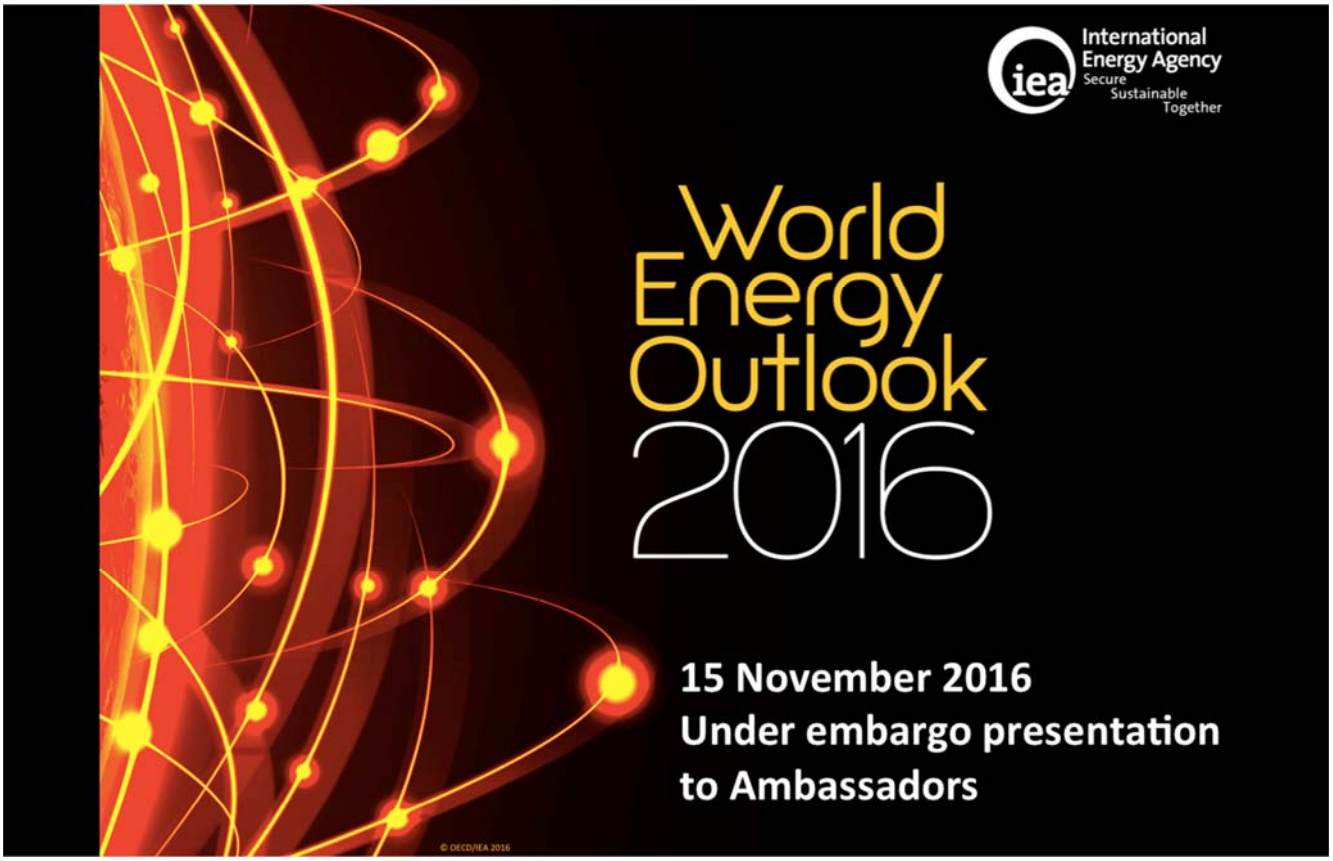
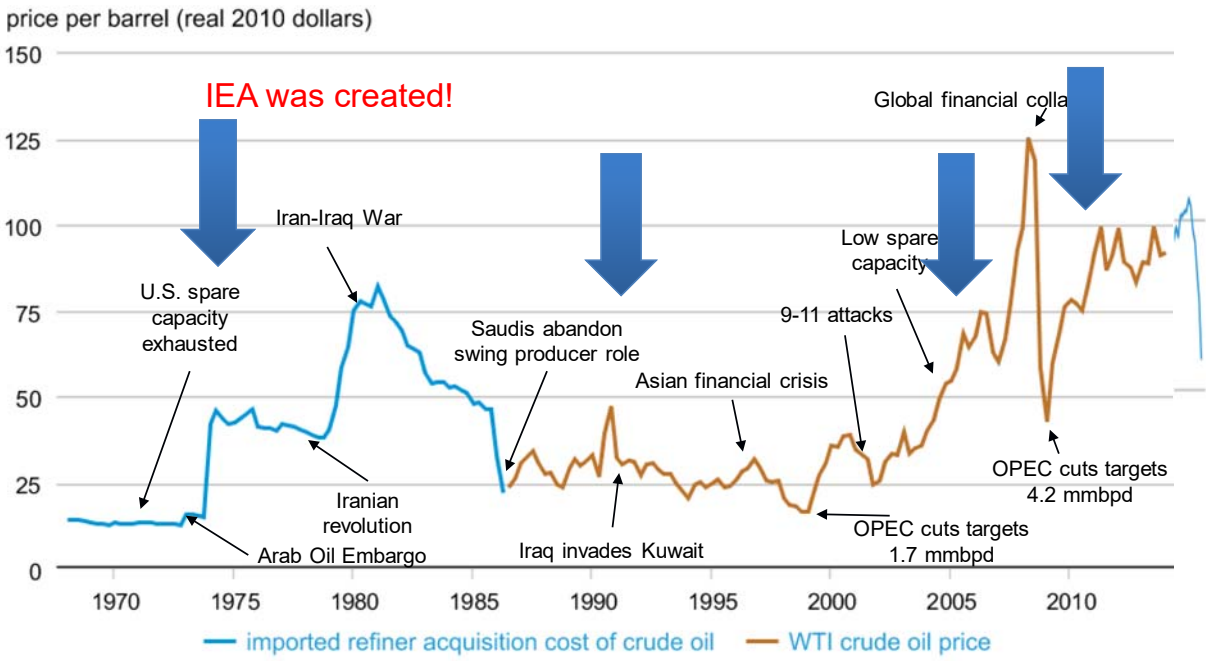
Stormy Energy Future:
Energy Security & Sustainability Strategy

2017-11-14 Japan-Russia Dialogue in Niigata

Former Executive Director, IEA
Chairman, the Sasakawa Peace Foundation
Nobuo TANAKA



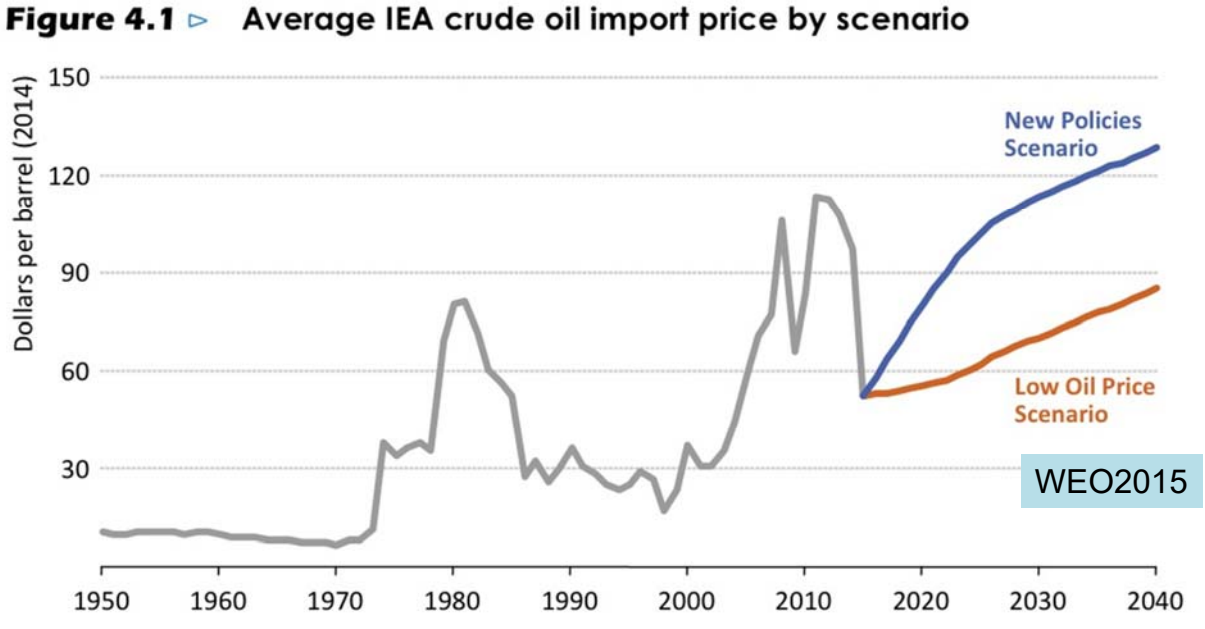
Historical Trend of Oil Price : Ups and Downs.



Sources: U.S. Energy Information Administration, Thomson Reuters

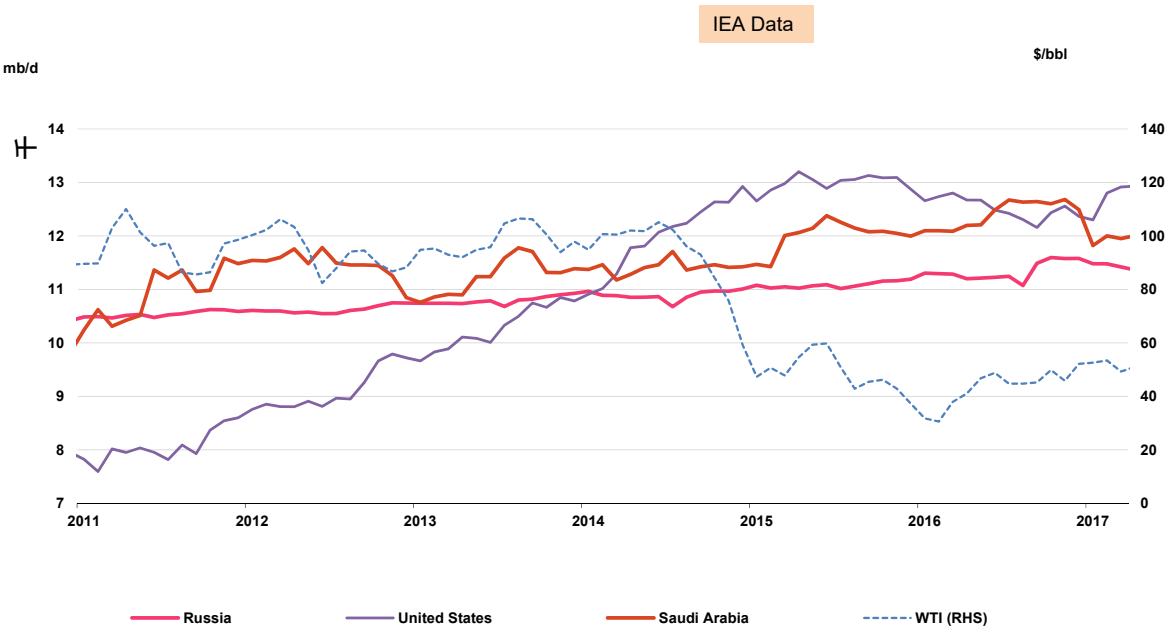
IEA released SPR three times in its history.

Low Oil Price Scenario: What are Pre-conditions for this scenario?



What will happen if Oil Price of $50 per barrel continues well into 2020s?

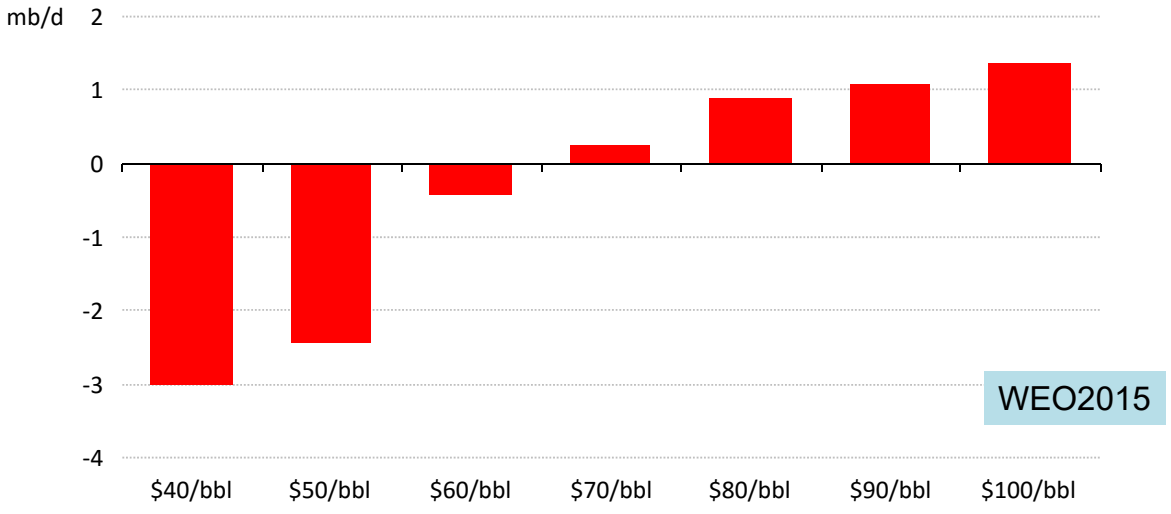
World's largest oil producers



US production has recovered to make it the largest producer. But who will be the world's largest producer in 2018 onward, the US, Saudi Arabia or Russia ?

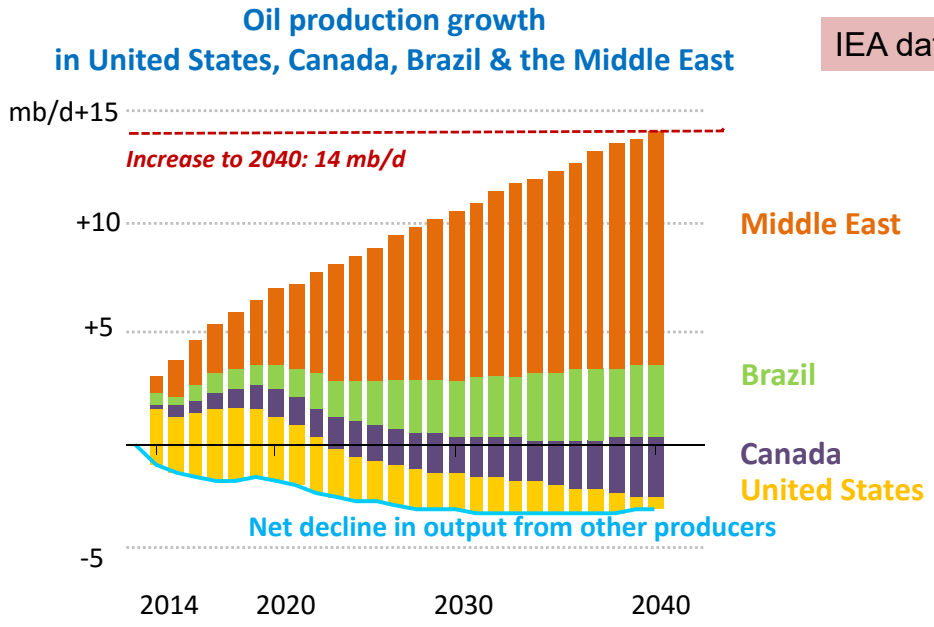
A new balancing item in the oil market?

