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Sustainable Solar PV Power Scale-up in Residential Sector in China

(Based on consumer's preference)

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Abstract

Solar PV power has been emerging in China, on one hand contributing to mitigate the energy security problem, especially by filling the current and future electricity supply gab in residential sector, on the other hand, serving as an effective approach to mitigate the GHGs emission and domestic environmental pollution threats.

Due to the relative high cost, promotional policy drivers, especially financial support like subsidies, are crucial to stimulate the scale-up process at the early transition stage. However, considering its feature as a temporary approach to create virtual price reduction, it is very important to systematically consider consumer's preference, dissemination effectiveness and cost for the public to ensure its sustainability, which is also the objective of this research.

Mayor promotional policies, in this case, investment subsidy and feed-in tariff are incorporated by conjoint analysis through the design of various virtual solar PV product, so that consumer's preference in China is identified, by which the annual diffusion rate is also calculated to estimate the potential dissemination effectiveness and policy cost. A case based scenario analysis is conducted for the PV scale-up in Shanghai by comparing the sustainability of two actual scale-up proposals and one hypothetic option. Several policy recommendations are generated for the decision makers.

Acknowledgements

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Glossary

AC	Alternative Current
BAU	Business As Usual
CNCCP	China's National Climate Change Programme
DC	Direct Current
EPIA	European Photovoltaic Industry Association
ERI	Energy Research Institute
FIT	Feed-in Tariff
GHG	Green House Gas
IEA	International Energy Agency
MWTP	Marginal Willingness to Pay
NDRC	National Development and Reform Committee
PV	Photovoltaic
PVPS	Photovoltaic Power Systems Programme
RUM	Random Utility Model
tce	Ton of Standard Coal Equivalent
WTP	Willingness to Pay

Content

1 Introduction

1.1 Background

1.1.1 Significance of solar PV power

1.1.1.1 Energy security

China is a large energy consumer. In 2007, China's primary energy consumption reaches 2.65 G tce[1], 7.7% more than the previous year. Within the primary energy consumption mixture, coal takes the share of 69.5%, followed by 19.7% of oil, 3.5% of natural gas and 7.3% of other sources like renewables and nuclear power. The oil import of 2007 is 211.4 million ton, as much as 57.7% of the total oil consumption (China's Yearbook 2008).

The energy security issue is a systematic challenging for China. China's strong energy desire attributes first of all to its development stage. The speed up of industrialization and urbanization process triggers the large and long lasting energy demand. Due to the laggard energy exploitation and utilization technology, China also suffers from a rather low energy intensity, not only very much behind those developed countries, even lower than the world average level (NDRC 2004). In addition, as the feature of this development stage, large amount of energy infrastructure is currently under construction in China. According to the "lock-in effect", once these low efficient utilities are constructed, those "poor energy intensity performance" will remain for decades (Jin 2009). Therefore, energy security, especially seeking for proper alternatives of conventional fossil based energy, becomes crucial and urgent to ensure China's sustainable development.

According to Hu (2004) from Institute of China's Electricity Power, despite of the assumed considerable exploitation of coal power, hydropower and nuclear power, the

[1] Ton of standard coal equivalent.

electricity supply gap remains 6.4% in 2010 and 10.7% in 2020 (Figure 1 and Figure 2). Therefore, renewable power, especially solar PV power, is supposed to make a significant contribution to fill this gap.

Figure 1: Estimation of China's Electricity Balance in 2010

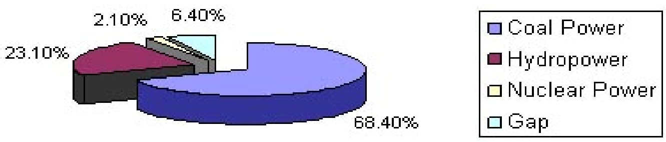
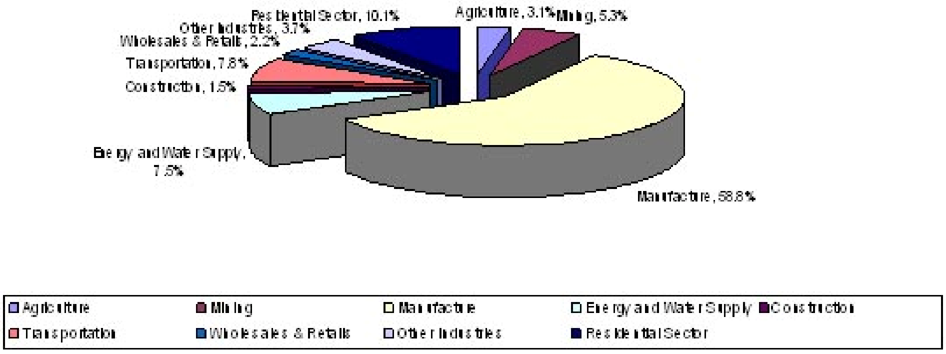


Figure 2: Estimation of China's Electricity Balance in 2020

Source: Report of China's PV Industry 2007

From the perspective of sector based energy consumption, manufacture industry is the largest consumer, contributing to 58.8% of China's energy consumption in 2007. Worth to mention is residential sector ranks second, consuming 10.1% (Figure 3). The expected continuous economic development will result in the improvement of people's life quality, and correspondingly increase the residential energy consumption. Besides, Chinese government has been very much highlighting the significance of the scale-up of domestic consumption, as the key approach to upgrade China's economic engine. Therefore, given its current considerable energy consumption share and large potential capacity, it is worthwhile to pay special attention to the residential sector.

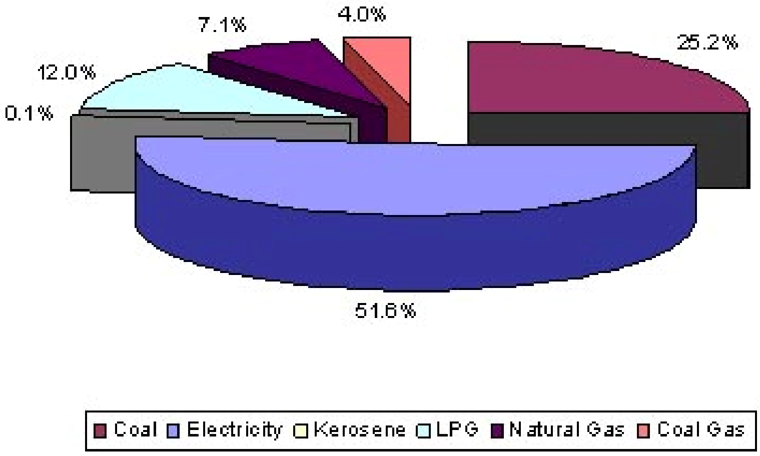
Figure 3: Energy Consumption by Sector in China, 2007



Source: Adapted from China's Yearbook 2008

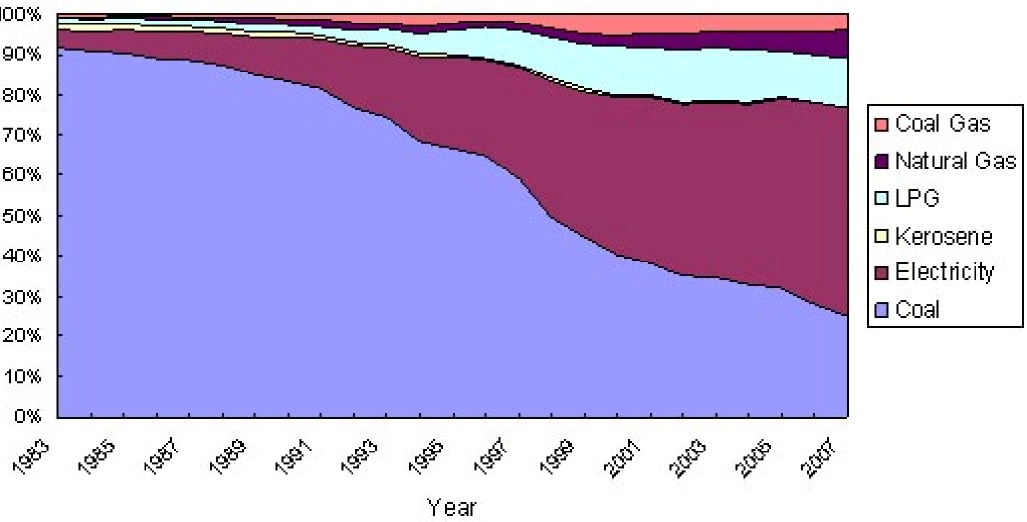
Within the residential sector, electricity consumption takes more than half of the Annual per Capita Energy Consumption of Households in 2007 in China (Figure 4). And from a historical perspective, the fast and steady growth of electricity consumption, from 4.4% in 1983 to 51.6% in 2007, also demonstrates its unique significance (Figure 5). Consequently, as an innovative and promising approach, introduction and scale-up of solar PV power is expected to make a contribution to satisfy the energy consumption, especially in the residential sector.

Figure 4: Share of Different Energy Type in Annual per Capita Energy Consumption of Households in 2007, China



Source: Adapted from China's Yearbook 2008

Figure 5: Historical Trend of Different Energy Type in Residential Sector



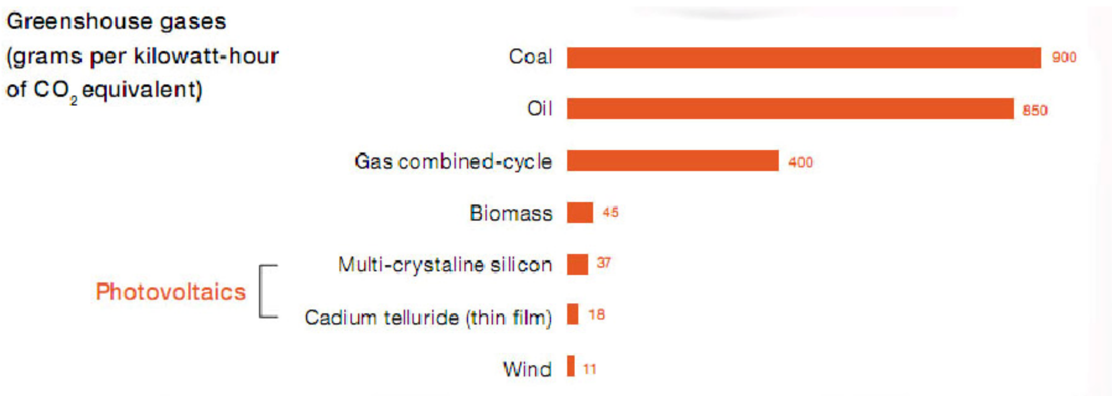
Source: Adapted from China's Yearbook 2008

1.1.1.2 Environmental Concerns

Global warming is the major environmental concern. China is a large GHG emitter. China's total GHG emission in 2004 is about 6,100 million tCO_2e, of which 5,050 million tons of CO_2, 720 million tCO_2e of CH_4 and 330 million tCO_2e of N_2O. From 1994 to 2004, the annual average growth rate of GHG emissions is around 4% (CNCCP 2007)

China's large GHG emission is closely linked to its high energy intensity as well as the booming economic growth. As predicted by the International Energy Agency / IEA, under the Business As Usual Scenario and Alternative Policy Scenario from 2005 – 2030, China's annual primary energy demand will increase 3.2% and 2.5% respectively. And correspondingly, energy related CO_2 emission will increase 3.3% and 2.2% (IEA 2007). Besides, China's energy supply heavily relies on coal. Within China's fossil resource stock, coal takes 94%, followed by oil and natural gas, only for 5.4% and 0.6%. Combining coal's dominating status and its high carbon intensity; it is rather difficult to reduce China's emission, unless alternative low carbon energy sources can be introduced. As one of the promising low carbon technology, solar PV power is expected play this crucial role (Figure 6).

Figure 6: GHG Emission of Different Energy Sources



Source: EPIA 2008a

Besides, environmental pollution is another key concern. As mentioned above, coal fired power is China's major energy supply approach, which causes 70%-80% of the total SO_2 and solid dust pollution. As a result, acid rain affected area has already covered one third of China's overall territory (NDRC 2004). As the reflection in terms of its economic loss, in 2020, China is expected to pay 13% of its GDP to compensate those environment and health related external cost caused by air pollution (Janet 2005). Compared with coal fired power, solar PV power causes almost no air pollution while generating electricity, so it is regarded as a clean alternative. However, worth to mention is, the manufacture process of PV model can cause other pollution, and whether it can be effectively recycled also affected its overall environmental performance.

1.1.2 Solar PV power in residential sector

1.1.2.1 Overview

The solar PV power market is booming. About 5.56 GW of PV capacity were installed during 2008. It is an increase of 150% over the previous year; as a result, by the end of 2008, the cumulative installed capacity of solar PV systems around the world had reached more than 13.4 GW (PVPS 2009a). This compares with a figure of 1.2 GW at the end of 2000. Installations of PV cells and modules around the world have been growing at an average annual rate of more than 35% since 1998. This impressive booming industry is now worth more than an annual € 13 billion. (EPIA 2008b)

China has also achieved an impressive progress in its solar PV power industry, especially in its PV manufacture industry. In 2006, China already produced 369.5 MW PV cells, ranking only after Japan and Germany. It is also said, due to its exponentially increased PV manufacturing capacity, China has already been pushed to the number one position amongst PV producing countries (PVPS 2009a).

However, despite of the excellent performance in PV manufacture industry, the domestic implementation of PV systems has been relatively underwhelming. Traditional PV has served an important but nonetheless relatively niche role in China as a means of providing off-grid electricity or power to mini-grids in remote areas.

Nevertheless, 2009 seems to be the entry of a new era, not only at the central governmental level but also locally, which is triggered by several strong policy signals. At the regulatory framework level, the policy maker has been keeping raising the national PV cumulative target by 2020 from 1.8 GW in 2007 to 10 GW in 2008, and in the upcoming National New Energy Development Plan, it is expected to reach as high as 20 GW (Figure 7). In terms of the supporting schemes, two eye-catching packages were released also in 2009, "The PV Proof Program" and "The Golden Sun Project", both of which offer generous subsidies for on-grid PV installations (Figure 8). At the local / provincial level, the Jiangsu Provincial Government has announced a feed-in tariff aiming at 400 MW of PV to be installed in the province up to 2011.

Figure 7: National Target of Development Plan by 2020

2007 Mid-Long Term Development Plan for Renewable Energy **1.8 GW**	2008 China's PV Development Report **10 GW**	2010 (expected) National New Energy Development Plan **20 GW**

Figure 8: Government Subsidy Programs for On-grid PV Installation

The PV Roof Program Issue date: 2009.3.23. Eligibility: - individual application > 50kw - Conversion efficiency ➢ monocrystalline silicon: > 16% ➢ polycrystalline silicon: > 14% ➢ Non-crystalline silicon: > 6% - Prioritized target group: BIPV Benefits: investment subsidy **20 Yuan / w**	**The Golden Sun Project** Issue date: 2009.7.16. Eligibility: - individual application > 300kw - Applicant entity possess the asset over 100 million Yuan; investment capital more than 30% of the total capital. - Construction period < 1 yr; Running period > 20 yr. Benefits: investment subsidy, **50% for on-grid**, 70% for off-grid.

Source: adapted from the official documents, Ministry of Finance

In the residential sector, various world-wide programs have been launched to promote decentralized PV systems. The first comprehensive dissemination program was the

German 1000 roof program launched in 1989 and completed in 1993. About 2200 roofs were equipped with PV systems of an average size of 2.6 kW. Similar programs are the Austrian 200 kW PV rooftop program, US's SMUD program and the famous Japanese residential PV promotion program.

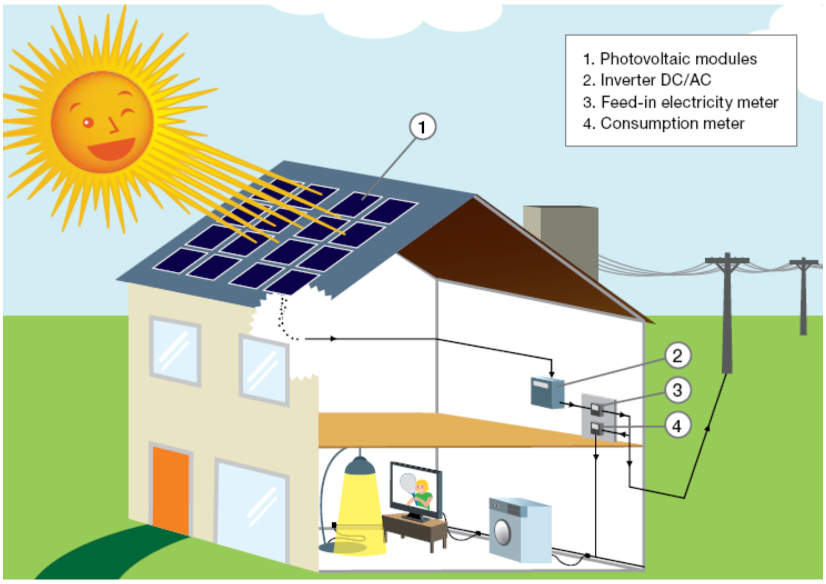
By 2005 there are 750,000 sets of solar PV systems that have been installed in the residential sector in China, however, mainly in the remote areas designated to solve the energy poverty problem. Nonetheless, a new trend is also emerging in those populated urban areas. Shanghai's 1000 Thousand Solar Roof Programme as the first program in agenda, is supposed to generate 430 million kWh electricity, moreover, this is the strong signal to trigger the switch of strategic priority of residential PV installation from rural village to urban city.

1.1.2.2 Technological and economic concerns

As defined by the Photovoltaic Power Systems Programme (IEA), there are four primary applications for PV systems: Off-grid Domestic, Off-grid Non-domestic, Grid-connected Distributed and Grid-connected Centralized. This research works on solar PV power in residential sector, so mainly focusing on Grid-connected Distributed application.

The Grid-connected Distributed system is the most popular type of solar PV system for homes and businesses application. Connection to the local electricity network allows any excess power produced to feed the electricity grid. If corresponding enabling policy is in position, this amount of electricity can be sold to the utility. Electricity is then imported from the network when there is no sun. An inverter is used to convert the direct current (DC) power produced by the system to alternative current (AC) power for running normal electrical equipments (Figure 9).

Figure 9: Working Mechanism of Grid-connected Distribute PV System



The economic performance of solar PV system is up to the ratio between electricity value and system cost.

Electricity value is dependent on electricity generation and electricity price. Electricity generation capacity varies widely for different regions. This is largely based on the amount of direct sunlight received in that region. Although specific regions may vary, the amount of direct sunlight is a function of latitude, climactic conditions, time of the year and etc. Regarding the electricity price, in the off-grid system, the generated electricity is only for self-sufficient purpose, just as an alternative of grid electricity. So its electricity price equals the market price. While in the on-gird system, system owner can decide how much those generated power to be sold to the grid (normally this selling price includes a premium part, called feed-in tariff / FIT), therefore it is higher than the grid tariff.

