Importance of minimizing social barriers to adoption of energy-efficient technologies for realizing emission reductions

Miyuki Nagashima
Researcher, Systems Analysis Group
Research Institute of Innovative Technology for the Earth (RITE)
Kyoto, Japan

Abstract

It has been widely acknowledged that there exists a great potential worldwide for reducing emissions in a low-cost or even a negative-cost manner. It is challenging, however, to achieve these potential reductions due to a variety of social barriers to adoption of energy-efficient technologies. When a new technology is adopted, many factors affect the payback period. This paper examines how a difference in payback periods in an investment decision will affect the selection of reduction technology and the marginal abatement costs. Our results indicate that an assumption of the payback period will have a significant impact on the technology selection and costs. Overcoming various social barriers such that an investment decision with a long payback period is made by companies and individuals will play an important role in saving energy and controlling climate change.

Key words: Social barriers, Payback-period, Bottom-up approach

1. Introduction

International cooperation on climate change control is difficult to achieve in the real world because of the widely varying national circumstances and the conflicts of interest among countries. This can explain the slow negotiation process of the United Nations Framework Convention on Climate Change. It has been widely acknowledged that there exists great potential worldwide for low-cost emission reduction. Energy saving measures, such as the use of super critical or ultra-super critical pressure coal-fired power plants and the coke dry quenching (CDQ) process in the iron and steel sector, can be implemented at low costs or even at negative costs. However, these measures are difficult to realize because of various social barriers that, for example, hamper the energy efficiency investment and technology diffusion. These social barriers differ among sectors and countries.

The purpose of this paper is to explore the impact of removing the social barriers to energy efficient investments on the selection of reduction technology and on marginal abatement costs by conducting a quantitative analysis. This paper discusses the research outcomes of the ALternative Pathways toward Sustainable development and climate stabilization (ALPS) project[1]. The rest of this paper is organized as follows: Section 2 presents various costs that the investors or consumers have to incur while selecting technologies and discusses the determinants of the decision on payback periods. Section 3 explains our quantitative methodology, and the model results are presented in Section 4. Section 5 concludes the paper.

2. Technology selection

Figure 1 shows the estimation of the global marginal abatement cost curve for the year 2020. The horizontal line indicates the CO_2 emission reduction in the technology frozen scenario, in which the CO_2 intensity level in the year 2020 by sector is assumed to be the same as the current level. The vertical line shows the CO_2 marginal abatement costs. This figure shows that there is great potential for mitigation at relatively low costs, such as the diffusion of high-efficiency technologies in the iron and steel sector and the efficiency improvement of coal and gas-fired power plants. From the perspective of technology costs, the low-cost or negative-cost mitigation technologies should have been adopted before high-cost technologies. In reality, however, these mitigation technologies have not yet been adopted because certain social barriers hamper their adoption.