Change in production (2015-2020) of US tight oil for a range of 2020 oil prices



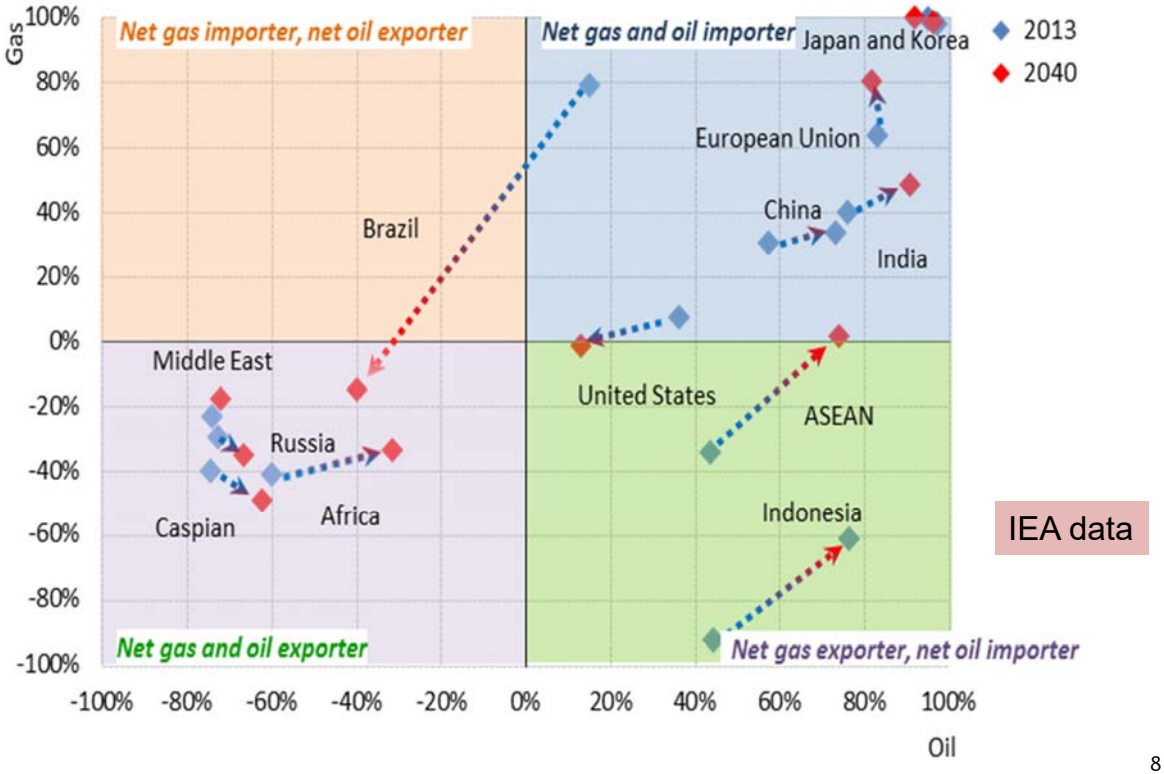
Tight oil has created more short-term supply flexibility, but there is no guarantee that the adjustment mechanism in oil markets will be smooth

Instability in the Middle East a major risk to oil markets



The short-term picture of a well-supplied market should not obscure future risks as demand rises to 103 mb/d & reliance grows on Iraq & the rest of the Middle East

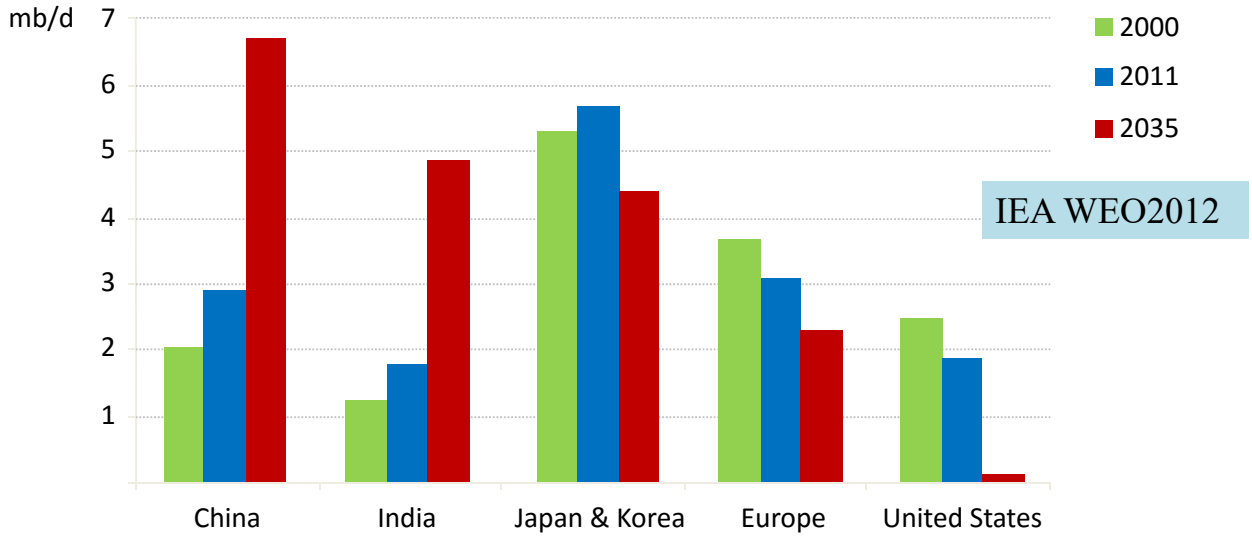
Geopolitics of the Shale Revolution: Strategic Positioning of Oil / Gas exporters and importers.



IEA data

North American Energy Independence and Middle East Oil to Asia: a new Energy Geopolitics

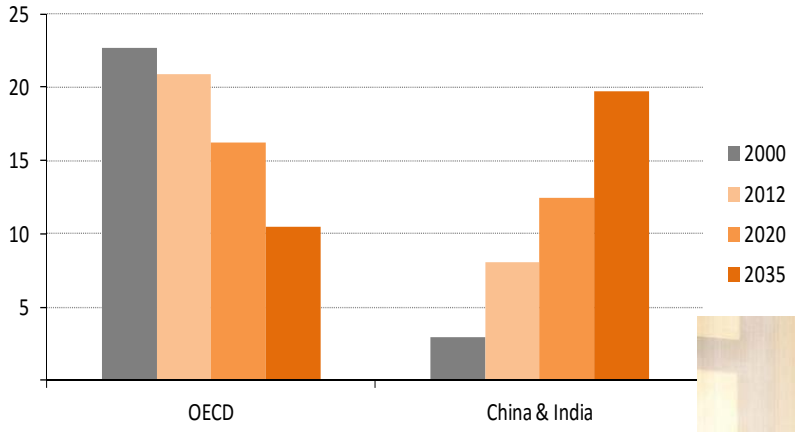
Middle East oil export by destination



IEA WEO2012

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

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



Should China and India join the IEA?

Asia becomes the unrivalled centre of the global oil trade as the region draws in a rising share of the available crude

The Choke Point: the Strait of Hormuz

85% of Japanese oil import
20% of Japanese LNG import
Chubu Electric depends 40% of its power supply on one source: Qatar.

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

82 million tons of LNG pa (30% of global demand)

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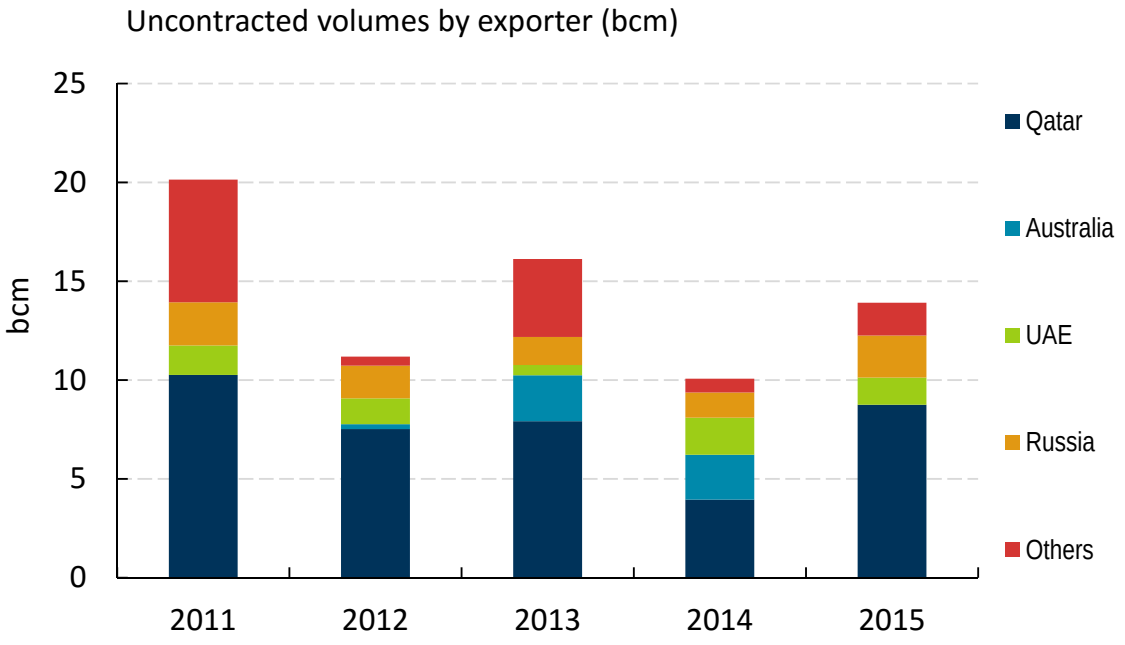
Qatar plays a pivotal role in LNG security



Qatar provides more than half of global uncontracted LNG volumes; Flexibility comes from uncontracted LNG, diversions, re-loads & contracts with open destinations

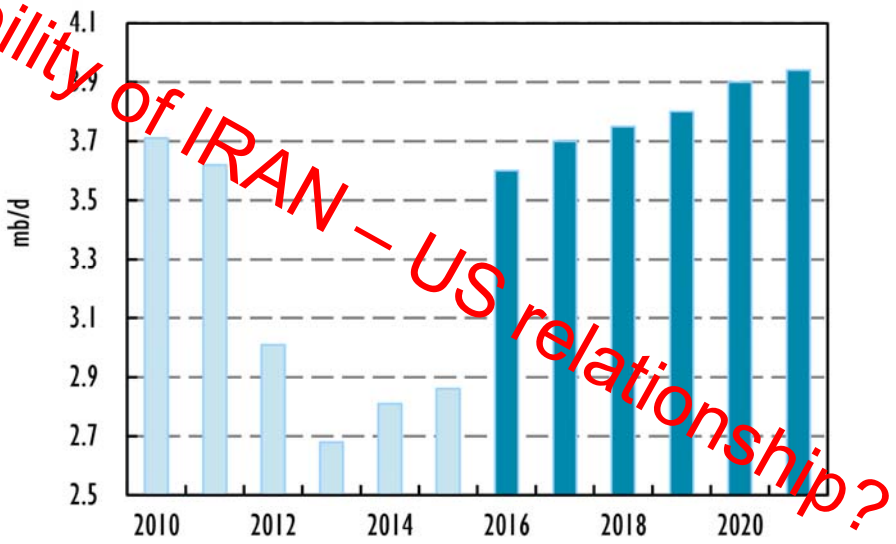
Global Gas Security Review2016

12

Post-sanctions Iran leads OPEC gains

Medium-Term Market Report 2016

Stability of IRAN – US relationship?



Actual production 2010-15, capacity thereafter

- ***Output to rise 1 mb/d to 3.9 mb/d by 2021***

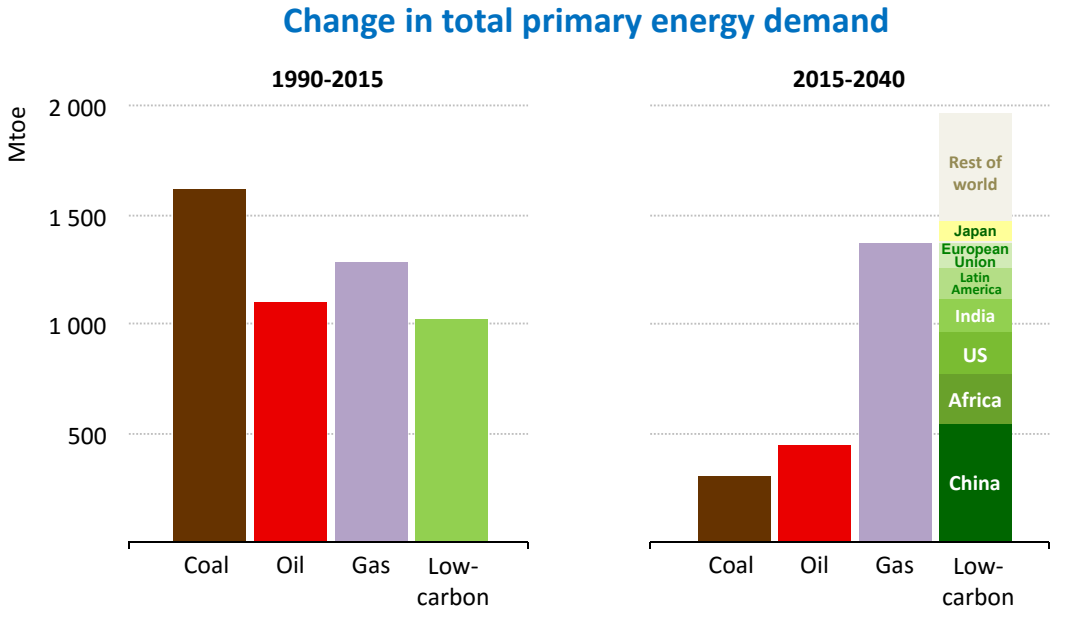
L'Aquila G8 Summit, 2009

Geopolitical risk linkage: MENA – NE Asia

Natural Gas: Sustainable and Secured Fuel

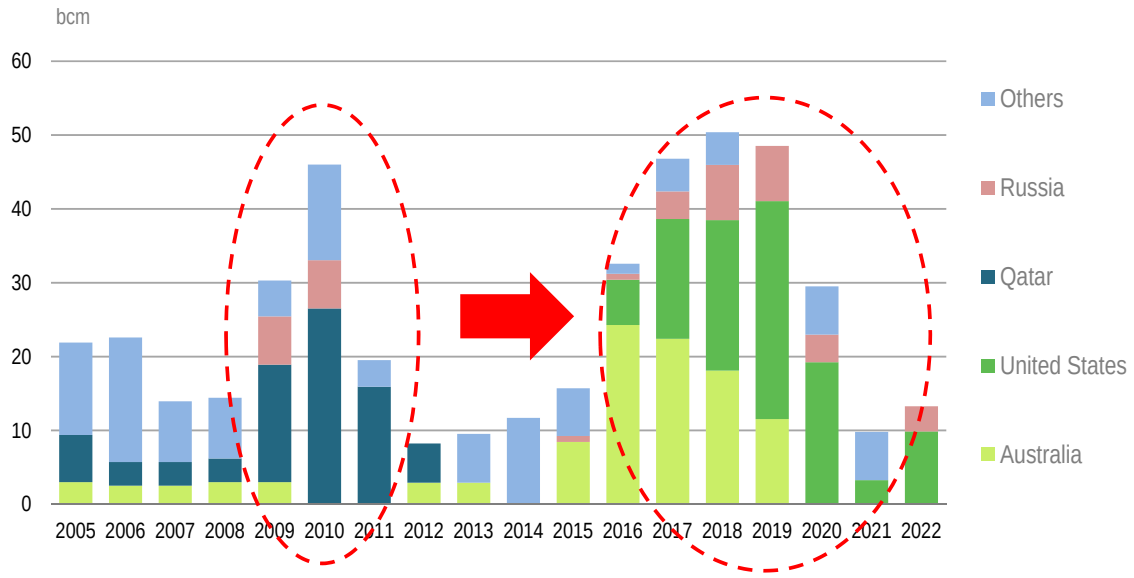
A new 'fuel' in pole position

WEO2016



Low-carbon fuels & technologies, mostly renewables, supply nearly half of the increase in energy demand to 2040