System cost consists of two parts: initial investment cost and maintenance cost. Initial investment cost embraces system components cost and installation cost, of which the former one is the major part including PV cell, inverter, controller, battery (if on-grid, battery can be waivered), supporting systems and etc (Table 1). Considering the maintenance cost, due to its rather easy maintenance process, compared to the system cost, it plays only a minor role.

Table 1: Initial Investment Cost of On-grid Solar PV System in China in 2006

Item	Investment (Yuan)	Portion (%)
Feasibility study	1,000	2.0
Project design	1,000	2.0
PV module	33,000	66.0
Inverter	5,000	10.0
Meter	5,000	10.0
Transportation cost	800	1.6
Installation cost	1,800	3.6
Connection to grid	800	1.6
Tax	1,600	3.2
Total	50,000	100.0

Source: China's PV Development Report 2007, ERI

Despite of the external environmental and social value of solar PV power, it is important to note, the economic perform still has the most significant influence on consumers when deciding which form of energy to use, especially in residential sector. Currently, among the existing various renewables, wind power proves to be the only competitive option compared with conventional coal fired power in terms of its economic performance (Figure 10). Worth to mention is that, even to include some external benefits such as CO_2 mitigation, environmental improvement, system integration, security of fuel supply and local benefits, solar PV power appears to be vulnerable, at least in the short-middle term (Figure 11).

Figure 10: Economic Performance of Renewables and Coal Fired Power

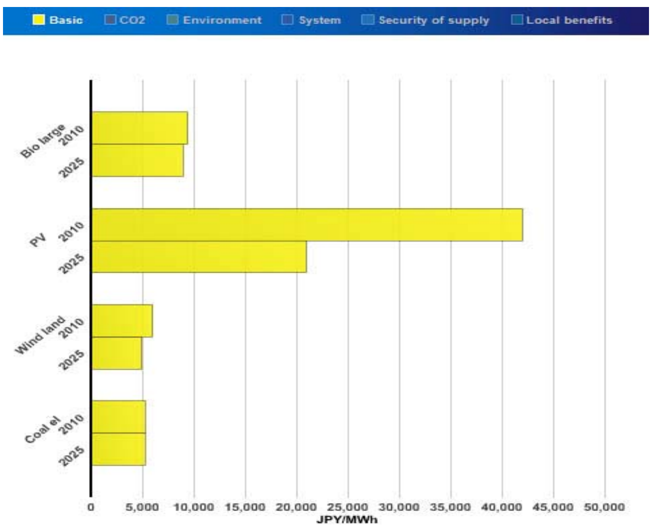
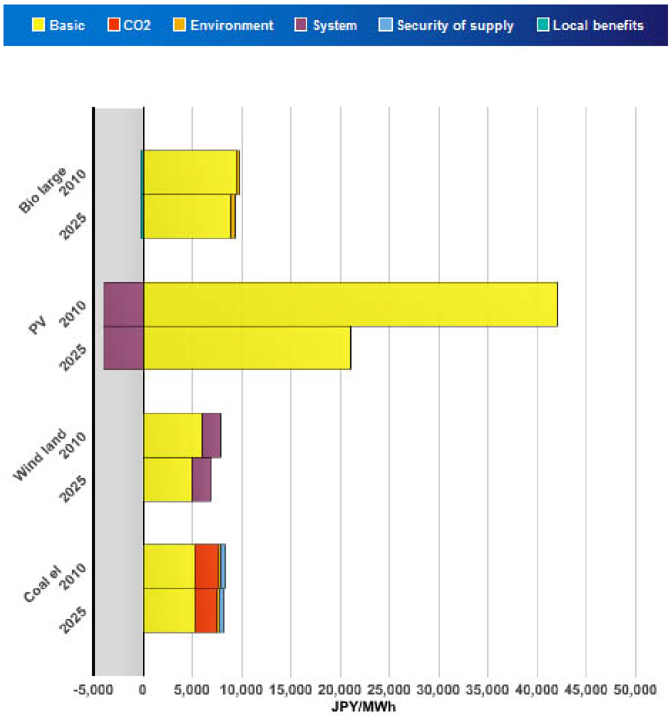


Figure 11: Economic Performance (with Externality) of Renewables and Coal Fired Power



Source: REcalculator, IEA-RETD

In China, due to relative low grid tariff, solar PV power is at the moment not competitive. However, given that the grid tariff has already stepped into the steady raising channel, and meanwhile, solar PV power is becoming cheaper, it is estimated (NDRC 2005) China is going to achieve the grid parity in around 2030 (Table 2).

Table 2: Estimation of Grid Tariff and PV Power Price in China

Year	2006	2010	2015	2020
Grid Tariff (Yuan/KWh)	0.310	0.349	0.404	0.406
PV Tariff / 1500h (Yuan/KWh)	3.7	2.4	1.4	0.8

Source: China's PV Development Report 2007, ERI

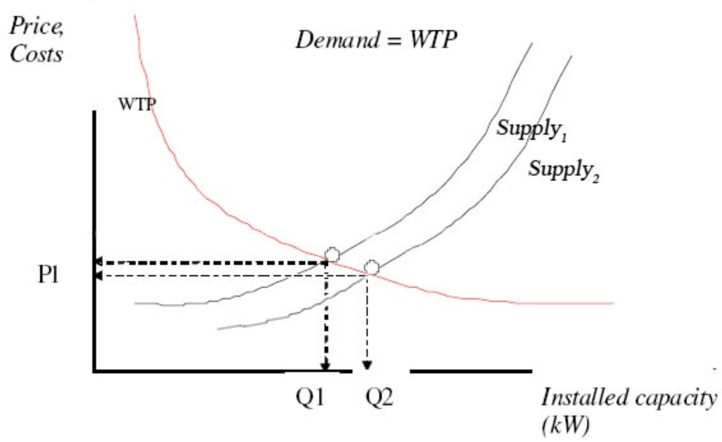
1.1.3 Promotional policy drivers and sustainable scale-up

In order to enhance the economic performance of residential PV system, and consequently contribute to the sustainable scale-up of PV power installation, especially within the period before the grid parity is achieved, a number of promotional policy drivers are crucial.

1.1.3.1 Promotional policy drivers

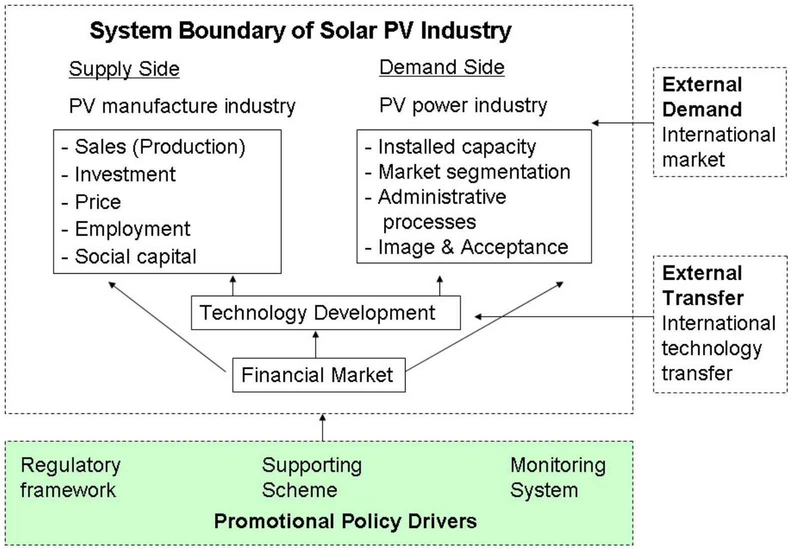
In order to understand the importance of policies and the meaning of some terms used, it is necessary to introduce some theoretical background (Haas 2002) at the first place, namely to understand the factors of prices, costs, and willingness to pay (WTP) for a product and how they may vary (Figure 12).

Figure 12: Demand and Supply Curve in PV Industry



This figure shows the supply and demand curves. The demand curve, WTP characterizes how much a consumer is ready to pay for a commodity (in this case a kW or kWh of PV). The supply curve is defined by the costs to produce a certain number of units of a product (kWh or kW of PV). The price market P1 is the point where supply curve and demand curve meets. P1 will be the market price if no factor affecting these curves changes. At P1 consumers are ready to buy (to install) the quantity Q1 and producers to produce the quantity Q1. Nevertheless there are factors that can affect the supply curve moving them and altering the final installed capacity Q2. This kind of moving process from Q1 to Q2 is defined as “Scale-up” and those factors are called promotional policy drivers, which are perceived in the systematic perspective as follow (Figure 13).

Figure 13: System View of PV Industry



According to the diagram above, promotional policy drivers can be perceived from two sides, namely supply side and demand side. From the supply side, promotional policies work on creating sound enabling conditions to enhance the technology innovation, so that technology advancement is accomplished. Consequently, a substantial price reduction is achieved, to move the meeting point from Q1 to Q2. In the demand side, promotional drivers are created because of some external requests or too high opportunity cost of not-to-do. Scale-up of solar PV is just good example. Due to the special significance, demand side promotional policy drivers are introduced to create a virtual reduction of system cost, by providing, for instance, financial support. This temporal price reduction is supposed to stimulate the scale-up process, on one hand, satisfying the external requests; on the other hand, give a hand to substantial price reduction through the learning effect.

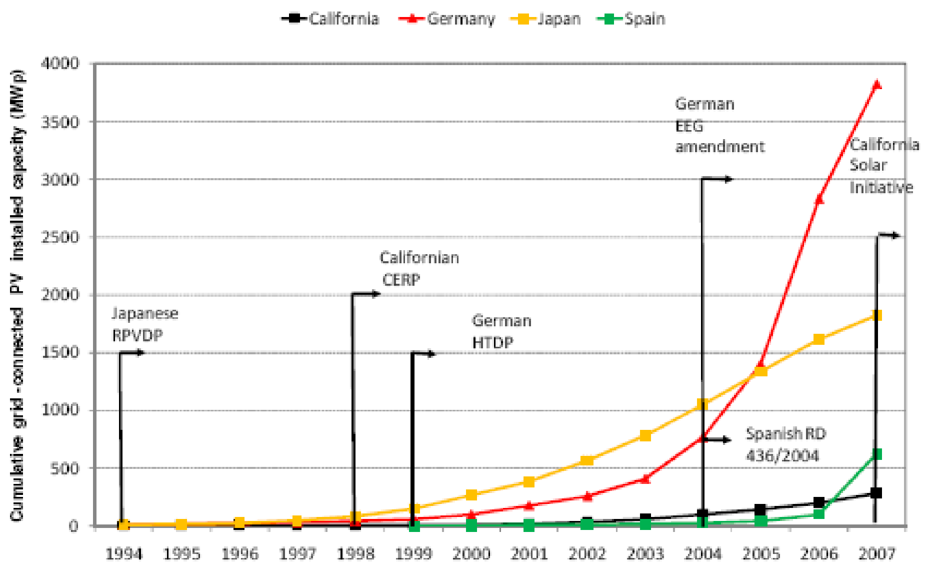
Several demand side based promotional policy drivers are listed as follow (Table 3):

Table 3: List of Mainstreaming Promotional Policy drivers in PV Sector

National regulatory framework	National PV support schemes
Feed-in laws / tariffs for PV electricity	Grant schemes
Subsidy schemes for PV investments	Soft loan schemes, in collaboration with financial institutions
Fiscal incentive schemes for PV investments	Other financing schemes, in collaboration with financial institutions / energy service companies (ESCOs)
	National PV monitoring systems
Tendering systems	Approaches to market monitoring
Quota obligation systems	Approaches to monitoring & performance measurement of PV incentive / support systems
Green pricing systems	

Despite of the rather diverse promotional policy drivers, from the consumer's point of view, the strategies that most directly affect him are those that provide financial incentives. Financial incentives can be received as a payment for every kWh produced or as a payment for the system capacity (money for every kW). Japanese type of subsidy schemes for PV investments and German type of feed-in tariff for PV electricity are considered as the most effective approaches (PVPS 2009b) (Figure 14, Box 1 and Box 2); therefore this research will focus only on these two types.

Figure 15: Cumulative grid installed capacity with important milestones in the largest grid-connected markets.



Source: PVPS 2009b

Box 1: Japanese Residential PV System Dissemination Program (RPVDP)

The Japanese Residential PV System Dissemination Program was launched in 1994. The program was combined with low-interest consumer loans and comprehensive education and awareness activities for PV. The subsidy was given in three categories: a) individuals installing PV systems to their own house, b) suppliers of housing development complexes or suppliers of houses built for sale, and c) local public organizations that introduce PV systems to public buildings. Subsidies in FY 2005 were 20 000 JPY/ kWp with a maximum output capacity of the PV system of 10 kWp. Rebates have been decreasing continuously over time. While in the first years of the program (1994-1999), the subsidies were a fixed percentage of the costs (decreasing from 50% to 33%) this concept changed into fixed amounts per kWp.

Box 2: German Renewable Energy Act (EEG)

The German Renewable Energy Act is the main market driver in Germany. The present EEG came into effect in April 2000 and was amended in 2004. It builds on the previous Electricity Feed Law from 1991. The 20 year fixed tariffs, which are granted for new projects each year, decrease by 5% each year. In 2008, a new law was passed which provides for adjustments to the FIT amount depending on the market response.

1.1.3.2 Sustainable scale-up

As mentioned in the previous section, demand side promotional policy drivers are designated to create virtual price reduction in stimulating the scale-up process, and consequently achieving the substantial price reduction. Therefore, the sustainability issue becomes crucial, namely to create large enough push under acceptable cost. In order to enhance the sustainability of PV scale-up, the following several criteria are very important, which is an adaption of the Photovoltaic Power Systems Programme's research:

a. Market Formation: Contribution of a policy to a sustainable PV market by satisfying the needs of the market.

A good design of program, in this circumstance namely a proper policy contributing to the formation of sustainable PV market, must capture the preference of customers.

This research focuses on the small PV on-grid system in the residential sector, so it is the residential consumer's preference that ultimately influences the market. Therefore, as the key requirement of sustainable solar PV scale-up, it is very important to identify consumer's preference while they are facing different promotional policy drivers. This serves as the fundamental element to determine the sustainability of PV scale-up in residential sector.

b. Dissemination Effectiveness: Degree to which a measure maximizes the installed power.

One of the objectives of any program must be to maximize the installed power. As mentioned in the previous chapter, it is necessary to promote the introduction of solar PV power in China, which is also proved by the ever-increasing national target. In addition, considerable scale-up also contribute to the technology advancement via learning effect. Therefore, as another important factor to indicate the sustainability of PV scale-up is the cumulated installed capacity within the program lifespan. It can be calculated by annual diffusion rate.

c. Cost for the Public: Measurement of the efficiency of a program. Amount of money spent for subsidies and other financial incentives compared with the output of the policy.

Any program entails related cost. In this kind of demand side scale-up, due to the temporary feature of virtual price reduction, it is more important to deliberately consider the program cost. Furthermore, in this case, no matter it is either investment subsidy type or feed-in tariff type promotional policy driver, the direct cost is taken by either central government or local government; nevertheless, it is the public that finally bears the whole cost through the channels like taxation. Therefore, as important criteria of sustainable scale-up, the cost for the public is also crucial, by measuring the efficiency of the program.

In this research, these above mentioned three indicators will be applied to frame the sustainable PV scale-up in residential sector in China.

1.2 Research objective and research framework

In order to better deal with energy security issue and combat global warming as well as other environment problems, it is necessary to scale up the installation of solar PV power, especially in residential sector. In China, due to its unique situation, this request turns out to be stronger. Therefore, ***this research aims to explore the proper promotional policy drivers to sustainable solar PV Power scale-up in residential sector in China.***

Market Formation (Consumer's Preference), as one key driver, together with two indicators: Dissemination Effectiveness and Cost for the Public, will be used to frame the concept of "Sustainable Scale-up". As a result, two specific research questions are formulated to approach the general objective.

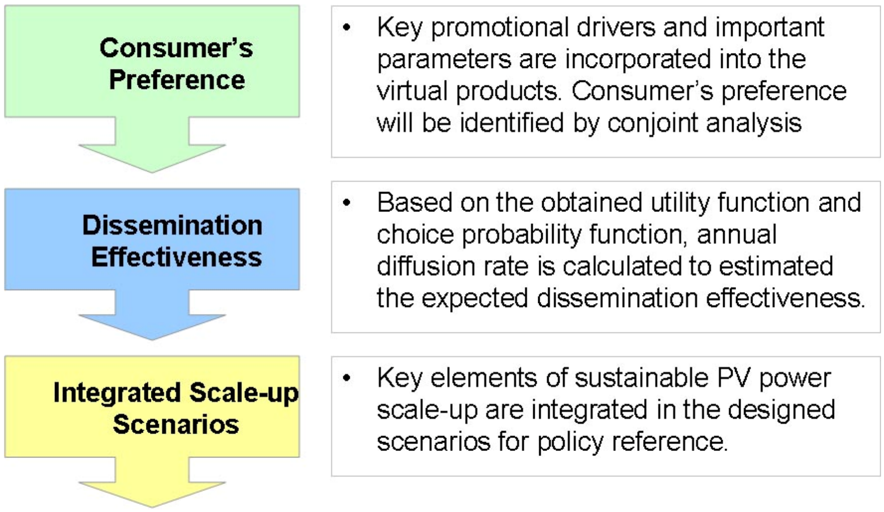
– *Research Question 1: What is the consumer's preference towards different promotional policy drivers?*

– *Research Question 2: What is the dissemination effectiveness and cost for the public under the potential promotional policy?*

In this research, this theory of sustainable PV scale-up will be applied into the case of China, the first trial in important emerging country, and the outputs will, on one hand, serve as a good reference for PV scale-up related policy formulation in China, on the other hand, also as a useful complement of the theory itself. From the methodological point of view, the simulation is based on the combination of adapted Yoshida Diffusion Utility Model and Country Utility Model of China.

This paper consists of four chapters. Chapter one is the introduction part, where the background and a general picture of this research are depicted. Chapter two will go through the methodologies that are used in this study, namely conjoint valuation method, diffusion simulation method and scenario analysis method. Besides, the corresponding research design will be also explained in detail. Chapter three will present the direct results from online survey as well as the in-depth analysis. Chapter four will include the discussion and conclusion part of the research (Figure 16).

Figure 16: Concept Map of Research Framework



2 Methodology and research design

2.1 Conjoint valuation method

2.1.1 Introduction

2.1.1.1 Overview

As one key issue to support sustainable PV scale-up, it is important to identify the real market needs. In this research, conjoint valuation method is applied to explore consumer's preference on different policy subsidy based PV system products.

In the domain of environmental assessment, there are basically two approaches: Revealed Preference Method / RP and Stated Preference Method / SP. RP mainly focus on the analysis based on people's already practiced activities, while SP is on the assumed potential activities through people's statement. In this research, the latter one is chosen, by means of Conjoint Analysis Method.

Conjoint Analysis was also called as Conjoint Measure at the earliest stage in 1960s. It was first developed by Luce and Tukey (1964), and was mainly used in the domain of econometric psychology. Later on, Green and Rao (1971) successfully introduced it into business marketing industry. In 1978, Carmone, Green and Jain further improved this method and renamed it as Conjoint Analysis. Since 1990s, it started its application in environmental economics. Our laboratory, Lab. of Matsuhashi & Yoshida in Tokyo University, has also been using this method very frequently.

