Energy Security for the 21st Century:
Role of Nuclear Power after the Fukushima

April 2014, New York

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Distinguished Fellow, Center on Global Energy Policy, Columbia U.
Global Associate for Energy Security and Sustainability of the IEEJ
Nobuo TANAKA
The engine of energy demand growth moves to South Asia

Primary energy demand, 2035 (Mtoe)

China is the main driver of increasing energy demand in the current decade, but India takes over in the 2020s as the principal source of growth

Share of global growth 2012-2035

OECD 4%
Non-OECD Asia 65%
Eurasia 5%
Latin America 8%
Africa 8%
Middle East 10%
A mix that is slow to change

Growth in total primary energy demand

Today's share of fossil fuels in the global mix, at 82%, is the same as it was 25 years ago; the strong rise of renewables only reduces this to around 75% in 2035
A United States oil & gas transformation

The surge in unconventional oil & gas production has implications well beyond the United States
before 2030. Combined, the two countries actually become energy self-sufficient in net terms much sooner – around 2020. Imports into Europe also decline, but at a slower pace, and due to reduced demand. By contrast, Asia becomes the global centre of inter-regional crude oil trade – accounting for 63% of the world total in 2035. China is about to become the world’s largest oil importer, overtaking the United States, and goes on to surpass the oil imports of the European Union by 2020. By 2035, China’s oil imports reach 12.2 mb, getting close to the peak historical level of imports into the United States. India’s oil imports are larger than those of Japan by 2020 and exceed those of the European Union by 2035: its import dependence increases to more than 90%. Brazil undergoes a pivotal shift, becoming a net oil exporter around 2015 and going on to export around 2.6 mb in 2035 (Figure 2.12). By 2035, Southeast Asia will import around 60% more oil than the United States (over 5 mb). Exports from the Middle East are slightly lower than today in 2020, but then increase to reach 24.6 mb in 2035. The share of Middle East production which is exported declines slightly, as domestic consumption increases more quickly than production. Russian oil exports decline to 6.2 mb, as new production fails to keep pace with the decline in mature fields.

Notes: Import shares for each fuel are calculated as net imports divided by primary demand. Export shares are calculated as net exports divided by production. A negative number indicates net exports. Southeast Asia, i.e. the ASEAN region, includes Indonesia.
North American Energy Independence and Middle East oil to Asia: a new Energy Silk Road

Middle East oil export by destination

By 2035, almost 90% of Middle Eastern oil exports go to Asia; North America’s emergence as a net exporter accelerates the eastward shift in trade
Blockage of the Strait of Hormuz may push Japan into the Economic Death Spiral.

85% of Japanese oil import
20% of Japanese LNG import
But if no nuclear reactors are running,,,,,,?

17 mbd of petroleum
(20% of global demand & 42% of trade)

82 million tons of LNG pa
(30% of global demand)
Economic Death Spiral may hit Japan

• Blockage of the Strait of Hormuz
  – Oil Price may double to $160 / barrel
  – Japan’s current account surplus (9 trillion yen in 2011) may turn to deficit of 6 trillion yen.
  – Without further restarting of nuclear power plants, deficits may reach 12 trillion yen.

• Confidence on Japan’s public finance may be lost.
  – Current Account surplus is the basis for confidence
  – Persisting Deficit may lead to capital flight from Japan
  – Power crisis enhances flight of manufacturing industries

• Loss of Confidence in JGB and Yen. Capital move into commodities means higher prices of oil.

• Total Economic Melt Down may happen.
China’s Import Transit Routes

[Map showing import transit routes to China, with labels and capacities for various routes such as Russia, Kazakhstan, Turkmenistan, and Burma.]

Note: All figures are based on 2011 data. Transit numbers will not total 100% as many shipments transit multiple shipping routes/chokepoints. Percentages reflect portion of overall imports by product group. Pipeline capacities represent designed capacity, not current flow rates.
Should China and India join the IEA?

Net oil imports of selected countries in the New Policies Scenario 2013 (mb/d)

Asia becomes the unrivalled centre of the global oil trade as the region draws in a rising share of the available crude
Two chapters to the oil production story

Contributions to global oil production growth

Conventional:
- Middle East
- Brazil
- Rest of the world

Unconventional:
- Light tight oil
- Oil sands, extra-heavy oil, coal/gas-to-liquids, & other

The United States (light tight oil) & Brazil (deepwater) step up until the mid-2020s, but the Middle East is critical to the longer-term oil outlook
Shale Gas revolution?