Second wave of additional LNG supply is already coming online

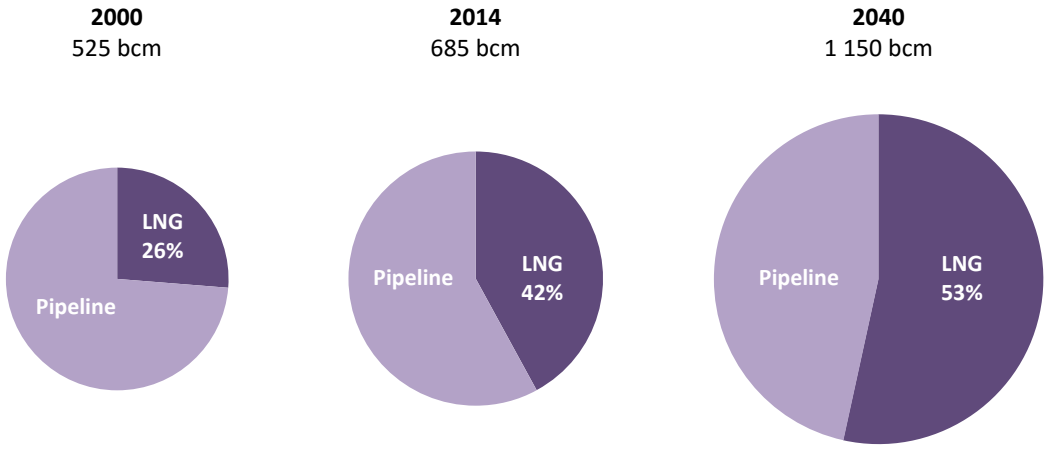


15 new projects with total export capacity of around 140 bcm are now under construction
Australia and the United States account for 75% of them

A wave of LNG spurs a second natural gas revolution

WEO2016

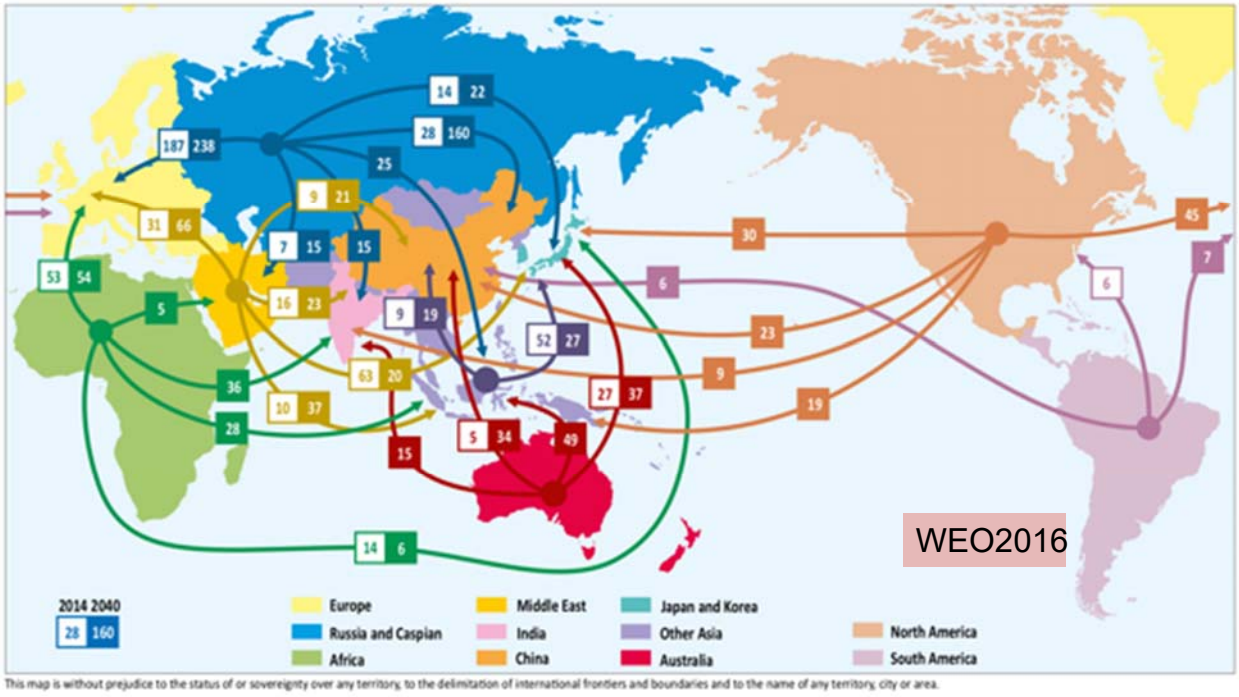
Share of LNG in global long-distance gas trade



Contractual terms and pricing arrangements are all being tested as new LNG from Australia, the US & others collides into an already well-supplied market

The concentration of import growth in Asia continues to redraw the inter-regional gas trade map, underpinning a fundamental shift in trade flows away from the Atlantic basin to the Asia-Pacific region

Figure 4.17 ▷ **Selected global gas trade flows in the New Policies Scenario** (bcm)



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The strong import growth in Asia underpins a fundamental shift in trade flows away from the Atlantic basin to the Asia-Pacific region

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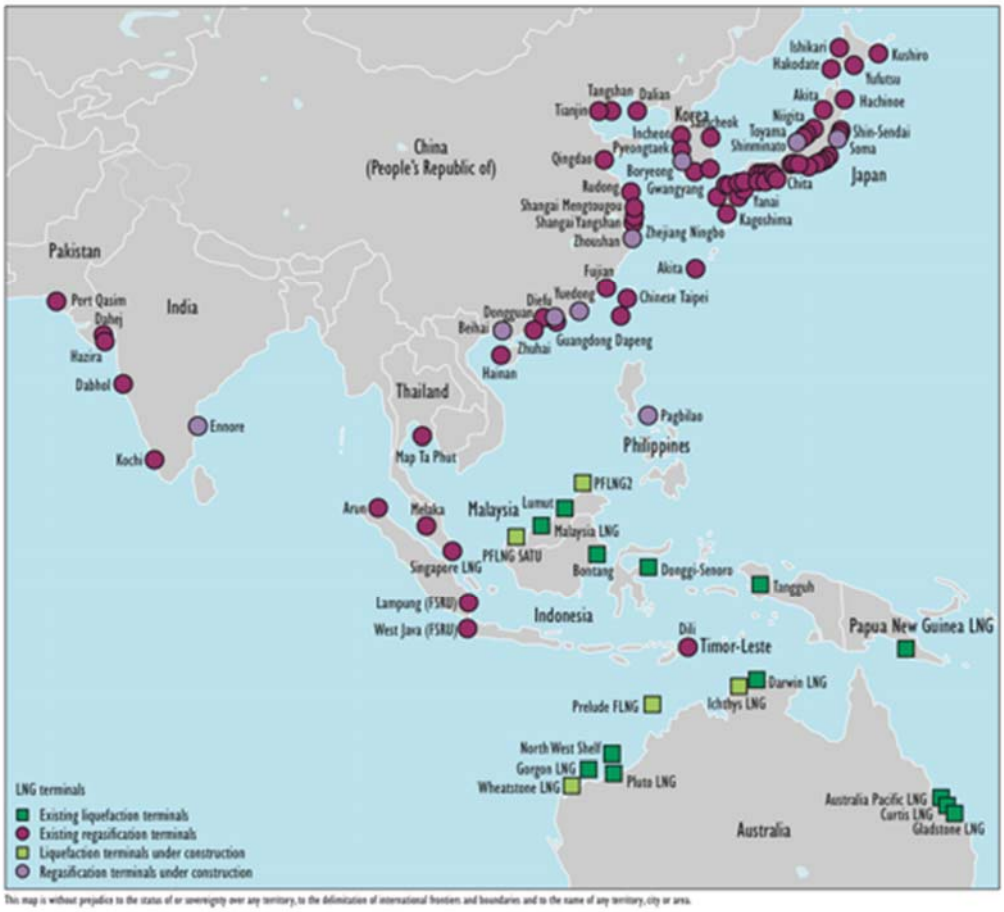
Map 3.1 Asia-Pacific LNG infrastructure



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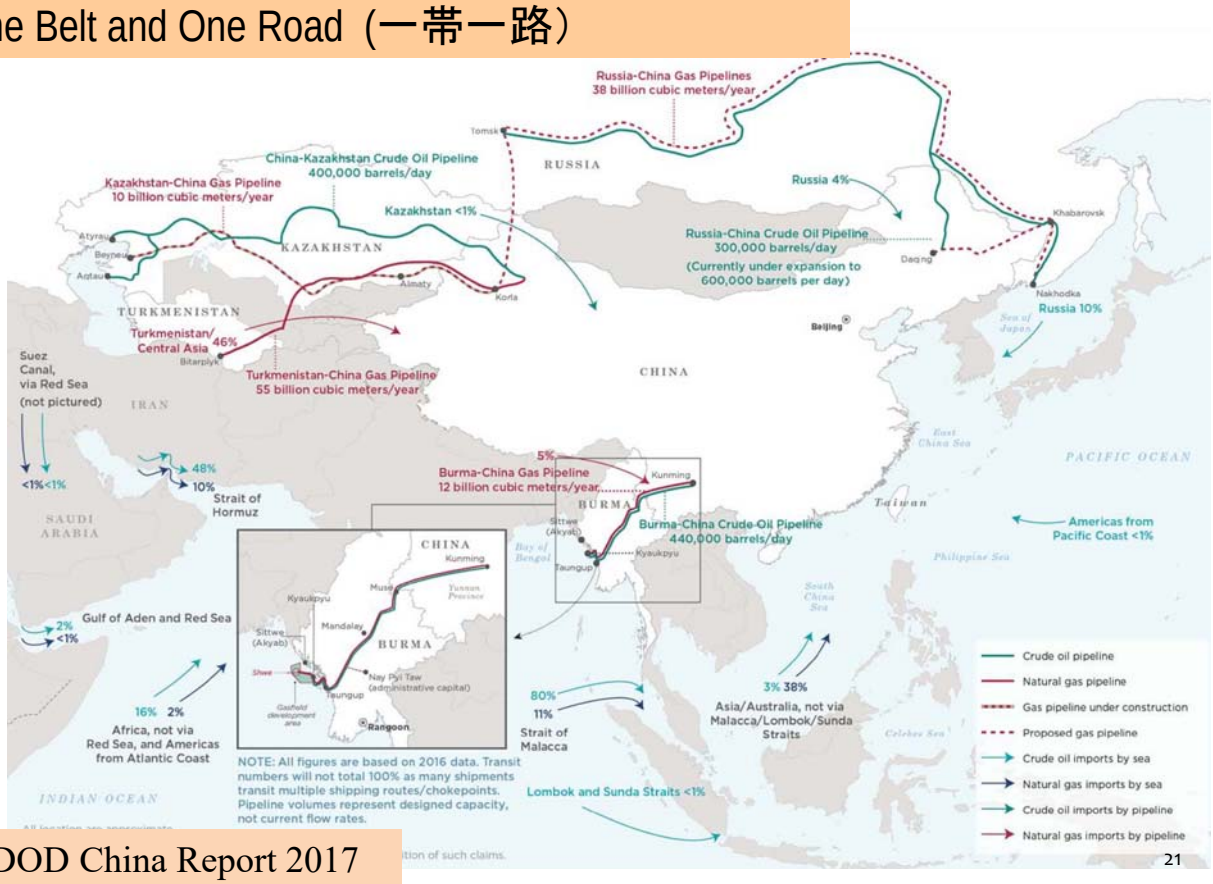
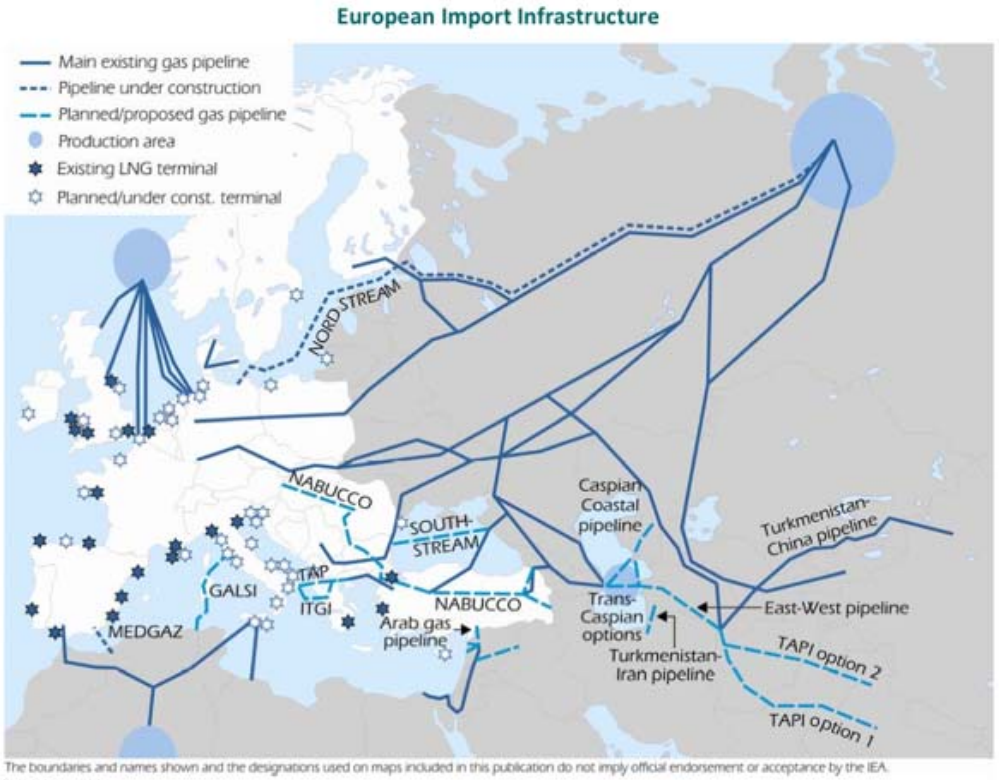
China's Oil and Gas Import Transit Routes:

One Belt and One Road（一帯一路）



USDOD China Report 2017

Natural Gas Import Infrastructure in Europe



Source: IEA.