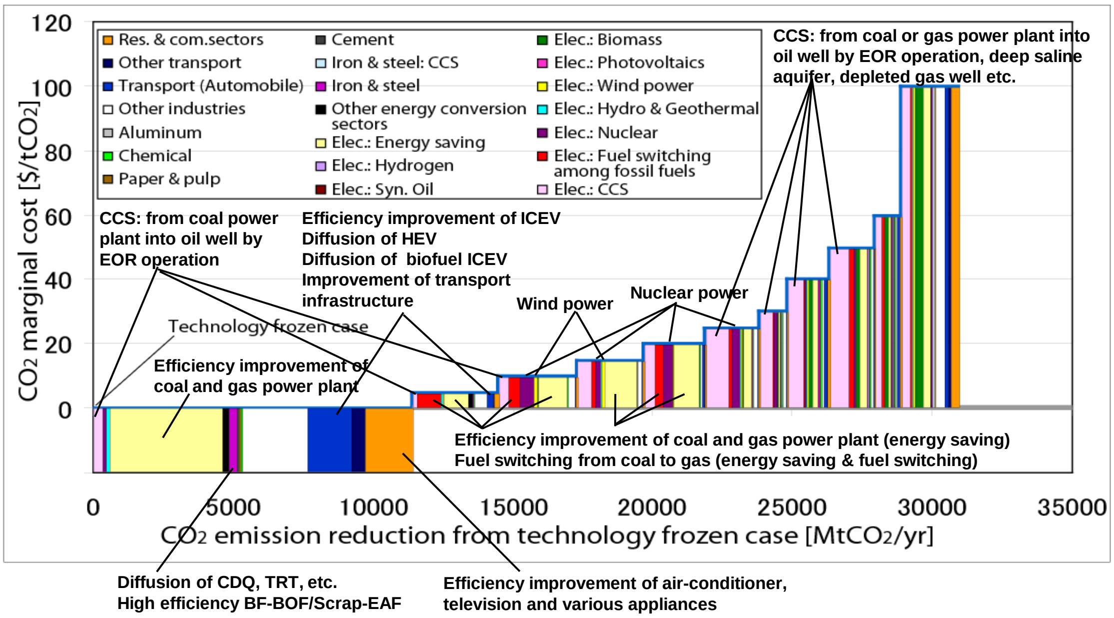
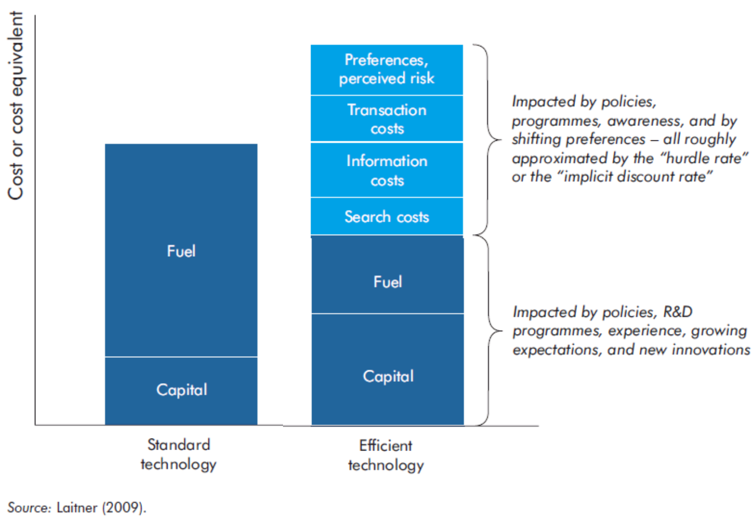


Figure 1. Global marginal abatement cost curve for the year 2020

[1] The detailed information is available at http://www.rite.or.jp/Japanese/labo/sysken/system-alps.html.

Figure 2 illustrates the different cost structures for two types of technologies: (i) standard technology and (ii) energy-efficient technology. In general, the initial capital costs of standard technology are lower than those of efficient technology. On the other hand, the overall fuel costs are lower in the case of the efficient technology than in the case of the standard technology. Given such a cost structure, the efficient technology will be selected as the fuel and initial capital costs in the case of this technology are lower than those in the case of standard technology. However, in reality, “hidden costs” will be added to the costs of the efficient technology. These “hidden” costs include the costs for searching better products, costs for collecting information, and costs caused by an individual’s time preference and risk perception. Therefore, the total costs associated with efficient technology will end up being higher than those associated with standard technology. The question here is how to reduce these “hidden” costs in order to promote the selection of highly efficient technology.



Source: IEA ETP 2010

Figure 2. Different costs related to technology selection

While purchasing a certain technology, the payback period is calculated as the years required to recoup the initial costs out of the cash inflow brought about by using the technology. Policy measures that promote a long payback period reduce the hidden costs. There are many factors that affect an investment decision, as shown in Table 1. For example, when an investor’s fund-raising capacity is small and the investor is financially conservative, a technology with low initial costs but a low fuel saving ability will be preferred over another technology with a high fuel saving ability but high initial costs as the investor is more focused on short-term goals rather than long-term benefits. Furthermore, limited access to information and limited capability for examination of the technology also influence the investment decision. The determinants of the decision on the payback period widely vary among countries, sectors, and individuals. Bottom-up studies are useful for the assessment of sector-specific options, which enable us to examine, for example, the impact of minimizing social barriers at a sectoral level.

