Japan Climate Vision 2050:

An energy future independent of nuclear power and fossil fuels

[Scenario projections]

2014.3

Kiko Network

Contents

Summary

Climate change, becoming ever more severe, is one of the major risks humanity is facing today. Furthermore, our continued dependence on fossil fuels creates a risk of resource depletion while the use of nuclear energy, as experienced in the accident at the Fukushima Nuclear Power Plant, involves a number of risks. When considering the options available to create a sustainable future, we must take these risks and constraints into account.

In Japan, a variety of energy efficiency technologies were developed in the aftermath of the first and second oil shocks, and much of the equipment introduced then is now in need of replacement thus creating highly favorable conditions for the further promotion of these technologies. The present level of energy efficiency at Japanese factories and offices is far from uniform, indicating that there is a significant potential for further improvements. These are not limited to the efficiency improvements enabled by already commercialized technologies; there is also a need to pay attention to the energy savings made possible by looking at the system as a whole.

Taking the risks and constraints deriving from climate change, nuclear energy and the use of fossil fuels into account, this report considers scenarios for sustainable climate visions with a focus on energy efficiency and renewable energy. We use bottom-up modeling in the scenario analysis and make conservative estimations based on the diffusion of already commercialized technologies. In addition, we consider one other case in which a degree of down-scaling has been achieved due to changes in resource use patterns, and which includes the limited introduction of new technologies.

The results of our estimations indicate that even in a scenario based entirely on the diffusion of already commercialized technologies, Japan would be able to realize a 25% reduction of CO2 emissions from energy use by 2020 and an 80% reduction by 2050, compared to 1990. It became clear that even greater reduction potential exists in the power and industry sectors. Furthermore, it is worth noting that these measures would lead to significant cost reductions in fossil fuel imports, which currently add up to 25 trillion yen annually, thus generating benefits for the domestic economy.

The results show that large GHG emission reductions are technically feasible even while Japan makes a transition away from its present dependence on nuclear energy and fossil fuels. These findings are important as Japan makes policy consideration for future climate actions, and point to the direction which the country should be setting today, some three years after the Fukushima Dai-Ichi nuclear accident.

This report was compiled by Kiko Network based on the result of the first part of a research project entitled “The analysis of energy efficiency potential in 2030 and research on enabling policies.” The report also reflects the presentations made at the annual conference of the Society for Environmental Economics and Policy Studies (SEEPS) in 2013 and the 30th conference of Japan Society of Energy and Resources. We thank Mitsui & Co., Ltd., Environment Fund for their generous support of this research activity.

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Introduction

Several organizations and institutions have made stern warnings that the further advance of climate change and its adverse effects will be very serious in the future, and the related risks are, indeed, becoming more obvious[i]. In addition, not only are fossil fuels regarded to be the main cause of climate change, but the continued use thereof also means that society will be dependent on a resource prone to a very high price volatility[ii]. In Japan, there is a renewed awareness of the problems and economic risks related to the dependence on fossil fuels after the price surges experienced since 2011. Furthermore, the accident at the Fukushima Dai-Ichi Nuclear Power Plants in March 2011 taught the Japanese that nuclear power generation entails tremendous risks. After the accident, public interest in energy issues has risen and, today, there are many voices in Japan calling for the realization of a society which is not dependent on nuclear energy[iii].

Taking this situation into consideration, climate and energy policy in Japan must consider not only the risk of climate change, but at the same time pursue a realistic solution to avoid the risks inherent in nuclear power generation and nuclear waste as well as to the reduction of the country’s consumption of fossil fuels and mineral resources. 1)

However, although a process to review energy policy including public discussions was initiated in 2012 under the former administration led by the Democratic Party of Japan, such deliberations, based on an integrated view of climate change and energy issues, have slowed down under the present Liberal Democratic Party administration. Thus today, more than three years after the Fukushima nuclear accident, Japan finds itself in the despicable situation of not having set a clear direction for the future.

So far, when making projections of the future supply and demand of energy or of greenhouse gas emissions, the government’s advisory councils on climate and energy policy have only foreseen limited deployment of energy efficiency technologies, and most scenarios have been based on assumptions of the continued utilization of nuclear energy and the extension of the current industrial structure. This general tendency is found also in projections made after the Fukushima nuclear accident[iv]. On the other hand, there are also several post-Fukushima analyses which deal more proactively with a possible energy transition [2)3)4)5)6)7)]. Some among these work with scenarios which include both a reduction or phase-out of nuclear power and a reduction of greenhouse gas emissions. [3)4)5)6)7)].

This report, taking such research efforts as a point of departure, describes the results of scenario deliberations on Japan's mid- to long-term climate energy policy direction, based on a long term vision of a sustainable society in which the reliance on nuclear energy has been reduced.

With this report, the authors hope to encourage an active discussion of Japan's vision for 2020, 2030 and 2050 leading to the implementation of effective strategies and policies.

Kimiko Hirata, lead author

1. Understanding the current situation and our concerns

1.1 Adverse effects and risks to be avoided

Climate change and other global environmental problems and environmental degradation are already of a very severe nature, and it is imperative that we, today, choose climate change and energy policies which help avoid further adverse effects and risks endangering the lives of future generations.[1)]

The major issue we are facing today is how to prevent further adverse effects of climate change. Internationally, it has been proposed to keep the increase of global mean temperature below 2 degrees Celsius, a goal included in several international agreements[v]. In order to keep temperature increase between 2 to 2.4 degrees from pre-industrial level, global CO2 emissions must peak by 2015 and decrease thereafter; further, a 50-85% reduction from 2000 levels by 2050 is required (IPCC Fourth Assessment Report). In order to realize this, the share of greenhouse gas reductions to be shouldered by the developed nations is estimated to be 25-40 % by 2020 and 80-95% by 2050, both compared to the 1990 level, and this level of reduction has, generally, been considered as basis for international target setting. Warnings have been made that if measures are not taken at a scale enabling this level of reduction, the future cost of adaption may greatly exceed the cost of mitigation.

A second issue is the risk of using fossil fuels. In the coming decades, the IEA (International Energy Agency) predicts that the price of fossil fuels will increase due to the fact that these resources are gradually being depleted. The rising demand in China and other emerging and developing countries create further risks of sudden price hikes or supply disruptions. In Japan, the price of crude oil and natural gas increased by about 40-50 % after the Fukushima nuclear accidents in 2011, compared to 2010. The total cost of fossil fuel imports in 2012 was 25 trillion yen, representing an increase of approximately 30%. Thanks to energy saving efforts, however, the total volume of fossil fuel imports had risen by only 5% in 2012 compared to 2010, which tells us that the rise in energy prices has been the main contributing factor to the overall cost increase. 25 trillion yen represents as much as 5% of Japan's GDP, a very significant figure. Furthermore, fossil fuel consumption causes not only climate change, but also creates problems related to atmospheric and other pollution issues deriving from the emission of harmful substances. The problem is particularly severe in the case of coal, the combustion of which leads to the emission of numerous toxic substances. When it comes to the exploitation of unconventional sources such as sea bed oil fields or shale gas, issues relating to contamination of local environments are gradually becoming evident.

A third issue we are facing today is the risk of nuclear power and radioactive waste. The Fukushima Dai-Ichi nuclear power accident caused severe nuclear contamination of the surrounding environment, and residents from a wide area have been forced to evacuate for a long period of time. Local people who were unable to evacuate have been exposed to radiation and there are concerns about possible future increases in related health problems. In many areas, it remains uncertain when decontamination will be completed or when people may return to their homes, and the recovery of the agriculture, forestry and fishery industries is expected to take even longer. In Japan, one of the most earthquake prone countries in the world, there are still 48 nuclear reactors and the risk of future accidents is thus higher than in other regions of the world. Even if future accidents were not to occur, the issue of how to deal with nuclear waste that has to be stored safely for more than 100,000 years remains. Japan is still totally unprepared for this task.

When considering future energy and environment policy scenarios, it is imperative that we take these issues into account, and this report is based on exactly such a perspective.

1.2 Progress in energy efficiency technologies

The electricity and industry sectors account for two thirds of Japan's total CO_2 emissions (direct emission, inner circle of figure 1), and the remaining one third is accounted for by the transportation, commercial and household sectors. In these sectors, there are great differences in the energy and CO_2 emissions efficiency of individual facilities and factories, indicating that, depending on the measures taken, significant reductions in CO_2 may be realized[vi]. Based on the benchmark standards for several key sectors[vii] set in the Energy Conservation Law, further reductions could be achieved simply by raising the efficiency level of sites with a low performance to the requirements found in the law. (Figure 2).

