |  |  |$\quad 0.51 .0 .51 ~$| kg |
| :---: |
| CO2e |
| $/ \mathrm{kWh}$ | | As per calculation |
| :--- |
| and guideline in |
| AMS- I.D./ |
| ACM0002. |

## Description of project in AMS-III.H.:

where :

| PEy | : Project activity emissions in year ( $\mathrm{tCO}_{2} \mathrm{e}$ ) |
| :---: | :---: |
| PEpower, ${ }_{\text {y }}$ | : Emissions from electricity or fuel consumption in year ( $\mathrm{tCO}_{2}$ ) |
| PEww,treatment,y | : Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation, in year ( $\mathrm{tCO}_{2} \mathrm{e}$ ) |
| PEs,treatment, ${ }_{\text {y }}$ | : Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ,in year ( $\mathrm{tCO}_{2} \mathrm{e}$ ) |
| PEww,discharge, ${ }_{\text {l }}$ | : Methane emissions from degradable organic carbon in treated wastewater in year ( $\mathrm{tCO}_{2} \mathrm{e}$ ) |
| PEs,final, ${ }_{\text {y }}$ | : Methane emissions from anaerobic decay of the final sludge produced in year( $\mathrm{tCO}_{2} \mathrm{e}$ ) |
| PEfugitive, ${ }^{\text {y }}$ | : Methane emissions from biogas release in capture systems in year ( $\mathrm{tCO}_{2} \mathrm{e}$ ) |
| PEflaring,y | : Methane emissions due to incomplete flaring in year ( $\mathrm{tCO}_{2} \mathrm{e}$ ) |
| PEbiomass,y | : Methane emissions from biomass stored under anaerobic conditions which dose not take place in the baseline situation ( $\mathrm{tCO}_{2} \mathrm{e}$ ) |

## Emissions from electricity or fuel consumption in year (PEpowery)

$P E_{\text {power }, y}=E P_{\text {consumed }} * E F_{\text {consumed }}$
$P E_{\text {power, },}($ for Ayutthaya site $)=349\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$P E_{\text {power, },}($ for Krabi site $)=381\left(\mathrm{tCO}_{2} \mathrm{e}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya <br> value | Krabi <br> value | Unit | Source/Reference |
| :--- | :--- | ---: | ---: | ---: | :--- |
| Electricity consumed by <br> project activity facilities in <br> year"y" | EP consumed | 684 | 748 | MWh | Calculated <br> estimation plant data <br> $106.3(k W e) * 24(h)$ |


|  |  |  |  |  | $* \mathrm{D}$ (operating days) |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Emission factor of <br> electricity consumed | EF consumed | 0.51 | 0.51 | kg <br> $\mathrm{CO}_{2 \mathrm{e}} \mathrm{e}$ <br> $/ \mathrm{kWh}$ | As per calculation <br> and guideline in <br> AMS- I.D./ |
| ACM0002. |  |  |  |  |  |

Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation, in year (PEww,treatment,y )
$P E_{w w, t r e a t m e n t y}=\sum_{k} Q_{w w, k, y} * C O D_{\text {removed, } P J, k, y} * M C F_{w w, \text { treatmen }, P, P, k} * B_{o, w w} * G W P_{C H 4} * U F_{P J}$
$P E_{w w, \text { treatment, },}($ for Ayutthaya site $)=0\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$P E_{\text {ww,treatment, },}($ for Krabi site $)=0\left(\mathrm{tCO}_{2} \mathrm{e}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Volume of wastewater per day | Qww,k,d | 0 | 0 | $\mathrm{m}^{3} / \mathrm{d}$ | There are none of volume for the system that not equipped with biogas recovery. |
| Operating days | D | 0 | 0 | Days | The annual average value of the factory results of 2006. |
| Volume of wastewater treated in baseline wastewater treatment system " $i$ " the year " $y$ " | $\mathrm{Qww}_{\mathrm{ww}, \mathrm{k}}$ | 0 | 0 | $\mathrm{m}^{3}$ | $\begin{aligned} & \text { Calculated as } \mathrm{Q}_{\mathrm{ww}, \mathrm{i}, \mathrm{y}} \\ & =\mathrm{Q}_{\mathrm{ww}, \mathrm{i}, \mathrm{~d}} * \mathrm{D} \end{aligned}$ |
| Chemical oxygen demand removed by project wastewater treatment system "k" in year " y ", measured as the difference between inflow COD and the outflow COD in system "k" | $\underset{\text { ed,,PJ,k,y }}{\mathrm{COD}}$ | 0 | 0 | $\begin{gathered} \text { tonnes } \\ \mathrm{m}^{3} \end{gathered}$ | Since there is no flow, therefore, there is no COD removed for this scenario |
| Methane correction factor for project wastewater treatment system "k" | $\underset{\text { eatment,BL,k }}{\mathrm{MCF}_{\mathrm{w}, \mathrm{t}}}$ | 0.8 | 0.8 | - | IPCC default value, as per AMS-III.H. table III.H.1. |
| Methane producing capacity of the wastewater | $\mathrm{B}_{\text {o,ww }}$ | 0.21 | 0.21 | $\left\|\begin{array}{l} \mathrm{kg} \mathrm{CH} 4 / \\ \mathrm{kg} \mathrm{COD} \end{array}\right\|$ | IPCC default value, as per AMS-III.H. |
| Global Warming Potential for methane | GWPсн4 | 21 | 21 | - | AMS-III.H. |
| Model correction factor to account for model uncertainties | UFbi | 0.94 | 0.94 | - | AMS-III.H. |

Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation, in year (PEs,treatment,y)
$P E_{s, \text { treatment, }, y}=\Sigma_{l} S_{l, P J_{l},} * M C F_{s, t r e a t m e n t, t} * G W P_{C H 4} * U F_{P J} * D O C_{s} * D O C_{F} * F * 16 / 12$
$P E_{s, \text { treatment. }, ~}($ for Ayutthaya site $)=0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$
$P E_{s, \text { treatment. } y}($ for Krabi site $)=0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Amount of dry matter in the sludge treated by the sludge treatment system " 1 " in the project scenario in year "y" | SI,PJ, y | 0 | 0 | tonne | Sludge is not envisaged for this baseline scenario. |
| Methane correction factor for the project sludge treatment | $\underset{\text { ment,l }}{\mathrm{MCF}_{\mathrm{s}, \text { treat }}}$ | 0.8 | 0.8 | - | IPCC default value, as per AMS-III.H. table III.H.1. |
| Global Warming Potential for methane | GWPch4 | 21 | 21 |  | AMS-III.H. |
| Model correction factor to account for model uncertainties | UFpJ | 1.06 | 1.06 | - | AMS-III.H. |
| Degradable organic content of the untreated sludge generated in the year | DOCs | 0.257 | 0.257 | - | AMS-III.H. |
| Fraction of DOC dissimilated to biogas | DOCF | 0.5 | 0.5 | - | IPCC default value, as per AMS-III.H. |
| Fraction of $\mathrm{CH}_{4}$ in biogas | F | 0.5 | 0.5 | - | IPCC default value, as per AMS-III.H. |

Methane emissions from degradable organic carbon in treated wastewater in year ( $\mathbf{P E}_{w w, d i s c h a r g e, y}$ )

$$
P E_{w v, d i s c h a r g e, y}=Q_{w w, y} * C O D_{w v, d i s c h a r g e, P J, y} * M C F_{w v, P J, d i s c h a r g e} * B_{o, w w} * G W P_{C H 4} * U F_{P J}
$$

$P E_{s, t \text { treatment } y}($ for Ayutthaya site $)=14,082\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$
$P E_{s, \text { treatmenty }, ~}($ for Krabi site $)=13,575\left(\mathrm{tCO}_{2} \mathrm{e}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Volume of wastewater per day | Qww,k,d | 323 | 464 | $\mathrm{m}^{3} / \mathrm{d}$ | Estimated plant data |
| Operating days | D | 268 | 293 | Days | The annual average value of the factory results of 2006. |
| Volume of treated wastewater discharge in the year " y " | Qww, y | 86,564 | 135,952 | $\mathrm{m}^{3}$ | $\begin{aligned} & \text { Calculated as } \mathrm{Qww}_{\mathrm{ww}, \mathrm{i},} \\ & =\mathrm{Qww}_{\mathrm{ww}, \mathrm{~d}} * \mathrm{D} \end{aligned}$ |
| Chemical oxygen demand removed by project wastewater treatment system " $k$ " in year " $y$ ", measured as the difference between inflow COD and the outflow COD in system "k" | $\underset{\text { ed,PJ, } \mathrm{k}, \mathrm{y}}{\mathrm{COD}}$ | 0.0435 | 0.0267 | tonnes/ $\mathrm{m}^{3}$ | It is assumed that Chemical Oxygen Demand (COD) is remained $30 \%$ after treated by anaerobic digester prior to discharge to the lagoon. |
| Methane correction factor base on discharge pathway in project situation (e.g. into sea, river or lake) of the wastewater | $\underset{\mathrm{J}, \text { discharge }}{\mathrm{MCF}_{\mathrm{ww}, \mathrm{P}}}$ | 0.8 | 0.8 | - | IPCC default value, as per AMS-III.H. table III.H.1. |
| Methane producing capacity of the wastewater | Bo,ww | 0.21 | 0.21 | $\begin{aligned} & \hline \begin{array}{l} \mathrm{kg} \mathrm{CH} 4 / \\ \mathrm{kg} \mathrm{COD} \end{array} \end{aligned}$ | IPCC default value, as per AMS-III.H. |
| Global Warming Potential for methane | GWPсн4 | 21 | 21 | - | AMS-III.H. |
| Model correction factor to account for model uncertainties | UFpJ | 1.06 | 1.06 | - | AMS-III.H. |

Methane emissions from anaerobic decay of the final sludge produced in year ( $\mathrm{PE}_{s, \text { final, }, \text { }}$ )
$P E_{s, f i n a l, y}=S_{\text {final }, P, y, y} * M C F_{s, P, J f n a l} * G W P_{C H 4} * U F_{P J} * D O C_{s} * D O C_{F} * F * 16 / 12$
$P E_{s, f n a l, y}($ for Ayutthaya site $)=0\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$P E_{s, f n a l y}($ for Krabi site $)=0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya <br> value | Krabi <br> value | Unit | Source/Reference |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Amount of dry matter in <br> final sludge generated by <br> the project wastewater <br> treatment systems in the <br> year " y " | Sfinal,P,y |  | 0 | 0 | tonne |


| Methane correction factor <br> of the disposal site that <br> receives the final sludge in <br> the project situation | MCF $_{\text {s,PJ,fi }}$ <br> nal | 0 | 0 | - | Estimated as per the <br> procedure described <br> in AMS- III.G |
| :--- | :--- | ---: | ---: | ---: | :--- |
| Global Warming Potential <br> for methane | GWPCH4 | 21 | 21 | - | AMS-III.H. |
| Model correction factor to <br> account for model <br> uncertainties | UFPJ |  | 1.06 | 1.06 | - |
| Degradable organic content <br> of the untreated sludge <br> generated in the year | DOCs | 0.257 | 0.257 | - | AMS-III.H. |
| Fraction of DOC <br> dissimilated to biogas | DOCF | 0.5 | 0.5 | - | IPCC default value, <br> as per AMS-III.H. |
| Fraction of CH4 in biogas | F | 0.5 | 0.5 | - | IPCC default value, <br> as per AMS-III.H. |

## Methane emissions from biogas release in capture systems in year (PEfugltive,y)

$P E_{\text {fugitive }, y}=P E_{\text {fugitive }, w w, y}+P E_{\text {fugitive }, s, y}$
$P E_{\text {fugitive, }}($ for Ayutthaya site $)=4,694\left(\mathrm{tCO}_{2 \mathrm{e}}\right)+0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$
$P E_{\text {fugitive }, y}($ for Krabi site $)=4,525\left(\mathrm{tCO}_{2} \mathrm{e}\right)+0\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$P E_{\text {fugitive,ww,y }}=\left(1-C F E_{W W}\right) * Q_{w w, y} * \sum_{k} C O D_{\text {removed, } P J, k, y} * M C F_{w w, t r e a t m e n t, P, J, k} * B_{o, W W} * G W P_{C H 4} * U F_{P J}$
$P E_{\text {fugitive,ww, } y}($ for Ayutthaya site $)=4,694\left(\mathrm{tCO}_{2} \mathrm{e}\right)$
$P E_{\text {fugitive, ww, },}($ for Krabi site $)=4,525\left(\mathrm{tCO}_{2} \mathrm{e}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Capture efficiency of the biogas recovery equipment in the wastewater treatment systems | CFEww | 0.9 | 0.9 | - | As per AMS-III.H. |
| Volume of treated wastewater discharge in the year "y" | $\mathrm{Q}_{\mathrm{ww}, \mathrm{y}}$ | 86,564 | 135,952 | $\mathrm{m}^{3}$ | Calculated as $\mathrm{Q}_{\mathrm{ww}, \mathrm{i}, \mathrm{y}}$ $=\mathrm{Q}_{\mathrm{ww}, \mathrm{i}, \mathrm{~d}} * \mathrm{D}$ |
| The chemical oxygen demand removed by the treatment system " $k$ " of the project activity equipped with biogas recovery system in | $\underset{\text { ed,PJ, }, \text {,y }}{ }$ | 0.145 | 0.089 | tonnes/ $\mathrm{m}^{3}$ | Estimated plant data |


| year "y" |  |  |  |  |  |
| :--- | :--- | ---: | ---: | ---: | :--- |
| Methane correction factor <br> for the project wastewater <br> treatment system "k" <br> equipped with biogas <br> recovery equipment | MCF $_{\mathrm{ww}, \mathrm{tr}}$ eatmentPJ,k | 0.8 | 0.8 | - | IPCC default value, <br> as per AMS-III.H. <br> table III.H.1. |
| Methane producing <br> capacity of the wastewater | $\mathrm{B}_{\mathrm{o}, \mathrm{ww}}$ | 0.21 | 0.21 | kg CH4/ <br> kg COD | IPCC default value, <br> as per AMS-III.H. |
| Global Warming Potential <br> for methane | GWPCH4 | 21 | 21 | - | AMS-III.H. |
| Model correction factor to <br> account for model <br> uncertainties | UFPJ | 1.06 | 1.06 | - | AMS-III.H. |

$P E_{\text {fugitive }, s, y}=\left(1-C F E_{W W}\right) * \Sigma_{l}\left(S_{l, P J, y} * M C F_{s, t r e a t m e n t, P J, l}\right) * U F_{P J} * D O C_{s} * D O C_{F} * F^{*} 16 / 12$
$G W P_{\text {CH } 4}$
$P E_{\text {fugitive,s,y }}($ for Ayutthaya site $)=0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$
$P E_{\text {fugitive, }, y}($ for Krabi site $)=0\left(\mathrm{tCO}_{2 \mathrm{e}}\right)$

Where :

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Capture efficiency of the biogas recovery equipment in the sludge treatment systems | CFEs | 0.9 | 0.9 | - | IPCC default value, as per AMS-III.H. |
| Amount of sludge treated in the project sludge treatment system "l" equipped with biogas recovery system (on dry basis) in year "y" | Sl,PJ,y | 0 | 0 | tonnes | No sludge treatment occurs. |
| Methane correction factor for the sludge treatment system equipped with biogas recovery equipment | $\underset{\text { ment,PJ,l }}{\mathrm{MCF}_{\text {s,trat }}}$ | 0.8 | 0.8 |  | IPCC default value, as per AMS-III.H. table III.H. 1 |
| Model correction factor to account for model uncertainties | UFPJ | 1.06 | 1.06 | - | AMS-III.H. |
| Degradable organic content of the untreated sludge generated in the year | DOCs | 0.257 | 0.257 | - | AMS-III.H. |
| Fraction of DOC dissimilated to biogas | DOCF | 0.5 | 0.5 | - | IPCC default value, as per AMS-III.H. |
| Fraction of $\mathrm{CH}_{4}$ in biogas | F | 0.5 | 0.5 | - | IPCC default value, as per AMS-III.H. |

Methane emissions due to incomplete flaring in year (PEflaring,y)
$P E_{\text {flaring }, ~}=0$

Methane emissions from biomass stored under anaerobic conditions which dose not take place in the baseline situation (PEbiomass,y)
$P E_{\text {biomass }, y}=0$

## APPENDIX II

## Estimation of electricity generation from captured biogas by UASB system

## Calculation of electricity generation from captured biogas by UASB

Electricity $(M W h / y)=Q_{w w, y} * C_{D_{r e m o v e d, y}} *$ Methane conversion factor $^{*}$ Calorific value

Electricity $_{y}($ for Ayutthaya site $)=28,107 \mathrm{MWh} / \mathrm{y}$
Electricity $_{\mathbf{y}}($ for Krabi site $)=27,095 \mathrm{MWh} / \mathrm{y}$

Where:

| Data/Parameter | Variables | Ayutthaya value | Krabi value | Unit | Source/Reference |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Volume of wastewater treated in UASB system in the year " $y$ " | Qww, y | 86,564 | 135,952 | $\mathrm{m}^{3}$ | $\begin{aligned} & \text { Calculated as } \mathrm{Q}_{\mathrm{ww}, \mathrm{i}, \mathrm{y}} \\ & =\mathrm{Q}_{\mathrm{www}, \mathrm{~d}} * \mathrm{D} \end{aligned}$ |
| Chemical oxygen demand removed by UASB system in year " $y$ ", measured as the difference between inflow COD and the outflow COD | $\underset{\text { ed }, y}{C O D_{\text {remov }}}$ | 101.5 | 62.3 | $\mathrm{kg} / \mathrm{m}^{3}$ | It is assumed that the UASB which can remove Chemical Oxygen Demand (COD) at 70\% efficiency. |
| Methane conversion factor |  | 0.35 | 0.35 | $\begin{array}{\|c\|} \hline \mathrm{m}^{3} / \mathrm{kg} \\ \mathrm{COD} \\ \text { removed } \end{array}$ | Theoretical value for anaerobic disgestor |
| Calorific value of methane | - | 9.14 | 9.14 | $\mathrm{kWh} / \mathrm{m}^{3}$ methane | Lower heating value for biogas (97\% methane) $=9.67$ $\mathrm{kWh} / \mathrm{m}^{3}$ <br> $9.67\left(\mathrm{kWh} / \mathrm{m}^{3}\right)$ $* 0.95 * 0.995=9.14$ <br> ( $\mathrm{kWh} / \mathrm{m}^{3}$ ) <br> Operation condition <br> Accidental factor:5\% <br> Transmission <br> lost:0.5\% |

## APPENDIX III

Analysis for CER generating cost, IRR, and net profit percentage/margin
Summarized results of economic assessment for biogas CDM project

| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \\ \hline \end{gathered}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\underset{\text { Value }}{\text { Krabi }}$ | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | Krabi Value |  |  |
| GHG emission reduction | 225000 | 216450 | 225000 | 216450 | 225000 | 216450 | 225000 | 216450 | 225000 | 216450 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs sale | 2.25 | 2.16 | 2.25 | 2.16 | 2.25 | 2.16 | 2.25 | 2.16 | 2.25 | 2.16 | Million USD | CERs price: 10 USD/t $\mathrm{CO}_{2} \mathrm{e}$ |
| Total power generation | 0.00 | 0.00 | 58166 | 63592 | 116332 | 127184 | 174498 | 190775 | 232664 | 254367 | MWh | Estimated plant data |
| Electricity sale | 0.00 | 0.00 | 4.80 | 5.25 | 9.60 | 10.50 | 14.40 | 15.75 | 19.20 | 21.00 | Million USD | VSPP tariff 2.96 Baht/kWh |
| Net profit | -3.85 | -3.22 | -0.22 | 0.80 | 3.19 | 4.63 | 6.59 | 8.45 | 9.99 | 12.28 | Million USD | Revenue-(depreciation taxable +corporation tax) |
| Initial cost investment | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| Total cost investment | 6.10 | 5.38 | 7.28 | 6.56 | 8.46 | 7.74 | 9.64 | 8.92 | 10.82 | 10.10 | Million USD | Depreciation taxable+operation cost |
| CER generating cost | 26.98 | 24.73 | 29.20 | 27.04 | 31.42 | 29.35 | 33.64 | 31.66 | 35.87 | 33.97 | USD/t CO2 | Cost investment/GHG emission reduction |
| CER margin | 100.00 | 100.00 | 31.91 | 29.20 | 18.98 | 17.09 | 13.51 | 12.08 | 10.49 | 9.35 | \% | CERs sale/selling price or revenue |
| Profit percentage | -63.13 | -59.78 | -2.99 | 12.21 | 37.65 | 59.76 | 68.34 | 94.73 | 92.34 | 121.58 | \% | Net profit/cost price |
| Profit margin | -171.24 | -148.61 | -3.09 | 10.81 | 26.88 | 36.53 | 39.57 | 47.18 | 46.58 | 53.01 | \% | Net profit/selling price or revenue |
| Internal rate of return |  |  | -0.72 | 2.82 | 8.63 | 13.24 | 15.48 | 20.89 | 20.97 | 27.02 | \% | Expected IRR in Thailand, 5.59\% |

A project with 14-year CER crediting period

| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi <br> Value | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | Ayutthaya Value | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value |  |  |
| GHG emission reduction | 315000 | 303030 | 315000 | 303030 | 315000 | 303030 | 315000 | 303030 | 315000 | 303030 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs sale | 3.15 | 3.03 | 3.15 | 3.03 | 3.15 | 3.03 | 3.15 | 3.03 | 3.15 | 3.03 | Million USD | CERs price: 10 USD/t $\mathrm{CO}_{2} \mathrm{e}$ |
| Total power generation | 0.00 | 0.00 | 81432 | 89029 | 162865 | 178057 | 244297 | 267086 | 325729 | 356114 | MWh | Estimated plant data |
| Electricity sale | 0.00 | 0.00 | 6.72 | 7.35 | 13.44 | 14.70 | 20.17 | 22.05 | 26.89 | 29.39 | Million USD | VSPP tariff 2.96 Baht/kWh |
| Net profit | -3.40 | -2.77 | 1.37 | 2.51 | 5.92 | 7.60 | 10.46 | 12.70 | 15.00 | 17.79 | Million USD | Revenue-(depreciation taxable +corporation tax) |
| Initial cost investment | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| Total cost investment | 6.36 | 5.61 | 7.83 | 7.08 | 9.30 | 8.55 | 10.78 | 10.02 | 12.25 | 11.49 | Million USD | Depreciation taxable+operation cost |
| CER generating cost | 19.27 | 17.66 | 20.86 | 19.31 | 22.44 | 20.96 | 24.03 | 22.61 | 25.62 | 24.26 | USD/t CO2 ${ }^{\text {e }}$ | Cost investment/GHG emission reduction |
| CER margin | 100.00 | 100.00 | 31.91 | 29.20 | 18.98 | 17.09 | 13.51 | 12.08 | 10.49 | 9.35 | \% | CERs sale/selling price or revenue |
| Profit percentage | -53.50 | -49.38 | 17.53 | 35.52 | 63.60 | 88.94 | 97.08 | 126.66 | 122.52 | 154.79 | \% | Net profit/cost price |
| Profit margin | -108.01 | -91.37 | 13.91 | 24.23 | 35.66 | 42.90 | 44.87 | 50.63 | 49.95 | 54.86 | \% | Net profit/selling price or revenue |
| Internal rate of return | -10.06 | -8.87 | 4.22 | 7.27 | 12.31 | 16.38 | 18.38 | 23.26 | 23.33 | 28.89 | \% | Expected IRR in Thailand, 5.59\% |

A project with 20-year CER crediting period

| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\underset{\text { Value }}{\text { Krabi }}$ | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\underset{\text { Value }}{\text { Krabi }}$ | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | Krabi Value |  |  |
| GHG emission reduction | 450000 | 432900 | 450000 | 432900 | 450000 | 432900 | 450000 | 432900 | 450000 | 432900 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs sale | 4.50 | 4.33 | 4.50 | 4.33 | 4.50 | 4.33 | 4.50 | 4.33 | 4.50 | 4.33 | Million USD | CERs price: 10 USD/t $\mathrm{CO}_{2} \mathrm{e}$ |
| Total power generation | 0.00 | 0.00 | 116332 | 127184 | 232664 | 254367 | 348995 | 381551 | 465327 | 508735 | MWh | Estimated plant data |
| Electricity sale | 0.00 | 0.00 | 9.60 | 10.50 | 19.20 | 21.00 | 28.81 | 31.49 | 38.41 | 41.99 | Million USD | VSPP tariff 2.96 Baht/kWh |
| Net profit | -2.73 | -2.10 | 3.76 | 5.08 | 10.01 | 12.07 | 16.27 | 19.06 | 22.52 | 26.05 | Million USD | Revenue-(depreciation taxable +corporation tax) |
| Initial cost investment | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| Total cost investment | 6.74 | 5.95 | 8.65 | 7.86 | 10.56 | 9.77 | 12.47 | 11.68 | 14.38 | 13.58 | Million USD | Depreciation taxable+operation cost |
| CER generating cost | 13.49 | 12.36 | 14.60 | 13.52 | 15.71 | 14.67 | 16.82 | 15.83 | 17.93 | 16.98 | USD/t CO2 ${ }_{2}$ | Cost investment/GHG emission reduction |
| CER margin | 100.00 | 100.00 | 31.91 | 29.20 | 18.98 | 17.09 | 13.51 | 12.08 | 10.49 | 9.35 | \% | CERs sale/selling price or revenue |
| Profit percentage | -40.43 | -35.26 | 43.44 | 64.73 | 94.79 | 123.63 | 130.41 | 163.26 | 156.58 | 191.84 | \% | Net profit/cost price |
| Profit margin | -60.58 | -48.43 | 26.65 | 34.29 | 42.24 | 47.67 | 48.84 | 53.21 | 52.48 | 56.24 | \% | Net profit/selling price or revenue |
| Internal rate of return | -4.58 | -3.61 | 7.23 | 9.84 | 14.26 | 17.92 | 19.74 | 24.26 | 24.32 | 29.57 | \% | Expected IRR in Thailand, 5.59\% |

[^3]Conditions of IRR calculation

| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{array}{\|c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | Krabi Value | $\begin{array}{\|c\|} \hline \text { Ayutthayaa } \\ \text { Value } \end{array}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi <br> Value | $\begin{aligned} & \text { Ayuthhaya } \\ & \text { Value } \end{aligned}$ | Krabi <br> Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi <br> Value |  |  |
| COD | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | t COD/m ${ }^{3}$ | Plant data |
| Flow rate of wastewater | 323 | 464 | 323 | 464 | 323 | 464 | 323 | 464 | 323 | 464 | $\mathrm{m}^{3} / \mathrm{d}$ | Plant data |
| COD loading | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | t COD/d | Plant data |
| Ratio of reactor volume | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 |  | Refer to calculation |
| Operating day | 268 | 293 | 268 | 293 | 268 | 293 | 268 | 293 | 268 | 293 | day/year | Plant data |
| Initial investment* | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| Manpower cost in the year | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | Million USD | Estimated plant data |
| Consumable cost in the year | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | Million USD | Estimated plant data |
| System maintenance cost in the year | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | Million USD | Estimated plant data |
| Gas engine maintenance cost in the year | 0.000 | 0.000 | 0.073 | 0.073 | 0.146 | 0.146 | 0.219 | 0.219 | 0.292 | 0.292 | Million USD | Estimated plant data |
| CDM monitoring in the year | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | Million USD | Estimated plant data |
| Electric power purchase price | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | Baht/kWh | VSPP tariff calculation |
| Generated electric power at generator output | 0 | 0 | 1063 | 1063 | 2126 | 2126 | 3189 | 3189 | 4252 | 4252 | kWe | Assumed generator output 1 set |
| Total power generation in the year** | 0 | 0 | 5817 | 6359 | 11633 | 12718 | 17450 | 19078 | 23266 | 25437 | MWh | Estimated plant data |
| GHG emission reduction in the year | 22500 | 21645 | 22500 | 21645 | 22500 | 21645 | 22500 | 21645 | 22500 | 21645 | $\mathrm{t} \mathrm{CO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs price | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | USD/t $\mathrm{CO}_{2} \mathrm{e}$ | Assumed conservative value |

Remarks: *Assume price of 1 MWe gas engine generator $=0.5$ Mil.USD
$* *$ Calculated estimation plant data: Operation condition No. of set x Gene
Remarks: *Assume price of IMWe gas engine generator $=0.5$ Mil.USD
$* *$ Calculated estimation plant data: Operation condition No. of set $x$ Generator output $(1063 \mathrm{kWe})$ x Operation hour x Operation day x Accident factor ( 0.95 ) x Transmission loss $(0.995) \times$ Internal demand $(0.9)$
Condition of tax and depreciation

| Item | $\begin{array}{\|c\|} \hline \text { Ayutthayaa } \\ \text { Value } \end{array}$ | Krabi Value | $\begin{array}{c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{array}{\|c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | Krabi Value | $\begin{array}{\|c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | Krabi Value | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Corporation tax | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | \% | Tax rate of Thailand (8 years tax holiday) |
| Interest, Borrowing period | - |  | - |  | - |  |  |  |  |  |  | Because it will be implemented in the fund on hand completely |
| Payment start time | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | year | - |
| Depreciation taxable | 5.46 | 4.82 | 5.91 | 5.27 | 6.36 | 5.72 | 6.81 | 6.17 | 7.26 | 6.62 | Million USD | Equipment cost and design expense |
| Depreciation period | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | years | Least 5 years |
| Depreciation method and rate | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% |  | Fixed installment method, 10\%, is general in Thailand. |
| Salvage value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | \% | Salvage value is zero. |
| Price inflation rate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | \% | It isn't considered for the IRR calculation |
| Exchange rate (Baht USD) | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | Baht/USD | - |

Summarized results of economic assessment for biogas CDM project (in the scheme of internal electricity reduction)
A project with 10-year CER crediting period

| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Ayutthaya Value | Krabi Value | Ayutthaya Value | Krabi <br> Value | Ayutthaya Value | Krabi <br> Value | Ayutthaya Value | $\underset{\text { Value }}{\text { Krabi }}$ | Ayutthaya Value | Krabi <br> Value |  |  |
| GHG emission reduction | 225000 | 216450 | 254670 | 248880 | 284340 | 281310 | 314010 | 313740 | 343680 | 346170 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs sale | 2.25 | 2.16 | 2.55 | 2.49 | 2.84 | 2.81 | 3.14 | 3.14 | 3.44 | 3.46 | Million USD | CERs price: 10 USD/t $\mathrm{CO}_{2} \mathrm{e}$ |
| Initial cost investment | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| CERs generating cost | 26.98 | 24.73 | 25.80 | 23.51 | 24.86 | 22.58 | 24.11 | 21.84 | 23.48 | 21.24 | USD/t CO2 ${ }^{\text {e }}$ | Cost investment/GHG emission reduction |
| A project with 14-year CER crediting period |  |  |  |  |  |  |  |  |  |  |  |  |
| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
|  | Ayutthaya Value | $\begin{aligned} & \hline \text { Krabi } \\ & \text { Value } \end{aligned}$ | Ayutthaya Value | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | Ayutthaya Value | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | Ayutthaya Value | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value |  |  |
| GHG emission reduction | 315000 | 303030 | 356538 | 348432 | 398076 | 393834 | 439614 | 439236 | 481152 | 484638 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs sale | 3.15 | 3.03 | 3.57 | 3.48 | 3.98 | 3.94 | 4.40 | 4.39 | 4.81 | 4.85 | Million USD | CERs price: 10 USD/t $\mathrm{CO}_{2} \mathrm{e}$ |
| Initial cost investment | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| CERs generating cost | 19.27 | 17.66 | 18.43 | 16.80 | 17.76 | 16.13 | 17.22 | 15.60 | 16.77 | 15.17 | USD/t $\mathrm{CO}_{2}{ }^{\text {e }}$ | Cost investment/GHG emission reduction |

