Promoting energy efficiency in industrial/commercial sector: Japanese Experience

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Abstract

This paper reviews the experience of energy efficiency policy in Japan, with a focus on the non-energy intensive industry and commercial sectors. In those sectors, there still remain substantial cost-effective potentials to improve energy efficiency. Policy response to exploit the potentials in Japan includes Energy Conservation Law and energy audit programs, both of which have been existing since the oil crises. These programs are effective to some extent in reinforcing energy management in firms and thus improving energy efficiency. The experience shows the importance of regulation and information instruments in overcoming barriers to energy efficiency.

1. Why energy efficiency policy matters

Energy efficiency is one of the top priorities in climate mitigation strategy. Literature shows that the potential of increasing energy efficiency is large, and that most of the potential has very favorable economics (IPCC, 2007; OECD/IEA, 2010). It is also widely recognized, however, that such cost-effective potentials of energy efficiency are not always implemented, because of the existence of various market barriers. Major barriers include imperfect information, split incentives, risk, and hidden costs (Sorrell et al., 2004). The fact that some of the barriers are associated with market failures calls for energy efficiency policy to overcome them (Brown, 2001).

This paper reviews Japanese policy experience to remove market barriers to energy efficiency, with a focus on the non-energy intensive industrial and commercial sectors. It begins with the evidence of substantial cost-efficient potentials still remaining in those sectors, and then explores two of the major regulations/programs to remove market barriers to energy efficiency, namely regulation on firms by Energy Conservation Law and free-of-charge energy audit programs.

2. Energy efficiency in Japanese industrial and commercial sectors

When talking about energy efficiency policy in Japan, it is often claimed that Japan is the most energy-efficient economy in the world and that there remains little low-cost opportunities because of the intensive energy conservation effort in the past. This claim seems to hold true for energy-intensive industries. For example, fossil power efficiency of Japan has been almost always the highest in the major OECD countries during the 1990's and 2000's, with average efficiency of

conversion around 43% (Ecofys, 2010). As for manufacturing sectors, an IEA assessment on energy saving potentials based on best available technologies revealed that Japan had the lowest potentials in iron and steel sector and cement sector, and the second lowest in pulp and paper sector (OECD/IEA, 2010). The evidence demonstrates that power industry and heavy industries in Japan are leading the world in energy efficiency.

The situation seems, however, different in other non-energy intensive sectors. The remainder of this section shows the existence of "energy-efficiency gap" in Japanese commercial sector. The energy efficiency gap is defined as the difference between the actual energy use and the level of energy efficiency that can be provided in a cost-effective way (Levine et al., 1995). Ventilation control and lighting control are discussed as two of the major energy conservation measures in existing commercial buildings.

Over-ventilation in commercial buildings

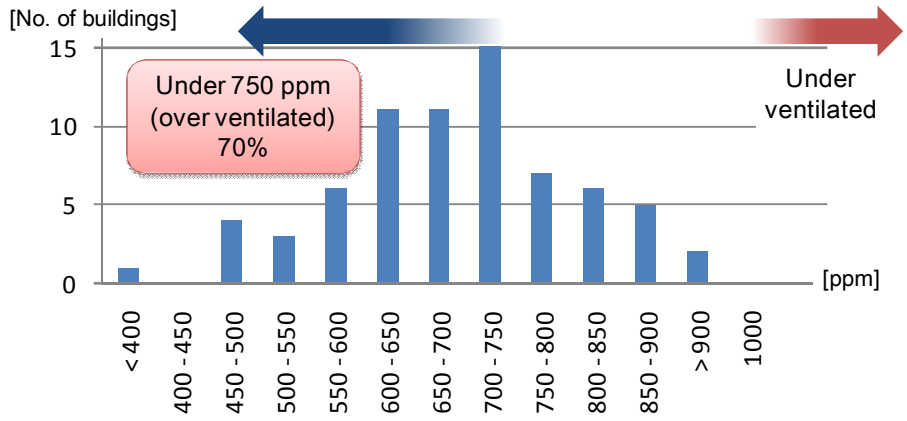
Ventilation is intended to control indoor air quality, supplying fresh air from outside and emit indoor air. Carbon dioxide concentration is commonly used as an indicator for indoor air quality. The Law for Management of Building in Japan requires carbon dioxide concentration to be below the level of 1,000 ppm for commercial buildings. But, from energy perspective, too much ventilation should be avoided because it increases energy demand for air-conditioning. Indeed, more than 30% of energy demand for air-conditioning comes from outside air (ECCJ, 2008). Therefore, controlling ventilation is an important energy conservation measure.

