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Assessment of Japan's Energy Mix and INDCs

Systems Analysis Group

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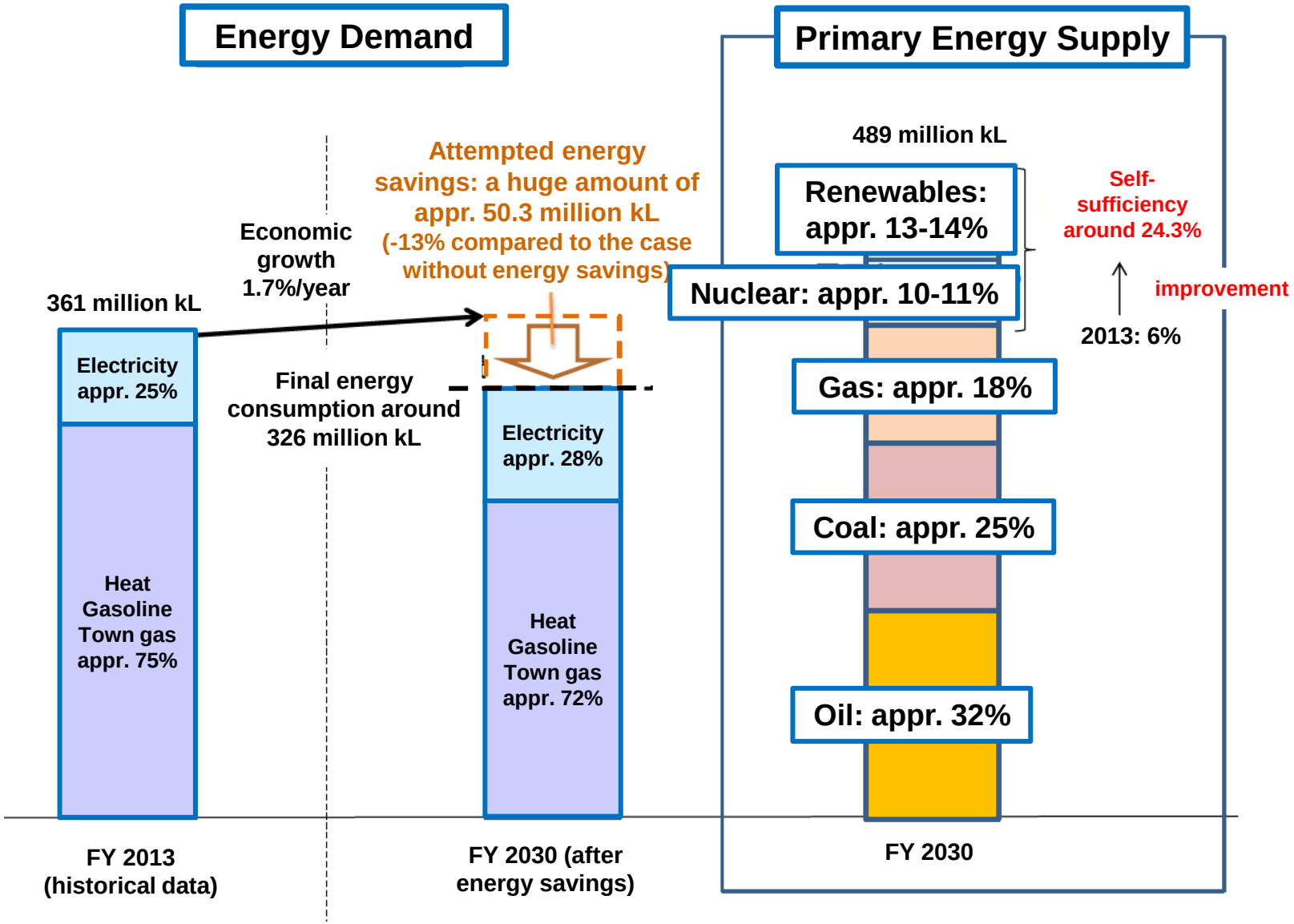
Introduction

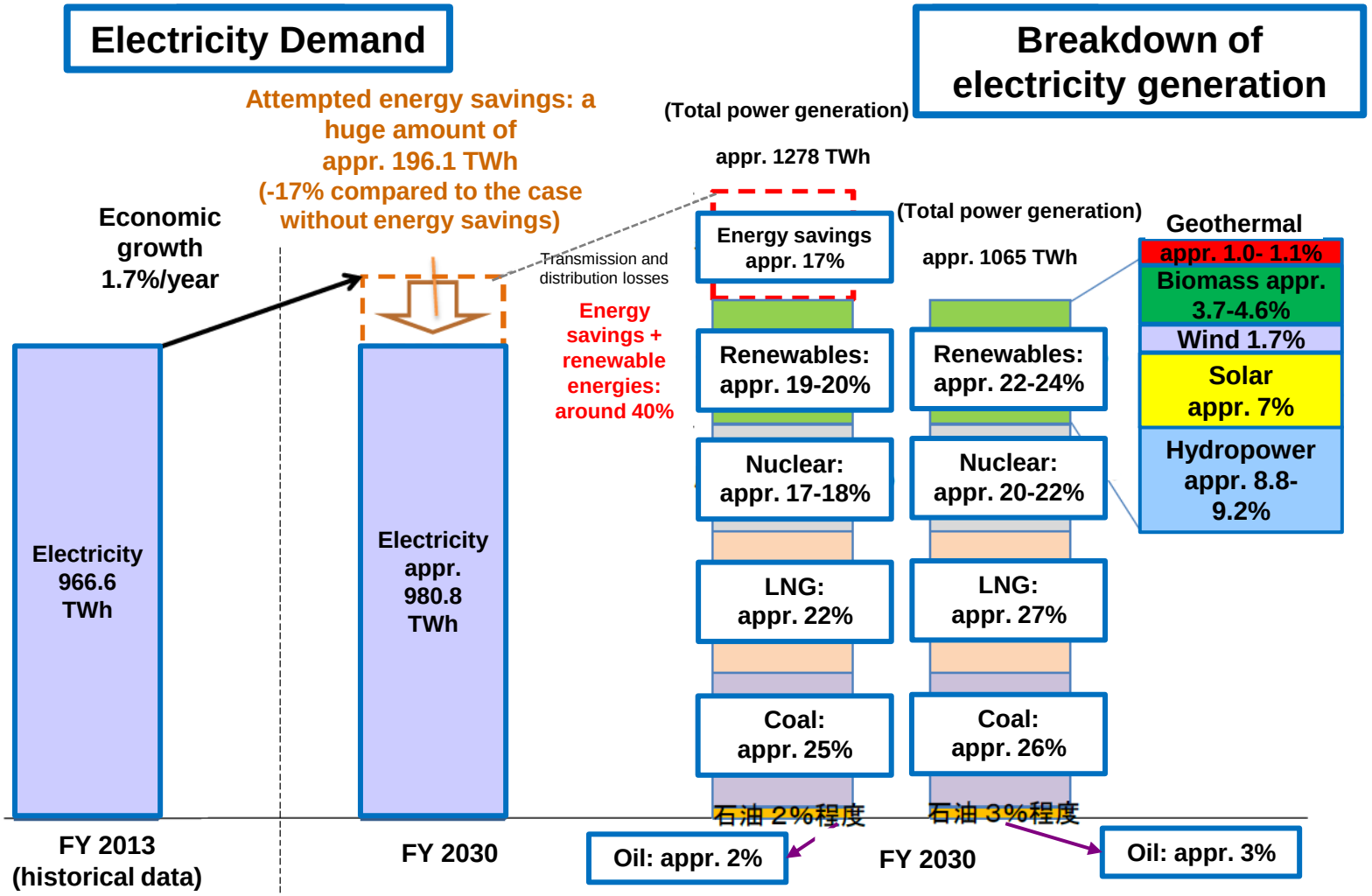
- After the Great East Japan Earthquake and the Fukushima nuclear power accident, the Strategic Energy Plan was adopted by the government in April 2014. However, it was not defined in concrete terms at the time.
- Moreover, discussions over post-2020 GHG emissions reductions are still ongoing worldwide, as it is hoped to reach an international agreement at the COP21 in December 2015. As the COP21 requested the participating countries to submit their INDCs (Intended Nationally Determined Contributions), some of them like the US or the EU have already submitted theirs to the Executive Office of the UNFCCC at the end of March 2015.
- In this context, the Japanese government decided the drafted energy mix for 2030 and GHG emissions reduction targets draft (INDCs) at the beginning of June.
- This presentation offers a quantitative analysis of Japan's INDCs in comparison with other countries on several points identified as essential.

The energy mix and INDCs proposed by the Government

The drafted energy mix for 2030



The drafted energy mix in 2030 – the composition of the power generation mix



In the standard case without energy savings, the GDP elasticity of electricity demand is 0.68. This elasticity is consistent with the one assessed in the RITE analysis, which is around 0.8 for the 2013-2020 period, and 0.6 for 2020-2030, and also consistent with that of the 'Current Policies' scenario in IEA WEO2014. As a result, the estimate by the government seems a reasonable one. However, in the energy savings case, a significant reduction of electricity demand (17%) is assumed (the elasticity then being 0.05), this point will be further examined in our analysis.

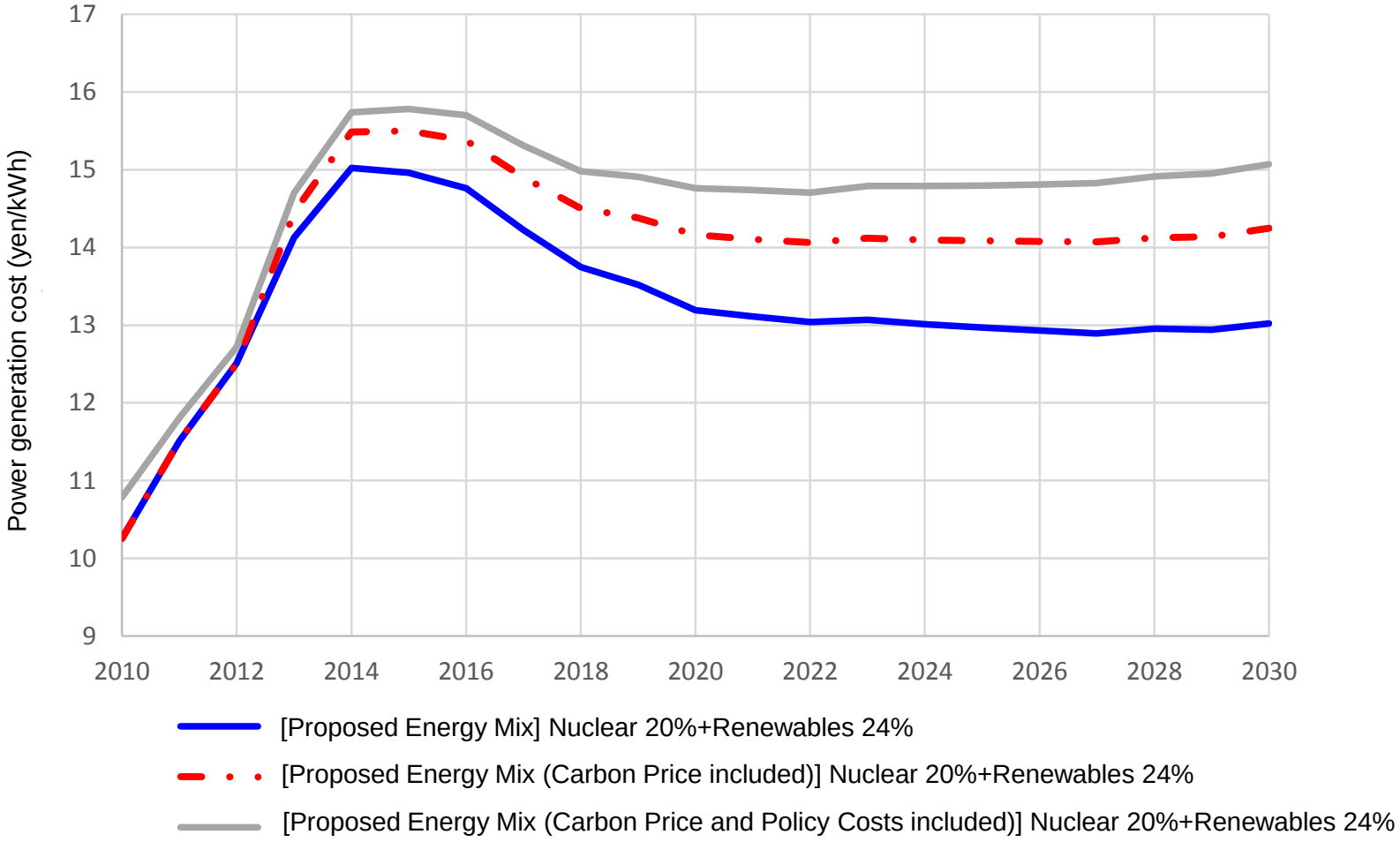
Japanese government's proposition for INDCs (2030)

Since GHG emissions are strongly dependent on energy mix issues, policy making and technology development for post-2020 targets need to take careful consideration of technical constraints and costs in order to set achievable goals. Based on this, the Japanese INDCs commit to reduce emission levels in 2030 by 26% compared to 2013 (which corresponds to 25.4% compared to 2005), including national emissions reduction and absorption (GHG emissions in 2030 would be about 1,042 million tCO_2 in total).

	Compared to 2013 (compared to 2005)
Energy-related CO2	-21.9% (-20.9%)
Other GHGs	-1.5% (-1.8%)
Reduction by absorption (LULUCF)	-2.6% (-2.6%)
Total GHGs	-26.0% (-25.4%)

Estimation of average generation cost

Estimation of the evolution of the average generation cost for the proposed mix



Estimation of average generation cost for the proposed mix, based on the estimation of generation costs 'source by source' made by the Experts' Working Group on Power Generation Costs (2015). For these calculations, the evolution of the energy mix composition until 2030 was determined by one fixed scenario.

