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Incentive Mechanisms for the Development of a Low-carbon Society in Asia

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Energy consumption in Asian countries has been increasing rapidly, and, in parallel, the emission of carbon dioxide has been rising. This rapid increase of energy consumption is triggered by the economic development and expanding business activities in these countries. Lack of energy-saving mechanisms is another factor contributing to the rising energy consumption level.

In this paper, we provide an overview of the energy consumption patterns in Asian countries, particularly in China, and examine the impediments not to operate incentives and mechanisms to reduce energy consumption in residential building and industry. We also demonstrate the alternative framework to promote incentives and the economic theory based on social optimum to create a low-carbon society.

1. Introduction

Energy consumption in Asian countries has been increasing rapidly, and, in parallel, the emission of carbon dioxide has been rising. This rapid increase of energy consumption is a reflection of the economic development and expanding business activities in these countries. Lack of energy-saving mechanisms is another factor contributing to the rising energy consumption level.

In this context, the development of a low-carbon society in Asian countries is a challenging issue. In this paper, we provide an overview of the energy situation in Asian countries, examine the incentives and mechanisms for reducing energy consumption in major sectors, and demonstrate the framework and economic theory for creating effective incentives for a low-carbon society.

2. Overview of the Energy Situation in Asia

According to the International Energy Agency (IEA; 2009a), energy consumption in member countries increased by 19% from 1990 to 2006. The transport and service sectors dominated this growth with 52% and 22%, respectively. However, the growth in non-member countries was 62%, with the service sector accounting for only 5%, as compared to 39% for the manufacturing sector and 34% for households. This means that as the stage of development advances, the relative shares of energy consumption shift from the manufacturing and household sectors to the service sector.

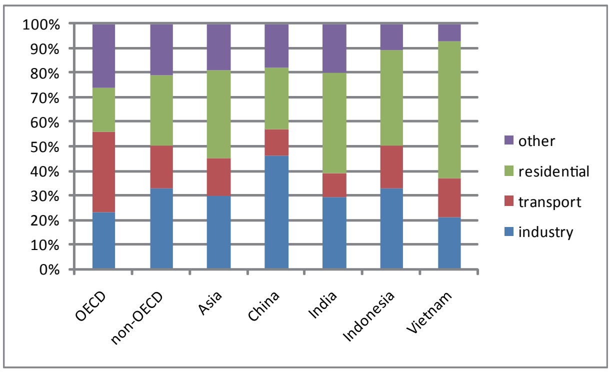

Fig. 1 Energy consumption by sector (2007 data).
Source: IEA (2009a).

Figure 2 shows that the energy intensity in non-OECD countries is high, compared to OECD countries, pointing to the high energy-saving potential in developing countries.

The energy intensity in Russia, China, and Mongolia is very high, which suggests that space heating is responsible for high levels of energy intensity in cold regions.

Figure 3 shows the residential energy consumption in several provinces of China. Consumption patterns in the Northern provinces show very high residential energy use for heating indoors—more than 40%, for example, in the Liaoning province. However, the heating share is

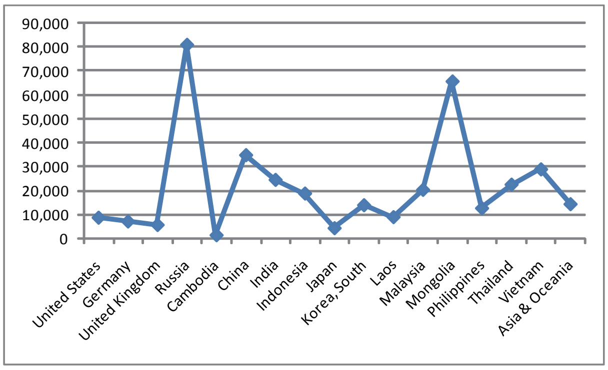

Fig. 2 Energy intensity in 2006.
Source: EIA (2009).