Then, how is the situation of ventilation control in Japan? A survey by Tokyo Metropolitan Government shows that many offices are over-ventilated. Fig. 1 shows the distribution of indoor carbon dioxide concentration in commercial buildings in Tokyo. 70% of the buildings are under 750 ppm, implying over-ventilation. This is not a result of intentional control, because another data from the same survey shows that 42% of the offices have un-controlled ventilations (Kimura et al., 2001). Since ventilation can be controlled by manual, no investment is needed to eliminate over-ventilation. This implies the existence of substantial energy conservation potential in commercial buildings only by operational improvement.

Over-illumination in offices

Similar case of unexploited potentials is in lighting. Fig. 2 shows the distribution of lighting levels in offices in Japan. While the designed levels in most samples are around 700 to 800 lx, because 500 to 1,000 are the recommended by JIS (Japanese Industrial Standard), the actual level is much higher. 36% of the sample buildings were over 1,000 lx, which is obviously more than a necessary lighting level for comfortable working environment in offices. Moreover, some research suggests that even the ambient lighting level of 500 lx might be sufficient to maintain comfort and productivity in offices (Sato et al., 1996; Inanuma et al., 2001). This implies that most offices can

reduce lighting energy by 30 to 50%, only by switching off excessive lighting.



(N=71, Survey by Tokyo Metropolitan Gov., 2006)

Fig. 1 Indoor CO2 concentration in commercial buildings in Tokyo.
70% of the buildings surveyed were over-ventilated. (Source: Kimura et al., 2011)

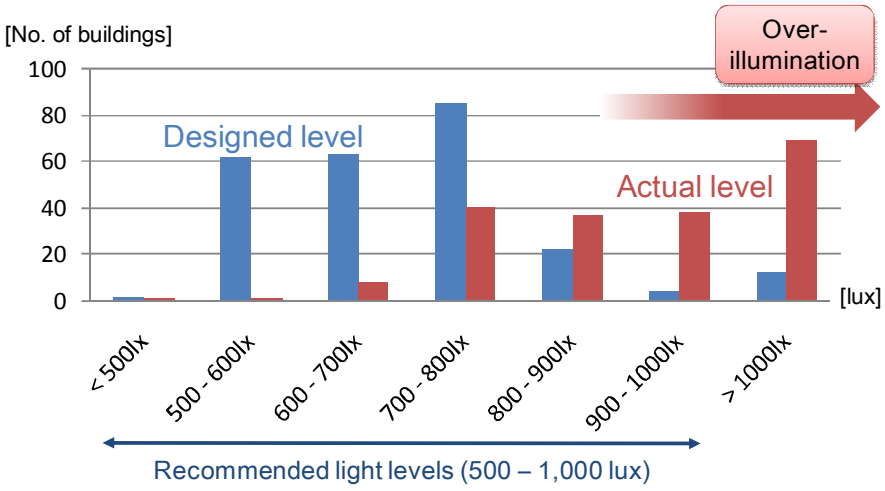


Fig. 2 Light levels in offices in Japan. 36% of the surveyed offices were over-illuminated.
(Source: Illuminating Engineering Institute of Japan, 2002)

Does energy conservation by operation improvement matter?

Operation improvements, such as improving ventilation control and lighting control, can have substantial impact on energy consumption in buildings. Fig. 3 shows the trends of energy consumption of the main buildings of Canon Marketing Japan and Panasonic Electric Works. They started their energy conservation projects 5 to 10 years ago, and so far they have achieved dramatic energy savings by 20% to 30%, compared to the level when the projects started. What is remarkable is that they achieved such reduction mainly by operational improvements and

fine-tuning of various equipments, especially air-conditioners and ventilations (Panasonic Electric Works, 2011; Saito, 2011). The two cases clearly show that energy management has substantial potentials of energy saving, implying that policy to enhance it has critical importance.