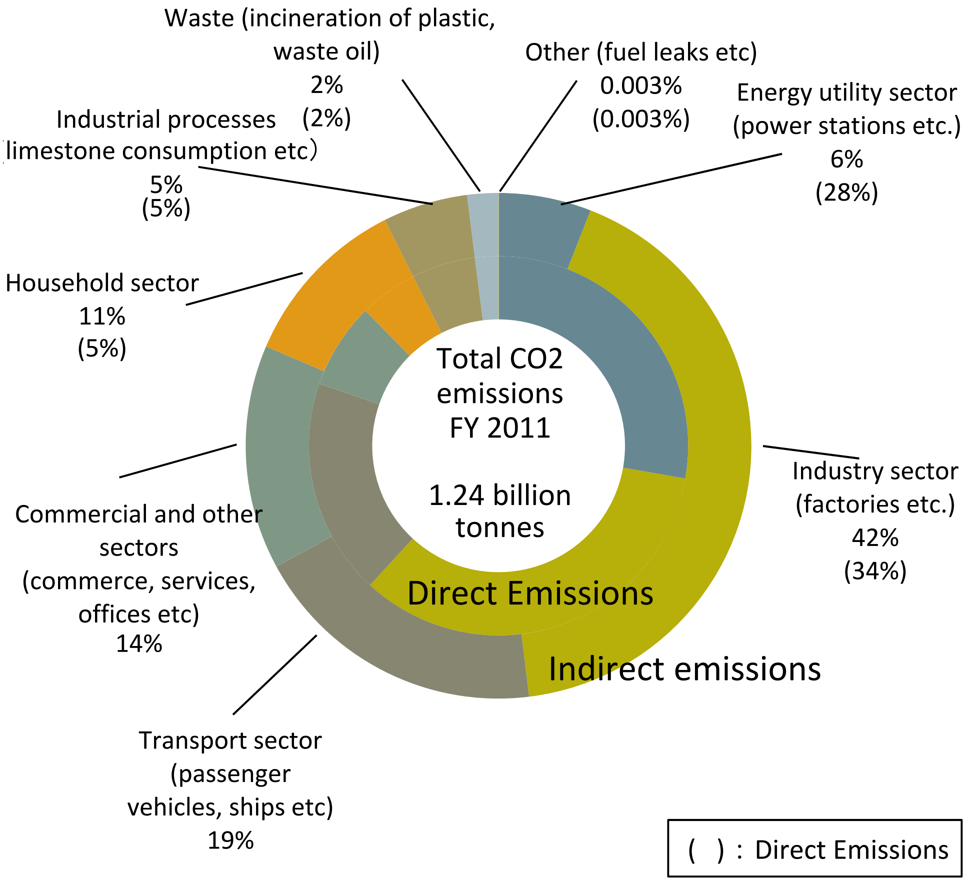

Figure 1: CO2 emissions by sector (FY2011)

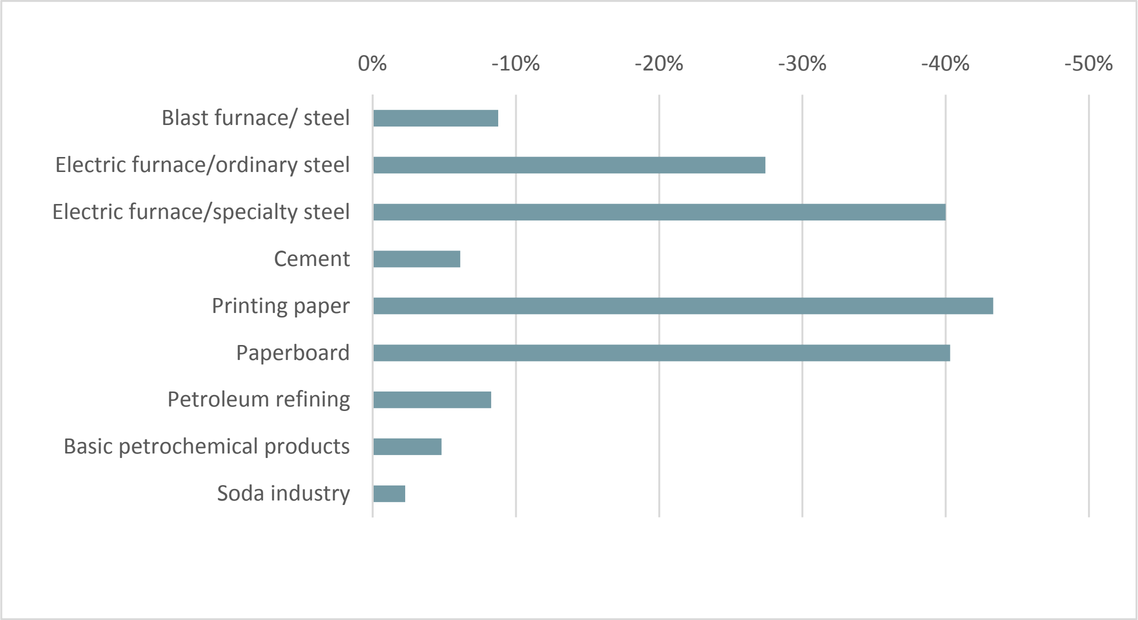

Figure 2: Reduction rates when benchmarks set in the Energy Conservation Law are met (compared to FY2010)

Further, in terms of energy efficiency measures, significant progress has been made in the development of new technologies after the oil shocks, so highly advanced technologies are commercially available in various sectors. Now is an opportune moment to replace the efficiency technologies which were introduced after the second oil shock, and which at the time were state-of-the-art.

In the electricity sector, for example, the efficiency of power generation with steam turbines in LNG power plants used to be below 40%, but in the 1990s, combined cycled power generation achieved 50% or higher efficiency (higher heating value), and the most advanced combined cycle power generation today reaches some 53-54% in efficiency. Even without using heat waste, a 25-30% reduction of fuels for power generation is thus possible.

In the industrial sector, a number of new technologies and energy conserving measures have enabled drastic improvements in total system efficiency - new production technologies, inverter technologies, control of number of units in operation, remediation of partially/locally over-engineered equipment, deployment of heat waste recovery technologies, cascade use of heat, and steam insulation, etc.

In the commercial and household sectors, technology development in refrigeration, air-conditioning and lighting has been significant. For lighting, lower levels of illumination and a shift to LED lighting have already brought about large improvements in efficiency, and in the near future, the commercialization of new technologies, such as organic EL, holds great promise. For refrigeration and air-conditioning, many facilities introduced after the oil shocks are becoming too old for use, and a significant potential for efficiency improvement is thus to be found in the replacement of such equipment. For the operation of clean rooms, data centers and other energy intensive facilities, adjusting temperature and humidity settings to an extent not damaging the equipment or products can help reduce energy consumption by 30-40% even without replacing any equipment. If these measures are combined with the replacement of aged air-conditioning equipment by state-of-the-art technology, energy consumption can be cut in half.

Technologies for thermal insulation of buildings and houses have also improved significantly in recent years. The introduction of BEMS (building energy management systems), HEMS (home energy management systems), CEMS (city energy management systems) holds promise in the improvement of energy information and supply-demand management control, as does the use of commissioning to achieve an optimized replacement of equipment.

In the transport sector, not only has advanced hybrid vehicle technology become available, but even some conventional gasoline driven cars have achieved a more than 20% reduction of fuel consumption compared to the 1990s. The diffusion of electric cars holds further promise.

In Japan, after the oil shocks, many have come to see the country as “a highly advanced energy efficiency nation” and it was long thought that there was little room for further efficiency improvements. Today, there is a tendency in Japan to believe this still holds true, but in reality, several decades have passed since these efficiency improvement efforts were undertaken, and many technologies are now outdated. There is thus great potential to be found in the deployment and steady diffusion of up-to-date, advanced energy efficiency technologies and systems with short payback times.

Most forms of renewable energy come without the cost of fuel, their environmental impact is low, and the experience of other countries indicates that the cost of these technologies drops as the introduction expands. Even existing analyses show that the potential exists for renewable energy technologies to produce more electricity than the current, total electricity demand in Japan, indicating a clear possibility for large scale expansion. In addition, the diffusion of renewable heat utilization holds a large potential for low temperature heat uses. Estimations have been made showing that Japan could feasibly achieve 100% renewable energy in the future 4).