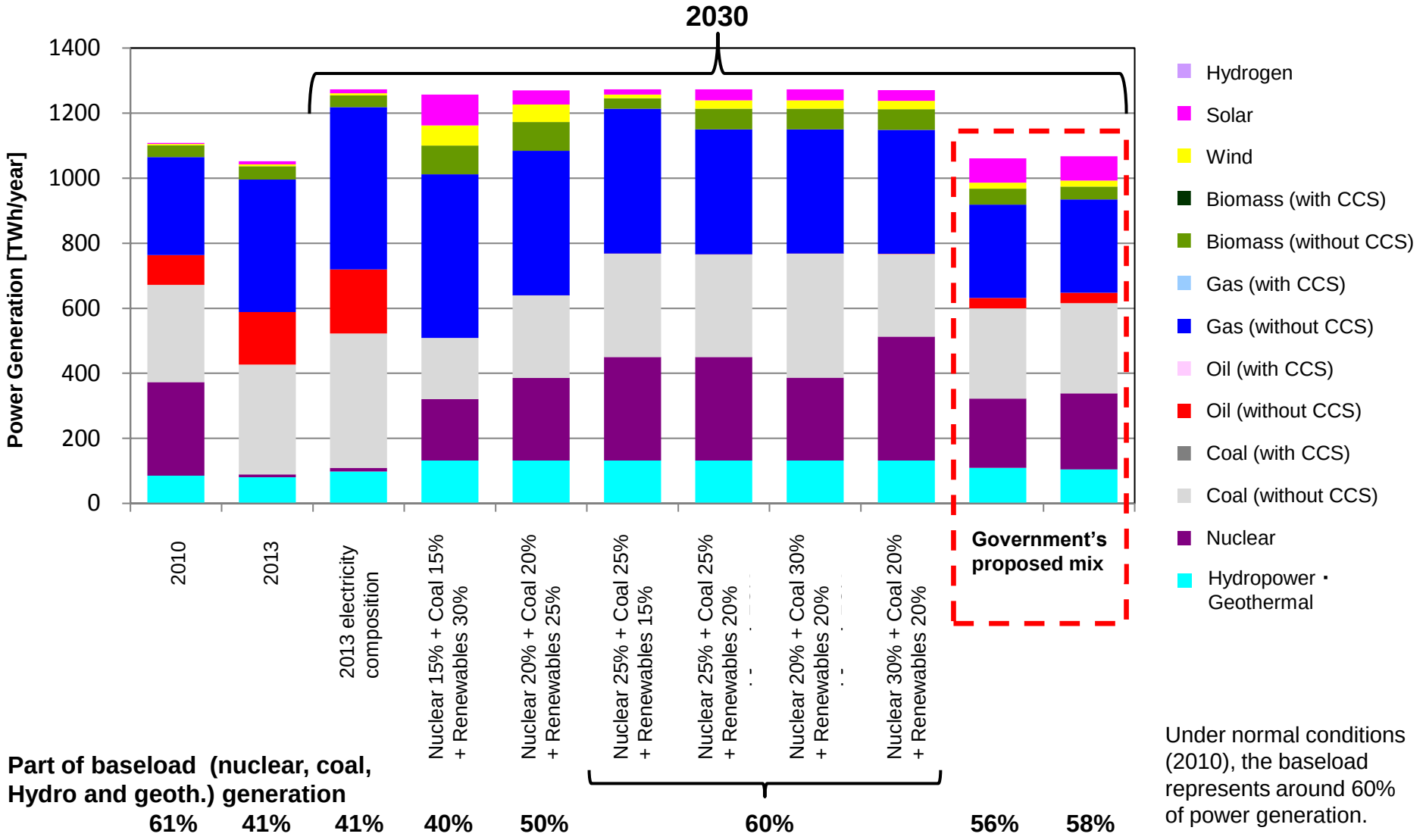
Costs in 2030 are anticipated to be 1 or 2 yen/kWh cheaper compared to current levels (2015). However, given that the development of renewable energies focuses on solar, costs inevitably increase compared to levels before the Great Earthquake (2010).

Comparison of RITE's analysis results* and government's proposition

*** published on the RITE website on March 31 and April 14, 2014**

Power Generation in 2030

(Estimates by using DNE21+ model under the carbon prices of WEO2014 New Policies Scenario* and the Government's drafted mix)



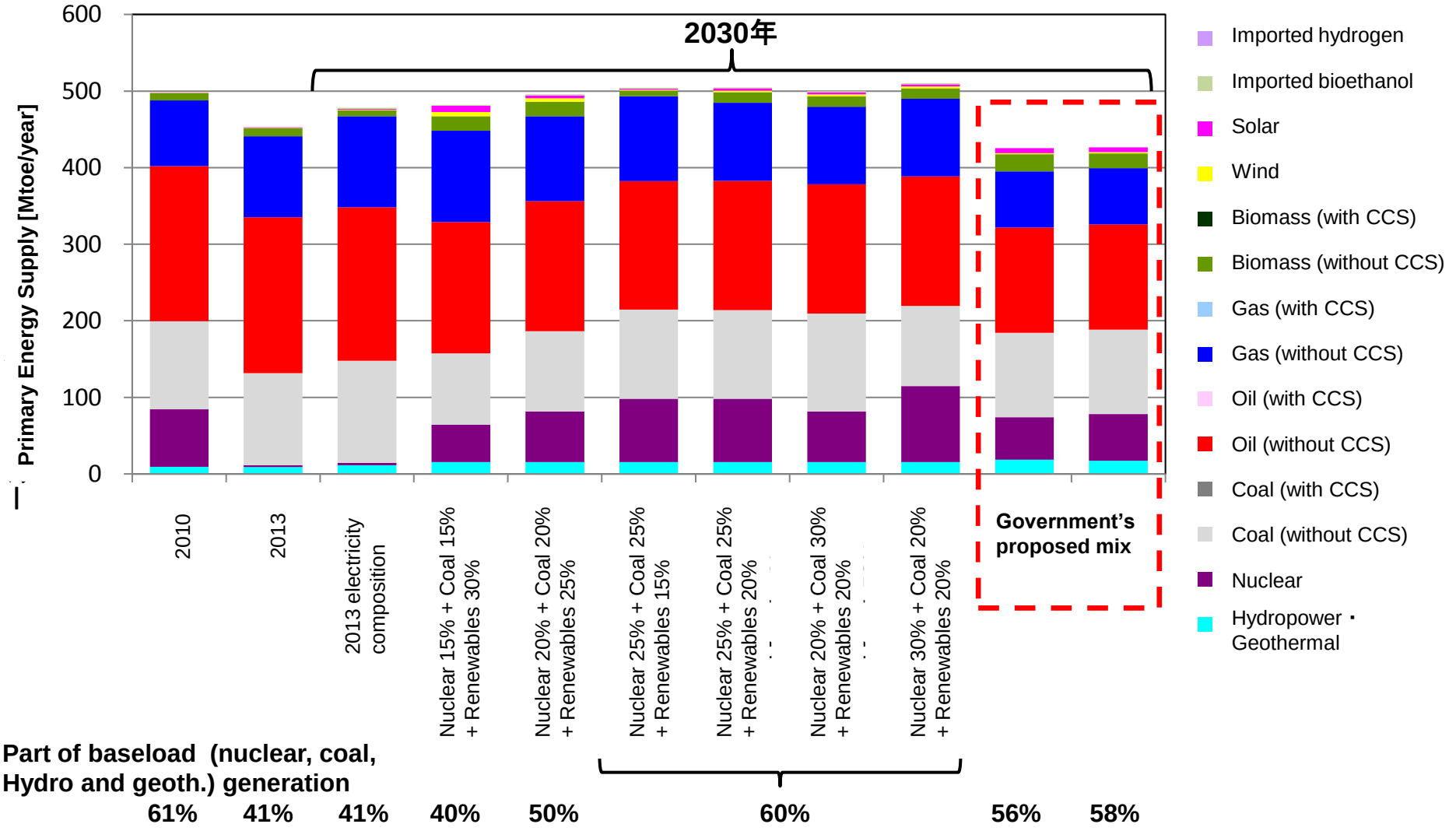
Part of baseload (nuclear, coal, Hydro and geoth.) generation

61%	41%	41%	40%	50%	60%	56%	58%

Under normal conditions (2010), the baseload represents around 60% of power generation.

*** Carbon price of 37 $/tCO2 (in 2013 price) for the WEO2014 New Policies Scenario (which corresponds to 23$/tCO2 (in 2000 price)) was assumed.**

Primary energy supply in 2030
(Estimates by using DNE21+ model under the carbon prices of WEO2014 New Policies Scenario* and the Government's drafted mix)

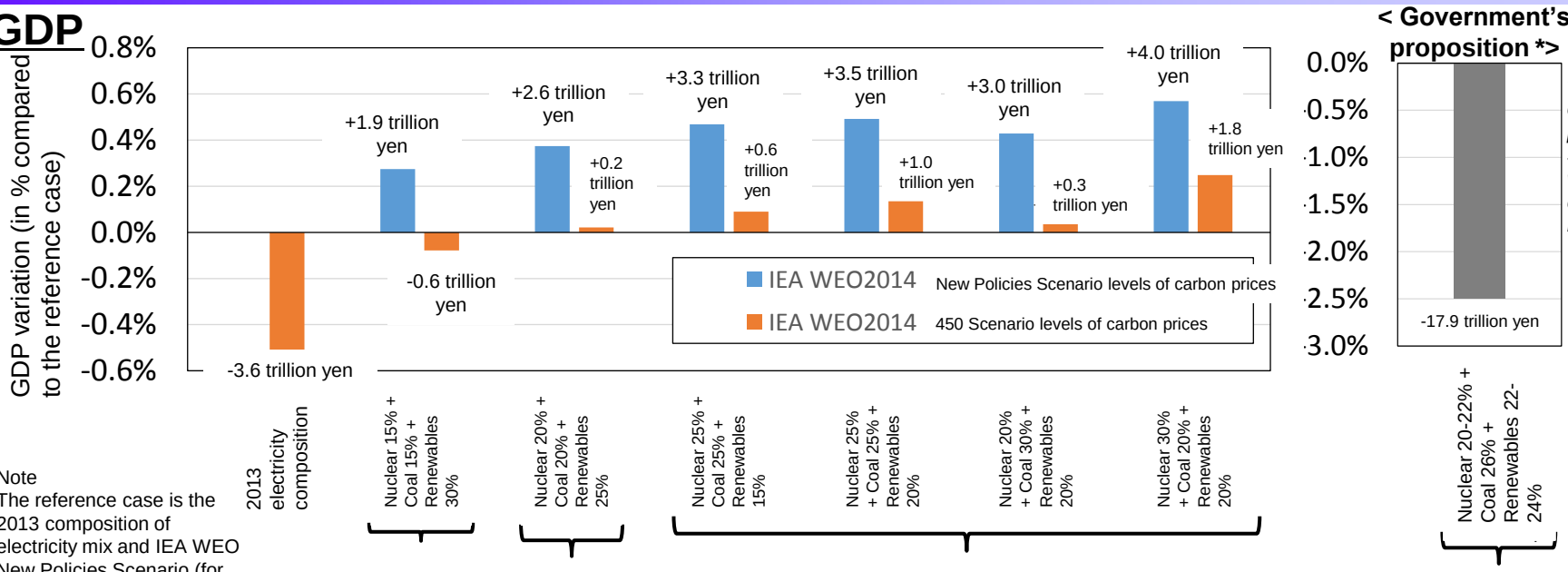


* Carbon price of 37 $/tCO2 (in 2013 price) for the WEO2014 New Policies Scenario (which corresponds to 23$/tCO2 (in 2000 price)) was assumed.