Conjoint analysis is a method used to represent individual preferences in multi-attribute contexts. That is, individuals are asked to choose the best alternative or rate/rank alternatives having varying values. Therefore, attributes and levels / rates are crucial in this method. For example, if consumer wants to purchase a laptop, they need to consider some attributes like price, weight, battery, CPU quality and etc. And within the price attributes, the price rates are also crucial for their final purchase decision. Considering all above, conjoint analysis method designs several assumed products or portfolios with combinations of different attributes and levels, and the data collection can be based on questionnaire survey.

There are basically two ways while compiling the portfolios, namely Full-profile Rating and Pair-wise Rating (also called trade-off rating or two-factor-at-a-time rating). In the Full-profile Rating, participants will answer the questions from survey organizer in a free manner, by which, a full profile is construction for further analysis. And in the Pair-wise Rating, participants need to face pair-like choices, and are supposed to make trade-offs between every two options, which is also called Choice-based Conjoint Analysis. Due to the closeness to real consumption behavior, this choice based Conjoint Analysis is more accepted by the consumers (Songphol 2009).

Table 4: Sample of Pair-wise Rating Compiling Approach

	Product A	Product B	Product C	I don't purchase
Price	￥ 10000	￥ 15000	￥ 20000	
Weight	1 kg	2 kg	3 kg	
Battery	5 hours	8 hours	10 hours	

2.1.1.2 Procedure

The procedure of conjoint analysis is clarified as follow:

a. Information collection: in order to produce sound profiles, it is very important to conduct thorough investigation on the targeted research group; in addition, the feedbacks from experts prove to be very useful.

b. Selection of proper attributes and levels: selected attributes should reflect the key elements of the assumed products, and an appropriate range of different levels are needed to maintain the independence of different attributes.

c. Profile design: several profiles should be well designed so that bias can be avoided or at least minimized.

d. Pre-survey: after having carefully checked the logical and ethical problem of the questionnaire, the pre-survey should be conducted within a small group targeted people. According to its result and people's feedback, further adjustment should be conducted continuously improving the quality of questionnaire.

e. Formal survey: the formal questionnaires are delivered to the target group, in this case by on-line survey.

f. Data process and analysis: survey result should be carefully treated, and as the input of further date analysis, which will be explained in detail in the next section.

2.1.1.3 Analysis method

Conjoint studies utilize a random utility model (RUM) to explain individuals' preferences. RUM models rely on choice behavior and assume that individuals will choose the alternative that gives them the highest level of utility. That is, RUM models estimate the probability that an individual will select a choice based on the attributes of each possible alternative. If the utility of alternative i is greater than the utility of alternative j, then the individual will choose i. Utility is comprised of both deterministic components V_i (environmental quality, income, etc.) and random components ε_i that are unobservable to the researcher. Assume it follows linearity, and then it is:

$$U_i = V_i + \varepsilon_i \quad (i = 1,\ldots,Q) \tag{2 - 1}$$

$$U_i = \sum_{k=1}^{M} \beta_k x_{ik} + \varepsilon_i \quad (i = 1,\ldots,Q) \tag{2 - 2}$$

Here, x_{ik} is the attribute value of product i, the β_k is the corresponding parameter.

The probability of consumer's choice of product i is based on the pre-condition that, the corresponding U_i is higher than other product j (j ≠ i), therefore:

$$
\begin{aligned}
Pi &= \Pr[U_i > U_j, j = 1,\dots,Q, j \neq i] \\
&= \Pr[V_i + \varepsilon_i > V_j + \varepsilon_j, j = 1,\dots,Q, j \neq i] \\
&= \Pr[V_i - V_j > \varepsilon_j - \varepsilon_i, j = 1,\dots,Q, j \neq i]
\end{aligned}
$$

(2 - 3)

If we assume the probabilities follows the Gumbel Distribution, $\Delta \varepsilon$ follows the Logistic Distribution, and consequently Pi can be applied in Conditional Logit Model as follow:

$$P_i = \frac{\exp(V_i)}{\sum_{j=1}^{Q} \exp(V_j)} \quad (i = 1,\dots,Q)$$

(2 - 4)

Given the question of r (r = 1… R), the reply of product i (i = 1… Q) is defined as n_{ri}. The likelihood estimator is as follow:

$$L = \prod_{r=1}^{R} \prod_{i=1}^{Q} P_{ri}^{\,n_{ri}}$$

(2 - 5)

Then, by calculating the maximum estimator under the following formula, we can obtain the parameter β :

$$\max_{\beta_1,\dots,\beta_M} \ln L = \sum_{r=1}^{R} \sum_{i=1}^{Q} n_{ri} \ln P_{ri}$$

(2 - 6)

The parameter vector is the Maximum Likelihood Estimator, which also fulfills the request of consistency, asymptotic normality and asymptotic efficiency.

In order to verify the reliability of model, T test is used in this case (the absolute value of t should be more than 2.0 to ensure the reliability of each parameter). And McFadden indicator is applied to test the fitness of model as follow:

$$\rho^2 = 1 - \frac{\ln L_{\hat{\beta}}}{\ln L_0}$$

(2 - 7)

ρ^2 is the McFadden indicator, $\ln L_{\hat{\beta}}$ is the Maximum Likelihood Estimator, $\ln L_0$ is the likelihood estimator while all constrains are 0. Value of McFadden is normally between 0 and 1. If it is within the range of 0.2 - 0.4, then the fitness of constructed proved to be very high. In the domain of medical and disaster analysis, the requirement of McFadden indicator is quite strict, nonetheless, in social research domain such as human behavior; sometimes low value of McFadden indicator also proves to be acceptable.

2.1.2 Research design

2.1.2.1 Attributes and levels

Consumers need to consider several issues when we are deciding whether or which kind of solar PV system should be installed. Some key issues are like feed-in tariff; initial investment subsidies; purchase cost; PV system capacity; payback time of investment; availability of soft loan; maintenance cost; guaranteed policy lifespan; technological risk; brand of system manufacturer; type of installation and etc.

The attributes of the profile will be derived from these issues. The past experiences show if too many attributes are included, consumers are easily overloaded and get tired, so it is better to choose a limited number but most crucial and targeting attributes. Besides, due to similar reason, it is also suggested to control the number of questions within 7 or 8.

As already mentioned in the background session, financial incentives are the most important issues while consumer is making the purchase choice, and also, as the key promotional policy drivers, “Feed-in Tariff” and “Initial Cost” are selected as the profile attributes. In addition, “Payback Time” and “Investment Risk” are also included.

2.1.2.2 Profiles

In this research, we focus on the 3kW roof-type solar PV system, which are currently the very popular type in on-grid distributed PV system all over the world. And after having chosen the attributes, the next step is to design the levels, namely the range of each attribute.

The current market price of 3kW roof-type solar PV system in China is about 80,000 Yuan. Therefore, three levels of initial cost are set as 80,000 Yuan, 60,000 Yuan (25% of initial investment subsidy), and 40,000 Yuan (50% of initial investment subsidy). Regarding the feed-in tariff / FIT, by considering the similar policies / policy proposals[2] at the moment in China, four levels are set: 1.0 Yuan, 1.6 Yuan, 2.2 Yuan and 2.8 Yuan.

Payback time means the number of years required to recover the cost of an investment. In this case, the calculation of payback time is simplified by the following equation:

$$n = \frac{I}{1000sp} \qquad (2 - 8)$$

n: payback time / PBT (year); *I*: initial cost (Yuan); *s*: system scale, in this case is 3kW; *p*: electricity selling price, in this case equals the FIT (Yuan/KWh). Due to the selected sampling groups are basically located in China's Level III solar resource zone with the average generation potential of 1050 – 1400 $KWh/m^2 \cdot a$. With the conservative manner and for the convenience of calculation, in this research, the latent indicator is defined as 1000.

In the attribute of investment risk, we mainly consider the risk of system reliability, namely the credibility of government long term guarantee; and the risk of technology stability, including the technological running stability, the effectiveness of connection to the grid, the retired time and etc. Another issue is the risk of transaction cost, namely the too much complicated application procedure, the in-cooperative manner of utility company and etc. 10% means a low level of risk by considering these two aspects, as well as 20% and 30% respectively indicating the middle and high level of risk.

---

[2] Current residential electricity price in Shanghai is 0.61 Yuan, Shanghai's newly proposed trial FIT is 2.00 Yuan, and the first FIT in Jiangsu Province is 3.70 Yuan.

The final produced profiles are as follow (Table 5):

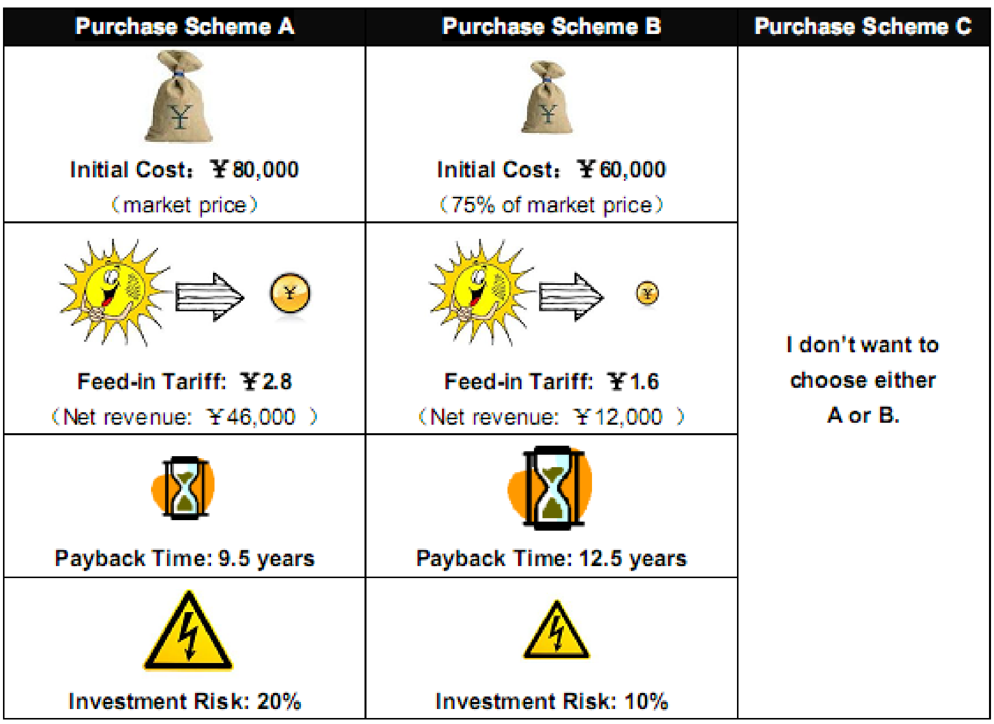
Table 5: Overview of Designed PV System Purchase Profiles

	Initial	FIT	PBT	Risk
Portfolio1-A	80000	2.8	9.5	0.2
Portfolio1-B	60000	1.6	12.5	0.1
Portfolio2-A	80000	2.2	12.1	0.2
Portfolio2-B	40000	1	13.3	0.3
Portfolio3-A	60000	2.8	7.1	0.3
Portfolio3-B	40000	1.6	8.3	0.2
Portfolio4-A	80000	2.2	12.1	0.1
Portfolio4-B	40000	1.6	8.3	0.3
Portfolio5-A	80000	2.8	9.5	0.2
Portfolio5-B	40000	1.6	8.3	0.1
Portfolio6-A	60000	2.2	9.1	0.1
Portfolio6-B	40000	1.6	8.3	0.2

2.1.2.3 Questionnaire

According to the profiles, questionnaire is prepared with one of the sample question as follow (Figure 17):

Figure 17: Sample Question of Purchase Options



2.2 Diffusion simulation method

2.2.1 Definition of diffusion rate

As another key factor to ensure the sustainability of PV scale-up, dissemination effectiveness is very important. This research uses the “Annual Diffusion Rate” as the core parameter. In this case, the diffusion simulation follows the approach of combined modeling method between the Yoshida Diffusion Utility Model (Yoshida 2008) and Country Utility Model, which is obtained from the conjoint analysis[3].

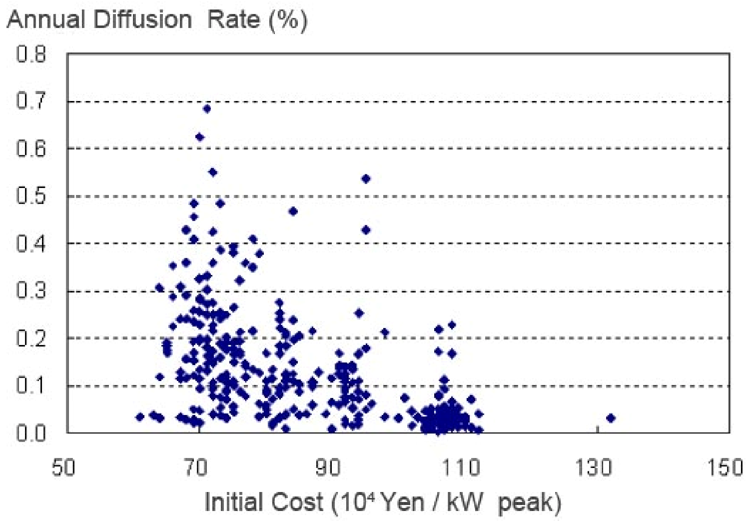
The annual diffusion rate is defined as follow:

$$\text{Annual Diffusion Rate} = \frac{\text{Annual Installation}}{(\text{Total Capacity} - \text{Installed Capacity})} \qquad (2 - 9)$$

2.2.2 Introduction of Yoshida Diffusion Utility Model

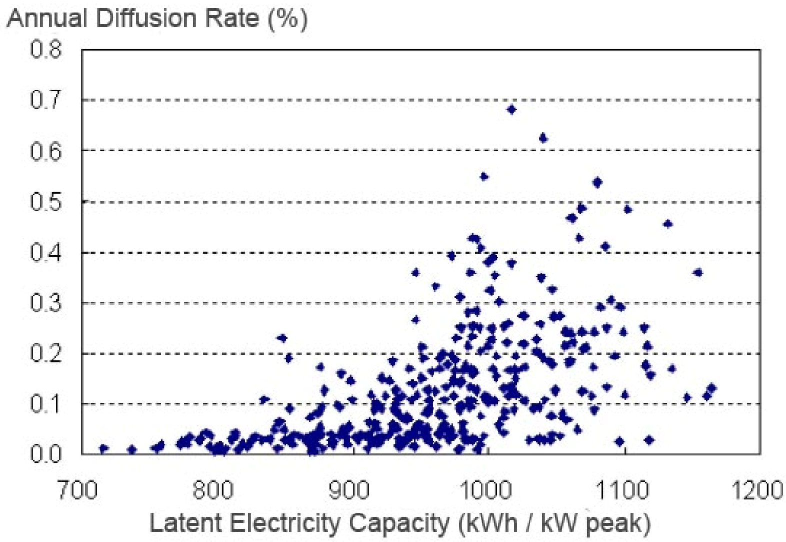
Yoshida uses initial cost and electricity generation capacity as key parameters of the utility modeling. The figures below show a draft correlation among these factors.

Figure 18: Annual Diffusion Rate and Initial Cost



[3] There are various approaches to calculate diffusion rate, in this case, due to special feature of PV system as a product, some key attributes of this product will affect consumer’s purchase decision and consequently influence the diffusion rate, and therefore, the annual diffusion is up to consumer’s preference.

Figure 19: Annual Diffusion Rate and Latent Electricity Capacity



Source: Yoshida 2008

From these two figures, it is quite clear that the low initial cost results in high diffusion rate. And the high latent electricity capacity causes high diffusion rate.

By using Logit model, Yoshida works out the Utility Function of solar PV system installation as follow:

$$U = \beta_1 latent + \beta_2 initial + \beta_3 pv\_inst + \varepsilon = V + \varepsilon \tag{2 - 10}$$

"Latent" is the potential electricity generation capacity, "Initial" is the initial cost (10^4 Yen / kW peak) of PV system. When PV system is introduced, pv_inst is 1, otherwise remains 0. In the case of no PV system is installed, *latent, intial* and *pv_inst* all equal 0, consequently the utility is also 0. Therefore, according to the Conditional Logit Model (2 - 4) mentioned before, the choice probability / P is defined as follow, which is also the annual diffusion rate:

$$P = \frac{\exp(V)}{1 + \exp(V)} \tag{2 - 11}$$

By analyzing the data of *latent* and *initial*, Yoshida gets the utility function as follow:

$$V = 5.12 \times 10^{-3} latent - 2.74 \times 10^{-2} initial - 9.51 \tag{2 - 12}$$

All the parameters are at the level of in 95% confidential interval, and the McFadden indicator is 0.21, which means very good fitness of this modeling.

2.2.3 Application of combined diffusion modeling method in the case of Japan and Germany

Songphol conducted research on consumer's preference towards different solar PV system. Through the conjoint analysis, he worked out the Country Utility Model (Songphol 2009) as follow:

$$V = -0.100 \text{ Initial} + 0.250 \text{ FIT (Japan)} \quad (2 - 13)$$

$$V = -0.024 \text{ Initial} + 0.054 \text{ FIT (Germany)} \quad (2 - 14)$$

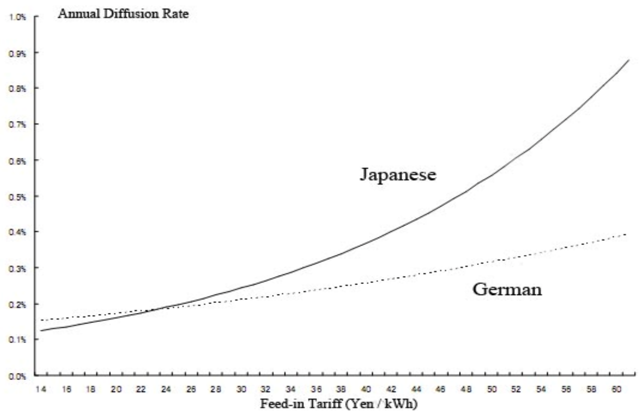
Table 6: Comparison of Japan and Germany in RUM

	Japan	Germany
Initial	(β_1) -0.100	(β_1) -0.024
	(t) -15.29	(t) -4.40
FIT	(β_2) 0.025	(β_2) 0.054
	(t) 15.92	(t) 7.81
No. of Observation	2202	21230
ln L_β	-583.4	-695.5
ln L_0	-763.2	-738.2
McFadden Value	0.2355	0.0579

With the assumption of 1000 kWh / kW peak as the latent electricity generation capacity and $7 * 10^5$ Yen / kW as initial cost, by combining the Country Utility Function to Yoshida Utility Function[4] (2 -12) and Diffusion Rate / Choice Probability Function (2 - 11), the annual diffusion rate modeling is obtained as follow:

[4] The combination is based on the common attribute, namely parameter of "Initial Cost"; therefore, these two utility functions are merged by converting two factors of Initial Cost into the same value.

