New Policy Agenda of Japan on Climate Change Issues : (provisional version)

Verifying the 25% Reduction Initiative and a New Proposal for Substantive Reductions

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Introduction

The new mid-term target presented by Prime Minister Hatoyama to reduce emissions by 25% from 1990 levels (or approximately 30% below 2005 levels; the government later having abandoned its adherence to the 1990 baseline year, both figures will be interchangeably referred to as the "new mid-term target" herein for descriptive purposes unless the context requires specification. Some figures and tables are explicitly based on a 30% reduction target with respect to 2005 emissions) entails an array of issues. First of all, in terms of the five requirements raised in a policy proposal for multinational climate change negotiations[1] published by the 21st Century Public Policy Institute in April, it lacks international equitability, technological feasibility and acceptability of burden. Even from the perspective of "providing momentum towards international negotiations," which was the original purpose of proposing the target, neither the US nor China has made any international commitments as of

[1] Akihiro Sawa (2009) "Chikyu Ondanka Kokusai Kosho ni Kansuru Seisaku Teigen –Dai Ichibu: Nihon ga Tuikyu subeki Kosho no Bottom Line" (Policy Proposals for Multinational Climate change Negotiations –Part I: Japan's Bottom Line in Negotiations), 21st Century Public Policy Institute http://www.21ppi.org/pdf/thesis/090417.pdf (Japanese only)

yet, and the EU is said to be ready to withdraw its pledge to reduce emissions by 30% below 1990 levels, to which it would commit only if other countries agreed to ambitious targets, and will confine itself to a 20% reduction target.[2] Therefore, the new mid-term target has made no diplomatic progress. The outcome of COP15 negotiations in Copenhagen being unpredictable, if the preconditions provided by Prime Minister Hatoyama for the new mid-term target, namely the establishment of "a fair and effective international framework in which all major economies participate" and an "agreement on ambitious targets by all major economies," cannot be met, Japan will have to return to the drawing board to review its international commitment[3].

Industry has expressed concerns regarding the new mid-term target - that it lacked transparency in terms of its grounds and how it can be achieved and that it had not fulfilled public accountability. The new mid-term target, or "30% reductions below 2005 levels" represents the most stringent of the four options[4] discussed in the Mid-Term Target Review Committee under the former administration. It had once been dismissed because it would have too large an impact on the economy and the policy tools and scale that it called for were unrealistic. Therefore, past analysis may have explored it far enough to reveal the potential impact it would have on industrial activity in the case that it were actually implemented – especially in terms of competitiveness, employment and local economy.

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[2] The Yomiuri Shimbun November 1, 2009 p1

[3] Minister of the Environment, Sakihito Ozawa also told Reuters in an interview that the government's international pledge to reduce CO2 emissions by 25% is hinged on the involvement of major emitters. He said, "The government announced with a precondition at the United Nations so of course it could change." The following article should be referred to:

http://jp.reuters.com/article/economicPolicies/idJPnTK034285820091023

[4] Details of debate can be found in:
http://www.kantei.go.jp/jp/singi/tikyuu/kaisai/index.html

This report will study international equitability according to the outcomes of research announced by analytical institutions around the world in Chapter 1. Chapter 2 will employ a model that considers international inter-industrial relations to provide an impact analysis of the industrial and economic effects of the new mid-term target. Chapter 3 will abandon the stereotypical idea that climate change can only be addressed using numerical targets, thereby studying the possibilities of public-private partnership in substantively reducing the world's GHG emissions and finally presenting a realistic policy proposal.

*This proposal is an outcome of research conducted by the 21st Century Public Policy Institute and does not represent the views of Nippon Keidanren.

November 25, 2009

Contents

Executive Summary

1. New Mid-Term Target and International Equitability
   (1) The target to reduce emissions by 25% compared with 1990 levels = new mid-term target is diplomatically hinged on establishing "a fair and effective international framework in which all major economies participate" and an "agreement on ambitious targets by all major economies." However, its criterion of "fairness," in particular, has not yet been clearly defined.
   (2) Japan has conventionally taken the position that the international criterion for equitability should mainly be based on equalized marginal abatement costs, which most precisely represent historical national energy conservation efforts. Studies by various research institutions and international organizations have also indicated that Japan's marginal abatement costs are the highest of all major economies.
   (3) Prime Minister Hatoyama's new mid-term target is considerably outstanding compared with those of other countries, not only based on the equalized marginal abatements costs but against other criteria for equitability as well.
   (4) If the preconditions are not met in international negotiations, the target should at least be lowered to an equitable level in respect of other nations, if not taken back to the drawing board to be properly reconsideration.

2. Assessing the New Mid-Term Target's Impact on Industry and the Economy
   (1) The Research Institute of Innovative Technology for the Earth (RITE)'s DEARS model, which can consider international inter-industrial relations, was used to analyze the impact of the new mid-term target. Outcomes showed that under the new mid-term target, value-added loss was enlarged in materials industries, in particular, causing serious

draining of employment and income accompanied by carbon leakage to countries such as China that are not do not have carbon restrictions.

(2) Macroeconomic indices showed that household consumption would drop significantly, along with a -9.1% GDP loss respective of the baseline and a 2.8% rise in the unemployment rate. Local economies weighted on materials industries will suffer great damage; related industries will also be influenced and regional discrepancies with widen.

(3) Furthermore, the price of products made in energy-intensive industries (iron and steel, cement) will be affected by surging energy prices. Depending on the system structure, incremented costs could be the equivalent of or several times the product price, therefore depriving Japan of its international competitiveness.

3. Vision for a Developed-Developing Country Cooperation Model: For International Contribution by Industry to Climate change Solutions

(1) Industry should also consider ways to "bridge" developed and developing countries. Contributions should be centered on substantively reducing GHG emissions through energy and environmental technology transfer and international intersectoral cooperation and agreement and supplying products that will contribute to creating a global low-carbon consumption society in terms of LCA (life cycle assessment).

(2) Japan, the US and China should launch a model project of developed-developing country cooperation based on public-private partnership in areas including energy conservation, renewable energies and nuclear energy. Reductions generated in the project should be trilaterally accredited among the three countries as offset credits that could be used for the purpose of staying in compliance with domestic schemes.

(3) Furthermore, industry could also look into setting up a new organization provisionally called the Institution for Engineering

Solutions for Climate change, which would be based on public-private partnership to promote the projects described above, to implement the Voluntary Action Plan in wider international dimensions and to collect benchmarking data.

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1. New Mid-term Target and International Equitability

1.1. Equalizing marginal abatement costs among countries as criterion of equitability

In his UN speech, Prime Minister Hatoyama stated that the new mid-term target to reduce emissions by 25% compared to 1990 levels was hinged on establishing "a fair and effective international framework in which all major economies participate," but made no clarification whatsoever of his standards for "fairness." In fact, perhaps equitability criteria have not yet been defined even within the government.

A policy proposal for multinational climate change negotiations[5] published by the 21st Century Public Policy Institute in April stated that international criteria for equitability should be mainly based on equalized marginal abatement costs, which most precisely represent historical national energy conservation efforts and which can secure the comparative equitability of costs entailed by additional measures.

The Japan's high marginal abatement costs indicate that all easy (inexpensive) energy conservation opportunities have already been fully exploited as a result of many years of cost reduction efforts on the part of industry and the "mottainai" culture in Japanese households. The remainder of opportunities being quite costly, attempts to achieve reductions by 25% with

[5] Akihiro Sawa (2009)

such narrowed options are bound to push carbon prices high. If there is a need to simultaneously introduce an emissions allocation scheme, prices will be as much as ten times higher than those in other countries. Therefore, in the event that it is linked with European and Chinese schemes, foreign dealers will be rushing to Japan's doorstep to sell emission allowances. Then, companies and households are likely to shift from investing in technology development and energy-saving equipment and products to importing these comparatively inexpensive emission allowances, thus letting Japanese income and employment opportunities to leak out overseas.

Considering the policy choices studied by the Mid-Term Target Review Committee of the former administration from the viewpoint of equalizing marginal abatement costs, we can see that Japan's choice of an equitable reduction target against those of the US and EU would have been "+4% from 1990 levels" (see Figure 1-1). The new mid-term target identifies with scenario (6) of the options laid out by the Committee and would impose upon Japan marginal abatement costs exceeding 470 USD/t-CO2eq, or ten times those of the US and EU which would be around 50 USD/t-CO2eq. This means that if the US and EU were to make reduction efforts with the marginal abatement costs required for Japan to comply with its mid-term target, they would have to set their reduction targets between 40% to 50% compared to 1990 levels.

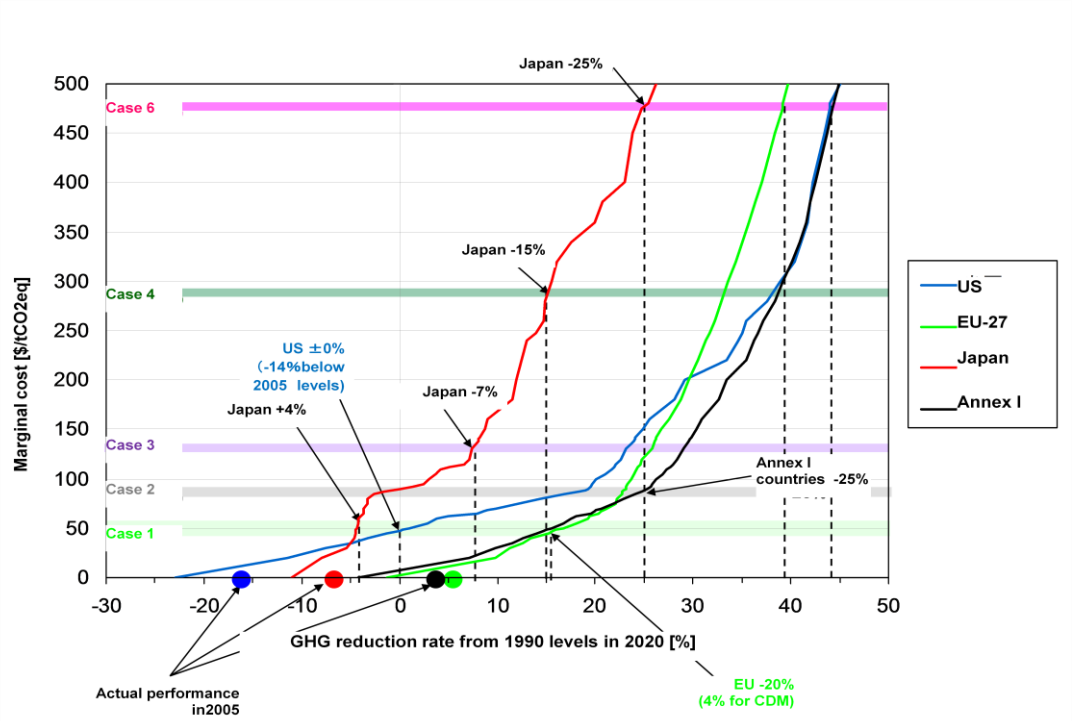

Figure 1-1 Cross-national comparison of marginal abatement costs
(Source: Research Institute of Innovative Technology for the Earth)

Figure 1-1 presents a model analysis conducted by a Japanese research institute. Marginal abatement cost analyses for each country using energy, technology and economic models from various overseas research institutes have been compiled in a study recently published by the International Institute for Applied Systems Analysis (IIASA)[6]. Figure 1-2 exhibits marginal abatement cost curves for Japan, the US and EU which suggest that in order to achieve the

[6] Markus Amann, Peter Rafaj, and Niklas Hohne (2009) "GHG Mitigation Potentials in Annex I Countries – Comparison of Model Estimates for 2020," IIASA IR-09-034, Sep. 2009.

same percentage of reductions, Japan would have to assume the highest marginal abatement cost across all models.

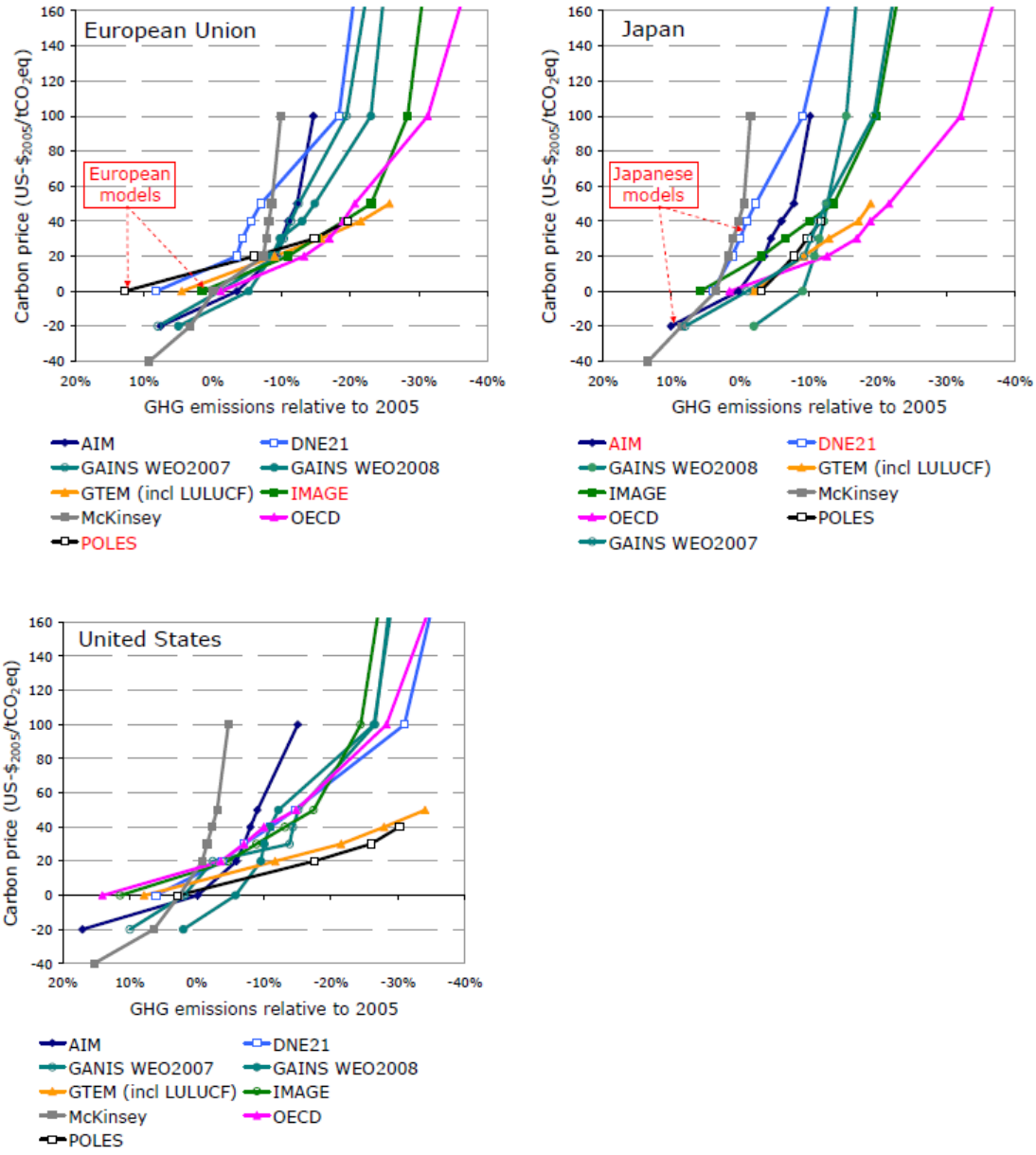

Figure 1-2 Marginal abatement cost analysis for major economies using major models