Figure 3.4 ▶ Change in annual natural gas production in selected countries in the New Policies Scenario

- China
- United States
- Russia
- Australia
- Qatar
- Iraq
- Brazil
- Turkmenistan
- Iran
- Algeria

2011-2020 2020-2035

© OECD/IEA, 2013
Russian Gas Pipelines

Source: IEA

Mid-Term Oil & Gas Market 2010, IEA
Natural Gas Pipeline from Russia to Japan
LNG pricing: a competitiveness burden on Asian economies

Developing a Natural Gas Trading Hub in Asia (2013 by IEA)
The higher the oil price goes, the lower the gas price becomes.

**Figure 4.7** Relationship between break-even price (gas price needed to recover well costs) and the liquid content of the gas produced

![Break-even price vs. liquid content graph](image)
LNG from the United States can shake up gas markets

Indicative economics of LNG export from the US Gulf Coast (at current prices)

New LNG supplies accelerate movement towards a more interconnected global market, but high costs of transport between regions mean no single global gas price
Destination clauses and inefficient trade with Europe is a USD 10 billion burden on Japan.
Impacts of US LNG and Nuclear restarting to the LNG prices to Japan

Japan’s LNG Price curve in 2012

Average, 16.7

15 Mt of displaced by U.S. LNG

21 Mt of displaced by restarting of nuclear to 2010 level

Mt

$/MBtu

0

5.0

10.0

15.0

20.0

0

10

20

30

40

50

60

70

80

90

IEEJ input to LNG conference 2013
Two Price Zones may appear.

Figure 3.11  Regional gas prices in the New Policies Scenario and in the Gas Price Convergence Case

- **New Policies Scenario (NPS):**
  - United States
  - Europe
  - Japan

- **Gas Price Convergence Case (GPCC):**
  - United States
  - Europe
  - Japan
Introduction - Chiyoda’s Hydrogen Supply Chain Outlook

- Chiyoda established a complete system which enables economic H2 storage and transportation.
- MCH, an H2 carrier, stays in a liquid state under ambient conditions anywhere.

H2 Supply of a 0.1-0.2mmtpa LNG equivalent scale (M.E. to Japan) could be feasible.
Resource estimates vary by several orders of magnitudes, with many falling between 1000 and 5000 tcm, or between 300 and 1500 years of production at current rates. The USGS estimates that gas hydrates worldwide are more than 10 to 100 times as plentiful as US shale gas reserves. The Japanese government aims to achieve commercial production in ten to fifteen years, i.e. by the mid- to late-2020s. (IEA WEO2013) (IEA)
World Electricity Generation grows by 70% led by renewables in OECD and by coal in non-OECD countries.

Figure 5.3  Electricity generation by source in the New Policies Scenario

OECD

Non-OECD

IEA WEO2013
Renewables needs $4.7 trillion of subsidies by 2035.

Figure 6.15 ▶ Global renewable energy subsidies by source in the New Policies Scenario

Notes: Other includes geothermal, marine and small hydro.
A decline in nuclear is compensated by a 3-fold increase in electricity from renewables, a continued high reliance on LNG imports & improvements in efficiency.
Who has the energy to compete?

Regional differences in natural gas prices narrow from today’s very high levels but remain large through to 2035; electricity price differentials also persist.
The Remarkable Renaissance of US petrochemicals

Chapter 8

Energy and competitiveness

Box 8.4

The slump in gas, ethane and LPG prices in the United States due to the boom in shale gas has given US petrochemical producers a major advantage over many competitors in Europe and other parts of the world that rely primarily on naphtha, an oil-based alternative feedstock. This sharp improvement in the profitability of bulk petrochemical production has boosted utilization rates at existing US plants and led to a surge in plans for new production facilities (Figure 8.15). Between 2010 and the end of March 2013, almost 100 chemical industry projects valued at around $72 billion were announced (ACC, 2013). According to the American Chemistry Council, these investments, were they all to proceed, would boost production capacity by 40% in 2020; provide 1.2 million jobs during the construction phase (to 2020); create over half a million permanent jobs; and give rise to total output worth $200 billion per year in the longer term. The majority of the planned projects, many of them for export, involve expansions of capacity for ethylene, ethylene derivatives (such as polyethylene and polyvinyl chloride), ammonia, methanol, chlorine, and to some extent for propylene. Roughly half of the announced investments to date are by firms based outside the United States. Much of the investment is aimed at making use of the rapidly growing volume of ethane coming onto the US market. However, using solely ethane as feedstock in steam crackers produces just ethylene and almost no other by-products, such as propylene, which may lead to local imbalances in derivative product markets.