Note) As in IEA statistics, (1) displayed values are in net calories, (2) the energy efficiencies for primary electricity generation are assumed to be 30% for nuclear, 10% for geothermal, 100% for hydropower & other. (RITE conversion from values published in the government's proposition)

Economic impact in 2030 Estimated by Using DEARS Model (GDP and households consumption)

GDP

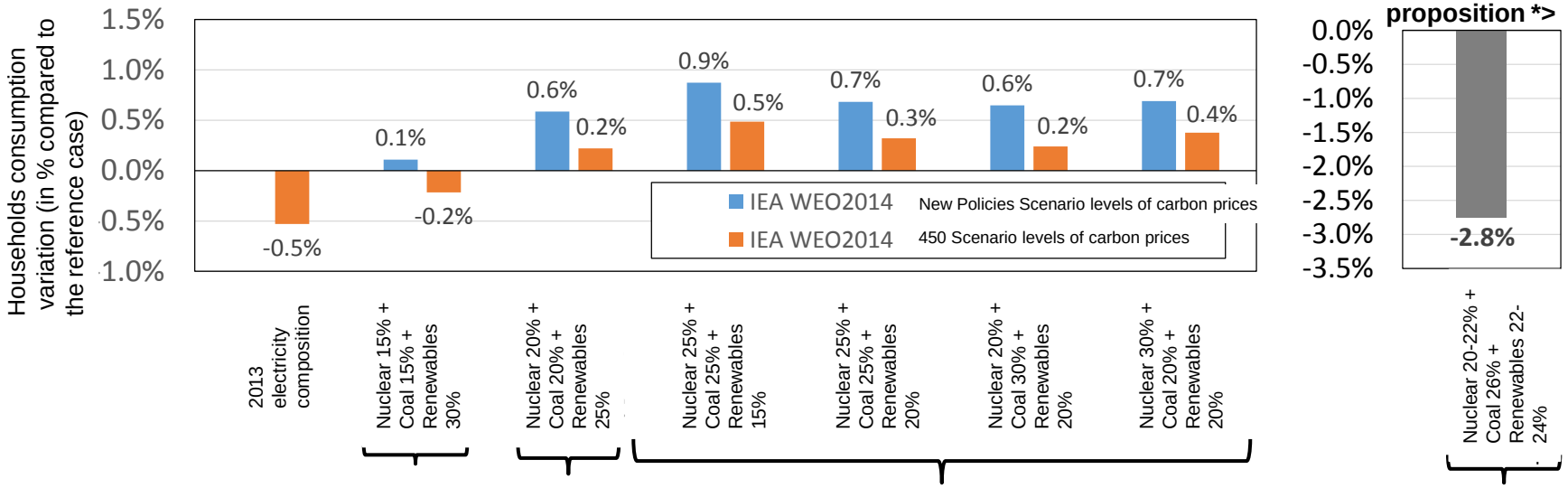


*The impact of carbon price of 380$/tCO2 which was estimated by DNE21+

Note
The reference case is the 2013 composition of electricity mix and IEA WEO New Policies Scenario (for carbon intensity)

Part of baseload generation (nuclear, coal, hydro and geothermal)

Households consumption



Comparison between RITE model's results and government propositions

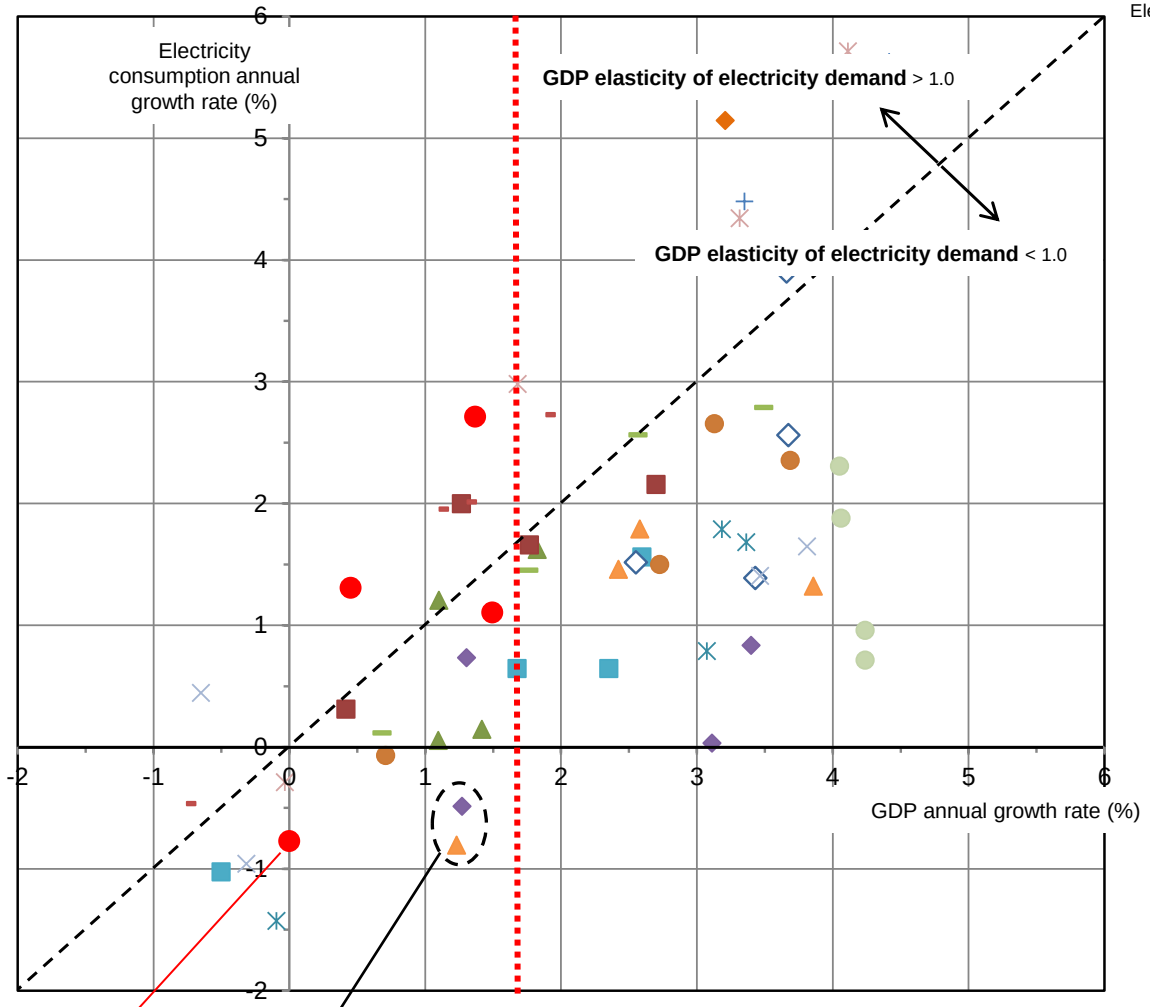
- As shown on P.5, despite a high GDP growth rate (1.7%/year) projection, the power generation after GHG reduction measures is anticipated to increase rather modestly.
- Compared with the results of the analysis of several scenarios with RITE's economic model, the GDP loss and consumption loss for the government's proposition is quite substantial.
- The electricity mix proposed by the government is well-balanced enough not to trigger important economic losses (The GDP under the energy mix is about +0.36 to +0.38% compared to that in the case assuming the 2013 electricity composition). However, substantial energy savings are expected, and therefore a high carbon price (whether explicit or implicit) is estimated to meet these goals (p.31). According to the assessment by our economic model, achieving these targets will require considerable costs as seen in p.12.

Assessment of electricity demand assumptions

Assessment of electricity demand outlook

- As we indicated, in the government's proposition, despite a high GDP growth rate (1.7%/year) projection, the power generation after GHG reduction measures is anticipated to increase rather modestly. Here are the results of a more detailed analysis conducted in order to assess the government's anticipations.
- First, we checked the relationship between GDP change and electricity demand variation (GDP elasticity of electricity demand) in the government's proposition against past values of electricity elasticity in OECD countries.
- Second, we took a look at past occurrences of high increases of electricity costs in major European countries (Germany, Italy, UK) and the cost increase effects on electricity demand.
- Last, we used past research by Prof. Nomura et al. (Keio University) that analyzed how the electricity cost increase in Germany and Italy affected the industry and related sectors' growth.

GDP elasticity of electricity demand for OECD countries (5-year average)



Electricity elasticity > 1.0

- Japan
- Germany
- France
- Italy
- United Kingdom
- Netherlands
- Denmark
- Sweden
- Spain
- United States
- Canada
- Australia
- Korea
- Hungary
- Poland
- Turkey

Variation rate on a 5-year span for 4 periods :

(1990-92)～(1995-97)
(1995-97)～(2000-02)
(2000-02)～(2005-07)
(2005-07)～(2010-12)

(We take 3-year averages in order to avoid singularities that may be caused by particular circumstances at one time point, such as natural catastrophy or financial crisis)

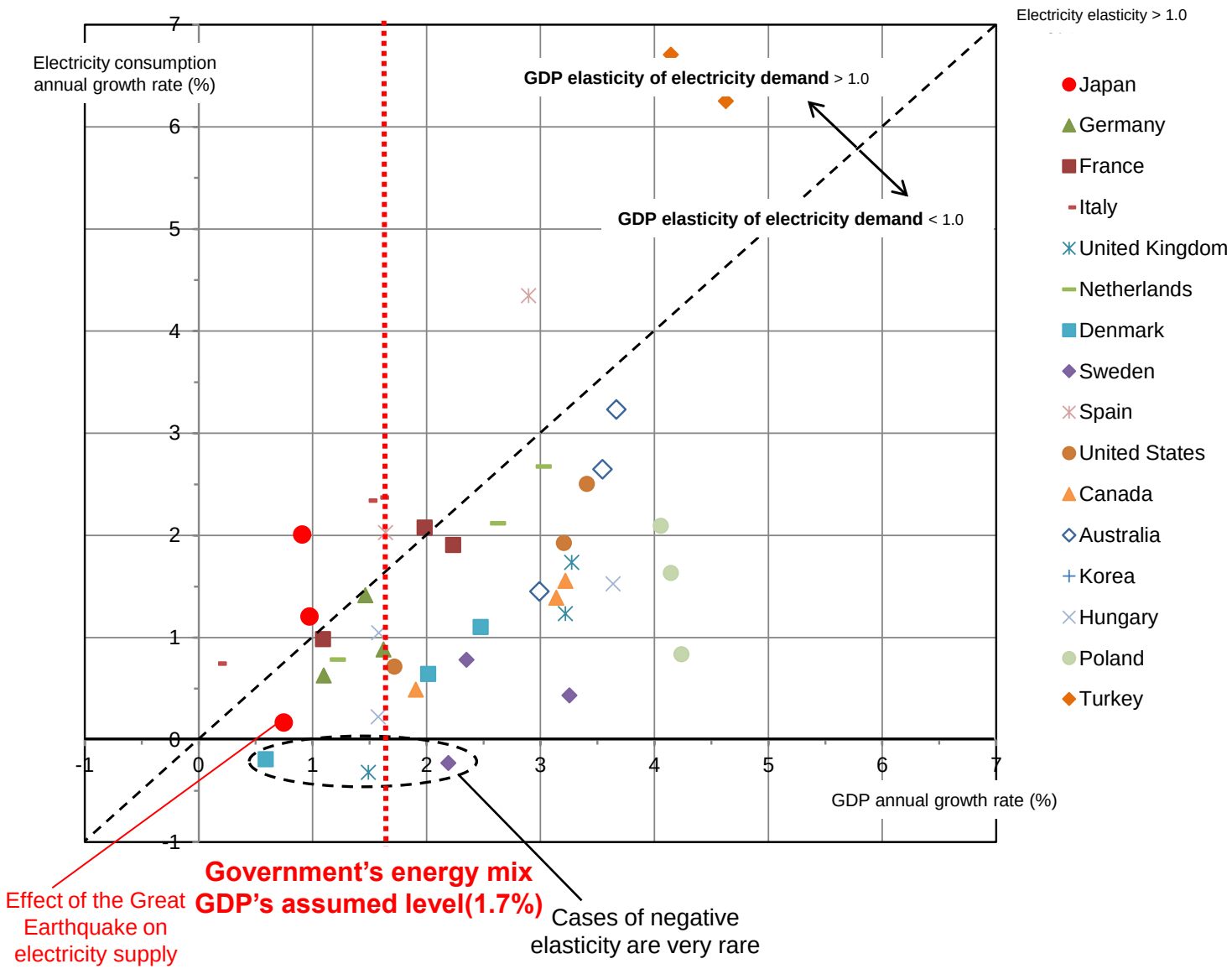
Effect of the Great Earthquake on electricity supply

Cases of negative elasticity are very rare

Government's energy mix GDP's assumed level(1.7%)

GDP elasticity of electricity demand is a little less than 1.0 in most OECD countries

GDP elasticity of electricity demand for OECD countries (10-year average)

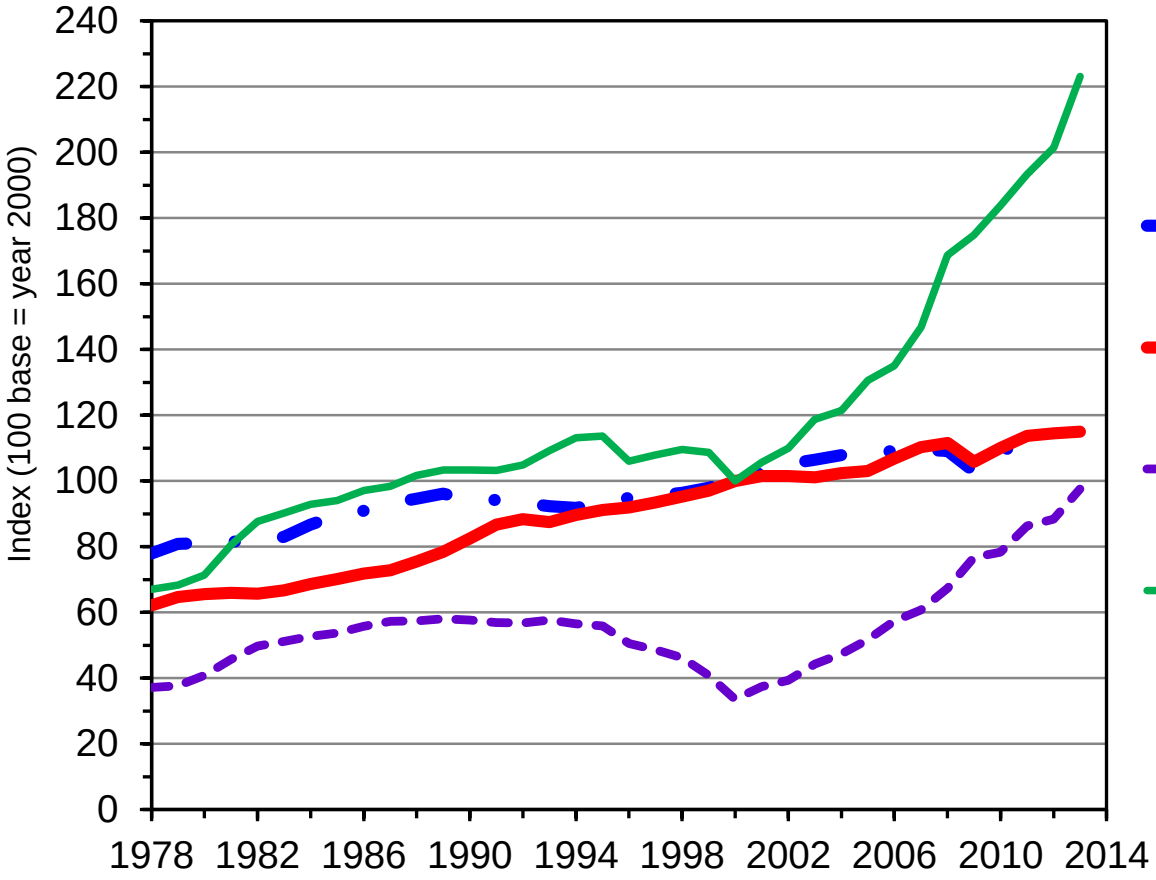


Variation rate on a 10-year span for 3 periods

(1990-92)～(2000-02)
(1995-97)～(2005-07)
(2000-02)～(2010-12)