Furthermore, the OECD-IEA makes an inter-institutional comparison of models[7]. Figure 1-3 displays an analysis of the reduction potential of each country in 2020 at 50 USD/t-CO2eq. The figure suggests that Japan's reduction potential towards 2020 with respect to the baseline year is the lowest of all countries covered in the analysis. A majority of models analyze Japan's reduction potential to be no more than 10%, whereas most models depict that the US and the wider EU, including Central and Eastern Europe have significantly high potential and thus much room for energy conservation

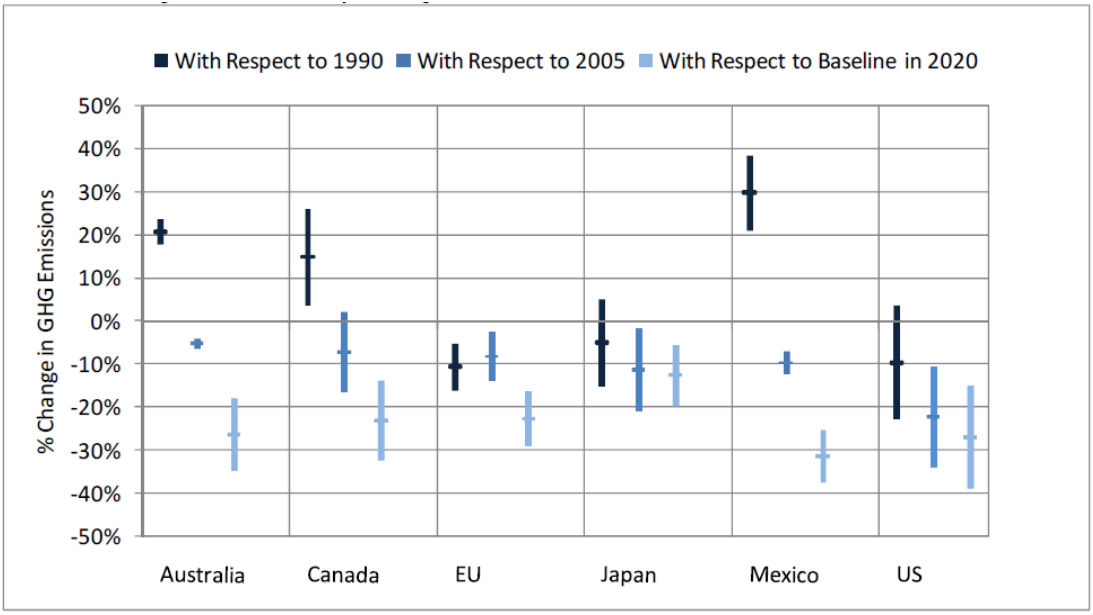

Figure 1-3 Summary of Model Analysis of Mitigation Potential by Country in 2020 at 50USD/t-CO2

Figure exhibits range and medium of amounts calculated by models. Models employed are: G-Cubed, GTEM, MMRF (Australia); EC_IDYGE, E3MC (Canada); GEM-E3, POLES (EU); AIM/Enduse, DNE21+ (Japan); LEAP/MEDEC (Mexico); ADAGR, EPPA MERGE, SGM (US); and ENV-Linkages, GAINS, McKinsey, WEM and WITCH (international institutions, private firms, etc.)

[7] Christa Clapp, Katia Karousakis, Barbara Buchnerm and Jean Chateau (2009) "National and Sectoral GHG Mitigation Potential: A Comparison Across Models," OECD-IEA, Nov. 2009

1.2. National Reduction Targets Based on Different Criteria for Equitability

Equalized marginal abatement costs are only one of various criteria for equitability, for example, equalized emissions per capita, equalized abatement costs per GDP and historical responsibility are among criteria that are often studied.

However, in order to employ equalized emissions per capita as an equitability standard, fundamental rules under the Kyoto Protocol regime must be altered. Negotiations on the Kyoto Protocol and the post-Kyoto framework are based on the idea that GHGs emissions should be counted by country of origin. However, with GHGs being generated as a result of the fossil fuel consumption accompanying human economic and daily life activities, the focus should be on "fossil-fuel consumption of individuals of a country" rather than on "country-specific emissions" in order for individuals around the world to bear a fair share of burden. In order to employ equalized emissions per capita as a criterion for equitability, emissions would be required to be counted according to how much GHG was indirectly emitted at the consumption level in the country where a product or service was consumed, instead of how much was emitted in the country of origin.

In reality, however, it is technically difficult to get hold of precise data on consumption-level emissions. Moreover, it is not easy to equitably reflect inevitable physical circumstances, including climate, national land area and population density. Furthermore, decisions on premises that will significantly affect national emissions, such as at what point in the future the indicator should be equalized and when to set the baseline year, are likely to complicate negotiations. Therefore, it must be concluded that per capita emissions entails many problems.

Table 1-1 compiles different proposals based on other criteria. Although national reduction ratios vary according to how equitability is defined, the following points can be made regarding all models:

Firstly, all cases reflect historical energy conservation efforts, thus requiring smaller reductions of Japan, compared to the EU. If Annex I (developed) countries were to collectively reduce emissions by 25% below 1990 levels, Japan would have to mitigate emissions by no more than 20%, which is comparable with the reduction level required of the US. The joint proposal by 37 countries, which has been formally made in international negotiations, determines equitability based on historical responsibilities and requires significantly smaller reductions of Japan compared with the US and EU.

Secondly, the larger the reductions determined for Annex I countries collectively, the closer the reduction ratios individually determined for Japan, the US and EU.

Thirdly, extremely large reductions are demanded of Russia, which means that in order to establish a globally fair framework, its 10% reduction target respective of 1990 levels must be reconsidered to be more ambitious.

	All Annex I Countries	Japan	US	EU	Russia	Definition of "equitability"
Ecofys	▲20%	0%	▲1%	▲26%	▲39%	Equalization of reduction costs per GDP
	▲20%	▲8%	1%	▲30%	▲45%	Equalization of marginal reduction costs
Project Catalyst	▲25%	▲20%	▲17%	▲27%	▲41%	Equalization of marginal reduction costs, taking into account national reduction potential
	▲40%	▲42%	▲33%	▲50%	▲48%	Equalization of marginal reduction costs, taking into account national reduction potential
Joint proposal by 37 countries	▲40%	▲19%	▲26%	▲28%	▲15%	Responsibility for historical emissions *for this proposal only, figures represent average mandatory emissions reductions from 2013-2020

Table1-1 Proposals of Reduction Commitments in 2020 by Annex I Countries (with respect to 1990)

Finally, we take a look at an analysis recently conducted by the International Energy Agency (IEA)[8]. IEA analyzes national reductions and costs required for the achievement of its "450ppm Scenario[9]" which projects CO2 emissions of energy origin through 2030. The breakdown of measures called for in the IEA 450 ppm Scenario is as follows: energy conservation accounts for more than half of reductions; renewable energy, 20%; nuclear energy, 10%. It also considers carbon capture and storage (CCS) to become important after 2020. In its calculation of country-specific emissions requirements, the scenario reflects: 1) national policies and measures; 2) sectoral approaches iron and steel, cement and other industrial sectors; and 3) equalizing marginal abatement costs through global emissions trading in the power generation and industrial sectors. Table 1-2 exhibits a comparison of figures calculated under the scenario with the mid-term reduction targets currently announced by each country.

	Announced emissions reduction target for 2020	Relative to 1990 emissions		Relative to 2005 emissions		Abatement in 450 Scenario v Reference Scenario (Mt)
		Target	450 Scenario	Target	450 Scenario	
US	-17% v 2005	-1 %	-3 %	-17 %	-18 %	749
EU	-20%/-30% v 1990	-20 %	-23 %	-18 %	-21 %	444
Japan	-25% v 1990	-25 %	-10 %	-34 %	-21 %	84
Russia	-10% to -15% v 1990	-10 %	-27 %	+29 %	+5 %	134
China	-		+275 %		+65 %	1 178
India	-		+224 %		+66 %	249
OECD+	-		-4 %		-17 %	1 656
Non-OECD+	-		+107 %		+41 %	2 194
World	-		+46 %		+13 %	3 850

Table 1-2 IEA Analysis of required reductions by country in 2020

In the 450 ppm Scenario, China accounts for 30%, and the US, for 20% of the additional reductions required globally, collectively being responsible for

[8] IEA (2009) *World Energy Outlook 2009*

[9] The IEA 450ppm Scenario requires developed countries to curb emissions by 17 percent compared to 2007 levels in 2020, and 41 percent in 2030, making global emissions peak out by 2020 in order to keep temperature increases below 2 percent Celcius.

half of the world's reductions, whereas Japan would need to contribute to only 2-3% of the reductions[10]. Table 1-2 suggests that while the targets proposed by the US and the EU would still be inadequate, Japan's new mid-term target largely exceeds its share of reductions in the 450ppm Scenario by as much as 15% and is therefore overly "ambitious" as it is.

1.3. The importance of international equitability

As we have observed above, the world agrees that Japan's well of energy conservation opportunities is almost dried up and the options remaining for Japan to take its energy conservation efforts further are considerably costly compared to those available for other countries. The mid-term target to achieve "15% reductions relative to 2005 emissions" announced by the Aso administration had been well accepted among other countries as an adequate target because it was supported by a wealth of research.

Prime Minister Hatoyama stated that he set out the new mid-term target with the intension to provide momentum towards deadlocked international negotiations[11], but despite the number of opportunities he has had in subsequent summit meetings with leaders of the US, China and other major countries, there have been no reports of the Prime Minister demanding his counterparts to consider more ambitious targets. In order to seek a "fair

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[10] The premises for Japan to achieve 10% reductions below 1990 levels are: boosting the operation rate of nuclear plants from 70% to 92%, or the OECD standard, constructing one new nuclear power plant and 270 wind power turbines every year, and raising the diffusion rate of next-generation vehicles to 50%.

[11] See Prime Minister Hatoyama's response to questions during a session of the Lower House Budget Committee on November 4, 2009.

framework" for his country, he needs to be able to provide an explanation of the equitability of his new mid-term target against the mid-term target announced by other countries. Otherwise, he will neither be able to press his counterparts for concrete compromises, nor be able to judge the acceptability of numerical targets that will be proposed in the tense final stage of negotiations in light of "fairness," which he himself set out as a precondition.

The analysis above has proven Japan's current target to be outstandingly "ambitious" compared with those of other countries, based on not only the equalized marginal abatements costs but against other criteria as well. If the preconditions of the new mid-term target cannot be met and the establishment of "a fair and effective international framework" and "agreement on ambitious targets by all the major economies" have no hope of being secured in international negotiations, Japan should return to the drawing board to reconsider its mid-term target, leaving lowering the current target among its options.

2. Assessing the New Mid-Term Target's Impact on Industry and the Economy

2.1. Method of analysis

The impact analysis in this chapter will employ the DEARS (Dynamic Energy-economic Analysis model with multi-Regions and multi-Sectors) model developed by the Research Institute of Innovative Technology for the Earth (RITE)[12].

The analysis conducted in the Mid-Term Target Review Committee employed RITE's world model and other domestic models, which all make calculations using given production amounts for individual industries. For example, raw steel production is given exogenously for each country as an invariable value. This method of analysis has been adopted based on the idea that equitability should be defined by comparable marginal abatement costs across all nations and that it was important to diplomatically realize a framework and relative targets that would secure such a state.

However, the Hatoyama regime set out a new mid-term target as part of its diplomatic policy without clarifying its criterion of equitability, as will be further discussed below. Japan has prioritized results – a 25% target - and hence the logic must be reanalyzed, keeping in mind that marginal abatement costs vary significantly among economies. Under these circumstances, Japan's international competitiveness could be greatly hindered, therefore intensifying the risks of leakage of employment, income and GHGs to other countries. Thus, this paper will conduct analysis using the DEARS model, which explicitly addresses reduction targets overseas and international inter-industry relations

[12] See Annex A for features of the model.

and is capable of multi-regional multi-sectoral analysis in order to address impacts on industrial competitiveness, which has not been largely covered in analyses to date. This model integrates a bottom-up energy system model that can analyze energy supply structures with a multi-regional model considering inter-industrial relations, therefore enabling the comprehensive assessment of the impacts that climate change measures may have on inter-industrial input-output and international industrial transfer. RITE's DNE21+ model which was used in the Mid-Term Target Review Committee will also be employed for a complementary analysis of the impacts on product costs in energy-intensive industries.