Additionally, as an interim measure towards the phasing out of fossil fuels, a fuel switch from coal to natural gas can help reduce CO2 emissions from the electricity sector significantly. Since the share of coal used in thermal power generation (including in-house power generation), for industrial steam and heat use in the industrial sector has increased in Japan from the 1990s onward, there is also significant reduction potential to be found in this field. In this case, the promotion of energy conserving initiatives and technologies would allow the consumption of natural gas to stay approximately at the current level.

1.3 Transition of industrial and social structures towards a sustainable society

Japan’s industrial and social structures are likely to change in the time up to 2050 in response to the emerging needs of society. When looking at the share of manufacturing or employment figures in Japan after the oil shocks, the general trends has been a shift away from resource and energy intensive industries towards industries creating added value in highly resource and energy efficient manners. Since Japan is already a mature society with a sufficient infrastructure stock, this trend is likely to accelerate in the future[viii].

In the transport sector, the conventional growth model which saw an expansion of public infrastructure and an increased of use of cars and airplanes is changing, and energy efficiency improvements can be realized not only by increasing the efficiency of individual vehicles, but also through efforts in the entire logistics system to reduce transport distance, shift modes of transportations, and manage stocks better.

In addition, due to emerging resource constraints, a reduction or more effective use of petrochemical products and raw materials is required, and in response to that, we expect to see a shift towards industrial activity enabling this and an economy contributing to local development.

2. A vision for Japanese Society in 2050

Based on the concerns and constraints described in the above, a vision for Japan in 2050 can be outlined in the following way.

- When thinking of countermeasures to climate change, Japan - as a developed nation with the world's fifth largest emission of greenhouse gases and as a country in which per capita emissions are far above world average - carries great responsibility to future generations. Concerted international action is needed to achieve a global solution to climate change, and here Japan's role in the transfer of technology and provision of funds to promote sustainable development in developing countries is significant. In order to make this happen, however, Japan must first act progressively and systematically on climate change domestically, urging Japanese companies to initiate further technological development and realizing a low carbon society. Through the sharing of these experiences and technologies, Japan can take on a leadership role in global society.
- An appropriate level of Japan's responsibility, in light of internationally shared objectives, would be to achieve a 25% in reduction of greenhouse gas emissions by 2020, and more than 80% reduction by 2050, compared to 1990, and the same reduction level is required when looking at CO2 emissions from energy use.
- Taking the various risks and constraints Japan faces into consideration, the country should not depend on nuclear power and must make the transition to a sustainable energy system based on enhanced energy efficiency and renewable energy, while decreasing its dependence on fossil fuels. This approach should not force people to live in austerity unable to fulfill their daily needs or live comfortable lives; rather the goal is the creation of a truly prosperous society for both rural and urban regions.
- Changes in the industrial and social structures will progress further, and on the basis of the more limited use of resources as well as the promotion of the cyclical use thereof, Japan should create a sustainable social system, social norms and industrial structure while liberating itself from today's highly energy intensive social structure.

3. Scenario methods and assumptions

The scenario considered here works only with CO2 emissions from energy use. Also, in order to include reductions from the diffusion of technology, we use bottom-up modeling and base our scenario on the below assumptions (see appendix for more details). In the scenario, we do not merely include energy efficiency improvements from individual facilities or equipment in the different sectors, but also take a total systems view of improvement potential, focusing our attention on the possible shift in economic development patterns to a society in which compatibility is achieved between high value-added economic activity (which is at the same time highly resource and energy efficient) and the protection of the environment and the observation of emerging environmental constraints.

3.1 Assumptions related to energy efficiency technologies (Table)

(1) How to contemplate the issue of yet-to-be developed technology

2030 may seem a rather limited time frame for technology development, but if we think of 2050, it is reasonable to assume that the development of new technologies will make significant progress. It is, however, difficult at present to predict the effect or deployment rates of such technologies. The reason is that new technology development involves both a "development risk" (that is, the risk of failure of the technological development itself) and a "commercialization risk (the risk that even if development is completed, the cost of introduction of the technology is so high that diffusion fails).

Taking these risks of new technology introduction into account, the assumptions relating to energy efficiency measures in this scenario take a conservative approach, including mainly the diffusion and expansion of already commercialized energy efficiency technologies. In addition, separate estimations are included for a limited area of new technologies, such as the improvement of existing furnace technology in the steel sector that goes beyond the enhancement of current technologies (assuming a 20% improvement in energy efficiency), and others.

(2) Concerning already commercialized technologies

Regarding already commercialized technologies, the scenario focuses mainly on three issues: the replacement of aged equipment, system improvements, and operational improvements (which do not lower the level of service provided or lead to the need for austerity measures).

In our evaluation of the potential effect of energy efficiency measures for sectors where technology data is widely available for equipment replacement and system improvement, we estimate the effect of individual cases of improvement measures. In sectors where such data is insufficient, or where the information on the efficiency of each facility (site) is available (such as for power plants), we estimate the reduction effect for each facility per unit of production (output level). The individual assumptions adopted are the following:

- For thermal power plants, since the (present) ultimate technological potential for the efficiency of power generation is well understood, we have adopted the efficiency level of current top runner facilities. For new power plants, we basically work with the supply plans of LNG thermal power plants from each power company toward 2020. Also, we place priority in estimations on the most recent types of power plants and assume that in 2020 there will only be a very limited use of old types of plants to cover peaks in electricity demand. We do not project any improvement in the efficiency of coal or oil thermal power plants.

- When looking at measures taken at factories, we look separately at the facilities of the material manufacturing industry and those of other industries including food production, machine manufacturing etc. In these factories, not only is the understanding today of the actual condition and improvement measures for energy intensive equipment insufficient, but the potential for total system improvements (such as output control, equipment number control, heat and steam recovery measures etc.) is often not included in improvement measures. We therefore work on the basis of the following assumptions for this sector.
    - In the material manufacturing industry, the scenario assumes that all facilities around 2030 meet benchmark standards set in the Energy Conservation Law.
    - In other manufacturing industry, setting production indicators is not easy, data for energy per unit of production is not complete, and information on individual measures is sporadic. Thus, in order to calculate energy efficiency improvement potential for these factories, we separate production related equipment from non-production equipment (such as lighting and air-conditioning for employees), and for production equipment assume that, around 2030, subsidized improvement projects and ESCO (energy savings company) initiatives will have had a certain level of effect in many factories.
- In transport, commercial, and household sectors, we work with estimations based on individual cases of technology measures.
    - For private vehicles, buses, and taxis for passenger transport, the assumptions used are based on the improvement of fuel efficiency improvement achieved when replacement of vehicles takes place. For trucks for freight transport, the same rate of efficiency improvement as for private vehicles is assumed.
    - It is assumed that environmentally friendly driving of corporate passenger vehicles, buses taxis and trucks will improve.
    - For commercial and household sectors, it is assumed that insulation will be improved or introduced in new constructions and mass renovation of buildings and houses, and that energy efficient appliances are introduced at the time of replacement. For heating, we assume a shift towards heat pumps and fluorinated gas-free (not-in-kind) technologies.

Table 1 Assumptions relating to energy efficiency technologies

Sectors		Assumed technologies (Existing best available technologies)	Assumed technologies (New technologies)
Energy conversion (electricity) sector		・LNG thermal power generation (steam power) will be fully replaced by combined cycle power generation by 2030. ・Coal and oil thermal power plants will decrease	
Industry sector	Material manufacturing industry	・Benchmark standards will be met by all factories by 2030 (*1)	New blast furnace technology in steel sector
	Other manufacturing industry	・Efficiency improvement of production facilities equipment is assumed to reach level of the voluntary emissions trading scheme of the Ministry of Environment and ESCO measures. This includes not only replacement of equipment, but also various improvements, such as heat recovery and operational management, for example temperature control for clean rooms. ・Efficiency improvement of lighting and air-conditioning for employee work space is assumed to comply with energy saving measures taken in the commercial sector.	
Commercial sector(*2)		・Efficiency improvement of equipment and appliances. ・Improvement of energy efficiency in buildings ・BEMS, CEMS	
Household sector (*2)		・Efficiency improvement of appliances ・Improvement of energy efficiency in housing ・HEMS, CEMS ・Heating and cooling using central boilers with CO2 heat pumps in condominiums and apartment complexes	Advanced control technologies for cooking devices
Passenger transport sector		・Gradual replacement of vehicles to top runner level	

(*1) Benchmark standards under the Energy Conservation Law are not at the level of top-runner technology (best available technology), so actual reduction potential is larger.

(*2) Assumptions do not include austerity measures forcing people to sacrifice amenities.

