Application to the Thematic Session

The 7th Congress of EAAERE (Singapore, 2017)

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(b)The title of the proposal

Modelling the sustainable low carbon power sectors toward 2050 in East Asia:
their economic and environmental impacts.

(c)A short description of the theme

This session describes and assesses the policies that are aimed at the development of sustainable, low-carbon power generation system toward 2050 in East Asia. We consider how existing policies, including carbon taxes, Feed-in-Tariff and regulations on nuclear and coal power change power mixes of East Asia, that is China, Japan, Korea and Taiwan, and how they could be improved upon for sustainable future in this region.

Our analysis is carried out in the context of the region's growing economic and environmental interdependence, which is likely to increase further in future, for example due to free-trade agreements, liberalization of finance and services. In relation to the sustainability of energy supply in East Asia, the use of nuclear power and renewable energy sources that do not emit CO_2 during power generation remain as important issues. Japan had set a goal of reducing greenhouse gas emissions(NDC 2030 and 2050 targets) and further expansion of nuclear power remained the primary means for doing so. The 2011 accident at the Fukushima Daiichi nuclear power plant hampered such policies. In contrast, China and South Korea still position nuclear power as the centerpiece of their low-carbon policies, and have maintained their plans for nuclear power expansion although Taiwanese new government declared to phase out nuclear. Nonetheless, increased use of nuclear power poses significant potential risks to neighboring countries. Interest in the widespread use of renewable energy is increasing worldwide, and East Asia is no exception.

We employ an analytical approach, using E3ME(Energy-Economy-Environment Macro-Econometric Model)-Asia developed by Cambridge Econometrics and Cambridge University linking FTT:Power (Future Technology Transformation for the power sector) bottom up sub model developed by Jean-Francois Mercure (2012). FTT: power is a representation of global power systems based on market competition, induced technological change (ITC) and natural resource use and depletion. This model is integrated with the global macroeconomic model E3ME. E3ME-Asia is a version of E3ME specialized to analyze policies in Asian countries.

In the first issue(Paper 1: **Modeling the power sectors toward 2050 in East Asia – The choice of power sources under regulations on nuclear and coal power generations**)) ,we simulate power sector transformation toward 2050 by the policy scenarios on (ⅰ)baseline scenario,(ⅱ)nuclear power regulation scenario,(ⅲ)coal power regulation scenario and(ⅳ)nuclear and coal power regulation scenario. We could watch how power mixes of East Asia change by those regulation policy scenarios. The economic(GDP, employment, etc.) and environmental(CO2 emission) implications of these measures are discussed in the second issue(paper 2:. **Modeling the power sectors toward 2050 in East Asia: economic and environmental impact of power sources under regulations on nuclear and coal power generation**). Also we could consider ways in which the East Asian countries could reduce CO_2 emissions without relying on nuclear and reducing coal power in this paper. The third issue(Paper 3: **Modelling the power sectors toward 2050 in East Asia : the choice of power sources and it economic impact by carbon taxes and feed-in-tariffs**)expands on this analysis in the case of mainly introducing carbon tax and Feed-in-Tariff, instruments using market mechanism. We can compare regulation policies and market mechanism on their effect to power mix transformation.

In conclusion, this session will suggest desirable policy mixes for low carbon sustainable power sector and show their economic and environmental impacts toward 2050 in East Asia.

References

Cambridge Econometrics (2016), E3ME Manual.

Jean-Francois Mercure (2012), FTT:Power : A global model of the power sector with induced technological change and natural resource depletion, Energy Policy, 2012.

Abstracts

Paper 1

Title of paper

Modeling the power sectors toward 2050 in East Asia – The choice of power sources under regulations on nuclear and coal power generations

Authors

*Azuma Aiko, Unnada Chewpreecha, Soocheol Lee, Ken'ichi Matsumoto

(* mark means speakers)

Objective

This paper discusses how different types of future policies by 2050 might affect the development and deployment of both conventional and renewable energy sources (RES) in each of the East Asian countries. All four East Asian countries and region(Japan, Korea, China, and Taiwan) have specific targets to increase the share of RES in energy supply. The aim of deploying RES is to reduce GHG emissions and develop new low carbon technologies by substituting fossil-fuel use and reducing nuclear power for energy. RES can also contribute to energy security of the country by reducing fuel imports, as East Asian countries are all net fuel importing countries.

This paper shows how RES and other power source shares will be changed by different type of regulation polices on nuclear and coal power generations by 2050 using E3ME(Energy-Economy-Environment Macro-Econometric Model) developed by Cambridge Econometrics and Cambridge University linking FTT(Future Technology Transformation):Power bottom up sub model, and suggests desirable policy toward sustainable low carbon electricity generation system.