The cases provided in Table 2-1 was analyzed using the model. It should be noted that here, Prime Minister Hatoyama's new mid-term target is referred to as the "30% reduction target relative to 2005 emissions" for the purpose of comparison with the mid-term target under the Aso regime (15% reduction target relative to 2005 emissions).

Table 2-1 Assumptions for analysis with the DEARS model

Case	Details
15% reduction case (Mid-term target under Aso regime)	Reductions in Japan by 15% compared to 2005 levels. Assumptions for other developed countries are in line with emissions reduction targets respectively announced to date.
30% reduction case (Mid-term target under Hatoyama regime)	Reductions in Japan by 30% compared to 2005 levels (25% below 1990 levels). Assumptions for other developed countries are in line with emissions reduction targets respectively announced to date.

Note: For photovoltaic generation, in both cases, figures used in assumptions for a domestic bottom-up model studied in Mid-term Target Review Committee (approximately 14 million kW and approximately 79 million kW, respectively) were exogenously given.

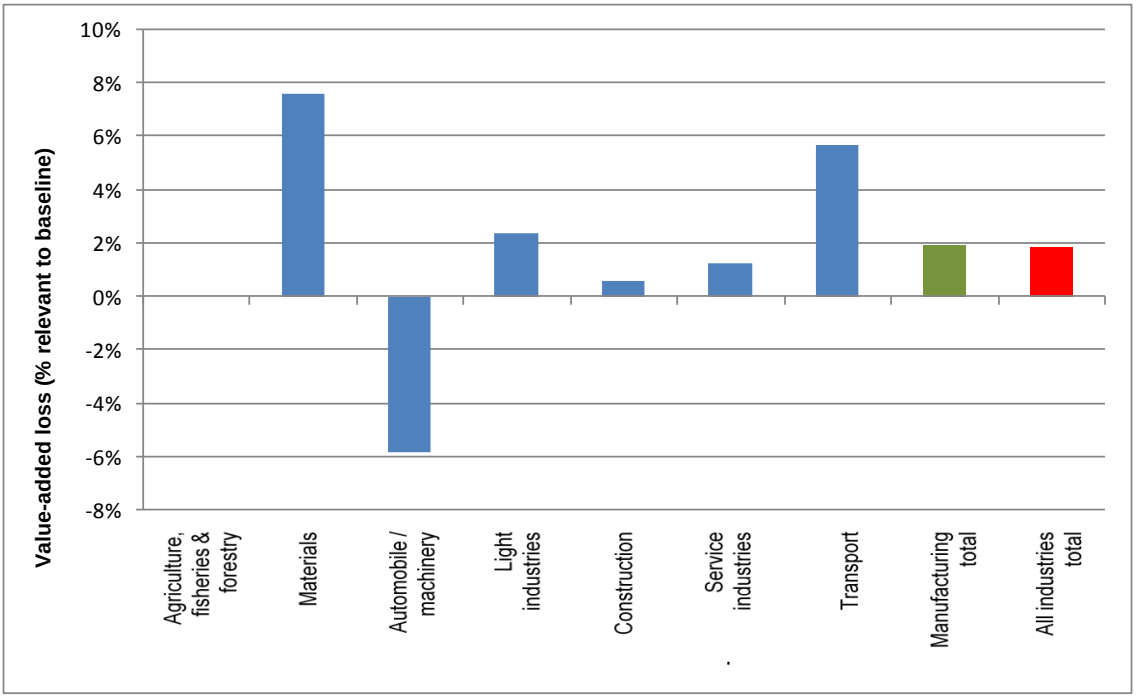
2.2. Analysis results

2.2.1. Impacts and leakage by sector

Figures 2-1 and 2-2 exhibit value-added losses compared to industry-specific baselines[13] for the cases of reductions by 15% and 30%, respectively.

The 15% reduction case would provoke change in domestic industrial structure: the materials and transportation service industries would be downsized (8% drop in the materials industry), whereas major industries in Japan, namely, the automobile and machinery industries, would expand (by approximately 6%). However, in the 30% reduction case, which would impose a far stricter reduction target, all industries would weaken, as shown in Figure 2-2. Value-added loss would range from -10% to -20% across all materials industries, with the iron and steel industry experiencing an outstanding loss of 35%.

[13] See Annex B for baselines



(Breakdown of materials industries)

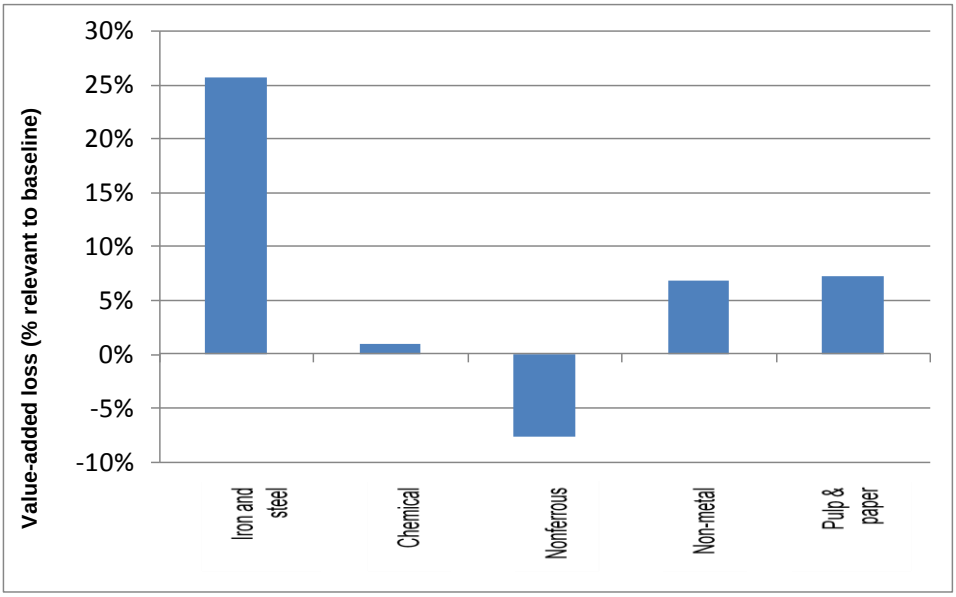
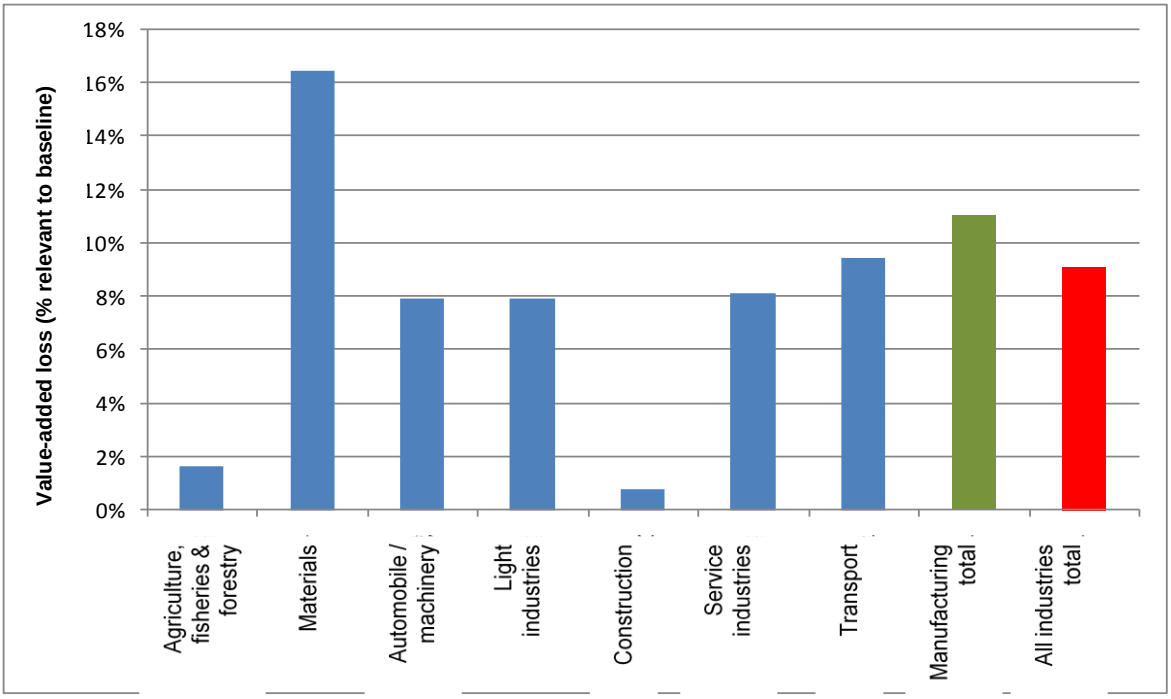


Figure 2-1 Value-added loss by industry in 15% reduction case



(Breakdown of materials industries)

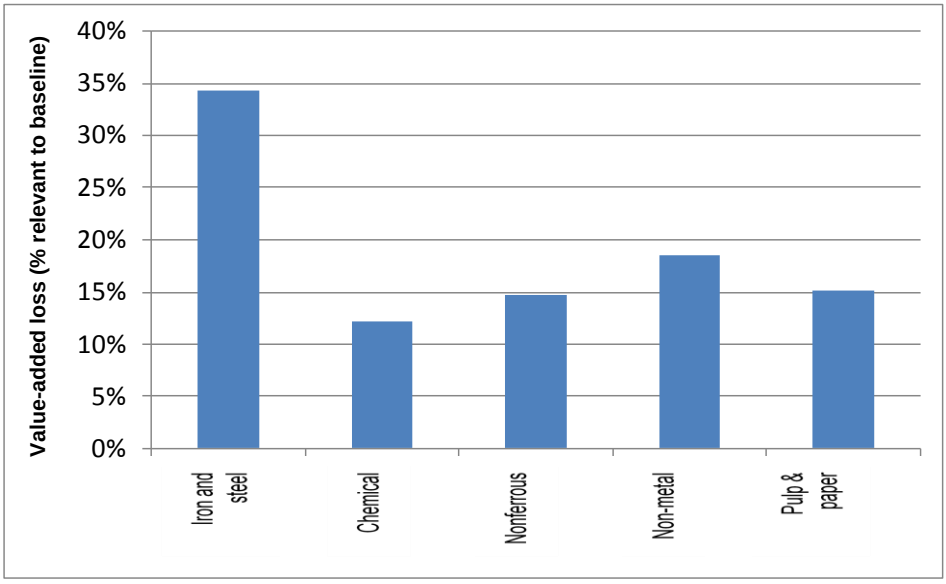


Figure 2-2 Value-added loss by industry in 30% reduction case

Figures 2-3-1 through 2-4-3 display the changes that would occur in the value-added of the entire economy, materials industries sector, and the iron and steel sector in major economies, as a result of 15% or 30% reductions.

Figure 2-3-1 through 2-3-3 show that if Japan implements a 15% reduction target, Japan's economic growth would be stagnated, thus lowering consumption and affecting economic growth in other countries. However, in materials industries, value-added loss in Japan would trigger carbon leakage, transferring production to China and other Asian and African countries (where value-added will be increased). The iron and steel sector apparently would experience particularly large amounts of leakage to China and other countries in Asia and Africa.

Figures 2-4-1 through 2-4-3 exhibit the impacts of Japan's implementation of a 30% reduction target. It should be noted that the scale differs from the previous series of figures; the percentage of value-added loss is as much as five times larger than that in the 15% reduction case and Japan would suffer a conspicuously negative effect. Leakage issues would be aggravated as well, with Japan's value-added loss being -17% in materials industries against +1% for China and +3% for other economies in Asia and Africa. In the iron and steel industry, in particular, Japan's value-added would decrease by 34% whereas it would increase by 9% in China and 13% in other Asian and African countries.