IEA Medium Term Oil and Gas Markets 2010

Russian Gas Pipelines Will Extend to the East: Recent China Deal

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: IEA

Mid-Term Oil & Gas Market 2010, IEA

Putin inaugurated the new Icebraker LNG tanker, “Christophe De Margerie” .

Possible Pipeline Project from Russia to Japan

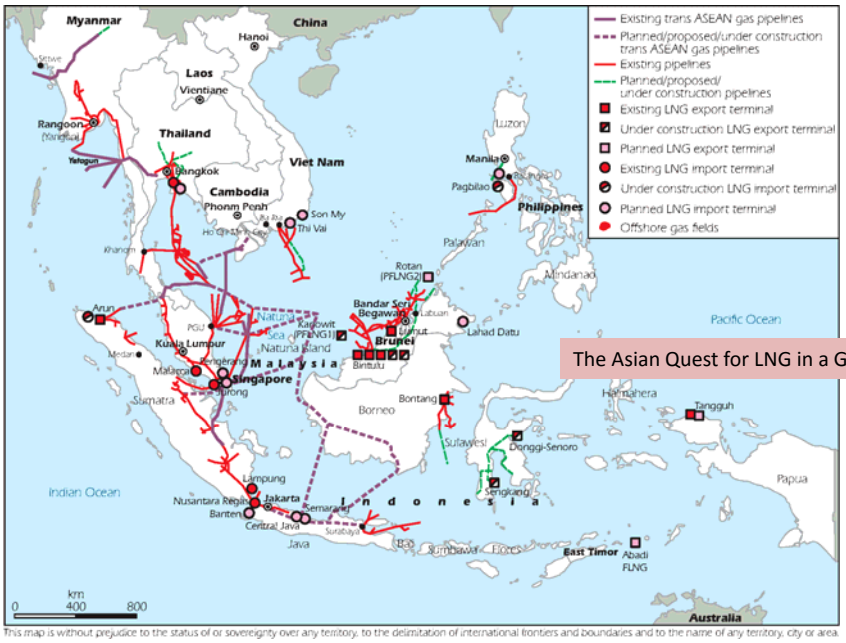
Figure 1. Proposed Subsea Pipeline Route*

* Only the Ishikari-Tomakomai section has onshore PL.

Estimated volume of 8bcm pa

Trading hub – Asian-tailored solution?

TAGP and LNG terminals in Southeast Asia



The Asian Quest for LNG in a Globalising Market

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

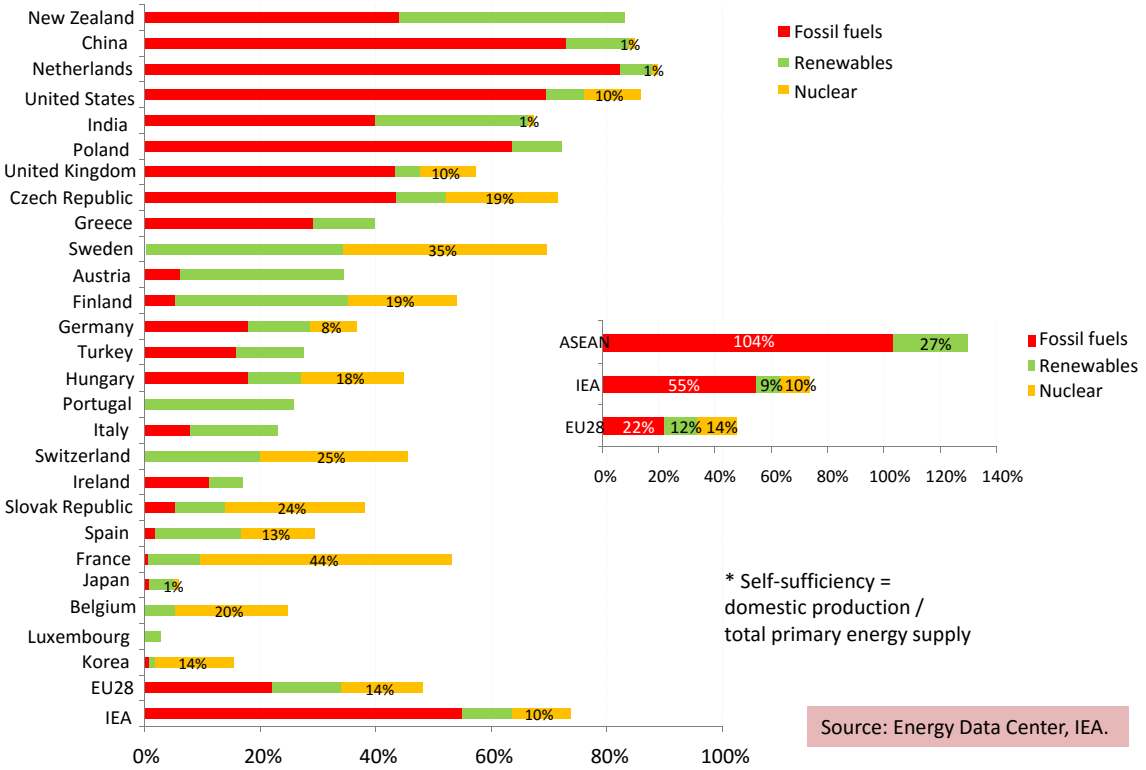
- Southeast Asian countries are already interlinked by pipeline and plan to increase these linkages through Trans ASEAN Gas Pipeline (TAGP) and LNG.

Blue Print for North East Asia Gas & Pipeline Infrastructure: Dr. Hirata's Concept

COLLECTIVE ENERGY SECURITY & SUSTAINABILITY

Collective Energy Security and Sustainability by Diversity, Connectivity and Nuclear

Energy self-sufficiency* by fuel in 2013



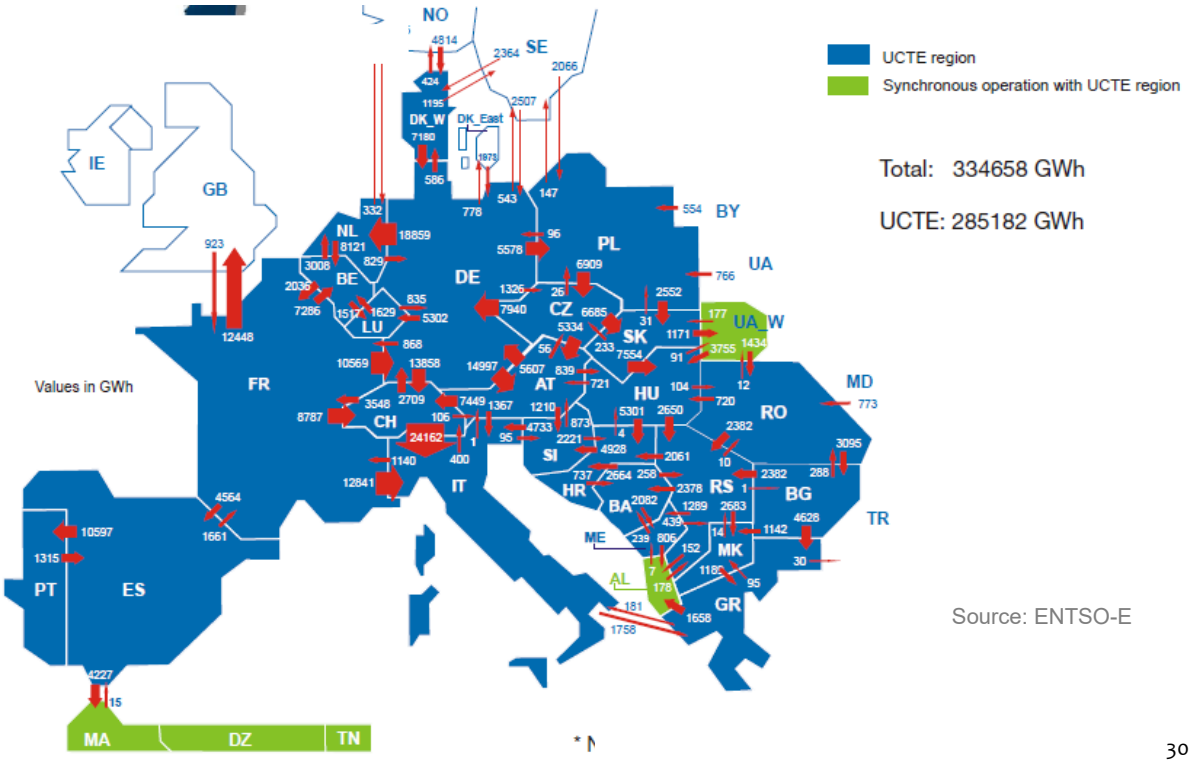
* Self-sufficiency = domestic production / total primary energy supply

Source: Energy Data Center, IEA.

Note: Does not include fuels not in the fossil fuels, renewables and nuclear categories.

Power Grid Connection in Europe: Collective Energy Security and Sustainability

Physical energy flows between European countries, 2008 (GWh)

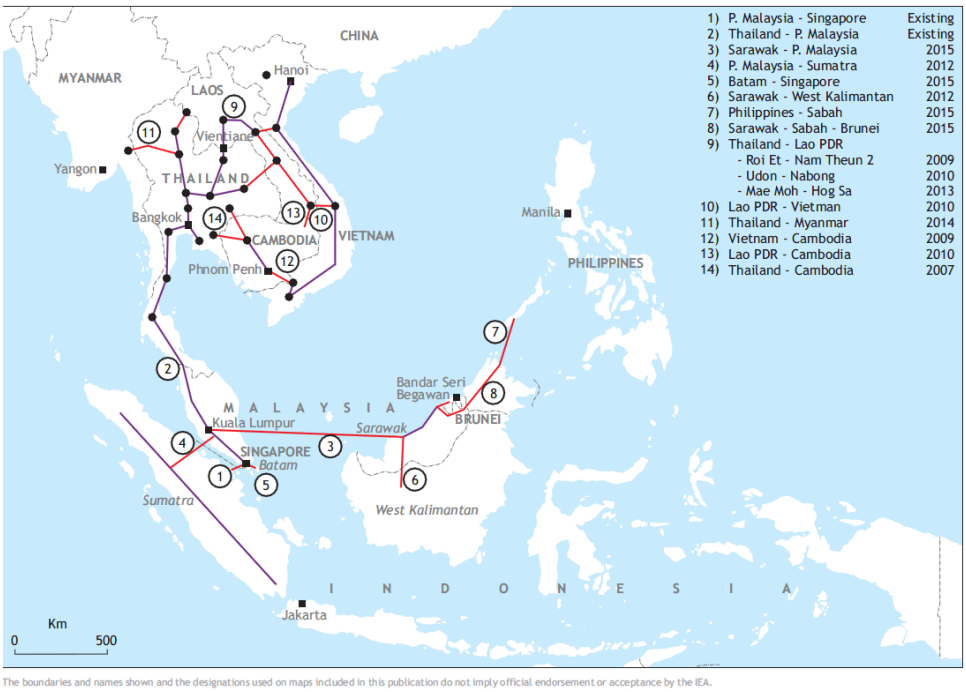


Source: ENTSO-E

Connecting MENA and Europe: " Desertec" as visionary “Energy for Peace"

Source: DESRETEC Foundation

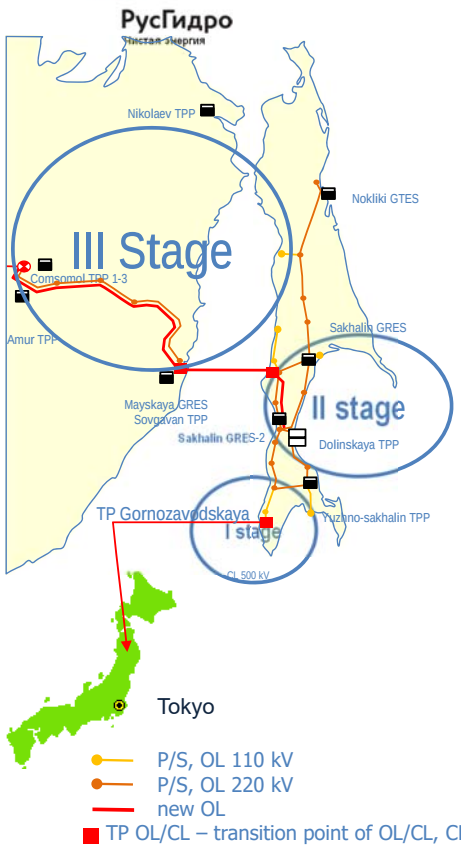
ASEAN power grid connection



GOBITECH Initiative

Renewable Energy in Asia through Sun and Wind

Power Bridge Project by Roshydro

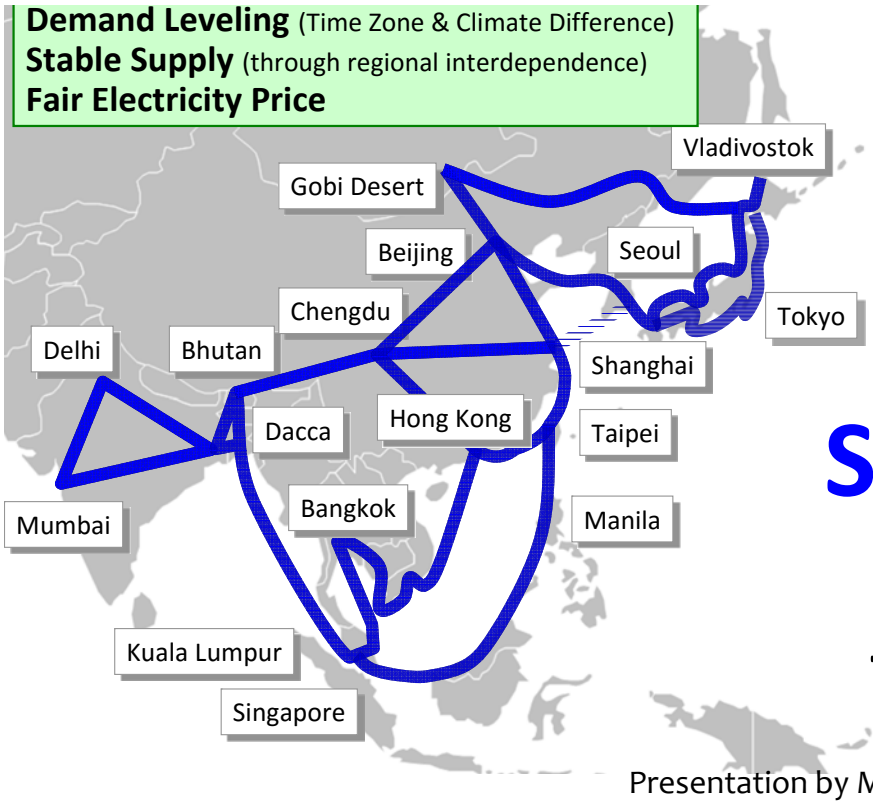


Stage	Ключевые мероприятия в российской части	Export volume	Actions for the laying of underwater cable
Stage I (2020)	• The construction of the 2-3 stages of the Sakhalin GRES-2 with the increase of installed capacity up to 360 MW • The construction of grid infrastructure (additional OL, OL/CL converter station Gornozavodskaya)	Up to 400 MW	Installation of underwater cable from Sakhalin island to Northern Hokkaido (Ishikari/Wakkanai) with a distance of 50-200 km*
Stage II (2022)	• The construction of a large export-oriented generation "Dolinskaya TPP" (up to 660 MW) • Further expansion of the network infrastructure	Up to 1000 MW	Installationof underwater cable from Hokkaido (Ishikari/Wakkanai) to Aomori (Honshu) with a distance of 650-800 km*
Stage III (2025)	• The connection of the Sakhalin energy system with the United Energy System of the East by underwater DC cable	2-4 GW	Installation of a submarine from Aomori (Honshu) cable to Kashiwazaki (Honshu) with a distance of 400 km

Total cost for 3 stages in the Russian part of the Project is estimated at USD 5.7 billion. excluding costs for the construction of additional generation in the UES of the East to increase exports volumes

* - depends on the choice of connection point in Japan

"Energy for Peace in Asia" New Vision?