Figure 20: Annual Diffusion Rate in Japan and Germany



Source: Songphol 2009

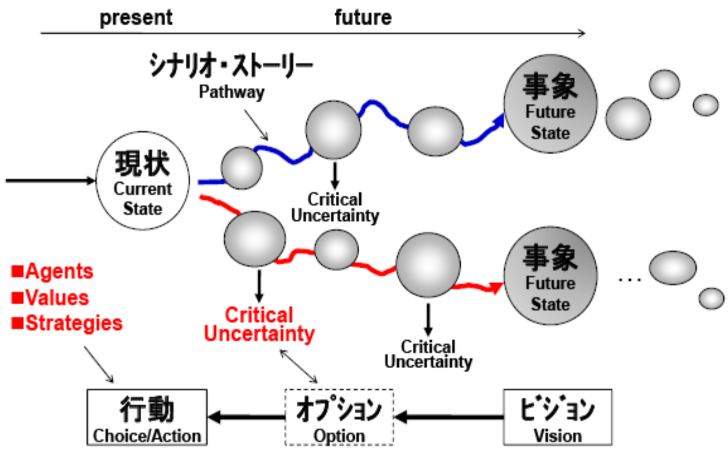
2.3 Scenario analysis method

In order to better capture the general picture of sustainable PV scale-up in residential sector in China as well as the interactive effects among these key factors, this research use scenario analysis method, on one hand better synthesizing the previous outputs, and one the other hand better approaching to research question 3.

2.3.1 Introduction

Scenario analysis is a process of analyzing possible future events by considering alternative possible outcomes/scenarios. And according to Azmi, Scenario Analysis, also called scenario planning or scenario analysis, is a strategic planning method hat some organizations use to make flexible long term plans. Therefore, scenario analysis is designed to allow improved decision-making by allowing consideration of outcomes and their implications (Figure 21).

Figure 21: Framework of Scenario Analysis



Source: Minato, Tokyo University, 2008

From the historical point of view, most scholars attribute the introduction of scenario planning to Herman Kahn through his work for the US Military in the 1950s at the RAND Corporation where he developed a technique of describing the future in stories as if written by people in the future. He adopted the term “scenarios” to describe those stories. In 1961 he founded the Hudson Institution where he expanded his scenario work to social forecasting and public policy (Chermack 2001). During the mid 1960s various authors from the French and American institutions began to publish scenario planning concepts. By the 1970s scenario planning was in full swing with a number of institutions now established to provide support to business including the Hudson Foundation, the Stanford Research Institute, and the SEMA Metra Consulting Group in France. Several large companies also began to embrace scenario planning including Dutch Royal Shell and General Electric (Bradfield 2005).

2.3.2 Procedure

Scenario analysis or scenario planning usually goes through the following procedure:

a. Decide on the key question to be answered by the analysis. By doing this, it is possible to assess whether scenario planning is preferred over the other methods.

b. Set the time and scope of the analysis. Take into consideration how quickly changes have happened in the past, and try to assess to what degree it is possible to predict common trends in demographics, product life cycles et al. A usual timeframe can be five to 10 years.

c. Identify major stakeholders. Decide who will be affected and have an interest in the possible outcomes.

d. Map basic trends and riving forces.

e. Find key uncertainties. Map the driving forces on two axes, assessing each force on an uncertain predictable and important/unimportant scale.

f. Define the scenarios, plotting them on a grid if possible. Usually, 2 to 4 scenarios are constructed. The current situation does not need to be in the middle of the diagram (inflation may already be low), and possible scenarios may keep one (or more) of the forces relatively constant, especially if using three or more driving forces.

g. Assess the scenarios. Are they relevant for the goal? Are they internally consistent? Are they archetypical? Do they represent relatively stable outcome situations?

h. Identify research needs. Based on the scenarios, assess where more information is needed. Where needed, obtain more information on the motivations of stakeholders, possible innovations that may occur in the industry and so on.

i. Develop quantitative methods. This step does of course require a significant amount of work compared to the others, and may be left out in back-of-the-envelope-analyses.

j. Converge toward decision scenarios. Retrace the steps above in an iterative process until you reach scenarios which address the fundamental issues facing the organization. Try to assess upsides and downsides of the possible scenarios.

More details about the scenario analysis will be explained in Chapter 3 by combining those outputs from previous two research questions.

3 Results

3.1 Consumer's preference of promotional policy drivers for PV scale-up

3.1.1 Overview of the survey

3.1.1.1 General information

The general information of this online survey is listed in the following table (Table 7):

Table 7: General Information of Online Survey

Survey company	ＮＴＴ レゾナント株式会社
Survey method	Online survey
Target group	Chinese citizens who currently or within 2-3 years have their own house / apartment
Survey duration	2009/12/14～2009/12/22
Language	Chinese
Valid answers	1000 (334 from Beijing, 333 from Shanghai, 333 from Guangzhou)

The full version of questionnaire is attached in Appendix I and Appendix II in both English and Chinese.

3.1.1.2 Demographic results

The demographic attributes of target group are recorded as follow:

Figure 22: Age Information of Participants

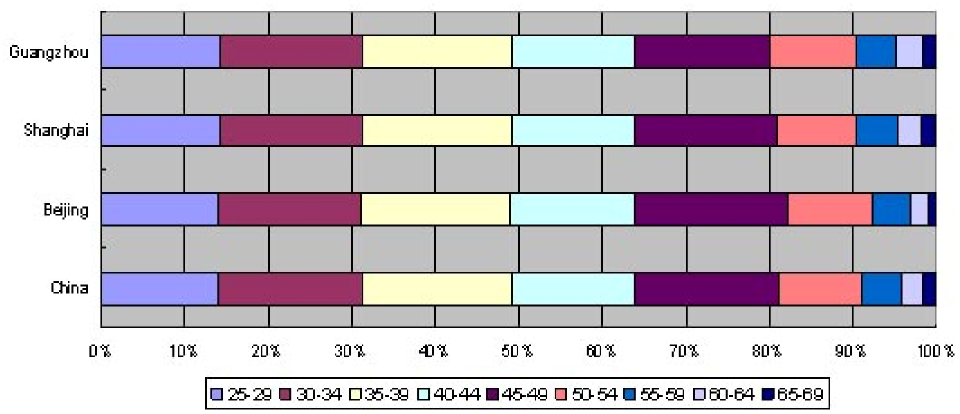


Figure 23: Gender Information of Participants

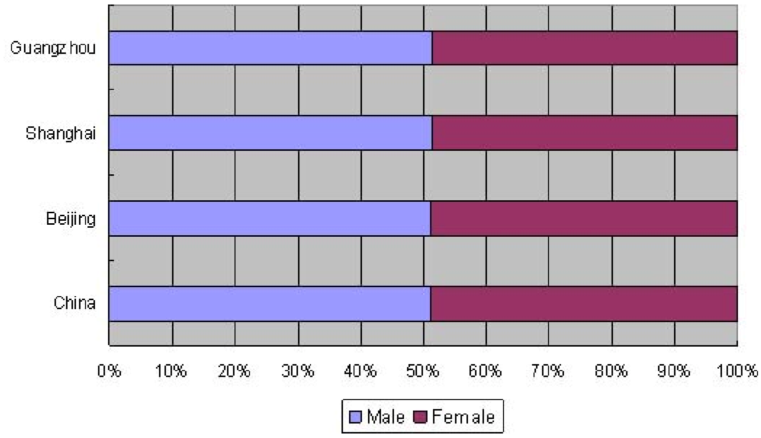


Figure 24: Income Information of Participants / Yuan

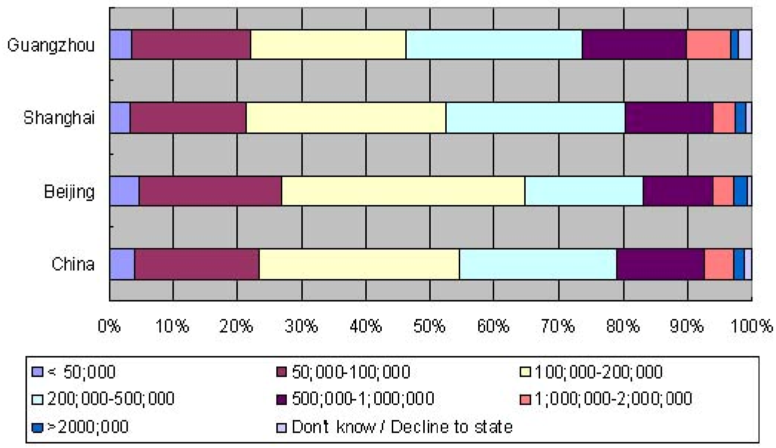
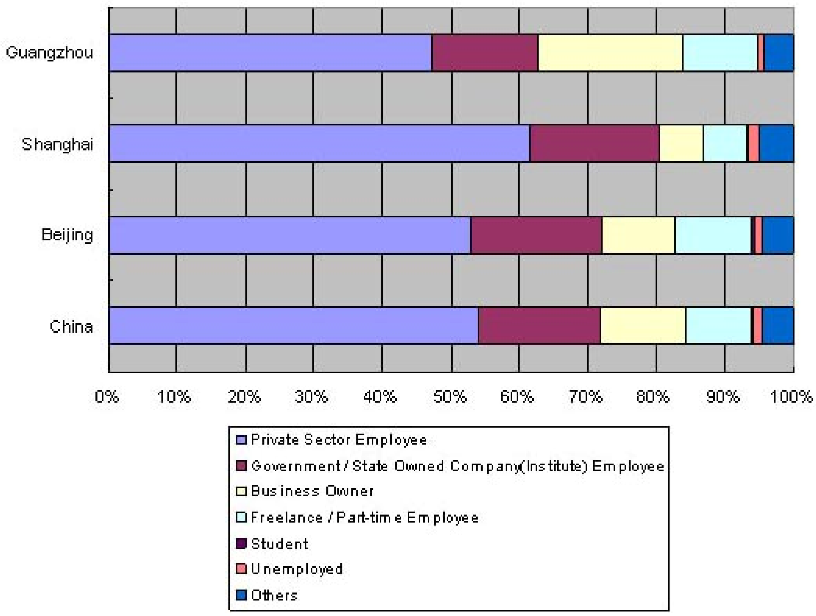


Figure 25: Occupation Information of Participants



3.1.2 Selection of model

As we already set “Initial Cost / Initial”, “Feed-in Tariff / FIT”, “Payback Time / Payback” and “Investment Risk / Risk’ as the key function attributes, the assumed primary model is as follow:

$$V = \beta_1 \text{ Initial} + \beta_2 \text{ FIT} + \beta_3\text{Payback} + \beta_4\text{Risk} \qquad (3 - 1)$$

The following table shows result of conjoint analysis (Table 8):

Table 8: Primary Results of the Conjoint Analysis

China	Parameter / β	t Value
Initial	-0.666	-9.790
FIT	1.642	8.565
Payback	0.251	15.485
Risk	-3.934	-7.136
No. of Observation	1000	
ln $L_{\hat{\beta}}$	-5841.6	
ln L_0	-6584.7	
McFadden Value	0.1128	

Therefore the primary function reads as:

$$V = -0.666 \text{ Initial} + 1.642 \text{ FIT} + 0.251 \text{ Payback} - 3.934 \text{ Risk} \qquad (3 - 2)$$

It is easy to understand there is a negative correlation between consumer’s utility and initial cost, payback time, investment risk, namely the larger the initial cost, payback time and invest risk are, the lower the consumer’s utility is. Similarly, there is a positive correlation between FIT and consumer’s utility. As a result, the parameter of payback time should be a native value, so the current 0.251 is not acceptable. The possible reason can be the inferred from high dependency between payback time and the other two attributes: initial cost and electricity price (FIT). Therefore, we screen the attribute of payback time, and then, a new round of conjoint analysis is conducted, with the outputs as follow (Table 9):

Table 9: Secondary Results of the Conjoint Analysis

China	Parameter / β	t Value
Initial	-0.372	-5.861
FIT	0.661	3.705
Risk	-4.841	-7.161
No. of Observation	1000	
ln $L_{\hat{\beta}}$	-3432.2	
ln L_0	-3615.4	
McFadden Value	0.0506	

Therefore, the new utility function reads as follow:

V = -0.372 Initial + 0.661 FIT - 4.841 Risk (3 - 3)

In this case, all parameters follow the common sense. Besides, both T value and McFadden Value is acceptable. So we accept this model as the final version of Chinese people's utility function in their preference of different decisive attributes.

In addition, the models of different regions, namely Beijing, Shanghai and Guangzhou are also listed.

V = -0.428 Initial + 0.702 FIT – 5.766 Risk (Beijing) (3 - 4)

V = -0.371 Initial + 0.608 FIT – 4.073 Risk (Shanghai) (3 - 5)

V = -0.329 Initial + 0.689 FIT – 4.778 Risk (Guangzhou) (3 - 6)

3.1.3 Marginal WTP

3.1.3.1 Marginal WTP of FIT

According to the utility function 3 - 3, the Marginal Willingness To Pay / MWTP of FIT can be derived from the following function:

$$MWTP_{FIT} = -\left(\frac{dV/d(FIT)}{dV/d(Initial)} \right) = -\frac{\beta_2}{\beta_1} \qquad (3 - 7)$$

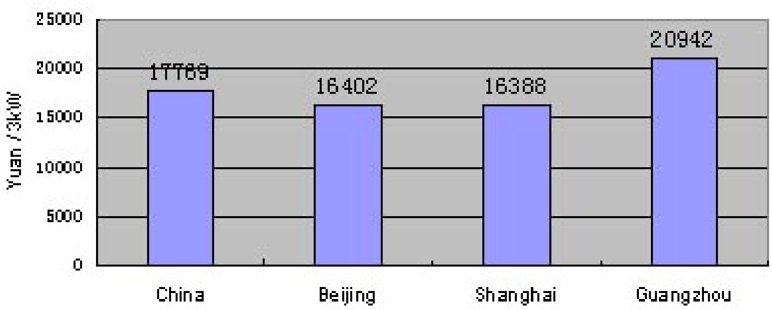
If the FIT has a change of 1 unit (1 Yuan / kWh), in order to have the same amount of utility change, the initial cost changes correspondingly. And this change of unit of initial cost equals the $MWTP_{FIT}$. In this case, the market price of 3kW roof-type PV system costs 80,000 Yuan, so the change of initial cost is based on 3kW system (for one set). The $MWTP_{FIT}$ *of* China (average), Beijing, Shanghai and Guangzhou are calculated as follow:

Table 10: $MWTP_{FIT}$ in China (Average), Beijing, Shanghai and Guangzhou

	China	Beijing	Shanghai	Guangzhou
Initial	(β_1) -0.372	(β_1) -0.428	(β_1) -0.371	(β_1) -0.329
	(t) -5.861	(t) -3.519	(t) -3.345	(t) -3.242
FIT	(β_2) 0.661	(β_2) 0.702	(β_2) 0.608	(β_2) 0.689
	(t) 3.705	(t) 2.095	(t) 1.949	(t) 2.386
No. of Observation	1000	334	333	333
ln L_β	-3432.2	-1106.7	-1104.6	-1195.7
ln L_0	-3615.4	-1198.0	-1166.5	-1237.2
McFadden Value	0.0506	0.0760	0.0531	0.0335
$MWTP_{FIT}$	1.7769	1.6402	1.6388	2.0942

Generally speaking, in China, the MWTP of FIT is 1.7769, namely to increase 1 Yuan's FIT (1 unit of FIT is 1 Yuan) equals to decrease 17,769 Yuan (1 unit of Initial Cost is 10^4 Yuan) in initial investment, or to increase 17,769 Yuan Yuan's investment subsidy. Similarly, Beijing is 16,402 Yuan, Shanghai is 16,388 Yuan, and Guangzhou is 20,942 Yuan (Figure 26). As a result, we can find the FIT has highest MWTP in Guangzhou, which means it is able to create a largest virtual price reduction and people in Guangzhou are most sensitive to the FIT policy compared with Beijing and Shanghai, as well as China average.

Figure 26: MWTP of FIT in China (Δ Yuan / kWh)



3.1.3.2 Marginal WTP of Risk

Similarly, the Marginal Willingness To Pay / MWTP of investment risk can be obtained as follow:

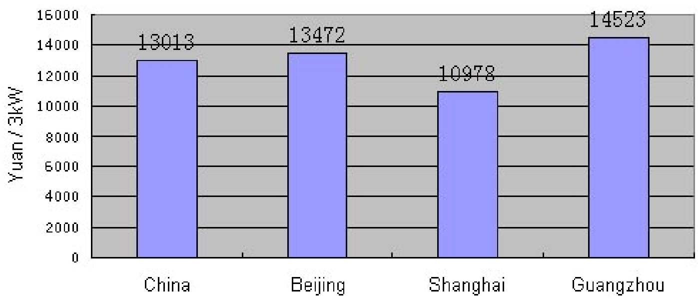
$$MWTP_{Risk} = \left(\frac{dV/d(Risk)}{dV/d(Initial)} \right) = \frac{\beta_3}{\beta_1} \qquad (3-8)$$

Table 11: $MWTP_{Risk}$ in China (Average), Beijing, Shanghai and Guangzhou

	China	Beijing	Shanghai	Guangzhou
Initial	(β_1) -0.372	(β_1) -0.428	(β_1) -0.371	(β_1) -0.329
	(t) -5.861	(t) -3.519	(t) -3.345	(t) -3.242
Risk	(β_2) -4.841	(β_2) -5.766	(β_2) -4.073	(β_2) -4.778
	(t) -7.161	(t) -4.449	(t) -3.452	(t) -4.429
No. of Observation	1000	334	333	333
ln L_β	-3432.2	-1106.7	-1104.6	-1195.7
ln L_0	-3615.4	-1198.0	-1166.5	-1237.2
McFadden Value	0.0506	0.0760	0.0531	0.0335
$MWTP_{Risk}$	13.013	13.472	10.978	14.523

Three levels of investment risks are designated in this research, namely "low, 10%", "moderate, 20%" and "high, 30%", therefore switch of one level, e.g. from low to moderate level, equals increase 0.1 unit (20% - 10%). Hereby, change of one level of investment risk equals change of 13013 Yuan in initial cost in China on average. Similarly, Beijing is 13472 Yuan, Shanghai is 10978 Yuan, and Guangzhou is 14523 Yuan (Figure 27). Therefore, in terms of investment risk, consumers in Guangzhou are most sensitive, and people in Shanghai are most tolerant to investment risk.

Figure 27: MWTP of Risk in China (Δ Risk Level)

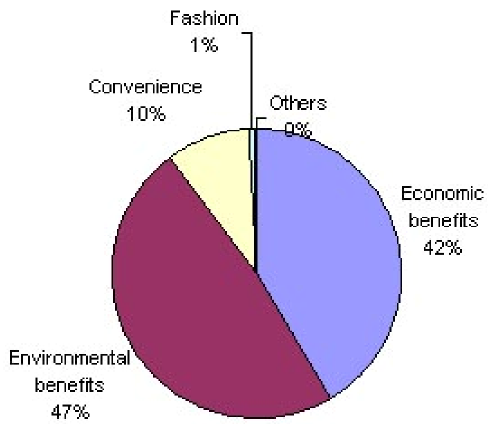


3.1.4 Results of open comments / questions

This online survey collects 1000 free style comments. Through primary screening process, 242 comments with substantial contents are selected.