(We take 3-year averages in order to avoid data distortion that may be caused by singularity at one time point, such as natural disaster or financial crisis)

GDP elasticity and price elasticity of electricity demand –Germany–



Electricity consumption

GDP

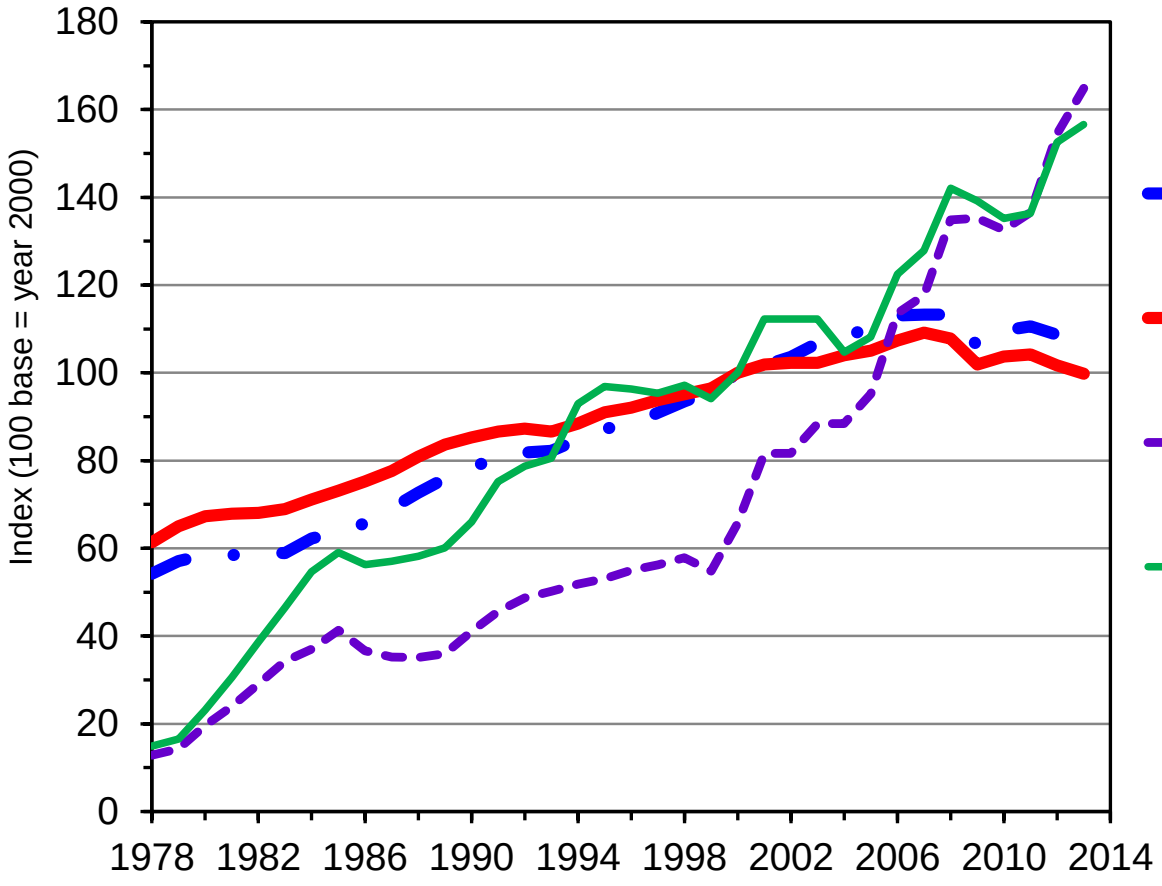
Electricity price for the industry sector
(base 100 = residential price in 1990)

Electricity price for the residential sector

【Multiple regression analysis】
1990-：GDP elasticity 0.76, Price elasticity -0.03
（Constant coefficient：0.89）
2000-：GDP elasticity 0.49, Price elasticity -0.03
（Constant coefficient ：0.41）

The GDP elasticity of electricity demand in Germany varies between 0.5 and 0.8. The lowest levels of electricity elasticity were observed twice : at the time of the reunification of Germany and recently, as the effects from the rapid increase in electricity costs are starting to appear on prices for consumers. However, the multiple regression analysis shows that the price elasticity remains small.

GDP elasticity and price elasticity of electricity demand –Italy–



Electricity consumption

GDP

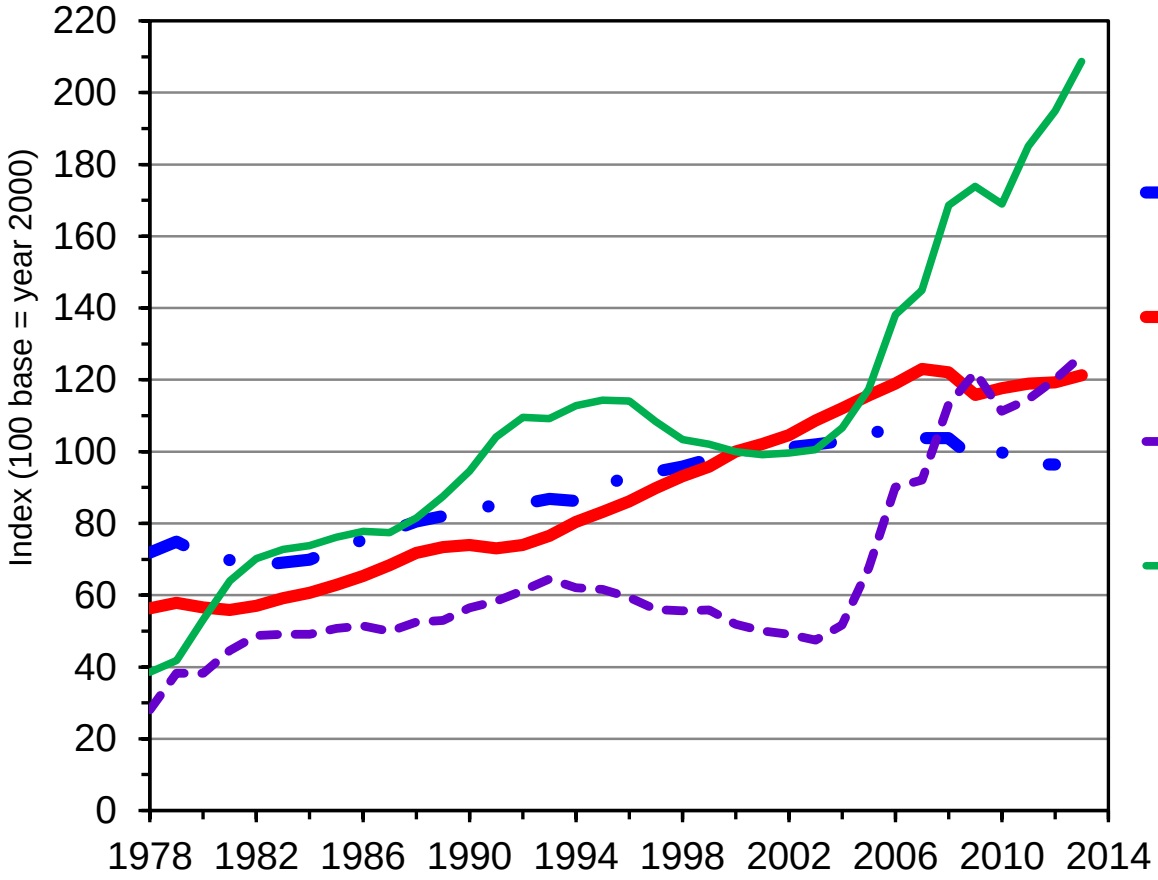
Electricity price for the industry sector
(base 100 = residential price in 1990)

Electricity price for the residential sector

【Multiple regression analysis】
1990-：GDP elasticity 1.27, Price elasticity -0.06
（Constant coefficient：0.99）
2000-：GDP elasticity 1.07, Price elasticity 0.06
（Constant coefficient ：0.85）

The GDP elasticity of electricity demand in Italy varies in a range of 1.0. Although the electricity consumption seemed to go down from 2006, the correlation with GDP is strong. As for Germany, the price elasticity remains small (against intuition, from 2000, it remains positive).

GDP elasticity and price elasticity of electricity demand –United Kingdom–



Electricity consumption

GDP

Electricity price for the industry sector
(base 100 = residential price in 1990)

Electricity price for the residential sector

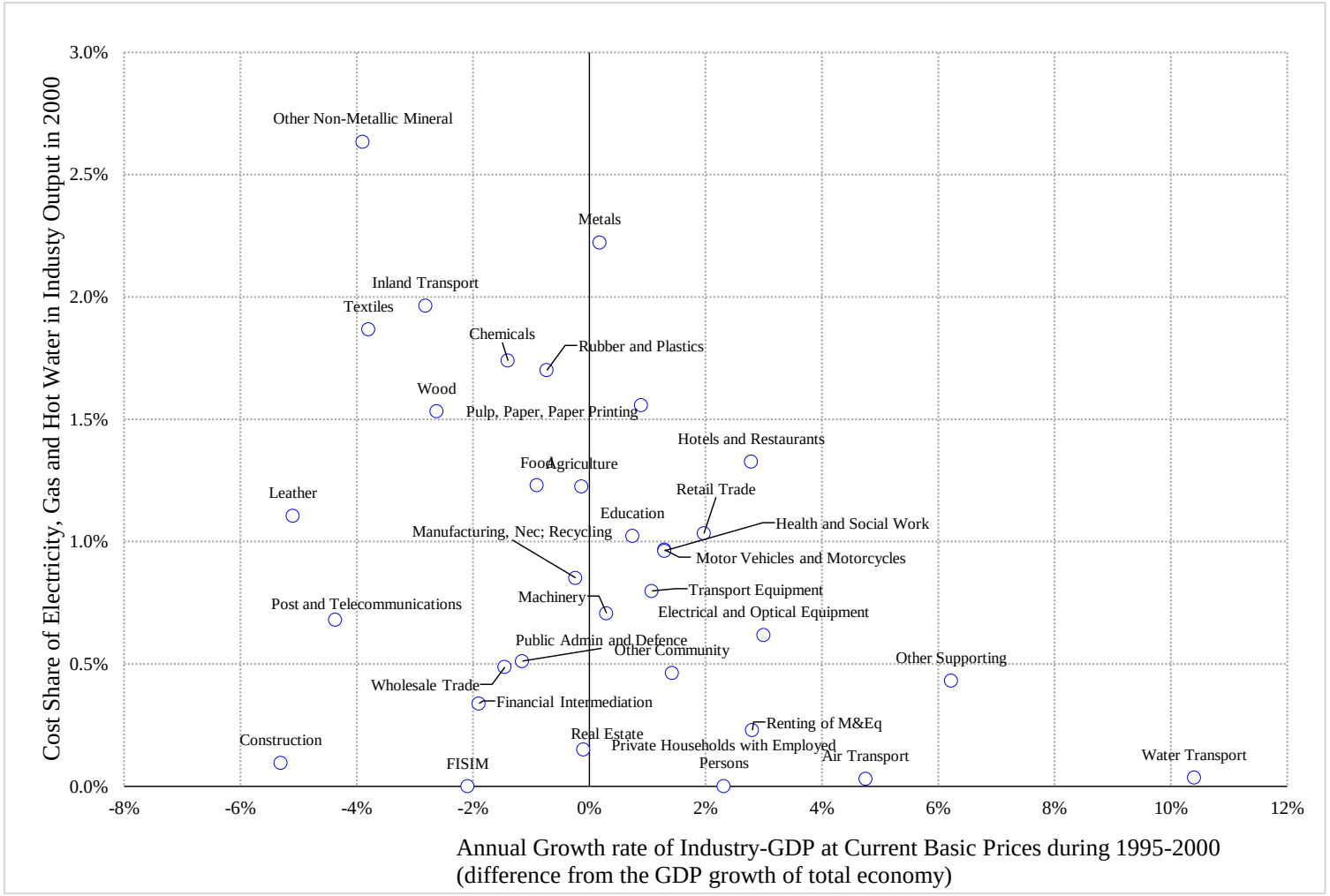
【Multiple regression analysis】
1990-：GDP elasticity 0.45, Price elasticity -0.10
（Constant coefficient：0.94）
2000-：GDP elasticity 0.61, Price elasticity -0.11
（Constant coefficient ：0.60）

Compared to Germany and Italy, the GDP elasticity of electricity demand of United Kingdom is rather low (which can be partly explained by the high share of financial services in the UK economy), but still varies within a 0.5 range. The price elasticity is significantly more important then in Germany and Italy with a value of -0.1 (which means that if the price increases by 100%, the demand decreases by 10%).