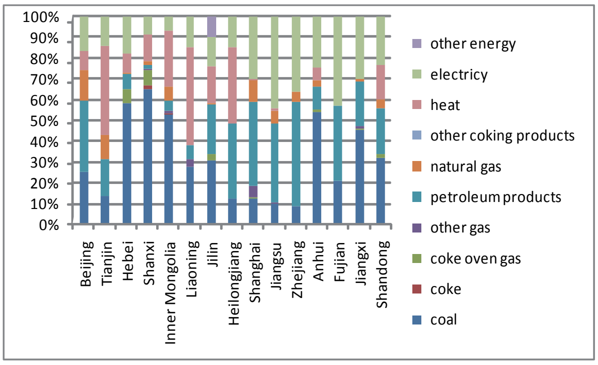

Fig. 3 Sources of energy for the household sector in the northern Chinese provinces (2007 data).
Source: National Bureau of Statistics (2008).

far lower in the Southern provinces. This indicates that district heating is a major factor leading to increased energy consumption in the northern areas.

Energy consumption and intensity patterns differ according to the stage of development and climatic conditions of a location. Therefore, incentives and policy measures to encourage energy saving should be considered in association with these factors.

3. Incentives and Policy Measures

The importance of energy saving, particularly in the industry and household sectors, has been indicated in the previous section. To encourage energy saving in these sectors, many policy measures have been considered. These policy measures are based on three approaches: command and control, a market-based approach, and a voluntary approach. Let us review the policy measures in the three sectors. (*1)

1) Residential buildings

Command and control: Mandatory building energy code.

Market-based approach: Providing subsidy, tax-incentive for replacements with more energy-efficient appliances and incentives for energy-efficient buildings; metering district heating to provide consumers incentives to monitor energy savings.

2) Industry

Command and control: Emission standard, target for improving energy efficiency, and reduction in consumption.

Market-based approach: Subsidy to support energy-saving equipment installation, emission trading, emission tax, tax-incentive, eco-labeling, rating, and providing incentives for energy-efficient equipment.

Voluntary approach: Voluntary agreement and action.

3) Household

Market-based approach: Supporting replacements with more energy-efficient products and solar generators (PV), providing incentives such as eco-labels and subsidies, creating public awareness about more eco-friendly lifestyles.

Table 1 shows incentives and policy measures applied in Asian countries. To date, Asian countries have introduced command and control policy measures to build low-carbon societies in some cases; however, they often use market-based approaches. In the industry sector, rating and voluntary approaches have been widely used. In residential buildings, space heating, especially in the northern area, is an important target, and metering is considered one of the effective measures.

Table 1 Incentive tools in sectors

	incentive	case in Asia	Japan
residential building			
metering, smart metering, space heating	visibility, metering	16sites in China	
PV	subsidy		○
heat gain (shutters, shade)	eco label, CASBEE		○
material			
heating &hot water (HP)	subsidy		○
efficient lighting	saving cost		○
cooking	saving cost		
efficient appliance (air-con, etc)	tax-incentive, subsidy, eco-label	the Philippines, Thailand, China	○
building energy code		China	○
alternate refrigerant			
household			
RBM, residential biogas model	subsidy	China	○
efficient stove (chacoal, coal, briquette, wood)	ditto	China	
effcient lighting	tax-incentive, subsidy, eco-label		○
biogas cooking	subsidy	China, Thailand	
biomass power station			○
public awarness			
industry			
voluntary agreement	subsidy, information service	China	○
unilateral agreement	ditto		
negotiated agreement	ditto		○
top runner			
bulletin system		China	
comand &control			
emission standard			
eco label （＊）	information service	China,Thailand, Indonesia, Korea	
corporate rating （＊）		Indonesia, China, Phillipines	
eco finance	financial support	China	○
emission trade	ditto		
tax			

note: (*) be used for environmental indicator

Source: References 3), 4), 8), 9), 10), 11).

4. Some Major Issues

In this section, we examine some important energy consumption issues.