"Environment Issue / Environment Protection / Energy Conservation" are the most frequently mentioned keywords, as many as 76 times, most of which think environmental problem is very important in China. It demonstrates a positive attitude towards environment friendly behaviors, showing the rising environmental awareness of Chinese people. This fits quite well to the participants' choice of their motivation to install solar PV system in Question 2-2 of the questionnaire, where 48.1% of them choose "Environment Benefits" as the most important reason (Figure 28).

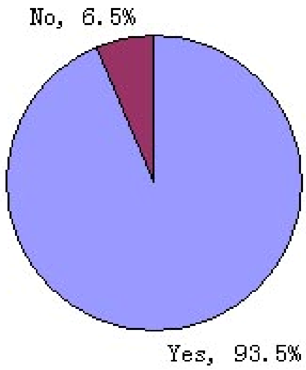
Figure 28: Motivation of PV System Adoption



However, despite of the improved environment awareness, there is still a large knowledge gap of residential PV system. 61 comments, second most frequently, are related to the enquiries of solar power and residential PV system. On one hand, it shows the high interests of potential future PV system adopters, on the other hand, it indicates the related promotion activities are still missing, or at least not effective.

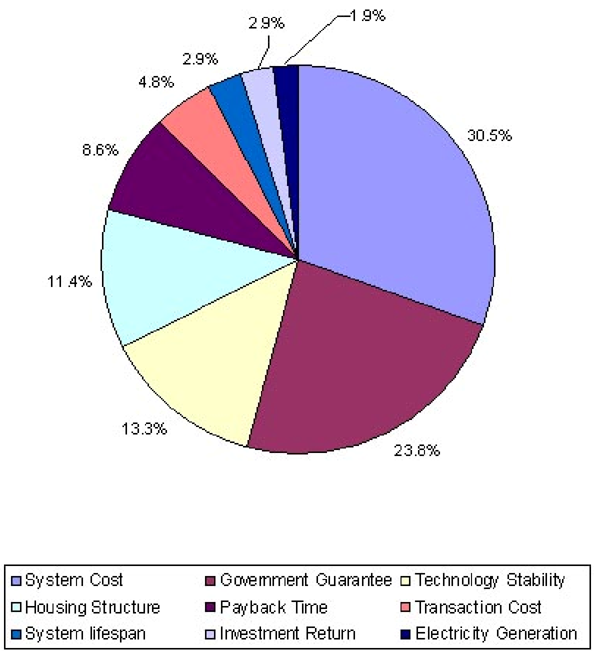
As indicated in Question 4-2, after taking the survey, 93% of the participants show their interests to install PV system in a foreseeable future (Figure 29). This corresponds also very well to their free comments. 39 comments, with the third top frequency, mention the importance to adopt residential PV system and to scale-up as soon as possible, by citing the key word of "Scale-up"

Figure 29: Choice to Install PV System in Future



Although strong interests and motivation are in position, scale-up appears not that easy. 21 persons think large scale introduction of PV system is "Not Promising / Very Difficult / Not Proper" by providing the following concerns: "Too Expensive / Too High Price", 32 votes; "Not Reliable Government / Policies, Not Clear Subsidy Rules", 25 votes; "Technology Stability", 14 votes; "Concerns Chinese Way of Housing Structure", 12 votes; "Too Long Payback Time", 9 votes; "High Transaction Cost", 5 votes; "System Lifespan", 3 votes; "Investment Return", 3 votes and "Electricity Generation", 2 votes (Figure 30).

Figure 30: Major Concerns of PV Power Scale-up



As indicated in the graph above, “System Cost” and “Government Guarantee” take more than half of the consumer’s concern. This proves again the significance of financial promotional policies in China, and meanwhile highlights the crucial role of government, namely to ensure their credibility of its subsidy guarantee, especially for those program like FIT, which needs long time commitment. Regarding the concerns on “Technology Stability”, most of the doubts are along with enquiries, which can be perceived as the problem of very limited information dissemination, rather than the substantial technological uncertainties.

All key words and their frequency are listed in the following table:

Table 12: Key Words and Their Frequency of Open Comments

Key Words	Frequency
Environment Issue / Environment Protection / Energy Conservation	76
solar power and residential PV system	61
Significant to Scale-up	39
Not Promising / Very Difficult / Not Proper	21
System Cost	32
Government Guarantee	25
Technology Stability	14
Housing Structure	12
Payback Time	9
Transaction Cost	5
System lifespan	3
Investment Return	3
Electricity Generation	2

3.2 Diffusion rate of PV scale-up in residential sector

In the previous chapter, the utility function of Chinese consumer’s preference on PV system introduction is calculated as follow:

$$V = -0.372 \text{ Initial} + 0.661 \text{ FIT} - 4.841 \text{ Risk} \qquad (3 - 9)$$

Combined with the Yoshida Diffusion Utility model (2 - 12), a compound utility function including key parameters like "Latent Electricity Generation Capacity", "Initial Cost", "FIT", and "Investment Risk" is in position[5]:

$$V = 5.12*10^{-3} \text{ Latent } -2.74*10^{-2} \text{ Initial } + 1.46*10^{-1} (\text{FIT}-23) - 8.04*10^{-2} \text{ Risk} - 9.51 \quad (3 - 10)$$

In this research, the average latent electricity generation capacity in China is defined as 1000 kWh / kW peak, which shares the same base as Yoshida model. The unit of initial cost in China is 10^4 Yuan / 3 kW and the Yoshida model uses 10^4 Yen / kW, so a correction factor[6] (13.3 / 3) is introduced. Similarly a factor of 13.3 is applied to transfer the unit from Yuan to Yen in the attribute of "FIT". Besides, the Yoshida model is calculated on the empty base of 23 Yen; therefore, 23 Yen is also deducted from the FIT in the function (3 - 9).

Latent electricity generation capacity is 1000 kWh / kW peak. In order to find out the relationship between annual diffusion rate and FIT, initial cost is set as constant value, namely 35.47 $*10^4$Yen / kW (8$*10^4$ Yuan / 3kW as the market price). Investment risk is assumed as 0. Therefore, the utility function reads as follow:

$$V = 1.46*10^{-1} (\text{FIT}-23) - 5.36 \quad (3 - 11)$$

And consequently, the Annual Diffusion Rate, namely Choice Probability / P is:

$$P = \frac{\exp[0.146*(FIT-23)-5.36]}{1 + \exp[0.146*(FIT-23)-5.36]} \quad \text{(China)} \quad (3 - 12)$$

Similarly, the diffusion rates in Beijing, Shanghai and Guangzhou are as follow:

$$P = \frac{\exp[0.135*(FIT-23)-5.36]}{1 + \exp[0.135*(FIT-23)-5.36]} \quad \text{(Beijing, Shanghai}^7\text{)} \quad (3 - 13)$$

$$P = \frac{\exp[0.172*(FIT-23)-5.36]}{1 + \exp[0.172*(FIT-23)-5.36]} \quad \text{(Guangzhou)} \quad (3 - 14)$$

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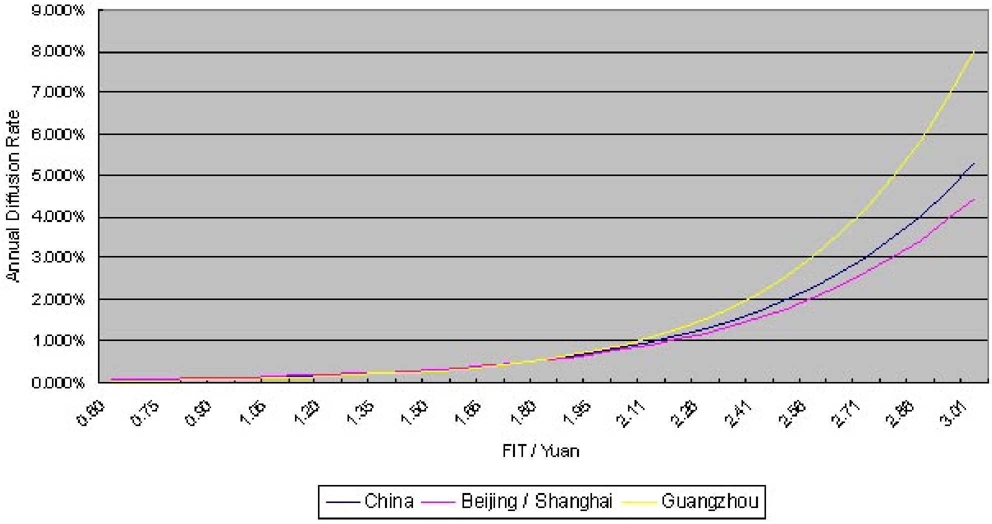
5 The combination is based on the common attribute, namely parameter of "Initial Cost"; therefore, these two utility functions are merged by converting two factors of Initial Cost into the same value.
6 13.3 is currency ratio of Chinese Yuan against Japanese Yen based on the date of 2010-1-18.
7 The cases of Beijing and Shanghai share very close result and their values at the magnitude of 0.001 are the same, therefore only one function is used to represent both cases.

Figure 31: Annual Diffusion Rate and FIT

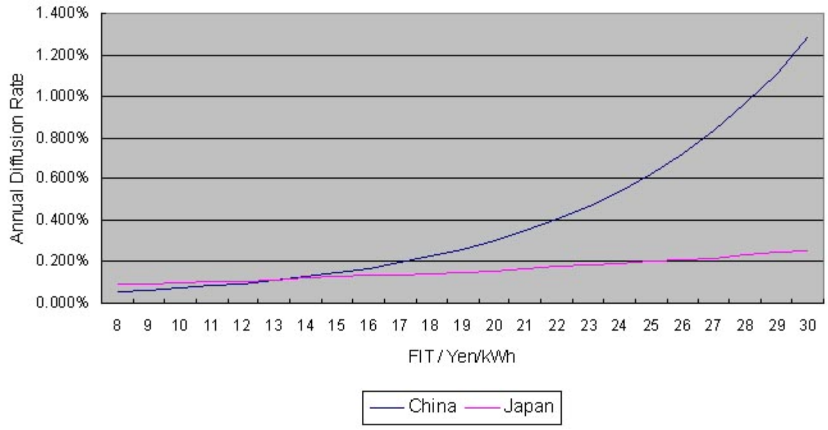


Given that no investment subsidy is provided (investment cost remains as market price), when low rate of FIT is introduced, the effects of stimulating annual diffusion rate is quite limited, nevertheless, while large intensity of FIT (more then 2 Yuan) is provided, its effect as promotion driver increases exponentially. Besides, from the graph it is again proved that Guangdong's consumer embraces the highest sensitivity towards FIT.

In addition, by comparing the situation in China and Japan[8], Chinese consumers demonstrate a much higher sensitivity to FIT (Figure 32). Main reason could be the high shadow feed-in premium caused by China's very low electricity price.

Figure 32: Comparison between China and Japan in Annual Diffusion Rate Graph

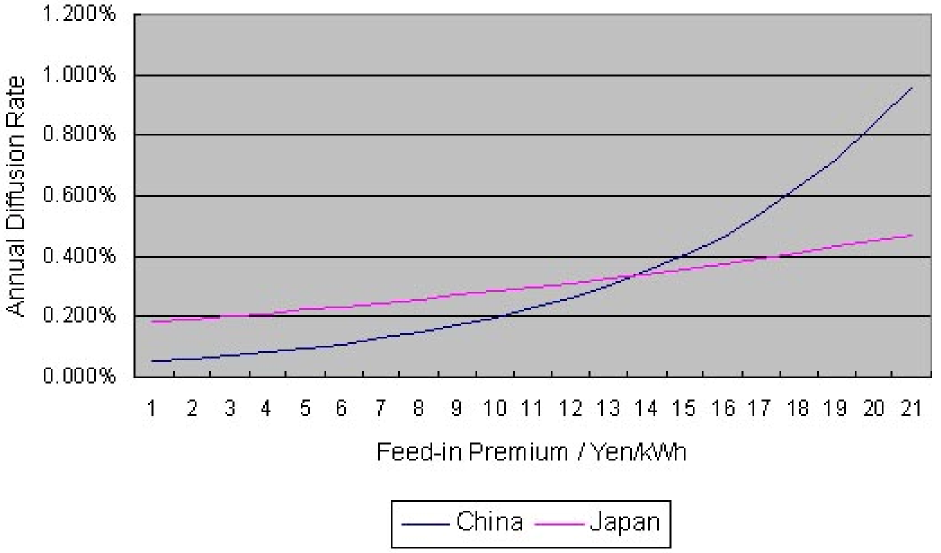
[8] Japan's case is based on the data of 2007 from Songphol's work, and China's case is based on result of this research in 2009, so this is just a rough comparison, intending to explain the possible relationship between high sensitivity of Chinese consumer's preference on FIT and their low electricity price.



As China is still a developing country, the average living expense is lower than developed countries like Japan. In addition, in order to maintain the social stability, Chinese government pays lots of attention to resource price, especially those that closely related to people’s daily life. Consequently, strict control is imposed to electricity price to maintain a relative low rate. Moreover, in China, in order to restrict the over consumption of electricity in industrial processing, the industrial electricity price is higher than residential price. All these above mentioned conditions result in the very low residential electricity price in China, e.g. in Shanghai, the most advanced region in China, its current residential electricity price is still as low as 0.61 Yuan (around 8 Yen), compared with 23 Yen in Japan in 2005.

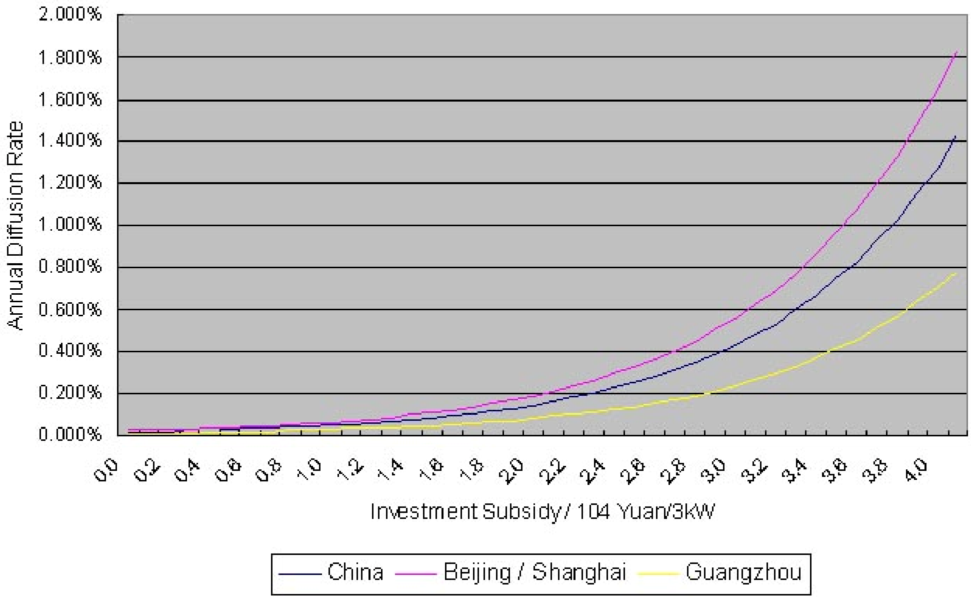
Therefore, if 40 Yen / kWh of FIT is introduced both in Japan and China, it equals to provide 17 Yen feed-in premium, nevertheless, in China the same rate of FIT means 32 Yen feed-in premium. As a result, another round of comparison based on the feed-in premium is conducted, and the difference in terms of sensitivity to “FIT” between two countries becomes milder (Figure 33).

Figure: Comparison between China and Japan in Annual Diffusion Rate Graph (revised)



Similarly, relationship between annual diffusion rate and investment subsidy is presented as follow (Figure 34):

Figure 34: Annual Diffusion Rate and Investment Subsidy



The graphs above show that citizens in Beijing and Shanghai are more favorable of investment subsidy than those in Guangzhou.

3.3 Moving forward towards different PV scale-up scenarios

3.3.1 Scenario design

3.3.1.1 Introduction

In this section, "Market Formation (Consumer Preference)", "Dissemination Effectiveness (Annual Diffusion Rate)" and "Cost of the Public (Policy Cost)" will be combined, and integrated scenario analysis is conducted to depict several future stories for policy reference.

In this research, Shanghai is chosen as the targeted scope of scenario analysis[9]. As one of the most prosperous city in China, Shanghai has be facing the severe electricity supply constrain, meanwhile, it is also the potential large solar power supplier. According to the policy proposal of "Shanghai's 100 Thousand PV Roof Plan", Shanghai embraces a large residential roof area of 200 million m^2, under rough estimation, if 20% of which, namely 40 million m^2 are able for PV installation, with the generation potential of 130 – 180W / m^2 (in this research, a constant value of 150W / m^2 is applied). Consequently, the potential overall capacity of PV scale-up program in Shanghai is 6000 MW with the designated dissemination target of 450 MW within 10 years.

By comparing the other large FIT programs in countries like Germany, Japan, Spain and etc, the proper length of FIT guarantee in China is 10 years with annual deduction rate of 5%. And lifespan of this scenario analysis is set for 10 years, namely from 2011 to 2020, which means within these 10 years, government subsidy program is open to the public.

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[9] China as a whole has the high difficulty in accurately estimating the valid residential roof areas in China (same reasons apply to the cases of Beijing and Guangzhou) and the high differentiation of income and consumption behaviors all over China. In addition, Shanghai Government has been working on the policy proposal of "Shanghai's 100 Thousand PV Roof Plan". Although FIT has not yet been in the agenda in this proposal, there is still plenty of reliable information on the background data of Shanghai's PV Installation. Therefore, this research chooses Shanghai as the research scope.

3.3.1.2 Drivers and uncertainties

As already mentioned in the first chapter, three factors are extracted to frame the idea of sustainable PV scale-up, so "Dissemination Effectiveness" and "Cost of the Public" becomes naturally the two core drivers towards future scenarios, and the decisive factors of "Market Formation", namely Investment Subsidy and FIT are set as the two major uncertainties.

In this case, dissemination effectiveness consists of two components: annual diffusion rate and cumulative installed capacity. As the direct outputs from the previous session, annual diffusion rate is able to be calculated by the diffusion modeling process; variable can be investment subsidy, FIT or even hybrid. Cumulative installed capacity / C_i (i = 1, 2, 3…) and newly installed capacity / N_i can be also obtained as follow:

$$C_i = C_{i-1} + N_i \qquad (3 - 15)$$

$$N_i = (6000 - C_{i-1}) * \text{Annual Diffusion Rate} \qquad (3 - 16)$$

Here, 6000 MW is the total potential residential roof capacity; Annual Diffusion Rate is also available when specific financial subsidy is chosen. C_1 is 0.

