Proposal of policies for promoting energy savings for households in Japan

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How can we establish the affluent energy saving and low-carbon society?

The most significant issue from people's daily lives is;

「Promotion of Green Innovation taking account of energy saving, low-carbon and economy of systems」

Green innovation as abatement options to mitigate climate change

① **Product innovations**: **These have large potentials in end-use products such as Electric vehicles, photovoltaics, energy saving electric appliances, batteries and so on.**

② **Process innovations**: **These are mainly innovations in energy intensive industries such as iron & steel. Since energy saving in these industries have been promoted since the first oil crisis in 1973, the residual potential is small for process innovation in Japan.**

③ **Market innovations**: **The feed-in-tariff for renewable energy technologies and the green-deal in UK for energy saving technologies correspond to the market innovation.**

④ **Innovations in supply chains**: **The smart grid and the smart community systems correspond to the innovation.**

⑤ **Innovations on institutions and organizations**: **These innovations activate new business models through new legislative regulation or deregulation such as the Top-runner standards.**

The green innovations and the green growths

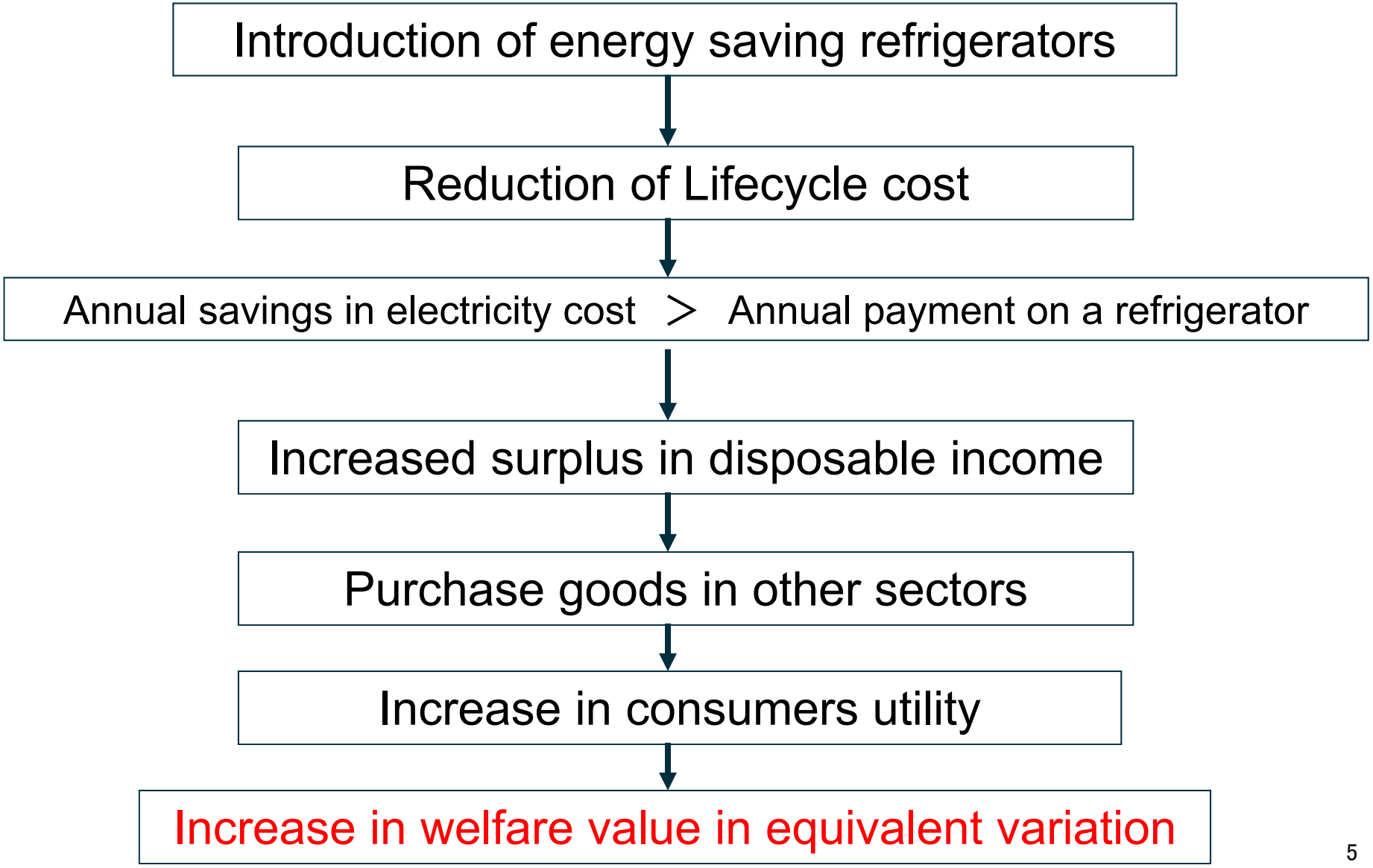
So as to realize green growth by activating green innovation, we first need to define the concept of the "green growth" as the different term from the green innovations.
Here the green growth is defined to decrease $\frac{CO_2}{GDP}$, while economic growth is sustained.

① **Type 1 Green Growth**：Combining product innovations as energy saving electric appliances, photovolatics and so on with market innovations to disseminate them, the Type 1 green growth decreases $\frac{CO_2}{GDP}$ in the residential sector, while contributing to economic growth.

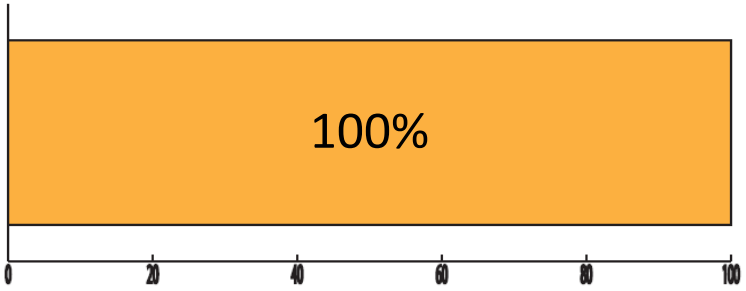
② **Type 2 Green Growth** ： Combining process innovations in energy intensive industries with innovations in institutions, the Type 2 green growth decrease $\frac{CO_2}{GDP}$, in industrial sectors while contributing to economic growth.