A project with 20-year CER crediting period

| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | $\begin{gathered} \text { Ayutthayaa } \\ \text { Value } \end{gathered}$ | $\begin{aligned} & \hline \text { Krabi } \\ & \text { Value } \end{aligned}$ | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\begin{aligned} & \hline \text { Krabi } \\ & \text { Value } \\ & \hline \end{aligned}$ | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | $\begin{aligned} & \hline \text { Krabi } \\ & \text { Value } \end{aligned}$ |  |  |
| GHG emission reduction | 450000 | 432900 | 509340 | 497760 | 568680 | 562620 | 628020 | 627480 | 687360 | 692340 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs sale | 4.50 | 4.33 | 5.09 | 4.98 | 5.69 | 5.63 | 6.28 | 6.27 | 6.87 | 6.92 | Million USD | CERs price: 10 USD/t $\mathrm{CO}_{2}{ }^{\text {e }}$ |
| Initial cost investment | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| CERs generating cost | 13.49 | 12.36 | 12.90 | 11.76 | 12.43 | 11.29 | 12.05 | 10.92 | 11.74 | 10.62 | USD/t $\mathrm{CO}_{2} \mathrm{e}$ | Cost investment/GHG emission reduction |

Conditions of economic assessment for biogas CDM project (in the scheme of internal electricity reduction)
Conditions of IRR calculation

| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \hline \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{array}{c\|} \hline \text { Ayutthaya } \\ \text { Value } \\ \hline \end{array}$ | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ |  |  |
| COD | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | t COD/m ${ }^{3}$ | ${ }^{3}$ Plant data |
| Flow rate of wastewater | 323 | 464 | 323 | 464 | 323 | 464 | 323 | 464 | 323 | 464 | $\mathrm{m}^{3} / \mathrm{d}$ | Plant data |
| COD loading | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | t COD/d | Plant data |
| Ratio of reactor volume | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 |  | Refer to calculation |
| Operating day | 268 | 293 | 268 | 293 | 268 | 293 | 268 | 293 | 268 | 293 | day/year | Plant data |
| Initial investment | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| Manpower cost in the year | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | Million USD | Estimated plant data |
| Consumable cost in the year | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | Million USD | Estimated plant data |
| System maintenance cost in the year | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | Million USD | Estimated plant data |
| Gas engine maintenance cost in the year | 0.000 | 0.000 | 0.073 | 0.073 | 0.146 | 0.146 | 0.219 | 0.219 | 0.292 | 0.292 | Million USD | Estimated plant data |
| CDM monitoring in the year | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | Million USD | Estimated plant data |
| Electric power purchase price | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | Baht/kWh | VSPP tariff calculation |
| Generated electric power at generator output | 0 | 0 | 1063 | 1063 | 2126 | 2126 | 3189 | 3189 | 4252 | 4252 | kWe | Assumed generator output 1 set |
| Total power generation in the year* | 0 | 0 | 5817 | 6359 | 11633 | 12718 | 17450 | 19078 | 23266 | 25437 | MWh | Estimated plant data |
| GHG emission reduction in the year | 22500 | 21645 | 25467 | 24888 | 28434 | 28131 | 31401 | 31374 | 34368 | 34617 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs price | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | USD/t $\mathrm{CO}_{2} \mathrm{e}$ | Assumed conservative value |


| Item | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{array}{c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | Krabi Value | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Corporation tax | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | \% | Tax rate of Thailand (8 years tax holiday) |
| Interest, Borrowing period | - | - | - | - | - |  |  |  | - | - |  | Because it will be implemented in the fund on hand completel |
| Payment start time | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | year |  |
| Depreciation taxable | 5.46 | 4.82 | 5.91 | 5.27 | 6.36 | 5.72 | 6.81 | 6.17 | 7.26 | 6.62 | Million USD | Equipment cost and design expense |
| Depreciation period | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | years | Least 5 years |
| Depreciation method and rate | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% |  | Fixed installment method, $10 \%$, is general in Thailand. |
| Salvage value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | \% | Salvage value is zero. |
| Price inflation rate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | \% | It isn't considered for the IRR calculation |
| Exchange rate (Baht USD) | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | Baht/USD |  |

IRR calculation for Ayutthaya site with 10-year CER crediting period, no generator investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 2.2500 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.6400 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 |  |
| Operating income |  | -0.3853 | $-0.3853$ | -0.3853 | $-0.3853$ | -0.3853 | $-0.3853$ | -0.3853 | -0.3853 | -0.3853 | -0.3853 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Current income |  | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 |  |
| Cumulative profits |  | -0.3853 | -0.7706 | -1.1559 | -1.5412 | -1.9265 | -2.3118 | -2.6971 | -3.0824 | -3.4677 | -3.8530 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.38 | -0.3853 | -0.3853 | -0.38 | -0.3853 |
| Depreciation |  | 0.5463 | 0.543 | 0.54 | 0.5463 | 0.5463 | 0.546 | 0.5463 | 0.5463 | 0.5463 | 0.5463 |
| Total cash inflows |  | 0.1610 | 610 | 610 | 610 | 0.1610 | 0.1610 | 1610 | 1610 | 1610 | 0.1610 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Repayment of borowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-ut flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Cash flow |  | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |


| Break-even calculation | Fiscal year | 2009 |  | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| :--- | ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |  |
| Accumulated after-tax cash flow |  | 0.1610 | 0.3220 | 0.4830 | 0.6440 | 0.8050 | 0.9660 | 1.1270 | 1.2880 | 1.4490 | 1.6100 |
| Accumulated after-tax cash flow - investment capital | -5.3020 | -5.1410 | -4.9800 | -4.8190 | -4.6580 | -4.4970 | -4.3360 | -4.1750 | -4.0140 | -3.8530 |  |
| IRR calculation data) | -5.463 | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ |
| Internal rate of return, before tax $(\%)$ |  |  |  |  |  |  |  |  |  |  | N/A |

IRR calculation for Krabi site with 10-year CER crediting period, no generator investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 2.1645 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.5643 |
| $\overline{\text { A finance institution }}$ | Borrowing cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 |  |
| Operating income |  | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -03217 | -0.3217 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Current income |  | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -03217 | -0.3217 |  |
| Cumulative profits |  | -0.3217 | -0.6433 | -0.9650 | -1.2867 | -1.6084 | -1.9300 | -2.2517 | -2.5734 | -2.8950 | -3.216 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 |  |
| Depreciation | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 |  |
| Total cash inflows | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 6 0}$ |  |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash-out flow | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ |  |
| Cash flow | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ |  |


| Break-even calculation | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :--- | ---: | ---: | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| After-tax cash flow | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 |  |
| Accumulated after-tax cash flow | 0.1600 | 0.3200 | 0.4801 | 0.6401 | 0.8001 | 0.9601 | 1.1201 | 1.2802 | 1.4402 | 1.6002 |  |
| Accumulated after-tax cash flow -investment capital | -4.6569 | -4.4969 | -4.3369 | -4.1768 | -4.0168 | -3.8568 | -3.6968 | -3.5368 | -3.3767 | -3.2167 |  |
| IIRR calculation data) | -4.82 | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  | N/A |  |

IRR calculation for Ayuthaya site with 10-year CER crediting period, 1 generator investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 7.0512 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 1.3700 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 |  |
| Operating income |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | $-0.0232$ | -0.0232 | -0.0232 | -0.0232 | $-0.0232$ |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | $-0.0232$ |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0070 | -0.0070 |  |
| Current income |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0162 | -0.0162 |  |
| Cumulative profits |  | -0.0232 | -0.0464 | -0.0695 | -0.0927 | -0.1159 | -0.1391 | -0.1623 | -0.1854 | -0.201 | -0.217 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 018 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.023 | 0.023 |
| Depreciation |  | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 |
| Total cash inflows |  | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | . 000 | 0.0000 | 0.000 | 0.0000 | 0.000 | -0.00 | -0.0070 |
| Repayment of borowed money |  | 0.0000 | . 000 | 0.00 | 0.0000 | 0.0000 | 0.00 | 0.000 | 0.0000 | 0.00 | 0.00 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0070 | -0.007 |
| Cash flow |  | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.56 | 0.5 | 0.5 | 0.57 |


| Break-even calculation | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5751 | 0.5751 |  |
| Accumulated after-tax cash flow |  | 0.5681 | 1.1362 | 1.7044 | 2.2725 | 2.8406 | 3.4087 | 3.9768 | 4.5450 | 5.1200 | 5.6951 |
| Accumulated after-tax cash flow - investment capital | -5.3449 | -4.7768 | -4.2086 | -3.6405 | -3.0724 | -2.5043 | -1.9362 | -1.3680 | -0.7930 | -0.2179 |  |
| (IRR calculation data) | -5.913 | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ |
| Internal rate of return, before tax $(\%)$ |  |  |  |  |  |  |  |  |  | $\mathbf{- 0 . 7 2 0 6}$ |  |

IRR calculation for Krabi site with 10-year CER crediting period, 1 generator investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 |  |
|  | CERs 10USD/t | 65 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.21 | 0.2165 |  |
|  | <Total> | 14 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 |  |
| ${ }^{\text {cost }}$ | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.01 | 0.0123 | 0.012 | 0.0123 | 0.0123 | 123 |  |
|  | Gas engine maintenance | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.073 | 0.0730 | 2730 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.013 | 0.0132 | 0.0132 | 0.013 | 0.01 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00 |  |
|  | <Total> | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.129 | 0.1294 | 0.129 | 0.129 | 0.1294 | 0.1294 |  |
| A finance institution |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 |  |
|  | Affer paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00 |  |
|  | Interest cost 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 |  |
| Depreciation |  | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.526 | 0.526 | 0.52 | 0.52 |  |
|  |  | 0.085 | 0.0852 | 085 | .08: | 0.08 | 0.08 ; | 0.085 | 0.0852 | 0.085 | .08, |  |
| Non-operating interst cost |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 1882 | 882 | 852 | 0.0852 | 0.0852 | 0.08 | 0.08 | 0.08 | 0.08 | 0.0852 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.000 | 0.0256 | 0.0256 |  |
| Current income |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0597 | 0.0597 |  |
| Cumulative profits |  |  |  |  |  |  |  |  |  |  |  |  |


| Cash flow statement Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.085 | 0.0852 | 0.0852 | 0.085 | 0.0852 | 0.0852 |
| Depreciation | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 |
| Total cash inflows | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.619 |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0256 | 0.0256 |
| Repayment of borowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.0000 |
| Total cash-out flow | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.02 | 6 |
| Cash flow | 0.6119 | 0.6119 | 0.6119 | 0.619 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.5864 | 0.58 |
|  |  |  |  |  |  |  |  |  |  |  |
| Brak-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 015 | 2016 | 2017 | 2018 |
| Atter-tax cash flow | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.5864 | 0.5864 |
| Accumulated afer-tax cash flow | 0.6119 | 1.2239 | 1.8358 | 2.447 | 3.0596 | 3.6716 | 4.2835 | 4.8954 | 5.48 | 6.0681 |
| Accumulated after-tax cash flow - investment capital | -4.650 | -4.0431 | -3.4311 | -2.8192 | -2.2073 | -1.5954 | -0.9834 | -0.3715 | 0.21 | 0.8012 |
| (IRR calculation data) -5.27 | 0.611 | 0.611 | 0.611 | 0.619 | 0.6119 | 0.611 | 0.611 | 0.619 | 0.6119 | 0.6119 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  | 2.824 |

IRR calculation for Ayutthaya site with 10-year CER crediting period, 2 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 11.8524 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 2.1000 |
| $\overline{\text { A finance institution }}$ | Borrowing cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 |  |
| Operating income |  | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 |  |
| Non-operating interest cost $00.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1017 | 0.1017 |  |
| Current income |  | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.2373 | 0.2373 |  |
| Cumulative profits |  | 0.3389 | 0.6779 | 1.0168 | 1.3558 | 1.6947 | 2.0336 | 2.3726 | 2.7115 | 2.9488 | 3.1860 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

IRR calculation for Krabi site with 10-year CER crediting period, 2 generators investment

| (Unit: Million USD) |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
|  | Electric generation income | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 1.2663 | 12663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 12.6626 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 2.0243 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 |  |
| Operating income |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1476 | 0.1476 |  |
| Current income |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.3445 | 0.3445 |  |
| Cumulative profits |  | 0.4921 | 09843 | 1.4764 | 1.9686 | 2.4607 | 2.9529 | 3.4450 | 3.9371 | 4.2816 | 4.62 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |

IRR calculation for Ayutthaya site with 10-year CER crediting period, 3 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 16.6536 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 2.8300 |
| A finance institution | Borrowing cost $0.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 |  |
| Operating income |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 |  |
| Current income |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.4907 | 0.4907 |  |
| Cumulative profits |  | 0.7011 | 1.4021 | 2.1032 | 2.8042 | 3.5053 | 4.2064 | 4.9074 | 5.6085 | 6.0992 | 6.5900 |  |


| Cash flow statement | Fisal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.701 | 0.70 | 0.70 | 0.7011 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.7011 |
| Depreciation |  | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 |
| Total cash inflows |  | 1.3824 | 13824 | 1.3824 | 1382 | 1.382 | 1.3824 | 1.3824 | 3824 | 1.382 | 1.3824 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 |
| Repayment of borowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-ut flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 |
| Cash flow |  | 1.382 | 13824 | 1.382 | 1.382 | 1.382 | 1.382 | 1.382 | 1.382 | 1.1720 | 1.1720 |


| Break-even calculation | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.1720 | 1.1720 |  |
| Accumulated after-tax cash flow |  | 1.3824 | 2.7647 | 4.1471 | 5.5294 | 6.911 | 8.2942 | 9.6765 | 11.0589 | 12.2309 | 13.4030 |
| Accumulated after-tax cash flow - investment capital | -5.4306 | -4.0483 | -2.6659 | -1.2836 | 0.0988 | 1.4812 | 2.8635 | 4.2459 | 5.4179 | 6.5900 |  |
| IRR calculation data) | -6.813 | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ | $\mathbf{1 . 3 8 2 4}$ |
| Internal rate of return, before tax $(\%)$ |  |  |  |  |  |  |  |  |  |  | $\mathbf{1 5 . 4 7 8 7}$ |

IRR calculation for Krabi site with 10-year CER crediting period, 3 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 17.9117 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 2.7543 |
| $\overline{\text { A finance institution }}$ | Borrowing cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 |  |
| Operating income |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 |  |
| Non-operating interest cost $00.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2697 | 0.2697 |  |
| Current income |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.6293 | 0.6293 |  |
| Cumulative profits |  | 0.8991 | 1.7981 | 2.6972 | 3.5962 | 4.4953 | 5.3943 | 6.2934 | 7.1924 | 7.8217 | 8.4511 |  |


| Cash flow statement Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 |
| Depreciation | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 |
| Total cash inflows | 1.5157 | 15157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2697 | 0.2697 |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2697 | 0.2697 |
| Cash flow | 1.5157 | 15157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.2460 | 1.2460 |
|  |  |  |  |  |  |  |  |  |  |  |
| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| After-tax cash flow | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.2460 | 1.2460 |
| Accumulated after-tax cash flow | 1.5157 | 3.0315 | 4.5472 | 6.0630 | 7.5787 | 9.0944 | 10.6102 | 12.1259 | 13.3720 | 14.6180 |
| Accumulated after-tax cash flow - investment capital | -4.6512 | -3.1354 | -1.6197 | -0.1039 | 1.4118 | 2.9275 | 4.4433 | 5.9590 | 7.2050 | 8.4511 |
| (IRR calculation data) $\quad-6.17$ | 1.5157 | 15157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  | 20.892 |

IRR calculation for Ayutthaya site with 10-year CER crediting period, 4 generators investment

| Profit and loss statement Sales | Fiscal year |  | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income |  | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 |  |
|  | CERs | 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> |  | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 21.4548 |
| Cost | Manpower |  | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable |  | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost |  | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance |  | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 |  |
|  | CDM monitoring |  | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> |  | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 3.5600 |
| $\overline{\text { A finance institution }}$ | Borrowing cost | 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost | 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  |  | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 |  |
| Operating income |  |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 |  |
| Corporation tax | Corporation tax | 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3190 | 0.3190 |  |
| Current income |  |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 0.7442 | 0.7442 |  |
| Cumulative profits |  |  | 1.0632 | 2.1264 | 3.1895 | 4.2527 | 5.3159 | 6.3791 | 7.4423 | 8.5054 | 9.2497 | 9.9939 |  |


| Cash flow statement Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 |
| Depreciation | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 |
| Total cash inflows | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3190 | 0.3190 |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3190 | 0.3190 |
| Cash flow | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.4705 | 1.4705 |
|  |  |  |  |  |  |  |  |  |  |  |
| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| After-tax cash flow | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.4705 | 1.4705 |
| Accumulated after-tax cash flow | 1.7895 | 3.5790 | 5.3684 | 7.1579 | 8.9474 | 10.7369 | 12.5264 | 14.3158 | 15.7864 | 17.2569 |
| Accumulated after-tax cash flow - investment capital | -5.4735 | -3.6840 | -1.8946 | -0.1051 | 1.6844 | 3.4739 | 5.2634 | 7.0528 | 8.5234 | 9.9939 |
| (IRR calculation data) $\quad-7.263$ | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  | 20.9655 |

IRR calculation for Krabi site with 10-year CER crediting period, 4 generators investment

| (Unit: Million USD) |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
|  | Electric generation income | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 2.3161 | 23161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 23.160 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 |  |
|  | CDM monitoring | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.3482 | 03482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 3.4820 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 |  |
| Operating income |  | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 1.3062 | 13062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3919 | 0.3919 |  |
| Current income |  | 1.3062 | 13062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 0.9143 | 0.9143 |  |
| Cumulative profits |  | 1.3062 | 2.6124 | 3.9186 | 5.2247 | 6.5309 | 7.8371 | 9.1433 | 10.4495 | 11.3638 | 12.2781 |  |


| Cash flow statement Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits | 1.3062 | 1.3062 | 1.306 | 1.306 | 1.306 | 1.30 | 1.3062 | 1.30 | 1.30 | 1.36 |
| Depreciation | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.66 | 0.6617 |
| Toal cash inflows | 1.9679 | 19679 | 79 | 9 | 1.9679 | 1.967 | 1.9679 | 1.9679 | 1.9679 | 1.9679 |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3919 | 0.3919 |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.000 | 0.0000 |
| Total cash-out flow | 0.0000 | 0.00 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3919 | 0.3919 |
| Cash flow | 1.9679 | 19679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.96 | 1.5760 | . 57 |
|  |  |  |  |  |  |  |  |  |  |  |
| Breakeven calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
| After-tax cash flow | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.967 | 1.9 | 1.9679 | 1.967 | 1.57 | 1.57 |
| Accumulated afer-tax cash flow | 1.9679 | 3.9357 | 5.9036 | 7.8715 | 9.8394 | 11.8072 | 13.7751 | 15.7430 | 17.319 | 18.89 |
| Accumulated afer-tax cash flow - investment capital | -4.6490 | -2.6812 | -0.7133 | 1.2546 | 3.2225 | 5.1903 | 7.1582 | 9.1261 | 10.7021 | 12.278 |
| (IRR calculation data) -6.62 | 1.9679 | 1967 | .9679 | 1.967 | 1.967 | 1.967 | 679 | 1.9679 | 1.967 | 1.9679 |
| Internal rate of reum, before tax (\%) |  |  |  |  |  |  |  |  |  | 27.019 |

IRR calculation for Ayutthaya site with 14-year CER crediting period, no generator investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 3.1 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.89 |
| A finance institution | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | .000 | 0000 | 0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 |  |  |  |  |  |
| Operating income |  | -0.3853 | $-0.3853$ | $-0.3853$ | -0.3853 | $-0.3853$ | $-0.3853$ | $-0.3853$ | $-0.3853$ | $-0.3853$ | $-0.3853$ | 0.1610 | 0.1610 | 0.1610 | 0.1610 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0483 | 0.0483 | 0.0483 | 0.0483 |  |
| Current income |  | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0,3853 | -0.3853 | 0.1127 | 0.1127 | 0.1127 | 0.1127 |  |
| Cumulative profits |  | -0.3853 | -0.7706 | -1.1559 | -1.5412 | -1.9265 | -2.3118 | -2.6971 | -3.0824 | -3.4677 | -3.8530 | -3.7403 | -3.6276 | -3.5149 | -3.4022 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits | -0.3853 | -0.3853 | -0.385 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |  |
| Depreciation | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash inflows | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 1}$ | $\mathbf{0 . 1 6 1 0}$ |  |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0483 | 0.0483 | 0.0483 | 0.0483 |  |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash-out flow | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 4 8 3}$ | $\mathbf{0 . 0 4 8 3}$ | $\mathbf{0 . 0 4 8 3}$ | $\mathbf{0 . 0 4 8 3}$ |  |
| Cash flow | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 1 2 7}$ | $\mathbf{0 . 1 1 2 7}$ | $\mathbf{0 . 1 1 2 7}$ | $\mathbf{0 . 1 1 2 7}$ |  |


| Break-even calculation | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| After-tax cash flow | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1127 | 0.1127 | 0.1127 | 0.1127 |  |
| Accumulated after-tax cash flow |  | 0.1610 | 0.3220 | 0.4830 | 0.6440 | 0.8050 | 0.9660 | 1.1270 | 1.2880 | 1.4490 | 1.6100 | 1.7227 | 1.8354 | 1.9481 | 2.0608 |
| Accumulated after-tax cash flow - investment capital | -5.3020 | -5.1410 | -4.9800 | -4.8190 | -4.6580 | -4.4970 | -4.3360 | -4.1750 | -4.0140 | -3.8530 | -3.7403 | -3.6276 | -3.5149 | -3.4022 |  |
| IRR calculation data) | -5.463 | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ | $\mathbf{0 . 1 6 1 0}$ |
| Internal rate of return, before tax $(\%)$ |  |  |  |  |  |  |  |  |  |  |  |  |  | $\mathbf{- 1 0 . 0 6 3 7}$ |  |

IRR calculation for Krabi site with 14-year CER crediting period, no generator investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 3.03 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.790 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | . 0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 |  |  |  |  |  |
| Operating income |  | -0.3217 | -0.3217 | $-0.3217$ | $-0.3217$ | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | 0.1600 | 0.1600 | 0.1600 | 0.1600 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -03217 | -0.3217 | 0.1600 | 0.1600 | 0.1600 | 0.1600 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0480 | 0.0480 | 0.0480 | 0.0480 |  |
| Current income |  | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -03217 | -0.3217 | 0.1120 | 0.1120 | 0.1120 | 0.1120 |  |
| Cumulative profits |  | -0.3217 | -0.6433 | -0.9650 | -1.2867 | -1.6084 | -1.9300 | -2.2517 | -2.5734 | -2.8950 | -3.2167 | . 1047 | -2.9927 | -2.8807 | -2.768 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Current profits | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | 0.1600 | 0.1600 | 0.1600 | 0.1600 |  |
| Depreciation | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash inflows | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ |  |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0480 | 0.0480 | 0.0480 | 0.0480 |  |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash-out flow | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 4 8 0}$ | $\mathbf{0 . 0 4 8 0}$ | $\mathbf{0 . 0 4 8 0}$ | $\mathbf{0 . 0 4 8 0}$ |  |
| Cash flow | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 6 0 0}$ | $\mathbf{0 . 1 1 2 0}$ | $\mathbf{0 . 1 1 2 0}$ | $\mathbf{0 . 1 1 2 0}$ | $\mathbf{0 . 1 1 2 0}$ |  |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1120 | . 1120 | .1120 | . 120 |
| Accumulated after-tax cash flow | 0.1600 | 0.3200 | 0.4801 | 0.6401 | 0.8001 | 0.9601 | 1.1201 | 1.2802 | 1.4402 | 1.6002 | 1.7122 | 1.8242 | 1.9362 | 2.048 |
| Accumulated after-tax cash flow - investment capital | -4.6569 | -4.4969 | -4.3369 | -4.1768 | -4.0168 | -3.8568 | -3.6968 | -3.5368 | -3.3767 | -3.2167 | -3.1047 | -2.9927 | -2.8807 | $-2.7687$ |
| (IRR calculation data) -4.82 | 0.160 | 0 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  | -8.867 |

IRR calculation for Ayuthaya site with 14-year CER crediting period, 1 generator investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 9.87 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 1.91 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 |  |  |  |  |  |
| Operating income |  | -0.0232 | -0.0232 | $-0.0232$ | $-0.0232$ | $-0.0232$ | $-0.0232$ | -0.0232 | -0.0232 | -0.0232 | -0.0232 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0070 | -0.0070 | 0.1704 | 0.1704 | 0.1704 | 0.1704 |  |
| Current income |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0162 | -0.0162 | 0.3977 | 0.3977 | 0.3977 | 0.3977 |  |
| Cumulative profits |  | -0.0232 | -0.0464 | -0.0695 | -0.0927 | -0.1159 | -0.1391 | -0.1623 | -0.1854 | -0.2017 | -0.2179 | 0.1798 | 0.5775 | 0.9752 | 13728 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Current profits | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |  |
| Depreciation | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash inflows | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ |  |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0070 | -0.0070 | 0.1704 | 0.1704 | 0.1704 | 0.1704 |  |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash-out flow |  | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0 0}$ | $-\mathbf{- 0 . 0 0 7 0}$ | $-\mathbf{- 0 . 0 0 7 7}$ | $\mathbf{0 . 1 7 0 4}$ | $\mathbf{0 . 1 7 0 4}$ | $\mathbf{0 . 1 7 0 4}$ | $\mathbf{0 . 1 7 0 4}$ |
| Cash flow | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 6 8 1}$ | $\mathbf{0 . 5 7 5 1}$ | $\mathbf{0 . 5 7 5 1}$ | $\mathbf{0 . 3 9 7 7}$ | $\mathbf{0 . 3 9 7 7}$ | $\mathbf{0 . 3 9 7 7}$ | $\mathbf{0 3 9 7 7}$ |  |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5751 | 0.5751 | 0.3977 | 0.3977 | 0.3977 | 0.3977 |
| Accumulated after-tax cash flow | 0.5681 | 1.1362 | 1.7044 | 2.2725 | 2.8406 | 3.4087 | 3.9768 | 4.5450 | 5.1200 | 5.6951 | 6.0928 | 6.490 | 6.8882 | 7.2858 |
| Accumulated after-tax cash flow - investment capital | -5.3449 | -4.7768 | -4.2086 | -3.6405 | -3.0724 | -2.5043 | -1.9362 | -1.3680 | -0.7930 | -0.2179 | 0.1798 | 0.5775 | 0.975 | 1.3728 |
| (IRR calculation data) -5.913 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  | 4.2 |

IRR calculation for Krabi site with 14-year CER crediting period, 1 generator investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 10.3790 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 1.8120 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 |  |  |  |  |  |
| Operating income |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0256 | 0.0256 | 0.1836 | 0.1836 | 0.1836 | 0.1836 |  |
| Current income |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0597 | 0.0597 | 0.4283 | 0.4283 | 0.4283 | 0.4283 |  |
| Cumulative profits |  | 0.0852 | 0.1705 | 0.2557 | 0.3409 | 0.4262 | 0.5114 | 0.5966 | 0.6819 | 0.7415 | 0.8012 | 1.2296 | 1.6579 | 2.0863 | 2.5146 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |
| Depreciation |  | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0256 | 0.0256 | 0.1836 | 0.1836 | 0.1836 | 0.1836 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0256 | 0.0256 | 0.1836 | 0.1836 | 0.1836 | 0.1836 |
| Cash flow |  | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.5864 | 0.5864 | 0.4283 | 0.4283 | 0.4283 | 0.4283 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.5864 | 0.5864 | 0.4283 | 0.4283 | 0.4283 | 0.4283 |
| Accumulated after-tax cash flow | 0.6119 | 1.2239 | 1.8358 | 2.4477 | 3.0596 | 3.6716 | 4.2835 | 4.8954 | 5.4818 | 6.0681 | 6.4965 | 6.9248 | 7.3532 | 7.7815 |
| Accumulated after-tax cash flow - investment capital | -4.6550 | -4.0431 | -3.4311 | -2.8192 | -2.2073 | -1.5954 | -0.9834 | -0.3715 | 0.2149 | 0.8012 | 1.2296 | 1.6579 | 2.0863 | 2.5146 |
| (IRR calculation data) -5.27 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  | 7.2671 |

IRR calculation for Ayutthaya site with 14-year CER crediting period, 2 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 16.59 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 2.94 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $0.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 |  |  |  |  |  |
| Operating income |  | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.9752 | 0.9752 | 0.9752 | 0.9752 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.3389 | 03389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.9752 | 0.9752 | 0.9752 | 0.9752 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1017 | 0.1017 | 0.2926 | 0.2926 | 0.2926 | 0.2926 |  |
| Current income |  | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.2373 | 0.2373 | 0.6827 | 0.6827 | 0.6827 | 0.6827 |  |
| Cumulative pro |  | 0.3389 | 0.6779 | 1.0168 | 1.3558 | 1.6947 | 2.0336 | 2.3726 | 2.7115 | 2.9488 | 3.1860 | 3.8687 | 4.5514 | 5.234 | 5916 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Current profits | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.9752 | 0.9752 | 0.9752 | 0.9752 |  |
| Depreciation | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash inflows | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 9 7 5 2}$ |  |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1017 | 0.1017 | 0.2926 | 0.2926 | 0.2926 | 0.2926 |  |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash-out flow | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 1 0 1 7}$ | $\mathbf{0 . 1 0 1 7}$ | $\mathbf{0 . 2 9 2 6}$ | $\mathbf{0 . 2 9 2 6}$ | $\mathbf{0 . 2 9 2 6}$ | $\mathbf{0 . 2 9 2 6}$ |  |
| Cash flow | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 9 7 5 2}$ | $\mathbf{0 . 8 7 3 6}$ | $\mathbf{0 . 8 7 3 6}$ | $\mathbf{0 . 6 8 2 7}$ | $\mathbf{0 . 6 8 2 7}$ | $\mathbf{0 . 6 8 2 7}$ | $\mathbf{0 . 6 8 2 7}$ |  |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.8736 | 0.8736 | 0.6827 | . 6827 | . 6827 | 0.6827 |
| Accumulated after-tax cash flow | 0.9752 | 1.9505 | 2.9257 | 3.9010 | 4.8762 | 5.8514 | 6.8267 | 7.8019 | 8.6755 | 9.5490 | 10.2317 | 10.9144 | 11.5970 | 12.279 |
| Accumulated after-tax cash flow - investment capital | -5.3878 | -4.4125 | -3.4373 | -2.4620 | -1.4868 | -0.5116 | 0.4637 | 1.438 | 2.3125 | 3.1860 | 3.8687 | 4.5514 | 5.2340 | 5.9167 |
| (IRR calculation data) $\quad-6.363$ | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | . 97 | 0.9752 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  | 12.3 |

