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LOW-CARBON WATERSHED MANAGEMENT: INTEGRATION OF RENEWABLE ENERGY SUPPLY AND DECENTRALIZED WASTEWATER TREATMENT : A CASE STUDY IN VIETNAM

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論文審査の結果の要旨

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Dissertation Title: LOW-CARBON WATERSHED MANAGEMENT: INTEGRATION OF RENEWABLE ENERGY SUPPLY AND DECENTRALIZED WASTEWATER TREATMENT - A CASE STUDY IN VIETNAM

Vietnam is among the most climate change vulnerable and disaster-prone nations, and water is the first sector to be affected by climate change. Being one of the developing countries launching climate policies, the country has recently announced to strive for a low-carbon economy. Nevertheless, there is a mismatch in the development strategy for the power sector and the climate-related policies which might lead to the ambiguous in the further implementation of climate change mitigation strategies. To achieve sustainable development and green growth, the government goal is to increase renewable energy share to 9.4 % and wastewater treatment to 80 % in the year 2030. However, there are no specific guidelines to accomplish the multiple targets. The research goal is to propose the integrated mechanism of renewable energy supply (run-off-river hydropower) and decentralized wastewater treatment system. The proposed mechanism is expected to reduce greenhouse gas emission from power generation and alleviate environment pollution from domestic wastewater.

The objective of this study has been three-fold. First, to estimate the potential of small hydropower (in the form of run-off-river hydropower) and its contribution to greenhouse gas emission reductions in the representative river basin of Vietnam. Second, to estimate the potential for greenhouse gas emission reductions by providing adequate domestic wastewater treatment facilities. Third, to demonstrate the co-benefits of the integrated mechanism through scenario analysis, considering social, financial feasibility and carbon crediting scheme.

The result of our study highlighted that run-off-river hydropower potential has potential to fulfill the electricity demand for the rural villages in the Vu Gia-Thu Bon River basin, especially remote communities without access to the grid with the total capacity 277 MW with a capacity factor of 40.2 %. Also, off grid hydropower can serve as alternative electricity source to ensure the reliability of the grid by reducing grid load, prevent from

blackout and brownout. Besides, renewable electricity generation from ROR hydropower scheme will provide power for decentralized wastewater treatment facilities within the watersheds.

This study identify and proposes a scenario to be the most applicable for the region with the GHG reduction amount of 0.45 million tCO_2eq. The scenario employs the Japanese Johkasou system and it could serve 30 % of the total rural household especially in the mountainous areas in the up and middle stream of the Vu Gia-Thu Bon River basin, where the population density is relatively lower than the downstream. In populated areas downstream, centralized or semi-centralized wastewater treatment system is favored and more efficient.

Full implementation of ROR hydropower generation and wastewater treatment system would reduce the total amount of 0.38 million $tCOt_2eq$ per year (on-grid) and 0.60 million $tCOt_2eq$ per year (off-grid).

Regarding financial aspect of investment in wastewater treatment facilities, the main budget comes from external assistant, Official Development Assistance (ODA), in the form of grants, technical assistance and loans; and the priority is to invest in urban wastewater treatment. Therefore, the obstacle for installation of Johkasou and wastewater treatment system in the rural and less developed area remains as one of the biggest challenges. Nevertheless, this treatment scheme, besides environmental conservation, a substantial amount of GHG emissions can be reduced. With existing Carbon trading schemes, this system has potential to attract carbon finance from Clean Development Mechanism (CDM) or Joint Crediting Mechanism (JCM) projects.

Emissions reduction from wastewater treatment can be credited to existing carbon-trading scheme, to minimize the initial cost of system construction including installation of Johkasou. On the other hand, GHG emissions can also be reduced utilizing renewable energy for wastewater treatment eliminates grid emissions. The high uncertainty of emission calculation can be minimized by the accessibility of local data or existing empirical data.

The research finding indicates government's GHG emissions reduction target in the waste sector can be set up to 16 %. Moreover, a method to develop emission inventory for wastewater treatment in rural areas of developing countries from the watershed approach is proposed. Also, this study raises the potential of utilizing existing carbon emission trading schemes for an initial investment of the wastewater treatment facilities through carbon credit.

Also, the small hydropower system has a lower cost compared with conventional diesel generator based system, and even lower than the retail electricity tariff from the government. The economic advantage can interest private entities to invest in rural electrification even without government subsidies. Therefore, creates advantages for

implementing on/off-grid hydropower than other renewable energy such as the wind or solar PV.

The negative abatement cost for small hydropower over conventional diesel generator which is - 195.51 USD/tCO_2 (off grid) or -48.18 USD/ tCO_2 indicates that cost for CO_2 mitigation can be saved. Although this result is vary depending on the fuel price projection as well as plant capacity and discounted value of electricity sold, the similar negative value is observed from Blum et al., (2013).

Finally, the demonstration of co-benefits was performed by scenario-based analysis. The result shows that under domestic conditions the project return period is 18.39 years, and IRR is 8.5 %. The IRR for base case is smaller than the benchmark IRR, which is 10% indicate that this project would likely not happen. If the project is implemented under the integrated mechanism, the project payback periods are from 7.31 years to 18.17 years and IRRs are from 10.04% to 26.57%.

Our study also emphasizes the potential of ROR hydropower development for rural electrification in the context of Vu Gia-Thu Bon River basin. This study employed the holistic approach to providing private entities as well as foreign investors with a comprehensive assessment of demand, supply, and economic values. The results from this study may assist the private sector to make the decision for investment in rural electrification projects.

The study provides quantitative evidences for the government of Vietnam, policy makers as well as developers. There is a potential to establish and implement an integrated mechanism for sustainable energy supply and rural development by utilizing existing emission trading schemes such as CDM co-benefits or JCM.

As mentioned above, results of this dissertation include valuable information to promote low-carbon society in rural area in Southeast Asian countries and have significant contribution to academic filed of sustainability science. This committee unanimously agreed to award degree of Doctor of Sustainability Science.

(1029 words)