③ **Type 3 Green Growth** ：Combining various kinds of innovations, sectors on ICT, service, medical and social welfare, education, culture and sports with low CO2 per value added production increase their shares, so that $\frac{CO_2}{GDP}$ is decreased in industrial sectors while contributing to economic growth in the Type 3 green growth. Namely, it is change in economic structure.

Why do the welfare values increase by promoting the Type Ⅰ green growth ?



If we estimate energy consumption without any energy saving as 100%・・・



※An evaluation for a household with annual income of 5 million to 5.5 million yen

Incandescent light with large electricity consumption

Houses with less heat insulation
Inefficient air conditioners

Old air conditioners with large electricity consumptions

The typical air conditioner made in 1995 with annual electricity consumption of 1492 kWh

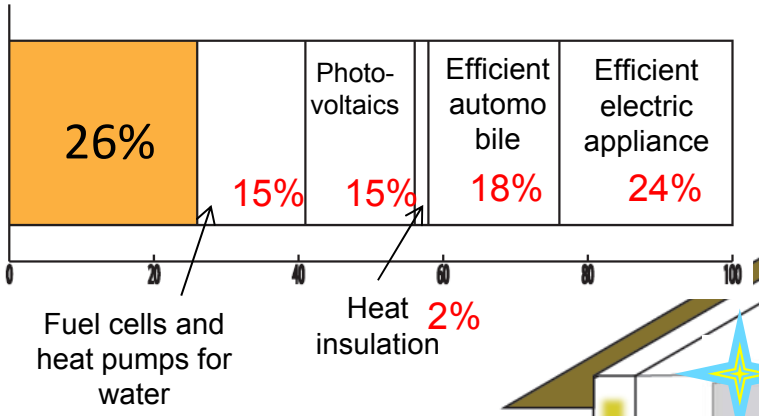
Passenger cars with inferior fuel economy

The typical refrigerator made in 1995 with annual electricity consumption of 990 kWh

The old refrigerator with large electricity consumption

Energy consumption of the house could be reduced by 74% as the figure below.

※An evaluation for a household with annual income of 5 million to 5.5 million yen



Energy saving by LED lighting

Electricity saving by solara power generation systems

An energy efficient air conditioner

The typical air conditioner made in 2010 with annual electricity consumption of 850kWh

Energy efficiency improvement by fuel cells, heat pump for water heating.

The typical refrigerator made in 2010 with annual electricity consumption of 220 kWh

Passenger cars with superior fuel economy

The type 1 Green Growth

Adoption of heat insulation

The energy efficient refrigerator

Improvement of heat insulation by a double glass

The Key to realize affluent low-carbon society

We have plenty of energy saving measures which reduce lifecycle costs.

↓

Adopting these measures lead to reduction of CO_2
while improving utility of citizens.

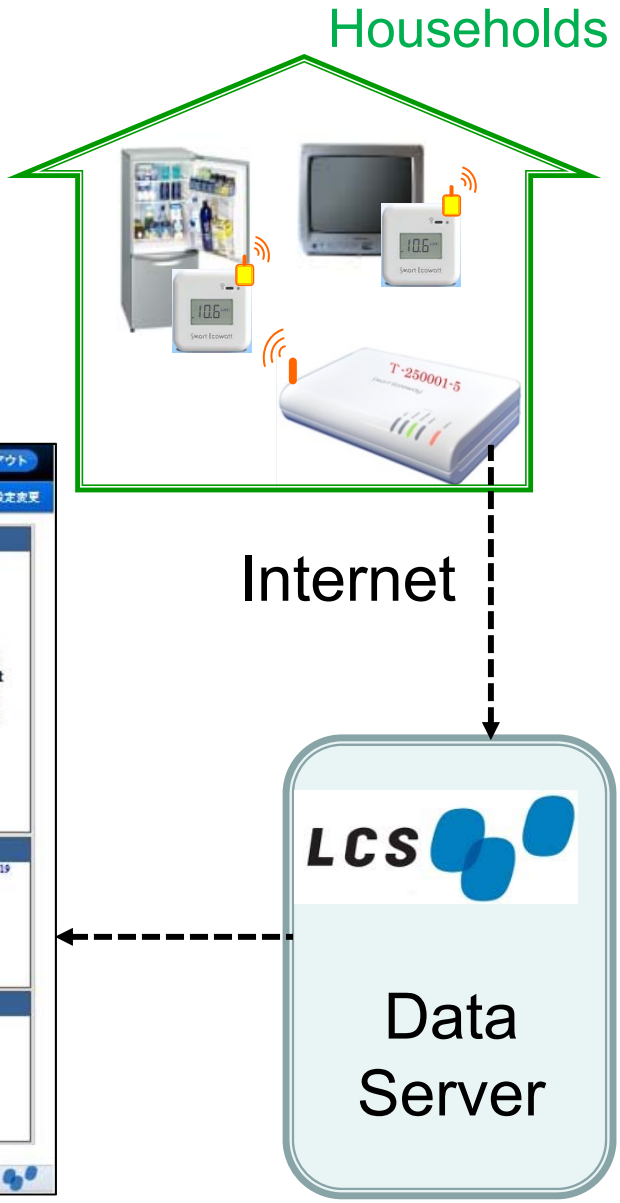
↓

Measures which reduce lifecycle costs are not necessarily adopted.

According to the achievements of researches on bound rationality, human beings are weak existences, which are tempted to postpone their work. They cannot behave as "rational economic man". Therefore it is not necessarily true that they always acquire goods to reduce lifecycle costs. From this viewpoint, the feed-in-tariff for renewable energy technologies may not be useful measures. Although the feed-in-tariff investors acquire payback by long-term stable electricity sales, the burden of initial investment is too heavy for household sectors. If rather, the green deal institution with zero investment cost would be desired, in which they can pay from saved electricity cost.

Experiments to visualize electricity consumption in households

- We Measure electricity consumption by air-conditioners, televisions and refrigerators as well as entire households.
- We provide “i-cosmos”, the web site to verify electricity consumption in real time.