3.2 Assumptions related to renewable energy (Table 2)

Assumptions for electricity from renewable energy in 2030 are based on projections made by the government's "Energy and Environmental Council"; for 2050, up to twice that volume is assumed. For heat use from renewable energy, it is assumed that in commercial and household sectors low temperature heat sources are introduced. For households, it is assumed that low temperature heat sources based on fossil fuels will be phased out by 2030, for the commercial sector by 2050.

3.3 Fuel transition (Table 2)

Among fossil fuels, CO2 emissions from coal are approximately twice as large as those from natural gas, and for oil some 40% larger than from natural gas. Using these fuel characteristics, when electricity generated at fossil-fuel based thermal power plants decreases in the future, it is assumed that, as part of fuel transition measures, priority will be placed on keeping low carbon energy sources (while phasing out CO2 intensive fuels preferentially). For industrial and commercial sectors, it is assumed that a transition will take place from costly oil toward natural gas. Concerning the transition from fossil fuels to electrification, it is assumed that about 50% of steel production will have shifted from blast furnaces to electric furnaces by 2030, and that 10-20% of vehicles will be electrically driven by 2030.

3.4 Nuclear power and other technologies (Table 2)

As for nuclear power generation, there are obviously safety problems in the case of accidents and radioactive waste problems. Also, since there are also many concerns in relation to nuclear safety regulation, it is assumed in this scenario that no existing nuclear power plants will be restarted, and that nuclear power generation will not be used in the future. The potential contribution of fuel cells, hydrogen use, CCS (CO2 capture and storage), international emission credits purchases are not included in estimations used for this scenario.

Table 2 Renewable energy, fuel transition and nuclear power

FY	Fuel transition	Renewable energy			Nuclear Power
		Electricity	Heat	Transport fuels	
2020	・Systematic transition from coal to gas	・Same level as the assumption of government’s “Energy and Environmental Council”8)	・Diffusion of solar water heating , biomass, and CO2HP in condominiums and apartment complexes	・No renewables are assumed	・Zero operation including in a BAU case, due to uncertainty of safety check process and other concerns
2030	・In electricity sector, zero consumption of coal and oil except in relation to byproduct gases	・Same level as “Energy and Environmental Council” 8)	・Diffusion of solar water heating, and wood biomass boilers in households	・10% of fuel from renewable sources	

3.5 Concerning level of economic activity

Two cases are considered in the scenario; one assumes the continuation of current trends, the other a gradual downscaling (decrease) of material consumption that influences energy consumption.

For the current trends case, the "cautious case" [ix] laid out by the "Energy and Environmental Council" 8) is used as a reference with regards to economic activity, such as production in key sectors, traffic volume, floor space in the commercial sectors, and number of households. However, taking into account the effect of the Lehman shock (economic crisis from 2008 onwards), the scenario adopts the Council's " low growth case" for crude steel production, cement production, and freight traffic. Also, it is assumed that economic activity will have decreased by 2050 due to the projected drop in Japan's population.

For the downscaling case, main assumptions are a further 10% reduction of steel production and a 20% of reduction of cement production as the result of an increase in long-life buildings and other measures in the construction sector.

For the projection of various other economic activities between 2030 and 2050, the population estimates adopted are the middle case birth and death rate projections from the National Institute of Population and Security Research. Further, as part of initiatives to make the transition to a sustainable society, it is assumed that the efficiency of material use and transportation will improve, as indicated in Table 3.

Table 3 Effective material use and efficiency improvements in transportation

Case	Effective material use	Efficiency improvements in transport
Case 1	・Increased use of recycled materials (higher ratio of electric furnaces)	・Environmentally friendly driving in transport industry and for corporate passenger vehicles
Case 2	・Reduction of resource consumption (steel, cement, pulp, aluminum, plastic, etc.) ・Reduction of building materials due to longer life buildings ・Shift from reinforced -concrete to steel frames in future building construction (reduction of cement) ・Reduction of material use through reuse and recycling of building materials and packages ・Shift to carbon fibers and woody materials	・Promotion of compact cities, reduction of transport distance through relocation of public facilities, etc. ・Increased share of public transport ・Expansion of modal shifts in freight transport

3.6 Cases considered in the scenario (Table 4)

Based on the above-mentioned assumptions, we consider three cases: a Business As Usual (BAU) case in which no particular measures are implemented, Case 1 which only works with measures based on already commercialized technology, and Case 2 which includes additional measures to those included in Action Case 1, such as the more efficient use of materials and more efficient transportation as well as the use of new technologies.

Table 4 Assumptions of each case

	Energy efficiency technologies	Efficiency improvement of material use and transportation
BAU Case	None	None
Case 1 (diffusion of commercialized efficiency technologies)	Diffusion of existing best technologies in energy efficiency, fuel transition, and renewable energy expansion	Continuation of currently envisioned future trends (government scenario is used but partly adjusted)
Case 2 (efficiency technology deployment + downscaling + new technology)	Introduction of promising new technologies in addition to those included in Action Case 1	Reduction of material consumption and traffic while maintaining present quality of required social services

4. Estimations

Based on the assumptions stated above, the estimations in the scenario are described as follows.

Firstly, estimation results for primary energy supply are shown in figures 3 to 5. Figure 3 shows the expected change in primary energy supply by fuel type, figure 4 shows changes by sector, and figure 5 changes in energy conversion loss, electricity, heat utilization and transportation fuel.

On the demand side, improvements in energy conversion loss ratios are foreseen, and in combination with the previously mentioned systematic renewal and renovation of equipment, it is estimated that energy consumption in Case 1 (diffusion of commercialized efficiency technologies) can be reduced to 50% of 2010 level by 2030 and to approximately 40% by 2050.

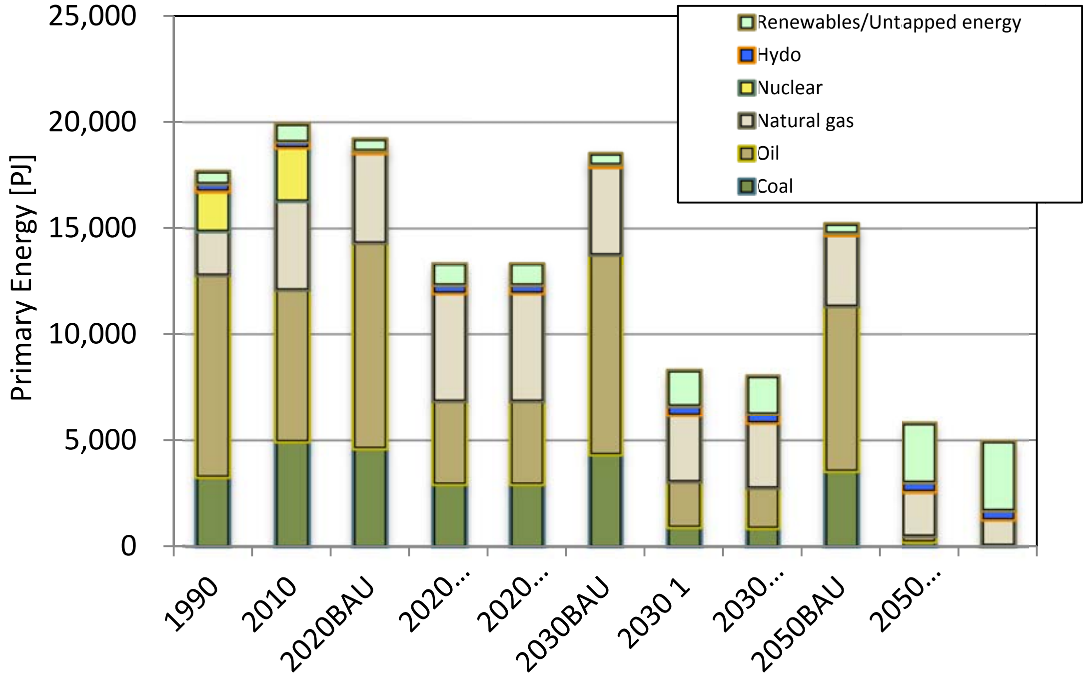

Figure 3: Domestic supply estimates for primary energy (by fuel type)