IRR calculation for Krabi site with 14-year CER crediting period, 2 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 1.2663 | 12663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 17.7277 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 2.8340 |
| A finance institution | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0000 | 0000 | 0000 | . 0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 |  |  |  |  |  |
| Operating income |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1476 | 0.1476 | 0.3192 | 0.3192 | 0.3192 | 0.3192 |  |
| Current income |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.3445 | 0.3445 | 0.7447 | 0.7447 | 0.7447 | 0.7447 |  |
| Cumulative profits |  | 0.4921 | 09843 | 1.4764 | 1.9686 | 2.4607 | 2.9529 | 3.4450 | 3.9371 | 4.2816 | 4.6261 | 5.3708 | 6.1155 | 6.8602 | 7.6049 |  |


| Cash flow statement Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |
| Depreciation | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1476 | 0.1476 | 0.3192 | 0.3192 | 0.3192 | 0.3192 |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1476 | 0.1476 | 0.3192 | 0.3192 | 0.3192 | 0.3192 |
| Cash flow | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 0.9162 | 0.9162 | 0.7447 | 0.7447 | 0.7447 | 0.7447 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| After-tax cash flow | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 0.9162 | 0.9162 | 0.7447 | 0.7447 | 0.7447 | 0.7447 |
| Accumulated after-tax cash flow | 1.0638 | 2.1277 | 3.1915 | 4.2553 | 5.3192 | 6.8830 | 7.4468 | 8.5107 | 9.4269 | 10.3431 | 11.0877 | 11.8324 | 12.5771 | 13.3218 |
| Accumulated after-tax cash flow - investment capital | -4.6531 | $-3.5892$ | -2.5254 | -1.4616 | -0.3977 | 0.6661 | 1.7299 | 2.7938 | 3.7100 | 4.6261 | 5.3708 | 6.1155 | 6.8602 | 7.6049 |
| (IRR calculation data) -5.72 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  | 163842 |

IRR calculation for Ayutthaya site with 14-year CER crediting period, 3 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 1.4404 | 1.4404 | 1.4404 | 1.440 | 1.4404 | 1.4404 | 1.4404 | 1.440 | 1.4404 | 1.4404 | 1.44 | 1.44 | 1.44 | 1.44 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2 | 0.2250 | 0.22 | 0.22 | 0.22 | 0.2250 | 0.22 | 0.225 |  |
|  | Manpower | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.66 | 1.6654 | 1.665 | 1.665 | 1.6654 | 1.66 | 1.6654 |  |
| Cost |  | 0.02 | 0.0200 | 0.0200 | 0.0200 | 020 | 0.0200 | 0.0200 | 0.020 | 0200 | 0.0200 | 0.020 | 0.020 | 0.0200 | 0.0200 |  |
|  | Consumable | 50 | 0150 | 0.0150 | 0150 | 0.0150 | . 015 | 0.015 | 0.0150 | 0.0150 | 0.015 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0140 | 0.014 | 0.01 | 0.0140 | 0.014 | 0.01 | 0.0140 | 0.01 | 0.014 | 0.0140 |  |
|  | Gas engine maintenance | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.219 | 0.219 | 0.2190 | 0.219 | 0.219 | 0.2190 |  |
|  |  | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.015 | 0.015 | 0.015 | 0.015 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.00 | 0.000 | 0.000 | 0.0000 |  |
|  | <Total> | 0.2830 | 0.2830 | 0.2830 | 2830 | 283 | 0.28 | 0.2830 | 0.2830 | 0.2830 | 0.28 | 0.28 | 0.283 | 0.28 | 0.283 |  |
| $\overline{\text { A finance institution }}$ | Borowing cost $0.0 \%$  <br> Repayment cost   | 0.0000 | 000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 0.00 | 0.00 | 0.000 | 0.000 | 0.000 |  |
|  |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00 | 0.000 | 0.000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | . 000 | 0.0000 | 0.0000 | 0.0000 | 0.00 | 0.000 | 0.0000 | 0.00 | 0.00 | 0.000 | 0.000 | 0.000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | . 00 |  |
| Depreciation |  | 0.6813 | 813 | 0.6813 | 0.6813 | 0.6813 | 0.681 | 0.6813 | 0.68 | 0.6813 | 0.6813 |  |  |  |  |  |
| Operating income |  | 0.7011 | 0.7011 | 011 | 0.7011 | 701 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 1.3824 | 1.382 | 1382 | 1.3824 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 1.3824 | 1.3824 | 1.3824 | 13824 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 | 0.4147 | 0.414 | 0.414 | 0.4147 |  |
| Current income |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.4907 | 0.4907 | 0.967 | 0.967 | 0.96 | 0.967 |  |
| Cumulative profits |  | 0.70 | 1.40 | 2.1032 | 2.8042 | 3.5053 | 4.2064 | 4.9074 | 5.0085 | 6.0992 | 6.9900 | 7.5576 | 8.523 | 9.4929 | 10.4606 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 1.3824 | 1.38 | 1.38 | 1.3824 |
| Depreciation |  | 0.6813 | 0.6813 | 813 | 0.6813 | 0.6813 | 0.6813 | 6813 | 0.6813 | 0.6813 | 0.6813 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 1.382 | 13824 | 1.382 | 1.382 | 1.382 | 1.382 | 1.3824 | 1.382 | 1.382 | 1.3824 | 1.3824 | 1.382 | 1.382 | 1382 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 | 0.4147 | 0.4147 | 0.4147 | 0.414 |
| Repayment of borowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 000 | 0.00 | 0.000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 | 0.4147 | 0.4147 | 0.4147 | 0.4147 |
| Cash flow |  | 1.3824 | 13824 | 1.382 | 1.3824 | 1.382 | 1.3824 | 1.3824 | 1.382 | 1.1720 | 1.1720 | 0.967 | 0.9677 | 0.9677 | 0.967 |


| Break-even calulation Fiscal year | 200 | 2010 | 201 | 2012 | 2013 | 2014 | 201 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.1882 | 1.382 | 1.3824 | 1.3824 | 1.382 | 1.3824 | 1.3824 | 1.1824 | 1.1720 | 1.1720 | 0.9677 | 0.967 | 0.9677 | 0.967 |
| Accumulated afer-tax cash flow | 1.3824 | 2.7 | 4.1471 | 5.5294 | 6.9 | 8.2 | 9.676 | 11.0589 | 12.230 | 13.40 | 3706 | 15.3883 | 16.3059 | 17.2736 |
| Accumulated afer-tax cash flow - investment capital | -5.43 | -4.0483 | -2.6659 | ${ }^{-1.2836}$ | 0.0988 | 1.4812 | 2.8635 | 4.2459 | 5.417 | 6.59 | . 5576 | 8.52 | 9.492 | 10.4606 |
| (IRR calculation data) $\quad-6.813$ | 1.382 | 1382 | 1.382 | 1.3824 | 1.382 | 1.382 | 1.382 | 1.38 | 1.382 | 1.38 | 1.3824 | 1.3824 | 1.3824 | 1.3824 |
| Internal rate of reum, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  | 183780 |

IRR calculation for Krabi site with 14-year CER crediting period, 3 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 25.0764 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 3.8560 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 |  |  |  |  |  |
| Operating income |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 1.5157 | 1.5157 | 1.5157 | 1.5157 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 1.5157 | 1.5157 | 1.5157 | 1.5157 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2697 | 0.2697 | 0.4547 | 0.4547 | 0.4547 | 0.4547 |  |
| Current income |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.6293 | 0.6293 | 1.0610 | 1.0610 | 1.0610 | 1.0610 |  |
| Cumulative profits |  | 0.8991 | 1.7981 | 2.6972 | 3.5962 | 4.4953 | 5.3943 | 6.2934 | 7.1924 | 7.8217 | 8.4511 | 9.5121 | 10.5731 | . 6341 | 12.6951 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Current profits | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 1.5157 | 1.5157 | 1.5157 | 1.5157 |  |
| Depreciation | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash inflows | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 5 1 5 7}$ |  |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2697 | 0.2697 | 0.4547 | 0.4547 | 0.4547 | 0.4547 |  |
| Repayment of borrowed money | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash-out flow |  | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 0 0 0 0}$ | $\mathbf{0 . 2 6 9 7}$ | $\mathbf{0 . 2 6 9 7}$ | $\mathbf{0 . 4 5 4 7}$ | $\mathbf{0 . 4 5 4 7}$ | $\mathbf{0 . 4 5 4 7}$ | $\mathbf{0 . 4 5 4 7}$ |
| Cash flow | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 5 1 5 7}$ | $\mathbf{1 . 2 4 6 0}$ | $\mathbf{1 . 2 4 6 0}$ | $\mathbf{1 . 0 6 1 0}$ | $\mathbf{1 . 0 6 1 0}$ | $\mathbf{1 . 0 6 1 0}$ | $\mathbf{1 . 0 6 1 0}$ |  |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.2460 | 1.2460 | 1.0610 | 1.0610 | 1.0610 | 1.0610 |
| Accumulated after-tax cash flow | 1.5157 | 3.0315 | 4.5472 | 6.0630 | 7.5787 | 9.0944 | 10.6102 | 12.1259 | 13.3720 | 14.6180 | 15.6790 | 16.7400 | 17.8010 | 18.8621 |
| Accumulated after-tax cash flow - investment capital | -4.6512 | -3.1354 | -1.6197 | -0.1039 | 1.4118 | 2.9275 | 4.4433 | 5.9590 | 7.2050 | 4511 | 9.5121 | 0.5731 | 1.6341 | 12.6951 |
| (IRR calculation data) $\quad-6.17$ | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 |
| Internal rate of return, |  |  |  |  |  |  |  |  |  |  |  |  |  | 23.2 |

IRR calculation for Ayutthaya site with 14-year CER crediting period, 4 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 30.03 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.3560 | 03560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 03560 | 4.98 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 |  |  |  |  |  |
| Operating income |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3190 | 0.3190 | 0.5368 | 0.5368 | 0.5368 | 0.5368 |  |
| Current income |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 0.7442 | 0.7442 | 1.2526 | 1.2526 | 1.2526 | 1.2526 |  |
| Cumulative profits |  | 1.0632 | 2.1264 | 3.1895 | 4.2527 | 5.3159 | 6.3791 | 7.4423 | 8.5054 | 9.2497 | 9.9939 | 11.2465 | 12.4992 | 13.7518 | 15.0044 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.063 | 1.063 | 1.0632 | 1.063 | 1.0632 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |
| Depreciation |  | 263 | 0.7263 | 263 | 63 | 63 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.0000 | 0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.78 |
| crporation |  | 0.0000 | 0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00 | 0.000 | 0.3190 | 0.3190 | 0.53 | 0.5368 | 0.5368 | 0.5368 |
| Repayment of borowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.00 | 0.0 | 0.3190 | 0.3190 | 0.5368 | 0.5368 | 0.53 | 0.5368 |
| ash flow |  | 1.78 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.4705 | 1.4705 | 1.2526 | 1.2526 | 1.2526 | 1.2526 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 202 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.4705 | 1.4705 | 1.2526 | 1.2526 | 1.2526 | 1.2526 |
| Accumulated after-tax cash flow | 1.7895 | 3.5790 | 5.3684 | 7.1579 | 8.9474 | 10.7369 | 12.5264 | 14.3158 | 15.7864 | 17.2569 | 18.5095 | 19.7622 | 21.0148 | 22.2674 |
| Accumulated after-tax cash flow - investment capital | . 735 | 840 | 946 | 1051 | 1.6844 | .473 | 5.2634 | 7.052 | 8.523 | 9.9939 | 11.2465 | 2.4992 | 13.7518 | 15.0044 |
| (IRR calculation data) $\quad-7.263$ | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.78 | 1.789 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  | 233 |

IRR calculation for Krabi site with 14-year CER crediting period, 4 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 23161 | 32.4251 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 |  |
|  | CDM monitoring | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 03482 | 4.8749 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 |  |  |  |  |  |
| Operating income |  | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.9679 | 1.9679 | 1.9679 | 19679 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.9679 | 1.9679 | 1.9679 | 19679 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3919 | 0.3919 | 0.5904 | 0.5904 | 0.5904 | 0.5904 |  |
| Current income |  | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 0.9143 | 0.9143 | 1.3775 | 1.3775 | 1.3775 | 13775 |  |
| Cumulative profits |  | 1.3062 | 2.6124 | 3.9186 | 5.2247 | 6.5309 | 7.8371 | 9.1433 | 10.4495 | 11.3638 | 12.2781 | 13.6556 | 15.0332 | 16.4107 | 17.7882 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Current profts | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.9679 | 1.9699 | 1.9679 | 1.9679 |
| Cepreciation |  | 0.6617 | 0.6617 | 0.6617 | 0.0617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.0000 | 0.0000 | 0.0000 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.5760 | 1.5760 | 1.3775 | 1.3775 | 1.3775 | 1.3775 |
| Accumulated after-tax cash flow | 1.9679 | 9357 | . 9036 | 7.8715 | 8, 394 | 11.8072 | 13.7751 | 15.7430 | 17.3190 | 18.8950 | 2726 | 21.6501 | 23.0276 | 24.4051 |
| Accumulated after-tax cash flow - investment capital | -4.6490 | -2.6812 | -0.7133 | 1.2546 | 3.2225 | 5.1903 | 7.1582 | 9.1261 | 10.7021 | 12.2781 | 13.6556 | 15.0332 | 16.4107 | 17.7882 |
| (IRR calculation data) $\quad-6.62$ | 1.9679 | 19679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 |
| Internal rate of retur |  |  |  |  |  |  |  |  |  |  |  |  |  | 28.88 |

IRR calculation for Ayutthaya site with 20-year CER crediting period, no generator investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Tota |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 4.5 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 | 0.0640 |  |
| $\overline{\text { A finance institution }}$ | Borrowing cost $0.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  |  | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 |  |  |  |  |  |  |  |  |  |  |  |
|  |  | -0.3853 | $-0.3853$ | $-0.3853$ | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.0853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 |  |
| Current income |  | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 |  |
| Cumulative profits |  | -0.3853 | -0.7706 | -1.1559 | -1.5412 | -1.9265 | -2.3118 | -2.6971 | -3.0824 | -3.4677 | $-3.8530$ | -3.7403 | $-3.6276$ | -35149 | -3.4022 | -3.2895 | -3.1768 | $-3.0641$ | -2.9514 | -2.838 | -2.7260 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | -0.3853 | $-0.3853$ | $-0.3853$ | -0.3853 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |
| Depreciation |  | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 | 0.0483 |
| Cash flow |  | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1127 |
| Accumulated after-tax cash flow | 0.1610 | 0.3220 | 0.4830 | 0.6440 | 0.8050 | 0.9660 | 1.1270 | 1.2880 | 1.4490 | 1.6100 | 1.7227 | 1.8354 | 1.9481 | 2.0608 | 2.1735 | 2.2862 | 2.3989 | 2.5116 | 2.6243 | 2.7370 |
| Accumulated after-tax cash flow - investment capital | -5.3020 | -5.1410 | -4.9800 | -4.8190 | -4.6580 | -4.4970 | -4.3360 | -4.1750 | -4.0140 | -3.8530 | -3.7403 | -3.6276 | -3.5149 | -3.4022 | -3.2895 | -3.1768 | -3.0641 | -2.9514 | -2.8387 | -2.7260 |
| $($ IRR calculation data) $\quad-5.463$ | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 | 0.1610 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | -4.5806 |

IRR calculation for Krabi site with 20-year CER crediting period, no generator investment

| Profit and loss statement Sales | Fiscal year |  | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CERs | 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> |  | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 4.3290 |
| Cost | Manpower |  | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable |  | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost |  | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CDM monitoring |  | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> |  | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 0.0564 | 1.1286 |
| A finance institution | Borrowing cost | 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost | 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  |  | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  |  | $-0.3217$ | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  |  | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1600 |  |
| Corporation tax | Corporation tax | 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0480 | 0.0480 | 0.0480 | 0.0480 | 0.0480 | 0.0480 | 0.0480 | 0.0480 | 0.0480 | 0.0480 |  |
| Current income |  |  | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | -0.3217 | 0.1120 | 0.1120 | 0.1120 | 0.1120 | 0.1120 | 0.1120 | 0.1120 | 0.1120 | 0.1120 | 0.1120 |  |
| Cumulative profits |  |  | -0.3217 | -0.6433 | -0.9650 | -1.2867 | -1.6084 | -1.9300 | -2.2517 | -2.5734 | -2.8950 | -3.2167 | -3.1047 | -2.9927 | -2.8807 | -2.7687 | -2.6567 | -2.5446 | -2.4326 | -2.3206 | -2.2086 | -2.0966 |  |


IRR calculation for Ayuthaya site with 20-year CER crediting period, 1 generator investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 14.102 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 0.1370 | 2.74 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | -0.0232 | -0.0232 | $-0.0232$ | $-0.0232$ | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0070 | -0.0070 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 |  |
| Current income |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0162 | -0.0162 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 |  |
| Cumulative profits |  | -0.0232 | -0.0464 | -0.0695 | -0.0927 | -0.1159 | -0.1391 | -0.1623 | -0.1854 | -0.2017 | -0.2179 | 0.1798 | 0.5775 | 0.9752 | 1.3728 | 1.7705 | 2.1682 | 2.5659 | 2.9636 | 3.3613 | 3.7590 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | -0.0232 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |
| Depreciation |  | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0070 | -0.0070 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0070 | -0.0070 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 | 0.1704 |
| Cash flow |  | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5751 | 0.5751 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5751 | 0.5751 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 | 0.3977 |
| Accumulated after-tax cash flow | 0.5681 | 1.1362 | 1.7044 | 2.2725 | 2.8406 | 3.4087 | 3.9768 | 4.5450 | 5.1200 | 5.6951 | 6.0928 | 6.4905 | 6.8882 | 7.2858 | 7.6835 | 8.0812 | 8.4789 | 8.8766 | 9.2743 | 9.6720 |
| Accumulated after-tax cash flow - investment capital | -5.3449 | -4.7768 | -4.2086 | -3.6405 | -3.0724 | -2.5043 | -1.9362 | -1.3680 | -0.7930 | -0.2179 | 0.1798 | 0.5775 | 0.9752 | 1.3728 | 1.7705 | 2.1682 | 2.5659 | 2.9636 | 3.3613 | 3.7590 |
| (IRR calculation data) -5.913 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 | 0.5681 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 7.2290 |

IRR calculation for Krabi site with 20-year CER crediting period, 1 generator investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 14.827 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 2.58 |
| $\widehat{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 000 | 0.0000 | 0.0000 | ,000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |  |
| Corporation tax | Corporation tax $\quad 30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0256 | 0.0256 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 |  |
| Current income |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0597 | 0.0597 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 |  |
| Cumulative profits |  | 0.0852 | 0.1705 | 0.2557 | 0.3409 | 0.4262 | 0.5114 | 0.5966 | 0.6819 | 0.7415 | 0.8012 | 1.2296 | 1.6579 | 2.0863 | 2.5146 | 29430 | 3.3713 | 3.7997 | 4.2280 | 4.6563 | 5.0847 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.0852 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |
| Depreciation |  | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0256 | 0.0256 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0256 | 0.0256 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 | 0.1836 |
| Cash flow |  | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.5864 | 0.5864 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.4283 | 0.428 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.586 | 0.586 | 0.4283 | 0.4283 | 0.428 | 0.4283 | 0.4283 | 0.4283 | 0.428 | 0.4283 | 0.4283 | 0.4283 |
| Accumulated after-tax cash flow | 0.6119 | 1.2239 | 1.8358 | 2.4477 | 3.0596 | 3.6716 | 4.2835 | 4.8954 | 5.4818 | 6.0681 | 6.4965 | 6.9248 | 7.3532 | 7.7815 | 8.2099 | 8.6382 | 9.0666 | 9.4949 | 9233 | 10.351 |
| Accumulated after-tax cash flow - investment capital | -4.6550 | -4.0431 | -3.4311 | -2.8192 | -2.2073 | -1.5954 | -0.9834 | -0.3715 | 0.2149 | 0.8012 | 1.2296 | 1.6579 | 2.0863 | 2.5146 | 2.9430 | 3.3713 | 3.799 | 4.2280 | 4.6563 | 5.084 |
| (IRR calculation data) $\quad-5.27$ | 0.611 | 0.611 | 0.6119 | 0.6119 | 0.6119 | 0.611 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 | 0.6119 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 9.84 |

IRR calculation for Ayutthaya site with 20-year CER crediting period, 2 generators investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 23.70 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 0.2100 | 4.20 |
| $\overline{\text { A finance institution }}$ | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 03389 | 0.3389 | 03389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1017 | 0.1017 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 |  |
| Current income |  | 03389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.2373 | 0.2373 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 |  |
| Cumulative profits |  | 03389 | 0.6779 | 1.0168 | 1.3558 | 1.6947 | 2.0336 | 2.3726 | 2.7115 | 2.9488 | 3.1860 | 3.8687 | 4.5514 | 5.2340 | 5.9167 | 6.5994 | 7.2820 | 7.9647 | 8.6474 | 9.3301 | 10.0127 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 |
| Depreciation |  | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1017 | 0.1017 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1017 | 0.1017 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 | 0.2926 |
| Cash flow |  | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.8736 | 0.8736 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.8736 | 0.8736 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 | 0.6827 |
| Accumulated after-tax cash flow | 0.9752 | 1.9505 | 2.9257 | 3.9010 | 4.8762 | 5.8514 | 6.8267 | 7.8019 | 8.6755 | 9.5490 | 10.2317 | 10.9144 | 11.5970 | 12.2797 | 12.9624 | 13.6450 | 14.3277 | 15.0104 | 15.6931 | 16.3757 |
| Accumulated after-tax cash flow - investment capital | -5.3878 | -4.4125 | -3.4373 | -2.4620 | -1.4868 | -0.5116 | 0.4637 | 1.4389 | 2.3125 | 3.1860 | 3.8687 | 4.5514 | 5.2340 | 5.9167 | 6.5994 | 7.2820 | 7.9647 | 8.6474 | 9.3301 | 10.0127 |
| (IRR calculation data) $\quad-6.363$ | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 | 0.9752 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 14.2615 |

IRR calculation for Krabi site with 20-year CER crediting period, 2 generators investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 12663 | 1.2663 | 12663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.263 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 25.32 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 0.2024 | 4.04 |
| A finance institution | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1476 | 0.1476 | 0.3192 | 0.3192 | 0.3192 | 0.3192 | 0.3192 | 0.3192 | 0.3192 | 0.3192 | 0.3192 | 0.3192 |  |
| Current income |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.3445 | 0.3445 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 |  |
| Cumulative profits |  | 0.4921 | 0.9843 | 1.4764 | 1.9686 | 2.4607 | 2.9529 | 3.4450 | 3.9371 | 4.2816 | 4.6261 | 5.3708 | 6.1155 | 6.8602 | 7.6049 | 83496 | 9.9942 | 9.8389 | 10.5836 | 11.3283 | 12.0730 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 0.4921 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |
| Depreciation |  | 0.5717 | 0.5717 | 0.5717 | 0.571 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.571 | 0.00 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |
| Corporation tax |  | 000 | ,000 | 000 | 0 | 0.0000 | 0000 | 0.0000 | 0.0000 | 0.1476 | 0.1476 | 0.3192 | 0.3192 | 92 | 92 | 0.3192 | . 3192 | 0.3192 | 0.3192 | 3192 | 0.3192 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1476 | 0.1476 | 0.3192 | 0.3192 | 0.3192 | 0.3192 | 03192 | 0.3192 | 0.3192 | 0.3192 | 0.3192 | 0.3192 |
| Cash flow |  | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 0.9162 | 0.9162 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 0.9162 | 0.9162 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 | 0.7447 |
| Accumulated after-tax cash flow | 1.0638 | 2.1277 | 3.1915 | 4.2553 | 5.3192 | 6.3830 | 7.4468 | 8.5107 | 9.4269 | 10.3431 | 11.0877 | 11.8324 | 12.5771 | 13.3218 | 14.0665 | 14.8112 | 15.5558 | 16.3005 | 17.0452 | 17.7899 |
| Accumulated after-tax cash flow - investment capital | -4.6531 | -3.5892 | -2.5254 | -1.4616 | -0.3977 | 0.6661 | 1.7299 | 2.7938 | 3.7100 | 4.6261 | 5.3708 | 6.1155 | 6.8602 | 7.6049 | 8.3496 | 9.0942 | 9.8389 | 10.5836 | 11.328 | 12.0730 |
| (IRR calculation data) $\quad-5.72$ | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 | 1.0638 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 17.9 |

IRR calculation for Ayutthaya site with 20-year CER crediting period, 3 generators investment

| Profit and loss statement Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 33.307 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 0.2830 | 5.660 |
| A finance institution | Borrowing cost 0.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 13824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 |  |
| Current income |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.4907 | 0.4907 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 09677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 |  |
| Cumulative profits |  | 0.7011 | 1.4021 | 2.1032 | 2.8042 | 3.5053 | 4.2064 | 4.9074 | 5.6085 | 6.0992 | 6.5900 | 7.5576 | 8.5253 | 9.4929 | 10.4606 | 11.4282 | 12.3959 | 13.3635 | 143312 | 15.2988 | 16.2665 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 0.7011 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.382 |
| Depreciation |  | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 |
| Total cash inflows |  | 13824 | 1.3824 | 13824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 13824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.382 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.414 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.0000 | 0.0000 | 0.000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2103 | 0.2103 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.4147 | 0.414 |
| Cash flow |  | 13824 | 1.3824 | 13824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.1720 | 1.1720 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.967 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 202 | 202 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.1720 | 1.1720 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.9677 | 0.967 | 0.967 |
| Accumulated after-tax cash flow | . 3824 | 2.7647 | 471 | 5.5294 | 118 | 8.2942 | , 765 | 11.0589 | 2309 | 13.4030 | 14.3706 | 15.3383 | 16.3059 | . 2736 | 18.2412 | 19.2089 | 20.1765 | 21.1442 | 22.1118 | 23.0795 |
| Accumulated after-tax cash flow - investment capital | -5.4306 | -4.0483 | -2.6659 | -1.2836 | 0.0988 | 1.4812 | 2.8635 | 4.2459 | 5.4179 | 6.5900 | 7.5576 | 8.5253 | 9.4929 | 10.4606 | 11.4282 | 12.3959 | 13.3635 | 14.3312 | 15.2988 | 16.2665 |
| (IRR calculation data) $\quad-6.813$ | 13824 | 1.3824 | 13824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 13824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 | 1.3824 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 19.73 |

IRR calculation for Krabi site with 20-year CER crediting period, $\mathbf{3}$ generators investment

| (Unit: Million USD) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| Sales | Electric generation income | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 |  |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 0.2754 | 5.5 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $0.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 15157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2697 | 0.2697 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 |  |
| Current income |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.6293 | 0.6293 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 |  |
| Cumulative profits |  | 0.8991 | 1.7981 | 2.6972 | 3.5962 | 4.4953 | 5.3943 | 6.2934 | 7.1924 | 7.8217 | 8.4511 | 9.5121 | 10.5731 | 11.6341 | 12.6951 | 13.7562 | 14.8172 | 15.8782 | 16.9392 | 18.0002 | 19.0613 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 0.8991 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.515 | 1.5157 | 1.515 | 1.5157 | 1.515 |
| Depreciation |  | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 5157 | 5157 | 5157 | 157 | 157 | . 5157 | 1.5157 | 1.5157 | 1.5157 | . 515 | 1.5157 | 515 | 1.515 | 1.515 | 1.5157 | 1.515 | 1.515 | 1.515 | 515 | 1.51 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2697 | 0.2697 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.45 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2697 | 0.2697 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 | 0.4547 |
| Cash flow |  | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.2460 | 1.2460 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.06 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.2460 | 1.2460 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 | 1.0610 |
| Accumulated after-tax cash flow | 1.5157 | 3.0315 | 4.5472 | 6.0630 | 7.5787 | 9.0944 | 10.6102 | 12.1259 | 13.3720 | 14.6180 | 15.6790 | 16.7400 | 17.8010 | 18.8621 | 19.9231 | 20.9841 | 22.0451 | 23.1061 | 24.1672 | 25.228 |
| Accumulated after-tax cash flow - investment capital | -4.6512 | -3.1354 | -1.6197 | -0.1039 | 1.4118 | , 2775 | 4.4433 | 5.9590 | 7.2050 | 4511 | 5121 | 10.5731 | . 6341 | 12.695 | 13.756 | 4.81 | 15.8782 | 16.9392 | 18.0002 | 19.0613 |
| (IRR calculation data) $\quad-6.17$ | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.5157 | 1.51 |
| Internal ra |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 24.25 |

IRR calculation for Ayutthaya site with 20-year CER crediting period, $\mathbf{4}$ generators investment

| (Unit: Million USD) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| Sales | Electric generation income | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 42.9 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total | 03560 | 0.3560 | 03560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 03560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 0.3560 | 7.1 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $0.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |  |
| Corporation tax | Corporation tax $\quad 30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3190 | 0.3190 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 |  |
| Current income |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 0.7442 | 0.7442 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 12526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 |  |
| Cumulative profits |  | 1.0632 | 2.1264 | 3.1895 | 4.2527 | 5.3159 | 6.3791 | 7.4423 | 8.5054 | 9.2497 | 9.9939 | 11.2465 | 12.4992 | 13.7518 | 15.0044 | 16.2571 | 17.5097 | 18.7624 | 20.0150 | 21.2676 | 22.5203 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.0632 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |
| Depreciation |  | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3190 | 0.3190 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3190 | 0.3190 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 | 0.5368 |
| Cash flow |  | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.4705 | 1.4705 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.7895 | 1.4705 | 1.4705 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 1.2526 | 2526 | 1.252 | . 252 | 1.2526 |
| Accumulated after-tax cash flow | 1.7895 | 3.5790 | 5.3684 | 7.1579 | 8.9474 | 10.7369 | 12.5264 | 14.3158 | 15.7864 | 17.2569 | 18.5095 | 19.7622 | 21.0148 | 22.2674 | 23.5201 | 24.7727 | 26.0254 | 27.2780 | 28.5306 | 29.7833 |
| Accumulated after-tax cash flow - investment capital | -5.4735 | -3.6840 | -1.8946 | -0.1051 | 1.6844 | 3.4739 | 5.2634 | 7.0528 | 523 | 9939 | 11.2465 | 12.4992 | 13.7518 | 15.0044 | 16.2571 | 17.5097 | 18.7624 | 20.0150 | 21.2676 | 22.5203 |
| (IRR calculation data) $\quad-7.263$ | 1.78 | 1.78 | 1.78 | 1.78 | 1. | 1.7895 | 1.78 | 1.7895 | 1.7895 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | 1.78 | . 78 | .789 | 1.7895 | 1.78 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 24.3 |

IRR calculation for Krabi site with 20-year CER crediting period, 4 generators investment

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 23161 | 2.3161 | 23161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 23161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 46.32 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 |  |
|  | CDM monitoring | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 |  |
|  | Interest cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | <Total> | 03482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 03482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 0.3482 | 6.964 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $0.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | After paid up balance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Interest cost 10.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Depreciation |  | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 13062 | 1.3062 | 13062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 19679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3919 | 0.3919 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 |  |
| Current income |  | 13062 | 1.3062 | 13062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 0.9143 | 0.9143 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 13775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 |  |
| Cumulative profits |  | 13062 | 2.6124 | 39186 | 5.2247 | 6.5309 | 7.8371 | 9.1433 | 10.4495 | 11.3638 | 12.2781 | 13.6556 | 15.0332 | 16.410 | 17.7882 | 19.165 | 20.5432 | 21.9207 | 23.2982 | 4.675 | 26.05 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.3062 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 |
| Depreciation |  | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 19679 | 1.9679 | 19679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 19679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3919 | 0.3919 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 |
| Repayment of borrowed money |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash-out flow |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3919 | 0.3919 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 | 0.5904 |
| Cash flow |  | 19679 | 1.9679 | 19679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.5760 | 1.5760 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 13775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.5760 | 1.5760 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 | 1.3775 |
| Accumulated after-tax cash flow | 19679 | 3.9357 | 5.9036 | 7.8715 | 9.8394 | 11.8072 | 13.7751 | 15.7430 | 17.3190 | 18.8950 | 20.2726 | 21.6501 | 23.0276 | 24.4051 | 25.7826 | 27.1601 | 28.5376 | 29.9151 | 31.2927 | 32.6702 |
| Accumulated after-tax cash flow - investment capital | -4.6490 | -2.6812 | $-0.7133$ | 1.2546 | 3.2225 | 5.1903 | 7.1582 | 9.1261 | 0.7021 | 12.2781 | 13.6556 | 15.0332 | 16.4107 | 17.7882 | 19.1657 | 20.5432 | 21.9207 | 23.2982 | 24.6757 | 26.0533 |
| (IRR calculation data) $\quad-6.62$ | 19679 | 1.9679 | 19679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 19679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 | 1.9679 |
| Internal |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 29.57 |