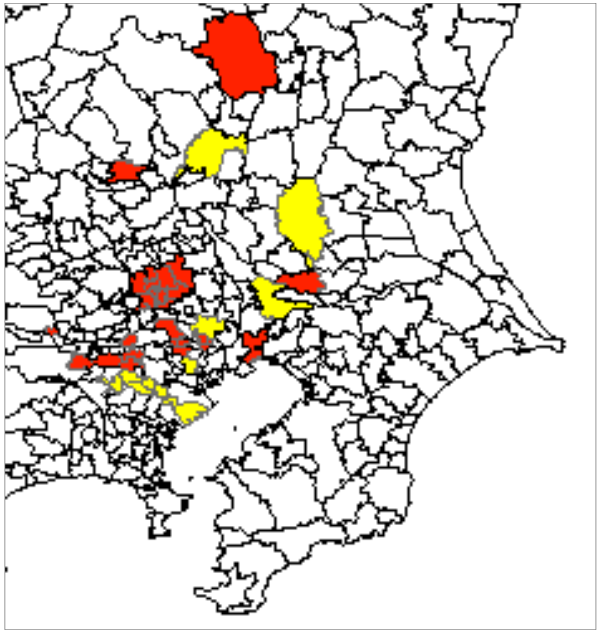
The strategy to promote the type 1 Green Growth

Coalition with municipalities

Kanto : 23 municipalities

Kansai : 1 municipality

We recruited 300 households for the experiments in H25 fiscal year.



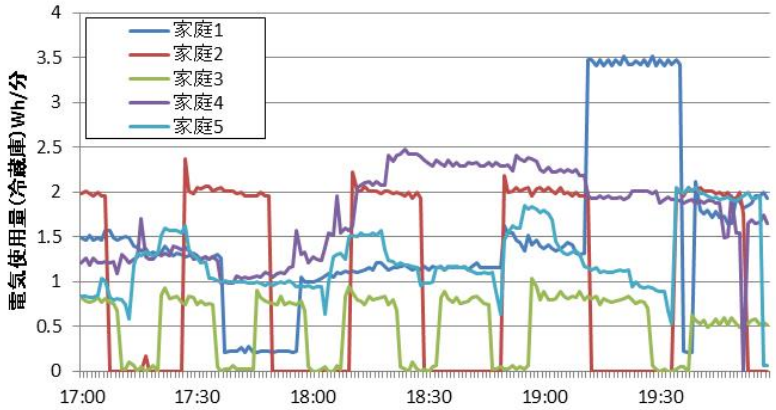
The first offer The second offer

Coalition also with Platinum-network

Study of measures to establish low carbon society

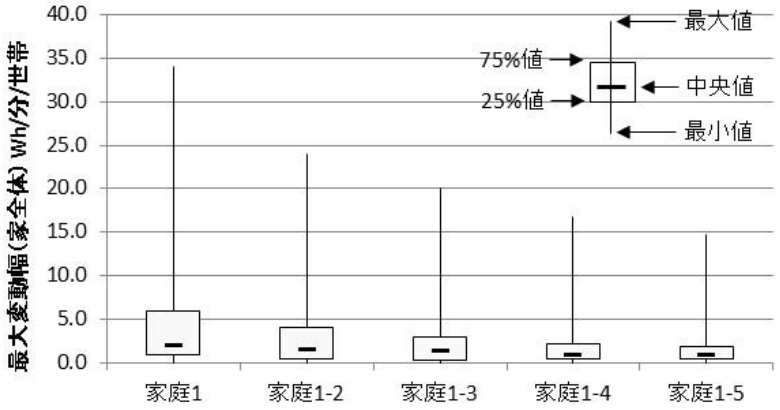
✓ Decrease CO2 emission in households

Ex. Promotion of replacing refrigerators



Decrease up to 75% by replacement

Ex. Leveling electric power load by CEMS, DR etc.



Decrease output variation by CEMS

The strategy to promote the type 1 Green Growth

Measure to realize the type 1 green growth

The Concept of Green Power Moderator（GPM)

As an organization to carry out the type 1 green growth, we propose the green power moderator, GPM.

① **GPM is an organization to take action under the necessary legislation after liberalization of the retail electricity for households.**

② **GPM supplies energy saving electric appliances or photovoltaics to more than 1000 households by its own investment (no initial costs for the households) , and takes the cash flow from the saved electricity bill as income source. Thus GPM contributes to realize energy saving and low carbon society.**

③ **GPM can manage revenue risk through portfolio of dealing with many households. At the same time, GPM appropriately combines the fluctuation of the PV outputs with the variation in the saved electricity so as to smooth the total fluctuations in a few minutes. Thus GPM mitigates the constraint of the load frequency control and solve the problem on mass introduction of renewable energy.**

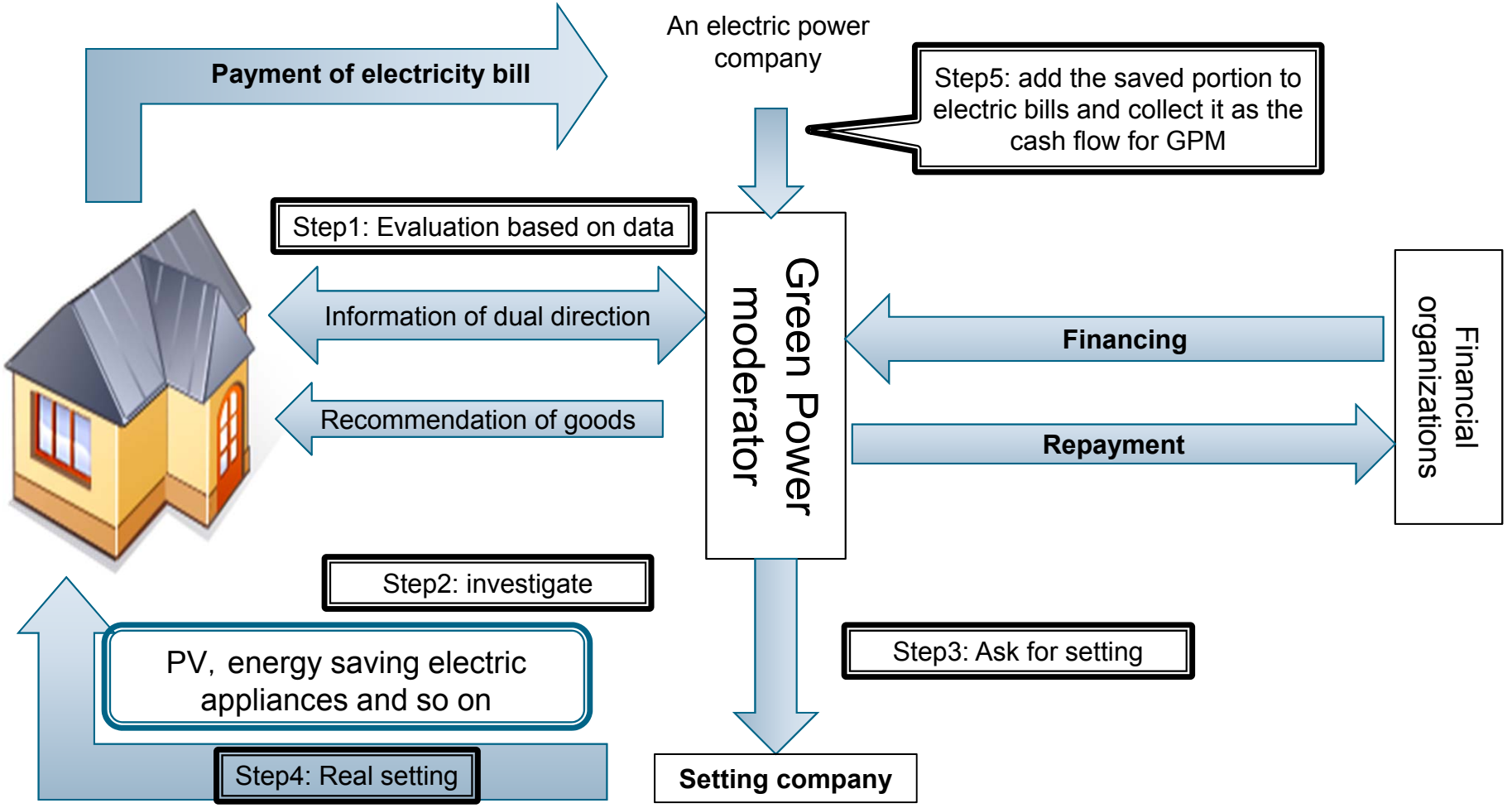
④ **These functions could be clarified by analyses of energy consumption data every one minute for more than 1000 households.**