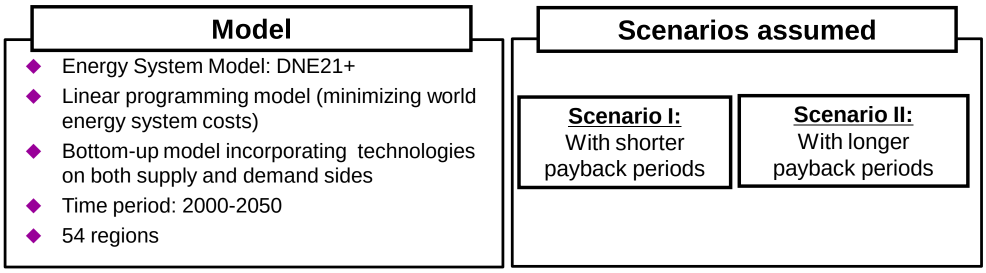
Table 1. Possible determinants of decision on payback period

■ Factors related to investors	
Funds	Financial surplus, fund-raising capacity
Rate of return for companies	The rate of return on investment (ROI) generally ranges from 10% to 20%. A large divergence from this range will be a barrier to the implementation of the investment.
Pure rate of time preference	Not only the manager's rate of time preference but also the manager's term of office will affect the payback period.
Subjective risk preferences	Subjective risk preferences of investment decision makers
Costs of access to information and organization of information	Costs of access to information and organization cannot be ignored in the case of small-scale investments.
Bounded rationality	Appropriate choices cannot be made because of limited examination capability.
■ Factors related to equipment and appliances	
Uncertainty of equipment lifetime	This uncertainty will lead to a barrier against an introduction of new equipment if its credibility is considered to be low because of its lack of performance.
Expectation of technological progress in equipment	There is an expectation that better equipment/appliances will be available in the future.
Resistance to and rejection of new equipment	Familiar equipment/appliances tend to be preferred on site.
Low priority for energy saving	
■ Factors related to external environment	
Uncertainty of energy prices	Investment decisions are influenced by the probabilities of increases in energy prices.
Market interest rate	Market interest rates have an impact on funding.
Stockholders' expectation for profits	Stockholders' decision depends on whether they expect profits in the short term or in the long term.

3. Methodologies

Model

We explore the impact of a change in the payback periods on the mitigation of costs by using our bottom-up assessment model, called the DNE21+ model, which addresses emission reduction technologies in detail from the perspective of both energy supply and energy demand (Akimoto *et al.* 2008 and 2010). This model is an intertemporal linear programming model for assessing global energy systems and global warming mitigation, in which worldwide energy system costs are minimized. The model covers the period from the year 2000 to the year 2050 and considers 54 regions. The bottom-up studies are useful for an assessment of sector-specific options, which enable us to examine, for example, the impact of minimizing social barriers to adoption of energy-efficient technologies at a sectoral level.



Assumed payback periods (year)

	Scenario I		Scenario II	
	Upper limit	Lower limit	Upper limit	Lower limit
Electricity generation sector	11.9	4.0	17.2	9.8
Nuclear power generation	9.0	3.6	17.2	9.8
Other energy conversion sector	6.6	3.3	13.3	9.8
Energy intensive sector	6.6	3.3	13.3	9.8
Transportation sector	3.3	2.0	7.6	4.7
Residential & commercial sector	3.3	1.7	7.6	4.7

Figure 3. Overview of our quantitative analysis

Scenarios

Two scenarios are considered in our analysis. Scenario I is a real-world scenario with people's diverse technology preferences, which indicate that cost-effective mitigation measures are not always taken into account while making an investment. There exist various barriers to technology diffusion. On the other hand, Scenario II describes a world in which the climate change policy is prioritized and people's behavior is rational in that mitigation measures are carried out in a cost-effective manner. This assumption is commonly applied in most of the conventional assessment models of climate change control.