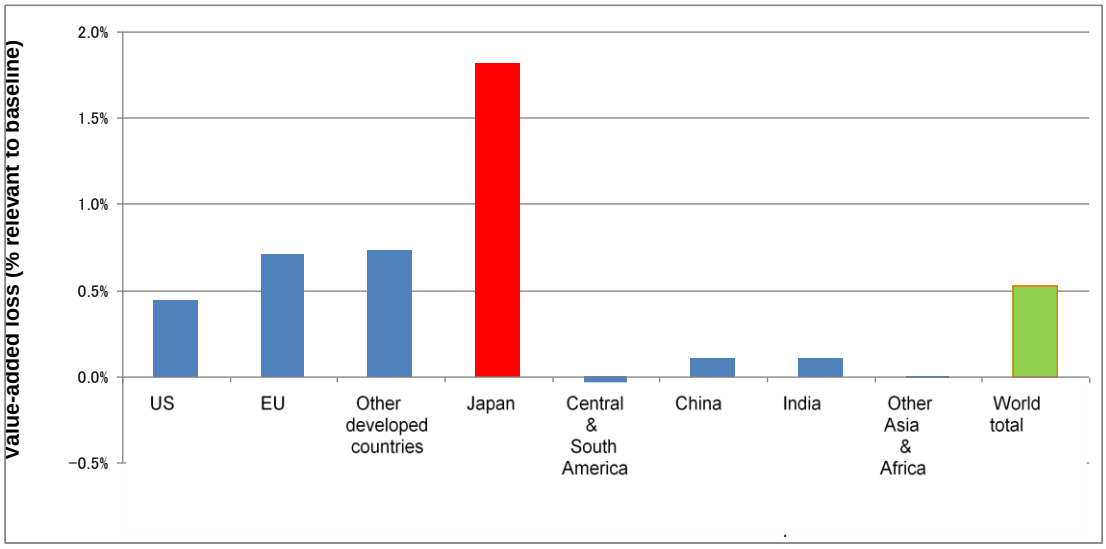


Figure 2-3-1 Value-added loss in 15% reduction case

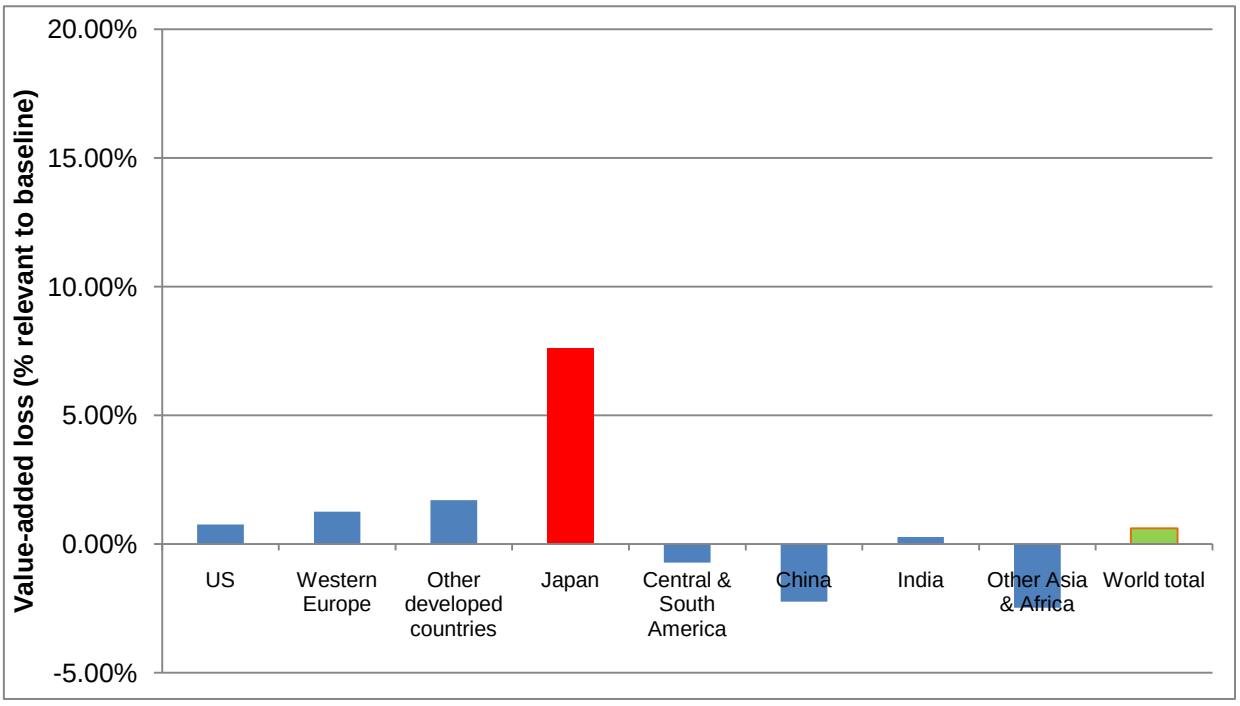


Figure 2-3-2 Value-added loss in materials industries in 15% reduction case

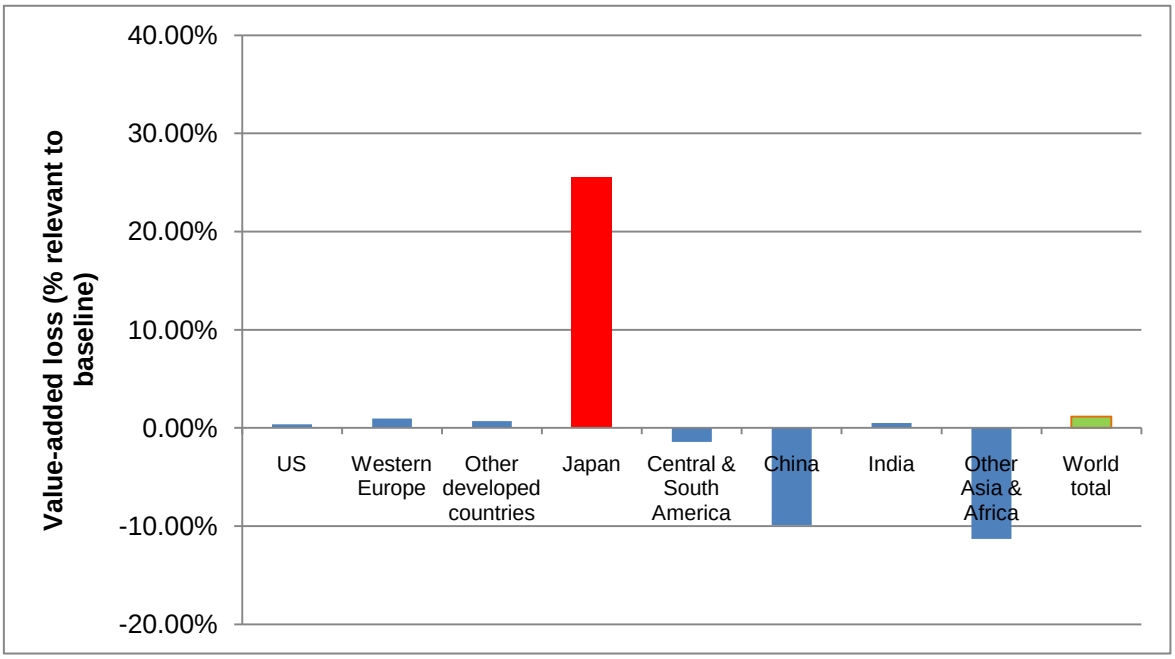


Figure 2-3-3 Value added loss in iron and steel sector in 15% reduction case

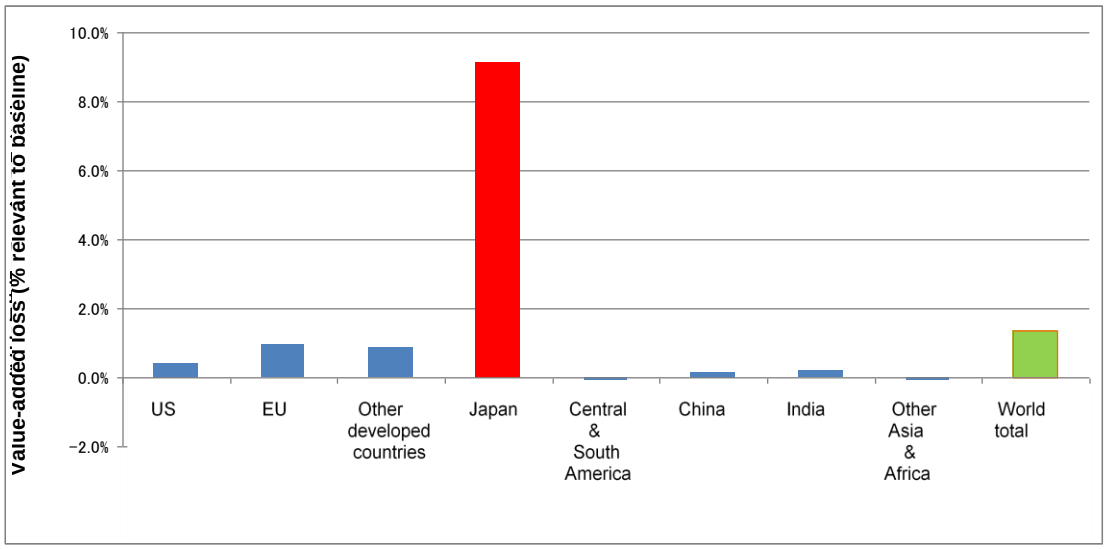


Figure 2-4-1 Value-added loss in 30% reduction case

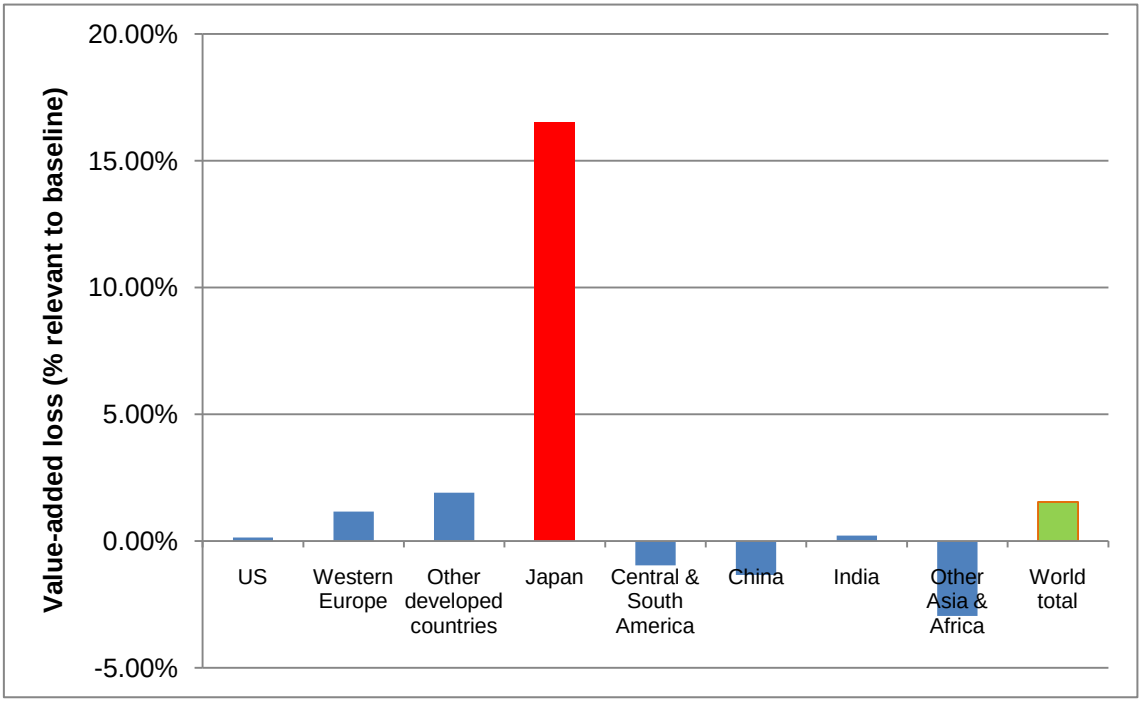


Figure 2-4-2 Value-added loss in materials industries in 30% reduction case

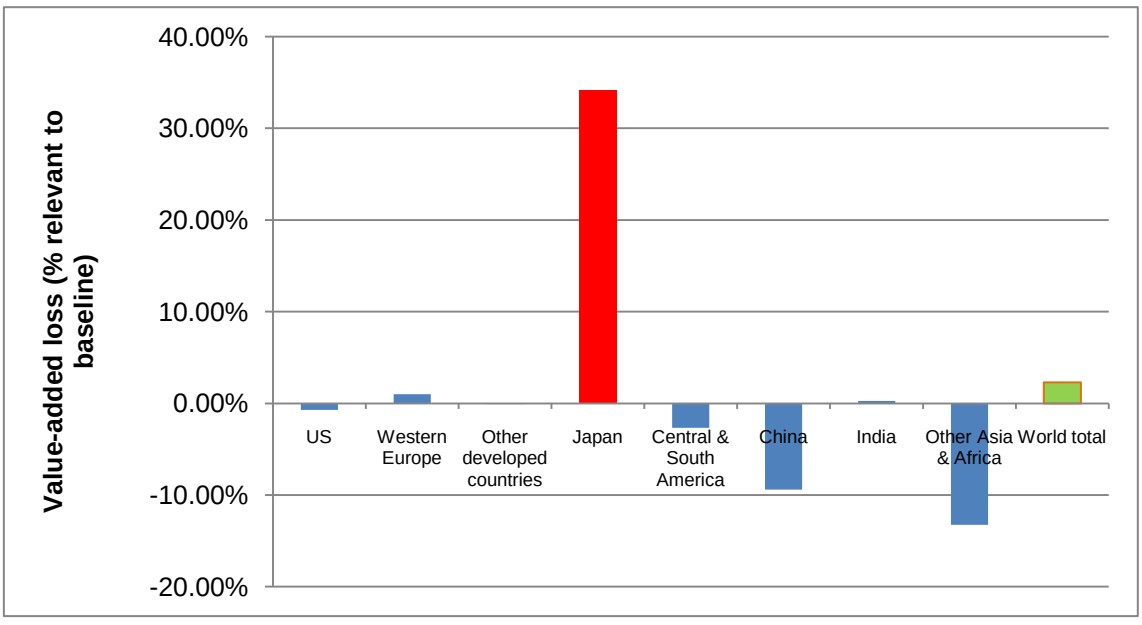


Figure 2-4-3 Value added loss in iron and steel sector in 30% reduction case

2.2.2. Impacts by prefecture

Figures 2-5 and 2-6 show the value-added loss for each prefecture in case of reductions by 15% and 30%, respectively (Tokyo=100). In the 15% reductions case, the results would vary greatly among prefectures, according to industrial structure; regions where prefectural economies are dependent on materials industries would suffer severe drops.

Regional discrepancies would be observed in the case of 30% reductions as well, but implementing this target would impact the entire economy to the extent that not a single prefecture can avoid a large decline in value-added.