⑤ **GPM forecasts the electricity demand of the day, and sends alarm to call for power saving to households when electricity supply and demand is stringent.**

Four functions of GPM（1）

Design of Japanese Green Deal institution and management

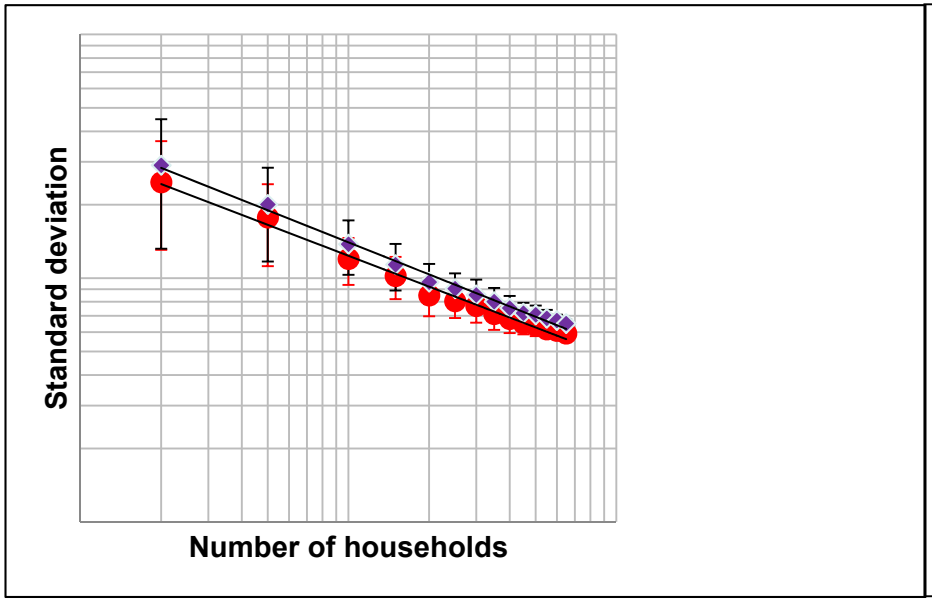
Green deal is the institution, in which ordinary households do not have to pay initial investment to adopt energy saving products. Repayment of the loan is made from the saved energy bill.

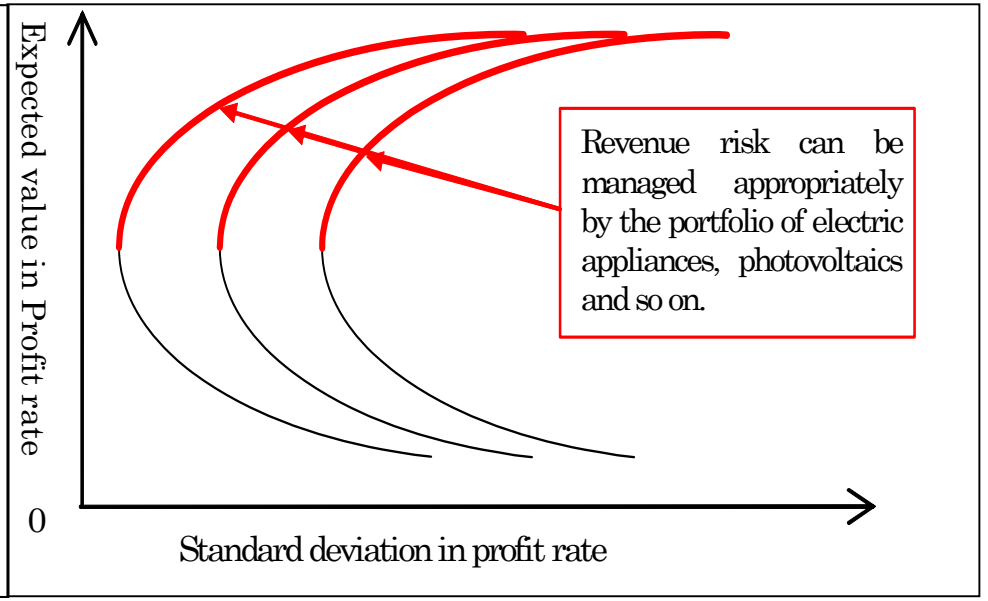


Four functions of GPM(2)

Management of revenue risk by portfolio of energy saving electric appliances and photovoltaics in many households

GPM supplies energy saving electric appliances or photovoltaics to more than 1000 households by its own investment (no initial costs for the households) , and takes the cash flow from the saved electricity bill as income source. Thus GPM contributes to realize energy saving and low carbon society. GPM can manage revenue risk through portfolio of dealing with many households.