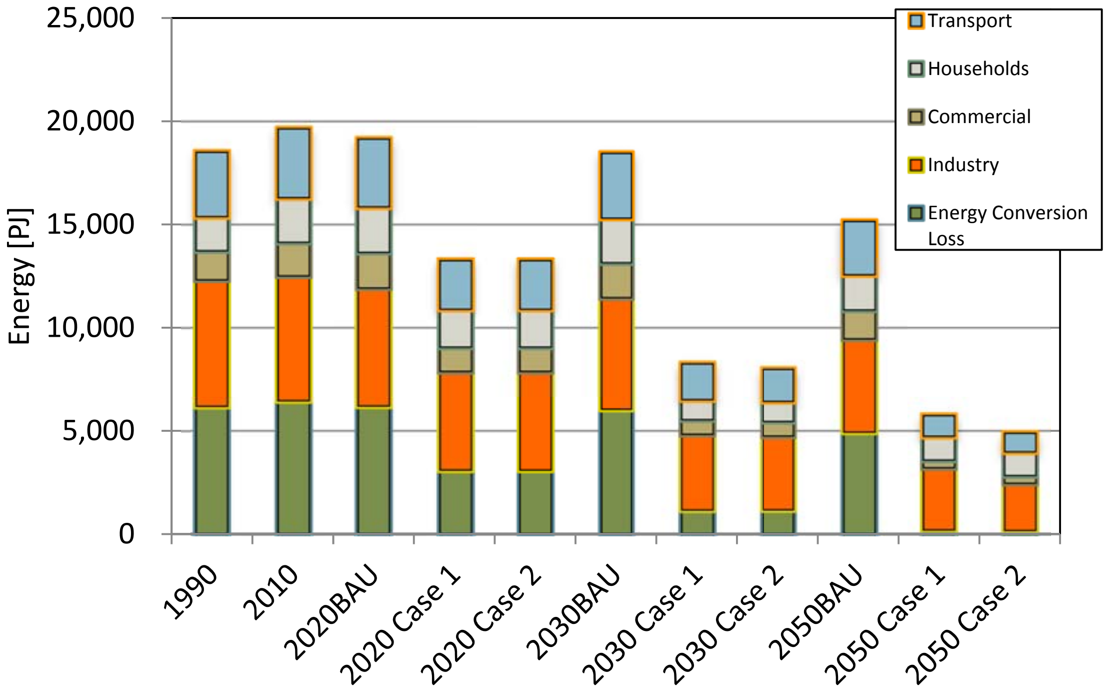

Figure 4: Domestic supply estimates for primary energy (by sector)

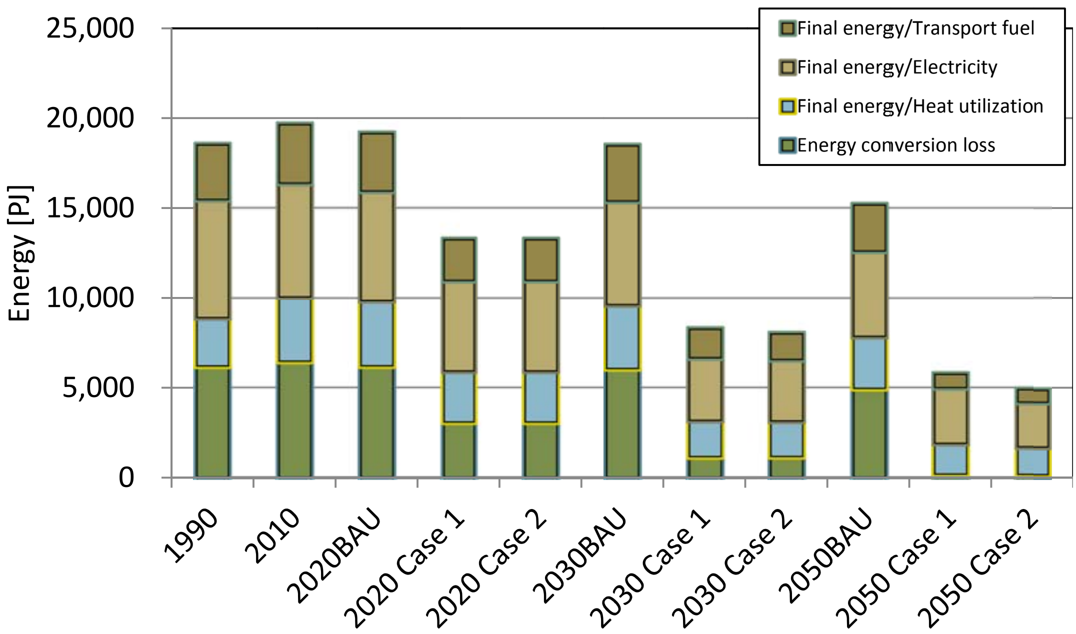

Figure 5: Domestic supply estimates for primary energy (by usage)

The next charts show estimations of CO2 emissions from energy use by sector (figure 6) and by fuel type (figure 7). Advancing energy efficiency and fuel transition measures, it is technically feasible even in Action Case 1 (diffusion of commercialized efficiency technologies) to reduce CO2 emissions from energy use by 25% by 2020, more than 50% by 2030, and more than 80% by 2050, all compared to 1990. If we assume that materials and transport will become more efficient, emissions may fall by 90% by 2050, and if new technologies are introduced, potentially by 95%. These reductions depend on the systematic diffusion of energy efficiency measures and a planned expansion of renewable energy, but there is little uncertainty in these estimations and, if implemented, steady progress can be expected.

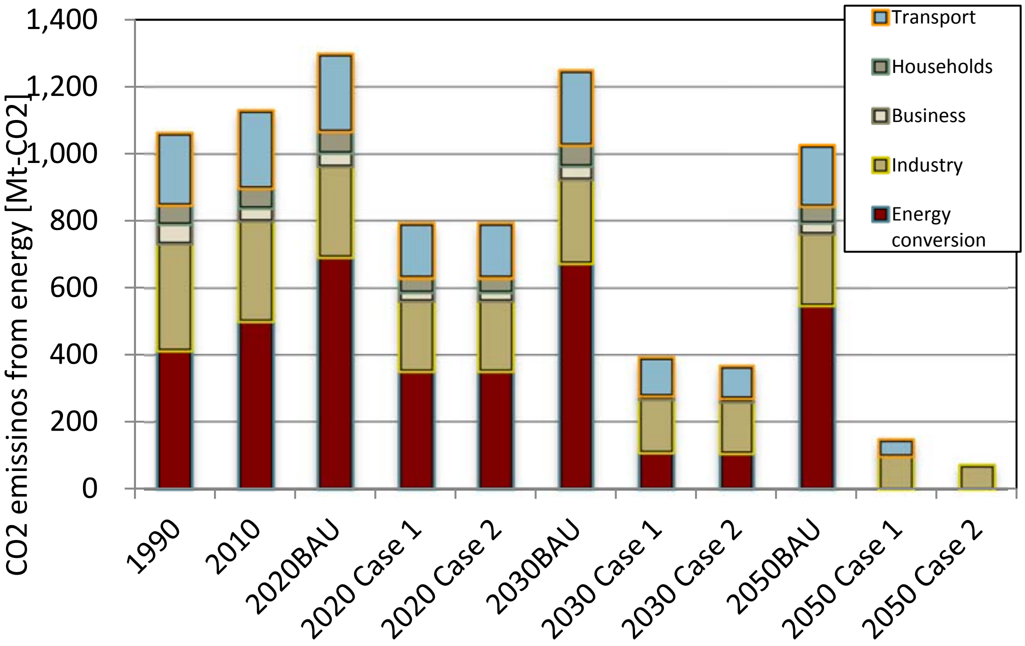

Figure 6: CO2 emission estimates from energy use (by sector)