Summarized results of economic assessment for biogas CDM project (with loan-debt condition)

| Item | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | Ayutthaya Value | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | Ayutthaya Value | Krabi <br> Value |  |  |
| GHG emission reduction | 450000 | 432900 | 450000 | 432900 | 450000 | 432900 | 450000 | 432900 | 450000 | 432900 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs sale | 4.50 | 4.33 | 4.50 | 4.33 | 4.50 | 4.33 | 4.50 | 4.33 | 4.50 | 4.33 | Million USD | CERs price: 10 USD/t $\mathrm{CO}_{2} \mathrm{e}$ |
| Total power generation | 0.00 | 0.00 | 116332 | 127184 | 232664 | 254367 | 348995 | 381551 | 465327 | 508735 | MWh | Estimated plant data |
| Electricity sale | 0.00 | 0.00 | 9.60 | 10.50 | 19.20 | 21.00 | 28.81 | 31.49 | 38.41 | 41.99 | Million USD | VSPP tariff 2.96 Baht/kWh |
| Net profit | -5.40 | -4.46 | 0.85 | 2.55 | 7.00 | 9.37 | 13.05 | 16.15 | 19.09 | 22.92 | Million USD | Revenue-(depreciation taxable +corporation tax) |
| Initial cost investment | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| Total cost investment | 9.63 | 8.49 | 11.77 | 10.64 | 13.92 | 12.78 | 16.07 | 14.93 | 18.22 | 17.07 | Million USD | Depreciation taxable+operation cost |
| CER generating cost | 13.49 | 12.36 | 14.60 | 13.52 | 15.71 | 14.67 | 16.82 | 15.83 | 17.93 | 16.98 | USD/t CO2 ${ }^{\text {e }}$ | Cost investment/GHG emission reduction |
| CERs margin | 100.00 | 100.00 | 31.91 | 29.20 | 18.98 | 17.09 | 13.51 | 12.08 | 10.49 | 9.35 | \% | CERs sale/selling price or revenue |
| Profit percentage | -56.14 | -52.53 | 7.19 | 24.01 | 50.31 | 73.30 | 81.19 | 108.14 | 104.78 | 134.27 | \% | Net profit/cost price |
| Profit margin | -120.10 | -102.98 | 6.00 | 17.22 | 29.55 | 37.00 | 39.17 | 45.07 | 44.48 | 49.49 | \% | Net profit/selling price or revenue |
| Internal rate of return | 0.00 | 0.00 | 2.97 | 5.66 | 10.13 | 13.76 | 15.56 | 20.01 | 20.07 | 25.22 | \% | Expected IRR in Thailand, 5.59\% |

[^4]IRR calculation for Ayutthaya site with 20-year CER crediting period, with no generator investment (In condition of $\mathbf{5 0 \%}$ capital cost loan)

| (Unit: Million USD) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
|  | Electric generation income | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  |  | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  |  | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 4.5000 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  |  | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | System maintenance cost <br> Gas engine maintenance | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.2883 | 0.2732 | 0.2580 | 0.2428 | 0.2276 | 0.2125 | 0.1973 | 0.1821 | 0.1669 | 0.1518 | 0.1366 | 0.1214 | 0.1062 | 0.0911 | 0.0759 | 0.0607 | 0.0455 | 0.0304 | 0.0152 | 0.0000 |  |
|  | <Total> | 03523 | 0.3372 | 0.3220 | 0.3068 | 0.2916 | 0.2765 | 0.2613 | 0.2461 | 0.2309 | 0.2158 | 0.2006 | 0.1854 | 0.1702 | 0.1551 | 0.1399 | 0.1247 | 0.1095 | 0.0944 | 0.0792 | 0.0640 | 4.1633 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $50.0 \%$ | 3.0350 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 | 0.1518 |  |
|  | After paid up balance | 2.8833 | 2.7315 | 2.5798 | 2.4280 | 2.2763 | 2.1245 | 1.9728 | 1.8210 | 1.6693 | 1.5175 | 1.3658 | 1.2140 | 1.0623 | 0.9105 | 0.7588 | 0.6070 | 0.4553 | 0.3035 | 0.1518 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.2883 | 0.2732 | 0.2580 | 0.2428 | 0.2276 | 0.2125 | 0.1973 | 0.1821 | 0.1669 | 0.1518 | 0.1366 | 0.1214 | 0.1062 | 0.0911 | 0.0759 | 0.0607 | 0.0455 | 0.0304 | 0.0152 | 0.0000 |  |
| Depreciation |  | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | -0.6736 | -0.6585 | $-0.6433$ | -0.6281 | -0.6129 | -0.5978 | -0.5826 | -0.5674 | -0.5522 | -0.5371 | 0.0244 | 0.0396 | 0.0548 | 0.0699 | 0.0851 | 0.1003 | 0.1155 | 0.1307 | 0.1458 | 0.1610 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.6736 | -0.6585 | -0.6433 | -0.6281 | -0.6129 | -0.5978 | -0.5826 | -0.5674 | -0.5522 | -0.5371 | 0.0244 | 0.0396 | 0.0548 | 0.0699 | 0.0851 | 0.1003 | 0.1155 | 0.1307 | 0.1458 | 0.1610 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0073 | 0.0119 | 0.0164 | 0.0210 | 0.0255 | 0.0301 | 0.0346 | 0.0392 | 0.0437 | 0.0483 |  |
| Current income |  | -0.6736 | -0.6585 | -0.6433 | -0.6281 | -0.6129 | -0.5978 | -0.5826 | -0.5674 | -0.5522 | -0.5371 | 0.0171 | 0.0277 | 0.0383 | 0.0490 | 0.0596 | 0.0702 | 0.0808 | 0.0915 | 0.1021 | 0.1127 |  |
| Cumulative profits |  | -0.6736 | -1.3321 | -1.9754 | -2.6035 | -3.2164 | -3.8141 | -4.3967 | -4.9641 | -5.5163 | -6.0534 | -6.0363 | -6.0086 | -5.9702 | -5.9213 | -5.8617 | -5.7915 | -5.7106 | -5.6192 | -5.5171 | -5.4044 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Cash flow statement Fiscal year |  | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |  |
| Current profits |  | -0.6736 | -0.6585 | -0.6433 | -0.6281 | -0.6129 | -0.5978 | -0.5826 | -0.5674 | -0.5522 | -0.5371 | 0.0244 | 0.0396 | 0.0548 | 0.0699 | 0.0851 | 0.1003 | 0.1155 | 0.1307 | 0.1458 | 0.1610 |  |
| Depreciation |  | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.5463 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
| Total cash inflows |  | -0.1273 | -0.1122 | -0.0970 | -0.0818 | -0.0666 | -0.0515 | -0.0363 | -0.0211 | -0.0059 | 0.0092 | 0.0244 | 0.0396 | 0.0548 | 0.0699 | 0.0851 | 0.1003 | 0.1155 | 0.1307 | 0.1458 | 0.1610 |  |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0073 | 0.0119 | 0.0164 | 0.0210 | 0.0255 | 0.0301 | 0.0346 | 0.0392 | 0.0437 | 0.0483 |  |
| Repayment of borrowed money |  | 0.2883 | 0.2732 | 0.2580 | 0.2428 | 0.2276 | 0.2125 | 0.1973 | 0.1821 | 0.1669 | 0.1518 | 0.1366 | 0.1214 | 0.1062 | 0.0911 | 0.0759 | 0.0607 | 0.0455 | 0.0304 | 0.0152 | 0.0000 |  |
| Total cash-out flow |  | 0.2883 | 0.2732 | 0.2580 | 0.2428 | 0.2276 | 0.2125 | 0.1973 | 0.1821 | 0.1669 | 0.1518 | 0.1439 | 0.1333 | 0.1227 | 0.1120 | 0.1014 | 0.0908 | 0.0802 | 0.0695 | 0.0589 | 0.0483 |  |
| Cash flow |  | -0.4157 | -0.3853 | $-0.3550$ | $-0.3246$ | -0.2943 | -0.2639 | -0.2336 | -0.2032 | -0.1729 | -0.1425 | -0.1195 | -0.0937 | -0.0679 | -0.0421 | -0.0163 | 0.0095 | 0.0353 | 0.0611 | 0.0869 | 0.1127 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Break-even calculation $\quad$ Fiscal year |  | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |  |
|  |  | -0.4157 | -0.3853 | -0.3550 | -0.3246 | -0.2943 | -0.2639 | -0.2336 | -0.2032 | -0.1729 | -0.1425 | -0.1195 | -0.0937 | -0.0679 | -0.0421 | -0.0163 | 0.0095 | 0.0353 | 0.0611 | 0.0869 | 0.1127 |  |
| Accumulated after-tax cash flow |  | -0.4157 | -0.8010 | -1.1559 | -1.4805 | $-1.7748$ | -2.0387 | -2.2722 | -2.4754 | -2.6483 | -2.7908 | -2.9102 | -3.0039 | -3.0718 | -3.1139 | -3.1302 | -3.1207 | $-3.0853$ | -3.0242 | -2.9373 | -2.8246 |  |
| Accumulated after-tax cash flow - investment capital |  | -5.8787 | -6.2640 | -6.6189 | -6.9435 | -7.2378 | -7.5017 | -7.7352 | -7.9384 | -8.1113 | -8.2538 | -8.3732 | -8.4669 | -8.5348 | -8.5769 | -8.5932 | -8.5837 | -8.5483 | -8.4872 | -8.4003 | -8.2876 |  |
| IRR calculation data) -5.463 <br> Internal rate of return, before tax (\%)  |  | -0.1273 | -0.1122 | -0.0970 | -0.0818 | -0.0666 | -0.0515 | -0.0363 | -0.0211 | -0.0059 | 0.0092 | 0.0244 | 0.0396 | 0.0548 | 0.0699 | 0.0851 | 0.1003 | 0.1155 | 0.1307 | 0.1458 | 0.1610 |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

IRR calculation for Krabi site with 20-year CER crediting period, with no generator investment (In condition of 50\% capital cost loan)

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | . 0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | CDM monitoring | 0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.2542 | 0.2408 | 0.2275 | 0.2141 | 0.2007 | 0.1873 | 0.1739 | 0.1606 | 0.1472 | 0.1338 | 0.1204 | 0.1070 | 0.0937 | 0.0803 | 0.0669 | 0.0535 | 0.0401 | 0.0268 | 0.0134 | 0.0000 |  |
|  | <Total> | 03107 | 0.2973 | 0.2839 | 0.2705 | 0.2571 | 0.2438 | 0.2304 | 0.2170 | 0.2036 | 0.1902 | 0.1769 | 0.1635 | 0.1501 | 0.1367 | 0.1233 | 0.1100 | 0.0966 | 0.0832 | 0.0698 | 0.0564 | 3.6 |
| A finance institution | Borrowing cost $50.0 \%$ | 2.6761 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 | 0.1338 |  |
|  | After paid up balance | 2.5423 | 2.4085 | 2.2747 | 2.1408 | 2.0070 | 1.8732 | 1.7394 | 1.6056 | 1.4718 | 1.3380 | 1.2042 | 1.0704 | 0.9366 | 0.8028 | 0.6690 | 0.5352 | 0.4014 | 0.2676 | 0.1338 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.2542 | 0.2408 | 0.2275 | 0.2141 | 0.2007 | 0.1873 | 0.1739 | 0.1606 | 0.1472 | 0.1338 | 0.1204 | 0.1070 | 0.0937 | 0.0803 | 0.0669 | 0.0535 | 0.0401 | 0.0268 | 0.0134 | 0.0000 |  |
| Depreciation |  | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | -0.5759 | -0.5625 | -0.5491 | -0.5358 | -0.5224 | -0.5090 | $-0.4956$ | -0.4822 | $-0.4689$ | -0.4555 | 0.0396 | 0.0530 | 0.0664 | 0.0797 | 0.0931 | 0.1065 | 0.1199 | 0.1333 | 0.1466 | 0.1600 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | -0.5759 | -0.5625 | -0.5491 | -0.5358 | -0.5224 | -0.5090 | -0.4956 | -0.4822 | -0.4689 | -0.4555 | 0.0396 | 0.0530 | 0.0664 | 0.0797 | 0.0931 | 0.1065 | 0.1199 | 0.1333 | 0.1466 | 0.1600 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0119 | 0.0159 | 0.0199 | 0.0239 | 0.0279 | 0.0319 | 0.0360 | 0.0400 | 0.0440 | 0.0480 |  |
| Current income |  | -0.5759 | -0.5625 | -0.5491 | -0.5358 | -0.5224 | -0.5090 | -0.4956 | -0.4822 | -0.4689 | -0.4555 | 0.0277 | 0.0371 | 0.0464 | 0.0558 | 0.0652 | 0.0745 | 0.0839 | 0.0933 | 0.1026 | 0.1120 |  |
| Cumulative profits |  | -0.5759 | -1.1384 | -1.6876 | -2.2233 | -2.7457 | -3.2547 | -3.7503 | -4.2325 | -4.7014 | -5.1569 | -5.1291 | -5.0921 | -5.0456 | -4.9898 | -4.9246 | -4.8501 | -4.7662 | -4.6729 | -4.5702 | -4.4582 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | -0.5759 | -0.5625 | -0.5491 | -0.5358 | -0.5224 | -0.5090 | -0.4956 | -0.4822 | -0.4689 | -0.4555 | 0.0396 | 0.0530 | 0.0664 | 0.0797 | 0.0931 | 0.1065 | 0.1199 | 0.1333 | 0.1466 | 0.1600 |
| Depreciation |  | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | -0.0942 | -0.0808 | -0.0674 | -0.0541 | -0.0407 | -0.0273 | -0.0139 | -0.0005 | 0.0128 | 0.0262 | 0.0396 | 0.0530 | 0.0664 | 0.0797 | 0.0931 | 0.1065 | 0.1199 | 0.1333 | 0.1466 | 0.1600 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0119 | 0.0159 | 0.0199 | 0.0239 | 0.0279 | 0.0319 | 0.0360 | 0.0400 | 0.0440 | 0.0480 |
| Repayment of borrowed money |  | 0.2542 | 0.2408 | 0.2275 | 0.2141 | 2007 | 0.1873 | 0.1739 | 0.1606 | 0.1472 | 0.1338 | 0.1204 | 0.1070 | 0.0937 | 0.0803 | 0.0669 | 0.0535 | 0.0401 | 0.0268 | 0.0134 | 0.0000 |
| Total cash-out flow |  | 0.2542 | 0.2408 | 0.2275 | 0.2141 | 0.2007 | 0.1873 | 0.1739 | 0.1606 | 0.1472 | 0.1338 | 0.1323 | 0.1229 | 0.1136 | 0.1042 | 0.0948 | 0.0855 | 0.0761 | 0.0667 | 0.0574 | 0.0480 |
| Cash flow |  | -0.3484 | -0.3217 | -0.2949 | -0.2682 | -0.2414 | -0.2146 | -0.1879 | -0.1611 | -0.1343 | -0.1076 | -0.0927 | $-0.0700$ | -0.0472 | -0.0245 | -0.0017 | 0.0210 | 0.0438 | 0.0665 | 0.0893 | 0.1120 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | -0.3484 | -0.3217 | -0.2949 | -0.2682 | -0.2414 | -0.2146 | -0.1879 | -0.1611 | -0.1343 | -0.1076 | -0.0927 | -0.0700 | -0.0472 | -0.0245 | -0.0017 | 0.021 | 043 | . 066 | 089 | 0.1120 |
| Accumulated after-tax cash flow | -0.3484 | -0.6701 | -0.9650 | -1.2332 | -1.4746 | -1.6892 | -1.8771 | -2.0382 | -2.1725 | -2.2801 | -2.3728 | -2.4428 | -2.4900 | -2.5144 | -2.5162 | -2.4951 | -2.4514 | -2.3848 | -2.2956 | -2.1836 |
| Accumulated after-tax cash flow - investment capital | -5.1653 | -5.4870 | -5.7819 | -6.0501 | -6.2915 | -6.5061 | -6.6940 | -6.8551 | -6.9894 | -7.0970 | -7.1897 | -7.2597 | -7.3069 | -7.3314 | -7.3331 | -7.3120 | -7.2683 | -7.2018 | -7.1125 | $-7.000$ |
| (IRR calculation data) $\quad-4.82$ | -0.0942 | -0.0808 | -0.0674 | -0.0541 | -0.0407 | -0.0273 | -0.0139 | -0.0005 | 0.0128 | 0.0262 | 0.0396 | 0.0530 | 0.0664 | 0.0797 | 0.0931 | 0.1065 | 0.119 | 0.133 | 0.146 | 0.160 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

IRR calculation for Ayutthaya site with 20-year CER crediting period, with 1 generator investment (In condition of 50\% capital cost loan)

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 | 0.4801 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 0.7051 | 14.10 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | . 0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 |  |
|  | CDM monitoring | 0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.3121 | 0.2957 | 0.2792 | 0.2628 | 0.2464 | 0.2300 | 0.2135 | 0.1971 | 0.1807 | 0.1643 | 0.1478 | 0.1314 | 0.1150 | 0.0986 | 0.0821 | 0.0657 | 0.0493 | 0.0329 | 0.0164 | 0.0000 |  |
|  | <Total> | 0.4491 | 0.4327 | 0.4162 | 0.3998 | 0.3834 | 0.3670 | 0.3505 | 0.3341 | 0.3177 | 0.3013 | 0.2848 | 0.2684 | 0.2520 | 0.2356 | 0.2191 | 0.2027 | 0.1863 | 0.1699 | 0.1534 | 0.1370 | 5.8 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $50.0 \%$ | 2850 | 0000 | .000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 | 0.1643 |  |
|  | After paid up balance | 3.1208 | 2.9565 | 2.7923 | 2.6280 | 2.4638 | 2.2995 | 2.1353 | 1.9710 | 1.8068 | 1.6425 | 1.4783 | 1.3140 | 1.1498 | 0.9855 | 0.8213 | 0.6570 | 0.4928 | 0.3285 | 0.1643 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.3121 | 0.2957 | 0.2792 | 0.2628 | 0.2464 | 0.2300 | 0.2135 | 0.1971 | 0.1807 | 0.1643 | 0.1478 | 0.1314 | 0.1150 | 0.0986 | 0.0821 | 0.0657 | 0.0493 | 0.0329 | 0.0164 | 0.0000 |  |
| Depreciation |  | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.5913 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | -0.3353 | -0.3188 | -0.3024 | -0.2860 | -0.2696 | -0.2531 | -0.2367 | -0.2203 | -0.2039 | -0.1874 | 0.4203 | 0.4367 | 0.4531 | 0.4696 | 0.4860 | 0.5024 | 0.5188 | 0.5353 | 0.5517 | 0.5681 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | -0.3353 | -0.3188 | -0.3024 | -0.2860 | -0.2696 | -0.2531 | -0.2367 | -0.2203 | -0.2039 | -0.1874 | 0.4203 | 0.4367 | 0.4531 | 0.4696 | 0.4860 | 0.5024 | 0.5188 | 0.5353 | 0.5517 | 0.5681 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1261 | 0.1310 | 0.1359 | 0.1409 | 0.1458 | 0.1507 | 0.1557 | 0.1606 | 0.165 | 0.1704 |  |
| Current income |  | -0.3353 | -0.3188 | -0.3024 | -0.2860 | -0.2696 | -0.2531 | -0.2367 | -0.2203 | -0.2039 | -0.1874 | 0.2942 | 0.3057 | 0.3172 | 0.3287 | 03402 | 0.3517 | 0.3632 | 0.3747 | 0.3862 | 0.3977 |  |
| Cumulative profits |  | -0.3353 | $-0.6541$ | -0.9565 | -1.2425 | -1.5120 | -1.7652 | -2.0019 | -2.2221 | -2.4260 | -2.6134 | -2.3192 | -2.0135 | -1.6963 | -1.3676 | -1.0274 | -0.6757 | -0.3125 | 0.0622 | 0.4483 | 0.8460 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | -0.3353 | -0.3188 | -0.3024 | -0.2860 | -0.2696 | -0.2531 | -0.2367 | -0.2203 | -0.2039 | $-0.1874$ | 0.4203 | 0.4367 | 0.4531 | 0.4696 | 0.4860 | 0.5024 | 0.5188 | 0.5353 | 0.5517 | 0.56 |
| Depreciation |  | 0.5913 | 0.5913 | 0.5913 | 0.591 | 0.591 | 0.5913 | 0.5913 | 0.5913 | 0.5913 | 0.591 | 0.000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.2560 | 0.2725 | 0.2889 | 0.3053 | 0.3217 | 0.3382 | 0.3546 | 0.3710 | 0.3874 | 0.4039 | 0.4203 | 0.4367 | 0.4531 | 0.4696 | 0.4860 | 0.5024 | 0.5188 | 0.5353 | 0.5517 | 0.5681 |
| Corporation tax |  | 000 | 00 | 000 | 0 | 0 | 0000 | 0 | 0.0000 | 0.0000 | 0.0000 | 0.1261 | 0.1310 | 0.1359 | 0.1409 | 0.1 | 0.1507 | 0.1557 | 0.160 | 0.1655 | 0.1704 |
| Repayment of borrowed money |  | 0.3121 | 0.2957 | 0.2792 | 0.2628 | 0.2464 | 0.2300 | 0.2135 | 0.1971 | 0.1807 | 0.1643 | 0.1478 | 0.1314 | 0.1150 | 0.0986 | 0.0821 | 0.0657 | 0.0493 | 0.0329 | 0.0164 | 0.0000 |
| Total cash-out flow |  | 03121 | 0.2957 | 0.2792 | 0.2628 | 0.2464 | 0.2300 | 0.2135 | 0.1971 | 0.1807 | 0.1643 | 0.2739 | 0.2624 | 0.2509 | 0.2394 | 0.2279 | 0.2164 | 0.2049 | 0.193 | 0.1819 | 0.1704 |
| Cash flow |  | -0.0560 | -0.0232 | 0.0097 | 0.0425 | 0.0754 | 0.1082 | 0.1411 | 0.1739 | 0.2068 | 0.2396 | 0.1464 | 0.1743 | 0.2022 | 0.2301 | 0.2581 | 0.2860 | 0.3139 | 0.3418 | 0.3698 | 0.3977 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | -0.0560 | -0.0232 | 0.0097 | 0.0425 | 0.0754 | 0.1082 | 0.1411 | 0.1739 | 0.2068 | 0.2396 | 0.146 | 0.1743 | 0.2022 | 0.2301 | 0.2581 | 0.2860 | 0.3139 | 0.3418 | 0.369 | 0.397 |
| Accumulated after-tax cash flow | -0.0560 | -0.0792 | -0.0695 | -0.0270 | 0.0484 | 0.1566 | 0.2976 | 0.4716 | 0.6783 | 0.9180 | 1.0643 | 1.2386 | 1.440 | 1.6710 | 19291 | 2.2151 | 2.5290 | 2.870 | 3.2406 | 3.638 |
| Accumulated after-tax cash flow - investment capital | -59690 | -5.9922 | -5.9825 | -5.9400 | -5.8646 | -5.7564 | -5.6154 | -5.4414 | -5.2347 | -4.9950 | -4.8487 | -4.6744 | -4.4721 | -4.2420 | -3.9839 | -3.6979 | -3.3840 | -3.0422 | -2.6724 | -2.274 |
| (IRR calculation data) -5.913 | 0.256 | 0.2725 | 0.2889 | 0.305 | 0.3217 | 0.3382 | 0.3546 | 0.3710 | 0.387 | 0.403 | 0.4203 | 0.436 | 0.4531 | 0.4696 | 0.4860 | 0.5024 | 0.5188 | 0.5353 | 0.5517 | 0.5681 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 2.96 |

IRR calculation for Krabi site with 20-year CER crediting period, with 1 generator investment (In condition of 50\% capital cost loan)

| Profit and loss statement <br> Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 | 0.5249 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 0.7414 | 14.8271 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 | 0.0730 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.2780 | 0.2633 | 0.2487 | 0.2341 | 0.2195 | 0.2048 | 0.1902 | 0.1756 | 0.1609 | 0.1463 | 0.1317 | 0.1170 | 0.1024 | 0.0878 | 0.0732 | 0.0585 | 0.0439 | 0.0293 | 0.0146 | 0.0000 |  |
|  | <Total> | 0.4074 | 0.3928 | 0.3781 | 0.3635 | 0.3489 | 0.3343 | 0.3196 | 0.3050 | 0.2904 | 0.2757 | 0.2611 | 0.2465 | 0.2318 | 0.2172 | 0.2026 | 0.1880 | 0.1733 | 0.1587 | 0.1441 | 0.1294 | 5.368 |
| A finance institution | Borrowing cost 50.0\% | 2.9261 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 | 0.1463 |  |
|  | After paid up balance | 2.7798 | 2.6335 | 2.4872 | 2.3408 | 2.1945 | 2.0482 | 1.9019 | 1.7556 | 1.6093 | 1.4630 | 1.3167 | 1.1704 | 1.0241 | 0.8778 | 0.7315 | 0.5852 | 0.4389 | 0.2926 | 0.1463 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.2780 | 0.2633 | 0.2487 | 0.2341 | 0.2195 | 0.2048 | 0.1902 | 0.1756 | 0.1609 | 0.1463 | 0.1317 | 0.1170 | 0.1024 | 0.0878 | 0.0732 | 0.0585 | 0.0439 | 0.0293 | 0.0146 | 0.0000 |  |
| Depreciation |  | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | -0.1927 | -0.1781 | -0.1635 | -0.1488 | -0.1342 | -0.1196 | -0.1050 | -0.0903 | -0.0757 | -0.0611 | 0.4803 | 0.4949 | 0.5095 | 0.5241 | 0.5388 | 0.5534 | 0.5680 | 0.5827 | 0.5973 | 0.6119 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | -0.1927 | -0.1781 | -0.1635 | -0.1488 | -0.1342 | -0.1196 | -0.1050 | -0.0903 | -0.0757 | -0.0611 | 0.4803 | 0.4949 | 0.5095 | 0.5241 | 0.5388 | 0.5534 | 0.5680 | 0.5827 | 0.5973 | 0.6119 |  |
| Corporation tax | Corporation tax 30.0\% | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1441 | 0.1485 | 0.1529 | 0.1572 | 0.1616 | 0.1660 | 0.1704 | 0.1748 | 0.1792 | 0.1836 |  |
| Current income |  | -0.1927 | -0.1781 | -0.1635 | -0.1488 | -0.1342 | -0.1196 | -0.1050 | -0.0903 | -0.0757 | -0.0611 | 0.3362 | 0.3464 | 0.3567 | 0.3669 | 0.3771 | 0.3874 | 0.3976 | 0.4079 | 0.4181 | 0.4283 |  |
| Cumulative profits |  | -0.1927 | -0.3709 | -0.5343 | -0.6832 | -0.8174 | -0.9370 | -1.0419 | -1.1323 | -1.2080 | -1.2690 | -0.9329 | -0.5864 | -0.2298 | 0.1371 | 0.5143 | 0.9016 | 1.2993 | 1.7071 | 2.1252 | 2.5536 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | -0.1927 | -0.1781 | -0.1635 | -0.1488 | -0.1342 | -0.1196 | -0.1050 | -0.0903 | -0.0757 | -0.0611 | 0.4803 | 0.4949 | 0.5095 | 0.5241 | 0.5388 | 0.5534 | 0.5680 | 0.5827 | 0.5973 | 0.6119 |
| Depreciation |  | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.5267 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.3340 | 0.3486 | 0.3632 | 0.3778 | 0.3925 | 0.4071 | 0.4217 | 0.4364 | 0.4510 | 0.4656 | 0.4803 | 0.4949 | 0.5095 | 0.5241 | 0.5388 | 0.5534 | 0.5680 | 0.5827 | 0.5973 | 0.6119 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1441 | 0.1485 | 0.1529 | 0.1572 | 0.1616 | 0.1660 | 0.1704 | 0.1748 | 0.1792 | 0.1836 |
| Repayment of borrowed money |  | 0.2780 | 0.2633 | 0.2487 | 0.2341 | 0.2195 | 0.2048 | 0.1902 | 0.1756 | 0.1609 | 0.1463 | 0.1317 | 0.1170 | 0.1024 | 0.0878 | 0.0732 | 0.0585 | 0.0439 | 0.0293 | 0.0146 | 0.0000 |
| Total cash-out flow |  | 0.2780 | 0.2633 | 0.2487 | 0.2341 | 0.2195 | 0.2048 | 0.1902 | 0.1756 | 0.1609 | 0.1463 | 0.2757 | 0.2655 | 0.2553 | 0.2450 | 0.2348 | 0.2245 | 0.2143 | 0.2041 | 0.1938 | 0.1836 |
| Cash flow |  | 0.0560 | 0.0852 | 0.1145 | 0.1438 | 0.1730 | 0.2023 | 0.2315 | 0.2608 | 0.2901 | 0.3193 | 0.2045 | 0.2294 | 0.2542 | 0.2791 | 0.3040 | 0.3289 | 0.3537 | 0.3786 | 0.4035 | 0.4283 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.0560 | 0.0852 | 0.1145 | 0.1438 | 0.1730 | 0.2023 | 0.2315 | 0.2608 | 0.2901 | 0.3193 | 0.2045 | 0.2294 | 0.2542 | 0.2791 | 0.3040 | 0.3289 | 0.3537 | 0.3786 | 0.4035 | 0.4283 |
| Accumulated after-tax cash flow | 0.0560 | 0.1412 | 0.2557 | 0.3995 | 0.5725 | 0.7748 | 1.0063 | 1.2671 | 1.5572 | 1.8765 | 2.0810 | 2.3104 | 2.5646 | 2.8437 | 3.1477 | 3.4766 | 3.8303 | 4.2089 | 4.6124 | 5.0407 |
| Accumulated after-tax cash flow - investment capital | -5.2109 | -5.1257 | -5.0112 | -4.8674 | -4.6944 | -4.4922 | -4.2606 | -3.9998 | -3.7098 | -3.3904 | -3.1859 | -2.9566 | -2.7023 | -2.4232 | -2.1192 | -1.7903 | -1.4366 | -1.0580 | -0.6545 | -0.2262 |
| (IRR calculation data) -5.27 | 03340 | 0.3486 | 0.3632 | 0.3778 | 0.3925 | 0.4071 | 0.4217 | 0.4364 | 0.4510 | 0.4656 | 0.4803 | 0.4949 | 0.5095 | 0.5241 | 0.5388 | 0.5534 | 0.5680 | 0.5827 | 0.5973 | 0.6119 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 5.6620 |

IRR calculation for Ayuthaya site with 20-year CER crediting period, with 2 generators investment (In condition of 50\% capital cost loan)