Errors in Projection to forecast energy consumption and savings decrease, as the number of electric appliances increases.

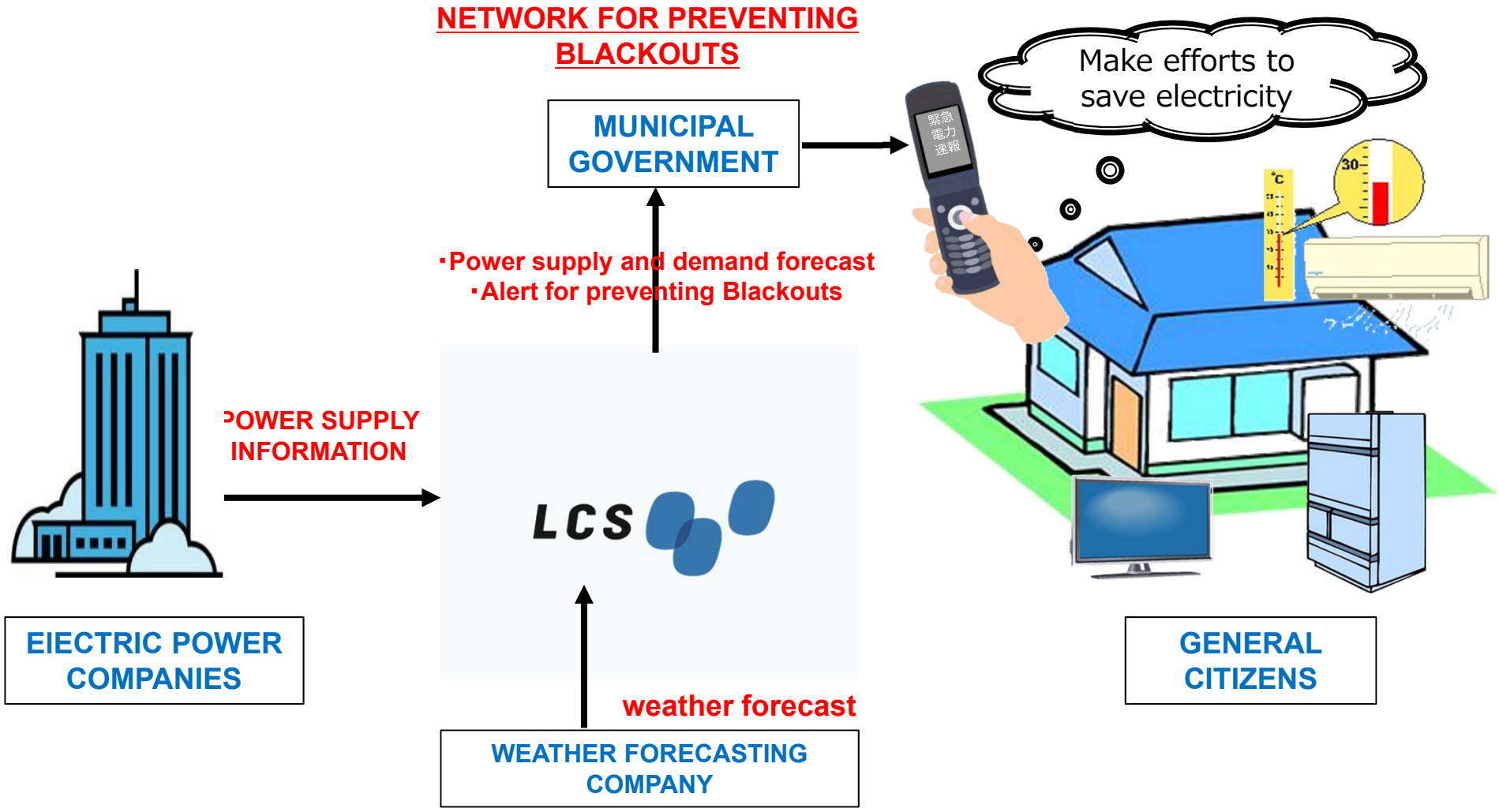
→

As the errors to forecast energy savings decrease, revenue risks of GPM also decrease.

Four functions of GPM（3）

Relaxation of stringent power supply and demand through the network for preventing blackouts and innovative technologies

GPM forecasts the electricity demand of the day, and performs alarm to call for power saving to households when electricity supply and demand is stringent.