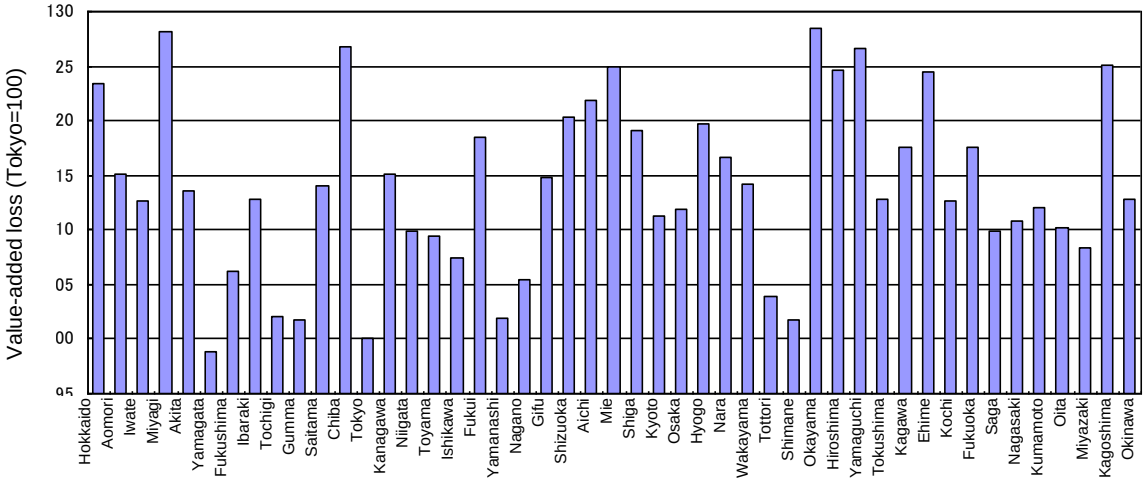


Figure 2-5 Value-added loss by prefecture in 15% reduction case

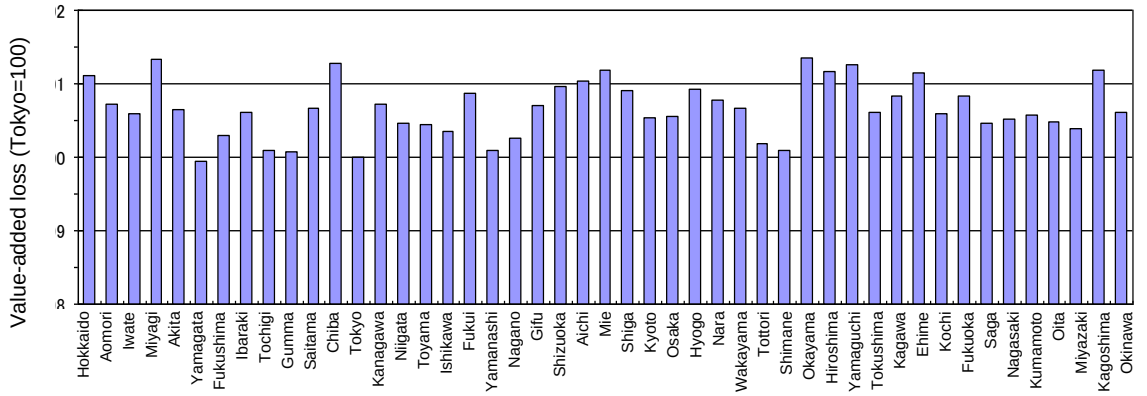


Figure 2-6 Value-added loss by prefecture in 30% reduction case

2.2.3. Impact on entire Japanese economy

Table 2-2-2 exhibits the impact that implementing a 15% or 30% reduction target would have on major macro-economic indices. In 2020, real GDP would be reduced by 1.8% in the case of reductions by 15% from the baseline, and 9.1%, with 30% reductions.

In Figure 2-1, imports appear to increase compared to the baseline with a 15% reduction target, as a result of increased production in import-oriented industries which manufacture major tradable goods, such as automobile and machinery. However, with the more stringent target of reducing emissions by 30%, marginal abatement costs (MAC) would acutely rise threefold, causing even the automobile and machinery industries to lose competitiveness, therefore shrinking production and imports, and hence decreased total imports.

The breakdown of GDP loss is shown in Figure 2-7 by each demand component's contribution to GDP change for both 15% and 30% reduction cases. As Figure 2-7 suggests, there would be a slight increase in private capital investment in order to adapt to the new investment environment, but contracted household consumption (-2.3% and 11.3%, respectively) would invite increased GDP loss in both cases.

Table 2-2-2 Impact on Japanese economy in reduction case

	15% reduction case	30% reduction case
Real GDP	-1.8%	-9.1%
Household consumption expenditure	-2.3%	-11.3%
Private capital investment	0.1%	0.2%
Imports	3.9%	-14.1%
Exports	5.4%	-15.5%
Gross production (all industries)	-0.9%	-9.5%
Gross production (manufacturing ind.)	0.4%	-9.7%
Gross production (energy-intensive ind.)	-7.9%	-17.4%
Gross production (capital goods manufacturing)	-0.6%	-0.8%
Electricity price	13.1%	19.5%
Final energy consumption	-21.3%	-33.0%
Consumer energy consumption	-4.8%	-8.9%
Electricity demand	-16.2%	-17.1%
MAC [$/tCO2]	158	484

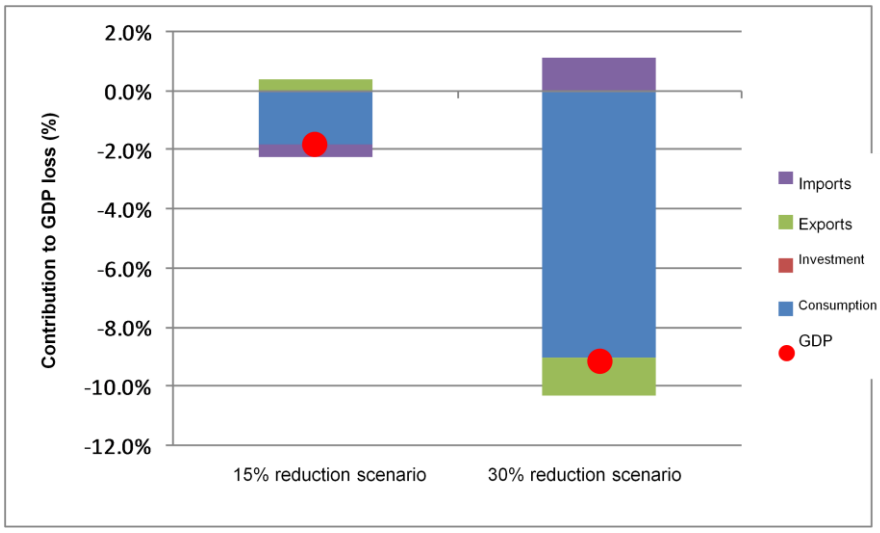


Figure 2-7 Breakdown of GDP loss

The DEARS model assumes full employment and therefore basically cannot calculate the unemployment rate. However, employment projections in relation with climate change measures have become an issue of high interest across all countries. Here, Okun's law has been used to estimate the unemployment rate trajectory relevant to the baseline defined for the reduction case for target year 2020. Okun's law is represented in the formula provided below:

Real GDP growth rate
= potential GDP growth rate – Okun coefficient × unemployment rate change

In order to estimate the unemployment rate trajectory for the reduction case using this formula, the real GDP growth rate, the Okun coefficient and the potential GDP growth rate must be determined for the period between 2005 and 2020. The GDP growth rates calculated using the DEARS model for the baseline case, the 15% reduction case and the 30% reduction case are 1.4%/year,

1.3%/year and 0.8%/year, respectively. The Okun coefficient of 3.45 for Japan in 1990-2008 was used[14].

Supposing the potential GDP growth rate was fixed across all cases, the potential GDP growth rate in the formula becomes a constant term; and therefore, the assumed potential GDP growth rate has no influence on the unemployment rate change from the baseline case to the reduction case. However, an assumption of potential GDP growth rate is necessary in order to estimate the unemployment rate for the baseline case in 2020. Given the difficulty of estimating Japan's potential GDP growth rate through 2020, it was assumed that the potential GDP growth rate for 2005-2020 was the equivalent of the baseline real GDP growth rate. Therefore, the baseline unemployment rate change is assumed to be 0 from 2005 to 2020, with the unemployment rate fixed (4.4%) since 2005.

The projected unemployment rate for the baseline case, the 15% reduction case and the 30% reduction case in 2020, determined by the abovementioned method is provided along with the respective difference from the baseline in Table 2-3. The unemployment rate for the 15% reduction case would be 4.93% and for the 30% reduction case, 7.18%, the difference from the baseline case thereby being 0.53 points and 2.78 points, respectively. The worst unemployment rate experienced in Japan since 1980 was 5.4% (2002), implying that in the 30% reduction case, which would affect the Japanese economy significantly, the unemployment rate could exceed the record figure.

[14] See Takao Komine (2009) Keizai Kyoshitsu, *Nihon Keizai Shimbun* February 11, 2009 morning edition

Table 2-3 Unemployment rate in 15% and 30% reduction cases

Brackets represent change from baseline.

	2005	2020		
	(record)	Baseline	15% reduction case	30% reduction case
Unemployment rate (%)	4.40	4.40	4.93 (+0.53)	7.18 (+2.78)

2.3. Analysis based on economic realities

Besides analyzing economic impact using a macroeconomic model, it is also possible to study the effects of declining corporate activity based on industrial status or the real situation of local economy.

Taking the iron and steel sector for example, let us assume that 10 million tons of crude steel production needed to be reduced. As studied below, he impact in terms of corporate management would include, 6000 jobs affected in the iron and steel industry, 1.8 trillion Yen(about US$20 billion) lost in production in related industries and 5 million tons of increased CO2 emissions in case of leakage to China.

Firstly, earnings per ton of crude steel were 15,737 Yen in 2006, 13,885 Yen in 2007 and 10,742 in 2008[15]. Therefore, lost earnings (costs from corporate management dimensions) as a result of a 10 million ton production cut would be 157.4 billion Yen in 2006, 138.9 billion Yen in 2007 and 107.4 billion Yen in 2008. From the formula, [lost earnings×labor distribution rate (labor costs / value-added) ÷average wage per capita (labor costs / labor population)[16]], 6802 people risk unemployment in 2006; 6098 people, in 2007; and 6114 people, in 2008.

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[15] Figures based on corporate statistics for iron and steel companies with sales of over 100 million Yen.

[16] Related data have has been derived from Ministry of Finance (2007)*Annual Report on Corporate Statistics 2007*.

The effects that 10 million tons production loss of crude steel would impose on related industries are studied below based on figures for 2007, for which relevant data are available:

Production loss in iron and steel sector:
approximately 720.6 billion Yen
=average price of 4 major steel products 72,057Yen/t (2007 average)×10 million t

Using the production loss calculated above as a basis, along with the production ripple effect for the iron and steel sector (2.4309) derived from the inter-industry relations table, the production loss in related sectors would be approximately 1 trillion 752.0 billion Yen; and the loss of value-added in related sectors, approximately 563.0 billion Yen.

Also, increased CO2 at a global level can be calculated to be 5.05 million tons = 10.00 million t × 1.74 (CO2 intensity for iron and steel, FY2008) × (129-100)/100 (RITE international comparison ratio, Japan : China). Therefore, carbon leakage would be a serious issue.

In the petrochemical sector, Japan's ethylene centers are projected to be hit dramatically in the event that the new mid-term target is implemented. However, the damage will not be limited to ethylene plants. If an ethylene plant closes operations, plants which are supplied ethylene via pipes will need an alternative supply source, which will not be readily found.

For example, ethylene oxide, which is used to make surfactants and water-absorbent resin, is a gaseous and hazardous substance that cannot be easily compressed to be loaded into tankers. Marine transport has its limits as well; without unused land ready to accommodate new receiving facilities (tanks, storage facilities or receiving piers), a plant would not only encounter financial burdens but also physical obstacles in overcoming carbon restrictions.

Therefore, by losing its ethylene centers, a region could be left with a battered local economy.

The petrochemical industry and major related industries together employ approximately 730 thousand people[17]. With 15 ethylene plants currently in operation, an average of around 50 thousand employees would be directly affected per plant. Furthermore, assuming that another 20 percent are employed in relative transport or maintenance jobs, a total of approximately 60 thousand people in each plant would suffer the consequences of implementation.

The prefectures significantly vulnerable to the effects of the new mid-term target compared to other local governments in Figures 2-5 and 2-6 tend to be home to petrochemical industries. These regions are often company towns of a petrochemical company, and therefore, a stagnant petrochemical industry would be detrimental to employment in office support services, local shopping areas and retail businesses. The weakening of the entire local economy is reflected in the figures.

For example, Shunan City, Yamaguchi Prefecture has a population of 150 thousand people. If 20% of the population were employed in related industries, approximately 30 thousand employees would be affected. As a result, the jobs or lifestyles of an average of 90 thousand people are estimated to be affected by each discontinued ethylene plant.

Also, in the cement sector, domestic production has already dropped by 25% from 87 million tons in 1990 to 66 million Yen in 2008. This production loss has halved employees from 18 thousand people to 9 thousand people; if

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[17] Japan Petrochemical Industry Association (2009) *Sekiyu Kagaku Kogyo no Genjo 2009*

implementing the new mid-term target should impose further production cuts, then it is likely to accompany considerable impacts on employment.

Aside from well-acknowledged macroeconomic model analysis, industries are expected to continue further in-depth analysis of the impacts on employment and local economy based on real life experiences and the realities of corporate management. Particularly, in the event that the new mid-term target is implemented, skyrocketing prices for energy, a basic commodity, would be inevitable, and thus will impose a regressive impact on income distribution[18]. No word has been heard of the government conducting analysis regarding impacts on income distribution in the "recalculation" that it is currently undertaking. It is a serious problem that impact analysis regarding income distribution and local economy, taken for granted in the US and EU, has been almost completely neglected in Japan. It is important for industries to engage in bottom-up economic impact analysis from the standpoint of the general public or consumers and in light of the roles of each industry.

In the midst of changing industrial and consumption structures, Japan has played the role of a manufacturing base to meet the global demand of high value-added products, whereas the US and EU have developed large service industries. The future will not alter these roles. Despite arguments that emissions can be reduced by shifting industrial structure, if the global consumption structure and the domestic productivity structure in each country are not changed, deliberately transforming the industrial structure of one country would be inefficient in terms of resource allocation. It should also be acknowledged that if economic principles are distorted in order to change trade structures, public welfare would be degraded.