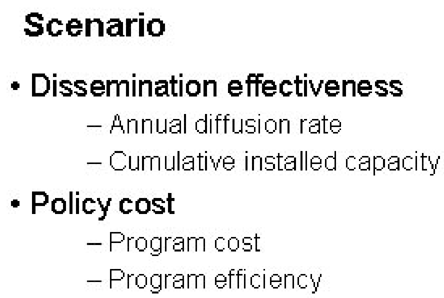
Policy cost also contains two parts: program cost and program efficiency. In order to get the program cost, cost of investment subsidy and cost of FIT should be calculated at the first place. Given that the yearly deduction rate is under consideration, both costs are calculated on the annual base. Besides, due to the special financial feature of FIT[10], two types of program cost are presented together, as a reference for policy makers.

Program efficiency is another key indicator, which is the ratio of policy output (cumulative installed capacity) and policy input (program cost). It has the unit of "W / Yuan".

[10] The subsidy payment of FIT is in the form of premium electricity purchase, which is based on the actual electricity generation; therefore, the payment will last continuously for another 10 years, ever since the installation is realized. In this case, program cost is calculation both in 10-year base and 20-year base (10 years of promotional program and another 10 to finalize the guaranteed payment)

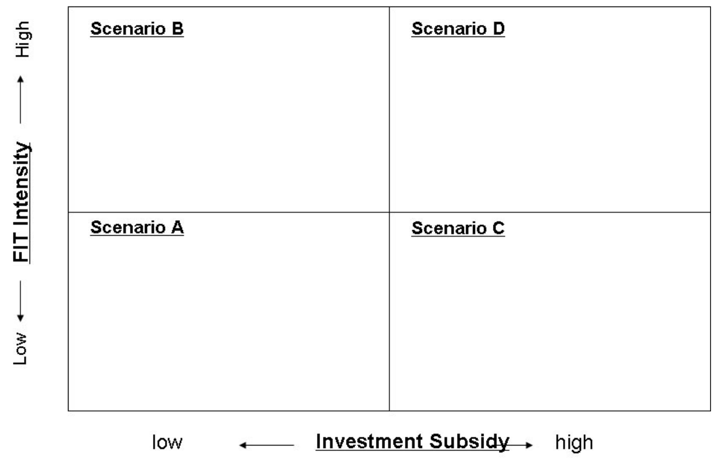
To put all elements into to consideration, the standardized scenario appears as the following format (Figure 35):

Figure 35: Format of Drivers in Scenario



The fundamental uncertainty is the intensity of investment subsidy and FIT, as well as their combination[11], therefore, the two attributes of uncertainty are allocated in the following axes (Figure 36).

Figure 36: Format of Uncertainties in Scenario

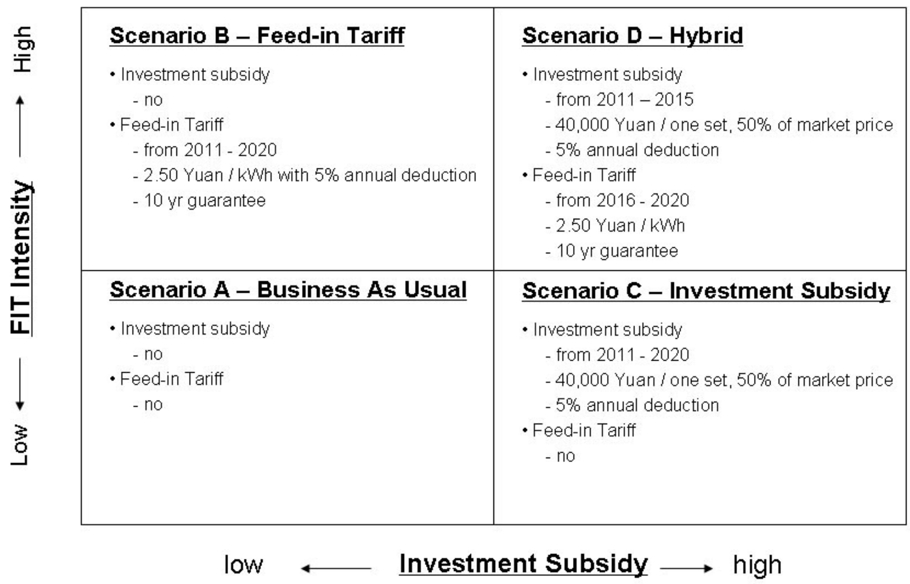


The high end of investment subsidy is based on Professor Cui's proposal (Cui 2009), which is mentioned in the formal 100 Thousand Roof plan. He suggests using investment subsidy, at the level of 50% market price, namely 4 * 10^4 Yuan / 3 kW. In order to encourage technology advancement, 5% of annual deduction is also introduced. The low end means no subsidy is provided.

[11] The hybrid type here means two-phase type subsidy, namely investment subsidy is applied in the first 5 years, and FIT for the second half.

On the dimension of FIT, the rate of 2.50 Yuan / kWh is assumed based on Professor Zhao's proposal (Zhao 2009). Similarly, it will request a 5% deduction annually. And the FIT is guaranteed by Government for 10 years. In the low end, no FIT is offered (Figure 37).

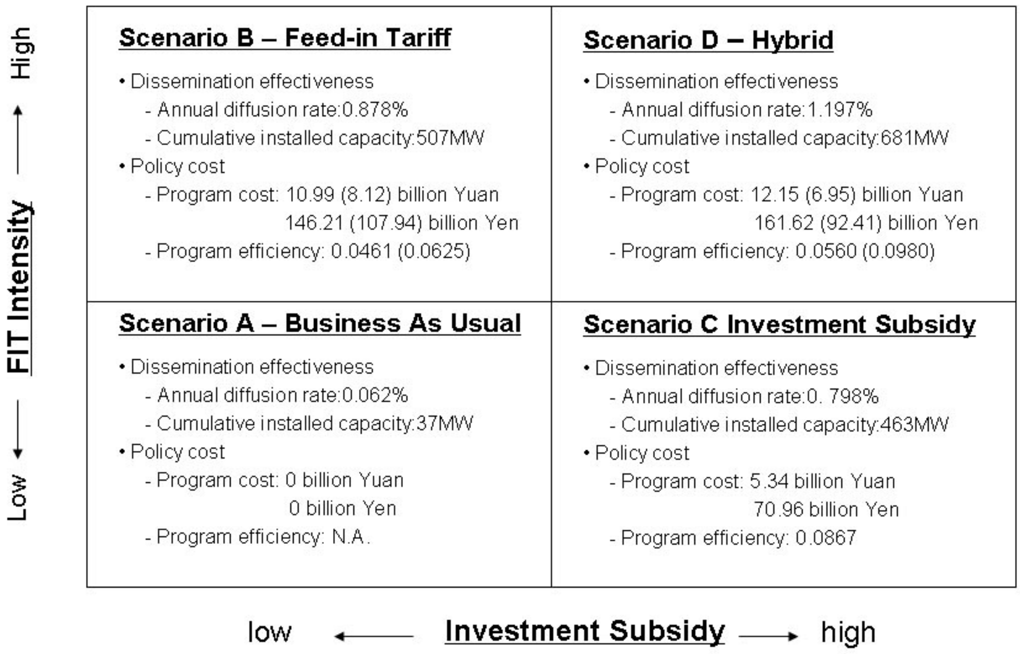
Figure 37: Explanation of Major Uncertainties



3.3.2 Scenario analysis

After simulation and calculation, the scenarios results are presented as follow (Figure 38):

Figure 38: Results of Scenario Analysis



Scenario A – BAU:

In this scenario, neither investment subsidy nor FIT is introduced. Consequently, its annual diffusion rate is as low as 0.062%, directly leading to very low cumulative installed capacity for only 37 MW, which is far below the dissemination target of 450 MW. It proves again, if no financial promotional driver is provided, solar PV scale-up turns out to be very difficult. Besides, it uses no government budget, so it is not able to calculate the program efficiency.

Scenario B – FIT:

In this scenario, attention has been paid to FIT, and no investment subsidy is provided. 2.5 Yuan / kWh FIT is a quite high intensity of support, which is 4 times as much as the current residential electricity price. Its feed-in premium is 1.89 Yuan (25 Yen), the same as the proposed new Japanese FIT law[12]. This results in 0.878% of annual diffusion rate. It is expected to fulfill the program target on the 8th year, namely in 2018 with the cumulative installed capacity of 465 MW and has 507 MW of cumulative installed capacity within the whole program lifespan. Despite of its remarkable dissemination effectiveness, it appears to be a very expensive project, with the total

[12] The new Japanese FIT law sets its tariff as 48 Yen / kWh, and the current residential electricity price is 23 Yen / kWh

payment of 10.99 billion Yuan (if the cost is only calculated according to the actually payment within the program lifespan, it costs 8.12 billion Yuan). Therefore, Scenario B has a rather low program efficiency, only 0.0461 W / Yuan (or 0.0625 W / Yuan at the high end).

Scenario C – Subsidy:

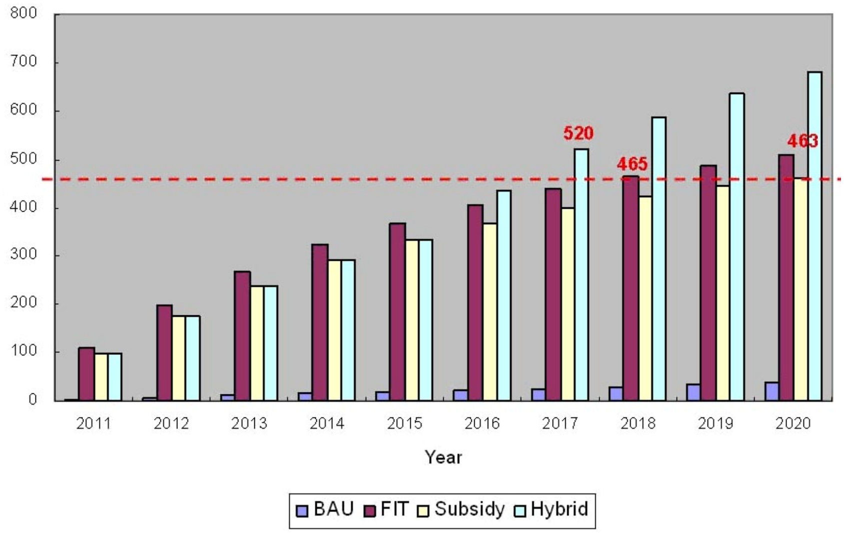
In this scenario, 50% of the initial cost is subsidized by government, however, with no feed-in premium. 0.798% of annual diffusion rate is expected. It will achieve the program target on the 10th year, namely 463 MW in total. It costs 5.34 billion Yuan for the government with the program efficiency of 0.0867. It proves to be most cost effective option.

Scenario D – Hybrid:

This is the adapted combination of the Scenario B and Scenario C and turns out to be the most effective scenario. It achieves the program target as early as the 7th year and ultimately reaches the total cumulative installed capacity of 681 MW. Also it bears a moderate level of program efficiency, with the high end of 0.098 W/Yuan and low end of 0.056 W/Yuan.

The scenario analysis proves again, financial promotional drivers are crucial to achieve the designated dissemination target. Both two actual proposals and the assumed hybrid option turn out to be effective enough to fulfill the program target (Figure 39).

Figure 39: Cumulative Installed Capacity of Different Scenarios



Regarding the program efficiency is, Scenario C demonstrates the best performance. Considering the current policy landscape in China, this kind of the investment subsidy is in the dominating position. The two existing national PV subsidy programs follow this track, namely 50% subsidy for the initial investment. One more reason worth to highlight is, direct investment subsidy can be designed and implemented in a relative convenient way, which is supposed to be the most sparking selling point, especially for the decision makers in China.

And in the contrast, the pure FIT, namely Scenario B seems to be too expensive to practice in China. Moreover, according to the free comments of survey participants, it is still lack of enough information dissemination activities, which leads to the low willingness to participate. Nonetheless, worth to mention, if considering the balance between the excellent dissemination effectiveness and acceptable efficiency, the Scenario D can also be a good candidate proposal in future. Besides, the first 5 years of investment subsidy period can also serve as the buffer phase, on one hand promote the scale-up process, and on the other hand, through the actual installation activities, bunch of dissemination information can spread rather effectively. Furthermore, the substantial payment of investment subsidy can also be a test stone for the long term guarantee.

4 Conclusions and future work

4.1 Conclusions

In order to satisfy various development and environmental requests, China needs to scale up its solar PV power in residential sector. And its sustainability should be ensured by the systematic consideration of consumer's preference, dissemination effectiveness and cost for the public.

Consumers in different regions in China have their own preference on various promotional drivers. Citizens in Guangzhou have the highest MWTP of FIT, which means they are most sensitive to FIT policy. Therefore, it will be an ideal choice to launch the trial FIT program in Guangzhou. However, Guangzhou is also the place that has the highest MWTP of investment risk. As a result, it is very important for government to provide well designed and explained promotional policy program as well as reliable long term commitment if program like FIT is employed, to reduce the system risk, and consequently enhance the dissemination effectiveness. In the contrast, Beijing and Shanghai can be good candidates, when investment subsidy is employed, and they are also more tolerant to uncertainty.

From the annual diffusion rate curve, it shows, while low rate of FIT is employed, it is not that effective in the scale-up process, but when FIT increases, especially then it is more than 2 Yuan / kWh, the corresponding diffusion rate increase exponentially. Similar condition also happens, if more than 25% initial investment is provided by government.

Generally speaking, consumers in China are more sensitive to FIT than those in Japan. Apart from the behavioral preference, the low residential electricity price is the major reason. Therefore, when the decision maker is planning for financial promotional policy like FIT, it is important to be aware of the difference between feed-in tariff in terms of absolute value and feed-in premium in terms of relative value. Appropriate rate of FIT should be offered, at one hand, speed up the scale-up process, and on the other hand, not cost too much for the public.

Those pictures depicted from scenario analysis show that, in order to ensure the sustainability of PV scale-up, the balance of dissemination effectiveness and cost for the public should be well considered. Despite of the considerable effectiveness of FIT approach, its low efficiency should be always bear in mind, which could probably undermine its sustainability, like the example in Spain. Investment subsidy has rather balanced performance, and furthermore, due to its feature of low requirement in design and implementation, is more appropriate in China at this stage. Worth to mention, the hybrid approach has the potential to serve as the buffer phase, on one hand promote the scale-up process, and on the other hand, through the actual installation activities, bunch of dissemination information can spread rather effectively. Besides, if the first phase is successfully implemented, it can ease citizens' worry on government credibility in long term guarantee.

4.2 Future work

Regarding the future work, from the methodology perspective, it is worth trying to embrace more elements such as technological concerns, reduction of system cost, to ensure the sustainability of PV scale-up. Specific attention could be paid on the relationship between scale-up effect and substantial price reduction through technology advancement. In addition more work can be conducted to improve the modeling design so that it could be more adaptive to China's low tariff system.

From the empirical point of view, "Two Steps" can be put into consideration. One step backward, it is very useful to study Japan's experience in initiating their scale-up program 15 years ago, which could be a good lesson. And one step further, it is very interesting to extend the research focus to industrial and public utility group. In this case, instead of willingness to pay, willingness to invest, namely the preference of system investor is the key factor to drive the PV scale-up, and this time in non-residential sector. Besides, due to the special tariff system, industrial electricity price is higher than residential one, and also put the scale effect into consideration;

those stakeholders seem to have larger motivation to join the PV group. It is also interesting to pay attention to the rural households where the electricity price is also higher than normal tariff.

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Appendix I: Questionnaire in English

A Study on Consumer Behavior towards Solar Power System

This survey is conducted by Tokyo University. By answering this survey, you help us understand how consumers make a decision to integrate solar power system to their residence. And based on your comments, we will try to formulate proper policy recommendation for the government to improve their subsidy policy.

Part 1- Demographic Questions

1. Age

☐ < 20 ☐ 20 – 29 ☐ 30 – 39 ☐ 40 – 49
☐ 50 – 59 ☐ 60 – 69 ☐ > 70

2. Gender

☐ Male ☐ Female

3. Where are you living? ____________ Province __________City

4. Do you own a house/apartment? ☐ Yes ☐ No

5. Do you intend to buy a house/apartment within 2-3 years from now? ☐ Yes ☐ No

6. Annual household income

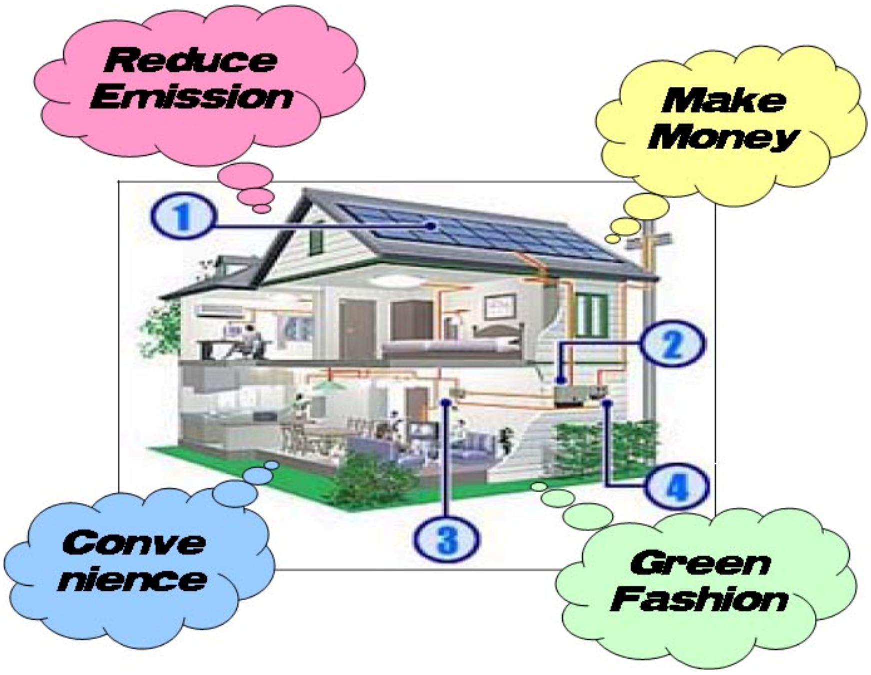
☐ < ￥50,000 ☐ ￥50,000 –￥100,000 ☐ ￥100,000 –￥200,000
☐ ￥200,000 –￥500,000 ☐ ￥500,000 –￥1000,000 ☐ ￥1000,000 –￥2000,000
☐ > ￥2000,000 ☐ Don't know / Decline to state

7. Occupation

☐ Private Sector Employee ☐ Government / State Owned Company(Institute) Employee
☐ Business Owner ☐ Freelance / Part-time Employee
☐ Student ☐ Farmer
☐ Unemployed ☐ Others

Part 2 - Background Information

Solar power system is now available also for residential usage. By installing one small scale (3kW) solar power system on the roof of your house or apartment, it can generate approximately 3000 kwh per year, which can not only cover all your electricity demand, but also generate some extra revenue, if appropriate feed-in tariff is introduced by government. And the clean solar electricity can reduce 2.36 ton of CO_2 emission per year, around 87% of your total CO2 emission. While possessing your own power station, you are also a green pioneer at the same time.