Four functions of GPM（4）

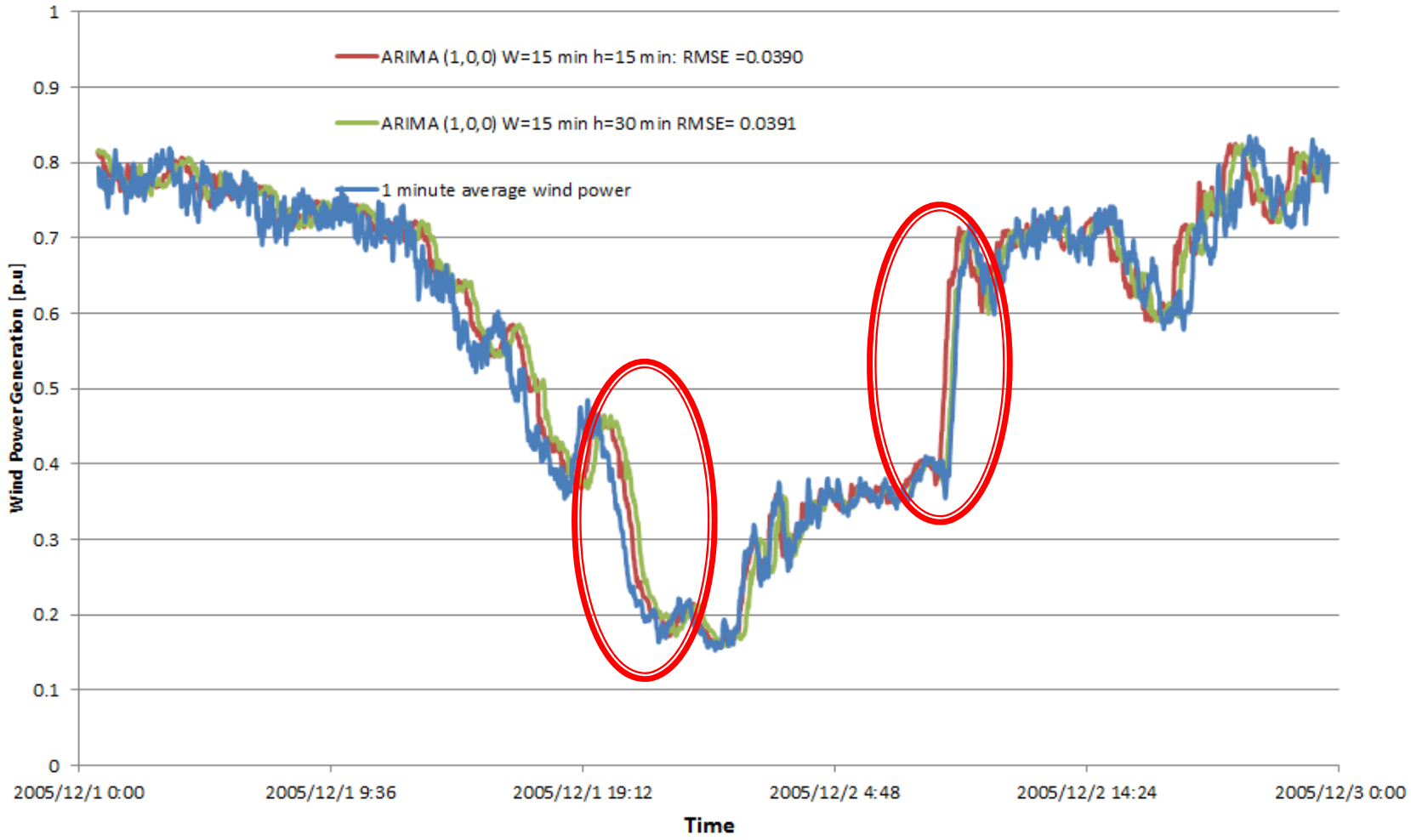
Pradeepa Lakmal Wevita，STUDY ON STOCHASTIC OUTPUT FLUCTUATIONS IN DISTRIBUTED WIND POWER GENERATION AND SHORT-TERM WIND POWER FORECASTING FOR POWER SYSTEM OPERATION，東京大学大学院電気系工学専攻2013年度修士論文，2014.2.12

➢ Sm

→relaxing the supply and demand balance

Predictions in Ramp event

Feb
April
Mar



Expected effect of GPM

① **Behaviors of households are different depending upon their income, family constitution, cultures and characters. GPM proposes appropriate measures for each household, based on information from ICT network. Utilities of households generally increase by introducing the Green Deal institution.**

② **Electric power companies also take advantages, since the constraints on mass introduction of renewable energy are mitigated. Now that the future operation of nuclear power plants is uncertain, investments in fossil-fired power plants lead to high revenue risk. Under these circumstances, GPM could help to decrease the investment risk through the function to save electricity.**

In order to activate the type 1 green growth by GPM,

- **We need to design the institution of power systems as Win-Win-Win relationships for households, electric power companies and GPM.**

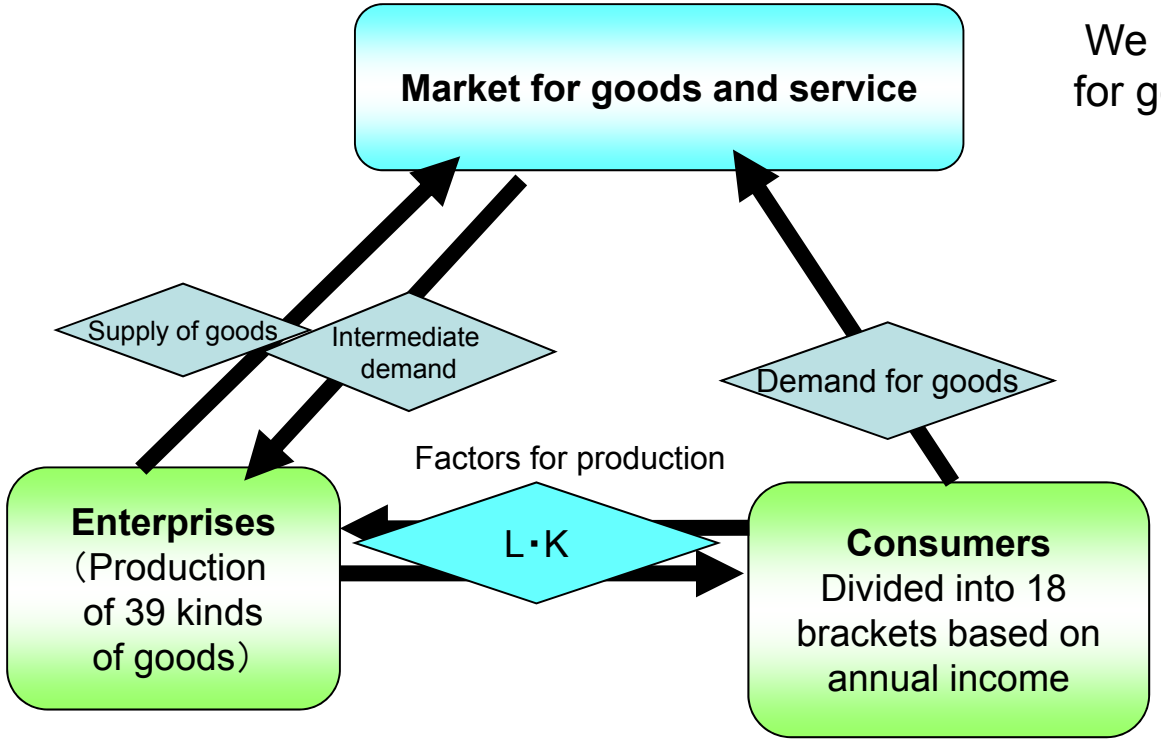
Overview of our analysis

Energy and Economy Evaluation Model

Multi-regional Power Planning Model

Final Energy Demand Model for Households

Structure of our evaluation model



We compute the point, in which markets for goods and services are in equilibrium.

Consumers are divided into 18 brackets based on annual income.
⇒ Evaluation of economic impact by introducing technologies.
⇒ Evaluation of economic impact in each income bracket.