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 028 | Tota |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 | 0.9602 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 1.1852 | 23.7 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.3358 | 0.3182 | 0.3005 | 0.2828 | 0.2651 | 0.2475 | 0.2298 | 0.2121 | 0.1944 | 0.1768 | 0.1591 | 0.1414 | 0.1237 | 0.1061 | 0.0884 | 0.0707 | 0.0530 | 0.0353 | 0.0177 | 0.0000 |  |
|  | <Total> | 0.5458 | 0.5282 | 0.5105 | 0.4928 | 0.4751 | 0.4575 | 0.4398 | 0.4221 | 0.4044 | 0.3868 | 0.3691 | 0.3514 | 0.3337 | 0.3161 | 0.2984 | 0.2807 | 0.2630 | 0.2454 | 0.2277 | 0.2100 | 7.553 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $50.0 \%$ | 3.5350 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 | 0.1768 |  |
|  | After paid up balance | 3.3583 | 3.1815 | 3.0048 | 2.8280 | 2.6513 | 2.4745 | 2.2978 | 2.1210 | 1.9443 | 1.7675 | 1.5908 | 1.4140 | 1.2373 | 1.0605 | 0.8837 | 0.7070 | 0.5302 | 0.3535 | 0.1767 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.3358 | 0.3182 | 0.3005 | 0.2828 | 0.2651 | 0.2475 | 0.2298 | 0.2121 | 0.1944 | 0.1768 | 0.1591 | 0.1414 | 0.1237 | 0.1061 | 0.0884 | 0.0707 | 0.0530 | 0.0353 | 0.0177 | 0.0000 |  |
|  |  | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 0.0031 | 0.0208 | 0.0385 | 0.0561 | 0.0738 | 0.0915 | 0.1092 | 0.1268 | 0.1445 | 0.1622 | 0.8162 | 0.8338 | 0.8515 | 0.8692 | 0.8869 | 0.9045 | 0.9222 | 0.9399 | 0.9576 | 0.9752 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.0031 | 0.0208 | 0.0385 | 0.0561 | 0.0738 | 0.0915 | 0.1092 | 0.1268 | 0.1445 | 0.1622 | 0.8162 | 0.8338 | 0.8515 | 0.8692 | 0.8869 | 0.9045 | 0.9222 | 0.9399 | 0.9576 | 0.9752 |  |
| Corporation tax | Corporation tax $\quad 30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0434 | 0.0487 | 0.2448 | 0.2502 | 0.2555 | 0.2608 | 0.2661 | 0.2714 | 0.2767 | 0.2820 | 0.2873 | 0.2926 |  |
| Current income |  | 0.0031 | 0.0208 | 0.0385 | 0.0561 | 0.0738 | 0.0915 | 0.1092 | 0.1268 | 0.1012 | 0.1135 | 0.5713 | 0.5837 | 0.5961 | 0.6084 | 0.6208 | 0.6332 | 0.6456 | 0.6579 | 0.6703 | 0.6827 |  |
| Cumulative profits |  | 0.0031 | 0.0239 | 0.0624 | 0.1185 | 0.1923 | 0.2838 | 0.3930 | 0.5198 | 0.6210 | 0.7345 | 1.3058 | 1.8895 | 2.4856 | 3.0940 | 3.7148 | 4.3480 | 4.9935 | 5.5515 | 6.3218 | 7.0044 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.0031 | 0.0208 | 0.0385 | 0.0561 | 0.0738 | 0.0915 | 0.1092 | 0.1268 | 0.1445 | 0.1622 | 0.8162 | 0.8338 | 0.8515 | 0.8692 | 0.8869 | 0.9045 | 0.9222 | 0.9399 | 0.9576 | 0.9752 |
| Depreciation |  | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.6363 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.6394 | 0.6571 | 0.6748 | 0.6924 | 0.7101 | 0.7278 | 0.7455 | 0.7631 | 0.7808 | 0.7985 | 0.8162 | 0.8338 | 0.8515 | 0.8692 | 0.8869 | 0.9045 | 0.9222 | 0.9399 | 0.9576 | 0.9752 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0434 | 0.0487 | 0.2448 | 0.2502 | 0.2555 | 0.2608 | 0.2661 | 0.2714 | 0.2767 | 0.2820 | 0.2873 | 0.2926 |
| Repayment of borrowed money |  | 0.3358 | 0.3182 | 0.3005 | 0.2828 | 0.2651 | 0.2475 | 0.2298 | 0.2121 | 0.1944 | 0.1768 | 0.1591 | 0.1414 | 0.1237 | 0.1061 | 0.0884 | 0.0707 | 0.0530 | 0.0353 | 0.0177 | 0.0000 |
| Total cash-out flow |  | 0.3358 | 0.3182 | 0.3005 | 0.2828 | 0.2651 | 0.2475 | 0.2298 | 0.2121 | 0.2378 | 0.2254 | 0.4039 | 0.3916 | 0.3792 | 0.3668 | 0.3544 | 0.3421 | 0.3297 | 0.3173 | 0.3049 | 0.2926 |
| Cash flow |  | 0.3036 | 0.3389 | 0.3743 | 0.4096 | 0.4450 | 0.4803 | 0.5157 | 0.5510 | 0.5430 | 0.5731 | 0.4122 | 0.4423 | 0.4723 | 0.5024 | 0.5324 | 0.5625 | 0.5925 | 0.6226 | 0.6526 | 0.6827 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.3036 | 0.3389 | 0.3743 | 0.4096 | 0.4450 | 0.4803 | 0.5157 | 0.5510 | 0.5430 | 0.5731 | 0.4122 | 0.4423 | 0.4723 | 0.5024 | 0.5324 | 0.5625 | 0.5925 | 0.6226 | 0.6526 | 0.6827 |
| Accumulated after-tax cash flow | 0.3036 | 0.6425 | 1.0168 | 1.4265 | 1.8715 | 2.3518 | 2.8675 | 3.4185 | 3.9616 | 4.5346 | 4.9469 | 5.3892 | 5.8615 | 6.3639 | 6.8963 | 7.4588 | 8.0513 | 8.6739 | 9.3265 | 10.0092 |
| Accumulated after-tax cash flow - investment capital | -6.0594 | -5.7205 | -5.3462 | -4.9365 | -4.4915 | -4.0112 | -3.4955 | -2.9445 | -2.4014 | -1.8284 | -1.4161 | -0.9738 | -0.5015 | 0.0009 | 0.5333 | 1.0958 | 1.6883 | 2.3109 | 2.9635 | 3.6462 |
| (IRR calculation data) -6.363 | 0.6394 | 0.6571 | 0.6748 | 0.6924 | 0.7101 | 0.7278 | 0.7455 | 0.7631 | 0.7808 | 0.7985 | 0.8162 | 0.8338 | 0.8515 | 0.8692 | 0.8869 | 0.9045 | 0.9222 | 0.9399 | 0.9576 | 0.9752 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 10.1268 |

IRR calculation for Krabi site with 20-year CER crediting period, with 2 generators investment (In condition of 50\% capital cost loan)

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 | 1.0498 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total | 1.2663 | 1.2663 | 12663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 1.2663 | 25.32 |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 | 0.1460 |  |
|  | CDM monitoring | 0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.3017 | 0.2858 | 0.2700 | 0.2541 | 0.2382 | 0.2223 | 0.2064 | 0.1906 | 0.1747 | 0.1588 | 0.1429 | 0.1270 | 0.1112 | 0.0953 | 0.0794 | 0.0635 | 0.0476 | 0.0318 | 0.0159 | 0.0000 |  |
|  | <Total> | 0.5042 | 0.4883 | 0.4724 | 0.4565 | 0.4406 | 0.4248 | 0.4089 | 0.3930 | 0.3771 | 0.3612 | 0.3454 | 0.3295 | 0.3136 | 0.2977 | 0.2818 | 0.2660 | 0.2501 | 0.2342 | 0.2183 | 0.2024 | 7.06 |
| $\widehat{\text { A finance institution }}$ | Borrowing cost 50.0\% | 3.1761 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 88 | 588 | 1588 | 1588 | 1588 | 1588 | 0.1588 | 0.1588 | 0.1588 | 0.1588 | 0.1588 | 0.1588 | 0.158 | 0.158 | 0.158 | 0.158 | 0.158 | 0.1588 | 0.1588 | 0.1588 |  |
|  | After paid up balance | 3.0173 | 2.8585 | 2.6997 | 2.5408 | 2.3820 | 2.2232 | 2.0644 | 1.9056 | 1.7468 | 1.5880 | 1.4292 | 1.2704 | 1.1116 | 0.9528 | 0.7940 | 0.6352 | 0.4764 | 0.3176 | 0.1588 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.3017 | 0.2858 | 0.2700 | 0.2541 | 0.2382 | 0.2223 | 0.2064 | 0.1906 | 0.1747 | 0.1588 | 0.1429 | 0.1270 | 0.1112 | 0.0953 | 0.0794 | 0.0635 | 0.0476 | 0.0318 | 0.0159 | 0.0000 |  |
| Depreciation |  | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.1904 | 0.2063 | 0.2222 | 0.2381 | 0.2539 | 0.2698 | 0.2857 | 0.3016 | 0.3175 | 0.3333 | 0.9209 | 0.9368 | 0.9527 | 0.9686 | 0.9844 | 1.0003 | 1.0162 | 1.0321 | 1.0480 | 1.0638 |  |
| Non-operating interest cost $0.0 \%$ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.1904 | 0.2063 | 0.2222 | 0.2381 | 0.2539 | 0.2698 | 0.2857 | 0.3016 | 0.3175 | 0.3333 | 0.9209 | 0.9368 | 0.9527 | 0.9686 | 0.9844 | 1.0003 | 1.0162 | 1.0321 | 1.0480 | 1.0638 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0952 | 0.1000 | 0.2763 | 0.2810 | 0.2858 | 0.2906 | 0.2953 | 0.3001 | 0.3049 | 0.3096 | 0.3144 | 0.3192 |  |
| Current income |  | 0.1904 | 0.2063 | 0.2222 | 0.2381 | 0.2539 | 0.2698 | 0.2857 | 0.3016 | 0.2222 | 0.2333 | 0.6446 | 0.6558 | 0.6669 | 0.6780 | 0.6891 | 0.7002 | 0.7113 | 0.7225 | 0.7336 | 0.7447 |  |
| Cumulative profits |  | 0.1904 | 0.3967 | 0.6189 | 0.8569 | 1.1109 | 1.3807 | 1.6664 | 1.9680 | 2.1902 | 2.4235 | 3.0682 | 3.7239 | 4.3908 | 5.0688 | 5.7579 | 6.4581 | 7.1694 | 7.8919 | 8.6255 | 9.3702 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.1904 | 0.2063 | 0.2222 | 0.2381 | 0.2539 | 0.2698 | 0.2857 | 0.3016 | 0.3175 | 0.3333 | 0.9209 | 0.9368 | 0.9527 | 0.9686 | 0.9844 | 1.0003 | 1.0162 | 1.0321 | 1.0480 | 1.0638 |
| Depreciation |  | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.5717 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 0.7621 | 0.7780 | 0.7939 | 0.8097 | 0.8256 | 0.8415 | 0.8574 | 0.8733 | 0.8892 | 0.9050 | 0.9209 | 0.9368 | 0.9527 | 0.9686 | 0.9844 | 1.0003 | 1.0162 | 1.0321 | 1.0480 | 1.0638 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0952 | 0.1000 | 0.2763 | 0.2810 | 0.2858 | 0.2906 | 0.2953 | 0.3001 | 0.3049 | 0.3096 | 0.3144 | 0.3192 |
| Repayment of borrowed money |  | 0.3017 | 0.2858 | 0.2700 | 0.2541 | 0.2382 | 0.2223 | 0.2064 | 0.1906 | 0.1747 | 0.1588 | 0.1429 | 0.1270 | 0.1112 | 0.0953 | 0.0794 | 0.0635 | 0.0476 | 0.0318 | 0.0159 | 0.0000 |
| Total cash-out flow |  | 0.3017 | 0.2858 | 0.2700 | 0.2541 | 0.2382 | 0.2223 | 0.2064 | 0.1906 | 0.2699 | 0.2588 | 0.4192 | 0.4081 | 0.3970 | 0.3858 | 0.3747 | 0.3636 | 0.3525 | 0.3414 | 0.3303 | 0.3192 |
| Cash flow |  | 0.4604 | 0.4921 | 0.5239 | 0.5557 | 0.5874 | 0.6192 | 0.6509 | 0.6827 | 0.6192 | 0.6462 | 0.5017 | 0.5287 | 0.5557 | 0.5827 | 0.6097 | 0.6367 | 0.6637 | 0.6907 | 0.7177 | 0.7447 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.4604 | 0.4921 | 0.5239 | 0.5557 | 0.5874 | 0.6192 | 0.6509 | 0.6827 | 0.6192 | 0.6462 | 0.5017 | 0.5287 | 0.5557 | 0.5827 | 0.6097 | 0.6367 | 0.6637 | 0.6907 | 0.7177 | 0.7447 |
| Accumulated after-tax cash flow | 0.4604 | 0.9525 | 1.4764 | 2.0321 | 2.6195 | 3.2387 | 3.8896 | 4.5724 | 5.1916 | 5.8378 | 6.3395 | 6.8682 | 7.4239 | 8.0066 | 8.6164 | 9.2530 | 9.9167 | 10.6074 | 11.3251 | 12.0698 |
| Accumulated after-tax cash flow - investment capital | -5.2565 | -4.7644 | -4.2405 | -3.6848 | -3.0974 | -2.4782 | -1.8273 | -1.1446 | -0.5253 | 0.1209 | 0.6226 | 1.1513 | 1.7070 | 2.2897 | 2.8994 | 3.5361 | 4.1998 | 4.8905 | 5.6082 | 6.3529 |
| (IRR calculation data) -5.72 | 0.7621 | 0.7780 | 0.7939 | 0.8097 | 0.8256 | 0.8415 | 0.8574 | 0.8733 | 0.8892 | 0.9050 | 0.9209 | 0.9368 | 0.9527 | 0.9686 | 0.9844 | 1.0003 | 1.0162 | 1.0321 | 1.0480 | 1.0638 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 13.7634 |

IRR calculation for Ayuthaya site with 20-year CER crediting period, with 3 generators investment (In condition of $\mathbf{5 0 \%}$ capital cost loan)

| Profit and loss statement <br> Sales | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Electric generation income | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 | 1.4404 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 1.6654 | 33.307 |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.3596 | 0.3407 | 0.3217 | 0.3028 | 0.2839 | 0.2650 | 0.2460 | 0.2271 | 0.2082 | 0.1893 | 0.1703 | 0.1514 | 0.1325 | 0.1136 | 0.0946 | 0.0757 | 0.0568 | 0.0379 | 0.0189 | 0.0000 |  |
|  | <Total> | 0.6426 | 0.6237 | 0.6047 | 0.5858 | 0.5669 | 0.5480 | 0.5290 | 0.5101 | 0.4912 | 0.4723 | 0.4533 | 0.4344 | 0.4155 | 0.3966 | 03776 | 0.3587 | 0.3398 | 0.3209 | 0.3019 | 0.2830 | 9.255 |
| A finance institution | Borrowing cost $50.0 \%$ | 3.7850 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 | 0.1893 |  |
|  | After paid up balance | 3.5958 | 3.4065 | 3.2173 | 3.0280 | 2.8388 | 2.6495 | 2.4603 | 2.2710 | 2.0818 | 1.8925 | 1.7033 | 1.5140 | 1.3248 | 1.1355 | 0.9463 | 0.7570 | 0.5678 | 0.3785 | 0.1893 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.3596 | 0.3407 | 0.3217 | 0.3028 | 0.2839 | 0.2650 | 0.2460 | 0.2271 | 0.2082 | 0.1893 | 0.1703 | 0.1514 | 0.1325 | 0.1136 | 0.0946 | 0.0757 | 0.0568 | 0.0379 | 0.0189 | 0.0000 |  |
| Depreciation |  | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.3415 | 0.3604 | 0.3793 | 0.3983 | 0.4172 | 0.4361 | 0.4550 | 0.4740 | 0.4929 | 0.5118 | 1.2120 | 1.2310 | 1.2499 | 1.2688 | 1.2877 | 1.3067 | 1.3256 | 1.3445 | 1.3634 | 1.3824 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.3415 | 0.3604 | 03793 | 0.3983 | 0.4172 | 0.4361 | 0.4550 | 0.4740 | 0.4929 | 0.5118 | 1.2120 | 1.2310 | 1.2499 | 1.2688 | 1.2877 | 1.3067 | 1.3256 | 1.3445 | 1.3634 | 1.3824 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1479 | 0.1535 | 0.3636 | 0.3693 | 0.3750 | 0.3806 | 0.3863 | 0.3920 | 0.3977 | 0.4034 | 0.4090 | 0.4147 |  |
| Current income |  | 0.3415 | 0.3604 | 03793 | 0.3983 | 0.4172 | 0.4361 | 0.4550 | 0.4740 | 0.3450 | 0.3583 | 0.8484 | 0.8617 | 0.8749 | 0.8882 | 09014 | 0.9147 | 0.9279 | 0.9412 | 0.9544 | 0.9677 |  |
| Cumulative profits |  | 03415 | 0.7019 | 1.0812 | 1.4795 | 1.8967 | 2.3328 | 2.7878 | 3.2618 | 3.6068 | 3.9651 | 4.8135 | 5.6752 | 6.5501 | 7.4383 | 83397 | 9.2543 | 10.1822 | 11.1234 | 12.0778 | 13.0455 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 202 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.3415 | 0.3604 | 0.3793 | 0.3983 | 0.4172 | 0.4361 | 0.4550 | 0.4740 | 0.4929 | 0.5118 | 1.2120 | 1.2310 | 1.2499 | 1.2688 | 1.2877 | 1.3067 | 1.3256 | 1.3445 | 1.3634 | . 382 |
| Depreciation |  | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.6813 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 1.0228 | 1.0417 | 1.0606 | 1.0796 | 1.0985 | 1.1174 | 1.1363 | 1.1553 | 1.1742 | 1.1931 | 1.2120 | 1.2310 | 1.2499 | 1.2688 | 12877 | 1.3067 | 1.3256 | 1.3445 | 1.3634 | 1.382 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1479 | 0.1535 | 0.3636 | 0.3693 | 0.3750 | 0.3806 | 0.3863 | 0.3920 | 0.3977 | 0.4034 | 0.4090 | 0.414 |
| Repayment of borrowed money |  | 0.3596 | 0.3407 | 0.3217 | 0.3028 | 0.2839 | 0.2650 | 0.2460 | 0.2271 | 0.2082 | 0.1893 | 0.170 | 0.1514 | 0.1325 | 0.1136 | 0.0946 | 0.075 | 0.056 | 0.0379 | 0.0189 | 0.0000 |
| Total cash-out flow |  | 03596 | 0.3407 | 0.3217 | 0.3028 | 0.2839 | 0.2650 | 0.2460 | 0.2271 | 0.3560 | 0.3428 | 0.5339 | 0.5207 | 0.5074 | 0.4942 | 0.4809 | 0.4677 | 0.4545 | 0.4412 | 0.4280 | 0.414 |
| Cash flow |  | 0.6632 | 0.7011 | 0.7389 | 0.7768 | 0.8146 | 0.8525 | 0.8903 | 0.9282 | 0.8181 | 0.8503 | 0.6781 | 0.7103 | 0.7424 | 0.7746 | 0.8068 | 0.8390 | 0.8711 | 0.9033 | 0.9355 | 0.967 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | . 6632 | 0.7011 | 0.7389 | .7768 | 46 | 0.8525 | 03 | 82 | 0.8181 | 0.8503 | 0.6781 | 0.7103 | 0.7424 | 0.7746 | 0.8068 | 839 | . 8711 | . 9033 | 0.9355 | 0.9677 |
| Accumulated after-tax cash flow | 0.6632 | 1.3643 | 2.1032 | 2.8799 | 3.6946 | 4.5470 | 5.4373 | 6.3655 | 7.1836 | 8.0339 | 8.7120 | 9.4223 | 10.1648 | 10.9394 | 11.7462 | 12.5851 | 13.4563 | 14.3596 | 15.2951 | 16.2627 |
| Accumulated after-tax cash flow - investment capital | -6.1498 | -5.4487 | -4.7098 | -3.9331 | -3.1184 | -2.2660 | -1.3757 | -0.4475 | 0.3706 | 1.220 | 1.8990 | 2.6093 | 3.3518 | 4.126 | 4.9332 | 5.7721 | 6.6433 | 7.5466 | 8.4821 | 9.449 |
| (IRR calculation data) $\quad-6.813$ | 1.0228 | 1.0 | 1.0606 | 1.0796 | .098 | 1.1174 | 1.1363 | 1.1553 | 1.1742 | 1.1931 | 1.2120 | 1.2310 | 1.24 | 1.268 | 1.2872 | 1.3067 | 1.3256 | 1.3445 | 1.36 | 1.3824 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 15.5 |

IRR calculation for Krabi site with 20-year CER crediting period, with 3 generators investment (In condition of 50\% capital cost loan)

| (Unit: Million USD) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 202 | 2028 | Total |
| Sales | Electric generation income | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 | 1.5747 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 | 1.7912 |  |
| Cost | Manpower | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 |  |
|  | Gas engine maintenance | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 | 0.2190 |  |
|  | CDM monitoring | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | Interest cost | 0.3255 | 0.3083 | 0.2912 | 0.2741 | 0.2570 | 0.2398 | 0.2227 | 0.2056 | 0.1884 | 0.1713 | 0.1542 | 0.1370 | 0.1199 | 0.1028 | 0.0857 | 0.0685 | 0.0514 | 0.0343 | 0.0171 | 0.0000 |  |
|  | <Total> | 0.6009 | 0.5838 | 0.5666 | 0.5495 | 0.5324 | 0.5153 | 0.4981 | 0.4810 | 0.4639 | 0.4467 | 0.4296 | 0.4125 | 0.3953 | 0.3782 | 03611 | 0.3440 | 0.3268 | 0.3097 | 0.2926 | 0.2754 | 8.7 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $50.0 \%$ | 3.4261 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 | 0.1713 |  |
|  | After paid up balance | 2548 | 3.0835 | 2.9122 | 2.7408 | 2.5695 | 2.3982 | 2.2269 | 2.0556 | 1.8843 | 1.7130 | 1.5417 | 1.3704 | 1.1991 | 1.0278 | 0.8565 | 0.6852 | 0.5139 | 0.3426 | 0.1713 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.3255 | 0.3083 | 0.2912 | 0.2741 | 0.2570 | 0.2398 | 0.2227 | 0.2056 | 0.1884 | 0.1713 | 0.1542 | 0.1370 | 0.1199 | 0.1028 | 0.0857 | 0.0685 | 0.0514 | 0.0343 | 0.0171 | 0.0000 |  |
| Depreciation |  | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.5736 | 0.5907 | 0.6078 | 0.6250 | 0.6421 | 0.6592 | 0.6764 | 0.6935 | 0.7106 | 0.7277 | 1.3616 | 1.3787 | 1.3958 | 1.4130 | 1.4301 | 1.4472 | 1.4644 | 1.4815 | 1.4986 | 1.5157 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.5736 | 0.5907 | 0.6078 | 0.6250 | 0.6421 | 0.6592 | 0.6764 | 0.6935 | 0.7106 | 0.7277 | 1.3616 | 1.3787 | 1.3958 | 1.4130 | 1.4301 | 1.4472 | 1.4644 | 1.4815 | 1.4986 | 1.5157 |  |
| Corporation tax | Corporation tax $\quad 30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2132 | 0.2183 | 0.4085 | 0.4136 | 0.4187 | 0.4239 | 0.4290 | 0.4342 | 0.4393 | 0.4444 | 0.4496 | 0.4547 |  |
| Current income |  | 0.5736 | 0.5907 | 0.6078 | 0.6250 | 0.6421 | 0.6592 | 0.6764 | 0.6935 | 0.4974 | 0.5094 | 0.9531 | 0.9651 | 0.9771 | 0.9891 | 1.0011 | 1.0131 | 1.0250 | 1.0370 | 1.0490 | 1.0610 |  |
| Cumulative profits |  | 0.5736 | 1.1643 | 1.7721 | 2.3971 | 3.0392 | 3.6984 | 4.3748 | 5.0682 | 5.5657 | 6.0751 | 7.0282 | 7.9933 | 8.9704 | 9.9594 | 10.9605 | 11.9736 | 12.9986 | 14.0356 | 15.0847 | 16.1457 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.5736 | 0.5907 | 0.6078 | 0.6250 | 0.6421 | 0.6592 | 0.6764 | 0.6935 | 0.7106 | 0.7277 | 1.3616 | 1.3787 | 1.3958 | 1.4130 | 1.4301 | 1.4472 | 1.4644 | 1.4815 | 1.4986 | 1.5157 |
| Depreciation |  | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.6167 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 1.1903 | 1.2074 | 1.2245 | 1.2417 | 1.2588 | 1.2759 | 1.2930 | 1.3102 | 1.3273 | 1.3444 | 1.3616 | 1.3787 | 1.3958 | 1.4130 | 1.4301 | 1.4472 | 1.4644 | 1.4815 | 1.4986 | 1.5157 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2132 | 0.2183 | 0.4085 | 0.4136 | 0.4187 | 0.4239 | 0.4290 | 0.4342 | 0.4393 | 0.4444 | 0.4496 | 0.4547 |
| Repayment of borrowed money |  | 0.3255 | 0.3083 | 0.2912 | 0.2741 | 0.2570 | 0.2398 | 0.2227 | 0.2056 | 0.1884 | 0.1713 | 0.1542 | 0.1370 | 0.1199 | 0.1028 | 0.0857 | 0.0685 | 0.0514 | 0.0343 | 0.0171 | 0.0000 |
| Total cash-out flow |  | 0.3255 | 0.3083 | 0.2912 | 0.2741 | 0.2570 | 0.2398 | 0.2227 | 0.2056 | 0.4016 | 0.3896 | 0.5626 | 0.5507 | 0.5387 | 0.5267 | 0.5147 | 0.5027 | 0.4907 | 0.4787 | 0.4667 | 0.4547 |
| Cash flow |  | 0.8648 | 0.8991 | 0.9333 | 0.9676 | 1.0018 | 1.0361 | 1.0704 | 1.1046 | 0.9257 | 0.9548 | 0.7989 | 0.8280 | 0.8572 | 0.8863 | 0.9154 | 0.9445 | 0.9737 | 1.0028 | 1.0319 | 1.0610 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 0.8648 | 0.8991 | 0.9333 | 0.9676 | 1.0018 | 1.0361 | 1.0704 | 1.1046 | 0.9257 | 0.9548 | 0.7989 | 0.8280 | 0.8572 | 0.8863 | 0.9154 | 0.9445 | 0.9737 | 1.0028 | 1.0319 | 1.0610 |
| Accumulated after-tax cash flow | 0.8648 | 1.7638 | 2.6972 | 3.6647 | 4.6666 | 5.7026 | 6.7730 | 7.8776 | 8.8033 | 9.7581 | 10.5570 | 11.3851 | 12.2423 | 13.1285 | 14.0440 | 14.9885 | 15.9621 | 16.9649 | 17.9968 | 19.0578 |
| Accumulated after-tax cash flow - investment capital | -5.3021 | -4.4031 | -3.4698 | -2.5022 | -1.5004 | -0.4643 | 0.6061 | 1.7107 | 2.6364 | 3.5912 | 4.3901 | 5.2182 | 6.0753 | 6.9616 | 7.8770 | 8.8216 | 9.7952 | 10.7980 | 11.8299 | 12.8909 |
| (IRR calculation data) -6.17 | 1.1903 | 1.2074 | 1.2245 | 1.2417 | 1.2588 | 1.2759 | 1.2930 | 1.3102 | 1.3273 | 1.3444 | 1.3616 | 1.3787 | 1.3958 | 1.4130 | 1.4301 | 1.4472 | 1.4644 | 1.4815 | 1.4986 | 1.5157 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 20.0054 |

IRR calculation for Ayuthaya site with 20-year CER crediting period, with 4 generators investment (In condition of $\mathbf{5 0 \%}$ capital cost loan)