Assumed payback periods

In Scenario I, we consider relatively short payback periods, assuming the ones observed in the real world. The rationale behind this assumption is that climate change control is not the first priority for investment decision makers and the payback periods are subjectively determined without considering a cost-effective way to save energy and to reduce emissions. On the other hand, we consider relatively long payback periods in Scenario II, in which climate change controls are prioritized and cost-effective reduction measures are carried out from the perspective of long-term energy saving. Further, Scenario II describes a world in which policy measures are implemented to remove social barriers to technology diffusion and to improve a bounded rational behavior. In both scenarios, the payback periods in the transportation, residential, and commercial sectors are assumed to be shorter than those in the industrial sector as the investment in fuel-saving technology is made from a relatively long-term point of view, especially in the electricity generation sector and the energy-intensive sector.

The proposed model assumes different payback periods among countries on the basis of the countries' economic development. In general, the payback periods in developing countries are shorter than in developed countries; therefore, the periods are assumed to lengthen with economic growth.

4. Results

This section shows some of the results obtained using the proposed model. Figure 4 presents an illustration of the baseline electricity generation in the case when there are no reduction targets. This figure indicates that more high-energy-efficiency technologies for power generation will be introduced in Scenario II than in Scenario I. The consideration of relatively long payback periods leads to an introduction of a large number of advanced technologies. For example, in the year 2050, more high-efficiency coal-fired and photovoltaic (PV) power plants are introduced in Scenario II than in Scenario I.

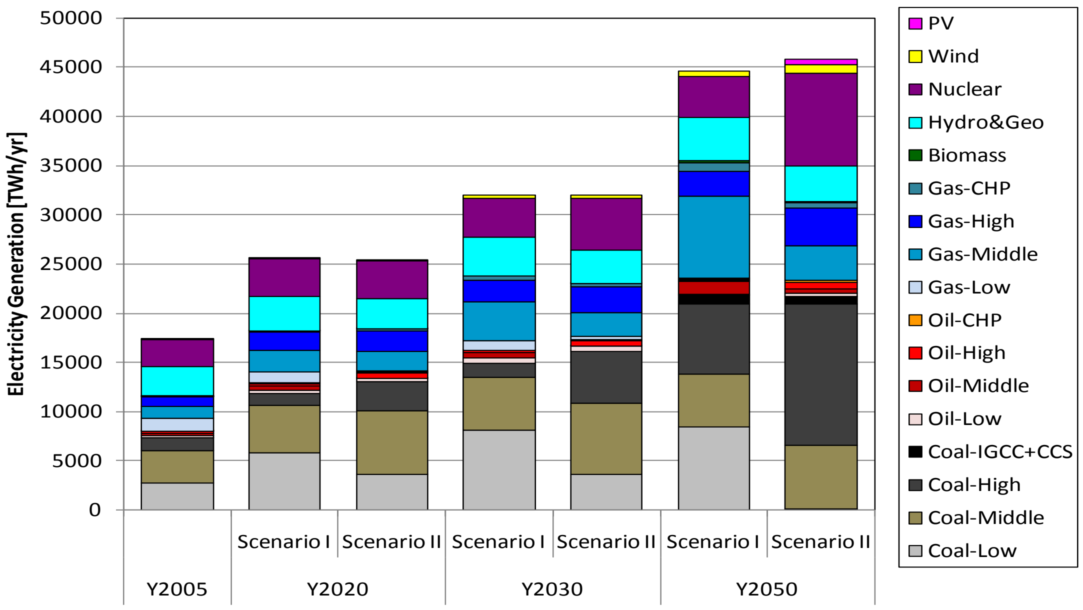


Figure 4. Baseline global electricity generation (without reduction targets)