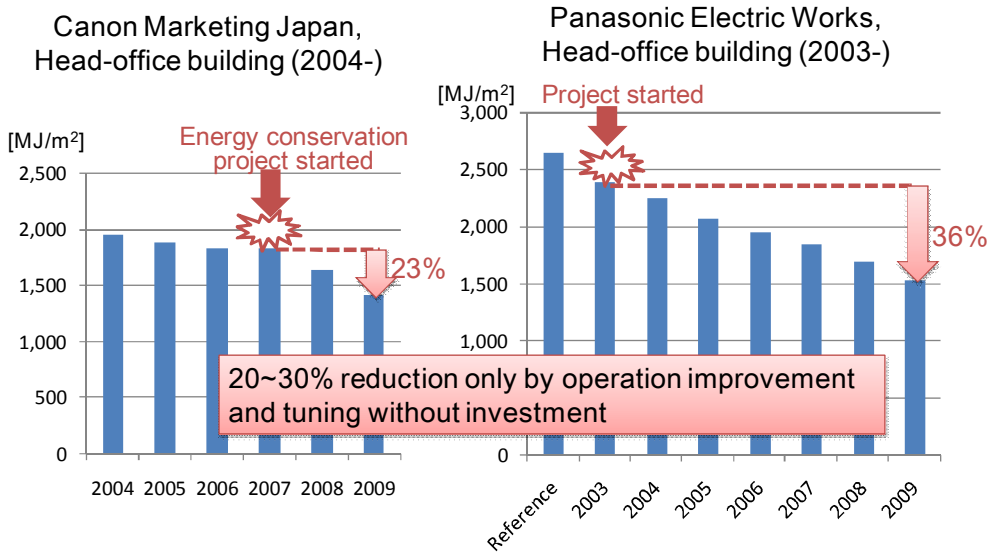


Fig. 3 Energy savings by proper energy management in commercial buildings: two successful cases. (Source: ECCJ, 2010; Saito, 2011)

3. Experience of energy efficiency policy in Japan

This section reviews the experience of two Japanese governmental programs which intend to enhance energy management by firms. One is regulation on firms by Energy Conservation Law, and the other one is free-of-charge energy audit programs by governmental subsidiary organizations.

As noted in Section 1, energy efficiency policy has an important role to remove market barriers to energy efficiency. There are three approaches in such policy intervention. One is regulation. This approach includes technology standards, performance standards, and management standards. The last type, which is also called enforced self-regulation or management-based regulation, is a way of regulation which requires firms to have some kind of management systems, and the firms determine the details of the management systems by themselves (Aires and Braithwaite, 1992; Gunningham and Grabosky, 1998). Japanese Energy Conservation Law on firms is a good example of management-based regulation. The second approach is providing information and education, such as guidelines, manuals and training. Energy audit programs in Japan belong to this category.

Energy Conservation Law of Japan

The law has a long history. It was established in 1980 and has been amended in 1993, 1998,

2002, 2005, and 2008. Every time it was amended the regulatory requirements have became severer and severer in scope and obligations. It covers large facilities consuming more than 1,500 kilo litters in crude oil equivalent per year (approximates 3,000 t-CO2 per year) are regulated. The regulated firms sum up to more than 14,000 facilities, and their energy consumption consist of 90% in industrial sector, and 10% in commercial sector.

The table 1 shows various requirements by the law. While the law basically intends to reinforce firms' energy management by introducing management tools, such as responsible organizations, reporting systems, and management standards, it also have voluntary standard for improving energy intensity. The government have been conducting on-site visits to all facilities consuming more than 3,000 kilo litters in crude oil equivalent per year (approximates 6,000 t-CO2 per year) to enhance compliance (Kimura and Noda, 2010a).

Tab. 1 Major requirements of the Japanese Energy Conservation Law

1. Assignment of qualified "Energy Manager" (mandatory)
   - both from working- and executive-levels
2. Development of responsible organization (mandatory)
3. Reporting (mandatory)
   - Energy use, flow, related equipments, CO2 emissions
   - Actions taken and plans for energy conservation
   - Compliance status with standards
4. Management standards (mandatory):
   - Develop firms' own "Standards for Energy Management" for major energy-consuming equipments (boilers, furnaces, motor-systems, etc)
5. Performance standard (voluntary):
   - 1% decrease in energy intensity annually (in five-year average)