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 | 1.9205 |  |
|  | CERs 10USD/t | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 | 0.2250 |  |
|  | <Total> | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 2.1455 | 42. |
| Cost | Manpower | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 | 0.0200 |  |
|  | Consumable | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | System maintenance cost | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 | 0.0140 |  |
|  | Gas engine maintenance | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 |  |
|  | CDM monitoring | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 | 0.0150 |  |
|  | Interest cost | 0.3833 | 0.3632 | 0.3430 | 0.3228 | 0.3026 | 0.2825 | 0.2623 | 0.2421 | 0.2219 | 0.2018 | 0.1816 | 0.1614 | 0.1412 | 0.1211 | 0.1009 | 0.0807 | 0.0605 | 0.0403 | 0.0202 | 0.0000 |  |
|  | <Total> | 0.7393 | 0.7192 | 0.6990 | 0.6788 | 0.6586 | 0.6385 | 0.6183 | 0.5981 | 0.5779 | 0.5578 | 0.5376 | 0.5174 | 0.4972 | 0.4771 | 0.4569 | 0.4367 | 0.4165 | 0.3964 | 0.3762 | 0.3560 | 10.95 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $50.0 \%$ | S 50 | 000 | 0.0000 | 000 | 000 | . 000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | .000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.000 | 0.0000 |  |
|  | Repayment cost | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 | 0.2018 |  |
|  | After paid up balance | 3.8333 | 3.6315 | 3.4298 | 3.2280 | 3.0263 | 2.8245 | 2.6228 | 2.4210 | 2.2193 | 2.0175 | 1.8158 | 1.6140 | 1.4123 | 1.2105 | 1.0088 | 0.8070 | 0.6052 | 0.4035 | 0.2017 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.3833 | 0.3632 | 0.3430 | 0.3228 | 0.3026 | 0.2825 | 0.2623 | 0.2421 | 0.2219 | 0.2018 | 0.1816 | 0.1614 | 0.1412 | 0.1211 | 0.1009 | 0.0807 | 0.0605 | 0.0403 | 0.0202 | 0.0000 |  |
| Depreciation |  | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.6799 | 0.7000 | 0.7202 | 0.7404 | 0.7606 | 0.7807 | 0.8009 | 0.8211 | 0.8413 | 0.8614 | 1.6079 | 1.6281 | 1.6483 | 1.6684 | 1.6886 | 1.7088 | 1.7290 | 1.7491 | 1.7693 | 1.7895 |  |
| Non-operating interest cost |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Current profits |  | 0.6799 | 0.7000 | 0.7202 | 0.7404 | 0.7606 | 0.7807 | 0.8009 | 0.8211 | 0.8413 | 0.8614 | 1.6079 | 1.6281 | 1.6483 | 1.6684 | 1.6886 | 1.7088 | 1.7290 | 1.7491 | 1.7693 | 1.7895 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2524 | 0.2584 | 0.4824 | 0.4884 | 0.4945 | 0.5005 | 0.5066 | 0.5126 | 0.5187 | 0.5247 | 0.5308 | 0.5368 |  |
| Current income |  | 0.6799 | 0.7000 | 0.7202 | 0.7404 | 0.7606 | 0.7807 | 0.8009 | 0.8211 | 0.5889 | 0.6030 | 1.1255 | 1.1397 | 1.1538 | 1.1679 | 1.1820 | 1.1961 | 1.2103 | 1.2244 | 1.2385 | 1.2526 |  |
| Cumulative profits |  | 0.6799 | 1.3799 | 2.1001 | 2.8405 | 3.6010 | 4.3818 | 5.1827 | 6.0037 | 6.5926 | 7.1956 | 8.3212 | 9.4608 | 10.6146 | 11.7825 | 12.9645 | 14.1607 | 15.3709 | 16.5953 | 17.8338 | 19.0865 |  |


| Cash flow statement Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits | 0.6799 | 0.7000 | 0.7202 | 0.7404 | 0.7606 | 0.7807 | 0.8009 | 0.8211 | 0.8413 | 0.8614 | 1.6079 | 1.6281 | 1.6483 | 1.6684 | 1.6886 | 1.7088 | 1.7290 | 1.7491 | 1.7693 | 1.7895 |
| Depreciation | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.7263 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows | 14062 | 1.4263 | 14465 | 1.4667 | 1.4869 | 1.5070 | 1.5272 | 1.5474 | 1.5676 | 1.5877 | 1.6079 | 1.6281 | 1.6483 | 1.6684 | 1.6886 | 1.7088 | 1.7290 | 1.7491 | 1.7693 | 1.7895 |
| Corporation tax | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2524 | 0.2584 | 0.4824 | 0.4884 | 0.4945 | 0.5005 | 0.5066 | 0.5126 | 0.5187 | 0.5247 | 0.5308 | 0.5368 |
| Repayment of borrowed money | 0.3833 | 0.3632 | 0.3430 | 0.3228 | 0.3026 | 0.2825 | 0.2623 | 0.2421 | 0.2219 | 0.2018 | 0.1816 | 0.1614 | 0.1412 | 0.1211 | 0.1009 | 0.0807 | 0.0605 | 0.0403 | 0.0202 | 0.0000 |
| Total cash-out flow | 03833 | 0.3632 | 03430 | 0.3228 | 0.3026 | 0.2825 | 0.2623 | 0.2421 | 0.4743 | 0.4602 | 0.6639 | 0.6498 | 0.6357 | 0.6216 | 0.6075 | 0.5933 | 0.5792 | 0.5651 | 0.5510 | 0.5368 |
| Cash flow | 1.0228 | 1.0632 | 1.1035 | 1.1439 | 1.1842 | 1.2246 | 1.2649 | 1.3053 | 1.0933 | 1.1276 | 0.9440 | 0.9783 | 1.0126 | 1.0469 | 1.0811 | 1.1154 | 1.1497 | 1.1840 | 1.2183 | 1.2526 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| After-tax cash flow | 1.0228 | 1.0632 | 1.1035 | 1.1439 | 1.1842 | 1.2246 | 1.2649 | 1.3053 | 1.0933 | 1.1276 | 0.9440 | 0.9783 | 1.0126 | 1.0469 | 1.0811 | 1.1154 | 1.1497 | 1.1840 | 1.2183 | 1.2526 |
| Accumulated after-tax cash flow | 1.0228 | 2.0860 | 3.1895 | 4.3334 | 5.5177 | 6.7422 | 8.0072 | 9.3124 | 10.4057 | 11.5332 | 12.4772 | 13.4555 | 14.4680 | 15.5149 | 16.5960 | 17.7115 | 18.8612 | 20.0453 | 21.2636 | 22.5162 |
| Accumulated after-tax cash flow - investment capital | -6.2402 | -5.1770 | -4.0735 | -2.9296 | -1.7453 | -0.5208 | 0.7442 | 2.0494 | 3.1427 | 4.2702 | 5.2142 | 6.1925 | 7.2050 | 8.2519 | 9.3330 | 10.4485 | 11.5982 | 12.7823 | 14.0006 | 15.2532 |
| (IRR calculation data) $\quad-7.263$ | 1.4062 | 1.4263 | 1.4465 | 1.4667 | 1.4869 | 1.5070 | 1.5272 | 1.5474 | 1.5676 | 1.5877 | 1.6079 | 1.6281 | 1.6483 | 1.6684 | 1.6886 | 1.7088 | 1.7290 | 1.7491 | 1.7693 | 1.7895 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 20.0664 |

IRR calculation for Krabi site with 20-year CER crediting period, with 4 generators investment (In condition of $\mathbf{5 0 \%}$ capital cost loan)

| Profit and loss statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | Total |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | Electric generation income | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 | 2.0996 |  |
|  | CERs 10USD/t | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 | 0.2165 |  |
|  | <Total> | 2.3161 | 2.3161 | 23161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 23161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 2.3161 | 46.3 |
| Cost <br>  <br>  <br>  | Manpower | 0.0176 | . 0176 | 0.0176 | 0.0176 | 0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 | 0.0176 |  |
|  | Consumable | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 | 0.0132 |  |
|  | System maintenance cost | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.0123 | 0.012 | 0.012 | 0.012 | 0.012 | 0.0123 |  |
|  | Gas engine maintenance | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 | 0.2920 |  |
|  | CDM monitoring | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 | 0.0130 |  |
|  | Interest cost | 0.3492 | 0.3308 | 0.3125 | 0.2941 | 0.2757 | 0.2573 | 0.2389 | 0.2206 | 0.2022 | 0.1838 | 0.1654 | 0.1470 | 0.1287 | 0.1103 | 0.0919 | 0.0735 | 0.0551 | 0.0368 | 0.0184 | 0.0000 |  |
|  | <Total> | 0.6974 | 0.6791 | 0.6607 | 0.6423 | 0.6239 | 0.6055 | 0.5871 | 0.5688 | 0.5504 | 0.5320 | 0.5136 | 0.4952 | 0.4769 | 0.4585 | 0.4401 | 0.4217 | 0.4033 | 0.3850 | 0.3666 | 0.3482 | 10.45 |
| $\overline{\text { A finance institution }}$ | Borrowing cost $50.0 \%$ | 3.6761 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |  |
|  | Repayment cost | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 | 0.1838 |  |
|  | After paid up balance | 3.4923 | 3.3085 | 3.1247 | 2.9408 | 2.7570 | 2.5732 | 2.3894 | 2.2056 | 2.0218 | 1.8380 | 1.6542 | 1.4704 | 1.2866 | 1.1028 | 0.9190 | 0.7352 | 0.5514 | 0.367 | 0.1838 | 0.0000 |  |
|  | Interest cost $10.0 \%$ | 0.3492 | 0.3308 | 0.3125 | 0.2941 | 0.2757 | 0.2573 | 0.2389 | 0.2206 | 0.2022 | 0.1838 | 0.1654 | 0.1470 | 0.1287 | 0.1103 | 0.0919 | 0.0735 | 0.0551 | 0.0368 | 0.0184 | 0.0000 |  |
| Depreciation |  | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 |  |  |  |  |  |  |  |  |  |  |  |
| Operating income |  | 0.9570 | 0.9753 | 0.9937 | 1.0121 | 1.0305 | 1.0489 | 1.0672 | 1.0856 | 1.1040 | 1.1224 | 1.8025 | 1.8208 | 1.8392 | 1.8576 | 1.8760 | 1.8944 | 1.9127 | 1.9311 | 1.9495 | 1.9679 |  |
| $\|$$\|c\|$ <br> Non-operating interest cost <br> Current profits |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | 0.9570 | 0.9753 | 0.9937 | 1.0121 | 1.0305 | 1.0489 | 1.0672 | 1.0856 | 1.1040 | 1.1224 | 1.8025 | 1.8208 | 1.8392 | 1.8576 | 18760 | 1.8944 | 1.9127 | 1.9311 | 1.9495 | 1.9679 |  |
| Corporation tax | Corporation tax $30.0 \%$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3312 | 0.3367 | 0.5407 | 0.5462 | 0.5518 | 0.5573 | 0.5628 | 0.5683 | 0.5738 | 0.5793 | 0.5848 | 0.5904 |  |
| Current income |  | 0.9570 | 0.9753 | 0.9937 | 1.0121 | 1.0305 | 1.0489 | 1.0672 | 1.0856 | 0.7728 | 0.7857 | 1.2617 | 1.2746 | 1.2874 | 1.3003 | 13132 | 1.3260 | 1.3389 | 1.3518 | 1.3646 | 1.3775 |  |
| Cumulative profits |  | 0.9570 | 1.9323 | 29260 | 3.9381 | 4.9686 | 6.0175 | 7.0847 | 8.1703 | 8.9431 | 9.7288 | 10.9905 | 12.2651 | 13.5525 | 14.8528 | 16.1660 | 17.4921 | 18.8310 | 20.1828 | 21.5474 | 22.9249 |  |


| Cash flow statement | Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Current profits |  | 0.9570 | 0.9753 | 0.9937 | 1.0121 | 1.0305 | 1.0489 | 1.0672 | 1.0856 | 1.1040 | 1.1224 | 1.8025 | 1.8208 | 1.8392 | 1.8576 | 1.8760 | 1.8944 | 1.9127 | 1.9311 | 1.949 | 1.967 |
| Depreciation |  | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.6617 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Total cash inflows |  | 1.6186 | 1.6370 | 1.6554 | 1.6738 | 1.6922 | 1.7106 | 1.7289 | 1.7473 | 1.7657 | 1.7841 | 1.8025 | 1.8208 | 1.8392 | 1.8576 | 18760 | 1.8944 | 1.912 | 1.9311 | 1.9495 | 1.967 |
| Corporation tax |  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3312 | 0.3367 | 0.5407 | 0.5462 | 0.5518 | 0.5573 | 0.5628 | 0.5683 | 0.5738 | 0.5793 | 0.5848 | 0.590 |
| Repayment of borrowed money |  | 0.3492 | 0.3308 | 0.3125 | 0.2941 | 0.2757 | 0.2573 | 0.2389 | 0.2206 | 0.2022 | 0.1838 | 0.1654 | 0.1470 | 0.1287 | 0.1103 | 0.0919 | 0.073 | 0.055 | 0.0368 | 0.0184 | 0.000 |
| Total cash-out flow |  | 03492 | 0.3308 | 03125 | 0.2941 | 0.2757 | 0.2573 | 0.2389 | 0.2206 | 0.5334 | 0.5205 | 0.7062 | 0.6933 | 0.6804 | 0.6676 | 0.6547 | 0.6418 | 0.6290 | 0.6161 | 0.6032 | 0.5904 |
| Cash flow |  | 1.2694 | 1.3062 | 13429 | 1.3797 | 1.4165 | 1.4532 | 1.4900 | 1.5267 | 1.2323 | 1.2636 | 1.0963 | 1.1275 | 1.1588 | 1.1900 | 1.2213 | 1.2525 | 1.2838 | 1.3150 | 1.3463 | 1.377 |


| Break-even calculation Fiscal year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| After-tax cash flow | 1.2694 | 1.3062 | 1.3429 | 1.3797 | 1.4 | 1.4532 | 00 | 1.5267 | 1.2323 | 1.2636 | 1.0963 | 1.1275 | 1.1588 | 1.1900 | 1.2213 | 1.2525 | 2838 | 1.3150 | 346 | 1.3775 |
| Accumulated after-tax cash flow | 1.2694 | 2.5756 | 3.9186 | 5.2983 | 6.7147 | 8.1679 | 9.6579 | 11.1847 | 12.4170 | 13.6805 | 14.7768 | 15.9044 | 17.0632 | 18.2532 | 19.4745 | 20.7270 | 22.0108 | 23.3258 | 24.6721 | 26.0496 |
| Accumulated after-tax cash flow - investment capital | -5.3475 | -4.0413 | -2.6984 | -1.3187 | 0.0978 | 1.5510 | 3.0410 | 4.5678 | 5.8001 | 7.0636 | 8.1599 | 9.2875 | 10.4463 | 11.6363 | 12.8576 | 14.1101 | 15.3939 | 16.7089 | 18.0552 | 19.4327 |
| (IRR calculation data) $\quad-6.62$ | 1.6 | 1.6 | 1.65 | 1.6738 | 1.692 | 1.7 | 1.7289 | 1.7473 | 1.7657 | 1.7841 | 1.8025 | 820 | 1.839 | 1.857 | 1.876 | 1.8944 | 1.912 | 1.9311 | 1.9495 | 1.967 |
| Internal rate of return, before tax (\%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 25.21 |

Conditions of IRR calculation

|  | 0 set generator |  | 1 set generator |  | 2 set generators |  | 3 set generators |  | 4 set generators |  | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Item | $\begin{gathered} \hline \text { Ayutthaya } \\ \text { Value } \\ \hline \end{gathered}$ | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | $\begin{gathered} \text { Krabi } \\ \text { Value } \end{gathered}$ | $\begin{array}{\|c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | $\begin{gathered} \text { Krabi } \\ \text { Value } \end{gathered}$ | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{array}{\|c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | Krabi Value |  |  |
| COD | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | 0.145 | 0.089 | t COD/ $\mathrm{m}^{3}$ | Plant data |
| Flow rate of wastewater | 323 | 464 | 323 | 464 | 323 | 464 | 323 | 464 | 323 | 464 | $\mathrm{m}^{3} / \mathrm{d}$ | Plant data |
| COD loading | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | 46.84 | 41.30 | t COD/d | Plant data |
| Ratio of reactor volume | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 | 1.00 | 0.88 |  | Refer to calculation |
| Operating day | 268 | 293 | 268 | 293 | 268 | 293 | 268 | 293 | 268 | 293 | day/year | Plant data |
| Initial investment* | 6.07 | 5.35 | 6.57 | 5.85 | 7.07 | 6.35 | 7.57 | 6.85 | 8.07 | 7.35 | Million USD | Estimated plant data |
| Manpower cost in the year | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | 0.020 | 0.018 | Million USD | Estimated plant data |
| Consumable cost in the year | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | Million USD | Estimated plant data |
| System maintenance cost in the year | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | 0.014 | 0.012 | Million USD | Estimated plant data |
| Gas engine maintenance cost in the year | 0.000 | 0.000 | 0.073 | 0.073 | 0.146 | 0.146 | 0.219 | 0.219 | 0.292 | 0.292 | Million USD | Estimated plant data |
| CDM monitoring in the year | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | 0.015 | 0.013 | Million USD | Estimated plant data |
| Electric power purchase price | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | 2.96 | Baht/kWh | VSPP tariff calculation |
| Generated electric power at generator output | 0 | 0 | 1063 | 1063 | 2126 | 2126 | 3189 | 3189 | 4252 | 4252 | kWe | Assumed generator output 1 set |
| Total power generation in the year** | 0 | 0 | 5817 | 6359 | 11633 | 12718 | 17450 | 19078 | 23266 | 25437 | MWh | Estimated plant data |
| GHG emission reduction in the year | 22500 | 21645 | 22500 | 21645 | 22500 | 21645 | 22500 | 21645 | 22500 | 21645 | $\mathrm{tCO}_{2} \mathrm{e}$ | Refer to calculation |
| CERs price | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | USD/t CO2 | Assumed conservative value |

Remarks: *Assume price of 1MWe gas engine generator $=0.5$ Calated estimation plant data: Operation condition No. of set $x$ Generator output ( 1063 kWe ) x Operation hour x Operation day x Accident factor ( 0.95 ) x Transmission loss ( 0.995 ) x Internal demand ( 0.9 )
Condition of tax and depreciation

| Item | Ayutthaya Value | $\begin{aligned} & \text { Krabi } \\ & \text { Value } \end{aligned}$ | $\begin{aligned} & \text { Ayutthaya } \\ & \text { Value } \end{aligned}$ | Krabi Value | $\begin{gathered} \text { Ayutthaya } \\ \text { Value } \end{gathered}$ | Krabi Value | $\begin{array}{\|c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | Krabi Value | $\begin{array}{c\|} \hline \text { Ayutthaya } \\ \text { Value } \end{array}$ | $\begin{gathered} \text { Krabi } \\ \text { Value } \end{gathered}$ | Unit | Remark |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Corporation tax | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | \% | Tax rate of Thailand (8 years tax holiday) |
| Interest, Borrowing period | - | - | - | - | - | - | - | - | - | - |  | Because it will be implemented in the fund on hand completely |
| Payment start time | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | 2010 | year | - |
| Depreciation taxable | 5.46 | 4.82 | 5.91 | 5.27 | 6.36 | 5.72 | 6.81 | 6.17 | 7.26 | 6.62 | Million USD | Equipment cost and design expense |
| Depreciation period | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | years | Least 5 years |
| Depreciation method and rate | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% | 10.00\% |  | Fixed installment method, $10 \%$, is general in Thailand. |
| Salvage value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | \% | Salvage value is zero. |
| Price inflation rate | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | \% | It isn't considered for the IRR calculation |
| Exchange rate (Baht USD) | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | 35.86 | Baht/USD | - |

## APPENDIX IV

Analysis for incline rate of CER generating cost, IRR, and net profit percentage/margin
Analysis of incline rate on IRR, net profit percentage, net profit margin for biogas CDM project

| Place | $\begin{aligned} & \text { loan } \\ & (\%) \\ & \hline \end{aligned}$ | $\begin{aligned} & \text { Contract } \\ & \text { (yrs) } \end{aligned}$ | Electricity (Mwh/y) | $\begin{gathered} \text { 1/Electricity } \\ (\mathrm{y} / \mathrm{Mwh}) \end{gathered}$ | $\begin{aligned} & \hline \text { Electricity } \\ & (\mathrm{Mwh} / \mathrm{y}) \end{aligned}$ | $\begin{array}{\|c\|} \hline \text { CERs investment } \\ \text { (USD/t CO } 2 \text { e } \end{array}$ | $\begin{array}{\|c\|} \hline \text { CERs } \\ \text { (USD/t } \left.\mathrm{CO}_{2} \mathrm{e}\right) \\ \hline \end{array}$ | $\begin{gathered} \text { Slope } \\ (-) \\ \hline \end{gathered}$ | IRR value <br> (\%) | $\begin{aligned} & \hline \text { IRR } \\ & (\%) \\ & \hline \end{aligned}$ | $\begin{gathered} \hline \text { Slope } \\ (-) \\ \hline \end{gathered}$ | $\begin{gathered} \hline \text { Profit percentage } \\ (\%) \\ \hline \end{gathered}$ | $\begin{gathered} \text { Profit percentage } \\ (\%) \end{gathered}$ | $\begin{gathered} \hline \text { Slope } \\ (-) \\ \hline \end{gathered}$ | $\begin{gathered} \text { Profit margin } \\ (\%) \\ \hline \end{gathered}$ | $\begin{gathered} \text { Profit margin } \\ (\%) \\ \hline \end{gathered}$ | Slope <br> (-) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Ayutthaya | 0.00 | 10.00 | 0 | 0.00000 | 0.00 | 26.98 |  |  |  |  |  | -63.13 |  |  | -171.24 |  |  |
| Ayutthaya | 0.00 | 10.00 | 5817 | 0.00017 | 5816.59 | 29.20 | 2.22 | 0.00038 | -0.72 | -0.72 |  | -2.99 | 60.14 |  | -3.09 | 168.15 |  |
| Ayutthaya | 0.00 | 10.00 | 11633 | 0.00009 | 5816.59 | 31.42 | 2.22 | 0.00038 | 8.63 | 9.35 | 0.0016 | 37.65 | 40.64 | 0.0070 | 26.88 | 29.97 | 0.00 |
| Ayutthaya | 0.00 | 10.00 | 17450 | 0.00006 | 5816.59 | 33.64 | 2.22 | 0.00038 | 15.48 | 6.85 | 0.0012 | 68.34 | 30.69 | 0.0053 | 39.57 | 12.69 | 0.00 |
| Ayutthaya | 0.00 | 10.00 | 23266 | 0.00004 | 5816.59 |  | 2.23 | 0.00038 | 20.97 | 5.49 | 0.0009 | 92.34 | 24.00 | 0.0041 | 46.58 |  |  |

A project with 10-year CER crediting period (Krabi site)

| Place | $\begin{aligned} & \text { loan } \\ & (\%) \\ & \hline \end{aligned}$ | $\begin{gathered} \text { Contract } \\ (\mathrm{yrs}) \end{gathered}$ | Electricity <br> (Mwh/y) | 1/Electricity (y/Mwh) | Electricity ( $\mathrm{Mwh} / \mathrm{y}$ ) | $\begin{array}{\|c\|} \hline \text { CERs investment } \\ \text { (USD/t } \mathrm{CO}_{2} \mathrm{e} \text { ) } \end{array}$ | $\begin{array}{c\|} \text { CERs } \\ \left(\text { USD/t } \mathrm{CO}_{2} \mathrm{e}\right) \end{array}$ | $\begin{gathered} \hline \text { Slope } \\ (-) \\ \hline \end{gathered}$ | IRR value <br> (\%) | $\begin{aligned} & \text { IRR } \\ & (\%) \\ & \hline \end{aligned}$ | Slope <br> (-) | $\begin{array}{\|c\|} \hline \text { Profit percentage } \\ (\%) \\ \hline \end{array}$ | $\begin{aligned} & \text { Profit percentage } \\ & (\%) \\ & \hline \end{aligned}$ | Slope <br> (-) | $\left\|\begin{array}{c} \text { Profit margin } \\ (\%) \end{array}\right\|$ | $\begin{gathered} \text { Profit margin } \\ (\%) \\ \hline \end{gathered}$ | $\begin{gathered} \text { Slope } \\ (-) \\ \hline \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Krabi | 0.00 | 10.00 | 0 | 0.00000 | 0.00 | 24.73 |  |  |  |  |  | -59.78 |  |  | -148.61 |  |  |
| Krabi | 0.00 | 10.00 | 6359 | 0.00016 | 6359.18 | 27.04 | 2.31 | 0.00036 | 2.82 | 2.82 |  | 12.21 | 71.99 |  | 10.81 | 159.42 |  |
| Krabi | 0.00 | 10.00 | 12718 | 0.00008 | 6359.18 | 29.35 | 2.31 | 0.00036 | 13.24 | 10.42 | 0.0016 | 59.76 | 47.55 | 0.0075 | 36.53 | 25.72 | 0.0040 |
| Krabi | 0.00 | 10.00 | 19078 | 0.00005 | 6359.18 | 31.66 | 2.31 | 0.00036 | 20.89 | 7.65 | 0.0012 | 94.73 | 34.97 | 0.0055 | 47.18 | 10.6 | 0.0017 |
| Krabi | 0.00 | 10.00 | 25437 | 0.00004 | 6359.18 | 33.97 | 2.31 | 0.00036 | 27.02 | 6.13 | 0.0010 | 121.58 | 26.85 | 0.004 | 53.01 |  | 0.000 | A project with 14-year CER crediting period (Ayutthaya site)


| Place | $\begin{aligned} & \text { loan } \\ & (\%) \end{aligned}$ | Contract <br> (yrs) | Electricity (Mwh/y) | 1/Electricity <br> ( $\mathrm{y} / \mathrm{Mwh}$ ) | $\begin{aligned} & \hline \text { Electricity } \\ & (\mathrm{Mwh} / \mathrm{y}) \end{aligned}$ | $\begin{array}{\|c\|} \hline \text { CERs investment } \\ \text { (USD/t } \mathrm{CO}_{2} \mathrm{e} \text { ) } \end{array}$ | $\begin{array}{\|c\|} \hline \text { CERs } \\ \text { (USD/t } \left.\mathrm{CO}_{2} \mathrm{e}\right) \\ \hline \end{array}$ | Slope <br> (-) | IRR value <br> (\%) | $\begin{aligned} & \text { IRR } \\ & (\%) \\ & \hline \end{aligned}$ | Slope <br> $(-)$ | $\begin{gathered} \text { Profit percentage } \\ (\%) \end{gathered}$ | $\begin{aligned} & \text { Profit percentage } \\ & (\%) \end{aligned}$ | Slope <br> (-) | $\begin{array}{\|c\|} \hline \text { Profit margin } \\ (\%) \end{array}$ | Profit margin <br> (\%) | Slope <br> (-) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Ayutthaya | 0.00 | 14.00 | 0 | 0.00000 | 0.00 | 19.27 |  |  | -10.06 |  |  | -53.50 |  |  | -108.01 |  |  |
| Ayutthaya | 0.00 | 14.00 | 5817 | 0.00017 | 5816.59 | 20.86 | 1.59 | 0.00027 | 4.22 | 14.28 | 0.0025 | 17.53 | 71.03 |  | 13.91 | 121.92 |  |
| Ayutthaya | 0.00 | 14.00 | 11633 | 0.00009 | 5816.59 | 22.44 | 1.58 | 0.00027 | 12.31 | 8.09 | 0.0014 | 63.60 | 46.07 | 0.0079 | 35.66 | 21.75 | 0.0037 |
| Ayutthaya | 0.00 | 14.00 | 17450 | 0.00006 | 5816.59 | 24.03 | 1.59 | 0.00027 | 18.38 | 6.07 | 0.0010 | 97.08 | 33.48 | 0.0058 | 44.87 | 9.21 | 0.0016 |
| Ayutthaya | 0.00 | 14.00 | 23266 | 0.00004 | 5816.59 | 25.62 | 1.59 | 0.00027 | 23.33 | 4.95 | 0.0009 | 122.52 | 25.44 | 0.0044 | 49.95 | 5.08 | 0.0009 |

A project with 14-year CER crediting period (Krabi site)

| Place | $\begin{aligned} & \text { loan } \\ & (\%) \end{aligned}$ | $\begin{gathered} \text { Contract } \\ (\mathrm{yrs}) \end{gathered}$ | Electricity (Mwh/y) | 1/Electricity ( $\mathrm{y} / \mathrm{Mwh}$ ) | $\begin{aligned} & \begin{array}{l} \text { Electricity } \\ (\mathrm{Mwh} / \mathrm{y}) \end{array} \\ & \hline \end{aligned}$ | $\begin{array}{\|c\|} \hline \text { CERs investment } \\ \text { (USD/t } \mathrm{CO}_{2} \mathrm{e} \text { ) } \end{array}$ | $\begin{array}{\|c\|} \hline \text { CERs } \\ \left(\text { USD } / \mathrm{CO}_{2} \mathrm{e}\right) \\ \hline \end{array}$ | Slope <br> (-) | IRR value <br> (\%) | $\begin{aligned} & \text { IRR } \\ & (\%) \\ & \hline \end{aligned}$ | Slope $(-)$ | $\begin{gathered} \text { Profit percentage } \\ (\%) \end{gathered}$ | Profit percentage <br> (\%) | Slope <br> (-) | Profit margin <br> $(\%)$ | Profit margin <br> (\%) | Slope <br> (-) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Krabi | 0.00 | 14.00 | 0 | 0.00000 | 0.00 | 17.66 |  |  | -8.87 |  |  | -49.38 |  |  | -91.37 |  |  |
| Krabi | 0.00 | 14.00 | 6359 | 0.00016 | 6359.18 | 19.31 | 1.65 | 0.00026 | 7.27 | 16.14 | 0.0025 | 35.52 | 84.90 |  | 24.23 | 115.60 |  |
| Krabi | 0.00 | 14.00 | 12718 | 0.00008 | 6359.18 | 20.96 | 1.65 | 0.00026 | 16.38 | 9.11 | 0.0014 | 88.94 | 53.42 | 0.0084 | 42.90 | 18.67 | 0.0029 |
| Krabi | 0.00 | 14.00 | 19078 | 0.00005 | 6359.18 | 22.61 | 1.65 | 0.00026 | 23.26 | 6.88 | 0.0011 | 126.66 | 37.72 | 0.0059 | 50.63 | 7.73 | 0.0012 |
| Krabi | 0.00 | 14.00 | 25437 | 0.00004 | 6359.18 | 24.26 | 1.65 | 0.00026 | 28.89 | 5.63 | 0.0009 | 154.79 | 28.13 | 0.0044 | 54.86 | 4.23 | 0.000 |

A project with 20-year CER crediting period (Ayutthaya site)

| Place | $\begin{aligned} & \text { loan } \\ & (\%) \end{aligned}$ | Contract (yrs) | Electricity (Mwh/y) | $\begin{gathered} \text { 1/Electricity } \\ (\mathrm{y} / \mathrm{Mwh}) \end{gathered}$ | $\begin{aligned} & \hline \begin{array}{l} \text { Electricity } \\ (\mathrm{Mwh} / \mathrm{y}) \end{array} \\ & \hline \end{aligned}$ | $\begin{array}{\|c\|} \hline \text { CERs investment } \\ \text { (USD/t } \mathrm{CO}_{2} \mathrm{e} \text { ) } \end{array}$ | $\begin{array}{\|c\|} \hline \text { CERs } \\ (\text { USD/t CO } 2 \text { e }) \\ \hline \end{array}$ | Slope <br> $(-)$ | IRR value <br> (\%) | $\begin{aligned} & \text { IRR } \\ & (\%) \\ & \hline \end{aligned}$ | $\begin{gathered} \text { Slope } \\ (-) \\ \hline \end{gathered}$ | Profit percentage $(\%)$ | $\begin{gathered} \text { Profit percentage } \\ (\%) \\ \hline \end{gathered}$ | Slope <br> (-) | Profit margin <br> $(\%)$ | $\begin{array}{c\|} \hline \text { Profit margin } \\ (\%) \\ \hline \end{array}$ | Slope <br> (-) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Ayuthaya | 0.00 | 20.00 | 0 | 0.00000 | 0.00 | 13.49 |  |  | -4.58 |  |  | -40.43 |  |  | -60.58 |  |  |
| Ayuthaya | 0.00 | 20.00 | 5817 | 0.00017 | 5816.59 | 14.60 | 1.11 | 0.00019 | 7.23 | 11.81 | 0.0020 | 43.44 | 83.87 |  | 26.65 | 87.23 |  |
| Ayuthaya | 0.00 | 20.00 | 11633 | 0.00009 | 5816.59 | 15.71 | 1.11 | 0.00019 | 14.26 | 7.03 | 0.0012 | 94.79 | 51.35 | 0.0088 | 42.24 | 15.59 | 0.0027 |
| Ayutthaya | 0.00 | 20.00 | 17450 | 0.00006 | 5816.59 | 16.82 | 1.11 | 0.00019 | 19.74 | 5.48 | 0.0009 | 130.41 | 35.62 | 0.0061 | 48.84 | 6.60 | 0.0011 |
| Ayuthaya | 0.00 | 20.00 | 23266 | 0.00004 | 5816.59 | 17.93 | 1.11 | 0.00019 | 24.32 | 4.58 | 0.0008 | 156.58 | 26.17 | 0.0045 | 52.48 | 3.64 | 0.000 |