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[18] This point is analyzed in Akihiro Sawa (2008) "Kokunai Haishutsuken Torihiki ni tsuite no Shoron" (The Domestic Emissions Trading System), 21st Century Public Policy Institute. http://www.21ppi.org/pdf/thesis/08111.pdf (Japanese only)

2.4. Analysis of impact on product costs induced by energy-intensive industries

This section will discuss how international competitiveness would be influenced by implementing the new mid-term target. It will include, in particular, analysis of iron and steel and cement, both tradable commodities that are susceptible to international competitiveness.

2.4.1. Method of analysis

The DNE21+ model used in the Mid-Term Target Review Committee was utilized to analyze the impacts on product costs in the iron and steel and cement industries, both energy-intensive industries. In the DNE21+ model, production of products (crude steel, clinker) are exogenously given for each region as separate scenarios and international inter-industrial shifts are not endogenous considered as in the DEARS model studied in the previous section. This implies that in regions that have set out comparatively stringent targets, large burdens will be imposed in terms of net abatement costs (net increases of cost, inclusive of cost reductions due to energy saving) and taxes, but production will be confined within the region. The scenarios described in Table 2-4 were assumed to quantitatively assess net abatement costs and regional discrepancies.

Table 2-4 Scenarios

	Increased net abatement costs (costs considered for abatements only)	New abatement costs and tax burdens (taxes imposed in addition to abatement costs)
15% reduction scenario	Scenario I-a: 15% reductions relevant to 2005 assumed for Japan. National emissions reduction targets announced by respective governments to date assumed for other countries. Net abatement costs considered to determine impact on product costs.	Scenario I-b: 15% reductions relevant to 2005 assumed for Japan. National emissions reduction targets announced by respective governments to date assumed for other countries. Net abatement costs and tax burdens considered to determine impact on product costs.
30% reduction scenario	Scenario II-a: 30% reductions relevant to 2005 assumed for Japan. National emissions reduction targets announced by respective governments to date assumed for other countries. Net abatement costs considered to determine impact on product costs.	Scenario II-b: 30% reductions relevant to 2005 assumed for Japan. National emissions reduction targets announced by respective governments to date assumed for other countries. Net abatement costs and tax burdens considered to determine impact on product costs.

2.4.2. Analysis results

Figure 2-8 presents the marginal abatement costs for major economies in 2020. Requiring $151/tCO2 in the 15% reduction scenario and $476/tCO2 in the 30% reduction scenario, Japan's marginal abatement cost runs extremely high compared with other developed countries. In the 30% reduction scenario, especially, Japan would bear an extremely severe target compared with other

countries, such as the US and EU with marginal costs less than $50/tCO2, as much as one digit less than in Japan.

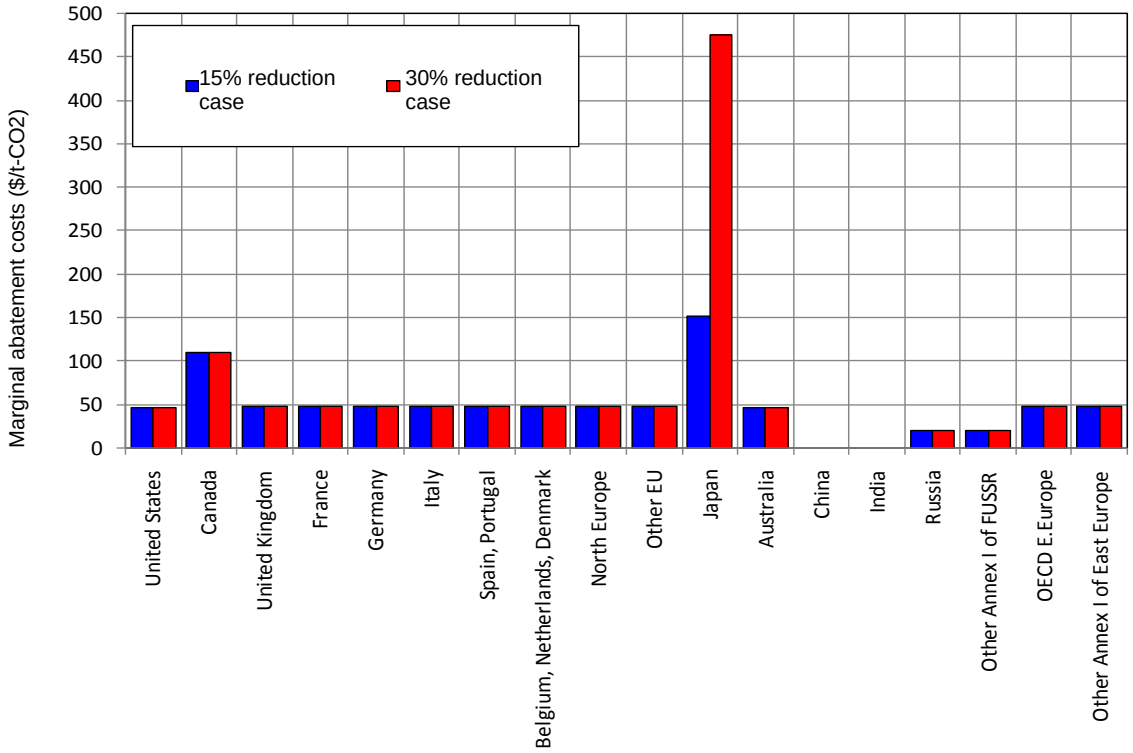


Figure 2-8 CO2 abatement costs for major countries in 2020

2.4.2.1. Impact on iron and steel industry

The net marginal abatement costs for the iron and steel sector in major regions are provided in Figure 2-9 (Scenarios I-a and II-a). Figure 2-10 includes tax burden (Scenarios 1-b and II-b).

Here, Canada bears the highest net abatement costs. The reasons for this are that: 1) Canada's national targets are more stringent (marginal CO2 abatement costs are higher) than those of the US and EU; (2) The energy efficiency of Canada's iron and steel sector is comparatively low, therefore requiring more reductions (investment) to achieve its target marginal abatement costs and thus increasing costs per unit production.

If burden was limited to the incremented costs required for reductions, Japan's net abatement cost of approximately $3/t-crude steel in the 15% reduction case would be only a few dollars more than that of other developed countries. However, in the 30% reduction case, its net abatement cost would be $8/t-crude steel, the difference thus expanding to as much as 6 dollars. Given the current market price for crude steel which ranges from 70 to 80 thousand Yen , the increased net abatement costs in the 30% reduction case would be the equivalent of 1% of the market price, by which Japan's price competitiveness would be weakened against that of its counterparts.

Furthermore, in case a tax on total emissions is imposed in addition to net abatement costs, Japan would have to bear $260/t-crude steel in the 15% reduction case, and $790/t-crude steel in the 30% reduction case (implying that the additional costs required would be close to the equivalent of the current market price), and therefore, Japan would lose its international competitiveness completely if taxes are not amortized.

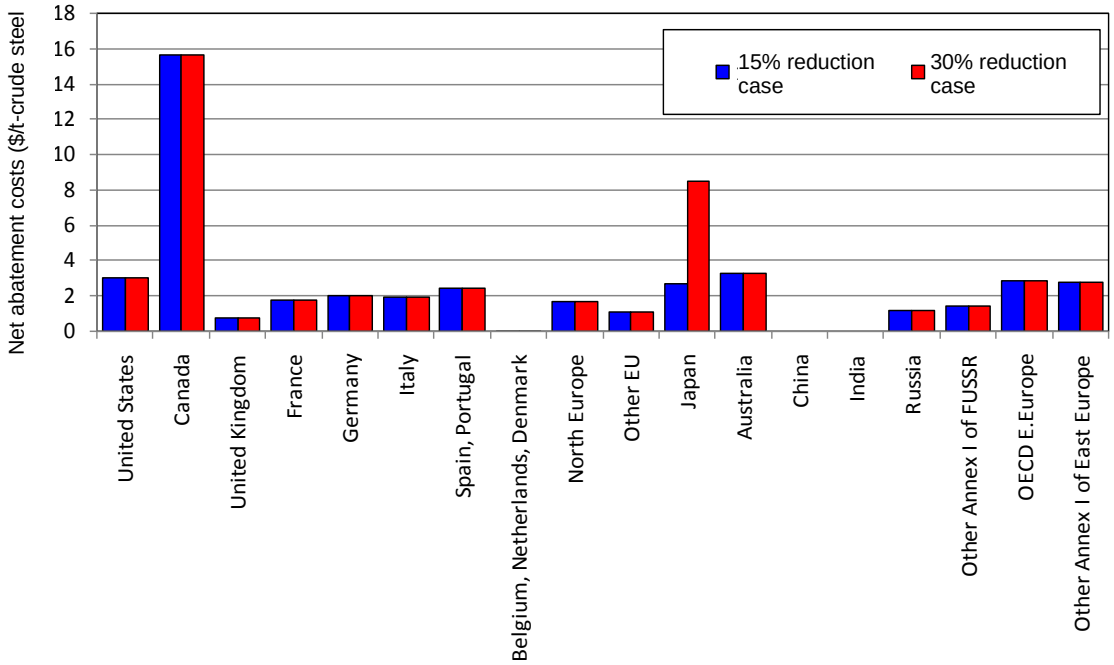


Figure 2-9 Net abatement costs in iron and steel sector of major economies in 2020

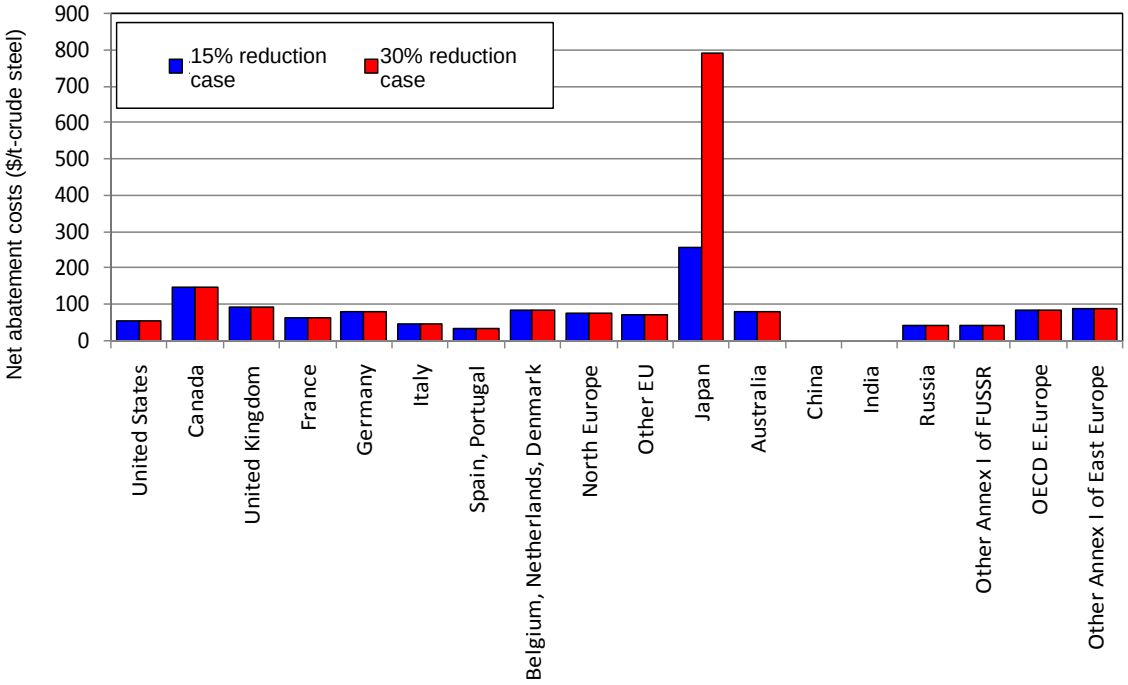


Figure 2-10 Net abatement costs + tax burden in iron and steel sector of major economies in 2020

2.4.2.2. Impacts on Cement Sector

Figures 2-11 and 2-12 exhibit analysis results for the cement sector.

Net abatement costs in Japan would be $2/t-clinker in the 15% reduction case and $6/t-clinker in the 30% reduction case. However, with regard to the fact that the market price for cement is approximately 10 thousand Yen (about US$111) per ton, the weakening of Japan's price competitiveness in the cement market would be even graver than in the iron and steel sector. Aggregating tax burden with net abatement costs, Japan would have to bear $110/t-clinker in the 15% reduction case and $340/t-clinker in the 30% reduction case. Therefore, without tax amortizations, Japan's price competitiveness would be completely shattered, similarly to the circumstances in the iron and steel sector.

Given the market price for cement, the damage is larger compared to that in the iron and steel sector.