Figure 8.15 ▶ Historical and planned ethylene capacity additions by region

Sources: ICIS (2013); IHS (2013); METI (2013); Platts (2013); US EIA (2013); and IEA analysis.
An energy boost to the economy?

Share of global export market for energy-intensive goods

The US, together with key emerging economies, increases its export market share for energy-intensive goods, while the EU and Japan see a sharp decline.
Emissions off track in the run-up to the 2015 climate summit in France

Non-OECD countries account for a rising share of emissions, although 2035 per capita levels are only half of OECD. The 2 °C ‘carbon budget’ is being spent much too quickly.
450ppm Scenario: reducing CO₂ by half by 2050 and containing temperature increase to 2 degrees C.

Energy efficiency reduces CO₂ emissions by 2.2 Gt in 2020 & 6.4 Gt in 2035, but efficiency’s share in CO₂ abatement falls by 2035 as renewables & CCS are used more
Can we build 16 GW of nuclear power plants a year?
+ Can we build 60 GW of wind power plants a year? (2010 = 198 GW)
+ Can we build 50 GW of Solar PV capacities a year? (2010 = 38 GW)
And CO2 price will be more than $120 per ton.
Impact of 450 ppm Scenario on Oil Market

**Figure 2.5** World primary energy demand by fuel in the New Policies Scenario

**Figure 8.5** Primary energy demand in the 450 Scenario by fuel

- Oil
- Gas
- Coal
- Bioenergy
- Nuclear
- Other Renewables
- Hydro

The Stone Age didn’t end because we ran out of stones.
In the New Policies Scenario global nuclear generation grows from 2658 TWh in 2011 to 4300 TWh in 2035, its share of total generation remaining constant at 12%. Growth in generation is underpinned by a corresponding expansion of capacity, which rises from 394 GW in 2012 to 578 GW in 2035. This is the net result of 117 GW of retirements and 302 GW of capacity additions during the projection period. The rate of expansion of nuclear power continues to be mainly policy driven. It expands in markets where there is a supportive policy framework, which in some cases actively targets a larger role for nuclear in the mix in order to achieve energy security aims. But policy frameworks can also hinder or eliminate nuclear power, often as a result of public opposition: even where there is no explicit ban, long permitting processes, such as in the United States, can significantly hinder development by increasing uncertainty about project completion and increasing costs.

Figure 5.12 Nuclear power installed capacity by region in the New Policies Scenario

The largest nuclear gross capacity additions are in China, which adds 114 GW during the projection period (or 38% of global nuclear additions before taking into account retirements). Of the total projected to be added, 28% is already under construction, with building expected to begin on several other plants by 2015. Russia adds 33 GW, the second-largest total globally (though around 60% is needed to replace units that are retired). Among OECD countries, Korea sees the biggest growth in installed capacity during the projection period, with gross capacity additions of 27 GW (Figure 5.12). If Korea is excluded, the OECD's capacity declines from present levels, with retirements of about 80 GW outweighing additions of 60 GW over 2013-2035. Capacity increases in the United States, which builds new units but also uprates existing plants (through the modernisation or replacement of certain plant components). Significant nuclear capacity is added in India (26 GW) to meet rapid growth in electricity demand. Moreover, several countries that aim to develop a nuclear power programme are projected to add their first units over the projection period, notably the United Arab Emirates, Turkey and Vietnam.
Share the Lessons of the Fukushima

• Lessons to be Shared
  – Think about the unthinkable; Tsunami and Station Black Out. Large scale Blackout. Change total mind set for “Safety”.
  – Prepare for the severe accidents by defense in depth, common cause failure & compound disasters. NRC’s B-5-b clause was not accepted despite its suggestion.
  – Clarify why it happened only to Fukushima Daiichi and NOT to other sites like Fukushima Daini, Onagawa, Tokai-daini.

• Safety Principles
  – Fukushima accident was caused by human error and should have been avoided. (Parliament Investigation Commission report )
  – International Cooperation : A nuclear accident anywhere is an accident everywhere.
  – Independent Regulatory authority ; Transparency and Trust, “Back Fitting” of regulation

• Secured supply of Electricity
  – Power station location
  – Strengthened interconnection of grid lines

• Once disaster has happened, Recovery from disaster is at least as important as preparing for it.
  – FEMA like organization and training of the nuclear emergency staff including the self defense force ; integration of safety and security.
  – New Technology. New type of Reactors such as Integral Fast Reactor.
There are 48 nuclear power plant units in Japan. All of them (in red) is in temporary shutdown as of February 17 2014.