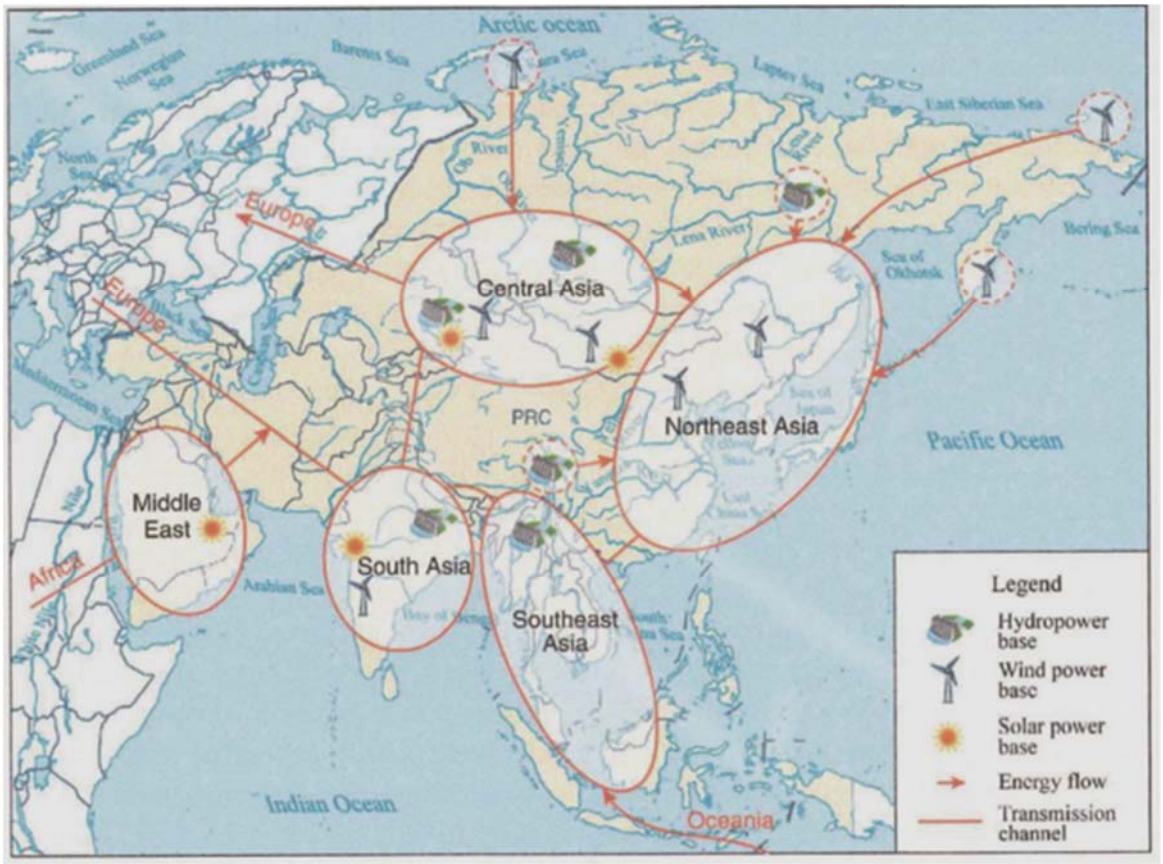
Phase 3

Asia Super Grid

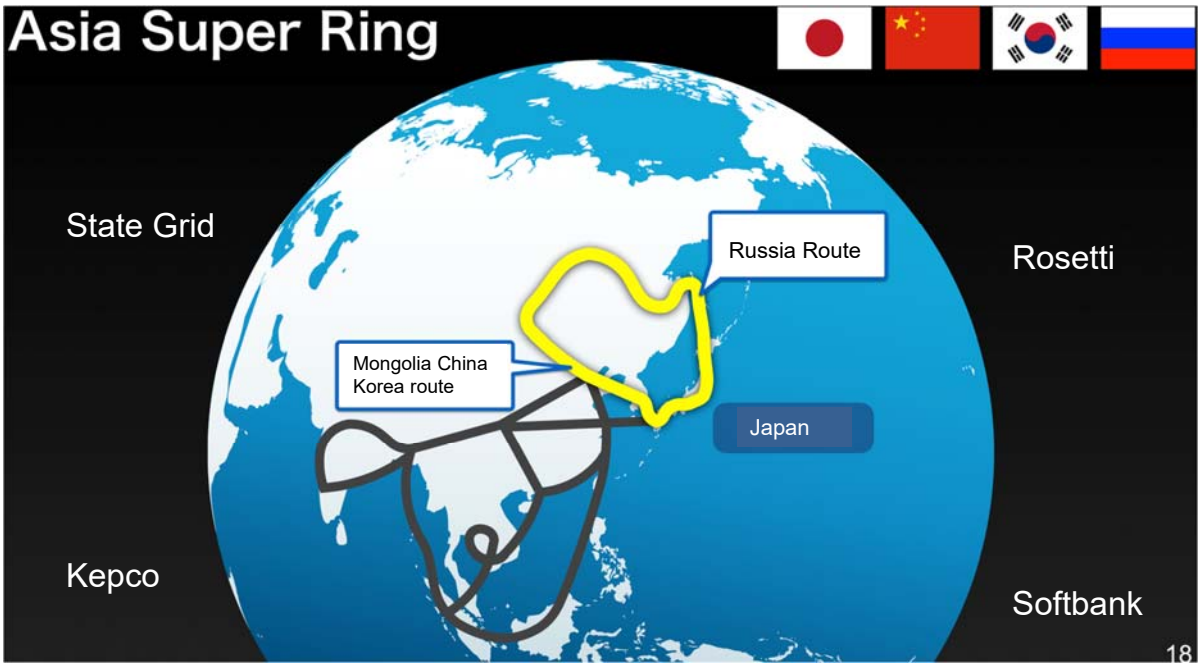
Total 36,000km

Presentation by Mr. Masayoshi SON

Global Energy Interconnection/ GEIDCO by State Gri

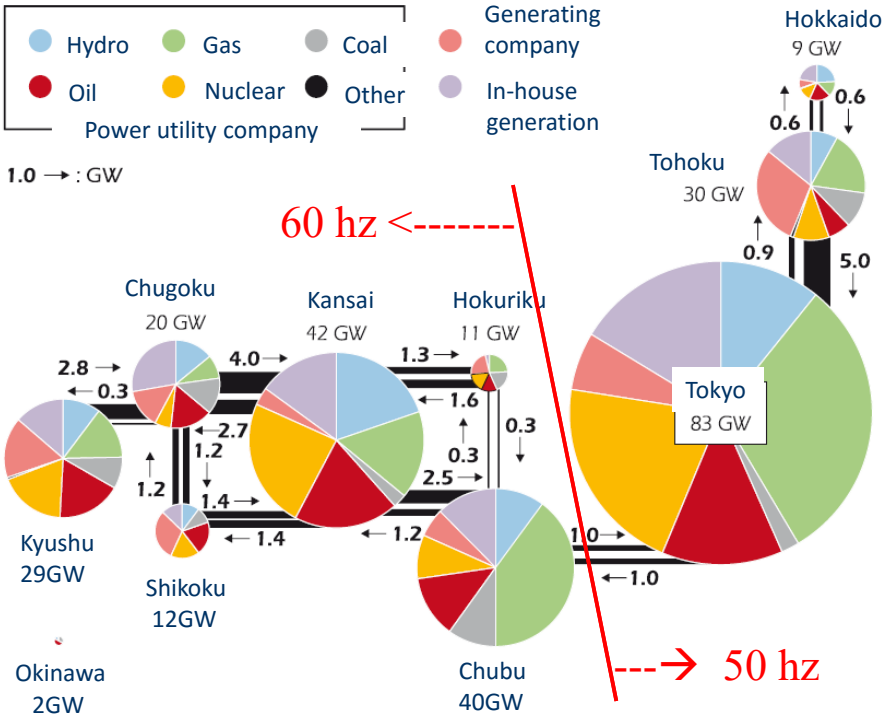


Asia Super Ring



Masayoshi SON's proposal

Lack of Grid connectivity in Japan



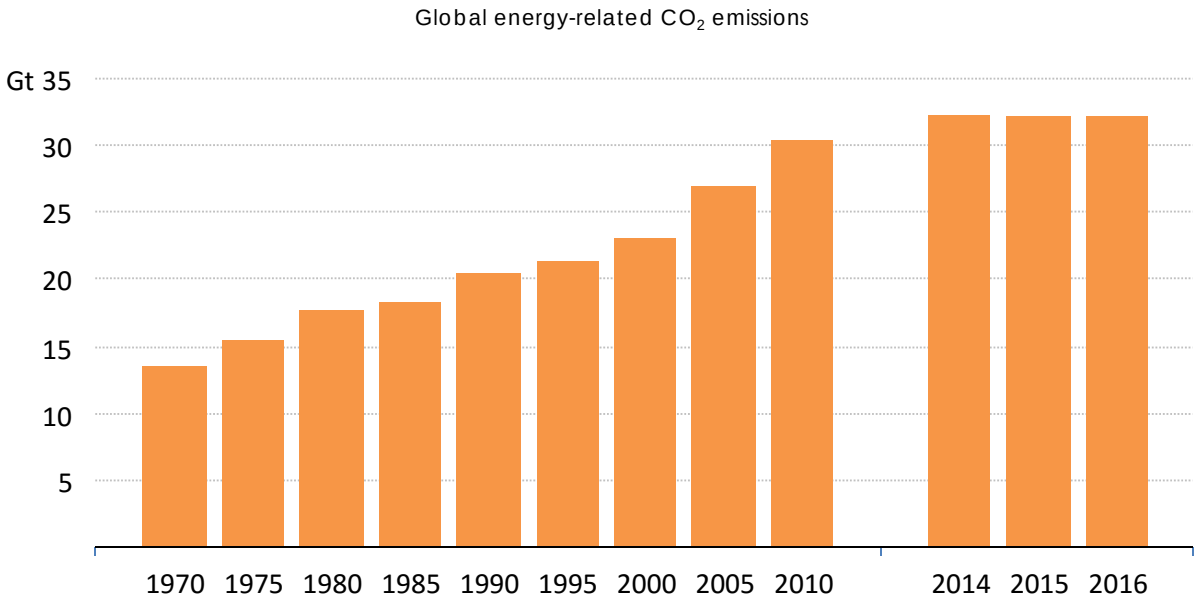
Source: Agency for Natural Resources and Energy, The Federation of Electric Power Companies of Japan, Electric Power System Council of Japan, The International Energy Agency

Climate Change: New Challenges to Energy

Energy Technology Perspectives 2017

Catalysing Energy Technology Transformations

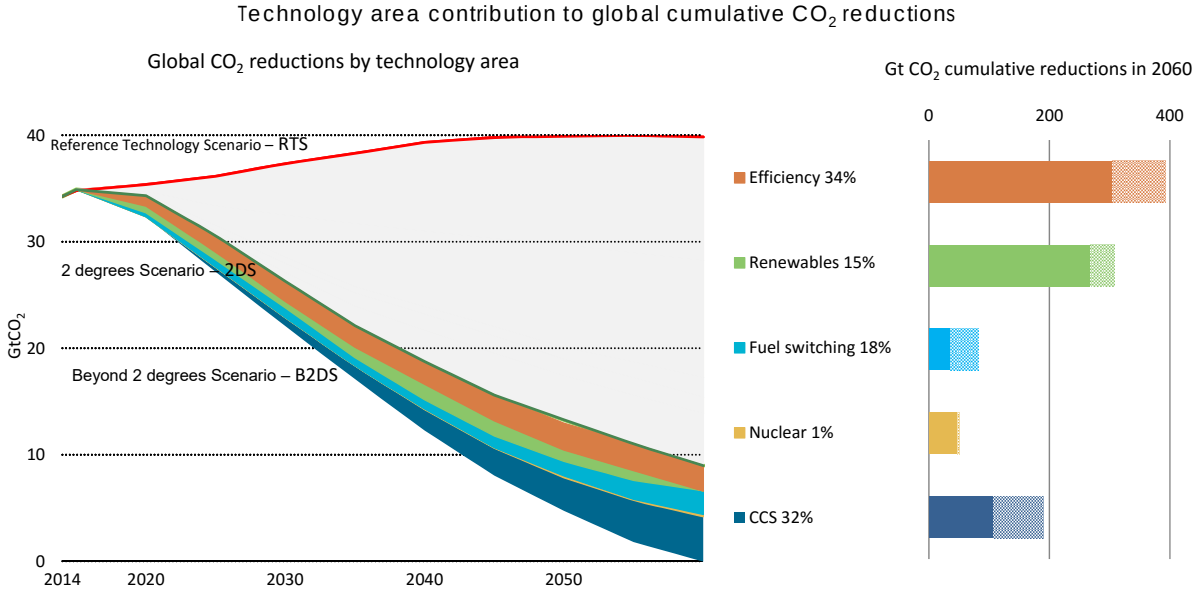
Global CO_2 emissions flat for 3 years – an emerging trend?