A project with 20-year CER crediting period (Krabi site)

| Place | $\begin{aligned} & \text { loan } \\ & (\%) \end{aligned}$ | $\begin{gathered} \text { Contract } \\ (\mathrm{yrs}) \end{gathered}$ | Electricity (Mwh/y) | 1/Electricity ( $\mathrm{y} / \mathrm{Mwh}$ ) | Electricity (Mwh/y) | $\begin{array}{\|c\|} \hline \text { CERs investment } \\ \text { (USD/t } \mathrm{CO}_{2} \mathrm{e} \text { ) } \\ \hline \end{array}$ | $\begin{gathered} \text { CERs } \\ \left(\text { USD } / \mathrm{CO}_{2} \mathrm{e}\right) \\ \hline \end{gathered}$ | Slope <br> (-) | IRR value <br> (\%) | $\begin{aligned} & \hline \text { IRR } \\ & (\%) \\ & \hline \end{aligned}$ | Slope <br> $(-)$ | $\begin{array}{\|c\|} \hline \text { Profit percentage } \\ (\%) \end{array}$ | $\begin{gathered} \text { Profit percentage } \\ (\%) \\ \hline \end{gathered}$ | $\begin{gathered} \hline \text { Slope } \\ (-) \\ \hline \end{gathered}$ | $\begin{gathered} \text { Profit margin } \\ (\%) \\ \hline \end{gathered}$ | $\begin{gathered} \hline \text { Profit margin } \\ (\%) \\ \hline \end{gathered}$ | Slope <br> (-) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Krabi | 0.00 | 20.00 | 0 | 0.00000 | 0.00 | 12.36 |  |  | -3.61 |  |  | -35.26 |  |  | -48.43 |  |  |
| Krabi | 0.00 | 20.00 | 6359 | 0.00016 | 6359.18 | 13.52 | 1.16 | 0.00018 | 9.84 | 13.45 | 0.0021 | 64.73 | 99.99 |  | 34.29 | 82.72 |  |
| Krabi | 0.00 | 20.00 | 12718 | 0.00008 | 6359.18 | 14.67 | 1.15 | 0.00018 | 17.92 | 8.08 | 0.0013 | 123.63 | 58.90 | 0.0093 | 47.67 | 13.38 | 0.0021 |
| Krabi | 0.00 | 20.00 | 19078 | 0.00005 | 6359.18 | 15.83 | 1.16 | 0.00018 | 24.26 | 6.34 | 0.0010 | 163.26 | 39.63 | 0.0062 | 53.21 | 5.54 |  |
| Krabi | 0.00 | 20.00 | 25437 | 0.00004 | 6359.18 | 16.98 | 1.15 | 0.00018 | 29.57 | 5.31 | 0.0008 | 191.84 | 28.58 | 0.0045 | 56.24 | 3.03 | 0.000 |

## APPENDIX V

Comparative cost for nitrate removal by ion exchange treatment process

## Relationship of cost and nitrate removal from ion exchange treatment process

| System size (people) | MCL level* | Raw nitrate level (gram) | Annualized combined cost range (USD) |
| :---: | :---: | :---: | :---: |
| Small size (501-3300) | 1X MCL | 170.34354 | 1.05 |
| Medium size (3301-10000) | 1X MCL | 170.34454 | 1.06 |
| Large size (10001-100000) | 1X MCL | 170.34554 | 0.97 |
| Small size (501-3300) | 2X MCL | 340.68708 | 1.70 |
| Medium size (3301-10000) | 2X MCL | 340.68708 | 1.60 |
| Large size (10001-100000) | 2X MCL | 340.68708 | 1.46 |
| Small size (501-3300) | 3X MCL | 511.03062 | 2.36 |
| Medium size (3301-10000) | 3X MCL | 511.03062 | 2.32 |
| Large size (10001-100000) | 3X MCL | 511.03062 | 1.96 |

* Remark: Maximum Concentration Level of raw nitrate



## APPENDIX VI

## Estimation of groundwater table (or depth $L$ )

 in the Green-Ampt approximationEstimation of depth $L$ in The Green-Ampt Approximation in Ayutthaya

| Contour position | Distance of contour line <br> (meter) | Ground altitude <br> (meter) | Groundwater table altitude <br> (meter) |
| :---: | ---: | :---: | :---: |
| 1 | 0 | 11 | -3 |
| 2 | 100 | 9 | -4 |
| 3 | 270 | 10 | -5 |
| 4 | 420 | 10 | -6 |
| 5 | 570 | 10 | -7 |
| 6 | 720 | 8 | -8 |


| Pond | Distance of contour line <br> (meter) | Pond surface altitude <br> (meter) | Pond bottom altitude <br> (meter) |
| :---: | ---: | ---: | ---: |
| pond1 | 100 | 9 |  |
| pond2 | 290 | 10 | 5.5 |
| pond3 | 435 | 10 | 6.3 |
| pond4 | 515 | 10 | 6.8 |
| pond5 | 640 | 9 | 5.1 |



| Depth L <br> (meter) |
| ---: |
| 10.5 |
| 12.3 |
| 13.3 |
| 12.6 |
| 12.175 |

Estimation of depth $L$ in The Green-Ampt Approximation in Krabi

| Contour position | Distance of contour line (meter) | Ground altitude (meter) | Groundwater table altitude (meter) |
| :---: | :---: | :---: | :---: |
| 1 | 0 | 100 | 60 |
| 2 | 272 | 98 | 54 |
| 3 | 362 | 99 | 52 |
| 4 | 465 | 96 | 50 |
| 5 | 750 | 91 | 44 |
| 6 | 827 | 92 | 42 |
| 7 | 931 | 94 | 40 |
| 8 | 1008 | 94 | 38 |
|  |  |  |  |
| Pond | Distance of contour line (meter) | Pond surface altitude (meter) | Pond bottom altitude (meter) |
| pond1 | 350 | 99 | 92 |
| pond2 | 430 | 97 | 90 |
| pond3 | 845 | 92 | 86 |
| pond4 | 930 | 94 | 88 |




## APPENDIX VII

Relationship of willingness-to-pay and cumulative probability of bidding

## Relationship of willingness to pay and cumulative probability of bidding

| Willingness to pay <br> (THB/household) | Cumulative probability of bidding |  |  |  |
| ---: | ---: | ---: | ---: | ---: |
|  | 0.994877 | 0.988778 | 0.995803 | 1.000000 |
| 20 | 0.943163 | 0.912624 | 0.946882 | 0.983052 |
| 25 | 0.896998 | 0.855220 | 0.900924 | 0.955344 |
| 40 | 0.724539 | 0.666913 | 0.724042 | 0.790914 |
| 50 | 0.609921 | 0.553061 | 0.605025 | 0.650739 |
| 100 | 0.239968 | 0.214096 | 0.225401 | 0.177638 |
| 200 | 0.045330 | 0.042900 | 0.037987 | 0.012672 |



## APPENDIX VIII

Lifereg analysis of SAS program

## Lifereg analysis of SAS program for Ayutthaya site

## life regression for data_Ayutthaya (at provincial level) distribution as lognormal

| Model Information |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Data Set |  |  | WORK.DATA_AYUTT |  |  |  |
| Dependent Variable |  |  | Log(Min_WTP) Min WTP |  |  |  |
| Dependent Variable |  |  | Log(Max_WTP_1_) |  | Max WTP(1) |  |
| Number of Observations |  |  | 89 |  |  |  |
| Non-censored Values |  |  | 37 |  |  |  |
| Right Censored Values |  |  | 0 |  |  |  |
| Left Censored Values |  |  | 0 |  |  |  |
| Interval Censored Values |  |  | 52 |  |  |  |
| Number of Parameters |  |  | 2 |  |  |  |
| Name of Distribution |  |  | Lognormal |  |  |  |
| Log Likelihood |  |  | -115.93 |  |  |  |
| Number of Observations Read |  |  | d 89 |  |  |  |
| Number of Observations Used |  |  | 89 |  |  |  |
| Fit Statistics |  |  |  |  |  |  |
| -2 Log Likelihood |  |  | 231.859 |  |  |  |
| AIC (smaller is better) |  |  | 235.859 |  |  |  |
| AICC (smaller is better) |  |  | 235.998 |  |  |  |
| BIC (smaller is better) |  |  | 240.836 |  |  |  |
| Fit Statistics (Unlogged Response) |  |  |  |  |  |  |
| -2 Log Likelihood |  |  | 557.183 |  |  |  |
| AIC (smaller is better) |  |  | 561.183 |  |  |  |
| AICC (smaller is better) |  |  | 561.322 |  |  |  |
| BIC (smaller is better) |  |  | 566.160 |  |  |  |
| Analysis of Maximum Likelihood Parameter Estimates |  |  |  |  |  |  |
| Parameter |  | Standard Estimate | 95\% Error | Confidence Limits | Chi-Square | Pr>ChiSq |
| Intercept | 1 | 4.1083 | 0.0763 | 3.9589,4.2578 | 2902.60 | <. 0001 |
| Scale | 1 | 0.7033 | 0.0549 | 0.6036,0.8196 |  |  |
| Estimated Correlation Matrix |  |  |  |  |  |  |
|  | Inter | cept | Scale |  |  |  |
| Intercept | 1.000 | 0000 | -0.017321 |  |  |  |
| Scale | -0.01 | 17321 | 1.000000 |  |  |  |

life regression for data_Ayutthaya (at national level) distribution as lognormal

| The LIFEREG Procedure |  |
| :--- | :--- |
| Model Information |  |
| Data Set | WORK.DATA_BKK |
| Dependent Variable | Log(Min_WTP) Min WTP |
| Dependent Variable | Log(Max_WTP_1_) Max WTP(1) |
| Number of Observations | 260 |
| Non-censored Values | 86 |
| Right Censored Values | 0 |
| Left Censored Values | 0 |
| Interval Censored Values | 174 |
| Number of Parameters | 2 |
| Name of Distribution | Lognormal |
| Log Likelihood | -363.3220583 |
| Number of Observations Read | 261 |
| Number of Observations Used | 260 |
| Fit Statistics |  |
| -2 Log Likelihood | 726.644 |
| AIC (smaller is better) | 730.644 |
| AICC (smaller is better) | 730.691 |
| BIC (smaller is better) | 737.765 |
| Fit Statistics (Unlogged Response) | 1482.366 |
| -2 Log Likelihood | 1486.366 |
| AIC (smaller is better) | 1486.413 |
| AICC (smaller is better) | 1493.488 |
| BIC (smaller is better) |  |

Analysis of Maximum Likelihood Parameter Estimates

| Parameter | DF | Standard <br> Estimate | $95 \%$ Error | Confidence <br> Limits | Chi-Square | Pr>ChiSq |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Intercept | 1 | 4.0119 | 0.0475 | $3.9188,4.1050$ | 7128.69 | $<.0001$ |
| Scale | 1 | 0.7488 | 0.0343 | $0.6845,0.8191$ |  |  |

Estimated Correlation Matrix

|  | Intercept | Scale |
| :--- | :--- | :--- |
| Intercept | 1.000000 | -0.016174 |
| Scale | -0.016174 | 1.000000 |

Life regression for data_Ayutthaya (at national level) distribution as lognormal with variables
The LIFEREG Procedure

| Model Information |  |
| :--- | :--- |
| Data Set | WORK.DATA_BKK |
| Dependent Variable | Log(Min_WTP) Min WTP |
| Dependent Variable | Log(Max_WTP_1_) Max WTP(1) |
| Number of Observations | 209 |
| Non-censored Values | 74 |
| Right Censored Values | 0 |
| Left Censored Values | 0 |
| Interval Censored Values | 135 |
| Number of Parameters | 14 |
| Name of Distribution | Lognormal |
| Log Likelihood | -164.2699553 |
| Number of Observations Read | 261 |
| Number of Observations Used | 209 |
| Fit Statistics |  |
| -2 Log Likelihood | 328.540 |
| AIC (smaller is better) | 356.540 |
| AICC (smaller is better) | 358.705 |
| BIC (smaller is better) | 403.333 |
| Fit Statistics (Unlogged Response) |  |
| -2 Log Likelihood | 978.742 |
| AIC (smaller is better) | 1006.742 |
| AICC (smaller is better) | 1008.907 |
| BIC (smaller is better) | 1053.535 |

Analysis of Maximum Likelihood Parameter Estimates

| Parameter | DF | Standard <br> Estimate | $95 \%$ Error | Confidence <br> Limits | Chi- <br> Square |  | Pr>ChiSq |
| :--- | :---: | :---: | ---: | :---: | ---: | ---: | ---: |
| Intercept | 1 | 3.6840 | 0.3592 | $2.9800,4.3881$ | 105.19 | $<.0001$ |  |
| Start | 1 | 0.0174 | 0.0009 | $0.0156,0.0192$ | 348.57 | $<.0001$ |  |
| Sex | 1 | -0.1549 | 0.0594 | $-0.2713,-0.0384$ | 6.80 | 0.0091 |  |
| Edu | 1 | -0.0017 | 0.0136 | -0.0284 .0 .0251 | 0.02 | 0.9025 |  |
| Occup | 1 | -0.0086 | 0.0199 | $-0.0476,0.0304$ | 0.19 | 0.6656 |  |
| Time | 1 | -0.0059 | 0.0024 | $-0.0107,-0.0011$ | 5.75 | 0.0165 |  |
| Mem | 1 | 0.0023 | 0.0257 | $-0.0481,0.0526$ | 0.01 | 0.9302 |  |
| Emplo | 1 | -0.0457 | 0.1377 | $-0.3157,0.2242$ | 0.11 | 0.7399 |  |
| Income | 1 | 0.0354 | 0.0105 | $0.0149,0.0559$ | 11.44 | 0.0007 |  |
| Know | 1 | -0.0641 | 0.0331 | $-0.1290,0.0008$ | 3.74 | 0.0530 |  |
| Been | 1 | 0.1320 | 0.1260 | $-0.1149,0.3789$ | 1.10 | 0.2947 |  |
| Attwq | 1 | -0.0996 | 0.0478 | $-0.1933,-0.0059$ | 4.34 | 0.0371 |  |
| Attimp | 1 | 0.0404 | 0.0299 | $-0.0182,0.0990$ | 1.83 | 0.1762 |  |
| Scale | 1 | 0.3874 | 0.0219 | $0.3468,0.4328$ |  |  |  |
|  |  |  |  |  |  |  |  |

Life regression for data_Krabi (at national level) distribution as lognormal with variables

| The LIFEREG Procedure |  |
| :--- | :--- |
| Model Information |  |
| Data Set | WORK.DATA_BKK |
| Dependent Variable | Log(Min_WTP) Min WTP |
| Dependent Variable | Log (Max_WTP_1_) Max WTP(1) |
| Number of Observations | 78 |
| Non-censored Values | 28 |
| Right Censored Values | 0 |
| Left Censored Values | 0 |
| Interval Censored Values | 50 |
| Number of Parameters | 16 |
| Name of Distribution | Normal |
| Log Likelihood | -191.57 |
| Number of Observations Read | 240 |
| Number of Observations Used | 78 |
| Fit Statistics |  |
| -2 Log Likelihood | 383.15 |
| AIC (smaller is better) | 415.15 |
| AICC (smaller is better) | 424.07 |
| BIC (smaller is better) | 452.86 |
| Fit Statistics (Unlogged Response) |  |
| -2 Log Likelihood |  |
| AIC (smaller is better) |  |
| AICC (smaller is better) |  |
| BIC (smaller is better) |  |

Analysis of Maximum Likelihood Parameter Estimates

| Parameter | DF | Standard <br> Estimate | 95\% Error | Confidence <br> Limits | Chi- <br> Square |  | Pr>ChiSq |
| :--- | :--- | ---: | ---: | :--- | ---: | ---: | ---: |
| Intercept | 1 | -27.02 | 42.02 | $-109.373,55.341$ | 0.41 | 0.52 |  |
| Start | 1 | 1.50 | 0.11 | $1.2836,1.7095$ | 189.77 | $<.0001$ |  |
| Sex | 1 | -6.67 | 7.32 | $-21.01,7.6782$ | 0.83 | 0.36 |  |
| Age | 1 | 0.13 | 0.48 | $-0.82,1.0755$ | 0.07 | 0.79 |  |
| Edu | 1 | 3.44 | 2.02 | $-0.5097,7.3937$ | 2.91 | 0.09 |  |
| Occup | 1 | -0.32 | 2.55 | $-5.3244,4.6890$ | 0.02 | 0.90 |  |
| Time | 1 | -0.02 | 0.50 | $-1.0111,0.9612$ | 0.00 | 0.96 |  |
| Mem | 1 | -0.28 | 2.80 | $-5.7786,5.2151$ | 0.01 | 0.92 |  |
| Emplo | 1 | 20.10 | 17.08 | $-13.38,53.5731$ | 1.38 | 0.24 |  |
| Income | 1 | -1.69 | 1.36 | $-4.3462,0.9723$ | 1.55 | 0.21 |  |
| Know | 1 | -4.19 | 4.48 | $-12.9730,4.6028$ | 0.87 | 0.35 |  |
| Been | 1 | 3.31 | 7.92 | $-12.2209,18.833$ | 0.17 | 0.68 |  |
| Attwq | 1 | -2.67 | 3.83 | $-10.1802,4.8472$ | 0.48 | 0.49 |  |
| Attimp | 1 | 1.11 | 4.19 | $-7.1078,9.3329$ | 0.07 | 0.79 |  |
| Scale | 1 | 26.58 | 2.37 | $22.3125,31.6588$ |  |  |  |

Life regression for data_Krabi (at provincial level) distribution as lognormal with variables

| The LIFEREG Procedure |  |
| :--- | :--- |
| Model Information |  |
| Data Set |  |
| Dependent Variable | WORK.DATA_KRABI |
| Dependent Variable | Log (Min_WTP) Min WTP |
| Number of Observations | 70 |
| Non-censored Values | 26 |
| Right Censored Values | 0 |
| Left Censored Values | 0 |
| Interval Censored Values | 44 |
| Number of Parameters | 14 |
| Name of Distribution | Normal |
| Log Likelihood | -159.27 |
| Number of Observations Read | 74 |
| Number of Observations Used | 70 |
| Fit Statistics |  |
| -2 Log Likelihood | 318.55 |
| AIC (smaller is better) | 346.55 |
| AICC (smaller is better) | 354.18 |
| BIC (smaller is better) | 378.03 |
| Fit Statistics (Unlogged Response) |  |
| -2 Log Likelihood |  |
| AIC (smaller is better) |  |
| AICC (smaller is better) |  |
| BIC (smaller is better) |  |

Analysis of Maximum Likelihood Parameter Estimates

| Parameter | DF | Standard <br> Estimate | $95 \%$ Error | Confidence <br> Limits | Chi- <br> Square | Pr>ChiSq |
| :--- | :--- | ---: | ---: | :---: | ---: | ---: | ---: |
| Intercept | 1 | -66.67 | 42.62 | $-150.2,16.865$ | 2.45 | 0.12 |
| Start | 1 | 0.91 | 0.11 | $0.7046,1.1162$ | 75.18 | $<.0001$ |
| Sex | 1 | -5.79 | 7.33 | $-20.17,8.5812$ | 0.62 | 0.43 |
| Age | 1 | 0.73 | 0.40 | $-0.0621,1.5218$ | 3.26 | 0.07 |
| Edu | 1 | 2.35 | 1.25 | $-0.1130,4.8042$ | 3.50 | 0.06 |
| Occup | 1 | 3.92 | 2.07 | $-0.1332,7.9814$ | 3.59 | 0.06 |
| Time | 1 | 0.04 | 0.27 | $-0.49,0.5722$ | 0.02 | 0.88 |
| Mem | 1 | 6.12 | 2.65 | $0.93,11.3000$ | 5.35 | 0.02 |
| Emplo | 1 | -2.78 | 14.66 | $-31.516,25.960$ | 0.04 | 0.85 |
| Income | 1 | 0.28 | 1.12 | $-1.9126,2.4709$ | 0.06 | 0.80 |
| Know | 1 | 3.86 | 3.91 | $-3.8005,11.5248$ | 0.98 | 0.32 |
| Attwq | 1 | -12.49 | 4.98 | $-22.2609,-2.7213$ | 6.28 | 0.01 |
| Attimp | 1 | 9.01 | 5.23 | $-1.2504,19.2638$ | 2.96 | 0.09 |
| Scale | 1 | 2.00 | 2.14 | $18.19,26.6164$ |  |  |

## APPENDIX IX

## Samples of questionnaire for Ayutthaya and Krabi respondents (in Thai)

## [ SAMPLE OF AYUTTHAYA QUESTIONNAIRE IN THAI]

คำชี้แจง โปรดทำเครื่องหมาย $\sqrt{ }$ และ/หรือ เติมข้อความในช่องว่างที่กำหนดให้
ส่วนที่ 1: ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม

1. เพศ $\qquad$ ชาย $\qquad$ หญิง
2. อายุ โปรดระบุ ปี
3. วุฒิการศึกษาสูงสุด

| ประถมคึกษาหรือต่ำกว่า |  | มัธยมตอนต้น |  |
| :--- | :--- | :--- | :--- |
| มัธยมตอนปลาย/ปวช |  | อนุปริญญาปปวส |  |
| ปริญญาตรี |  | ปริญญาโทหรือสงกว่า |  |

4. อาชีพ

| รับราชการ |  | ประกอบธุรกิจส่วนตัว |  |
| :--- | :--- | :--- | :--- |
| พนักงานวิสาหกิจ |  | พนักงานบริษัทเอกชน |  |
| รับจ้าง |  | นักเรียน/นักศึกษา |  |
| แม่บ้าน/ข้าราชการบำนาญ | ผู้ทึศึกษา/ทำงานเกี่ยวกับสิ่ง <br> แืดล้อม |  |  |
| ผู้ที่ศึกษา/ทำงานเกี่ยวกับการเกษตร | ผู้ทึศึกษา/ทำงานเกี่ยวกับการ <br> ปีะมง |  |  |
| อื่นๆ โปรดระบุ ........................... |  |  |  |

5. (ตามชื่อในทะเบียนบ้าน) ท่านอยู่ในอยุธยาหรือไม่ $\qquad$ ใช่ (ถ้าใช่ ไปคำถามข้อ 8) ไม่ใช่ 6. (ตามชื่อในทะเบียนบ้าน) ท่านมาจากจังหวัดอะไร โปรดระบุ $\qquad$
6. ท่านอาศัยอยู่ในอยุธยามานานเท่าใด โปรดระบุ ปี
7. สมาชิกในครอบครัว (ไม่รวมตัวท่าน)

| จำนวน | สถานะ <br> (พ่อ, แม่, พี่, น้อง) <br> ไม่ต้องระบุชื่อ | เพศ <br> (ช/ญ) | อายุ <br> (ปี) | ทำงาน <br> (ใช่/ไม่) | การศึกษา: (1-ประถมหรือต่ำกว่า, <br> 2-มัธยมต้น, 3-มัธยมปลาย/ปวช, <br> 4-อนุปริญญา/ปวส, 5-ปริญญาตรี, <br> 6-ปริญญาโทหรือสูงกว่า) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |


| จำนวน | สถานะ <br> (พ่อ, แม่, พี่, น้อง) <br> ไม่องระบุชื่อ | เพศ <br> (ช/ญ) | อายุ <br> (ปี) | ทำงาน <br> (ใช่/ไม่) | การศึกษา: (1-ประถมหรือต่ำกว่า, <br> 2-มัธยมตตน, 3-มัธยมปลาย/ปวช, <br> 4-อนุปริญญา/ปวส, 5-ปริญญาตรี, <br> 6-ปริญญาโทหรือสูงกว่า) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 7 |  |  |  |  |  |
| 8 |  |  |  |  |  |

9. ปัจจุบันรายได้หลังหักภาษีต่อครอบครัวต่อเดือนสูงสุดโดยประมาณ (รวมรายได้ของทุกคนในข้อ 8)
$\qquad$

น้อยกว่า 10,000 บาท
$20,001-30,000$ บาท
40,001 - 50,000 บาท
$60,001-70,000$ บาท
$80,001-90,000$ บาท
............ มากกว่า 100,001 บาท
$10,001-20,000$ บาท
$30,001-40,000$ บาท
$50,001-60,000$ บาท
$70,001-80,000$ บาท
$90,001-100,000$ บาท

ส่วนที่ 2: ความรู้และความเข้าใจเกี่ยวกับคุณภาพน้ำ

| ข้อความข้างล่างนี้ถูหรือผิด | ถูก | ผิด |
| :---: | :---: | :---: |
| 10. น้ำเสีย หมายถึง น้ำที่เสื่อมคุณภาพ หรือ น้ำที่ผ่านการใช้งานมาแล้ว |  |  |
| 11. น้ำเสียสามารถถูกปรับปรุงคุณภาพใหด้ขี้นได้ด้วยสิ่งก่อสร้างและเทคโนโลยีที่มนุษย่ สร้างขึ้น |  |  |
| 12. ปริมาณออกซิเจนในน้ำสามารถใช้บงบอกระดับคุณภาพน้ำของประเทศไทย |  |  |
| 13. น้ำเสียจากโรงงานอุตสาหกรรมเป็นปัจจัยหลักที่ทำให้คุณภาพน้ำในประเทศไทย เสื่อมโทรม |  |  |
| 14. การใช้ปุ่ยอินทรีย์และปุยเคมีทางการเกษตรในปริมาณที่มากเกินไปก่อให้เกิดป๋ญหา มลพิษทางน้ำได้ |  |  |
| 15. ค่าใช้จ่ายในการผลิตน้ำประปาสูงกว่าค่าใช้จ่ายในการบำบัดน้ำเสีย |  |  |

ส่วนที่ 3: การรับรู้ข้อมูลและทัศนคติต่อคุณภาพแหล่งน้ำในจังหวัดอยุธยา
**ขอใหผู้ตอบแบบสอบถามอ่านข้อความด้านล่างก่อนตอบคำถามต่อไปนี้**

## สถานการณ์และระดับคุณภาพแหล่งน้ำในจังหวัดอยุธยา

จังหวัดอยุธยามีขนาดพื้นที่ 2,556 ตารางกิโลเมตร ตั้งอยู่ในตำแหน่งที่แม่น้ำสามสายมาบรรจบกัน ได้แก่ แม่น้ำเจ้าพระยา แม่น้ำลพบุรี และแม่น้ำป่าสัก อีกทั้งเป็นเขตเศรษฐกิจที่สำคัญ โดยมีผลิตภัณฑ์มวลรวมของจังหวัด มูลค่าสูงเป็นอันดับ 3 ของประเทศในฐานะเป็นแหล่งปลูกข้าวที่สำคัญ จังหวัดอยุธยามีประวัติศาสตร์ความเป็นมาที่ ยาวนานในฐานะที่เคยเป็นราชธานี, (เมืองหลวง) ของราชอาณาจักรสยามนานถึง 417 ปี ซึ่งมิได้เป็นเพียงช่วงแห่ง ความเจริญสูงสุดของชนชาติไทยเท่านั้น แต่ยังเป็นการสร้างสรรค์อารยธรรมของหมู่มวลมนุษยชาติซึ่งเป็นที่ประจักษ์ แก่นานาอุารยประเทศอีกด้วย แม้ว่าอยุธยาจะถูกทำลายเสียหายจากสงครามกับประเทศเพื่อนบ้านหรือจากน้ำมือการ บุกรุกขุดค้นของพวกเรากันเอง แต่สิ่งที่ปรากฏให้เห็นในปัจจุบันนี้ยังมีร่องรอยหลักฐานซึ่งแสดงอัจฉริยภาพและ ความสามารถอันยิ่งใหญ่ของบรรพบุรุษแห่งราชอาณาจักรผู้อุทิศตนสร้างสรรค์ความเจริญรุ่งเรืองทางศิลปวัฒนธรรม และความมั่งคั่งไว้ให้แก่ผืนแผ่นดินไทย หรือแม้แต่ชาวโลกทั้งมวล จึงเป็นที่น่ายินดีว่าองค์การ ยูเนสโก้ โดยคณะ กรรมการมรดกโลกได้มีมติรับนครประวัติศาสตร์ พระนครศรีอยุธยา ซึ่งมีอาณาเขตครอบคลุมอุทยานประวัติศาสตร์ พระนครศรีอยุธยาไว้ในบัญชีมรดกโลก เมื่อวันที่ 13 ธันวาคม 2534

ในปัจจบบันคณภาพน้ำของแม่น้ำในจังหวัดอยธยาส่วนใหญ่ถกจัดอย่ในประเภทที่ 3 (คุณภาพน้ำที่สามารถใช้ ประโยชน์ในระดับปานกลาง) ซึ่งหมายถึง สามารถใช้ประโยชน์ในการอุปโภคบริโภคได้ก็ต่อ่เมื่อผ่านการบำบัดและ ฆ่าเชื้อโรคก่อน และใช้เพื่อการเกษตรเท่านั้น ไม่เหมาะสมสำหรับกิจกรรมสันทนาการ เช่น ตกปลา ว่ายน้ำ และกีฬา ทางน้ำ เป็นต้น ซึ่งกำหนดตามมาตรฐานอรรถประโยชน์ในแต่ละประเภทแหล่งนำผิวดินของประเทศไทย ผ้้ตอบ แบบสอบถามสามารถดูภาพประกอบด้านล่างเพื่อเปรียบเทียบรูปลักษณะและการใช้ประโยชน์ของคุณภาพน้ำใน แต่ละประเภท

|  | ประเภท แหล่งน้ำ | รูปลักษณะ | การใช้ประโยชน์ |
| :---: | :---: | :---: | :---: |
| สะอาด | ประเภทที่ 1 |  | ได้แก่ แหล่งน้ำที่คุณภาพน้ำมีสภาพตามธรรมชาติโดยปราศจาก น้ำทิ้งจากกิจกรรมทุกประเภทและสามารถเป็นประโยชน์เพื่อ <br> (1) การอุปโภคและปริโภคโดยต้องผ่านการฆ่าเชื้อโรคตามปกติ กอน <br> (2) การขยายพันธุ์ตามธรรมชาติของสิ่งมีชีวิตระดับพื้นฐาน <br> (3) การอนรักษ์ระยปนิเวศนขของแหล่งน้ำ |
| ประเภท แหล่งน้ำ ในอยุธยา <br> สกปรก | ประเภทที่ 2 |  | ได้แก่ แหล่งน้ำที่ได้รับน้ำทิ้งจากกิจกรรมบางประเภท และสามารถ เป็นประโยชน์เพื่อ <br> (1) การอุปโภคและปริโภคโดยต้องผ่านการฆ่าเชื้อโรคตามปกติ และผ่านกระบวนการปรับปรุงคุณภาพน้ำทั่วไปก่อน <br> (2) การอนรักษ์สัตว์น้ำ <br> (3) $ก า ร ป ร ะ ม ข$ <br> (4) การว่ายน้ำและกีพาทางนน้า |
|  | ประเภทที่ 3 |  | ได้แก่ แหล่งน้ำที่ได้ร้บน้ำทิ้งจากกิจกรรมบางประเภท และสามารถ เป็นประโยชน์เพื่อ <br> (1) การอุปโภคและบริโภคโดยต้องผ่านกการฆ่าเซื้อโรคตามปกติ และผ่านกระบวนการปรับปรุงคุณภาพน้ำทั่วไปก่อน <br> (2) การเกษตร |
|  | ประเภทที่ 4 |  | ได้แก่ แหล่งน้ำที่ได้รับน้ำทิ้งจากกิจกรรมบางประเภท และสามารถ เป็นประโยชน์เพื่อ <br> (1) กุารอุปโภคและปริโภคโดยต้องผ่านการฆ่าเชื้อโรคตามปกติ และผ่านกระบวนการปรับปรุงคุณภาพน้ำเป็นพิเศษก่อน <br> (2) การ曰ตสาหกรรม |
|  | ประเภทที่ 5 |  | ได้แก่ แหล่งน้ำที่ได้รับน้ำทิ้งจากกิจกรรมบางประเภท และสามารถ เป็นประโยชนเพื่อการคมนาคมเท่านั้น |

16. ในความคิดเห็นของท่านคุณภาพแหล่งน้ำ ในจังหวัดอยุธยาอยู่ในระดับเท่าใด

แย่มาก แย่ $\qquad$ พอใช้ $\qquad$ ดี $\qquad$ ดีมาก $\qquad$ ไม่ทราบไม่มีความคิดเห็น
17. ในความคิดเห็นของท่าน ท่านคิดว่าสาเหตุใดที่มีผลต่อคุณภาพแหล่งน้ำในจังหวัดอยุธยา (เลือกตอบได้มากกว่า 1 ข้อ)

| ปุ่ยจากเกษตรกรรม |  | สารเคมีตกค้างจากเกษตรกรรม |  |
| :--- | :--- | :--- | :--- |
| น้ำเสียอินทร์ย์จากโรงงานอุตสาหกรรม |  | สารเคมีจากโรงงานอุตสาหกรรม |  |
| น้ำเสียอินทรีย์และแบคทีเรียจากการ <br> ปศุสตต่ต | น้ำเสียอินทรีย์และแบคทีเรียจากบ่อ <br> เกรอะของคร้วเรือน |  |  |
| การพัฒนาทางเศรษฐกิจและการขยายตัว <br> ของเมือง |  |  |  |
| ไม่ใช่ทั้งหมด, ท่านคิดว่าไม่มีสาเหตุใดที่มีผลต่อคุณภาพแหล่งน้ำในจังหวัดอยุธยา |  |  |  |