17 units (in blue squares) are under review for restart by the Nuclear Regulation Authority in accordance with its new safety standard.
Evaluation of each energy source

Feasible energy mix will be promptly proposed, considering the situation of restart of NPPs and introduction of renewable energy, etc.

(1) Nuclear Power

- Nuclear power is an important base load power source to be utilized from the viewpoint of stable supply, cost reduction, and global warming on the major premise of safety assurance.

- The dependency on nuclear power generation will be lowered as much as possible by energy saving and introducing renewable energy as well as improving the efficiency of thermal power generation, etc. Under this policy, the necessary scale of nuclear power will be identified and maintained taking Japan’s energy situations into account such viewpoint as energy security, cost reduction, global warming and maintaining nuclear technologies and human resources.

- Put the highest priority to safety and on the premise that the government makes the best efforts to sweep away concerns among public, and the nuclear power plants whose safety has been confirmed by the Nuclear Regulation Authority are proceeded to restart.

(2) Petroleum: important energy source continued to be utilized

(3) Natural Gas: important energy source expanding the role in the future

(4) Coal: base load power source excellent in stability and economic efficiency

(5) Renewable Energy: promising domestic energy source free from GHG emissions
Generations of Nuclear Energy

- Generation I: Early Prototypes
  - Shippingport
  - Dresden
  - Magnox

- Generation II: Commercial Power
  - PWRs
  - BWRs
  - CANDU

- Generation III: Advanced LWRs
  - CANDU 6
  - System 80+
  - AP600

- Generation III+: Evolutionary Designs
  - ABWR
  - ACR1000
  - AP1000
  - APWR
  - EPR
  - ESBWR

- Generation IV: Revolutionary Designs
  - Safe
  - Sustainable
  - Economical
  - Proliferation Resistant and Physically Secure

History:
- 1950: Gen I
- 1960: Gen I
- 1970: Gen II
- 1980: Gen II
- 1990: Gen III
- 2000: Gen III
- 2010: Gen III+
- 2020: Gen IV
- 2030: Gen IV

http://www.gen-4.org/Technology/evolution.htm
History of Nuclear Reactors

Figure 12.1 ● Nuclear reactor construction starts, 1951-2011

Three Mile Island
First oil shock
Chernobyl
Fukushima
Daiichi

* Data as of 31 Aug 2011.
“WHEN WAS THE LAST TIME YOU SAW A DOCUMENTARY THAT FUNDAMENTALLY CHANGED THE WAY YOU THINK?”
Owen Gleiberman, Entertainment Weekly

(PHOTO SIZE)
WHAT IF THIS CUBE COULD POWER YOUR ENTIRE LIFE?

FROM ACADEMY AWARD NOMINATED DIRECTOR ROBERT STONE

PANDORA’S PROMISE

AT THE BOTTOM OF THE BOX SHE FOUND HOPE.

www.pandoraspromise.com
Integal Fast Reactor and Pyroprocessing

Pyroprocessing was used to demonstrate the EBR-II fuel cycle closure during 1964-69


Dr. YOON IL CHANG
Argonne National Laboratory
Loss-of-Flow without Scram Test in EBR-II

Dr. YOON IL CHANG
Argonne National Laboratory
Technical Rationale for the IFR

✓ Revolutionary improvements as a next generation nuclear concept:
  – Inexhaustible Energy Supply
  – Inherent Passive Safety
  – Long-term Waste Management Solution
  – Proliferation-Resistance
  – Economic Fuel Cycle Closure

✓ Metal fuel and pyroprocessing are key to achieving these revolutionary improvements.