ETP2017

IEA analysis shows that global CO_2 emissions remained flat in 2016 for the third year in a row, even though the global economy grew, led by emission declines in the US and China

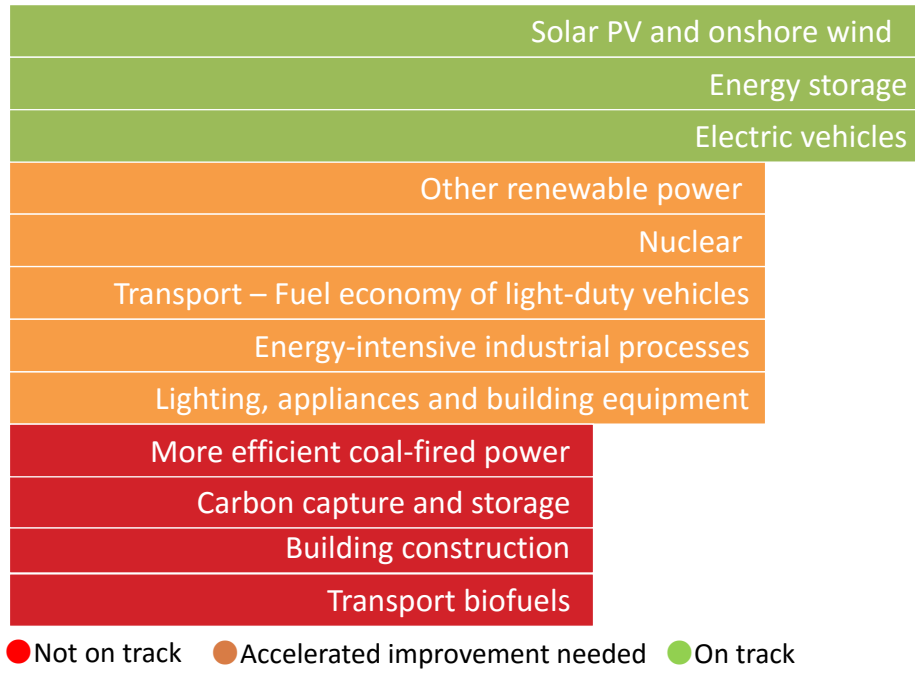
How far can technology take us?



ETP2017

Pushing energy technology to achieve carbon neutrality by 2060 could meet the mid-point of the range of ambitions expressed in Paris

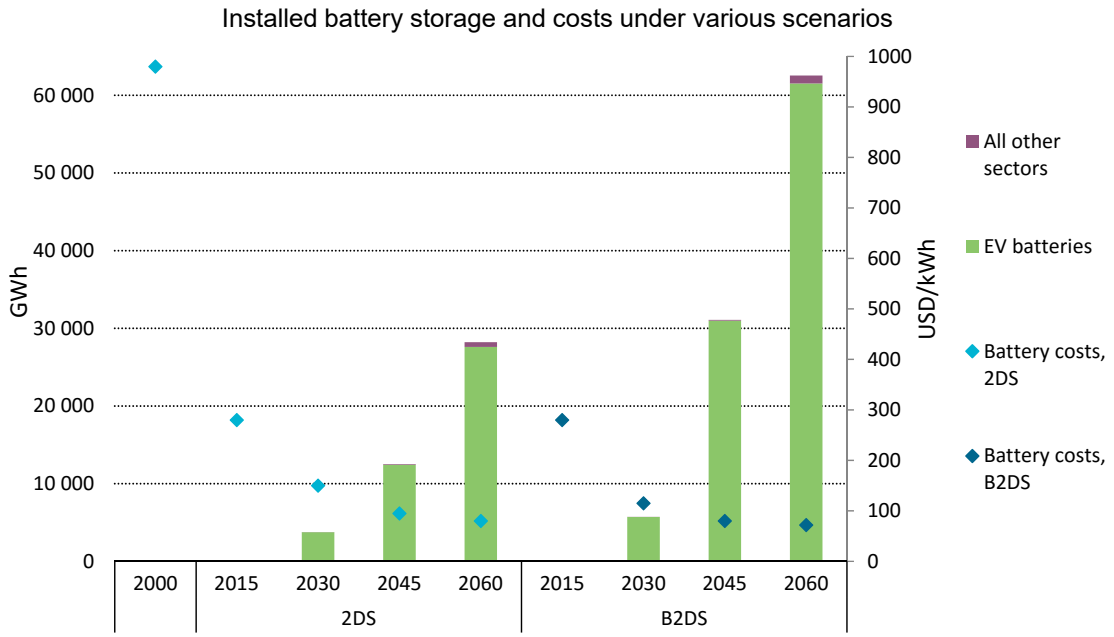
The potential of clean energy technology remains under-utilised



ETP2017

Recent progress in some clean energy areas is promising, but many technologies still need a strong push to achieve their full potential and deliver a sustainable energy future

Can we enact a storage revolution

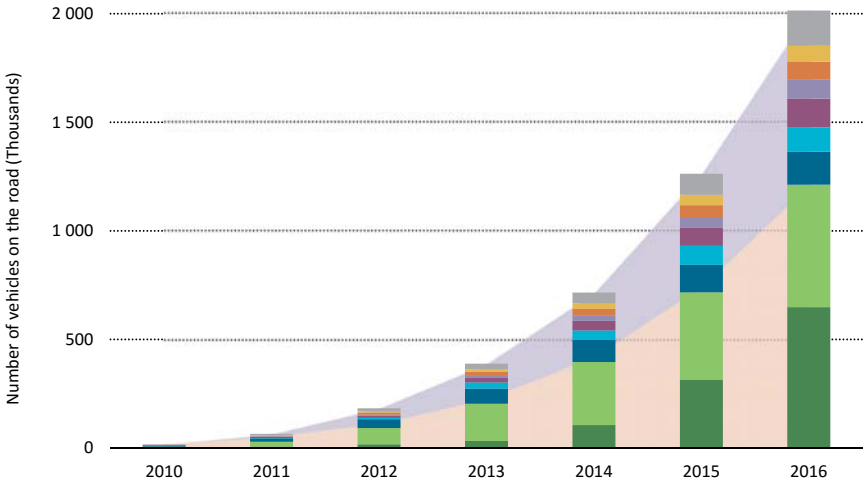


ETP2017

Batteries experience a huge scale-up in the B2DS, with EV battery markets leading other sectors in size

EVs are still on track,

Evolution of the global BEV and PHEV stock, 2010-2016

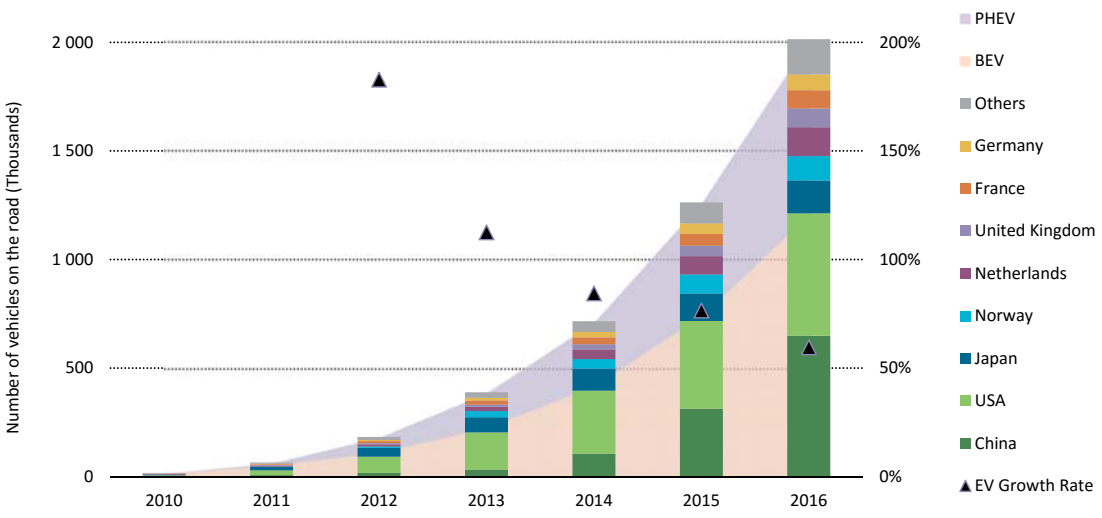


ETP2017

The global PEV car stock has reached 2 million units in circulation last year,

EVs are still on track, but need continued support

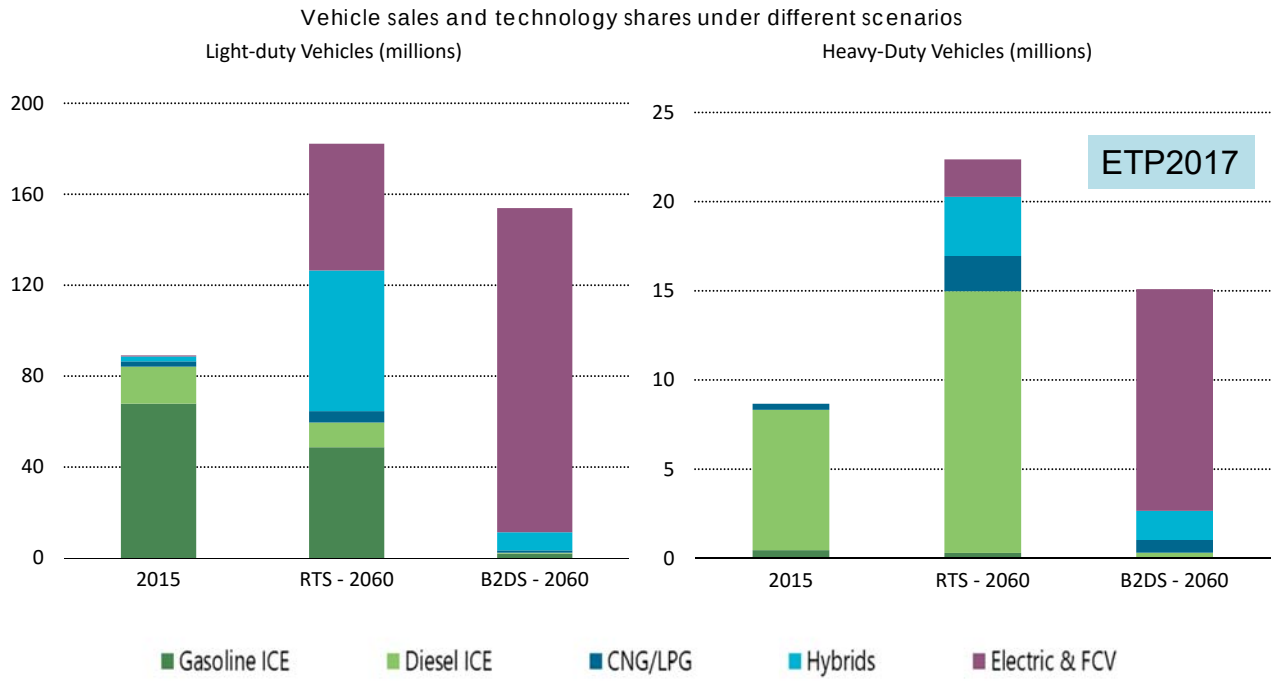
Evolution of the global BEV and PHEV stock, 2010-2016



ETP2017

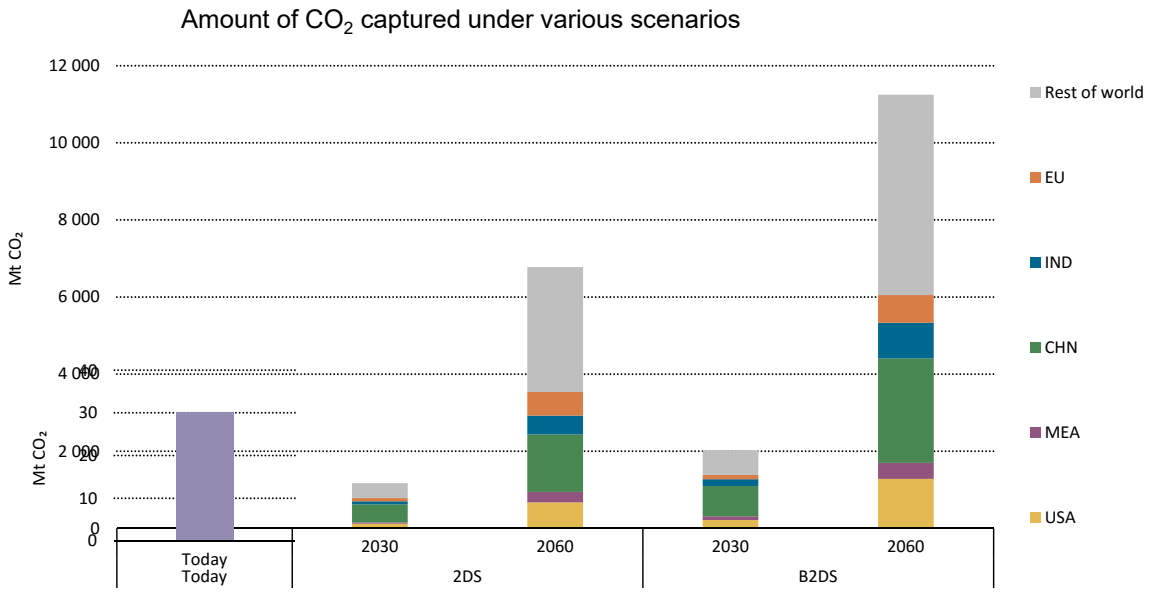
The global PEV car stock has reached 2 million units in circulation last year, but sales growth went from 70% last year to 40% this year, suggesting an increasing risk to start diverging from a 2DS trajectory. By 2030, RTS means 56million EVs, 2DS 160 million, and B2DS 200 million.

Can we change the landscape of transport ?



the B2DS would require strong policy signals, such as no emissions zone and bans on the sale of internal combustion engines (ICEs)

A challenging task ahead for CCS



ETP2017

CCS is happening today, but needs to be ramped up hundreds of times to achieve long-term goals
The role for CCS varies based on local circumstances

Saudi Aramco is worrying about Peak Demand of Oil.