Methods adopted

This paper will describe the scenarios that will be developed to assess the future power generation targets and ways in which they could be met (through the power sector). The policies already announced in each country will be considered as the baseline. Baseline scenario of this paper will be the reference scenario of Asia/World Energy Outlook issued by IEEJ(The Institute of Energy Economic, Japan) by 2040 and extend straightly from 2030 to 2040 trend of above reference scenario by 2050 because Asia/World Energy Outlook disclosure data by 2040.

The policy scenarios are (ⅰ) constraint not to build new nuclear power plant and keep 40 year rule strictly in each country and (ⅱ) phase out coal-fired power by 2050 from 2030 (constant from 2017-2030) in each country. The policies analyzed will be (scenario 1) baseline, (scenario 2) baseline + (ⅰ), (scenario 3) baseline + (ⅱ) and (scenario 4) baseline + (ⅰ) + (ⅱ). As well as presenting the key findings and comparing the

results from the scenarios, this paper will explain the main mechanisms through which the results are derived.

The remainder of the paper will describe the modelling approaches that will be used. This includes the E3ME-Asia and "FTT: power model", Future Technology Transformation for the power sector. FTT: power is a representation of global power systems based on market competition, induced technological change (ITC) and natural resource use and depletion. This model is integrated with the global macroeconomic model E3ME (multi-national, multi-sectoral econometric model developed by Cambridge Econometrics). E3ME-Asia is a version of E3ME specialized to analyze policies in Asian countries.

Major findings

The model analysis using E3ME-Asia and FTT:Power indicates that, in the power sector, a phasing out of nuclear power is likely to result in increases in conventional energy sources and, on its own, does not contribute much to the diffusion of renewable energy. In contrast, phasing out coal-fired power plants results in substantial increases in renewable energy. This is because coal-fired power is a very low-cost baseload technology that dominates the power sector in each region, leaving little market space for renewable energy technologies.

It may, thus, be important to regulate the share of coal-fired power generation in the power sector to enable a significant increase in renewable energy sources. Without stronger support for renewable energy or the regulation of coal-fired power, decreasing nuclear power does not contribute to an increase in renewable energy; this is because most nuclear power would be replaced by coal-fired power generation – also a baseload technology.

References

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Klein. A .• Held, A., Ragwitz. M .. Resch. G .. Faber. T. (2008), "Evaluation of Different Feed·in Tariff Design Options: Best Practice Paper for the International Feed-in Cooperation", Energy Economics Group 8. Fraunhofer Institute Systems and Innovation Research, Germany.

Ryan Wiser (2008), "Renewable Portfolio Standards in the United States - A Status Report with Data Through 2007", Lawrence Berkeley National Laboratory, 2008.

Paper 2

Title of paper

Modeling the power sectors toward 2050 in East Asia: economic and environmental impact by choice of power sources under regulations on nuclear and coal power generation

Authors

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(* mark means speakers)

Objective

In this paper, we apply the power mix obtained from the simulation results under the policy scenarios of regulations on nuclear and coal power generation through 2050 to estimate and confirm the impact on the economy (GDP, employment, etc.) and environment (CO_2 emissions) by using E3ME(Energy-Economy-Environment Macro-Econometric Model). E3ME was developed by Cambridge Econometrics and Cambridge University and has widely used to evaluate EU energy and climate policies.

To ascertain what power mix is desirable from a social perspective, it is necessary to scientifically assess the effects of various power mixes on the economy and environment, via quantitative analysis and evaluation using a reliable estimation model.

Restricting nuclear and coal-fired thermal power in East Asia would increase power generation costs and exert a negative influence on the economy (particularly the GDP), but we show the effect of investment demand into alternative power sources—that is, the construction of renewable energy power plants—and a reduction in imports of fossil energy would ameliorate the negative impacts over time. Regarding CO_2 emissions, the study highlighted considerable reductions although the amounts will differ between countries.