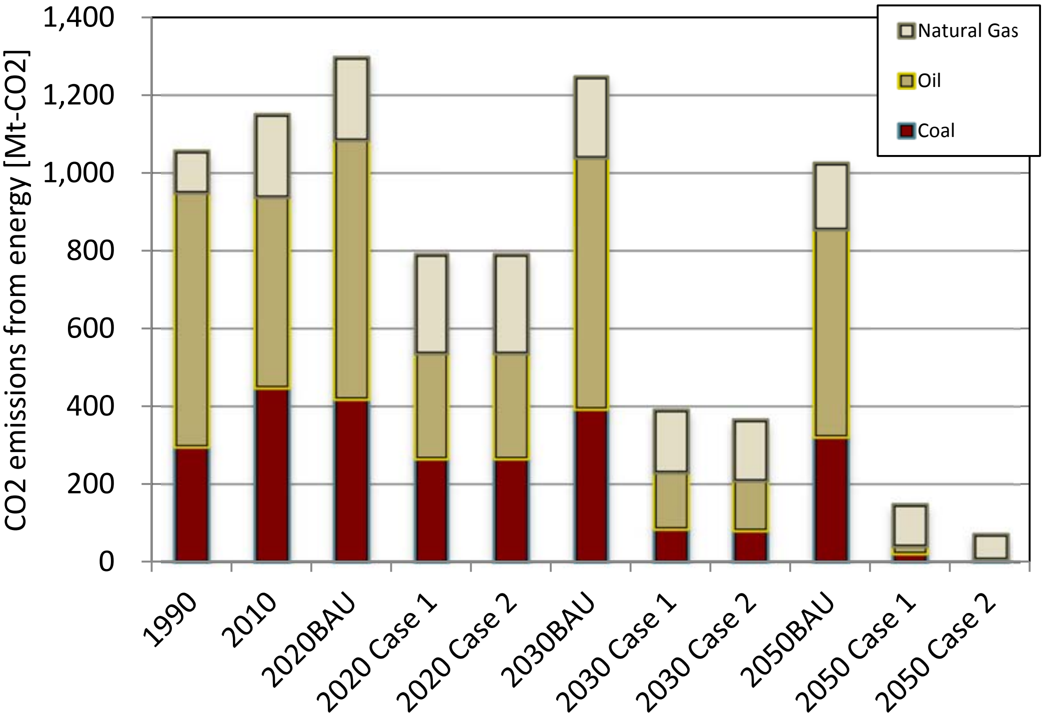

Figure 7: CO2 emission estimates from energy use (by fuel type)

The following chart (figure 8) illustrates changes in total fossil fuel imports in yen (for the sake of convenience, prices for fossil fuel imports are fixed at FY 2011 level). Compared to BAU cases where no measures are taken, it is possible to drastically reduce the cost of imported fossil fuels for both other cases. Thanks to this, if the funds which used to flow overseas are instead used for equipment improvement measures or maintenance, or if the savings realized in utility costs are used for other investments or for personnel expenditures, we may expect to see positive effects on the Japanese economy through increased domestic demand and new employment.

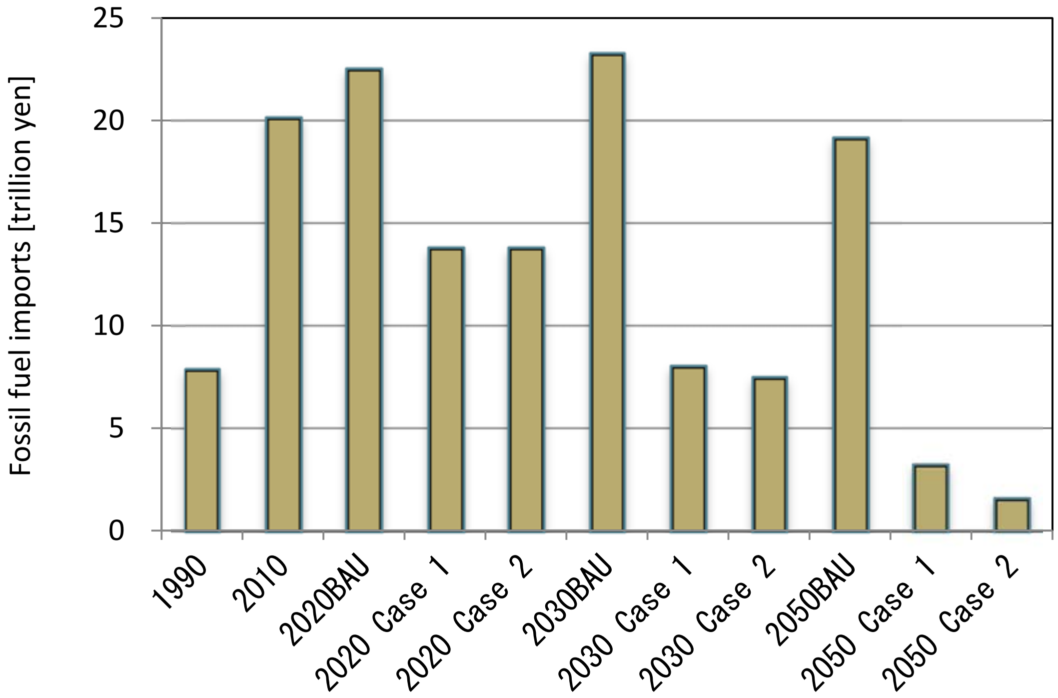

Figure 8: Estimation of fossil fuel import cost (price per unit based on FY 2011 data)

5. Key findings

5.1 Concerning the estimation results

With the constraints and risks deriving from climate change, the continued use of fossil fuels and nuclear power as our point of departure, we have looked at the prerequisites for the supply and demand of energy which do not negatively affect future generations, and at climate change measures and shifts in the energy paradigm towards 2020, 2030 and 2050, arriving at the following findings:

- Assuming that the current level of economic activity continues, it is technically feasible to reduce CO2 emissions from energy use by 25% by 2020, 50% by 2030 and 80-95 % by 2050 (all estimates compared to 1990) . This can be achieved without depending on nuclear energy, and without the need for austerity measures or fundamentally new technologies involving development risks, by promoting the diffusion of already commercialized technologies for energy efficiency, fuel transition, and renewable energy. However, for the 2020 cases, it is assumed that renewal and updating of equipment will commence in 2014 and, thus, if delays occur in the introduction of such measures the potential effect will gradually diminish.

- Analyzing factors that may cause the level of economic activity to change, it is technically feasible even when adopting the “cautious scenario” of the government’s Energy and Environment Council – which assumes that trends in material production will move towards the high levels seen before the Lehman Shock – to achieve CO2 reductions of more than 25% by 2020, more than 50% by 2030 and more than 80% by 2050 (all estimates compared to 1990). Additionally, if expected changes in industrial and social structures are taken into account, a shift in the structure of our energy system which corresponds to the risks deriving from climate change, and the related reduction in greenhouse gas emissions, can be achieved with significant leeway.
- Considering economic impacts, compared to cases where no measures are taken, those that do can greatly lower fossil fuel import costs. The results also suggest that if the saved money is used for investment in efficiency measures and other initiatives generating demand for domestic industry and creating jobs, positive effects on the economy may be realized.
- Furthermore, even though calculations do not include any possible economic ripple effect, by adopting Case 1 (use of already commercialized efficiency technologies) or Case 2 (commercialized technologies and other measures), a return on investments from direct investments on equipment would, on the basis of certain assumptions, be possible within a medium-term period of about five years. Through such relatively cost-effective measures, total medium-term costs will drop, and after return on investment has been achieved, this amount will translate into an economic gain. It also appears likely that a majority of investments for related measures will benefit domestic companies, which in turn will contribute to the domestic economy by generating new employment.

5.2 Comparisons with previous research

Comparing with research prior to ours, the following points can be made:

- Our scenario indicates that there is a larger potential for greenhouse gas reductions, and that the speed of fuel transition and the introduction of renewable energy is potentially higher, than in any of the models created by the government’s Energy and Environment Council. It is, thus, a model which allows for a swifter transition to a sustainable society.
- Compared to scenario research prior to our model, it is characteristic of our research that it expects a significant degree of reductions in CO2 emissions through fuel transition and the spread of energy efficiency technologies in the energy utility sector as well as through the diffusion of energy efficiency technologies in the industrial sector. As a whole, our scenario responds effectively to all the constraints mentioned in the above. For Case 1, we assume that already existing efficiency technologies will be used, making it a conservative scenario.
- It is another characteristic of our model that is recognizes the possibility of a downward trend in the domestic production volume of basic heavy chemical industry products due to long-term changes in the demand structure. Our model partly reflects this and, while taking existing constraints into consideration, aligns its estimations with visions for the future. In contrast, many of the models considered by the government as well as voluntary action plans established by industry do not reflect reality and assume a continued upward growth trend.

6. Proposals based on the scenario estimations

As shown in the estimations included in this model, even working from the conservative assumption of technical measures based primarily on the diffusion of already commercialized technologies, not only is it feasible to achieve reductions of up to 80% by 2050, but if the diffusion of technology is implemented without delay, major reductions can also be realized by 2020 and 2030. The real issue is that accelerating the diffusion of this technology depends on policy decision making and implementation.

In Japan, it is sometimes argued that in order to set ambitious targets for greenhouse gas emissions in 2020 or 2030, the restart of nuclear power plants is imperative, but our model suggest that if measures focus on the major source of emissions, namely coal combustion, and if clever energy saving measures are implemented on the demand side in combination with the expansion of renewable energy, large emissions reductions are possible particularly in the power generation sector, making nuclear power dispensable. It is entirely feasible for Japan to plan and implement climate change policies and targets that do not take the restarting of nuclear power plants as a foregone conclusion.