WEO 2013

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

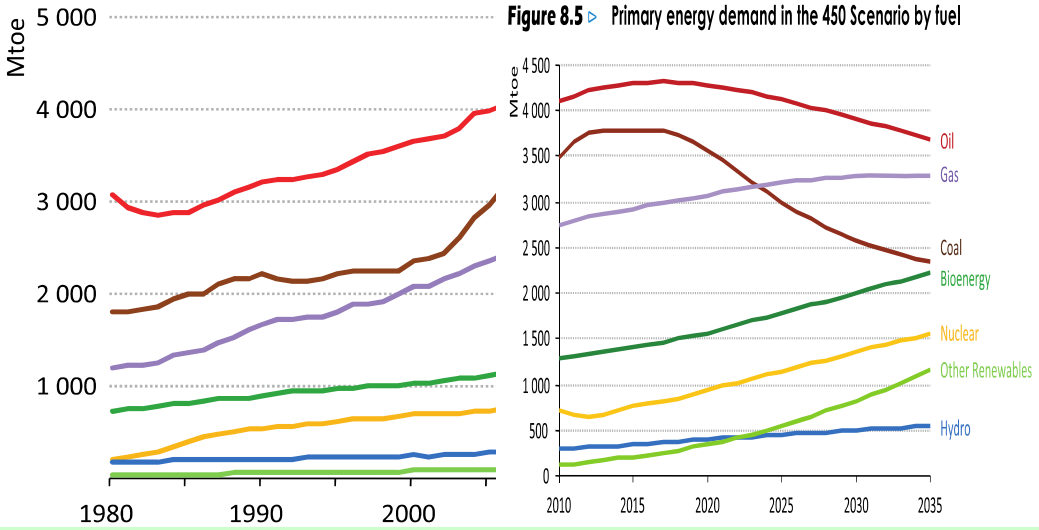
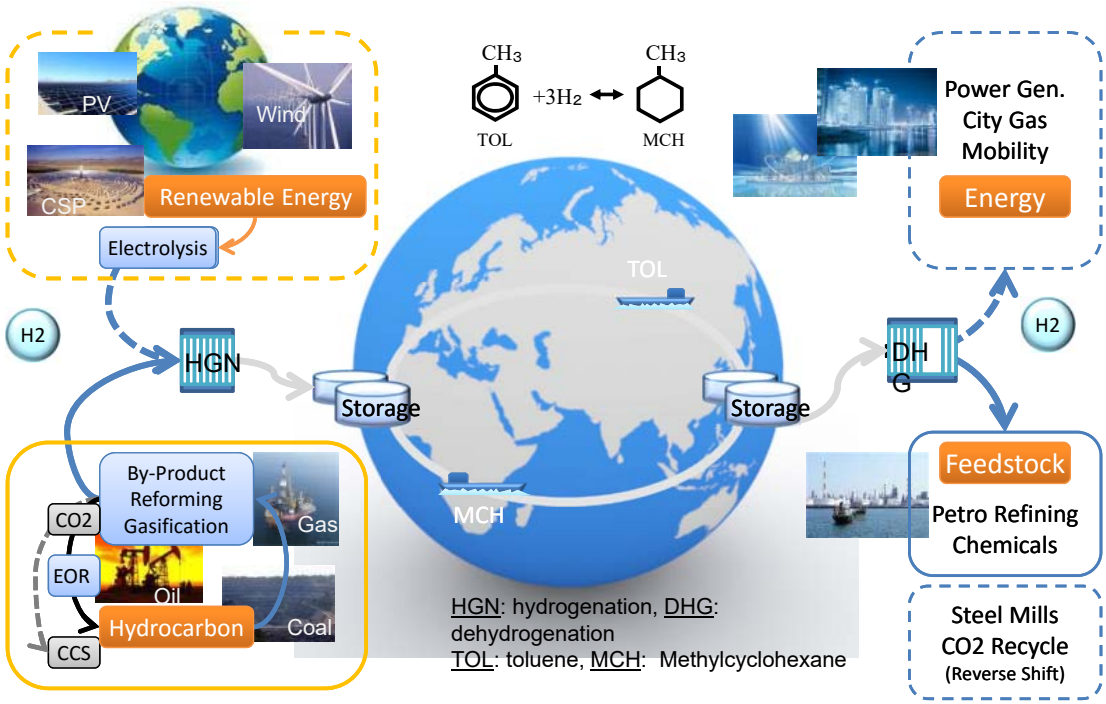


Figure 8.5 ▷ Primary energy demand in the 450 Scenario by fuel

The Stone Age didn't end because we ran out of stones.

Hydrogen as solution: Chiyoda's Supply Chain Proposal

- 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.



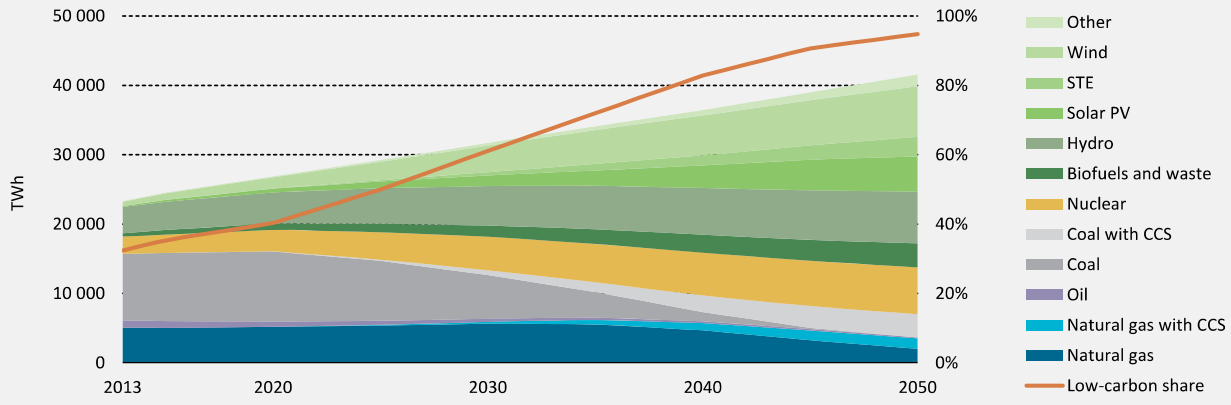
- H2 Supply of a 0.1-0.2mmtpa LNG equivalent scale (M.E. to Japan) could be feasible.

CHIYODA CORPORATION

SUSTAINABLE NUCLEAR POWER

Figure 1.7 Global electricity generation mix in the 2DS, 2013-50

ETP2016



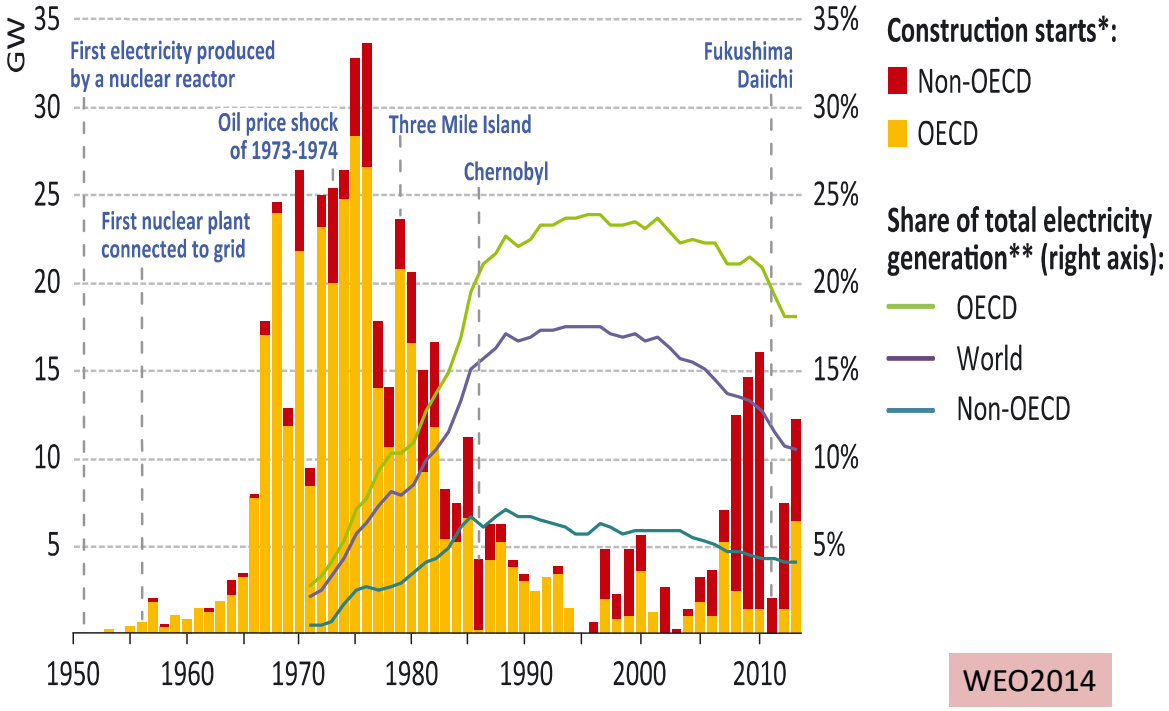
Notes: STE = solar thermal electricity. Low-carbon share refers to the combined share of the generation of electricity from renewables, nuclear and CCS.
Source: IEA analysis and IEA (2015f), *World Energy Statistics and Balances*, www.iea.org/statistics.

Key point *Today fossil fuels dominate electricity generation with 68% of the generation mix; by 2050 in the 2DS, renewables reach a similar share of 67%.*

- 2013 Generation share
  - Fossil fuels: 68%
  - Renewables: 22%
  - Nuclear : 11%

- 2DS 2050
  - Renewables: 67%
  - Fossil fuels: 17% (CCS12%)
  - Nuclear : 16%

History of Construction of Nuclear Reactors

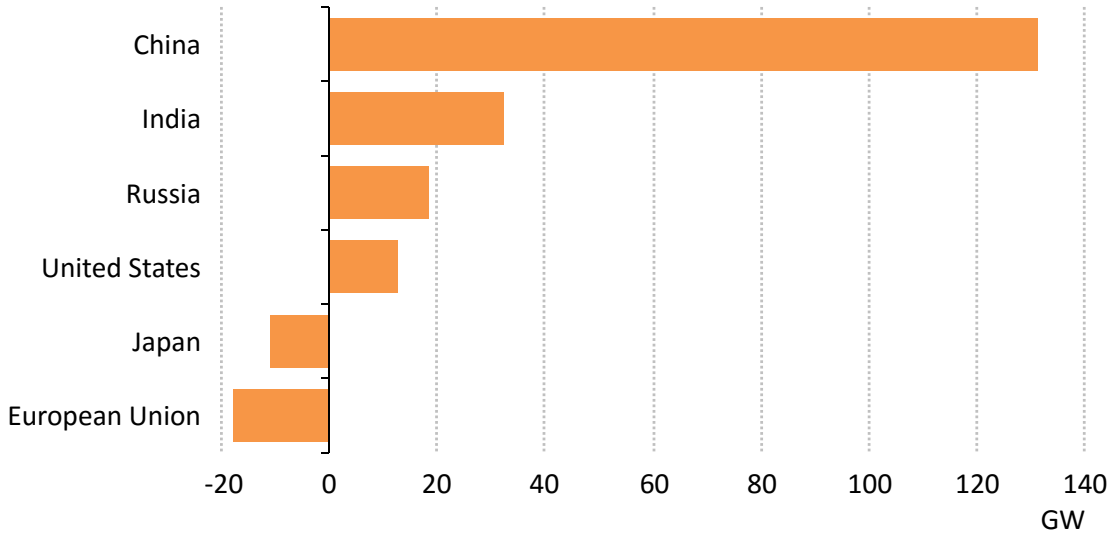


WEO2014

Nuclear capacity grows by 60%, but no nuclear renaissance in sight

WEO2014

Net capacity change in key regions, 2013-2040

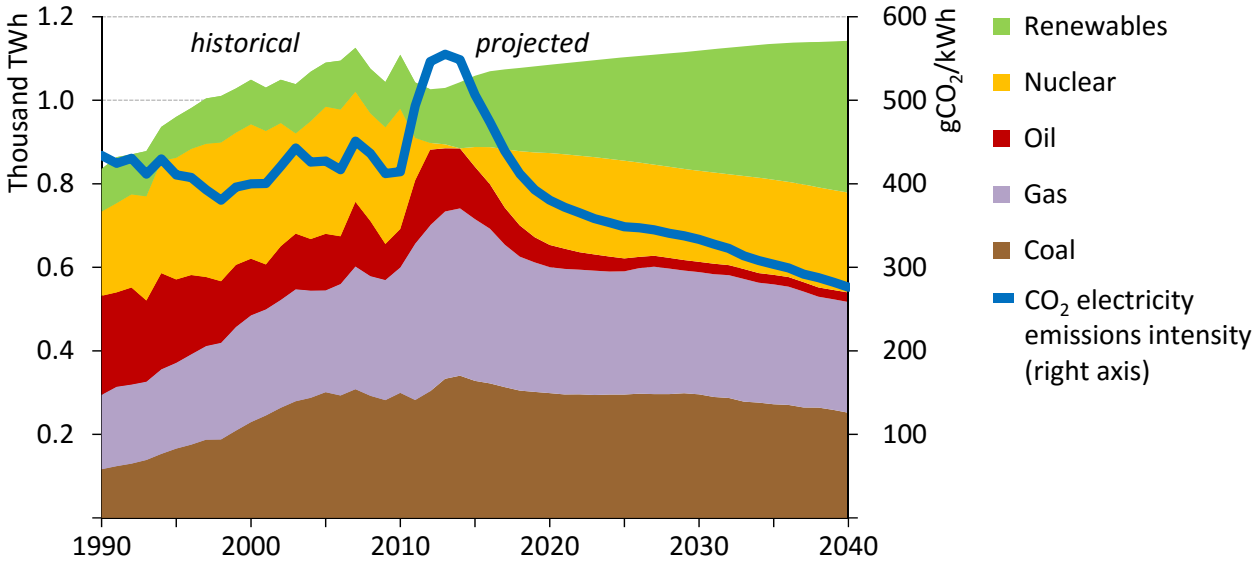


Capacity grows by 60% to 624 GW 2040, led by China, India, Korea & Russia; yet the share of nuclear in the global power mix remains well-below its historic peak

Japan's power system: moving to a more diverse & sustainable mix

WEO2014

Japan electricity generation by source and CO2 intensity



With nuclear plants expected to restart & increased use of renewables, Japan's electricity mix becomes much more diversified by 2040 (Renewables 32%, Nuclear 21%, gas 23%, coal 22%)

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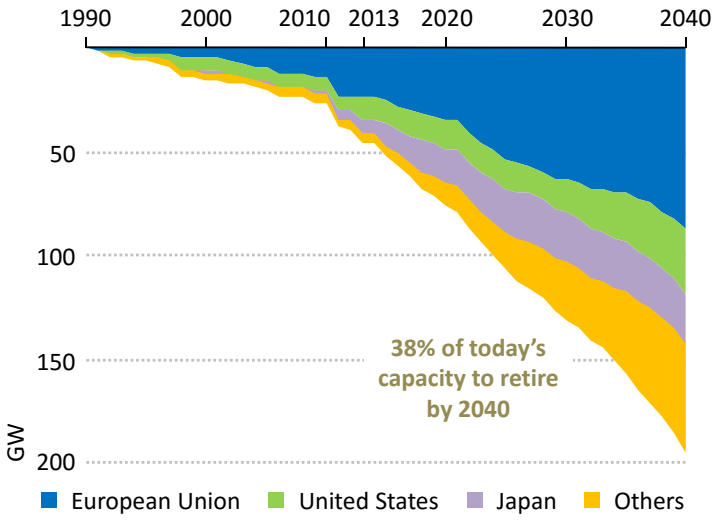
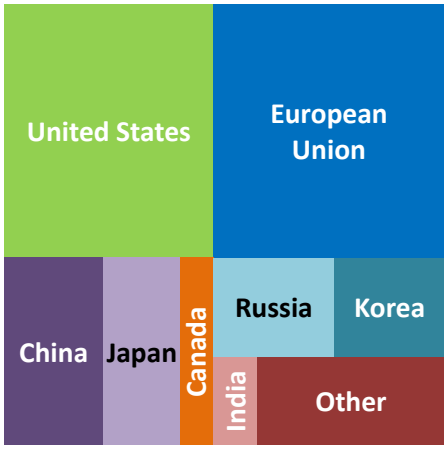
Nuclear power: public concerns must be heard and addressed