Electricity cost and growth rate for industry sectors –Germany (before electricity price hike)–

Cost share of electricity in industry sectors (vertical axis) and annual growth rate of Industry-GDP (horizontal axis) in Germany(1995-2000)

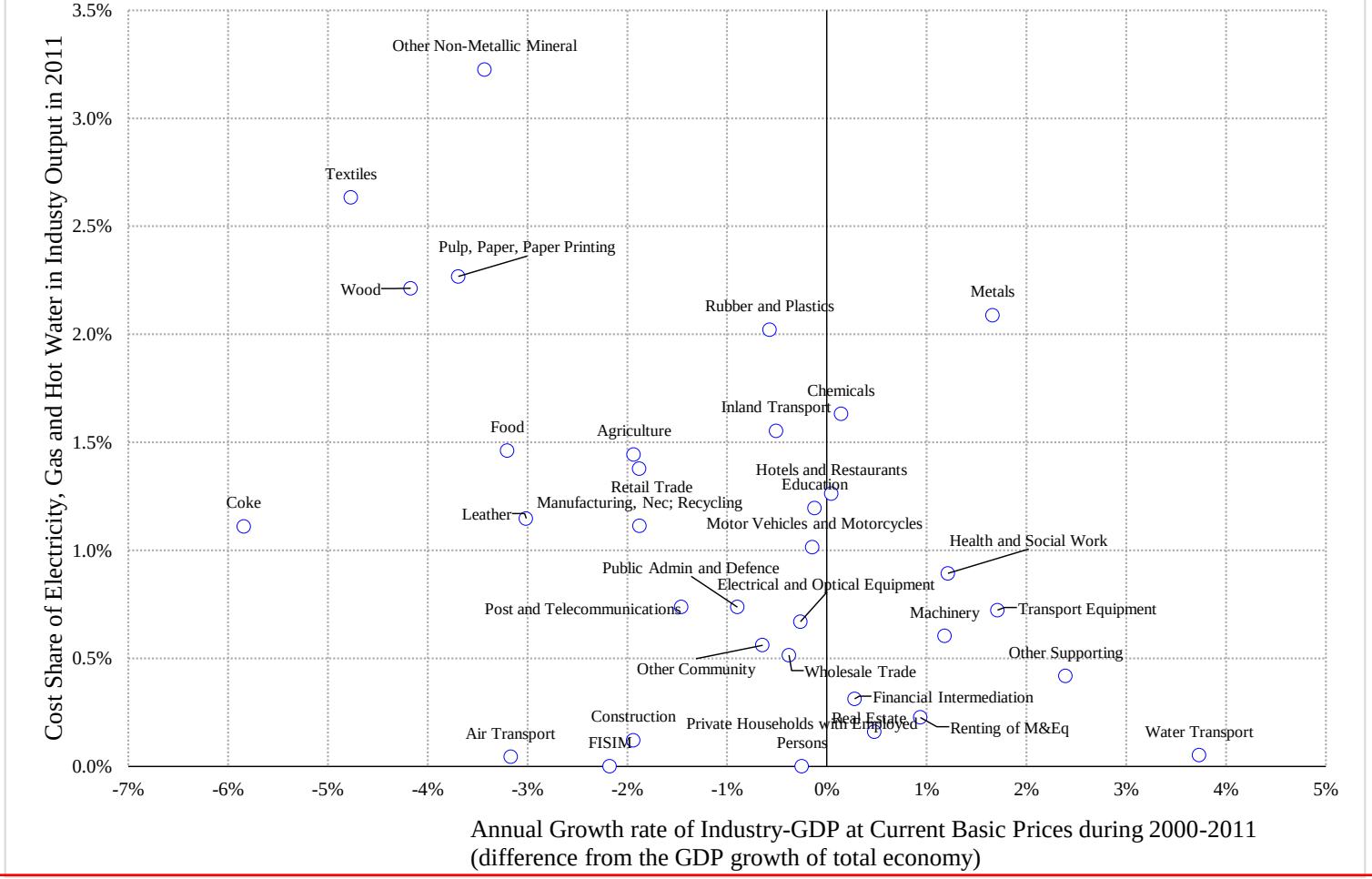
Source: Keio University, Prof. Nomura, WIOD Data（http://www.wiod.org/）. Calculation base on German National Use Tables（Feb. 2015）



Electricity cost and growth rate for industry sectors –Germany (after electricity price hike)–

Cost share of electricity in industry sectors (vertical axis) and annual growth rate of Industry-GDP (horizontal axis) in Germany(2000-2011)

Source: Keio University, Prof. Nomura, WIOD Data（http://www.wiod.org/）. Calculation base on German National Use Tables（Feb. 2015）

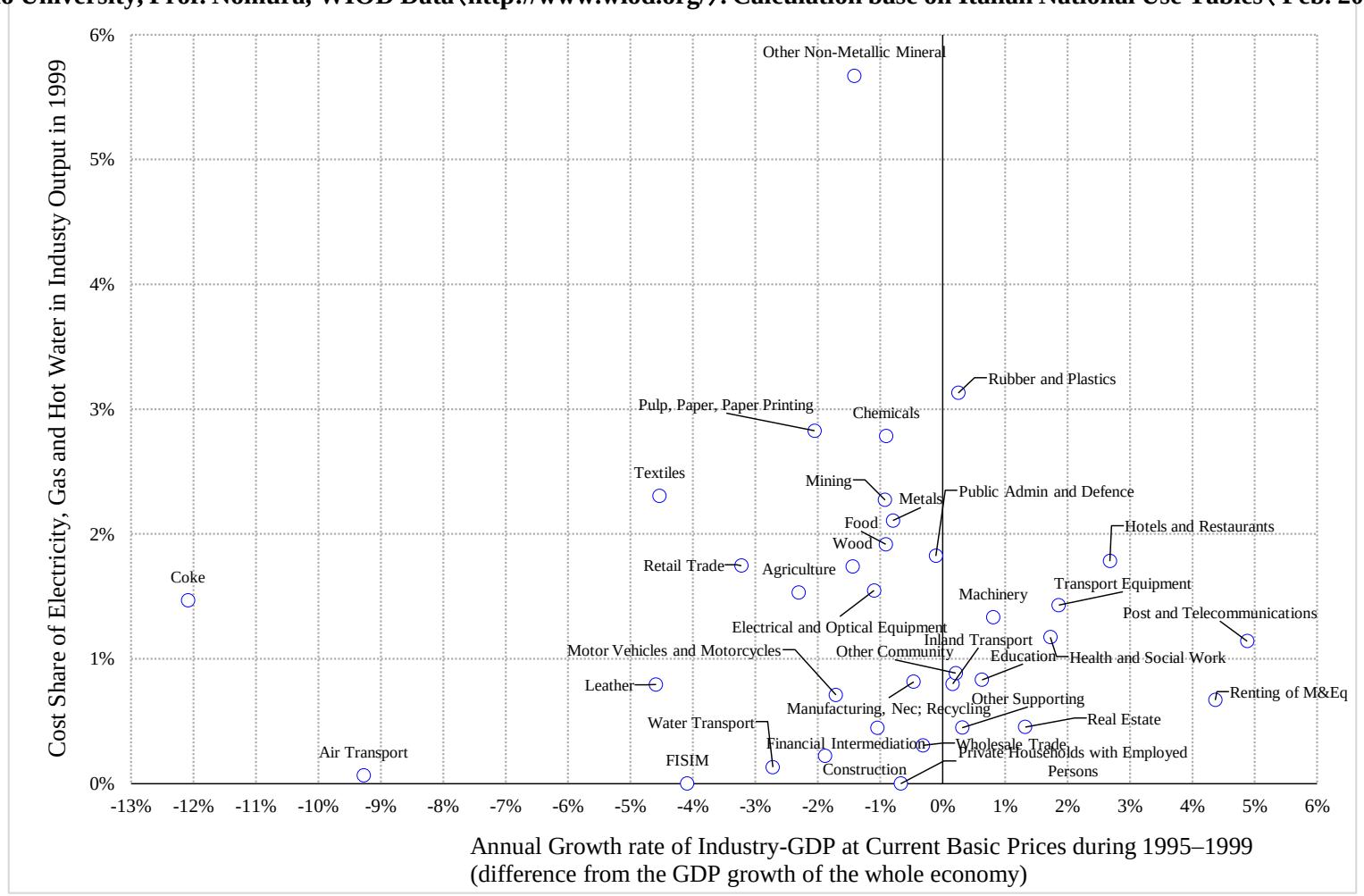


Although moderate, the correlation between electricity costs and economic growth in the industry sector can be seen on this graph.

Electricity cost and growth rate for industry sectors –Italy (before electricity price hike)–

Cost share of electricity in industry sectors (vertical axis) and annual growth rate of Industry-GDP (horizontal axis) in Italy (1995-1999)

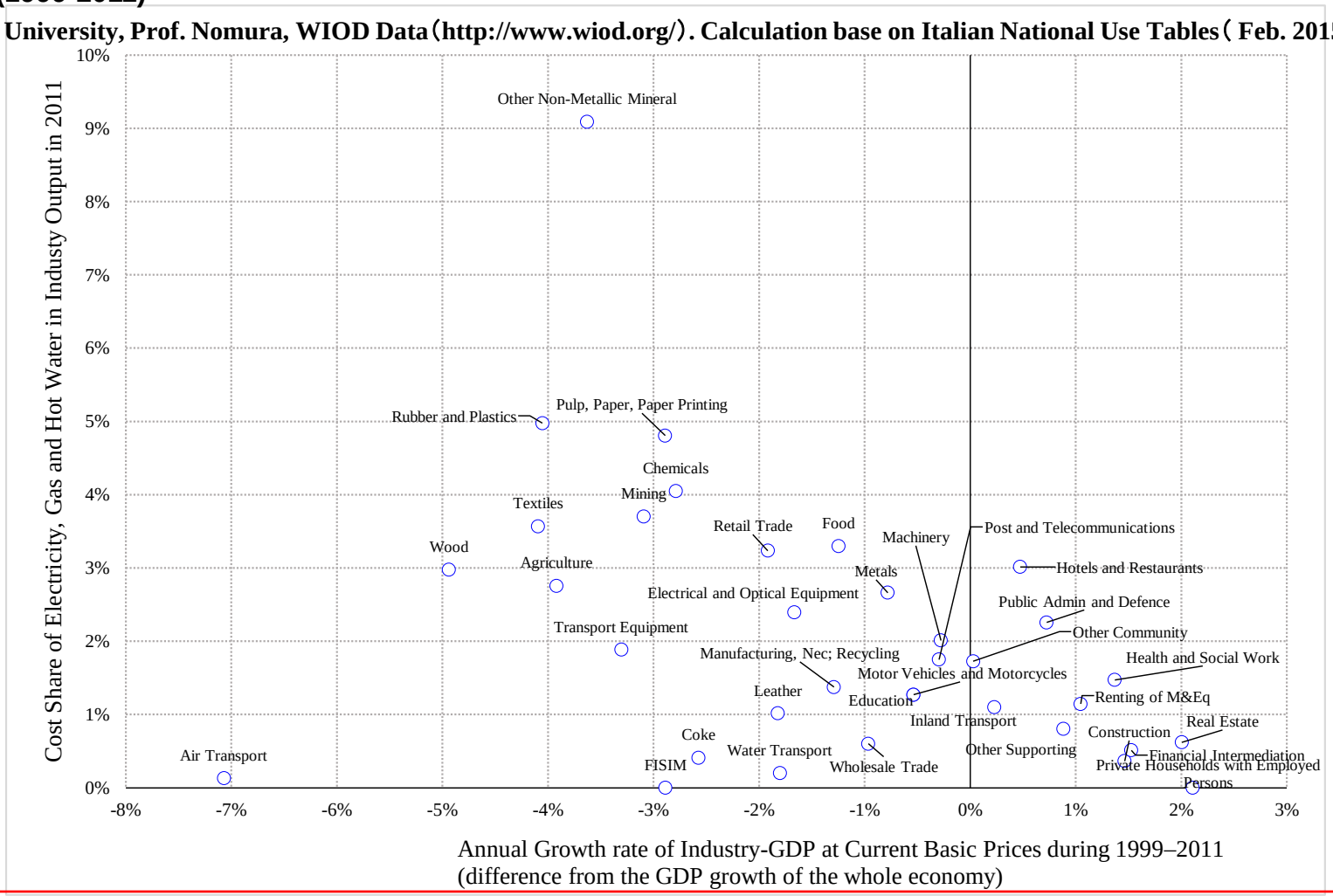
Source: Keio University, Prof. Nomura, WIOD Data（http://www.wiod.org/）. Calculation base on Italian National Use Tables（Feb. 2015）



Electricity cost and growth rate for industry sectors –Italy (after electricity price hike)–

Cost share of electricity in industry sectors (vertical axis) and annual growth rate of Industry-GDP (horizontal axis) in Italy (1999-2011)

Source: Keio University, Prof. Nomura, WIOD Data（http://www.wiod.org/）. Calculation base on Italian National Use Tables（ Feb. 2015）



Although moderate, the correlation between electricity costs and economic growth in the industry sector can be seen on this graph.