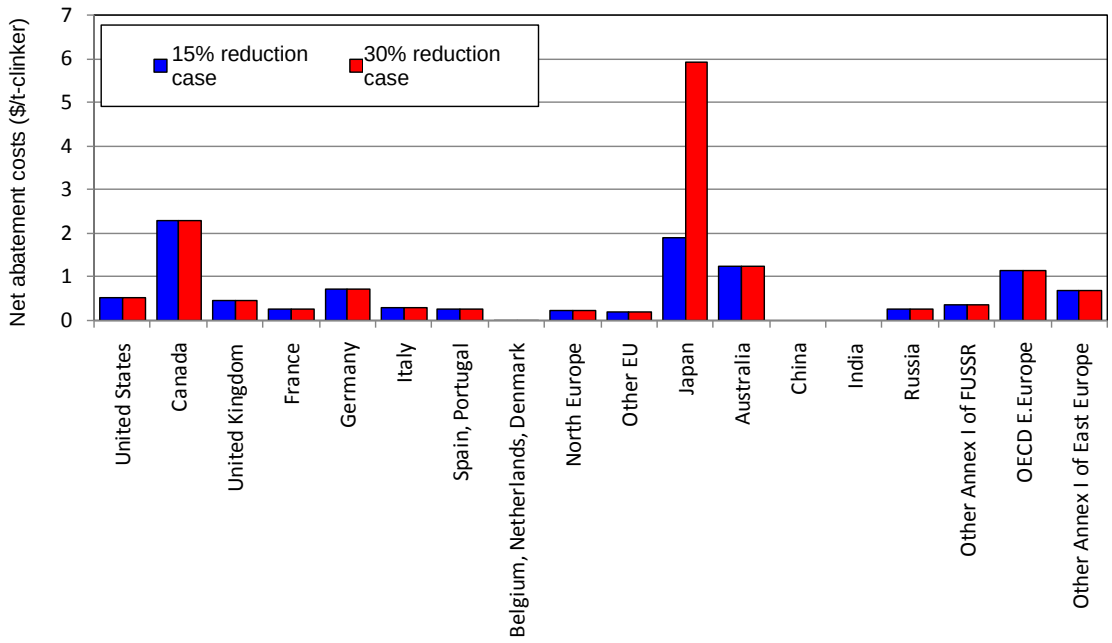


Figure 2-11 Net Abatement Costs of Cement Sector in Major Economies in 2020

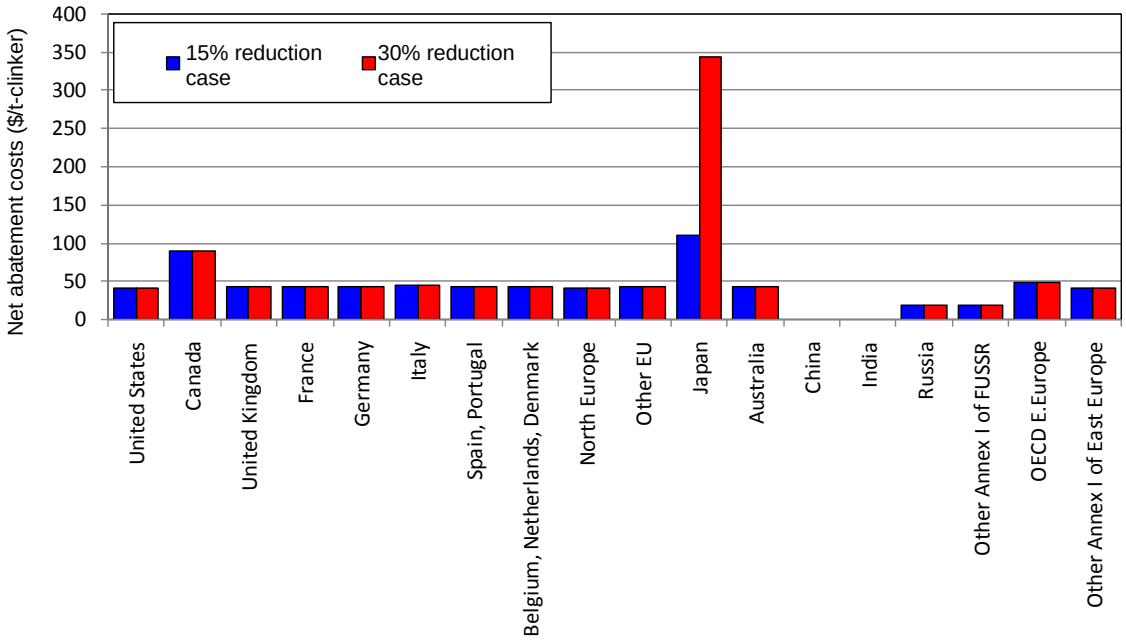


Figure 2-12 Net Abatement Costs + Tax Burden of Cement Sector in Major Economies in 2020

3. Vision for a Developed-Developing Country Cooperation Model: *For International Contribution by Industry to Climate Change Solutions*

3.1. Basic concept of international contribution by industry

In the analysis herein, we have seen that the new mid-term target announced by Prime Minister Hatoyama is: 1) ambiguous in terms of its equitability criterion and 2) would impose large negative effects on the macro-economy and the competitiveness of Japanese industry. The government will need to press other nations to take their targets further and agree to more "ambitious" reduction targets and take domestic policy measures to mitigate impacts on public daily life, local economy and the macro-economy and to hinder regressive income distribution.

Industry should also look into measures to contribute internationally to providing solutions for the conflict of interests between developed and developing countries that have pushed international negotiations into stalemate. The basic concept for such measures is threefold:

1) Contribute to global GHG reductions by transferring Japan's energy conservation and other anti-climate change technologies to major economies.
2) Speed up institutional design for continued and enhanced real reduction actions through cross-border cooperation among industries and companies, in order to avoid delayed GHG reduction action due to stalled international climate change negotiations among nation states.
3) The essential solution to climate change is to focus on reducing fossil fuel use on a consumption basis and to build a global "low-carbon society." Therefore, solutions over the long term require evolving from the current framework where individual governments bear emissions-based reduction obligations to LCA-based global GHG reductions.

This approach does not deviate from conventional sectoral approaches and promises to provide the slightest solution for the leakage issues analyzed in Section 2.

3.2. Vision for the developed-developing country cooperation model

This section proposes the organization of a cooperation model involving a limited number of developed and developing countries in a way that complements the UNFCCC process, depending on the outcomes of the COP15 meeting in Copenhagen.

As an example of such a model, this section will study a scheme in which Japan, the US and China, which collectively represent almost half of global emissions, would cooperate in the areas of renewable and nuclear energy in order to achieve significant reductions in GHG emissions. Japan, the US and China are only provided as examples of partners; the scheme elaborated below could be specifically designed to encompass any group of countries as long as both developed and developing countries are included, and tailored to the special circumstances of any region or participating country. Furthermore, this vision does not require multilateral participation from the beginning and can be launched bilaterally. It can also be expanded to address other sectors including transport, office, household and sinks.

The basic elements of the vision are given below. The achievements made in sectoral cooperation in the Asia-Pacific Partnership on Clean Development and Climate (APP) and the various ideas on developing country cooperation studied in relation to sectoral approaches by research institutions in each country can be referred to as well.

(1) Conclude a trilateral "Administrative Agreement for Mutual Cooperation in Preventing Climate change" among Japan, the US and China.

(2) The elements of the Agreement are given below:

(i) The government and private sector experts should identify and decide on projects in energy conservation, renewable energy and nuclear power that can be developed in trilateral public-private cooperation. Relative companies in the participating countries can start discussions on details of how to take endorsed projects forward.

(ii) GHG reduction targets (e.g. 0.5-1 billion tons) respective of a baseline or intensity-based targets to be achieved by such projects should be established.

(iii) Offset credits that are generated by achieving the target described in (ii) should be jointly "accredited" by a MRV (measurable, reportable and verifiable) method agreed upon trilaterally and allocated according to the respective level of financial and technological contribution. The offset credits generated as thus shall be valid in domestic schemes. In Japan, for example, they can be counted as offset credits to be used for compliance with the Voluntary Action Plan. In the US, they could be accredited as overseas credits under the American Clean Energy and Security Act.

(iv) In order to establish low-carbon societies in the three countries, public assistance towards supplying products reducing GHG in terms of LCA should also be considered as a source of credit generation.

(v) The three party countries should set up a public-private advisory committee to mediate financial and technological transfer and address

issues regarding the implementation of MRV methods. They should also abolish trade barriers (tariffs on environmentally-friendly goods).

(vi) Japan and the US should offer credits to China sourced by public funds through a newly established fund or public financial institutions in both countries.

(3) The Agreement should be kept open to other countries and other developed and developing countries should be invited to join, on condition that parties to the Agreement pledge an intensity-based or absolute volume-based emissions target exceeding non-binding target levels. Also, if in the future an offset crediting mechanism is established in the UNFCCC framework, the Agreement shall be amended for linkage with the new mechanism.

(4) If UNFCCC-based negotiations should enter into deadlock, then this vision could be developed into an essential element of the post-Kyoto framework and "establish a new registry under the UNFCCC to register sectoral agreements on international cross-industry technology cooperation and absolute volume-based or intensity-based improvements. Neutral independent experts would monitor and verify the implementation status."

3.3. Vision for establishing a new public-private institution

Another promising option for Japanese industry would be to launch an "Institution for Engineering Solutions for Climate Change" (provisional name) based on public-private cooperation to serve the proposed scheme. In order to realize "public-private partnership," not only private sources but also the Development Bank of Japan (DBJ) and the Japan Bank for International

Cooperation (JBIC) should be called upon to invest in the new institution. Relevant government ministries should effectively employ the new institution in international cooperation to address climate change and are therefore expected to make relevant budget requests.

(1) Project studies, consulting and engineering for GHG reductions in major developing countries
(2) Financing arrangement
(3) Collection of national intensity data for determining the benchmarks required in sectoral approaches
(4) Acquisition of the offset credits necessary to be in compliance with the Voluntary Action Plan
(5) Research and diffusion of MRV methodologies and international standards related to climate change

Conclusion

If the aim of announcing the new mid-term target had been to gain international leadership in diplomatic relations, Japan needs to enhance its presence at COP15 and the international negotiations to follow. Also, steering diplomatic negotiations so that all of the elements and preconditions raised by Prime Minister Hatoyama are completely met would be the touchstone of public reliance in the government's measures against climate change. If these conditions cannot be met, adverse impacts on the economy - especially severe damage to employment and local economy - surely cannot be avoided and Japan will have to start again with a clean slate for a new target.

However, the stalemate of intergovernmental negotiations on contributing to climate change mitigation measures does not mean that industry can get away with sitting back with hands folded. Japanese industry, in particular, must take the initiative in supplying the world with environmental technology as well as products and facilities that can reduce CO2 in the manufacturing process or at the consumption level. It is important for industry to proactively become involved in the developing country assistance measures currently discussed in the government and expand the coverage of the Voluntary Action Plan adopted in 1997 to include CO2 reductions through international contribution. It is also expected that in the process of such discussions, the establishment of a new institution for extending technological and financial contributions to the world through public-private partnership will also rise on the agenda.

Annex A Outline of DEARS Model

The DEARS (Dynamic Energy-economic Analysis model with multi-Regions and multi-Sectors) model is based on the GTAP (Global Trade Analysis Project) model and its database which is a static multi-sectoral multi-regional general equilibrium model, but is nevertheless an intertemporal nonlinear optimization model. The model is designed to consistently calculate sectoral production in each region and cost-efficient structures of the energy supply required to perform such production activities as well as household consumptions, maximizing the discounted total consumption utilities of the entire time frame across all regions. The model contains a simplified energy module covering seven types of primary energy (coal, crude oil, natural gas, biomass, nuclear, hydro and photovoltaics and wind) and four secondary energy types (solid fuel, liquid fuel, gaseous fuel and electricity). It is suitable for analyzing changes in energy systems and industrial structure as a result of mid-term climate change measures and can also conduct constructive analysis or assessment by region or by sector. Figure A-1 depicts the input and output of the model. A feature of the model is that a multi-sectoral economic module based on an inter-industrial model is hard-linked with a bottom-up energy systems module defining energy flow. The model divides the world into 18 regions and covers 18 non-energy industrial sectors. The 18 regions defined in the model are shown in Figure A-2 and the 18 non-energy industries are provide in Table A-1.