First, the key to lower consumption in the residential building sector is to encourage residents to save energy by showing them the benefits of doing so. However, governments in Asia often provide energy as a welfare program; therefore, energy supply and demand are not determined by the market.

Second, in Asian countries, the regulatory framework to enforce energy conservation in industry is not strong enough, because currently, institutional structures do not exist. Therefore, other mechanisms such as incentive-driven tools are needed. Let us consider those mechanisms which would be effective in promoting energy efficiency in business activities.

4.1 Residential building

Of the total energy use in China, consumption in residential buildings accounts for 23%. Space heating consumes a significant amount of energy in the northern part of China, where consumption is two to three times as much as in other places with similar latitude (Zhao et al., 2009). In China, space heating is important in 70% of the land, and heating demand is high, especially in the northern area.

One of the reasons for the rise in energy consumption is the district heating system widely used in northern China. Energy consumption for district heating is significantly high, while the incentive for energy saving is low because of the current charge system, which is based on floor space, and not consumption volume.

A pay-as-you-go system is regarded as an effective tool to provide incentives for energy saving. Recently, government introduced the meter system on a trial basis; by the eleventh five-year plan, the system will be introduced in a 150-km^2 area (Zhao et al., 2009).

The district heating system is a typical case of the lack of incentives for energy saving. The system is regarded as a social welfare program as well as an energy supply tool that does not allow market mechanisms to operate. In general, if consumption is linked to costs, the demand and supply are balanced. On the other hand, public goods, or goods supplied by public agencies, are often oversupplied, because the price paid by the consumer does not reflect the actual cost. Over-consumption in district heating can be explained by the lack of linkages between consumer perception and the real cost. The low perceived cost not only discourages energy saving but also leads to low awareness about environmental damage. This would not be the case if the cost burden were correctly passed on to the consumer on the basis of actual consumption.

In a number of similar cases, energy saving can be achieved through incentives to consumers—for example, in the installation of solar panels in residential houses. The solar panel is an effective tool to reduce CO_2 emission by substituting for fossil fuel. Further, the incentive to the household for the energy saved is visible in the form of reduced payments for power consumed.

In this case, the energy consumed would be a private good, not a public good, and the demand and supply would be determined accordingly. This is an effective way to create energy-saving incentives.

4.2 Industry

In developing countries, companies cannot afford energy-saving investment, and the regulatory framework is not well developed. In this situation, companies do not focus on energy saving. The important issue is, how companies can be convinced as to the economic merits of promoting energy saving. We will review several policy measures adopted to provide incentives and consider the relatively more effective techniques to establish an incentive mechanism.

According to classical economic theory, all policy measures such as subsidy, tax, and emission trading result in the same welfare quotient. However, companies receive different welfare benefits and incentives according to the various policy measures.

We will evaluate following policy measures in these respects: (a) command and control, (b) emission tax, (c) voluntary agreement, (d) voluntary action, (e) tax incentive, (f) subsidy, and (g) rating. In general, as one moves down the list, the resistance of companies to the measures applied becomes progressively lower. The ideal point can be realized with command and control measures if the government has perfect information. Otherwise, taxes and subsidies are other effective market-based methods that can be used.

Companies tend to respond to voluntary agreements and action and rating systems, considering the social environment and their reputation in society. These are more effective than unreasonable actions of the government. These market-based approaches have been introduced not only in OECD countries but in Asian developing countries as well. According to the OECD, the incentives for voluntary action are the benefits derived by the company on considering the alternative of regulation, improvement in production, and the value added effect. In Japan, the EU, and the US, voluntary agreements have already been introduced as one of the tools in the global environment policy.

Rating is also an effective measure that companies in these countries respond to because of their public image. In Asian countries such as China, Indonesia, Japan, and Korea, eco-labeling has been introduced. Indonesia and the Philippines have established a rating system. In the Shandon province of China, a rating system for companies based on energy saving has been introduced. These are indicative policy measures that can be adopted as alternates to the command and control system. These measures, including rating, which are based on sharing information with the public, are sometimes categorized as a third approach in addition to regulation and market-based methods.