Assessment of INDCs (emissions reduction targets for 2030) –Focus on international fairness and ambition level–

Equity assessment of the emission reduction efforts across countries

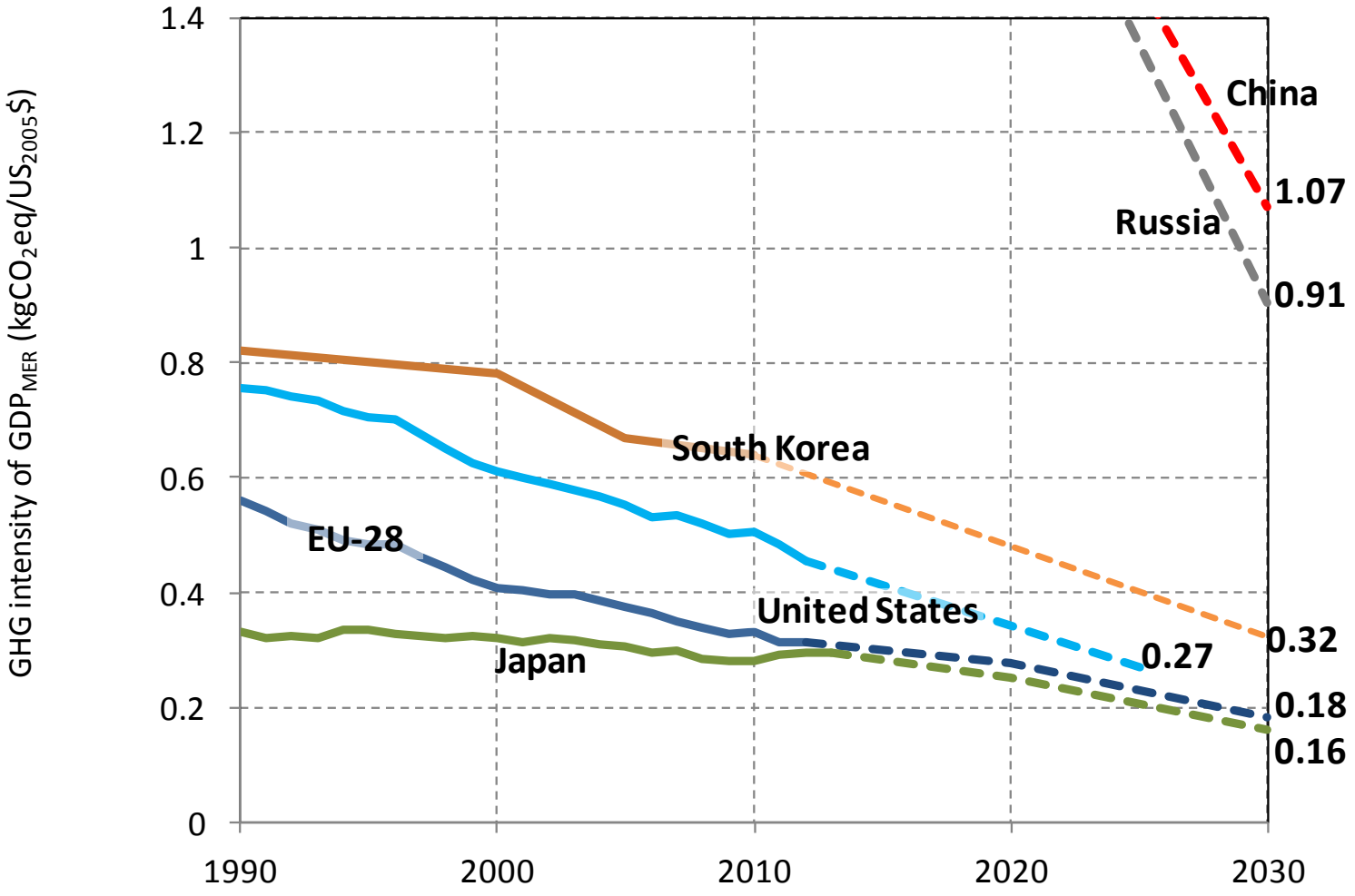
- Obviously there are disparities between countries: it is essential that emission reduction efforts should be as equitable as possible, taking into account the specific contexts of all countries.
- However, in a context of international competition, if there are major disparities in marginal abatement costs from one country to another, production is likely to shift from countries with high marginal abatement costs to countries with low abatement costs - even if the energy efficiency of their production processes is higher in the former countries - which would make difficult to continue sustained effort. Moreover, if the countries with low marginal abatement costs have low energy efficiency as well, they may increase world total emissions. As a result, emissions targets have an urgent need for international balance especially regarding marginal abatement costs.
- In order to make a proper assessment of emissions reductions efforts and their reduction implementation, it is important to look at them in the light of appropriate indicators.
- Since every indicator has strong and weak points, it is difficult to evaluate emissions reductions efforts with one single indicator. It is thus important to choose an appropriate set of several indicators, to show emission reduction efforts, identify the potential weaknesses leading to further emission cuts.
- For instance, the emission reduction rate estimated from one particular reference year is not representative. In particular, choosing a year from the distant past such as 1990 does not allow taking into account the major changes that later occurred in society, and is all the more unlikely to be representative of emission reduction efforts.

Emissions reduction rate from base year of INDCs for Japan and other major countries

	Emissions reduction rate from base year		
	From 1990	From 2005	From 2013
Japan：in 2030, -26% from 2013 levels	-18.0%	-25.4%	**-26.0%**
US：in 2025, about -26 to -28% from 2005 levels	-14 to -16%	**-26 to -28%**	-18 to -21%
EU28：in 2030, -40% from 1990 levels	**-40%**	-35%	-24%
Russia：in 2030, -25% to -30% from 1990 levels	**-25 to -30%**	+10 to +18%	—
China：in 2030, -60% to -65% of CO_2 intensity from 2005 levels	+329 to +379%	+105 to +129%	—

If we take 2013 as the base year, the Japanese targets are more ambitious in the emissions reduction rate than the US or European ones.

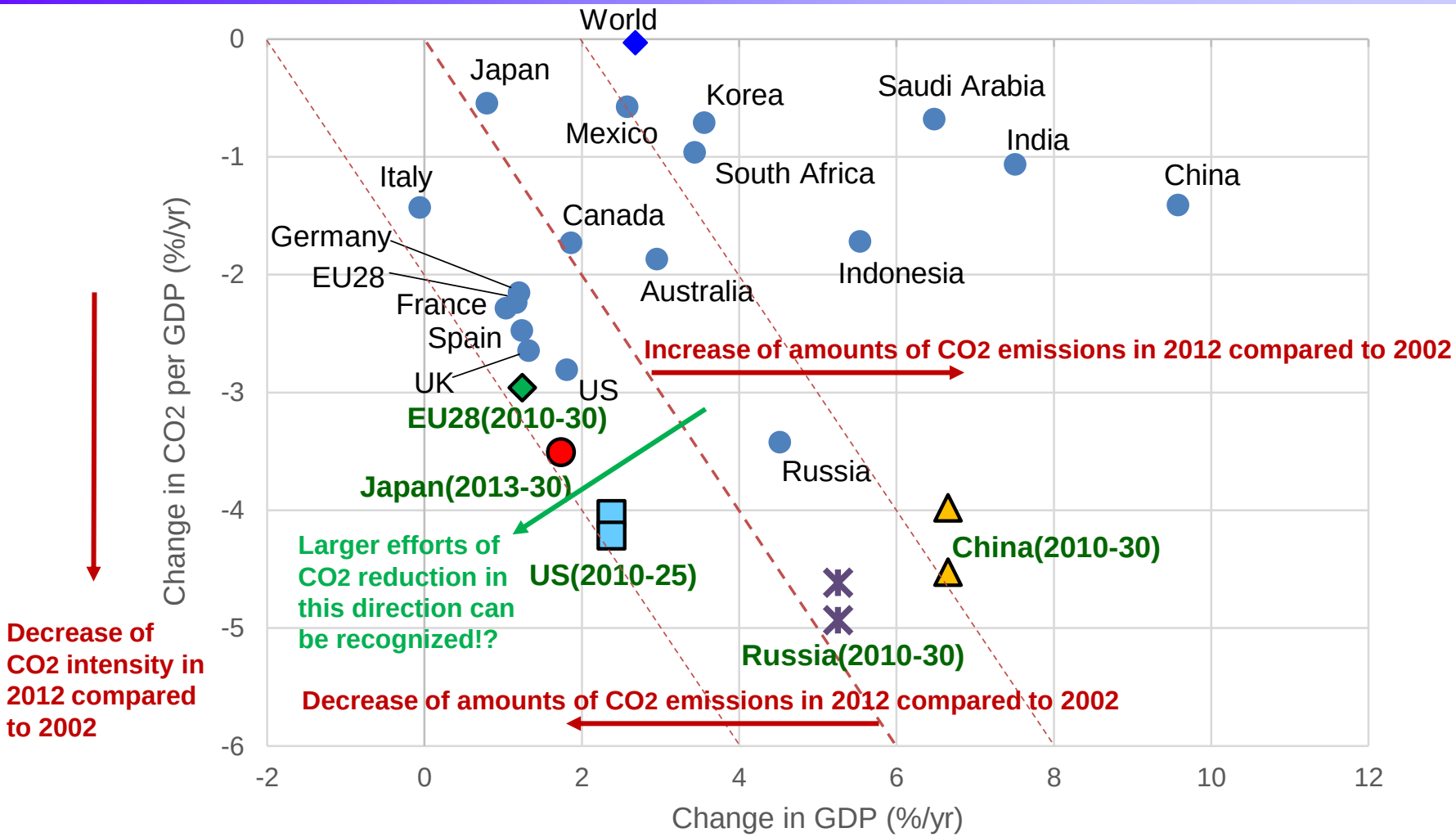
GHG intensity of GDP (MER)



Note) The lower range of emission targets are shown for the countries submitting their INDCs with ranges.

Even from the GHG intensity, the Japan's INDC sets a more demanding target than the US or the EU.

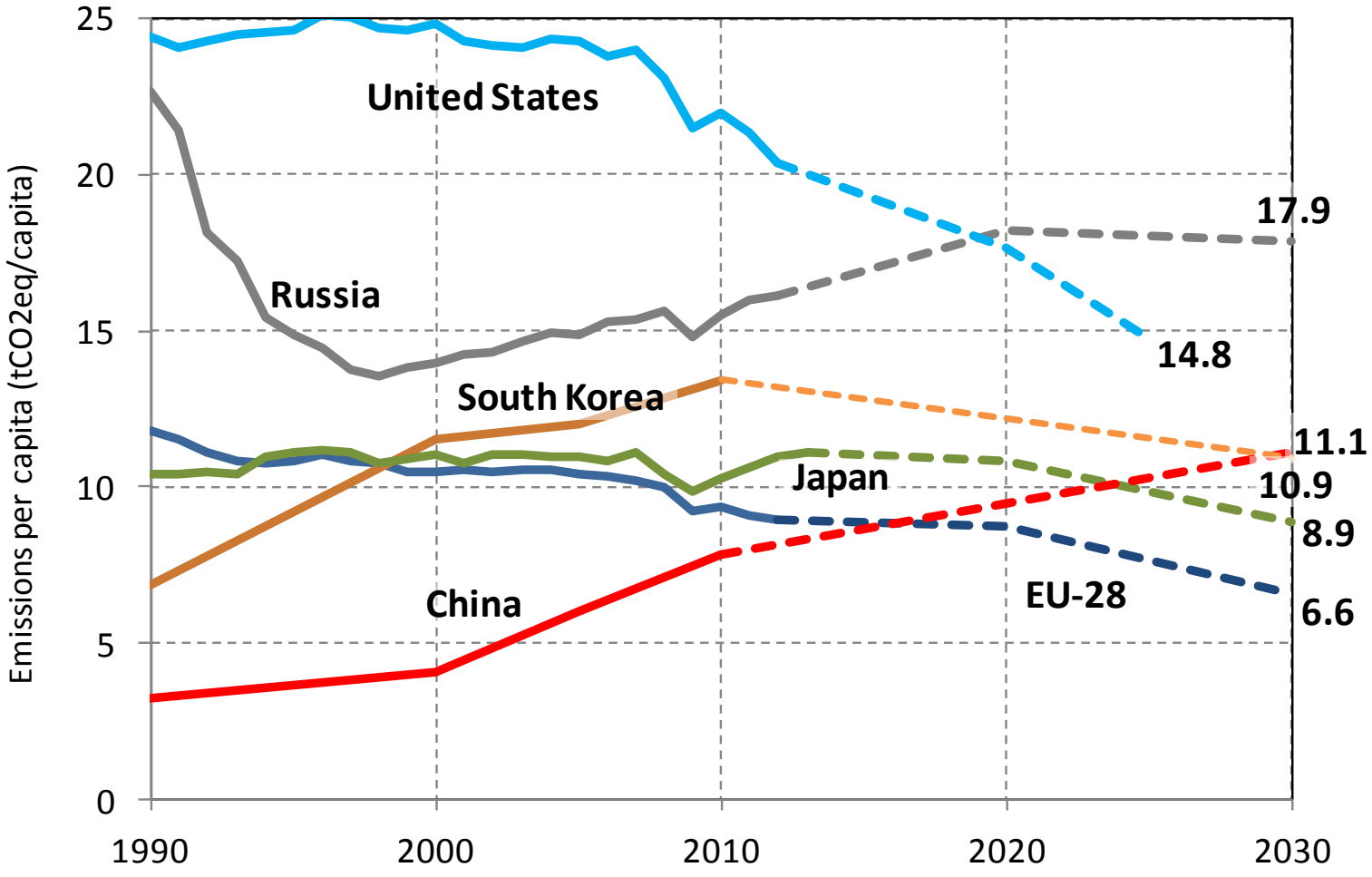
Changes in GDP and CO2 intensity
–Records for the 10-year period from 2002 to 2012 and INDCs–



Note : The CO_2 intensity in 2012 for Japan was strongly impacted by the shut down of all nuclear reactors.

Even based on the relationship between GDP growth rate and emissions intensity changes, the Japanese INDCs appear as ambitious emissions reduction targets.

GHG emissions per capita



Note) The lower range of emission targets are shown for the countries submitting their INDCs with ranges.