Methods adopted

This paper will describe the scenarios that will be developed to assess the future power generation targets and ways in which they could be met (through the power sector). The policies already announced in each country will be considered as the baseline. Baseline scenario of this paper adopt the reference scenario of Asia/World Energy Outlook issued by IEEJ(The Institute of Energy Economic, Japan) by 2040 and extend straightly from 2030 to 2040 trend of above reference scenario to 2050

The policy scenarios are, ⅰ. constraint not to build new nuclear power plant and keep 40 year rule strictly in each country, and ⅱ. phase out coal-fired power by 2050 from 2030 (constant from 2017-2030) in each country. The policies analyzed will be (Scenario 1) baseline, (Scenario 2) baseline + ⅰ, (Scenario 3) baseline + ⅱ and (Scenario 4) baseline + ⅰ + ⅱ. As well as presenting the key findings and comparing the

results from the scenarios, this paper will explain the main mechanisms through which the results are derived. The economic impacts of following these scenarios will be presented as well. The outcomes will include impacts on:

- GDP growth, Employment
- Sectoral output, trade and competitiveness
- GHG emissions

Each of the four East Asian countries and region will be assessed, over a time period up to 2050.

Major findings

In this paper, we conducted simulations through 2050 to predict power mixes under the above four policy scenarios and see the effect on the economy and environment in East Asia.

Restrictions on nuclear power alone (Scenario 2) have a negative short-term impact on the economy due to higher power costs and a shift to coal-fired power. In addition, carbon dioxide emissions increase. Under restrictions on coal-fired power alone (Scenario 3), power costs increase and there is a modest burden on the economy, but there is a further shift to renewable energy and LNG, so there is a significant decrease in carbon dioxide emissions. Under simultaneous restrictions on nuclear and coal-fired power output (Scenario 4), there is a larger initial burden on the economy than in Scenario 2 and 3, but this turns positive over the medium and long term due to reduced capital costs for renewable energy and the impact of investment in renewables, as well as a reduction in fossil-fuel energy imports. Carbon dioxide emissions differ somewhat by country, but large reductions are forecast.

Our research shows that despite severe restrictions on nuclear and coal power, the negative impact on the economy is limited, and it is possible to shift to a sustainable low carbon power mix. Further, if the restriction on coal-fired power plants is implemented in all four regions simultaneously, the negative effect on GDP becomes lower in Japan and Korea, who face severe international trade competition with the price of electricity becoming a determinant of comparative competitiveness.

References

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Hector Pollitt, Park Seung-Joon, Lee Soocheol, Kazuhiro Ueta (2014)An economic and environmental assessment of future electricity generation mixes in Japan – an assessment using the E3MG macro-econometric model, Energy Policy 67243–254

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Soocheol Lee, Hector Pollitt and Park Seung-Joon(2015) "Low-carbon, Sustainable Future in East Asia : Improving energy systems, taxation and policy cooperation" Routledge

Paper 3

Title of paper

Modelling the power sectors toward 2050 in East Asia : the choice of power sources and its economic impact by feed-in-tariffs and carbon taxes

Authors

*Taeyeon Lee, Hector Pollitt, Ken'ichi Matsumoto, Sunhee Suk

(* mark means speakers)

Objective

In this paper, we show how power sector will change and what is economic and environmental impacts under carbon tax, Feed-in-Tariff and regulation on coal power by using E3ME-Asia and FTT:Power sub model developed by Cambridge and Cambridge University. And we suggest desirable policy mixes for the sustainable low carbon power system toward 2050. To do this, First, we estimate carbon taxes to meet the 2030 NDCs of CJKT(China, japan, Korea and Taiwan) and simultaneously carbon taxes to meet the 2 degree target(WEO 450PPM) of CJKT.

And we will see economic impacts of carbon taxes under various levels of efforts in power sector to meet the INDCs and 2C targets. We expect that carbon taxes to meet the INDCs and 2C targets will be lower by the additional policies like Feed-in-Tariff and coal power regulation. Concretely, we focus on the power sector and will see how power mixes of CJKT will be influenced by Feed-in Tariff, carbon tax and policy mixes with coal power regulation on power sector by 2050.

Methods adopted

In this paper, carbon tax and FIT will be used to meet the 2030 INDCs and WEO 2C targets. We will estimate carbon cost(as carbon tax rates) to meet targets both the NDCs in 2030 and 2C in 2050 for CJKT by using E3ME. We set four policy scenarios including baseline scenario, as shown below.