18. ในความคิดเห็นของท่าน คุณภาพแหล่งน้ำ ในอยุธยามีความสำคัญต่อท่านในระดับใด
.......... ไม่มี เล็กน้อย ปานกลาง มาก มากที่สุด ไม่มีความเห็น
19. ถ้าคุณภาพแหล่งน้ำในอยุธยาเสื่อมโทรมลง ท่านคิดว่าท่านจะได้รับผลกระทบในด้านใดบ้าง (เลือกตอบได้ มากกว่า 1 ข้อ)

| เศรษฐกิจ |  | ความดึงดูดใจในการท่องเที่ยว |  |
| :--- | :--- | :--- | :--- |
| ความสวยงามของธรรมชาติ |  | อื่นๆ โปรดระบุ ................................. |  |

## ส่วนที่ 4: ความเต็มใจที่จะจ่ายเพื่อปรับปรุงคุณภาพแหล่งน้ำ

## ความส่าคัญของหลักความเต็มใจที่จะจ่าย

ความต้องการของสินค้าโดยทั่วไปในท้องตลาดจะขึ้นอยู่กับราคาของสินค่านั้นๆ ว่าผ้้ซื้อสินค้าเต็มใจที่จะ จ่ายเพื่อแลกกับประโยชน์หรือความพอใจที่จะได้รับ แต่าำหรับสินค้าสาธารณะ เช่น สถานที่พักผ่อนหย่อนใจ และ แหล่งน้ำที่เราใช้ประโยชน์ ที่ทุกคนสามารถเข้าถึงและใช้ประโยชน์โดยไม่สามารถกีดกันบุคคลใดบุคคลหนึ่งจาก การใช้ประโยชน์จากสินค้าสาธารณะเหล่านั้นได้ จากเหตุผลดังกล่าวการกำหนดราคาใหกับสินค้าสาธารณะจึงเป็น เรื่องที่ค่อนข้างยุ่งยากและซับซ้อน

การที่แหล่งน้ำซึ่งถือเป็นสินค้าสาธารณะเสื่อมโทรมลงทำให้เกิดการกีดกันการใช้สินค้ากับคนที่ต้องการใช้ ประโยชน์จากแหล่งน้ำที่มีคุณภาพดี การใช้เงินจำนวนหนึ่งเพื่อปรับปรงคคณภาพน้ำเป็นสิ่งที่ควรกระทำเพราะถีอว่า เป็นทรัพสินของคนทกคน ไม่ว่าเงินจำนวนนั้นจะถุกเก็บโดยตรง (เงินค่าบ่าบัดน้ำเสีย) หรือทางอ้อม (เงินภาษี) ก็ตาม ดังนั้นเพื่อที่จะประเมินมมลค่าทางสังคมที่มีต่อการปนเปี้อนของแหล่งน้ำสาธารณะและการปรับปรงคณภาพน้ำ ให้ดีขี้นเพื่อเป็นประโยชนต่อทกคนอย่างเสมอภาค จังมีความจำเป็นที่จะต้องทราบความเต็มใจที่จะจ่ายของแต่ละ บคคลที่มีต่อสินค้าสาธารณะ แบบสอบถามนี้จัดทำขึ้นโดยมีวัตถุประสงค่เพื่อประเมินความเต็มใจที่จะจ่ายและปัจจัยที่ มีความสัมพันธ์ โดยการตอบแบบสอบถามนี้ท่านสามารถช่วยให้การประเมินมูลค่าสำเร็จได้

## สถานการณ์สมมติของการปรับปรงคณภาพน้ำในจังหวัดอยุธยา

ถึงแม้ว่าคุณภาพของแม่น้ำในจังหวัดอยุธยาในปัจจุบันจะจัดอยู่ในระดับปานกลาง แต่คุณภาพน้ำในจังหวัด อยุธยามีแนวโน้มที่จะเสื่อมโทรมลงเรื่อยๆ เนื่องจากปริมาณสารอินทรีย์และแบคทีเรียจากน้ำเสียครัวเรือน โรงงาน อุตสาหกรรม เกษตุรกรรม และปศุสัตว์ ซึ่งมีสาเหตุมาจากการพัฒนาทางเศรษฐกิจและการขยายตัวของเมืองโดยรวม ทั้งประเทศจนทำให้ปริมาณสิ่งสกปรกมีมากเกินกว่าความสามารถในการบำบัดตัวเองของแหล่งน้ำตามธรรมชาติ เมื่อ

คุณภาพแหล่งน้ำเสื่อมโทรมลง ผลกระทบนี้ย่อมเกิดกับทกคนไม่ว่าทางตรงหรือทางอ้อม ในทางกลับกันถ้าแหล่งน้ำมี คณภาพดีขึ้นเพราะมีการปรับปรงคณภาพน้ำแล้ว ทกคนก็จะได้ประโยชน์ในส่วนนี้ด้วยกันทั้งสิ้นไม่ว่าเขาาผ้น้น้นจะอย่ ในเขตพื้นที่ใด เช่น ผลผลิตสัตว่น้ำและพืชผล กิจกรรมสันทนาการ และความสวยงามของทัศนียภาพ เป็นตัน

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                        **ขอให้ผู้สัมภาษณ์อ่านเงื่อนไขข้างล่างก่อนตอบคําถามต่อไปนี้**
4 สถานการณ์ข้างต้นนี้เบ็นการสมมติขึ้นเพื่อให้สามารถประเมินมูลค่าของผลกระทบและการปรับปรุงคุณภาพ
    แหล่งน้ําเพื่อให้ทราบถึงความตระหนักถึงความสําคัญของคุณภาพแหล่งน้ํา
4 จํานวนเงินที่จ่ายจะส่งผลทําให้ท่านมีเงินในการจับจ่ายใช้สอยเพื่อซื้อสินค้าและบริการอื่นลดลง
4 การเก็บเงินเพื่อปรับปรงคณภาพแหล่งน้ําจะดําเนินการใหมีความเป็นธรรมและเสมอภาคกับทกคน และมีการ
    ติดตามตรวจสอบการใช้เงินจากองค์กรกลางและภาคประชาชน
4 ดูภาพประกอบด้านล่างก่อนตอบแบบสอบถามข้อต่อไป
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โครงการปรับปรงคุณภาพแม่น้ำในจังหวัดอยุธยา

20. ในฐานะที่ท่านเป็นบุคคลหนึ่งที่มีส่วนได้รับประโยชน์จากการปรับปรงงคุณภาพน้ำในจังหวัดอยุธยา ที่านมีความ ยินดีที่จะจ่ายเงินเพื่อเป็นส่วนหนึ่งของโครงการปรับปรงคณภาพแหล่งน้าในจังหวัดอยยธาหรือไม่ เพื่อให้ทางการนำา, ไปปรับปรงคณภาพน้ำอย่างเป็นระปบ เช่น ส่งเสริมการดำเนินงานการจัดการมลพิษน้ำทางการเกษตร ส่งเสริมการใช้ เทคโนโลยีที่สะอาดเพื่อลดการปลดปล่อยมลพิษของโรงงานอตสาหกรรม การติดตามตรวจสอบการปล่อยมลพิษจาก แหล่งกำเนิด ประเมินศักยภาพการรองรับมลพิษของแหล่งน้ำ รณรงค์สร้างความตระหนักและแนวปภิบิติที่ดีเพื่อลด ปัญหาน้ำเลียจากครัวเรือน ฯลฯ
$\qquad$ ยินดี (ไปคำถามข้อ 21)
............ ไม่ยินดี (ไปคำถามข้อ 22)
21. ถ้าทางการทำโครงการปรับปรุงคุณภาพแหล่งน้ำในจังหวัดอยุธยาโดยมีเป้าหมายพัฒนาคุณภาพน้ำจากสภาพ ปัจจุบันที่ ไม่เหมาะสมต่อการลงเล่นน้ำและตกปลา มาเป็นคุณภาพแหล่งน้ำที่ดีขึ้นจนเหมาะสมที่จะลงเล่นน้ำและตก ปลา รวมถึงสภาพน้ำใสขึ้น ท่านมีความเต็มใจที่จะจ่ายร่วมสมทบกับโครงการปรับปรุงคุณภาพแหล่งน้ำเป็นจำนวน เงินกี่บาทต่อเดือน (ทำเครื่องหมาย $\sqrt{ }$ ใน $\square$ )

22. ถ้าท่านไม่ยิ่นดีที่จะมีส่วนร่วมในโครงการปรับปรุงคุณภาพแหล่งน้ำในจังหวัดอยุธยา โปรดอธิบายเหตผลตาม
ความคิดของที่น
$\qquad$
$\qquad$

## **ขอขอบพระคุณเป็นอย่างยิ่งที่เสียสละเวลาในการตอบแบบสอบถาม**

 ท่านสามารถใช้ส่วนท้ายนี้ในการเสนอความคิดเห็นและข้อเสนอแนะเพิ่มเติม$\qquad$
$\qquad$
$\qquad$
$\qquad$

## [ SAMPLE OF KRABI QUESTIONNAIRE IN THAI]

คำชี้แจง โปรดทำเครื่องหมาย $\sqrt{ }$ และ/หรือ เติมข้อความในช่องว่างที่กำหนดให้
ส่วนที่ 1 : ข้อมูลทั่วไปของผู้ตอบแบบสอบถาม

1. เพศ $\qquad$ ชาย $\qquad$ หญิง
2. อายุ โปรดระบุ ปี
3. วุฒิการศึกษาสูงสุด

| ประถมศึกษาหรือต่ากว่า | มัธยมตอนต้น |  |
| :--- | :--- | :--- | :--- |
| มัธยมตอนปลาย/ปวช | อนุปริญญา/ปวส |  |
| ปริญญาตรี | ปริญญาโทหรือสูงกว่า |  |

4. อาชีพ

| รับราชการ | ประกอบธุรกิจส่วนตัว |  |  |
| :--- | :--- | :--- | :--- |
| พนักงานวิสาหกิจ |  | พนักงานบริษัทเอกชน |  |
| รับจ้าง | นักเรียน/นักศึกษา |  |  |
| แม่บ้าน/ข้าราชการบำนาญ | อี่นๆ โปรดระบุ ............................ |  |  |

5. (ตามชื่อในทะเบียนบ้าน) ท่านอยู่ในจังหวัดกระบี่หรือไม่ $\qquad$ ใช่ (ถ้าใช่ ไปข้อ 6) ไม่ใช่
6. (ตามชื่อในทะเบียนบ้าน) ท่านมาจากจังหวัดอะไร โปรดระบุ $\qquad$
7. ท่านอาศัยอยู่ในจังหวัดกระบี่มานานเท่าใด โปรดระบุ. .ปี
8. สมาชิกในครอบครัว (ไม่รวมตัวท่าน)

| จำนวน | สถานะ <br> (พอ, แม่, พี่, น้อง) | เพศ <br> (ช/ญ) | อายุ <br> (ป) | ทำงาน <br> (ใช่/ไม่) | วุฒิการศึกษาสูงสุด |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 |  |  |  |  |  |
| 2 |  |  |  |  |  |
| 3 |  |  |  |  |  |
| 4 |  |  |  |  |  |
| 5 |  |  |  |  |  |
| 6 |  |  |  |  |  |
| 7 |  |  |  |  |  |
| 8 |  |  |  |  |  |
| 9 |  |  |  |  |  |
| 10 |  |  |  |  |  |

9. ปัจจุบันรายได้หลังหักภาษีต่อครอบครัวต่อเดือนสูงสุดโดยประมาณ (รวมรายได้ของทุกคนในครอบครัว)

| $\ldots \ldots \ldots \ldots$. น้อยกว่า 10,000 บาท | $\ldots \ldots \ldots \ldots .10,001-20,000$ บาท |
| :--- | :--- |
| $\ldots \ldots \ldots \ldots .20,001-30,000$ บาท | $\ldots \ldots \ldots . .30,001-40,000$ บาท |
| $\ldots \ldots \ldots . .40,001-50,000$ บาท | $\ldots \ldots \ldots . .50,001-60,000$ บาท |
| $\ldots \ldots \ldots \ldots .60,001-70,000$ บาท | $\ldots \ldots \ldots . .70,001-80,000$ บาท |
| $\ldots \ldots \ldots \ldots .80,001-90,000$ บาท | $\ldots \ldots \ldots . .90,001-100,000$ บาท |
| $\ldots \ldots \ldots .$. มากกว่า 100,001 บาท |  |

ส่วนที่ 2: ความรู้เละความเข้าใจเกี่ยวกับคุณภาพน้ำ

| ข้อความข้างล่างนี้ถูหรือผิด | ถูก | ผิด |
| :---: | :---: | :---: |
| 10. น้ำเสีย หมายถึง น้ำที่เสื่อมคุณภาพ หรือ น้ำที่ผ่านการใช้งานมาแล้ว |  |  |
| 11. น้ำเสียสามารถถูกปรับปรุงคุณภาพใหด้ขึ้นได้ด้วยสิ่งก่อสร้างและเทคโนโลยีที่มนษษย์ สร้างขึ้น |  |  |
| 12. ปริมาณออกซิเจนในน้ำสามารถใช้บ่งบอกระดับคุณภาพน้ำของประเทศไทย |  |  |
| 13. น้ำเสียจากโรงงานอุตสาหกรรมเป็นปัจจัยหลักที่ทำใหคคณภาพน้ำในประเทศไทย เสื่อมโทรม |  |  |
| 14. การใช้ปุยยทางการเกษตรในปริมาณที่มากเกินไปก่อให้เกิดปัญหาคุณภาพน้ำบาดาล ได้ |  |  |
| 15. ค่าใช้จ่ายในการผลิตน้ำประปาสงกว่าค่าใช้จ่ายในการบำบัดน้ำเสีย |  |  |

ส่วนที่ 3: การรับรู้ข้อมูลและทัศนคติต่อคุณภาพแหล่งน้ำ ในจังหวัดกระบี่
**ขอให้ผู้ตอบแบบสอบถามอ่านข้อความด้านล่างก่อนตอบคำถามต่อไปนี้**
ความสำคัญและคคณภาพแหล่งน้ำของจังหวัดกระบี่


เขาขนาบน้ำ
สัญลักษณ์เมืองกระบี่


ป่าชายเลน บริเวณพื้นที่ชุ่มน้ำปากแม่น้ำกระบี่

จังหวัดกระบี่เป็นจังหวัดหนึ่งในภาค ใต้ของประเทศไทย และเป็น เมืองท่องเทียวทีมีชือเสียงแห่งหนึงของภาคใต้โดยถูกเรียกขนานนามว่า มรกตแห่งอันดามัน กระบีมีชือเสียงในระดับโลกจากแหล่งท่องเทียว ธรรมชาติอันงดงามและระบบนิเวศทางทะเลทีอุดมสมบูรณ์ เช่น หาดทราย ขาว น้ำทะเลใส ปะการัง ถ้า และหมู่เกาะน้อยใหญ่กว่า 100 เกาะ (ทะเล แหวก เกาะพีพี) รวมทังยังมีพืนทีชุมน้ำบริเวณปากแม่น้ากระบีซึงถูกขึน ทะเบียนให้เป็นพืนทีชุมมน้า 1 ใน 10 ทีมีความสำคัญระหว่างประเทศ ปาก แม่น้ำกระบีเกิดจากการทีแม่น้ำหลายสายในพืนทีภาคใต้ไหลมาบรรจบกันที อ่าวพังงา ประกอบด้วยปาชายเลน หญ้าทะเล และแนวปะการัง เป็นแหล่ง อาหารทีสาคัญ รวมถึงเป็นพืนทีอนุบาลและวางไข่ของสึงมีชีวิตในทะเล จังหวัดกระบีมีแม่น้ำ ลำคลอง มากมาย เช้น แม่น้ากระบี แม่น้ามะรุ่ย คลอง กระบีใหญ่ เป็นต้น ลำน้าสววนใหญ่จะไหลลงสูลำนำใหญ่ในลักษณะรูปขนนก และออกทะเลทีปากน้ากระบีผังทะเลอันดามัน ดังนันคุณภาพน้ำในลำน้ำของ จังหวัดกระบีจึงมีความสำคัญต่อระบบนิเวศและการท่องเทียวภายในประเทศ

ในปัจจบันคณภาพน้ำของลำน้ำ ในจังหวัดกระบี่ส่วนใหญ่ถกจัดอย่ในประเภทที่ 2 และ 3 (คุณภาพน้ำที่ สามารถใช้ประโยชน์ในระดับดีและระดับพอใช้) ซึ่งหมายถึึง มีลำน้ำบางส้วนที่ไม่เหมาะสมต่อการอนูรักษ์สัตว์น้ำและ ไม่เหมาะสมสำหรับกิจกรรมสันทนาการ เช่น ตกปลา ว่ายน้ำ กีฬาทางน้ำ เป็นต้น แต่สามารถใช้ประโยชน์เพียงเพื่อ การเกษตร และใช้เป็นแหล่งน้ำดิบ ในการปรับปรุงคุณภาพเพื่ออุปโภคบริโภค

## ผ้ตอบแบบสอบถามสามารถดูภาพประกอบด้านล่างเพื่อเปรียบเทียบรูปลักษณะและการใช้ประโยชน์ของคุณภาพน้ำ ในแต่ละประเภท ในประเทศไทย

|  | ประเภท แหล่งน้ำ | รูปลักษณะ | การใช้ประโยชน์ |
| :---: | :---: | :---: | :---: |
| สะอาด | ประเภทที่ 1 ดีมาก |  | แหล่งน้ำตามธรรมชาติที่ปราศจากน้ำทิ้งจากกิจกรรมของมนุษย์ สามารถเป็นประโยชน์ เพื่อ <br> การขยายพันธุ์ตามธรรมชาติของสิ่งมีชีวิตระดับพื้นฐาน การอนุรักษ์ระบบนิเวศน์ของแหล่งนน้ำ |
| ประเภท ลำน้ำ ในกระบี่ | ประเภทที่ 2 <br> ดี |  | แหล่งน้ำที่ได้รับน้ำทิ้งจากกิจกรรมบางประเภท และสามารถเป็น ประโยชน์เพื่อ <br> การอนุรักษ์สัตว์น้ำ การประมง การว่ายน้ำและกีฬาทางน้ำ |
|  | ประเภทที่ 3 พอใช่ |  | แหล่งน้ำที่ได้รับน้ำทิ้งจากกิจกรรมบางประเภท และสามารถเป็น ประโยชน์เพื่อ การเกษตร |
|  | ประเภทที่ 4 เสื่อมโทรม |  | แหล่งน้ำที่ได้รับน้ำทิ้งจากกิจกรรมมางประเภท และสามารถเป็น ประโยชนนเพื่อ การอุตสาหกรรม |
|  | ประเภทที่ 5 เสื่อมโทรม มาก |  | แหล่งน้ำที่ได้รับน้ำทิ้งจากกิจกรรมบางประเภท และสามารถเป็น ประโยชน์เพื่อการคมนาคมเท่านั้น |

16. ในความคิดเห็นของท่านคุณภาพแหล่งน้ำ ในจังหวัดกระบี่อยู่ในระดับเท่า ใด
$\qquad$ เสื่อมโทรมมาก $\qquad$ เสื่อมโทรม $\qquad$ พอใช้ $\qquad$ ดี $\qquad$ ดีมาก $\qquad$ ไม่ทราบไม่มีความคิดเห็น
17. ในความคิดเห็นของท่าน ท่านคิดว่าสาเหตุใดที่มีผลต่อคุณภาพแหล่งน้ำในจังหวัดกระบี่ (เลือกตอบได้มากกว่า 1 ข้อ)

| ปุ๋ยจากเกษตรกรรม | สารเคมีตกค้างจากเกษตรกรรม |  |
| :--- | :--- | :--- | :--- |
| น้ำเสียอินทรีย์จากโรงงานอุตสาหกรรม | สารเคมีจากโรงงานอุตสาหกรรม |  |
| น้ำเสียอินทรีย์และแบคทีเรียจากการปศุสัตว์ | น้ำเสียอินทรีย์และแบคทีเรียจากบ่อเกรอะ <br> ของครัวเรือน |  |
| การพัฒนาทางเศรษฐกิจและการขยายตัว <br> ของเมือง | ไม่ใช่ทั้งหมด, ท่านคิดว่าไม่มีสาเหตุใดที่มี <br> ผลต่อคุณภาพแหล่งน้ำ |  |

18. ในความคิดเห็นของท่าน คุณภาพแหล่งน้ำในกระบี่มีความสำคัญต่อท่านในระดับ ใด
$\qquad$ ไม่มี $\qquad$ เล็กน้อย $\qquad$ ปานกลาง $\qquad$ มาก $\qquad$ มากที่สุด ไม่มีความเห็น
19. ถ้าคุณภาพแหล่งน้ำในกระบี่เสื่อมโทรมลง ท่านคิดว่าท่านจะได้รับผลกระทบในด้านใดบ้าง (เลือกตอบได้มากกว่า 1 ข้อ)

| เศรษฐกิจ |  | ความดึงดูดใจในการท่องเที่ยว |  |
| :--- | :--- | :--- | :--- |
| ความสวยงามของธรรมชาติ |  | อื่นๆ โปรดระบุ ................................... |  |

## ส่วนที่ 4: ความเต็มใจที่จะจ่ายเพื่อปรับปรุงคุณภาพแหล่งน้ำ

## สถานการณ์สมมติของการปรับปรงคณภาพน้ำในจังหวัดกระบี่

ถึงแม้ว่าคุณภาพของแม่น้ำลำคลองส่วนใหญ่ของจังหวัดกระบี่ในปัจจุบันจะจัดอยู่ในระดับดี แต่ก็ยังมีลำน้ำที่ มีคุณภาพระดับพอใช้ เช่น บริเวณปลายคลองกระบี่ใหญ่เข้าสู่ปากน้ำกระบี่ (คลองกระบี่ใหญ่เคยถูกจัดเป็นแหล่งน้ำ คุณภาพเสื่อมโทรมในปี 2552) แต่อย่างไรก็ตามคุณภาพลำน้ำโดยรวมในจังหวัดกระบี่มีแนวโน้มที่จะเสื่อมโทรมลง เรื่อยๆหากปราศจากการควบคุมและดูแล เนื่องจากปริมาณสารอินทรีย์และแบคทีเรียจากน้ำเสียครัวเรือน โรงงาน อุตสาหกรรม เกษตรกรรม และปศุสัตว์ ซึ่งมีสาเหตุมาจากการพัฒนาทางเศรษฐกิจและการขยายตัวของเมืองจนทำให้ ปริมาณสิ่งสกปรกมีมากเกินกว่าความสามารถในการบำบัดตัวเองของแหล่งน้ำตามธรรมชาติ เมื่อคณภาพแหล่งน้ำ เสื่อมโทรมลง ผลกระทบนี้ย่อมเกิดกับทกคน ไม่ว่าทางตรงหรือทางอ้อม ในทางกลับกันถ้ามีการปรับปรงคณณาพแหล่ง น้ำมีคณภาพดีขึ้น ทกคนก็จะได้ประโยชนใใน่วนนี้ด้วยกันทั้งสิ้นไม่ว่าเขาผ้นั้นจะอย่ในเขตพื้นที่ใด เช่น การท่อง เที่ยว ผลผลิตสัตว่น้ำและพืชผล กิจกรรมสันทนาการ และความสวยงามของทัศนียภาพ เป็นต้น

## เป้าหมายของโครงการปรับปรูงคุณภาพแม่น้ำในจังหวัดกระบี่

สถานการณ์ปัจจบันก่อนปรับปรงคณภาพน้ำ


ประเภท 2 มีลำน้ำประเภท 3 (พอใช้) บางพื้นที่ซึ่ง

- ไม่เหมาะสมต่อการอนุรักษ์สัตว้น้ำ
- ไม่เหมาะสมต่อการลงเล่นน้ำและตก ปลา
- น้ำมีความขุ่นมากกว่าแหล่งน้ำประเภท ที่ 2

สถานการณ์ใหม่หลังปรับปรงคณภาพน้ำ

การ $\xrightarrow[\substack{\text { คุณภาพ } \\ \text { น้ำ }}]{\text { ปรับปรง }}$


ประเภท 2
ลำน้ำประเภท 2 (ดี) ทกพื้นที่ซึ่ง

- สัตว้น้ำมีมากขึ้น
- เหมาะสมต่อการลงเล่นน้ำและ ตกปลา
- น้ำใสขึ้น มีความขุ่นน้อยลง

ทัศนียภาพดีขึ้น

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**ขอให้ผู้สัมภาษณ์อ่านเงื่อนไขข้างล่างก่อนตอบคำถามต่อไป**
ล สถานการณ์ข้างต้นนี้เป็นการสมมติขึ้นเพื่อให้สามารถประเมินมูลค่าของผลกระทบและการปรับปรุงคุณภาพ แหล่งน้ำเพื่อให้ทราบถึงความตระหนักถึงความสำคัญของคุณภาพแหล่งน้ำ
ม จำนวนเงินที่จ่ายจะส่งผลทำให้ท่านมีเงินในการจับจ่ายใช้สอยเพื่อซื้อสินค้าและบริการอื่นลดลง
ค การเก็บเงินเพื่อปรับปรงคณภาพแหล่งน้ำจะดำเนินการให้มีความเป็นธรรมเสมอภาคกับทกคน และมีการ ติดตามตรวจสอบการใช้เงินจากองค์กรกลางและภาคประชาชน
4 ดูภาพประกอบด้านบนก่อนตอบแบบสอบถามข้อต่อไป
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20. ในฐานะที่ท่านเป็นบุคคลหนึ่งที่มีส่วนได้รับประโยชน์จากการปรับปรุงคุณภาพน้ำ ในจังหวัดกระบี่ ท่านมีความยินดีที่จะ

จ่ายเงินเพื่อเป็นส่วนหนึ่งของโครงการปรับปรงคณภาพแหล่งน้าในจังหวัดกระบี่หรือไม่ เพื่อนำไปใช้ในการปรับปรง คณณภาพน้ำอย่างเป็นระบบ เช่น ส่งเสริมการดำเนินงานการจัดการมลพิษนำทางการเกษตร ส่่งเสริมการใช้เทคโนโลยีที่ สะอาดเพือลดการปลดปล่อยมลพิษจากโรงงานอุตสาหกรรม การติดตามตรวจสอบการปล่อยมลพิษจากแหล่งกำเนิด ประเมินศักยภาพการรองรับมลพิษของแหล่งน้ำ รณรงค์สร้างความตระหนักและแนวปฏิบัติที่ดีเพื่อลดปัญหาน้ำเสียจากครัว เรือน ขลข

ยินดี (ไปคำถามข้อ 24)
ไม่ยินดี (ไปคำถามข้อ 25)
21. ท่านมีความเต็ม ใจที่จะจ่ายร่วมสมทบกับโครงการปรับปรุงคุณภาพแหล่งน้ำในจังหวัดกระบี่เป็นจำนวนเงินกี่บาทต่อ เดือน (ทำเครื่องหมาย $\sqrt{ }$ ใน $\square$ )

22. ถ้าท่านไม่ยินดีที่จะมีส่วนร่วม ในโครงการปรับปรุงคุณภาพแหล่งน้ำในจังหวัดกระบี่ โปรดอธิบายเหตุผลตามความคิด ของท่าน
$\qquad$
$\qquad$
$\qquad$

## **ขอขอบพระคุณเป็นอย่างยิ่งที่เสียสละเวลาในการตอบแบบสอบถาม** ท่านสามารถใช้ส่วนท้ายนี้ในการเสนอความคิดเห็นและข้อเสนอแนะเพิ่มเติมต่อแบบสอบถาม


[^0]:    * Synthetic organic compounds such as pesticide, insecticide, detergent, food additive, pharmaceutical, paint, plastic, volatile organic compound, Polychlorinated biphenyls (PCBs)

[^1]:    Remarks: UASB $=$ Upflow anaerobic sludge blanket, CAS $=$ Conventional activated sludge
    MLE $=$ the Modified Ludzack-Ettinger
    Consent of public water release, COD $<120 \mathrm{mg} / \mathrm{l}, \mathrm{TN}<100 \mathrm{mg} / \mathrm{l}$
    Assuming COD removal efficiency of UASB $=70 \%$
    Assuming CAS can treat wastewater of COD $<10,000 \mathrm{mg} / \mathrm{l}$ to COD $<120 \mathrm{mg} / \mathrm{l}$
    COD: N ratio $=1: 0.05$ for aerobic treatment and 1:0.02 for anaerobic treatment

[^2]:    Remarks: Value + = dominance , value - = submission
    $\mathrm{i} 1=$ indicator of total produced CERs ( $\mathrm{tCO} 2 \mathrm{e} / \mathrm{y}$ ), $q_{k}=0 \mathrm{tCO}_{2} \mathrm{e} \mathrm{y}, p_{k}=233,500 \mathrm{tCO}_{2} \mathrm{e} / \mathrm{y}$
    $\mathrm{i} 2=$ indicator of CER generating cost (USD/ $\left.\mathrm{tCO}_{2} \mathrm{e}\right), q_{k}=0$ USD/ $/ \mathrm{CO}_{2} \mathrm{e}, p_{k}=23.51 \mathrm{USD} / \mathrm{CO}_{2} \mathrm{e}$
    $\mathrm{i} 3=$ indicator of IRR (\%), $q_{k}=0 \%=39.63 \%$
    i4 = indicator of net profit percentage ( $\%$ ), $q_{k}=0 \%, p_{k}=257.97 \%$

[^3]:    Remarks:
    GHG emission reduction $=$ GHG generation per year $*$ CER crediting period
    CER sale $=$ GHG emission reduction $*$ CER price per tCO -eq
    Total power generation $=$ Electricity production per year * CER crediting period
    Total power generation $=$ Electricity production per year * CER crediting period
    Electricity sale $=$ Total power production * Electricity purchase price per kWh
    CER generating cost $=$ Initial cost investment/GHG emission reduction
    CER generating cost $=$ Initial cost investment/GHG emission re
    CER Margin $=[\text { CERs sale/(CERs sale }+ \text { Electricity sale) }]^{*} 100$
    Net profit $=$ Cumulative profit in an investment period (in IRR calculation sheet)
    Profit percentage $=($ Net profit/Total cost investment)* 100
    Profit margin $=[\text { Net profit/(CER sale }+ \text { Electricity sale) }]^{*} 100$
    Internal rate of return = discount rate of profitability (in IRR calculation sheet)

[^4]:    Remarks:
    CER generating cost $=$ Initial cost investment/GHG emission reduction
    CER Margin $=[$ CERs sale/(CERs sale + Electricity sale) $)]^{*} 100$
    Net profit $=$ Cumulative profit in an investment period in IRR cal
    Net profit $=$ Cumulative profit in an investment period in IRR calculation sheet
    Profit percentage $=(\text { Net profit/Total cost investment })^{*} 100$
    Profit percentage $=($ Net profit/Total cost investment $){ }^{*} 100$
    Profit margin $=[\text { Net profit/(CER sale }+ \text { Electricity sale) }]^{*} 100$
    Internal rate of return = discount rate of profitability in IRR calculation sheet