✓ Implications on LWR spent fuel management

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Argonne National Laboratory
Uranium utilization is <1% in LWR

- Uranium Ore: 170 tons
- Enrichment: 150 tons
- Depleted Uranium: 20 tons
- Used Uranium Reserve: 18.73 tons U, 0.25 tons Pu
- 1000 MWe LWR
  - 18.73 tons Uranium
  - 1.00 tons Fission Products
  - 0.25 tons Plutonium
  - 0.02 tons Minor Actinides
- Reprocessing: 1.00 tons F.P., 0.02 tons M.A.
- Used Uranium Reserve
- Disposal (300,000 years)
  - European recycle
    - Saves 15% uranium
    - But no reduction in waste life
- Spent Fuel
- Disposal (300,000 years)
  - Direct disposal is the current U.S. policy

Dr. YOON IL CHANG
Argonne National Laboratory

18.73 tons Uranium
LWR Pyroprocessing
One-time processing of 700 tons of LWR spent fuel provides long-life fuel supply

Initial Inventory
80 tons Uranium
10 tons Actinides

Annual Budget
12.0 tons U
1.5 tons Actinides

10.5 tons Uranium
2.0 tons Actinides
1.0 tons Fission Products

On-site Pyroprocessing

1.0 tons Fission Products

Disposal (300-year lifetime)

35 tons Fission Products

575 tons Uranium

Used Uranium Reserve

1.5 tons Uranium Makeup

0.5 tons excess actinides For new IFR startup

Dr. YOON IL CHANG
Argonne National Laboratory
In still another controversy with the Midwestern universities—this time over the appropriate site for a large accelerator—and with the accumulation of other aggravations, Zinn resigned in 1955. Staying on for a grace period, in 1956 he left the directorship and the lab and established his own firm, the General Nuclear Engineering Company (GNEC). (It was later acquired by Combustion Engineering Company, with Zinn as the head of its growing Nuclear Division.) With him went a number of key laboratory people.

Zinn's ten year experience as Argonne director had been a constant battle to establish a laboratory meeting his expectations, and at the same time to rapidly develop the most promising reactor type for each important application of the day. His deputy, Norm Hilberry, succeeded him and continued Zinn's policies. The laboratory ran according to principles that Hilberry described in this way:

![Figure 1-8. Reactors developed by Argonne](image)
前国際エネルギー機関事務局長

田中 伸男

ドキュメンタリー映画『海軍少将ロバート・ストーン監督のドキュメンタリー映画『海軍少将リッコーバー提督の伝説』』

リッコーバー提督の伝説

2014.1.1

前国際エネルギー機関事務局長

田中 伸男

ドキュメンタリー映画『海軍少将ロバート・ストーン監督のドキュメンタリー映画『海軍少将リッコーバー提督の伝説』』

リッコーバー提督の伝説

2014.1.1
Joint Program on Pyroprocessing with Japan

✓ Central Research Institute of Electric Power industry (CRIEPI): $20 million cost sharing signed in July 1989.
✓ Power Reactor and Nuclear Fuel Development Corporation (PNC): $60 million cost sharing program agreed to in February 1994, but canceled by DOE.
✓ These joint programs ended when the IFR Program was terminated in October 1994.

Dr. YOON IL CHANG
Argonne National Laboratory
Importance of LWR Pyroprocessing Demonstration

✓ The public views adequate nuclear waste management as a critical linchpin in further development of nuclear energy.
✓ The backend of the nuclear fuel cycle cannot be addressed independent of the next-generation reactor options. A systems approach is required.
✓ Basically, three options exist:
   – LWR once-through only and direct disposal of spent fuel
   – PUREX reprocessing and MOX recycle in LWRs in interim
   – LWR once-through, followed by pyroprocessing and full recycle in fast reactors
✓ A key missing link for decision making is a pilot-scale demonstration of pyroprocessing for LWR spent fuel.

Dr. YOON IL CHANG
Argonne National Laboratory
A Plausible Path forward Option

✔ As an immediate step, develop a detailed conceptual design and cost/schedule estimates for a pilot-scale (100 ton/yr) pyroprocessing facility to treat LWR spent fuel.
  – This will provide data for industry to evaluate viability.
✔ Follow with a construction project for 100 ton/yr LWR pyroprocessing facility to validate economics and commercial viability.
✔ In parallel, initiate an IFR demonstration project based on GEH’s PRISM Mod-B (311 MWe).
  – Licensing preparations
  – Negotiations with the U.S. industry and international partners
✔ A modest sized prototype demonstration project on a DOE site can be done at a fraction of the cost.
  – A vital project to preserve the technology base and develop next-generation engineers for the future.

Dr. YOON IL CHANG
Argonne National Laboratory
S-PRISM Nuclear Steam Supply System
Extending PRISM... recycling used LWR fuel closes the nuclear fuel cycle with two technologies . . .

Benefits include:
- Waste half-life ... 300-500 years
- Uranium energy ... extracts 90%
- Non-proliferation ... no plutonium separation
- Environmentally responsible ... dry process
Transuranic disposal issues

The 1% transuranic (TRU) content of nuclear fuel is responsible for 99.9% of the disposal time requirement and policy issues.