① Solar PV panel
② Inverter
③ Power distributer
④ Electricity meter

1. Have you installed a solar cell power system to your residence?

☐ Yes ☐ No

2. If you want to install a solar cell power system, which is the most important reason?

☐ Economic benefits ☐ Environmental benefits ☐ Convenience ☐ Fashion
☐ Others ____________ (please specify)

3. What do you think of the following statements?

a. "I think environmental problems have a direct effect on my daily life."
☐ Yes ☐ Maybe ☐ No ☐ I don't care

b. "I think economical development should be put before environmental conservation."
☐ Yes ☐ Maybe ☐ No ☐ I don't care

c. "I usually cut down power consumption by turning down air-conditioning or heating"
☐ Yes ☐ Maybe ☐ No ☐ I don't care

d. "I buy environmentally friendly products even if they cost a little bit more"
☐ Yes ☐ Maybe ☐ No ☐ I don't care

e. "I separate most of my waste for recycling."
☐ Yes ☐ Maybe ☐ No ☐ I don't care

f. "I use recycled products if available."
☐ Yes ☐ Maybe ☐ No ☐ I don't care

g. "I Choose locally produced products or groceries, while avoiding products that come from far away."
☐ Yes ☐ Maybe ☐ No ☐ I don't care

h. "I think it is acceptable to pay a little more in taxes to help protect the environment."

☐ Yes ☐ Maybe ☐ No ☐ I don't care

Part 3 – Purchase Options of Solar Power System

In this part, you will be presented with the 3kw photovoltaic system purchase scheme.

Based on the detail of the schemes, you are asked to make a decision whether or not to install a photovoltaic system on your rooftop and if you choose to install, which scheme would you want to participate in.

To participate in a purchase scheme:

You must first pay the installation cost for the system indicated in the scheme. Once the installation is completed, you can sell the electricity generated from your photovoltaic system back to your electricity supplier, at a predetermined rate / Feed-in Tariff indicated in the scheme.

This rate tends to be higher than the "electricity buy rate" (the rate for which you pay when you buy electricity from your electricity supplier) and is guaranteed by government for 15 years. As a result, you can cut down your electricity bill or even earn extra revenue without paying for your electricity at all. The estimated net revenue within the policy life cycle (15 years) will be also given as a reference.

The payback period (the number of years required to recover the cost of an investment) for each scheme is also calculated for your convenience.

The investment risk consists of "system risk", "technology risk" and "transaction risk", namely the uncertainty of policy stability, technology stability and inconvenience in transaction.

There are three questions in this part. There is no correct answer.

Please read the following questions carefully, consider the detail of the schemes presented below, and choose your most acceptable purchase scheme.

Example

If the most acceptable scheme within the portfolio is to set up your solar power system under the initial cost of **￥80,000**, with the feed-in tariff of **￥2.2** and the payback time of **12.1 years**, under the investment risk of **30%**, you choose the purchase scheme as follow:

	Purchase Scheme A	Purchase Scheme B	Purchase Scheme C
Initial Cost	**￥80,000**	￥40,000	I don't want to choose either A or B.
Feed-in Tariff	**￥2.20**	￥1.60	
Payback Time	**12.1 years**	8.3 years	
Investment Risk	**30%**	20%	
	☐	☐	☐

Please read the upcoming questions carefully, and choose your preferred purchase scheme. There is no correct answer, so please just choose what you think is most appropriate from your own perspective. Besides, you can only choose only **one** scheme within the three.

Portfolio 1：

Purchase Scheme A	Purchase Scheme B	Purchase Scheme C
Initial Cost：￥80,000 （market price）	**Initial Cost：￥60,000** （75% of market price）	
Feed-in Tariff: ￥2.8 （Net revenue: ￥46,000 ）	**Feed-in Tariff: ￥1.6** （Net revenue: ￥12,000 ）	**I don't want to choose either A or B.**
Payback Time: 9.5 years	**Payback Time: 12.5 years**	
Investment Risk: 20%	**Investment Risk: 10%**	
☐	☐	☐

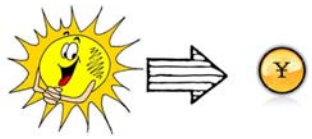
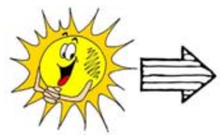
Portfolio 2：

Purchase Scheme A	Purchase Scheme B	Purchase Scheme C
Initial Cost：￥80,000 （market price）	**Initial Cost：￥40,000** （50% of market price）	
Feed-in Tariff: ￥2.2 （Net revenue: ￥19,000）	**Feed-in Tariff: ￥1.0** （Net revenue: ￥5,000 ）	**I don't want to choose either A or B.**
Payback Time: 12.1 years	**Payback Time: 13.3 years**	

Investment Risk: 20%	Investment Risk: 30%	

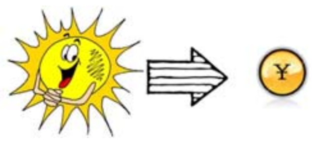
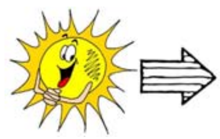
☐ ☐ ☐

Portfolio 3：

Purchase Scheme A	Purchase Scheme B	Purchase Scheme C
 **Initial Cost：￥60,000** （75% of market price）	 **Initial Cost：￥40,000** （50% of market price）	**I don't want to choose either A or B.**
 **Feed-in Tariff: ￥2.8** （Net revenue: ￥66,000 ）	 **Feed-in Tariff: ￥1.6** （Net revenue: ￥32,000 ）	
 **Payback Time: 7.1 years**	 **Payback Time: 8.3 years**	
 **Investment Risk: 30%**	 **Investment Risk: 20%**	

☐ ☐ ☐

Portfolio 4：

Purchase Scheme A	Purchase Scheme B	Purchase Scheme C
 **Initial Cost：￥80,000** （market price）	 **Initial Cost：￥40,000** （50% of market price）	**I don't want to choose either A or B.**
 **Feed-in Tariff: ￥2.2** （Net revenue: ￥19,000 ）	 **Feed-in Tariff: ￥1.6** （Net revenue: ￥32,000 ）	
 **Payback Time: 12.1 years**	 **Payback Time: 8.3 years**	

Investment Risk: 10%	**Investment Risk: 30%**	

☐ ☐ ☐

Portfolio 5：

Purchase Scheme A	Purchase Scheme B	Purchase Scheme C
Initial Cost：￥80,000 （market price）	**Initial Cost：￥40,000** （50% of market price）	**I don't want to choose either A or B.**
Feed-in Tariff: ￥2.8 （Net revenue: ￥46,000 ）	**Feed-in Tariff: ￥1.6** （Net revenue: ￥32,000 ）	
Payback Time: 9.5 years	**Payback Time: 8.3 years**	
Investment Risk: 20%	**Investment Risk: 10%**	

☐ ☐ ☐

Portfolio 6：

Purchase Scheme A	Purchase Scheme B	Purchase Scheme C
Initial Cost：￥60,000 （75% of market price）	**Initial Cost：￥40,000** （50% of market price）	**I don't want to choose either A or B.**
Feed-in Tariff: ￥2.2 （Net revenue: ￥39,000 ）	**Feed-in Tariff: ￥1.6** （Net revenue: ￥32,000 ）	
Payback Time: 9.1 years	**Payback Time: 8.3 years**	

 **Investment Risk: 10%**	 **Investment Risk: 20%**	
☐	☐	☐

Part 4 - Feedbacks

1. How did you find the questions in this our survey?

☐Very Difficult ☐Difficult ☐Normal ☐Easy ☐Very Easy

2. After this survey, would you like to purchase your own solar power system, or in the foreseeable future?

☐ Yes ☐ No ☐ Not sure, need further consideration

3. In order to have your own residential solar PV power station, also as a contribution to China's sustainable development, at the maximum, how much are you willing to pay for a photovoltaic system to be installed to your house? ￥___________

(Reference market price is ￥80,000)

4. As the last question, do you have any comments or suggestions regarding our survey?

____

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Again, thank you very much for your cooperation!

Appendix II: Questionnaire in Chinese

关于家用小型太阳能光伏电站的消费者选好研究

这项网络调查是由东京大学在读的中国学生设计进行的非商业性质的学术研究。通过此次问卷调查，旨在更深入的理解中国消费者对于购买使用家用小型太阳能光伏电站的行为偏好，为政府将来制定更科学的清洁能源推广政策提供第一手辅助资料。

对于您在问卷中涉及的个人信息，我们将严格保密。您大概需要10-15分钟左右的时间完成这份调查问卷。再一次，感谢您的合作与支持！

第一部分 基本信息

1、年龄

☐ < 20岁 ☐ 20 – 29岁 ☐ 30 – 39岁 ☐ 40 – 49岁

☐ 50 – 59岁 ☐ 60 – 69岁 ☐ > 70岁

2、性别

☐ 男 ☐ 女

3、您的居住地 ________ 省/直辖市 __________市

4、您现在拥有一套具有独立屋顶使用权的住房吗？（包括平房，洋房，普通顶层公寓房等，可以是按揭中） ☐ 是 ☐ 否

5、您打算在两到三年内购买这样的住房吗？ ☐ 是 ☐ 否

6、您家庭的年收入

☐ < 5万 ☐ 5万 – 10万 ☐ 10万 – 20万

☐ 20万 – 50万 ☐ 50万 – 100万 ☐ 100万 – 200万

☐ > 200万 ☐ 不清楚 / 保密

5、您的职业

☐ 企业雇员 ☐ 政府/事业单位

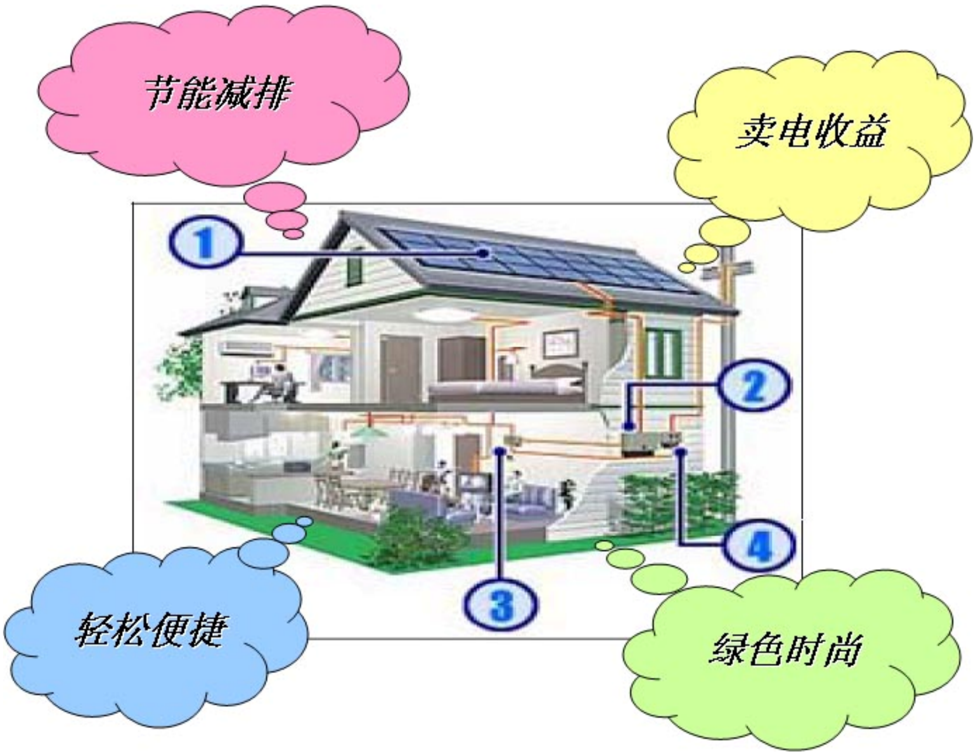
☐ 私营企业主 ☐ 自由职业者/打工者

☐ 学生 ☐ 务农

☐ 无业 ☐ 其他

第二部分 背景信息

作为新一代绿色低碳能源方式，小型太阳能光伏电站已经开始向家庭用户普及。按我国平均的日照时间，只要您在您家的屋顶上安装一套3千瓦的小型太阳能发电系统，每年预计可以发电3000度。这些太阳能绿色电力一方面可以完全满足您的家庭日常用电需求，另一方面，配合政府提供的合适的卖电补贴，您还可以获得一笔不小的绿色收入。同时，清洁的太阳能电力每年将会为您的家庭减少2.36吨的二氧化碳排放量，占您全家总排放量的87%。您在拥有属于自己的发电站的同时，也将成为倡导绿色环保的先锋。



①光电（太阳能电池）模块：光电模块将太阳能转换成电能。

②逆变器（电力调节器）：变换器将光电模块产生的直流电转换成交流电并自动控制整个系统。

③室内配电盘：配电盘向家用电器输送适当的电负载。

④电度表：计量输上电网的电量。

1、 您家里是否装了家用小型太阳能电站？

☐ 是　　☐ 否

2、 如果您想装一套家用小型太阳能电站，最主要是基于以下哪个原因？

☐ 经济效益　　☐ 环保效益　　☐ 方便舒适　　☐ 时尚潮流　　☐ 其他________

3、 在下面的各种说法中，请选出适合您的选项

a. “我认为环境问题对我的日常生活有直接的影响。”

☐ 是　　☐ 可能吧　　☐ 否　　☐ 我不在乎

b. “我认为经济发展不应该以牺牲环境为代价。”

☐ 是　　☐ 可能吧　　☐ 否　　☐ 我不在乎

c. “我经常通过调节合适的空调或是暖气温度来省电。”

☐ 是　　☐ 可能吧　　☐ 否　　☐ 我不在乎

d. “即使价格贵一些，我也会购买环保型产品。”

☐ 是 ☐ 可能吧 ☐ 否 ☐ 我不在乎

e. “我会自觉对家里垃圾进行分类后再分别处理。”

☐ 是 ☐ 可能吧 ☐ 否 ☐ 我不在乎

f. “如果可能的话，我会尽量使用可再生产品，像可再生纸，布袋，非一次性餐具。”

☐ 是 ☐ 可能吧 ☐ 否 ☐ 我不在乎

g. “我在购物时，会尽量选择本地产品，而不是长途运输过来的产品。”

☐ 是 ☐ 可能吧 ☐ 否 ☐ 我不在乎

h. “为了保护环境，我可以适当得多交一些环保税。”

☐ 是 ☐ 可能吧 ☐ 否 ☐ 我不在乎

第三部分 正式问卷

在调查问卷的这个部分，您可以决定是否购买您自己家用的小型太阳能光伏电站（3千瓦屋顶型），并选择适合自己的购买方案。

在回答每个问题时，您将面对三种购买方案。“购买方案A”和“购买方案B”中您将综合考虑四种因素，即：初期投资，卖电价格，投资回报期和投资风险。如果A和B方案中没有适合您的，可以选择不购买，即“购买方案C”。但是在每个问题的三种购买方案中，您只能选择一项。

“初期投资额”：指购买并安装一套3千瓦屋顶型太阳能光伏电站的一次性费用成本。

“卖电价格”：在您的太阳能电站开始运行后，电站发的电将输送给国家电网，并以高于一般家庭用电电价的价格卖给当地电力公司，从而产生一定的经济效益。按照国际惯例，政府将以国家信誉做担保连续15年以溢价购买太阳能电。

“投资回报期”：指使您的3千瓦屋顶型太阳能光伏电站产生的经济效益等于最初的投资费用（即上述的初期投资额）时所需要的时间。例：如果您的投资回报期为10年，那么从第11年开始，太阳能电站产生的经济效益即为您的纯收益，直至电站报废。

“投资风险度”：体现购买并安装使用家用太阳能电站的风险。这里的风险主要包括“政策风险”，即：政策稳定性；“技术稳定性风险”，即：电站运行产生技术故障的风险，比如电站无法有效联网，发电量少于预期，或电站提前报废等；和“交易成本风险”，即：补贴申请手续过于复杂，或当地电力公司不合作（不愿或拖延购买太阳能电站发的电）等。在购买选项中的不同“投资风险度”值包含的意义如下：投资风险为“10%”为较低风险；投资风险为“20%”为一般中等风险；投资风险为“30%”为较高风险。

<u>购买方案范例：</u>

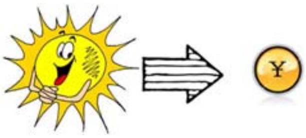
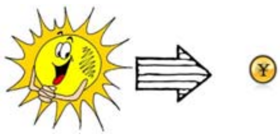
如果您认为在各种选项中，您最可以接受初期投资额为**<u>8万元</u>**的太阳能光伏电站，按照**<u>2.2元</u>**每度的价格卖电，预计投资回报期为**<u>12.1年</u>**，投资风险为**<u>30%</u>**的购买方案，那么您的选择如下：

	购买方案A	购买方案B	购买方案C
初期投资额	**8万元**	4万元	A和B都不适合，所以我选择不购买。
卖电价格	**2.2元/度**	1.6元/度	
投资回报期	**12.1年**	8.3年	

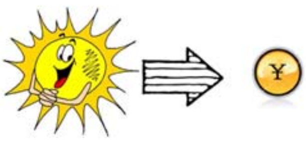
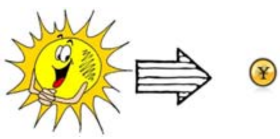
投资风险度	**30%**	20%	
	☐	☐	☐

请仔细阅读以下各个问题，并选择您自己的购买方案。下面的问题都没有正确答案，请您选择最适合自己的购买方案，但在这三种购买方案中，您只能选择一项。

问题1：

购买方案A	购买方案B	购买方案C
 **初期投资：8万元** （市场价格原价）	 **初期投资：6万元** （市场价格的75%）	
 **固定卖电价格：2.8元/度** （政府承诺期内卖电额外收益：4.6万元）	 **固定卖电价格：1.6元/度** （政府承诺期内卖电额外收益：1.2万元）	**A和B都不适合，所以我选择不购买。**
 **投资回报期：9.5年**	 **投资回报期：12.5年**	
 **投资风险：20%**	 **投资风险：10%**	
☐	☐	☐

问题2：

购买方案A	购买方案B	购买方案C
 **初期投资：8万元** （市场价格原价）	 **初期投资：4万元** （市场价格的50%）	
 **固定卖电价格：2.2元/度** （政府承诺期内卖电额外收益：1.9万元）	 **固定卖电价格：1.0元/度** （政府承诺期内卖电额外收益：0.5万元）	**A和B都不适合，所以我选择不购买。**

投资回报期：**12.1**年	投资回报期：**13.3**年	
投资风险：**20%**	投资风险：**30%**	
☐	☐	☐

问题3：

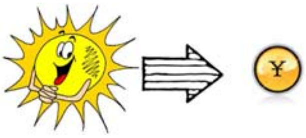
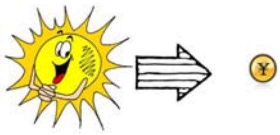
购买方案**A**	购买方案**B**	购买方案**C**
初期投资：**6**万元 （市场价格的75%）	初期投资：**4**万元 （市场价格的50%）	**A**和**B**都不适合，所以我选择不购买。
固定卖电价格：**2.8**元/度 （政府承诺期内卖电额外收益：6.6万元）	固定卖电价格：**1.6**元/度 （政府承诺期内卖电额外收益：3.2万元）	
投资回报期：**7.1**年	投资回报期：**8.3**年	
投资风险：**30%**	投资风险：**20%**	
☐	☐	☐