5. Economic theory

5.1 Energy savings of households

Let us assume that n households with the same lifestyle and type of housing live in a certain area. Let E_i denote energy consumption of household i (= $1,\cdots,n$) for district heating. The household gets the comfort of centralized heating but suffers the effects of environmental damage, which depends on total energy consumption, $E \equiv \sum_{i=1}^{n} E_i$. The comfort and the damage can be evaluated in monetary terms, and are denoted by a benefit function $B(E_i)$ and a damage function $D(E)$. The local government supplies energy E for a cost $C(E)$. We make reasonable assumptions regarding the properties of these functions, that is, $B' > 0$, $B'' < 0$, $D' > 0$, $D'' > 0$, $C' > 0$, and $C'' > 0$. The government collects taxes equally from each household, and supplies energy using the tax revenues.

The welfare (payoff) of a household i is

$$\pi_i = B(E_i) - D(E) - C(E) / n. \quad (1)$$

Household i chooses E_i, satisfying the first-order condition

$$d\pi_i / dE_i = B'(E_i) - D'(E) - C'(E) / n \quad (2)$$

to maximize π_i. Social welfare is expressed as

$$SW = \Sigma_{i=1}^{n} \pi_i = \Sigma_{i=1}^{n} B(E_i) - nD(E) - C(E), \quad (3)$$

and the first-order condition to be satisfied by E_i to maximize (3) is

$$dSW / dE_i = B'(E_i) - nD'(E) - C'(E) = 0. \quad (4)$$

If we denote E_i that solves (2) and (4) by E_i^* and $\hat{E}_i$, respectively, $E_i^* > \hat{E}_i$ holds, as we can see from Figure 4. This shows that energy would be over-consumed relative to the social optimum.

Under these conditions, how would consumption change when energy is priced according to pay-as-you-go systems at p per unit? In this case, the payoff to household i becomes

$$\pi_i = B(E_i) - D(E) - pE_i. \quad (5)$$

From (5) we see that the household chooses E_i which satisfies

$$d\pi_i / dE_i = B'(E_i) - D'(E) - p \quad (6)$$

Social welfare is unchanged and is expressed by (3). (Note that the net revenue of the government is $pE-C(E)$.)

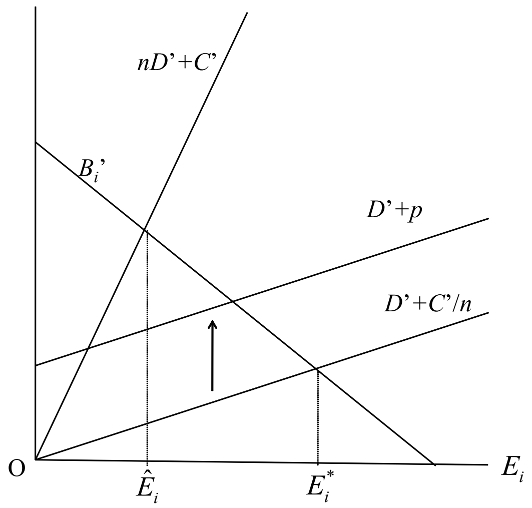

Fig. 4 Decision making on energy consumption.

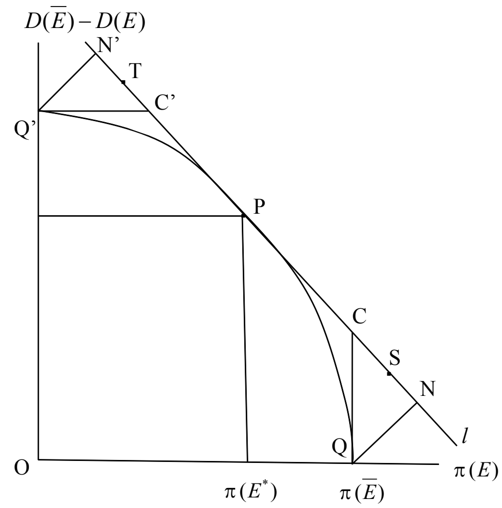

Fig. 5 Policy measures and payoff allocation.