Consumption and production sectors of our evaluation models

		1	2	⋯	18
1	Food				
2	Dwelling				
3	Electricity				
4	Gas				
5	Light & Fuel				
6	Water & Sewage				
7	Durable goods				
8	Heating & Cooling				
9	General furnitures				
10	Other furnitures				
11	Clothing and shoes				
12	Medical & Health				
13	Transport				
14	Automobiles				
15	Gasoline				
16	Communication				
17	Education				
18	Entertainment				
19	Other consumptions				

Decrease by energy saving

Increased cost

Increased cost

Decrease by energy saving

1	−200
2	200−250
3	250−300
4	300−350
5	350−400
6	400−450
7	450−500
8	500−550
9	550−600
10	600−650
11	650−700
12	700−750
13	750−800
14	800−900
15	900−1000
16	1000−1250
17	1250−1500
18	1500−

Brackets by income

1	Agriculture, forestry and fishery	20	General machinery
2	Limestone	21	Electric machinery
3	Coal	22	Automobiles
4	Oil	23	Transport machinery
5	Natural gas	24	Precision machinery
6	Other minerals	25	Other manufacturing
7	Food	26	Construction
8	Textiles	27	Electricity
9	Wood products	28	Gas
10	Pulp & paper	29	Heat
11	Printing	30	Water & Sewage
12	Chemicals	31	Waste disposal
13	Petroleum products	32	Commerce
14	Coal products	33	Finance & Insurance
15	Ceramic products	34	Real estate
16	Cement	35	Transport
17	Iron & steel	36	Broadcasting
18	Non-ferrous metals	37	Service
19	Metal products	38	Governmental service
		39	Private non-profit

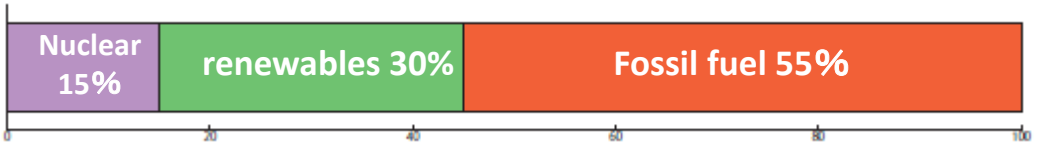
19 consumption goods ⟷ 39 production goods

Measures adopted in our analyses

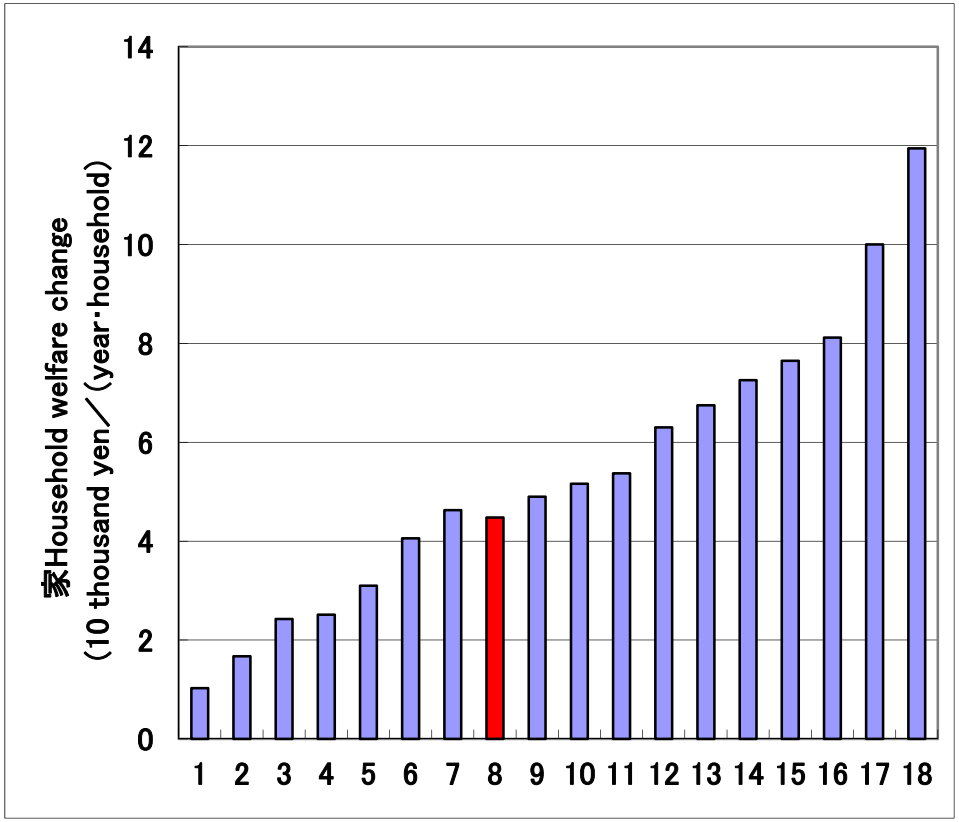
Measures to mitigate global warming	① Natural gas is assumed to replace 80% (relative to 2005 levels) of petroleum products and fuel, including heavy oil, used by all manufacturing sectors (except the petrochemical industry). ② Promoting modal shift: based on input-output analysis of distribution, CO_2 emissions in the transportation sector are assumed to be cut by up to 44%. ③ Promoting energy savings in industrial sectors: in accordance with the law promoting energy conservation, the annual improvement of energy intensity in each industry is assumed to be 1%.
Measures to promote energy saving in households	④ The percentage of next-generation energy efficient homes (1999 standard) as a stock base is assumed to be 48% in 2030, in accordance with the National Institute of Construction. ⑤ We assume to continue the top runner standards regarding home electric appliances, passenger cars and so on. ⑥ The percentage of next-generation passenger cars as a stock base is assumed to be 51% in 2030. Next-generation passenger cars are hybrid, plug-in-hybrid, electric, fuel cell vehicles and the like. ⑦ We assume efficiency improvement of lighting by introducing LED. ⑧ We assume to introduce solar power generation systems to 16 million households. ⑨ We assume to introduce fuel cells to 7.2 million households. ⑩ We assume to introduce heat pumps for hot water to 5.3 million households.

We took measures ①～⑩ to mitigate global warming or to save energy in households into consideration, focusing on ④ ～ ⑩ especially for the type 1 green growth.

Evaluated results using our energy-economy model



Regarding power mix, we assume as follows this time, although much uncertainty exists.