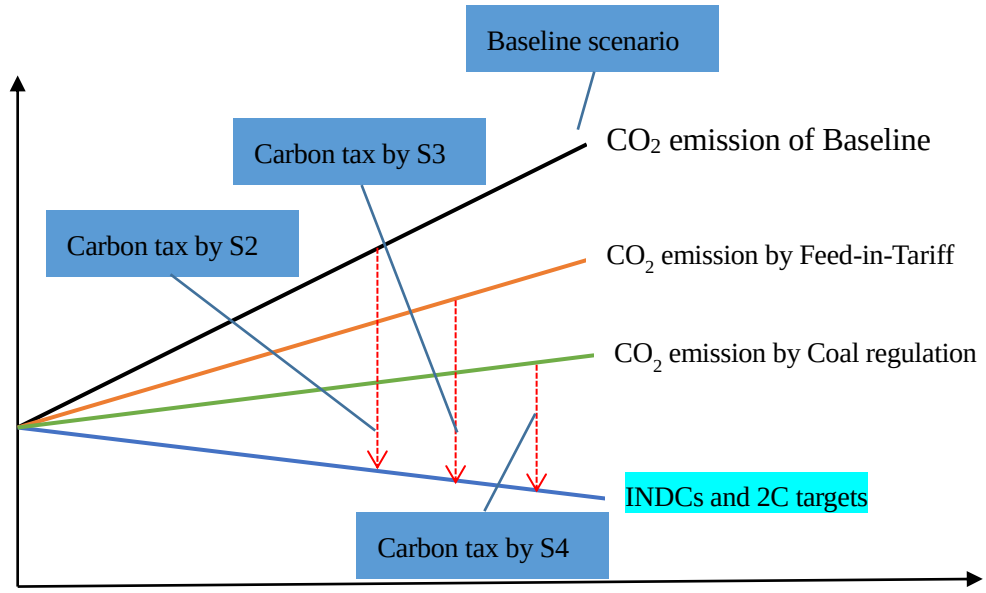
The Scenario 2 is Carbon tax alone to meet the 2030 INDCs and 2050 2C targets in Figure 1(tax revenue recycling(Scenario2-1) and no recycling(Scenario2-2)). We expect the high carbon tax rate to meet targets. In the Scenario 3, we consider that the impact of policy mix such as carbon tax and subsidy (Feed-in Tariff; FIT)(carbon tax recycling(Scenario3-1) and no recycling(Scenario3-2)).

In East Asian countries, FIT has been introduced in the power sector to increase the penetration rate of renewable energy by guaranteeing to purchase electricity generated from renewable energy sources at a fixed price for a set length of time. For instance, in the Japan, a FIT system introduced in 2012, it guarantees the purchase of electricity generated from five renewable energy at a price of 13.65 to 57.75 JPY/kw for 10 to 20 years depending on the type. In the Scenario 4, we estimate the impact of policy mix as carbon tax and FIT and coal power regulation phasing out coal-fired power by 2050 from 2030 (constant

from 2017-2030) in each country. We will review and adopt renewable subsidies of other East Asia countries as policy scenarios.

- Scenario 1 : Baseline (IEEJ,World/Asia Energy Outlook 2016; IEA, WEO2015)
- Scenario 2: East Asia 2030 INDC targets (national) and WEO 2050 2C targets
  - via carbon tax only(carbon tax recycling and non recycling)
- Scenario 3: East Asia 2030 INDC targets (national) and WEO 2050 2C targets via Feed-in-Tariff and carbon tax(carbon tax recycling and non recycling)
- Scenario 4: East Asia 2030 INDC targets (national) and WEO 2050 2C targets via Feed-in-Tariff, coal regulation and carbon tax (carbon tax recycling and non recycling)

Figure 1: Schematic of BAU, target and Scenarios



Major findings

Under Scenario 2,low carbon power mix in East Asia will be realized by high carbon tax. High carbon tax increase electricity highly and give negative economic impact both short and long term. But if carbon tax revenue is recycled as lump sum subsidy, for example to household, economy will recover in the mid-term stimulated by household consumption. Double dividend effect could be realized in the revenue recycling scenario.

Under Scenario 3, low carbon power mix in East Asia will be realized by the lower carbon tax than Scenario 2 and Feed-in-Tariff. This also increase electricity price much and give negative economic impact. Meanwhile, in the mid and long term, negative economic impact will be recovered by increasing investment of renewable power sources supported by Feed-in-Tariff and decreasing fuel imports. Total impacts on economies in East Asia will be determined by strength

of two minus and plus impacts above. Double dividend effect could be also realized by carbon tax revenue recycling scenario.

Under Scenario 4, low carbon power mix in East Asia will be realized by the policy mix of lowest carbon tax, Feed-in-Tariff and coal power regulation. This also increase electricity price much and give negative economic impact. Meanwhile, in the mid and long term, negative economic impact will be recovered as the same facts of Scenario 3.

This paper will give implication to design desirable policy mixes of market instrument and regulation toward sustainable low carbon power systems in East Asia.

References

Cambridge Econometrics. (2016). E3ME Manual.

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