CO2 marginal abatement costs for the INDCs of Japan and other major countries (RITE DNE21+ estimate)

	Marginal abatement cost ($/tCO2eq)	
	Low case	High case
Japan: in 2030, -26% from 2013 levels	**About 380** (for the target of energy-related CO2 only, the estimate is about 260)	
US: in 2025, about -26 to -28% from 2005 levels	**60**	**69**
EU28: in 2030, -40% from 1990 levels	**166**	
Russia: in 2030, -25% to 30% from 1990 levels	**0**	**6**
China: in 2030, -60% to -65% of CO2 intensity from 2005 levels	**～0**	**～0**

Note : All the costs do not consider LULUCF measures.

The marginal abatement cost for the Japan's INDCs is estimated to be substantially higher than in other countries, because high energy savings are expected in the INDCs despite of good performances in energy efficiency in Japan (see References).

Emissions reduction costs relation to GDP for the INDCs of Japan and other major countries (RITE DNE21+ estimate)

	Emissions reduction costs per GDP (%)	
	Low case	High case
Japan：in 2030, -26% from 2013 levels	About 0.7	
US：in 2025, about -26 to -28% from 2005 levels	**0.36**	**0.42**
EU28：in 2030, -40% from 1990 levels	**0.82**	
Russia：in 2030, -25% to 30% from 1990 levels	**～0**	**～0**
China：in 2030, -60% to -65% of CO_2 intensity from 2005 levels	**～0**	**～0**

The Japanese target appears as stringent as the European ones in the light of the indicator of emission reduction costs per GDP.

Linkage with long-term targets

Linkage with the Article 2 of the United Nations Framework Convention on Climate (long-term goals)

[Article 2 of the United Nations Framework Convention on Climate]

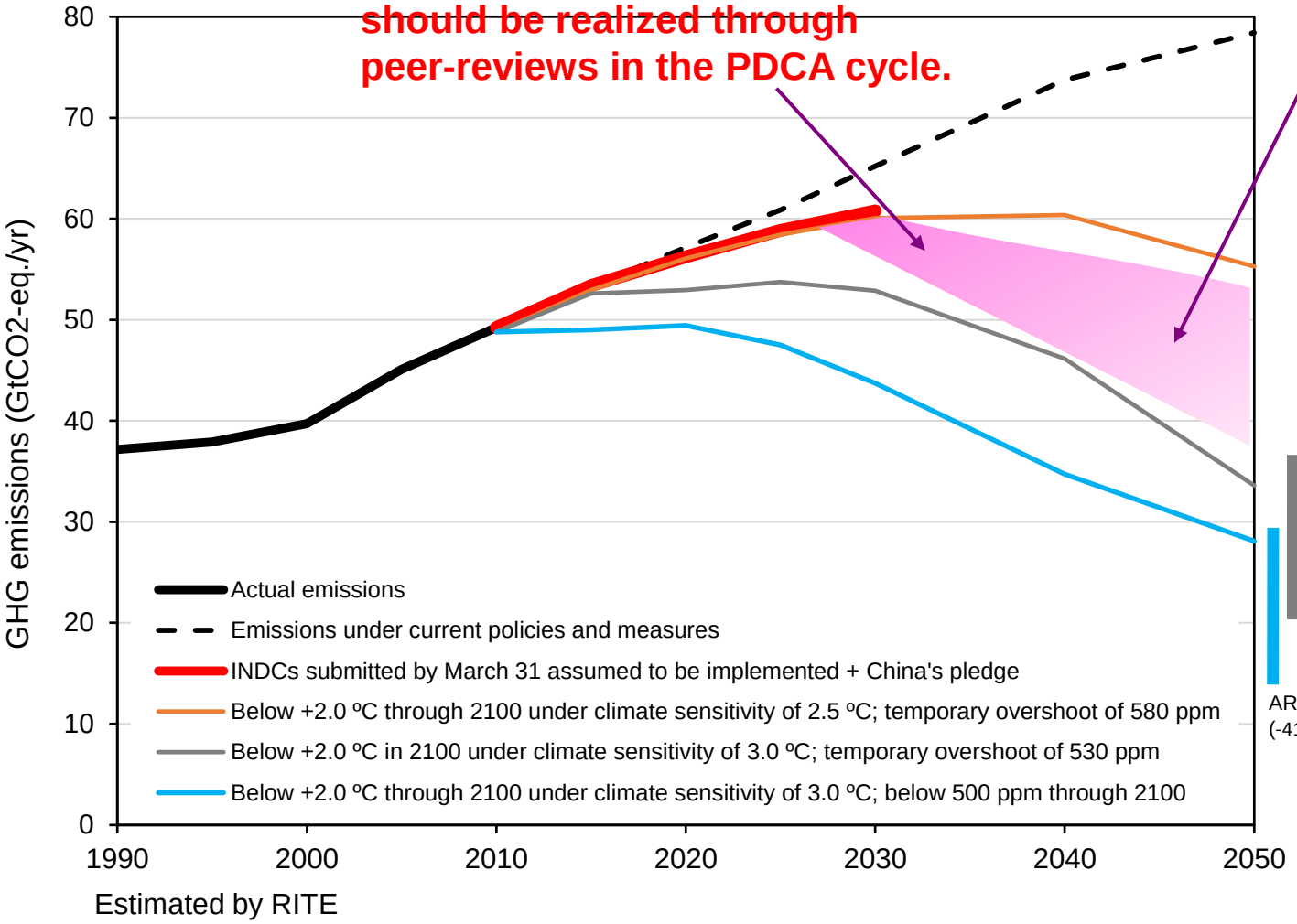
The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

- **Since the objectives of the Article 2 of the Convention are not described in concrete terms, international targets are widely subject to debate: it is much discussed whether the INDCs are consistent with the "2°C target" (the target that limits temperature rise below 2°C compared to preindustrial levels).**
- **At first, the consistency between the required emissions pathways for the 2°C target and the submitted or announced INDCs of major countries (Japan also included) was analyzed.** (RITE published its understanding of the last IPCC report about what path to choose for the 2°C target, on its website on April 22, 2015: "Interpretation of IPCC AR5 Scenarios under better understanding of climate sensitivity assessments, and the implications of INDCs in terms of 2°C target". Please also see.)
- **At second, we made an analysis regarding the balance of the burden sharing in Japan in terms of emission reduction costs in 2030 and 2050.**

Relationship between climate sensitivity and global emission pathways for 2°C target, and outlook on INDCs

Larger emission reductions should be realized through peer-reviews in the PDCA cycle.

Deeper emission reductions should be realized through technology innovations although they are uncertain.



AR5 530-580 ppm (+7– -47%)

AR5 480-530 ppm (-25– -57%)

AR5 430-480 ppm (-41– -72%)

+2 °C with around 50% probability

The probability achieving below +2°C increases. On the other hand, measures with unrealistically high costs have to be adopted.

There are large gaps between the expected global emission under current INDCs and the emission pathway to 2°C target under climate sensitivity of 3.0°C. However, the INDCs are consistent with 2°C target if climate sensitivity is 2.5°C.

The framework of the processes to induce future emission reductions are more important than the levels of INDCs decided in COP21.

Assessment of equity across generations in terms of emissions reduction costs for future time points

- **Emission reduction costs in 2030 and 2050 were compared, applying INDCs emissions reduction for 2030 and assuming a cut by half of world total energy-related CO2 emissions in 2050 compared to 2005 levels as a long-term goal (Marginal abatement costs are assumed to be equal across countries in 2050.).**
- **The expected marginal abatement cost is 431$/tCO$_2$ in 2050 for the long-term goal. At that time, the Japanese emissions are assessed to be about half of 2005 emissions levels under the equal marginal abatement costs, and the ratio of emissions reductions costs compared to GDP to be 0.74%. In other words, the economic burden of Japanese INDCs for 2030 is about the same level as the cut by half of emissions worldwide in 2050.**

GHG emission, marginal abatement costs, ratio of emissions reduction costs compared to GDP for Japan

	2030	2050 (Reduction by half of world total energy-related CO2 emissions after equalization of marginal abatement costs)
GHG emissions (compared to 2005 levels)	-25.4%	-50%
Marginal abatement cost ($/tCO2)	**381**	**431**
Ratio of emissions reduction costs compared to GDP (%)	**0.72**	**0.74**

[Reference]
In the case of below +2°C through 2010 under climate sensitivity of 2.5°C, the required GHG emission for Japan in 2050 is -32% compared to 2005, and the marginal abatement cost is 40$/tCO$_2$; the emissions reduction costs per GDP is 0.22%.
In the case of below +2°C in 2010 (overshoot of temperature) under climate sensitivity of 3.0°C, the required GHG emission for Japan in 2050 is -48% compared to 2005, and the marginal abatement cost is 360$/tCO$_2$; the emissions reduction costs per GDP is 0.65%.

Main points on long-term targets

- Even if we assume to stay within a 2℃ warming compared to preindustrial levels, there is great uncertainty regarding the actual outcome due to climate sensitivity; based on the latest expertise of the IPCC Fifth Assessment Report, the emissions pathways for the "+2℃" target present a high flexibility. The INDCs published so far, including the Japanese ones, are within the pathway range to meet the 2℃ target as long as the expected value is used (under a climate sensitivity of 2.5℃).
- In a long-term perspective, we should keep enhancing the INDCs thorugh the enforcement of PCDA cycles and development of innovative technologies.
- The maximum allowable global emissions are comprised within a wide range, which makes it difficult to assess the right amount; and for now, we might assume the long-term target consists of cutting emissions by half compared to 2005, which is pretty stringent. Still, if we measure the Japanese intergenerational emissions reduction efforts for 2030 and 2050 in terms of the ratio of emission reduction costs to GDP, they are estimated to be roughly the same: 0.72% in 2030 and 0.74% in 2050. In regard with the long-term targets, the Japanese INDCs for 2030 can thus be assessed as sufficiently large.

Conclusions

Conclusions (1/2)

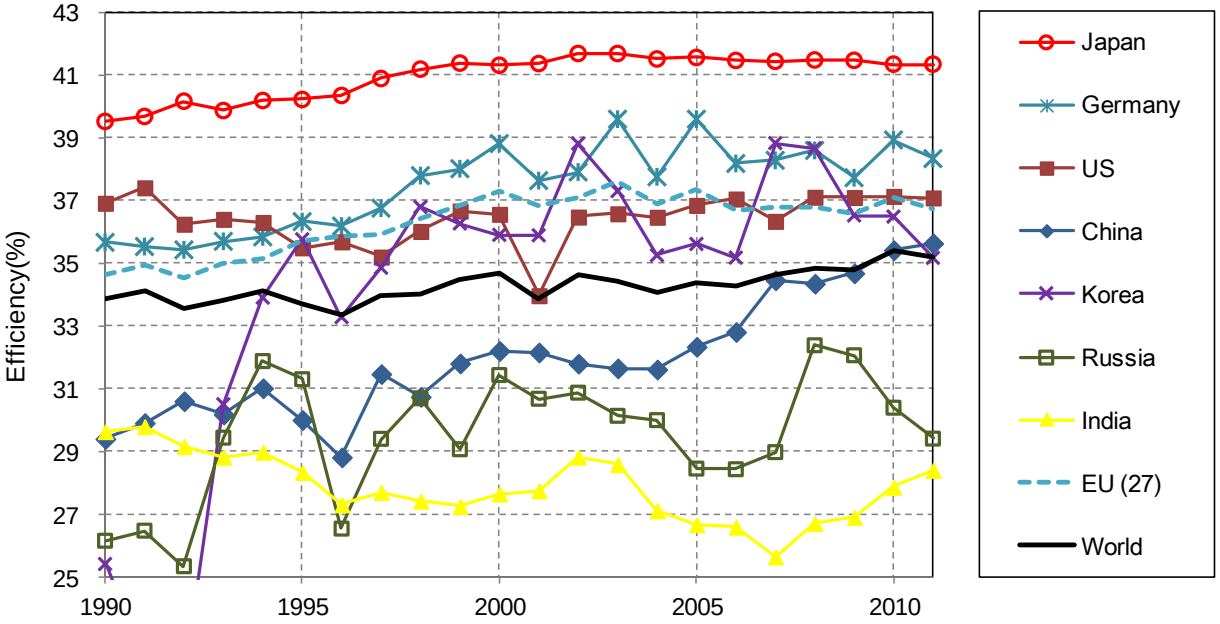
- Considering the need to answer in a balanced way to the national preoccupations known as the 3E+S, namely: controlling electricity costs, reducing CO2 emissions, ensuring energy security and stability of supply, the government's proposition for the energy mix is generally assessed as appropriate.
- However, the government's energy outlook anticipates a GDP growth of 1.7% per year, and simulteanously, a growth of electricity demand of 0.1% only (the GDP elasticity: 0.05). The electricity in Japan is estimated close to 1.0 if we set aside the time right after the Great Earthquake when electricity savings were endeavored at all costs; since many OECD countries have an elasticity between 0.5 and 1.0, the government projection is small compared to historical records.
- Even among countries where the GDP elasticity seems low, in many of them electricity demand is constrained through the effects of rising electricity costs on prices. On the other hand, in many countries where we observe a low price elasticity, keeping the demand in control requires considerably high electricity prices.
- In the government's outlook for long-term energy demand, the basic policy intends to "decrease prices under current levels". According to the above-mentioned facts, given the strong correlation between GDP and potential electricity demand, decreasing electricity demand substantially thourgh electricity savings while "decreasing prices under current levels" – even a little – is a challenge which has not yet been addressed anywhere in the world.