As for policy deliberations, in order to realize the fully technically viable estimations in our model, it is necessary first to set a clear direction for policy which does not make Japan dependent on nuclear power and which aims for a decrease in fossil fuel consumption, and then to examine what steps must be taken to implement concrete plans and policies. Specifically, it is necessary to consider how to set annual targets for the consumption of fossil fuels, how to establish measures, organizational structures and institutional frameworks for the promotion of renewable energy, and, on the demand side, what measures and institutional frameworks are needed to achieve a steady reduction in energy consumption. In addition to this, it is required that Japan sets a more ambitious reduction target and develop a national framework oriented towards the United Nation’s “2015 agreement”, the new global framework.

Furthermore, our research suggests that there is significant room for additional measures in the renewal and improvement of various technologies in factories and commercial facilities as well as through operational improvements (excluding measures that call for austerity measures or lead to a lowering of service level). It is necessary to collect, share and organize a variety of information that can lead to a greater understanding of the current situation, and for different players to utilize this knowledge in an effective manner.

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[i] For example, ”Turn Down the Heat”, World Bank (2013), etc. http://documents.worldbank.org/curated/en/2013/06/17862361/turn-down-heat-climate-extremes-regional-impacts-case-resilience-full-report

[ii] For example, ”The World Energy Outlook”, International Energy Agency (2012)(2011), etc. http://www.worldenergyoutlook.org/publications/weo-2012/

[iii] According to “Results of a national debate” by the Cabinet Office Strategy Division (2012), at a public hearing 70-90% supported eliminating nuclear power, and discussion-style opinion polls support for the same policy rose by 50% after deliberation. http://www.cas.go.jp/jp/seisaku/npu/policy09/pdf/20120904/shiryo1-2.pdf

[iv] Precondition that utilizes estimations from the Agency for Natural Resources and Energy (under the Ministry of Economy, Trade and Industry) “Energy mix choices draft” and the Central Environment Council’s (under the Ministry of Environment) “Post 2013 policies and measures report (draft of options for global warming measures)”

[v] Cancun Agreement, etc. Cancun Agreement(2011), FCCC/CP/2010/7/Add.1

[vi] “The reality of Japan’s greenhouse gas emissions – an analysis of Japan’s emission disclosure system”, Kiko Network (2010) http://www.kikonet.org/research/archive/disclosure/CO2emission_analysis2007.pdf

[vii] This standard is set at a standard deviation of 60% and is not the best available technology.

[viii] “Building a future without nuclear power or climate change”, Kimiko Hirata (2012), Commons, pp. 46-49

[ix] Cabinet Office Strategy Division (2012) “Scenario Data Details” (Growth case/low-growth case added) (excel) “Energy and environment choices”, URL: http://www.cas.go.jp/jp/seisaku/npu/policy09/sentakushi/database/shousai-data_shincho+seicho+teiseicho.xls. The government proposed three cases for 2030 in regards to economic growth: a cautious case, a growth case and a low-growth case. In the “cautious case”, the annual economic growth rate was 1.1% on average in the 2010s and is hypothesized to be at an average of 0.8% for the 2020s. This case emphasizes important points, however, crude steel production was estimated to stay at levels equal to those prior to the Lehman shock and freight transport volume is expected to increase in the future. In contrast, in the “growth case” the annual economic growth rate was projected at the high values of 1.8% for the 2010s and 1.2% for the 2020s; this is based on the Basic Strategy for Revitalizing Japan which was formulated in November 2010, before the Fukushima Dai-Ichi nuclear accident. Crude steel production is projected to be the same as in the “cautious case”, whereas cement production is expected to expand further. The “low-growth case” which extrapolates growth rate data from the past 10 years until 2030 estimates annual growth rate to be 0.2% in the 2010s and 0.4% for the 2020s. Under this case, it is expected that crude steel production, cement production etc. will gradually decrease.

Table A1-1 Technology for improving energy efficiency

			Case 1 (Diffusion of technology)		Case 2 (New technology/downscaling)	
			Technology	Degree/Aim	Technology	Degree/Aim
Energy conversion	Power plants	LNG thermal fired power plants	Systematically introduce newest equipment for energy efficiency	By converting to combined cycle technology for all power plants by 2030, fuel consumption can be cut by 25%.	Same as case 1	
		Other fossil fuel plants	None		Same as case 1	
	Refineries		Update technology at the time of large scale renovations/replacement introducing the newest equipment for energy efficiency and other energy efficiency renovations	Achieve energy efficiency benchmarks (Energy Conservation Law) by 2030 for all facilities（improvement of 8.3%　(emissions intensity) compared to 2010）	Same as case 1	
Industry	Non-manufacturing		Update to newest energy efficiency technology at time of large scale renovation		Same as case 1	
	Manufacturing	Iron & Steel	Update technology at the time of large scale renovations/replacement introducing the newest equipment for energy efficiency and other energy efficiency renovations	Achieve energy efficiency benchmarks by 2030 for all facilities (for blast furnaces, an improvement of 9% compared to 2010 and 27% for electric furnace (ordinary steel) (both emissions intensity improvements)	Introduction of new blast furnace technology	
		Chemicals (materials)	Update technology at the time of large scale renovations/replacement introducing the newest equipment for energy efficiency and other energy efficiency renovations	Achieve energy efficiency benchmarks by 2030 for all facilities (for basic organic chemical products, an improvement of 5% (emissions intensity) compared to 2010 levels)	Same as case 1	
		Cement	Update technology at the time of large scale renovations/replacement introducing the newest equipment for energy efficiency and other energy efficiency renovations	Achieve energy efficiency benchmarks by 2030 for all facilities (improvement of 6.1% (emissions intensity) compared to 2010)	Same as case 1	
		Paper	Update technology at the time of large scale renovations/replacement introducing the newest equipment for energy efficiency and other energy efficiency renovations	Achieve energy efficiency benchmarks for all facilities by 2030 (improvement of 43% (emissions intensity) compared to 2010)	Same as case 1	

		Non-material	Update technology at the time of large scale renovations/replacement introducing the newest equipment for energy efficiency and other energy efficiency renovations	At production, equipment, reductions matching the Ministry of Environment's voluntary emissions trading scheme are assumed for 2030. For utility equipment, reductions are assumed to be comparable to those in commercial sector.	Same as case 1	
Households			・Efficiency improvement of appliances ・Advancement of energy efficiency for house construction ・HEMS, CEMS ・In housing complexes, hot water supply and heating/cooling systems with boilers utilizing CO2 heat pumps		・Advanced control techniques for cooking appliances ・Same as case 1	
Commercial			・Efficiency improvements of equipment and appliances ・Efficiency improvements of buildings ・BEMS, CEMS		Same as case 1	
Transportation	Passenger transport	Passenger vehicles	Update to latest energy efficiency technology at time of replacement. Promote environmentally friendly driving of private and company cars, taxis and buses. Also introduce hybrid and electric cars	By 2030, improve fuel consumption of cars to match top performance level of each type of car, increase the proportion of electric car to 10%	Same as case 1	Increase proportion of electric cars to 20%.
	Freight	Trucks	Update to latest energy efficiency technology at time of replacement		Same as case 1	

Table A2-1 Trends in supply and demand of energy(Case: diffusion of existing technologies) Unit: PJ

	2010			2020			2030			2050		
	Total	Heat・Fuel	Electricity	Total	Heat・Fuel	Electricity	Total	Heat・Fuel	Electricity	Total	Heat・Fuel	Electricity
Primary energy: domestic supply	19,669			13,286			8,287			5,779		
Energy conversion loss	6,436			3,081			1,149			176		
Power generation loss (as part thereof)	5,201			2,746			903			0		
Final energy consumption	13,233	9,642	3,591	10,206	7,396	2,810	7,138	5,113	2,025	5,603	3,884	1,719
Industry	6,050	4,625	1,425	4,780	3,585	1,195	3,669	2,730	939	3,017	2,277	740
Non-manufacturing	342	332	9	299	291	8	256	249	7	256	249	7
Manufacturing	5,708	4,293	1,416	4,481	3,294	1,187	3,413	2,481	932	2,761	2,028	733
Materials	3,118	2,516	602	2,365	1,858	507	1,750	1,360	390	1,381	1,058	323
Non-materials	2,590	1,776	814	2,116	1,436	680	1,662	1,120	542	1,380	970	411
Households	2,154	1,155	999	1,842	1,002	840	970	538	432	1,148	760	388
Commercial	1,633	634	999	1,177	478	699	706	186	520	375	34	341
Transport	3,396	3,329	68	2,407	2,332	75	1,792	1,659	133	1,063	813	250
Passenger transport	2,107	2,043	64	1,372	1,303	68	953	833	120	564	364	200
Freight	1,289	1,286	3	1,035	1,028	7	839	826	14	499	449	50
Primary energy (compared to 2010)				-32%			-58%			-71%		
Final energy (compared to 2010)				-23%			-46%			-58%		