问题4：

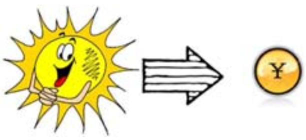
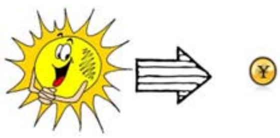
购买方案**A**	购买方案**B**	购买方案**C**
初期投资：**8**万元 （市场价格原价）	初期投资：**4**万元 （市场价格的50%）	**A**和**B**都不适合，所以我选择不购买。
固定卖电价格：**2.2**元/度 （政府承诺期内卖电额外收益：1.9万元）	固定卖电价格：**1.6**元/度 （政府承诺期内卖电额外收益：3.2万元）	

 投资回报期：**12.1年**	 投资回报期：**8.3年**	
 投资风险：**10%**	 投资风险：**30%**	
☐	☐	☐

问题5：

购买方案A	购买方案B	购买方案C
 初期投资：**8万元** （市场价格原价）	 初期投资：**4万元** （市场价格的50%）	
 固定卖电价格：**2.8元/度** （政府承诺期内卖电额外收益：4.6万元）	 固定卖电价格：**1.6元/度** （政府承诺期内卖电额外收益：3.2万元）	**A和B都不适合，所以我选择不购买。**
 投资回报期：**9.5年**	 投资回报期：**8.3年**	
 投资风险：**20%**	 投资风险：**10%**	
☐	☐	☐

问题6：

购买方案A	购买方案B	购买方案C
 初期投资：**6万元** （市场价格的75%）	 初期投资：**4万元** （市场价格的50%）	
 固定卖电价格：**2.2元/度** （政府承诺期内卖电额外收益：3.9万元）	 固定卖电价格：**1.6元/度** （政府承诺期内卖电额外收益：3.2万元）	**A和B都不适合，所以我选择不购买。**

 **投资回报期：9.1年**	 **投资回报期：8.3年**	
 **投资风险：10%**	 **投资风险：20%**	
□	□	□

第四部分 信息反馈

1、您觉得本次调查问卷的难易程度如何？

□很难　□有点难　□普通　□比较简单　□很简单

2、经过本次调查后，您是否开始考虑购买一套家用小型太阳能电站了？

□ 是　□ 否　□还需要再考虑一下

3、 为了购买并安装使用一套属于您自己的家用小型太阳能电站，同时也是支持国家的低碳环保事业，您愿意支付的最高心理价位是？ ￥ ________ 元 （参考市场价格为8万元）

4、最后，对于此次问卷调查您还有什么建议和意见？

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我们期待能尽早受到您的回复，再一次感谢您的支持与合作！

Appendix III: Free Comments from the Survey

- 关键是投资回收期和政府的担保问题
- 政府应该给予支持
- 投资过高，回报低，很难推广。
- 问题在深入一些
- 能源很重要,节能很需要.
- 对太阳能产品的介绍不足
- 支持环保事业，造福人类！！
- 一年 3000 度有些小，故障率低最重要。
- 具体说明该项目对家庭的用电方面有什么影响
- 回报期太长
- 在城市的洋房，公寓，高层楼宇，有可能搞这个吗？！
- 挺好，让我了解了环保能源
- 环保很重要，加油！
- 环保是大家都应该做的事情。
- 该调查产品新颖，内容吸引人，容易产生共鸣。希望以后多提供此类关于新产品的调查。
- 這個方案很不錯，環保，可以多多推廣!
- 想对家用小型太阳能光伏电站有更进一步的了解，不知哪里能找到这些信息
- 希望这种产品能够尽快为保护环境体现自己的优势。
- 有关环境的应给以支持了
- 建议国家制定好的补贴和优惠政策和实施细则
- 为了环保,大家应该尽力.
- 调查很实际 切合我们得实际生活，本人觉得太阳能对环保做很大贡献，应该提倡
- 很好，使我了解了一项不错的环保计划。不过可能对此发电器还是了解不多
- 产品的权威以及产品的性能没有详细的介绍
- 太阳能发电站我很喜欢，贵公司的产品我一定会大力支持！
- 虽然是对环保有益的很有创意的一件事，但是我认为在中国目前的国情好象还不是很现实。
- 调查很好,让我们更加关注环保.
- 挺有意义的
- 希望太阳能在发电方面能稳定，风险小一些，还有希望在卖的电度方面能有一些保证。
- 最好价格不要太高
- 支持环保事业
- 让我有了新的认识，今后思路会多转向环保事业
- 关于电的储存未提及，用户具体收益存在不确定性建议问题站在用户角度还不是光是考虑市场
- 应该推广

- 希望能够普及，让我们生活变得更美好。
- 通过这次调查能更好的了解太阳能电站，希望以后继续这样的环保调查。
- 技术上如何解决?
- 非常好，但是不太实际
- 增加一些概念的解释
- 中国很多家庭住宅都是楼房，并没有屋顶，适用人群太少了
- 其实　有这么好的产品国家应该　大力推广．．老百姓都会自己算的．．更主要的是能对我们生活的环境改变很多．．．现在社会上好多东西都有了创新，问题是很多好的发明和对环境改变很好的都没有推广，，希望不仅仅是调查　而是要推广到实际生活中去．．
- 希望能详细的介绍一下产品的信息
- 本次调查对于我们老年人来说是很不适合的，我们不愿意用好几年才收回成本，虽然我们也很支持环保。
- 主要还是要宣传功能，另外要有样品展示
- 希望除了可以电以外还可以提供一些别的附加功能
- 希望此设备转换效率和稳定性再高些。
- 经过这个调查后觉得这样的方案真不错，只不过自己不太可能拥有带独立屋顶的住房
- 节能产品的推广势在必行的。
- 希望能够可以让我们每个人真正关注环境
- 很好，让我了解了多点太阳能小型发电方面的市场信息。谢谢！
- 提倡环保，要大力推广
- 给我一个参考
- 很好的调查话题，在环保的大前提下，我们人类都应该讲环保。
- 最好有一些已经成型商品的相关介绍
- 希望尽快实施
- 这个环保创意产品比较有吸引力，但不知技术成熟度如何，是否实用，维护如何
- 如果可以，从格再低一点会更吸引人
- 家庭小型电站，如果能有非屋顶式的，如墙面型的更好。屋顶型的受居住环境太大。
- 对问卷没有任何问题。
- 还挺有意思的，支持环保事业
- 从内心来说我看到这个方案很感兴趣，现在每个人都有责任为环保事业作出自己的贡献，当然前提还是尽自己的能力。可是此件事还是不太可靠，你投资了好几万元，国家能为你的事担保么？多余的电进国家电网好象不太可能的事情，都这样供电局他还能赚到你的钱？他能愿意么？
- 希望推出更多比较适合平民化的方案
- 希望能对所调查的小型太阳能电站多一些介绍，并且可以加一些举例。
- 这个问卷不错，但还需要更详细的一些内容，让我们能更多的了解太阳能电站的知识。
- 如果此类设备的的维护成本不高，相对耗材的价格不太贵，市场的前景可能会更好，但有些受限于房屋的类型。
- 希望此项技术能普及
- 希望设备的初始价格能够更低些.这样才能快速和规模化的进入市场.
- 希望可尽快降低建造成本，可广泛推广太阳能发电站
- 更多相关知识
- 应该大力推广这种清洁的能源
- 因为是新产品``投资的保证性有多少呢？

- 支持环保事业。
- 在中国，能指望国家来买老百姓的电？不强制拆除就不错了。垄断恶政猛于虎啊！
- 问题可行性更加强就更好
- 希望能通过问卷让更多人开始重视环保。
- 介绍一下方案的回报率
- 最好经济实惠 普通家庭都能承受
- 这个计划的可行性，是否能及时实行。
- 没有相关产品的具体情况及资料
- 我觉得还有很多不确定的因素，所以是否购买还需要进一步的了解当地政府的相关政策。
- 对环境保护很好的建议
- 就怕国家不买电价太高
- 调查相对简单，应该还要提供其他资料，例如这套设备的使用寿命
- 很有意思，希望未来的岁月真的很多家庭都可以有自己的小型太阳能发电机
- 让我了解了太阳能电站这么一个投资项目，很有潜力，而且国家扶持，又环保，投资价格不是适中，我很想试一试，很好
- 国家补贴再大些
- 没有提及需要多少面积安置太阳能
- 支持环保。
- 设计此问卷的人对太阳能发电站的市场根本不了解
- 可以联系小区顶层用户 风险公摊 利益共享!
- 还不成熟
- 解释更详细点
- 这套系统对很多家庭来说价格太高了，即使是城市，只能小范围推广。
- 希望初始投资成本低些为好
- 能介绍给我们更多好的环保产品
- 无。经济发展不能以损害环境为代价
- 很好很环保
- 对调查没有意见，但是此类环保产品的推广仍然需要大量的宣传普及大众的环保知识。
- 增加我对太阳能的认识
- 家居太阳能离我们还是太远，这些年都不可能实现，但是这是一个很好的开始。
- 非常好.但行不通.现在从政府和个人都没有达到对环保的人之水平.
- 不适合中国国情
- 符合国情和市场需要
- 支持环保
- 应该加上发电的的效率是多少，每年的发电量、每年的碳减排等数据，以便更好的判断投资回报率的问题
- 方案还可以更多些
- 不错好 很有意识
  在做调查的同时提高人的环保意识
- 不错的调查，希望真有这样的计划，但希望周期缩短到 5 年。
- 我对你们这个项目感兴趣，我公司是上海节能学会理事单位，如果有意的话，我们可以他合作推广，并争取得到政府有利支持和补贴。可以联系我。谢谢
- 请问这样的发电机副射大吗，容易致癌吗？对人安全吗？要是没有以上问题我觉得我会投资，等于投资基金一样而已。

- 如果有这种电站的话，我希望可以更深刻的了解，整体调查比较科学简单
- 希望能尽早见到有实际产品上市,当然价格不要太贵,必竟这样的产品使用环境还是有限,需要有较大的空间,中国人口太多,大空间的地方人们都不算是太有钱,主要是能将产品推向大众最好,也最有利.
- 百姓再环保有什么用？我不是不关心环保，也不是不肯牺牲经济来促进环保，而是心理不平衡。高官们都在歇斯底里的破坏着环境（至少目前我看到的是这样，如大排量汽车，别墅洋房，糜烂奢华的消费），算了吧，我能做到差不多就行了，就算是有一天 2012 了，也无所谓，大家一起完蛋。不信可以去搜一下，google 和百度。玩性福的，躲猫猫的，楼歪歪的，桥烈烈的。雷人的事情，天天都能看见最新版的。百姓，百姓还能说什么呢。
- 这次的调查非常好,让人们了解到环保还可以赚钱.
- 对于太阳能发电站的介绍还不够详细。
- 觉得此类调查很有趣，没有什么商业气味，反而可以宣传环保意识，希望今后多一点这类的调查。
- 问题应该更全面一些，如关于投资的效益，多种选择方案，风险等
- 如果技术条件具备，我都幻想过自己做一套这样的设备，拥有太阳能自发电系统是我一直想要得，就是不知在中国能不能尽快的推广。如果家庭安装了该设备，应立法保护环保消费者，对那些阻碍家庭安装太阳能发电设备以及卖电等行为的利益集团和奸商，予以最严厉的打击和制裁，消费者才能放心投资购买并推广。
- 环保人人都在说，做到很难
- 节能环保的调查，应涉及目前国家环保的现状和处理状况
- 价格太贵是否合适国情
- 很好.提高人们对低碳的认识
- 安装所需的工作面有没有条件啊
- 问卷的出发点很好。太阳能是很有前途的清洁能源，但是可靠性、实用性、低成本是保证实施的关键。
- 方案还可以再多一点选择
- 环保是我们以后相当重要的一个问题，像这种太阳能类的东西要特别提倡
- 这样的电站在中国还不一定适合,现在大家都住楼房,而且层数很高,有楼顶的是极少数,真正有钱的人有谁在乎这一点的投资回报呢
- 调研完了，最好有市场行为。
- 此次问卷很好，让我对小型光伏电有了很深刻的认识，在不久的将来我应该会考虑买一台。
- 希望这种产品性价比非常高.
- 没有什么了，希望能早日用上。
- 这个方案太好了，我希望尽快能够付诸实施，是利国利民的大事！如果能让投资人的风险降低，我宁愿要低回报。
- 适合于冬季零下 20 度左右的地区的客户使用吗？
- 这次调查让我了解到更多的有关环保的知识，希望有更多这样的调查
- 希望政府能多补贴点
- 学到了知识，但还是有疑惑：电量可存储吗？晚上也能正常发电或者正常使用太阳能发的电吗？没有看到过类似的宣传，政府会以为那么高的价格购买自己太阳能发的电吗？
- 方案很好,就是总价太高了,如果把总价降到 1-2 万,我觉得支持的人会很多的.
- 没有，很好，很环保的问卷
- 什么地方有这种东西？
- 很接近生活。而且是以 环保为前提的。很感兴趣

- 很好，能有更多这样的调查
- 这种环保发电对我们日常生活提供了非常便利的条件，希望加强宣传，让更多人知道这个产品
- 无调查问卷中所提及的房屋，其他单元房的人有此想法，如何实现？住单元房的人是多数。
- 积极支持响应国家低碳环保政策
- 希望价格能便宜点
- 我觉得这种东西离我还是比较远
- 调查从各方面分析了成本与回报风险之间的关系，给消费者提供了多方面的考虑，我会慎重考虑好后再决定是否购买
- 再详细些就好了
- 但是这样的做法在大城市里有多大的可行性是个问题
- 非常有意义 普及和实用意义都有
- 应提供国家在税收及环保方面的优惠政策
- 我缺乏这方面的知识，如果详细介绍一下更好
- 这样的调查问卷很好，支持环保事业
- 多些购买方案.
- 提供更多关于小型太阳能发电站的咨询
- 这些完全是种假设。就像开始提到的不确定性，而这种不确定性的风险，是由购买人来承担的。是否统计过能够一次性投入 8 万元作为一种投资，同时又支持国家环保事业的家庭，月收入或者年收入在多少的时候才会考虑那？
- 太阳能发电只适合独立的房屋，而不适宜多家合住的公寓，因为绝大部分住户都没有屋顶可安装。
- 价格还是高，不容易推广
- 需要了解更详细的技术资料。
- 希望周期再短些，5 年最好。
- 环境保护确实是应该考虑的
- 最好提供一些式样能在网上观看
- 很好，支持环保！
- 支持环保,你我做得到
- 前期投资再低点，不一定要考虑卖电，风险再小点。
- 希望能尽快推出
- 这个调查很好，可以让我了解到一些环保的知识。
- 在发电机械的性能要求方面应该要多做一些功夫
- 让我了解了一项新的产品，以前从来没听过在家也能自己发电。问卷做的非常清楚，很好选择。
- 保护环境是每个公民应尽的义务，可惜我们的国家让公民在尽义务与享权力之间太不靠谱了。所以，作为公民，我们是有心无力或者说是心已被伤透了。节能环保的事情事情是国家来扛吧！我们的钱还等着养老支付医疗费呢！
- 对电站的介绍可以详细一点，比如安全性，操作性等方面的信息
- 投资的话，最好还是需要有政府引导的。
- 让我知道了更多好的理念
- 应该还问一些关于太阳能站的设备
- 增加了一些知识
- 支持环保很好

- 如果真要投入一套太阳能发电装置的话，我不在乎能否卖电盈利，自用足够就可以，所以希望初始投入成本越少越好
- 支持环保
- 最好是既经济既环保
- 希望价格方面再优惠一点
- 不知道普通楼房如何安装?回收期较长,风险出现时客户如何处理等问题没讲清楚.暂时不考虑.
- 很感兴趣 希望能推出这样的产品
- 多点研发这种有利于民的产品，减低点成本更好
- 适当考虑下中低收入的家庭
- 建太阳能电力站环保又方便,从长远利益来看值得提昌.
- 应该价格较适中较好
- 希望小投资有高回报
- 比较有意义的一份问券
- 希望质量好一些，用的时间长点
- 对于现在小家庭来说，应该开发更多小型的设备，可以节约成本，同时节约了小家庭的开支
- 环保的、节能的、有创意的，不错。
- 希望尽快实施，从大城市和东部地区开始。投资建设配套的输电网。
- 对于中年人来说大多数人都是风险规避的
- 建议增加此种环保类调查
- 希望这个话题可以实施
- 多多推广 让更多的人都明白
- 没有地方政府的配合终究是损失
- 支持环保，希望大家都能够重视环保，保护我们居住的环境。
- 这个调查很有意恩，从这项调查中学习了有关的知识，也谈了自己的看法，这是个好调查。
- 收益性时间长点
- 希望这样的环保新产品早点投入使用。为保护我们的地球多做贡献
- 希望能够得到更详尽的了解
- 尽快提供相关资料
- 环保的产品我觉得价格有点贵，最好是降低些。
- 问题还可以详细些
- 由于是城市，空间有限。而对于农村或小城市则较为合适，又或是在新兴城市有较大的市场潜力。
- 希望该产品适合广大工薪阶层的消费者，或者和地厂商合作一起搞该项目
- 爱护环境！人人有责
- 对政府承诺购电部分分析持怀疑态度。
- 经济实惠
- 支持环保事业，保护环境，保护地球，从个人做起。
  此调查的投资方案用图表方式对比，令人明了易懂。
- 普通住宅不现实
- 这次条查针对环境保是好的，但也要降低成本与风险。
- 希望这种与居民生活密切相关，且节能环保的调查再多一些。这种调查很有意义。
- 了解了国家对小型发电的发展
- 设想不错，普及有困难

- 希望以后通过调查提供更多的知识
- 这个主意很好，要抓紧办。
- 支持环保
- 支持环保，但希望再便宜一点。
- 有确切的地方可以咨询
- 需要更实际的相关政策
- 价格再便宜点
- 我觉得国家应该大力支持和发扬这种高科技又环保的东西，这样可以提高国家的实力与竞争力。
- 很好的项目。最好是快些。
- 问卷设计的比较好，如果能描述更清楚就更好
- 希望这样的产品可以早日面市！
- 对环保不益都是挺好的，不然以后地球都不知道被污染成什么样了，让人们都知道环保是多么的重要。
- 做的很好 增长了见识
- 希望有更佳的方案,能给我们更好的实惠
- 希望高科技环保节能快点实现
- 希望能提供更为详细的一些资料和更中肯的建议
- 希望能够再描述一下更详细的情况，调查还不错哦
- 节能环保是一件大事,如果有这样的实惠,还是愿意购买的
- 要想大家都用环保用品就得极低的价格才能实现！
- 问题可以更仔细
- 对于这个节能产品不了解，不怎么好回答问题
- 很容易使用.
- 我们现在用一度电才 0.61 元
  从经济上来讲发电站没有优势
- 很好，了解了新的环保产品，希望继续参与这样的问卷
- 希望更多的人支持环保
- 便宜点更好。