Conclusions (2/2)

- As for GHG emissions targets, the comparison of the INDCs of major countries through several indicators leads to high evaluation of Japan's INDCs. However, since these ambitious targets are based on high expectations from the energy savings policy (corresponding marginal abatement costs in Japan are exceedingly high compared to other countries), it will not be easy to achieve such ambitious target. The international competition in the industry is also a concern.
- Regarding long-term targets (the "2°C" target), the range for emission pathways to achieve the 2°C target is very wide; the INDCs are likely to be on the track of the pathways of 2°C target if more than 50% achievability for the target is adopted and the median value of equilibrium climate sensitivity is 2.5 °C. (The climate sensitivity was changed from 2.0-4.5°C in the IPCC AR4 to 1.5-4.5°C in the IPCC WG1 AR5.)
- Moreover, we evaluated the burden sharing of emissions reduction costs between 2030 and 2050 in Japanese target: for now, the long-term target consists in cutting emissions by half compared to 2005. The Japanese intergenerational emissions reduction efforts for 2030 and 2050 in terms of the ratio of emission reduction costs to GDP are estimated to be roughly the same and rather than passing the costs to future generations, they offer a really good intergenerational balance of burden sharing.

References

Comparison of energy efficiencies in major energy sectors (1/2)



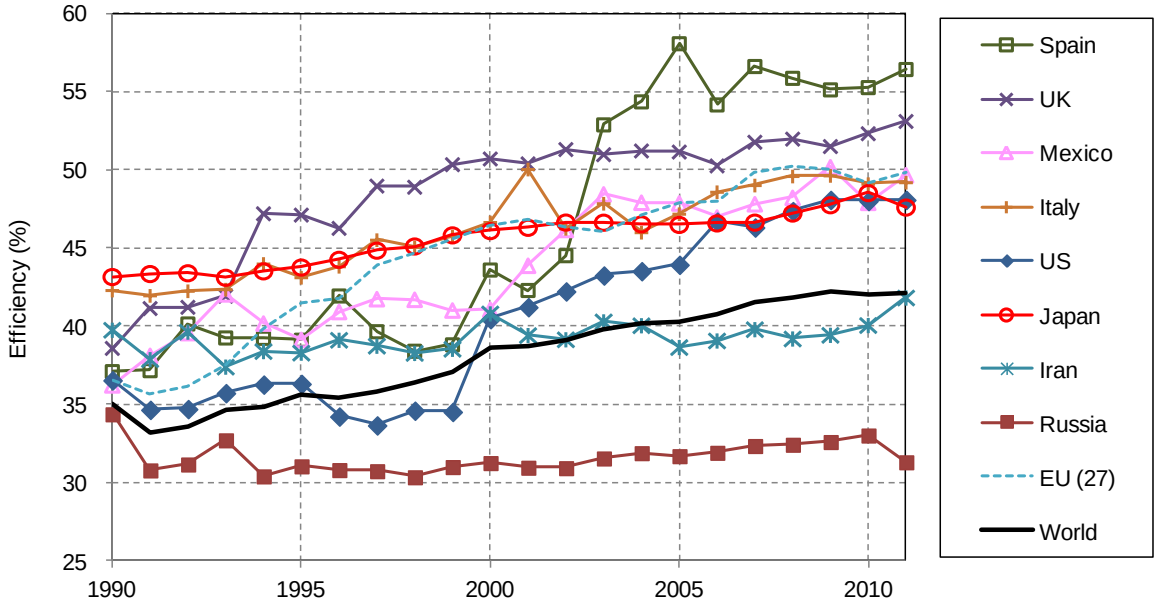
Coal power generation

Source: RITE, 2014 (estimation based IEA data, 2013)

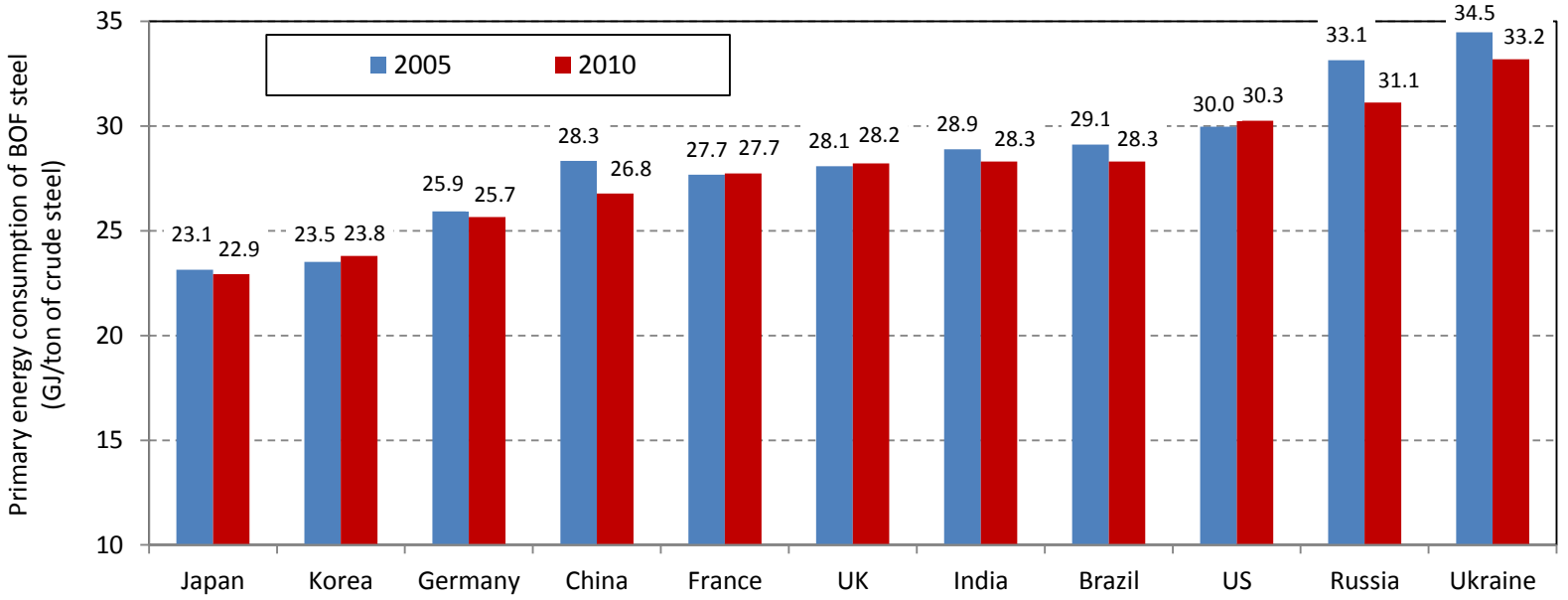
Gas power generation

Source: RITE, 2014 (estimation based IEA data, 2013)

The value of the ratio of energy outputs to GDP level (the ratio of primary energy consumption to GDP) varies according to the structure of the industry. Moreover, in order to evaluate the emission reduction efforts, it is necessary to measure separately the energy intensities (energy efficiency) of the main sectors and the production processes.



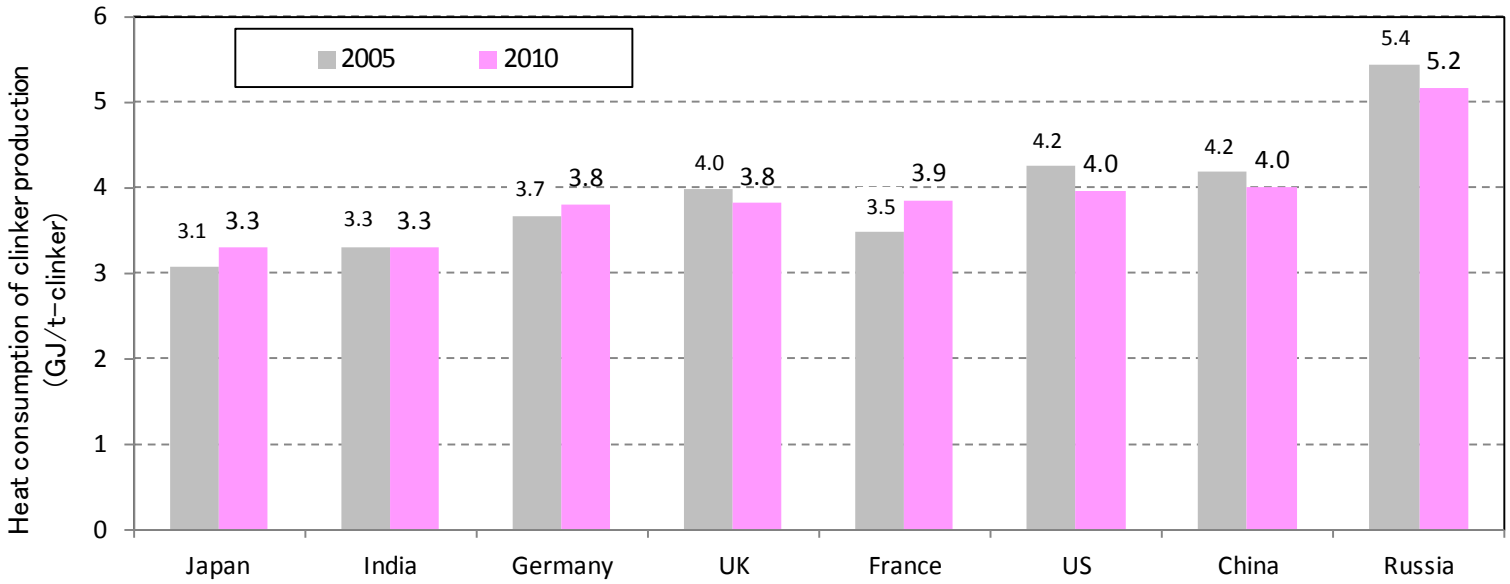
Comparison of energy efficiencies in major energy sectors (2/2)



Iron and steel (BOF steel)

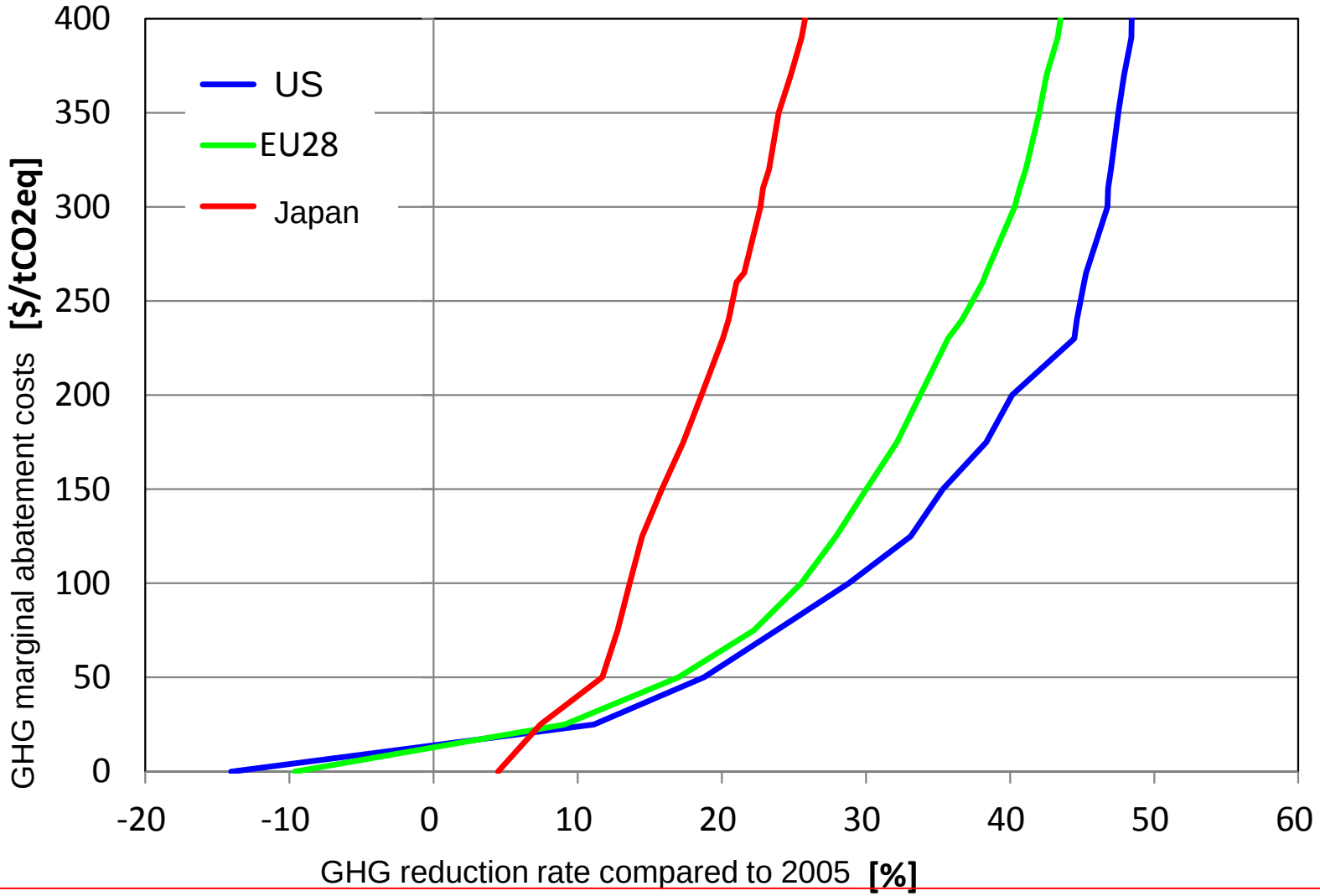
Source: Oda et al. 2012; RITE, 2012

Cement (Clinker)



Source: RITE estimate based on WBCSD/CSI data

Comparison of marginal abatement cost curves in major countries (2030)



For the same GHG emissions reduction ratio compared to 2005, the marginal abatement cost is higher in Japan than in the US or Europe.

*For this marginal cost abatement curve, we made the assumption of an equalization of world abatement costs for each price range.