Removal of uranium, plutonium, and transuranics makes a 300,000 year problem a 300 year problem.
Korea seeks to change the 1-2-3 Agreement

Long-term Plan for SFR and Pyroprocess

Korea-USA Joint Fuel Cycle Study

SCGJ Conference, UC Berkeley, October 2-3, 2012
For such an alliance to exist, the United States and Japan will need to come to it from the perspective, and as the embodiment, of tier-one nations. In our view, tier-one nations have significant economic weight, capable military forces, global vision, and demonstrated leadership on international concerns. Although there are areas in which the United States can better support the alliance, we have no doubt of the United States’ continuing tier-one status. For Japan, however, there is a decision to be made. Does Japan desire to continue to be a tier-one nation, or is she content to drift into tier-two status?

Energy Security
(Nuclear)
Understandably, the Fukushima nuclear disaster dealt a major setback to nuclear power. The setback reverberated not only throughout Japan, but also around the world. Japan has made tremendous progress in boosting energy efficiency and is a world leader in energy research and development. While the people of Japan have demonstrated remarkable national unity in reducing energy consumption and setting the world’s highest standards for energy efficiency, a lack of nuclear energy in the near term will have serious repercussions for Japan.
Issue of High-level Waste Disposal

Finland Model:
Olkiluotp Nuclear Power Plant and Onkalo nuclear spent fuel repository

HQ of Teollisuuden Voima Oyj Utility which owns Olkiluoto Nuclear Power Plant exists in the Plant site.
## Energy self-sufficiency* by fuel in 2011

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<th>Country</th>
<th>Fossil fuels</th>
<th>Renewables</th>
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### Note:
- Does not include fuels not in the fossil fuels, renewables and nuclear categories.
- Source: Energy Data Center, IEA.
Natural Gas Import Infrastructure in Europe

IEA Medium Term Oil and Gas Markets 2010
ASEAN is working on Gas Pipeline System.

Figure 15.16  The Trans-ASEAN Gas Pipeline (TAGP)

The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA. Source: ASCOPE Secretariat
Blue Print for North East Asia Gas & Pipeline Infrastructure

[Map showing natural gas infrastructure in North East Asia with major connections to Russia, China, Japan, and other countries.]

Legend:
- Gas Field
- Existing LNG Receiving Terminal
- Planned LNG Receiving Terminal
- Existing LNG Export Plant
- Planned LNG Export Plant
- Capital City
- Major Existing Pipeline
- Major Planned Pipeline
- Major Possible Pipeline

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Power Grid Connection in Europe

Physical energy flows between European countries, 2008 (GWh)

Source: ENTSO-E
Connecting MENA and Europe: "Desertec" as visionary "Energy for Peace"

Source: DESRETÉC Foundation
ASEAN power grid connection
“Energy for Peace in Asia”

New Vision?

Demand Leveling (Time Zone & Climate Difference)
Stable Supply (through regional interdependence)
Fair Electricity Price

Phase 3

Asia Super Grid

Total 36,000km

Presentation by Mr. Masayoshi SON
Japan’s Pipeline network

Map of the Japanese Gas Grid

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.
Source: Country submission (compiled by ANRE from data provided by relevant companies).
Power grid in Japan

Comprehensive Energy Security and Sustainability

- Urgent need for restarting nuclear power plants. Prepare scenarios for Iranian Crisis.
- Nuclear Power will continue to play a major role in the world. Japan’s role after Fukushima is to share the lessons learned for safer Nuclear Power deployment in Asia and elsewhere. (ex. rejection of B5b implementation) International collaboration on Integral Fast Reactor, Fuel cycle technology development at Fukushima.
- Energy Security for the 21st Century must be Collective and Comprehensive Electricity Supply Security under sustainability constraints. EU’s connectivity approach can be a model especially for Asia. Domestic reform issues of power market: 50-60 hrz problem, FIT reform, unbundling of utilities, international grid connection with Korea and Russia.
- Golden Age of Natural Gas will come with golden rules including sustainability requirements and a new pricing formula. Russia remains as a key player with pipelines and LNG facilities. LNG exports from North America including Alaska may be a game-changer.
- New technologies help; Hydrogen economy, Methane-hydrate, Super-conductivity grid, EVs, Smart Grids, Storage, CCS, Solar PV etc.
- China and India should join the IEA. Need for the North East Asian Energy Security Forum
Thank you for your attention