Conducting a comparative static analysis on the price p, we can easily see that E_i decreases with an increase in p (see Figure 4). Moreover, if the price p is equal to $(n\text{-}1)D'(n\hat{E}_i)+C'(n\hat{E}_i)$, E_i satisfying (6) also satisfies (4), and the social optimum is attainable.

From these discussions, we have shown that since households do not care about environmental damage to other households, there is no incentive under the fixed charge system for them to reduce their energy consumption on district heating. It is also clear that if district heating is priced according to the meter system, every household would save energy, and the social optimum would be achieved.

Energy-saving activity by a household is regarded as the provision of public goods since it results in a better environment for all other households. However, under the fixed charge system, even if one household saves energy, the merit perceived is too limited to give the household an incentive to save energy. The meter system, which provides monetary benefits to households, should be introduced for increased energy saving. Here, the price works as a signal of the value of an improved environment.

5.2 Policy measures to enhance incentives to firms and their energy savings

Section 4 describes a variety of policy measures introduced by different governments. Here, we discuss the effects of these measures.

Consider a firm that uses energy in the production process, emitting a pollutant, and a consumer affected by the pollutant. The firm gets a profit of $\pi(E)$, using energy E, and causes a damage of $D(E)$. We assume $\pi' > 0$, $\pi'' < 0$, $D(0) = 0$, $D' > 0$, and $D'' > 0$. This is a case of external diseconomy, since only the consumer is affected by the damage.

If no policy measure is taken, the firm is considered to have a right to pollute because the environment is generally regarded as a free good, so it chooses the energy input $\bar{E}$ that satisfies $\pi'(\bar{E}) = 0$. On the other hand, the socially optimal energy input is E^*, which maximizes $\pi(E)\text{-}D(E)$; that is, it satisfies $\pi'(E^*)\text{-}D'(E^*) = 0$. Therefore, $\bar{E}$ is not a socially optimal level, and it is necessary that the government implement suitable policies.

In Figure 5, the horizontal axis represents the payoff to the firm (profit), and the vertical axis represents the payoff to the consumer, which is equal to the reduction of damage due to the decrease of energy input from $\bar{E}$. The downward-sloping curve QQ' is called a Pareto frontier; it shows the combination of payoffs corresponding to various values of E.

Direct regulation is a policy that simply imposes E^* on the firm, which occurs at point P in Figure 5, at which social welfare is maximized. In case this regulation is determined by bargaining between the government and the firm, the government subsidizes the firm according to its entitlement. If the firm has a right to emit the pollutant freely, the start point of the bargaining is Q. If the government imposes energy input E^* on the firm and at the same time pays a subsidy funded by tax revenue, the feasible region is line l, which passes through P and has a slope of -1. If the government considers that the firm should be guaranteed a profit corresponding to point Q, the subsidy is $\pi(\bar{E})\text{-}\pi(E^*)$ and a point C is realized. The Nash bargaining solution with a disagreement point Q is represented by a point N, so the firm gets more subsidies.

On the other hand, suppose that no right to pollute is given to the firm. If the firm must compensate consumers for all the damage it causes, payoff allocation C' is realized. The disagreement point and the Nash bargaining solution are Q' and N', respectively. In this case, the amount of subsidy is negative, and the firm must pay a part of its profit. Thus, the realized outcome depends on the rights given to the firm.

If a unit tax is levied for energy use, energy input decreases as the tax rate increases, and coincides with E^* when the tax rate is equal to $\pi'(E^*)$ or $D'(E^*)$. The tax that leads to social optimum is called the Pigovian tax. If the revenue from the Pigovian tax is given back to the consumer, the payoff allocation is shown by a point T, which is located on line l in the upper left region of C'. The positional relation between T and C' follows from the convexity of D and the fact that $D(0) = 0$.