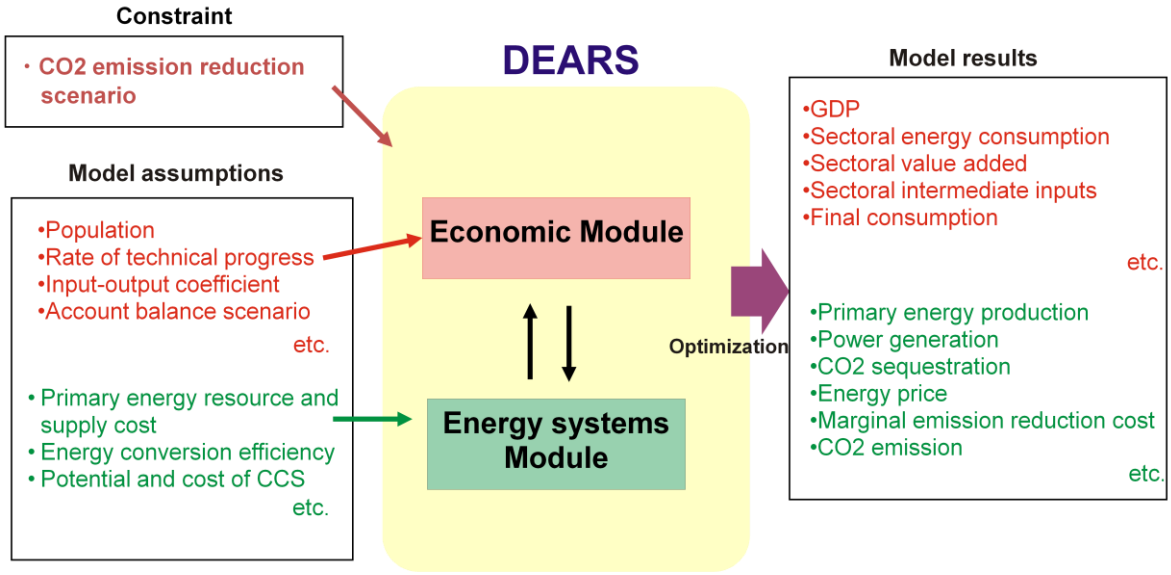


Figure A-1 Relations between input and output of DEARS

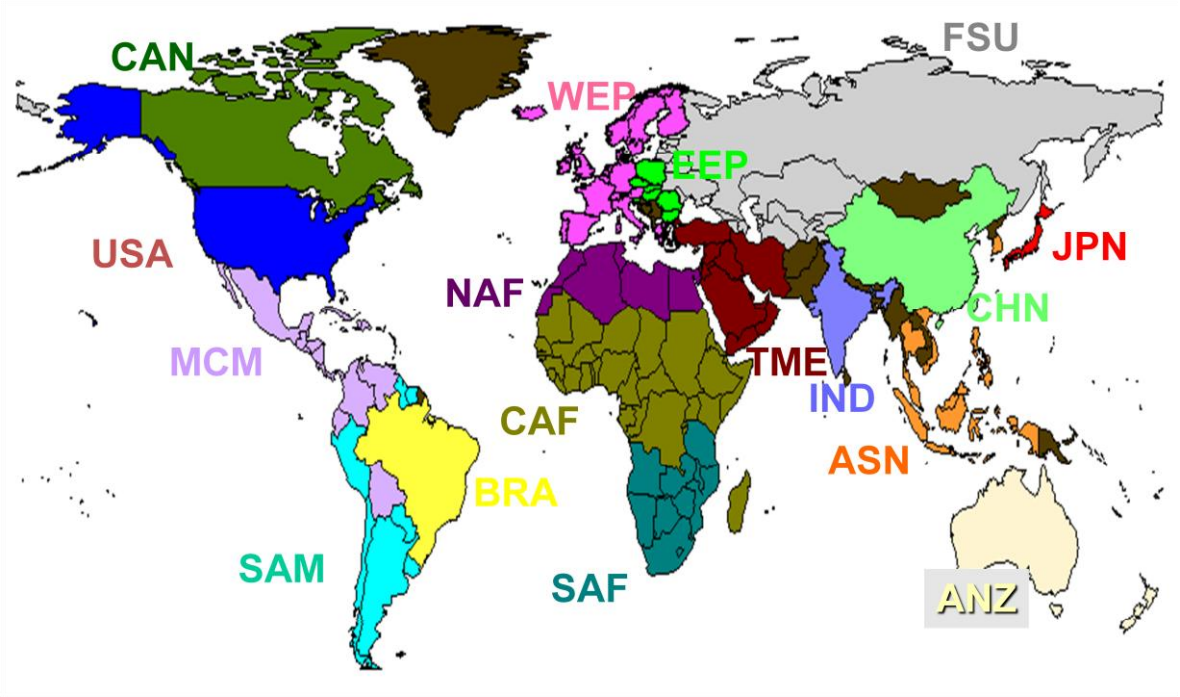


Figure A-2 Division of 18 regions in DEARS structure

Table A-1 Sectoral division in DEARS structure

Sectoral division in DEARS model	Larger categories for reference in this paper
Agricultural products	Agriculture, forestry and fisheries
Iron and steel	Materials
Chemical products	
Non-ferrous metals	
Non-metallic materials	
Paper, pulp and printings	
Wood and wood products	
Transport equipments	Automobile / machinery
Other machinery	
Other manufacturing	
Minings	
Food products	Light industries
Textiles, wearing, apparel and leather	
Construction	Construction
Business services	Service industries
Social services	
Transportation	Transportation industries
Aviation	

The economic data employed in the model are based on GTAP5 (baseline year 1997) and energy statistics are consistent with IEA statistics. The DEARS model considers the population to be an exogenous variable and employs UN median population projections, which are also used in the IPCC SRES B2 Scenario. GDP is decided endogenously under the maximization of consumption utilities and harmonized with GDP in the SRES B2 Scenario by adjusting various parameters such as the rate of technological development. Macroeconomic variables for each country, with the exception of population, are determined endogenously by the model using the Cobb Douglas production function, which contains population, capital and energy. The production structure of each industry is basically defined using the Leontief production function. The intermediate input coefficients used in the production function have been assumed exogenously for each time point according to the projected future industrial structure. Energy-related parameters are based on the DNE21 or DNE21+ model.

Production for each industry is determined endogenously using a model with considerations of international inter-industry relations and therefore is not equal to the figures reviewed in the Mid-Term Target Review Committee. Parameters including the level of technological advancement determining GDP have been adjusted to fit the SRES-B2 scenario; nevertheless the figures representing Japan are close to the baseline values estimated in the DNE21+ model. Japan's GDP in 2020 was projected to be 6081 billion dollars in the DNE21+ model used in the Mid-Term Target Review Committee, whereas the value used in the DEARS model employed in the analysis herein was 6197 billion dollars, approximately 2% larger than the DNE21+ model. Figure B-1 exhibits production in Japan by sector as determined by the DEARS model. See Figure B-2 for regional shares of production in major industries.

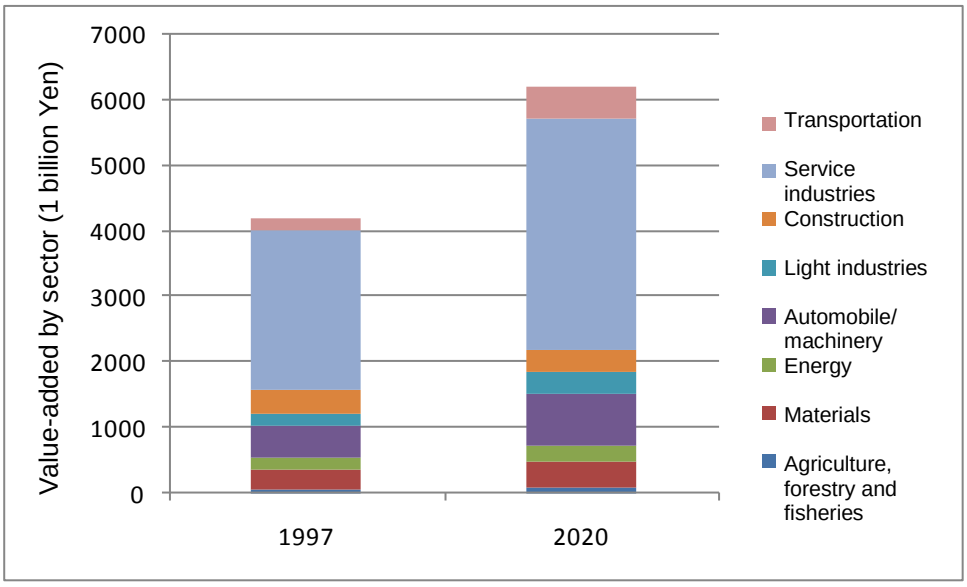
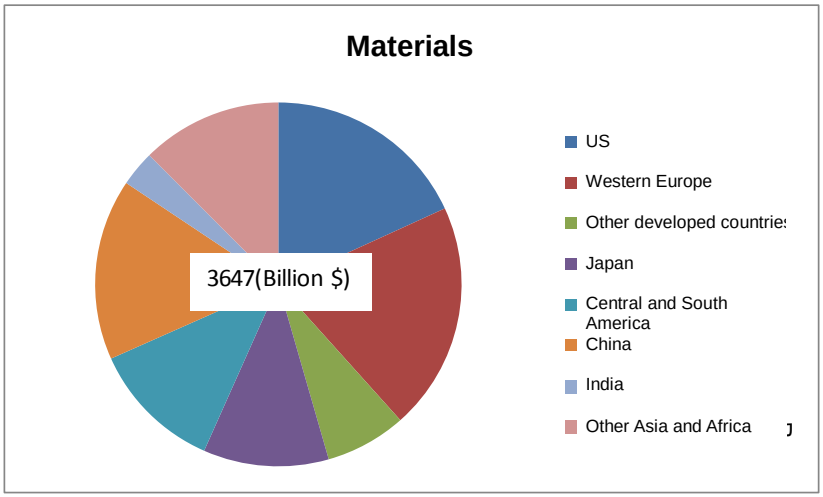
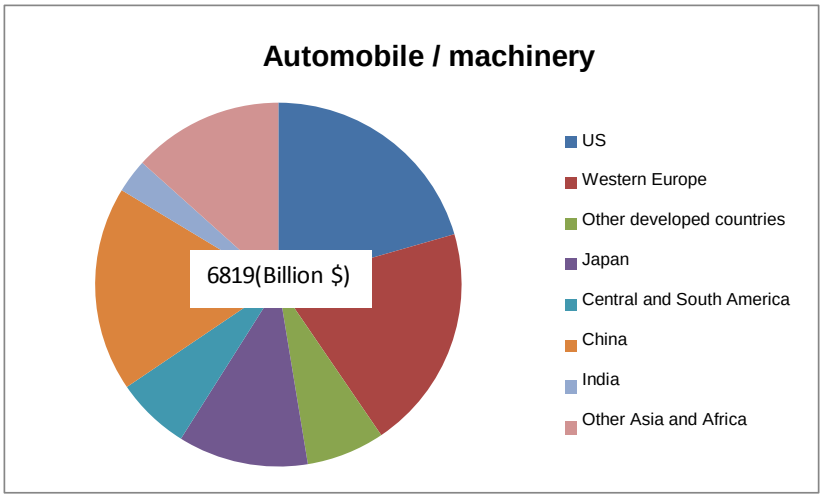


Figure B-1 Production by sector in Japan in 2020(baseline)





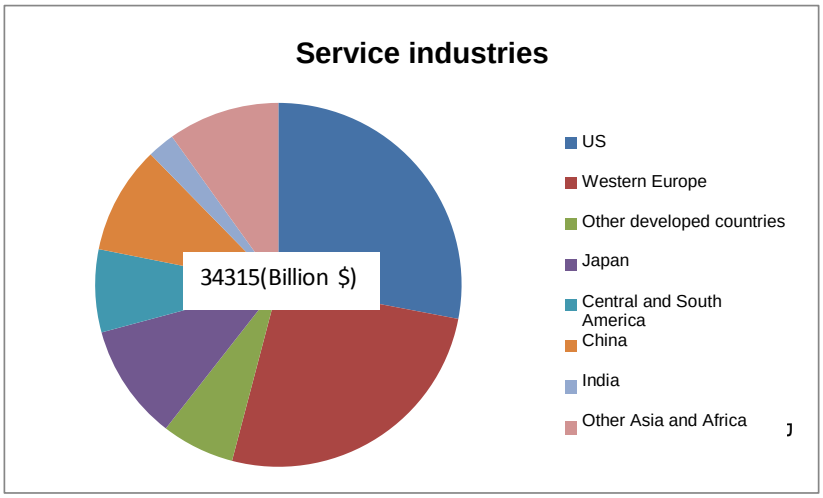


Figure B-2 Projected value-added production in major sectors by region in baseline 2020

Although the DEARS model does not explicitly address production, the production scenario based on physical quantity studied in the Mid-Term Review Committee and the trajectory of value-based production in the reference case of the DEARS model are compared below.

(1) Iron and steel sector

The Mid-term Target Review Committee forecasted crude steel production to grow by 0.5%/year but the DEARS model scenario projects the annual growth of value-added production in the iron and steel sector to be 1.6%/year. This means that based on crude steel production in the DNE21+ model, the value-added per unit crude steel production can be calculated to increase by 1.1% yearly in the DEARS model, supported by increased value-added through 2020. The DNE21+ model forecasted crude steel production to increase by 7.6%/year through 2020 in China, whereas the DEARS model scenario projects that value-added in the Chinese iron and steel sector will increase by 8.3% annually. The value-added per unit crude steel production will increase by 1.4%/year in China. Globally, the DNE21+ model assumed that crude steel production would grow by 3.1%/year through 2020, and in the DEARS model scenario, the value-added of the iron and steel sector will increase by 2.1% yearly.

(2) Non-metallic materials sector (including cement)

The definition of the non-metallic materials sector varies greatly among models and it is therefore difficult to make a simple comparison. The DNE21+ model assumes that clinker production will decrease by 0.6%, whereas in the DEARS model scenario, the value-added of the non-metallic materials sector will drop by 1.0% every year. The DNE21+ model assumed that clinker production in the Chinese non-metallic materials sector would increase by 4.7% through 2020, whereas the DEARS model scenario projects an annual growth of 4.6% for the value-added of the non-metallic materials sector. Globally, the DNE21+

model assumed that clinker production would grow by 3.3%/year through 2020, and in the DEARS model scenario, the value-added of the non-metallic materials sector will increase by 1.5% yearly.

(3) Pulp and paper sector

The DNE21+ model assumes that paper and paperboard production will increase by 0.0%, whereas in the DEARS model scenario, the value-added of the pulp and paper sector will grow by 1.1% every year. The DNE21+ model assumed that paper and paperboard production in the Chinese pulp and paper sector would increase by 4.2% through 2020, whereas the DEARS model scenario projects an annual growth of 6.6% for the value-added of the pulp and paper sector. Globally, the DNE21+ model assumed that paper and paperboard production would grow by 1.6%/year through 2020, and in the DEARS model scenario, the value-added of the pulp and paper sector will increase by 1.6% yearly. The world's value-added per unit production of paper and paperboard will increase by 0.1% through 2020.

(4) Non-ferrous metals sector (including aluminum)

The definition of the non-ferrous metals sector varies greatly among models and it is therefore difficult to make a simple comparison. The DNE21+ model assumes that aluminum production in Japan would be 0, whereas in the DEARS model scenario, the value-added of the non-ferrous metals sector will increase by 1.4% every year. The DNE21+ model assumed that aluminum production in the Chinese non-ferrous metals sector would increase by 7.9% through 2020, whereas the DEARS model scenario projects an annual growth of 5.2% for the value-added of the non-ferrous metals sector. Globally, the DNE21+ model assumed that clinker production would grow by 3.9%/year through 2020, and in the DEARS model scenario, the value-added of the non-ferrous metals sector will increase by 1.7% yearly.

(5) Chemical sector (including ammonium)

The definition of the chemical sector varies greatly among models and it is therefore difficult to make a simple comparison. The DNE21+ model assumes that ammonium production will decrease by 1.4%, whereas in the DEARS model scenario, the value-added of the chemical sector will grow by 2.4% every year. The DNE21+ model assumed that ammonium production in the Chinese chemical sector would increase by 4.6% through 2020, whereas the DEARS model scenario projects an annual growth of 6.7% for the value-added of the chemical sector. Globally, the DNE21+ model assumed that ammonium production would grow by 3.3%/year through 2020, and in the DEARS model scenario, the value-added of the chemical sector will increase by 2.8% yearly.