エネルギー起源CO2 emissions from energy consumption（compared with 1060 million ton-CO2 in 1990）	▲26.9%
Real GDP（506 trillion yen in 2005）	617 trillion yen
Increase of aggregate welfare of households※1	2.76 trillion yen

※1 We estimated increase of equivalent income of all households, compared with the case we do not promote energy saving by GPM.

【Economic influences to typical households with annual income of 5 to 5.5 million yen】

Approximately 45 thousand yen increase of welfare in a typical household

A Plan on activating GPM

① **In this plan, we propose to utilize J-credit system. The J-credit system is now operated by Japanese government, based on the established validation and verification entities.**

② **Most of methodologies on available energy savings are already registered to the J-credit system. Therefore we can easily introduce GPM, by using all these infrastructure.**

③ **In this scheme, GPM primarily promote dissemination of energy saving electric apparatus, renewable energy technologies and so on. Cost-effectiveness of these technologies are assessed based on the data collected through ICT networks.**

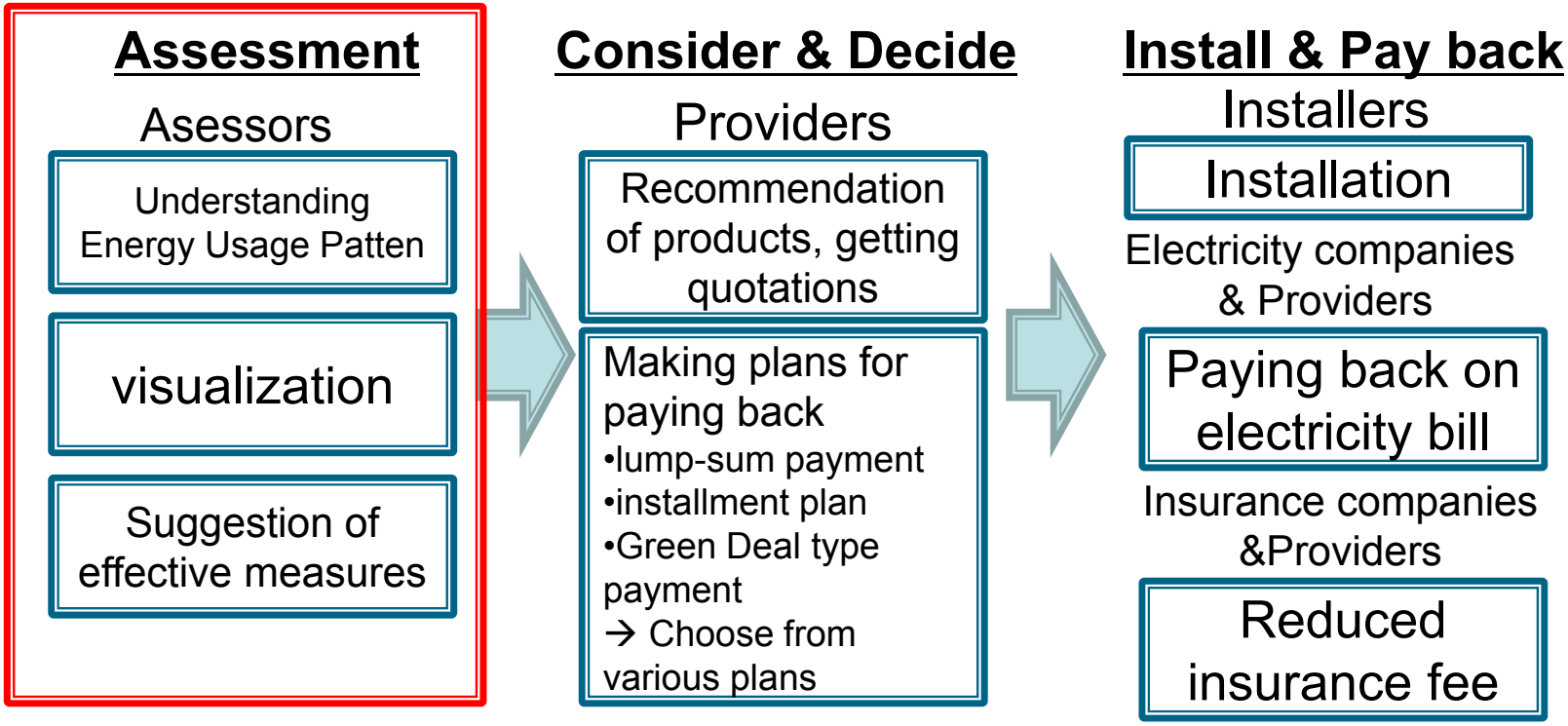
④ **The program type J-credit system is suitable for disseminating the above energy saving technologies.**

Household Energy Assessment Scheme by MOE

Source: MOE web site
（https://www.uchieco-shindan.go.jp/2013/_bosys/wp-content/uploads/2014/02/kouen1.pdf）

Japanese Green Deal based on Household Energy Assessment by MOE

- **Next step is to establish scheme of "providers" who will recommend specific products, get quotations, make plans for paying back.**
- **Providers would arrange payment on electricity fee.**
- **Better insulation will reduce risks of diseases and death, and possibly reduces insurance fee of people living in better insulated houses. (Co-Benefit)**



Houses / Buildings Sector
(Ministry of Land. Infrastructure, Transport and Tourism)

✓ Revision of Energy Saving Act

- Assessment of energy efficiency of houses/buildings including not only the insulation but the equipment based on primary energy consumption
- From voluntary reporting to mandatory reporting of the assessment result

For spread of ZEB/ZEH/ LCCMH

➡ 2020 Goal: from Reporting to Adapting

✓ Necessity of Non Energy Benefit Evaluation

- Low energy benefit on insulation enhancement in Japanese low heating demand buildings (Decrease economic incentives)
- Evaluation of NEB (ex. improvement of occupant comfort and intellectual productivity, health-promoting effect) for promotion of high energy efficient houses/buildings

Conclusions

(1) We defined the five kinds of green innovations and the three types of green growths, focusing on the type 1 green growth, which decreases $\frac{CO_2}{GDP}$ in the residential sector, promoting dissemination of energy saving electric appliances, renewable energy technologies and so on.

(2) We proposed the concept of GPM to promote the type 1 green growth and the several schemes to realize its functions. We need to design some new institutions such as the Green Deal so as to activate GPM.

(3) We quantitatively evaluated the type 1 green growth using our energy economy model. The computed results indicated that the type 1 green growth make high effects on households.