Table A2-2 Energy configuration (Case: diffusion of existing technologies)

	2010						2020					2030					2050				
	Total PJ	Coal	Oil	Gas	Nuclear	Renewables	Total PJ	Coal	Oil	Gas	Renewables	Total PJ	Coal	Oil	Gas	Renewables	Total PJ	Coal	Oil	Gas	Renewables
Primary energy: domestic supply	19,669	25%	36%	21%	13%	5%	13,286	22%	30%	38%	10%	8,287	12%	26%	38%	25%	5,779	4%	5%	36%	55%
Power generation input	9,179	29%	9%	27%	27%	7%	5,837	31%	10%	47%	12%	3,131	4%	1%	55%	40%	1,891	0%	0%	0%	100%
Heat utilization (excl. electricity)																					
Final energy consumption	9,642	20%	61%	16%		4%	7,396	16%	45%	31%	8%	5,113	16%	41%	28%	15%	3,884	7%	7%	54%	32%
Industry	4,625	40%	34%	18%		7%	3,585	32%	22%	37%	9%	2,730	30%	23%	39%	9%	2,277	11%	1%	67%	20%
Non-manufacturing	332	0%	88%	12%		0%	291	0%	66%	30%	5%	249	0%	65%	31%	5%	249	0%	14%	44%	43%
Manufacturing	5,708	43%	31%	19%		8%	4,481	35%	18%	37%	10%	3,413	32%	18%	40%	9%	2,761	13%	0%	70%	18%
Households	2,154	0%	58%	40%		2%	1,842	0%	29%	44%	27%	970	0%	0%	0%	100%	1,148	0%	0%	0%	100%
Commercial	1,633	0%	59%	41%		0%	1,177	0%	29%	71%	0%	706	0%	30%	70%	0%	375	0%	0%	0%	100%
Transport fuel (excl. electricity)																					
Transport	3,329		100%			0%	2,332		92%	8%	0%	1,659		85%	15%	0%	813		30%	69%	2%
Passenger transport	2,107		100%			0%	1,372		99%	1%	0%	953		97%	3%	0%	564		45%	51%	4%
Freight	1,289		100%			0%	929		82%	18%	0%	756		73%	27%	0%	414		17%	83%	0%

Totals may not add up due to rounding.

Table A2-3 CO2 emissions from energy use (Case: diffusion of existing technologies) Unit: M t-CO_2

	1990	2010	2020	2030	2050
Primary energy: domestic supply	1,059	1,123	788	388	145
Energy conversion		503	353	112	0
Power generation (including in-house power generation)		421	338	99	0
Steam for Industry (especially for material manufacturing)		44	16	13	0
Final energy consumption		622	436	277	145
Industry		297	211	157	101
Non-manufacturing		22	17	15	8
Manufacturing		275	194	143	93
Materials		165	111	78	55
Non-materials		110	83	65	38
Households		61	42	0	0
Commercial		39	26	10	0
Transport		225	156	109	44
Passenger transport		137	89	57	20
Freight		88	60	47	18
Compared to 1990		6%	-26%	-63%	-86%
Compared to 2010			-30%	-65%	-87%

Table A3-1 Trends in supply and demand of energy (Case: new technology introduction and downscaling) Unit: PJ

	2010			2020			2030			2050		
	Total	Heat/Fuel	Electricity	Total	Heat/Fuel	Electricity	Total	Heat/Fuel	Electricity	Total	Heat/Fuel	Electricity
Primary energy: domestic supply	19,669			13,286			8,023			4,923		
Energy conversion loss	6,436			3,081			1,156			158		
Power generation loss (as part thereof)	5,201			2,746			865			0		
Final energy consumption	13,233	9,642	3,591	10,206	7,396	2,810	6,866	4,880	1,986	4,766	3,229	1,536
Industry	6,050	4,625	1,425	4,780	3,585	1,195	3,577	2,663	914	2,286	1,703	583
Non-manufacturing	342	332	9	299	291	8	256	249	7	256	249	7
Manufacturing	5,708	4,293	1,416	4,481	3,294	1,187	3,321	2,414	907	2,030	1,454	576
Materials	3,118	2,516	602	2,365	1,858	507	1,658	1,294	364	650	484	165
Non-materials	2,590	1,776	814	2,116	1,436	680	1,662	1,120	542	1,380	970	410
Households	2,154	1,155	999	1,842	1,002	840	970	538	432	1,148	760	388
Commercial	1,633	634	999	1,177	478	699	706	186	520	375	34	341
Transport	3,396	3,329	68	2,407	2,332	75	1,613	1,493	120	957	732	225
Passenger transport	2,107	2,043	64	1,372	1,303	68	858	750	108	508	328	180
Freight	1,289	1,286	3	1,035	1,028	7	755	743	12	449	404	45
Primary energy compared to 2010				-32%			-59%			-75%		
Final energy compared to 2010				-23%			-48%			-64%		

Table A3-2　Energy configuration（Case: new technology introduction and downscaling）

	2010						2020					2030					2050				
	Total PJ	Coal	Oil	Gas	Nuclear	Renewables	Total PJ	Coal	Oil	Gas	Renewables	Total PJ	Coal	Oil	Gas	Renewables	Total PJ	Coal	Oil	Gas	Renewables
Primary energy: domestic supply	19,669	25%	36%	21%	13%	5%	13,286	22%	30%	38%	10%	8,023	11%	23%	38%	27%	4,923	2%	0%	25%	73%
Power generation start up	9,179	29%	9%	27%	27%	7%	5,837	31%	10%	47%	12%	3,049	4%	1%	53%	41%	1,690	0%	0%	0%	100%
Heat utilization（excl. electricity）																					
Final energy consumption	9,642	20%	61%	16%		4%	7,396	16%	45%	31%	8%	4,880	16%	37%	29%	18%	3,229	3%	0%	38%	58%
Industry	4,625	40%	34%	18%		7%	3,585	32%	22%	37%	9%	2,663	29%	23%	41%	10%	1,703	6%	0%	71%	23%
Non-manufacturing	332	0%	88%	12%		0%	291	0%	66%	30%	5%	249	0%	65%	31%	5%	249	0%	0%	54%	46%
Manufacturing	5,708	43%	31%	19%		8%	4,481	35%	18%	37%	10%	3,321	31%	19%	42%	10%	2,030	7%	0%	74%	19%
Households	2,154	0%	58%	40%		2%	1,842	0%	29%	44%	27%	970	0%	0%	0%	100%	1,148	0%	0%	0%	100%
Commercial	1,633	0%	59%	41%		0%	1,177	0%	29%	71%	0%	706	0%	30%	70%	0%	375	0%	0%	0%	100%
Transport fuel（excl. electricity）																					
Transport	3,329		100%			0%	2,332		92%	8%	0%	1,493		78%	15%	0%	732		0%	0%	100%
Passenger transport	2,107		100%			0%	1,372		99%	1%	0%	858		90%	3%	0%	508		0%	0%	100%
Freight	1,289		100%			0%	929		82%	18%	0%	681		67%	27%	0%	373		0%	0%	100%

Totals may not add up due to rounding.

Table A3-3 CO2 emissions from energy use (Case: new technology introduction and downscaling) Unit: M t-CO_2

	1990	2010	2020	2030	2050
Primary energy: domestic supply	1,059	1,123	788	363	69
Energy conversion		503	353	109	0
Power generation (including in-house power generation)		421	338	95	0
Steam for Industry (especially for material manufacturing)		44	16	15	0
Final energy consumption		622	436	254	69
Industry		297	211	152	69
Non-manufacturing		22	17	15	7
Manufacturing		275	194	137	62
Materials		165	111	73	24
Non-materials		110	83	65	38
Households		61	42	0	0
Business		39	26	10	0
Transport		225	156	91	0
Passenger transport		137	89	47	0
Freight		88	60	39	0
Compared to 1990		6%	-26%	-66%	-94%
Compared to 2010			-30%	-68%	-94%

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