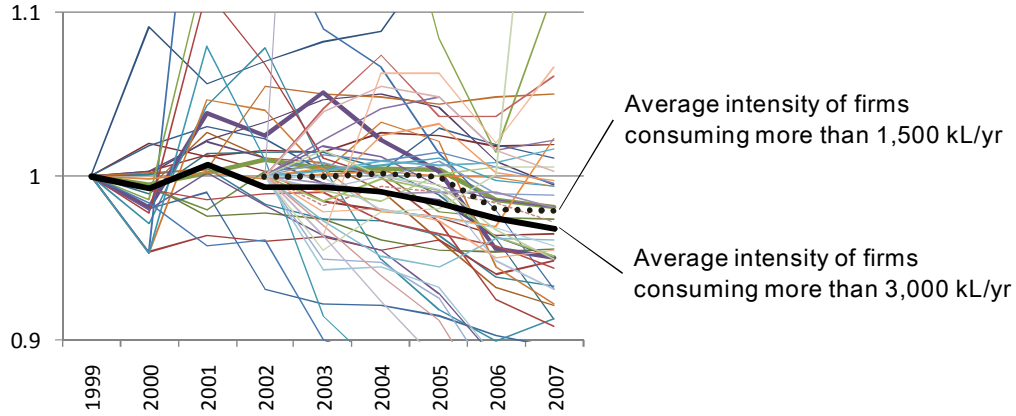


Fig. 3 Trends of energy intensity of regulated firms by industry, 1999-2007. Colored lines show the trends of various industries, and the thick black one and dotted one show average. 1999 level = 100. (Source: Kimura and Noda, 2010b)

How is the impact of the law? Although there are few ex-post evaluations, it seems that the law was effective in increasing energy efficiency in regulated firms to some extent. Fig. 3 shows the declining trend of energy intensity in regulated firms (3% decrease from 1999 to 2007). Arimura and Iwata (2007) made an econometric analysis by focusing on the hotel sector as an example. Based on panel data of the regulated 142 companies in the sector, they estimate that tightening of the regulation from 2002 to 2004 decreased fuel consumption and fuel intensity by 2.8% and by 2.4%, respectively.

Energy Audit Programs in Japan

Energy audit is a procedure to analyse the firm's energy profile and find out cost-effective energy saving potentials (AUDIT, 2000). It intends to provide firms with detailed information and technical support for energy management and energy efficiency investments. In Japan, the government has been conducting several energy audit programs since the oil crisis. They are operated by governmental subsidiary organization, such as ECCJ (Energy Conservation Center Japan) and NEDO (New Energy and Industrial Technology Development Organization). The ECCJ audit program conducts about 300 to 1,000 audits annually in small-and-medium sized enterprises (SMEs), while NEDO's program offered about 40 to 100 audits per year to large facilities from 1999 to 2007. Most of the audits were provided for firms in non-energy intensive industry which did not have enough expertise in energy management in-house. Most of the recommendations are operational improvement that requires no investment, but also include investment measures with short payback periods (usually less than three years).

Tab. 2 Trends of energy intensity of regulated firms by industry, 1999-2007.

	Program costs [Mil. JPY]	CO2 emission avoided [MM t-CO2]	Governmental cost-effectiveness *3) [JPY/t-CO2]	Societal cost-effectiveness *4) [JPY/t-CO2]
ECCJ audits for SMEs *1)	999	0.38	2,600	-6,086
NEDO audits for large facilities *2)	1,673	1.12	1,488	-3,809

*1) 2,409 audits conducted during 2004-2007.

*2) 501 audits conducted during 1999-2007.

*3) Program costs per CO2 emission avoided.

*4) (Program cost + investment costs - energy costs saved) per CO2 emission avoided.

(Source: Kimura and Noda, 2010a)

Were the programs effective in increasing energy efficiency? Tab. 2 shows an estimation of their cost-effectiveness (Kimura and Noda, 2010a). The program costs per CO2 emission avoided were around 1,500 to 2,600 JPY/t-CO2 (approximately 20 to 30 USD/t-CO2 at the exchange rate of 80

JPY/USD), which is in the same order with cost-effectiveness of DSM programs in the US (Gillingham et al., 2006) and of similar audit programs in European countries (AUDIT II, 2002). Furthermore, the societal cost of saving energy or reducing carbon emission was negative, both in the ECCJ program for SMEs and in the NEDO's one for large facilities. Thus, energy audit program is a effective approach to improve energy efficiency in firms.

4. Conclusion

This paper explored the Japanese experience of energy efficiency policy by focusing on and two governmental programs. It is shown that regulatory and informational instruments can be effective approach to remove market barriers and thus increase energy efficiency in non-energy intensive sectors. While direct-carbon pricing measures, such as carbon tax and emission cap-and-trading system, are important to address environmental externalities, non-price measures, such as regulatory and informational ones, also have an important role to play in removing market barriers. It should be recognized, however, that every policy is subject to governmental failures (Jaffe and Stavins, 1994). The two Japanese programs discussed in this paper are no exceptions and have some problems to be addressed (Kimura and Noda, 2010a,b). It is thus important to evaluate policy effectiveness regularly and to learn from the past experience.

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