Figure 5 shows the global CO_2 marginal abatement costs when the global emissions are halved by the year 2050. The marginal costs in Scenario I with relatively short payback periods reach \$476/tCO_2 in the year 2050, which is significantly higher than those in Scenario II (\$285/tCO_2). The marginal cost in Scenario I represents an explicit carbon price under explicit carbon pricing policies, and that in Scenario II represents an implicit carbon price under bottom-up policies that minimize social barriers such as energy standards, technology regulations, and labeling. This difference in marginal abatement costs indicates that public policies that minimize social barriers to technology diffusion will play an important role in achieving emission reductions at low costs.

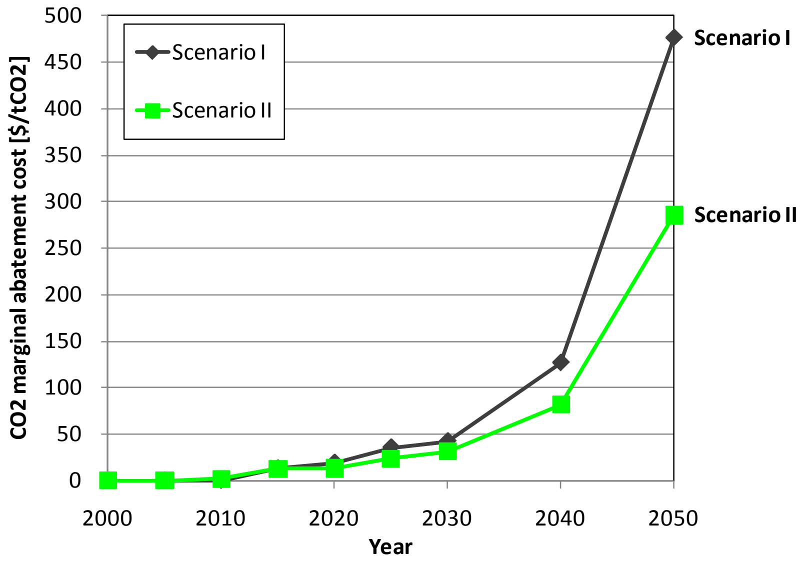


Figure 5. CO_2 marginal abatement costs when global emissions are halved by the year 2050

5. Conclusion

This paper explored the impact of minimizing social barriers to the adoption of energy-efficient technologies on the selection of mitigation technology and the marginal abatement costs; the model assumption regarding the payback periods could have a significant impact on the results and the quality of policy suggested.

Our results indicated that policies that could close the gap between Scenario I and Scenario II were effective in realizing large emission reductions at low costs. Overcoming various social barriers such that an investment decision with a long payback period is made by companies and individuals will play an important role in saving energy and controlling climate change. The "hidden" costs can be overcome by introducing policy measures such as labeling to increase awareness of purchasing energy-saving appliances, although the realization of such policy measures would be challenging.

For promoting energy-efficient technology diffusion in developing countries, the reduction of the initial capital costs through subsidies provided by developed countries is another important option. Tailor-made international cooperation and policy instruments that consider each country's and sector's conditions are the key to promoting the selection of high-energy-efficiency technologies.

It should be noted that the modeling estimation does not perfectly describe the real world; however, it provides valuable scientific insights for policy makers. Accurate interpretation and precise understanding of the model analysis will enable the effective estimation of policy implications.

References

Akimoto, K., F. Sano, T. Homma, J. Oda, M. Nagashima and M. Kii (2010): Estimates of GHG emission reduction potential by country, sector and cost, *Energy Policy*, 38 (7), 3384-3393.

Akimoto, K., F. Sano, J. Oda, T. Homma, U.K. Rout and T. Tomoda (2008): Global emission reductions through a sectoral intensity target scheme, *Climate Policy*, 8, S46-S59.

IEA (2010): Energy Technology Perspective 2010, International Energy Agency, Paris, France.