When a subsidy is paid, the energy input is the same as in the case of a tax. However, the payoff allocation corresponding to the Pigovian subsidy is shown by a point S located on line *l* in the lower right region of C. The positional relation between S and C follows from the concavity of π. These analyses reveal why firms oppose tax policies but welcome subsidy policies.

Voluntary actions by firms have been frequently observed in the recent past. The cost of energy saving is generally the private information of the firm, and it is unknown to the government. Consequently, governmental regulation tends to be inefficient, with firms being required to purchase unnecessarily expensive equipment. Moreover, monitoring compliance is considered to be costly. If such regulation is anticipated, firms try to avoid it by offering voluntary action plans of energy reduction in advance. If the monitoring cost is high and the inefficiency of regulation is negligible, payoff allocation shown by a point like D_1, in Figure 6, is expected as a result of direct regulation, and D_1 becomes a disagreement point. Firms offer voluntary action plans to reduce energy input to $\hat{E}_1$, and consequently payoff allocation V_1 is realized. On the contrary, if the inefficiency of regulation is high and the monitoring cost is negligible, a point like D_2 becomes the disagreement point. Firms offer voluntary action plans to reduce energy input to $\hat{E}_2$, and payoff allocation V_2 is realized. Positional relations among V_1, V_2, and other points in Figure 6 depend on the position of the disagreement point.

With respect to rating, the demand for the goods produced by highly rated firms increases, and the price goes up. As a result, the profit of the firm increases, and the Pareto frontier shifts to the right, similar to Q'Q" in Figure 6, and the payoff allocation is shown by R.

As seen in the preceding discussions, the policy measures available, in the order of the burden on the firm, are negotiation with no rights allowed (Pigovian tax), direct regulations, negotiation with rights allowed to the firm (voluntary action, Pigovian subsidy, and rating).

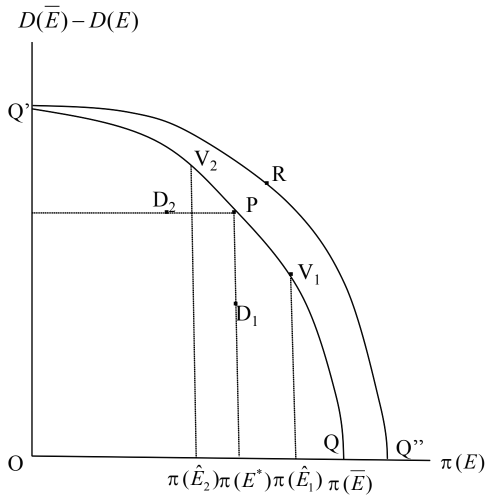

Fig. 6 Voluntary actions and rating.

6. Conclusion

This paper shows the critical importance of incentive mechanisms to encourage energy saving. Energy conservation is not emphasized in economic development, especially in developing countries, and introducing obligatory regulation is not easy. To build low-carbon societies, governments need to implement effective incentive mechanisms for both people and firms.

In this paper, we examine the features of energy consumption in Asian countries, and focus on some important issues such as district heating systems and energy-saving incentives for industry. The district heating system in China is a typical case of the lack of energy-saving incentives. Cost incentive mechanisms such as meter systems are more effective than the present setup, in which energy is regarded as a public good. Several incentive mechanisms that encourage firms to save energy exist—such as subsidies, voluntary action, and rating systems. These are explained as effective alternatives for governmental regulation—if the government does not have full information.

Incentives should be designed after careful examination of the situation, as well as a theoretical analysis to establish the universality of the procedures.

(*1) Note: The policies for households may in fact overlap with the residential sector. However, many articles focus on the household and residential sectors separately. Accordingly, we list the policies for the two sectors separately.

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