WEO2014

Retirements of nuclear power capacity 1990-2040



Spent nuclear fuel 1971-2040: 705 thousand tonnes



Key public concerns include plant operation, decommissioning & waste management; & the amount of spent fuel doubles By 2040, almost 200 reactors are retired

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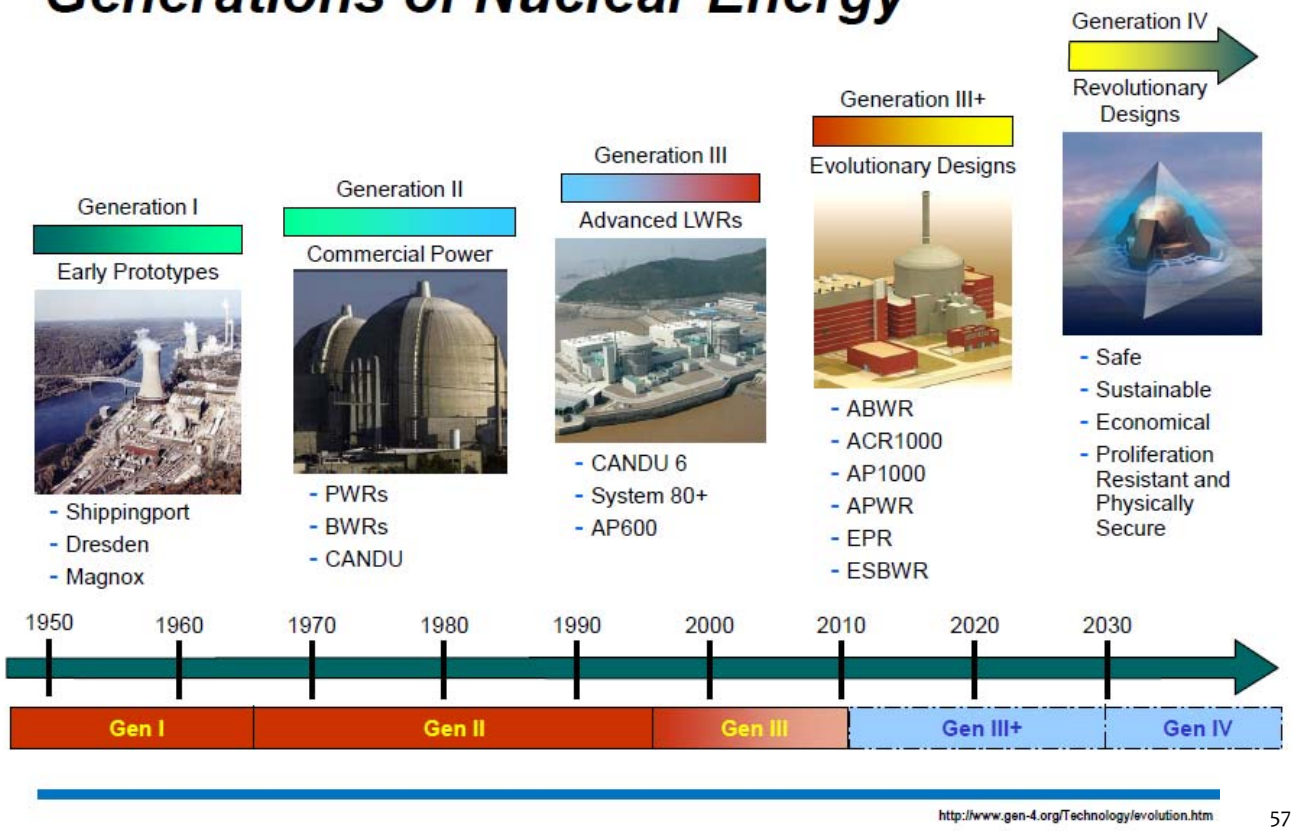
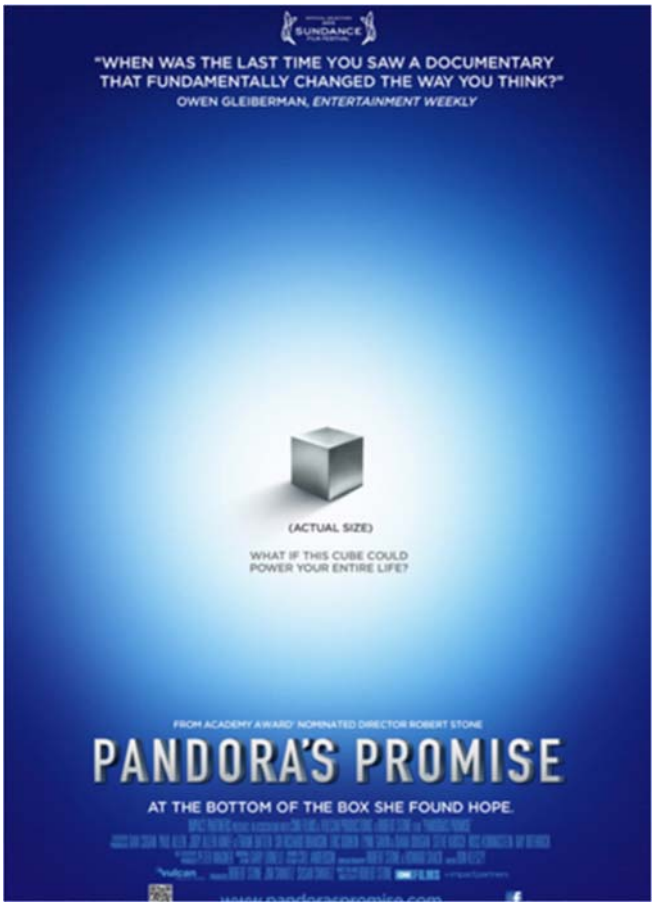
Generations of Nuclear Energy



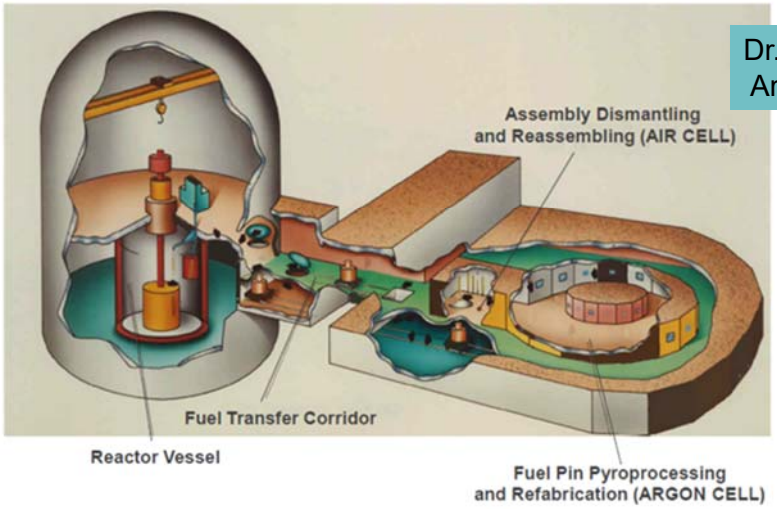
http://www.gen-4.org/Technology/evolution.htm



"Pandora's Promise", a movie directed by Robert Stone, is a documentary of environmentalists who changed their views about Nuclear Power.
IFR (EBR2) story comes up as missed opportunity.

Time for Safer, Proliferation resistant and Easier Waste Management Paradigm: Integral Fast Reactor and Pyroprocessing

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

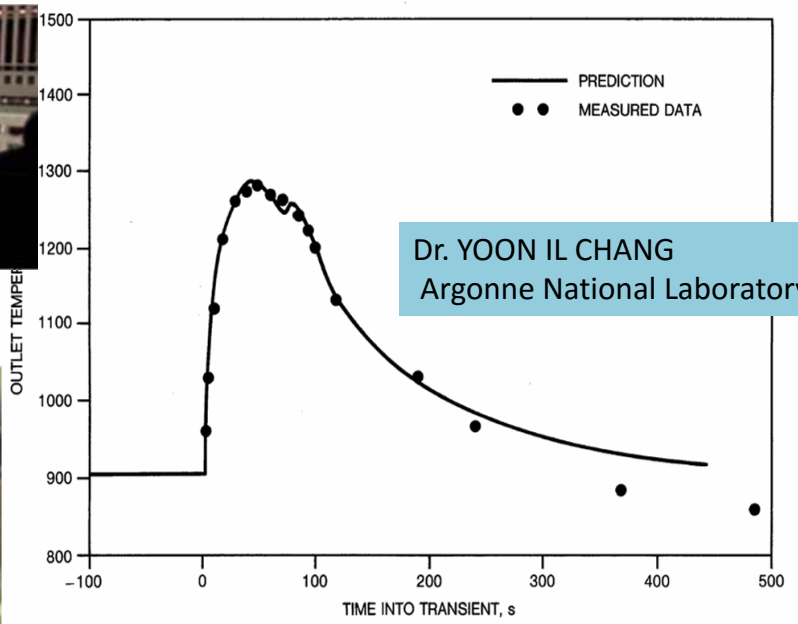


Dr. YOON IL CHANG
Argonne National Laboratory

IFR has features as Inexhaustible Energy Supply ,Inherent Passive Safety ,Long-term Waste Management Solution , Proliferation-Resistance , Economic Fuel Cycle Closure.
High level waste reduces radioactivity in 300 years while LWR spent fuel takes 100,000 years.

Passive Safety was proven by the 1986 Experiment very similar to the Fukushima event.

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

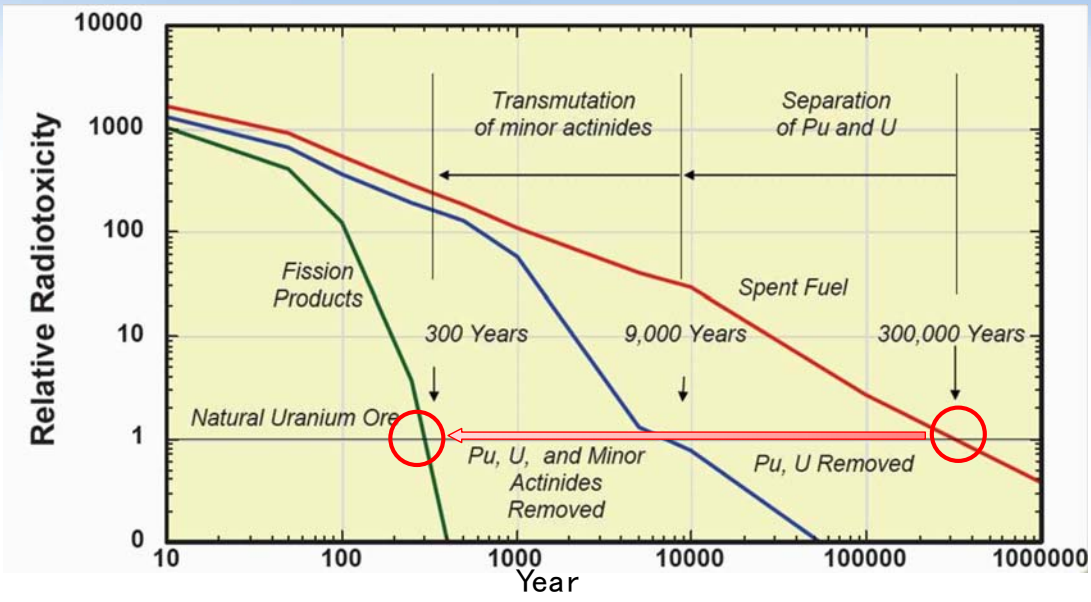
✓Metal fuel and pyroprocessing are key to achieving these revolutionary improvements.

✓Implications on LWR spent fuel management

Dr. YOON IL CHANG
Argonne National Laboratory

Transuranic disposal issues

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



HITACHI

Removal of uranium, plutonium, and transuranics makes a 300,000 year problem a 300 year problem

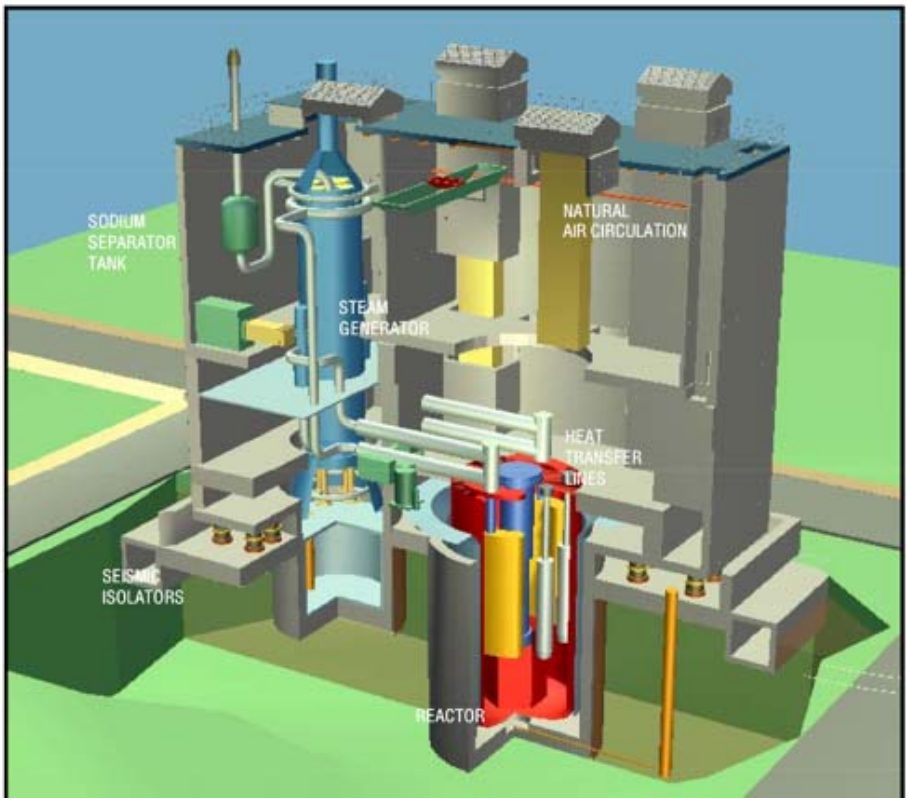
Pyroprocessing costs much less than Aqueous Reprocessing

Capital Cost Comparison ($million)
Fuel Cycle Facility for 1400 MWe Fast Reactor

	Pyroprocessing	Aqueous Reprocessing
Size and Commodities		
Building Volume, ft³	852,500	5,314,000
Volume of Process Cells, ft³	41,260	424,300
High Density Concrete, cy	133	3,000
Normal Density Concrete, cy	7,970	35-40,000
Capital Cost, $million		
Facility and Construction	65.2	186.0
Equipment Systems	31.0	311.0
Contingencies	24.0	124.2
Total	120.2	621.2

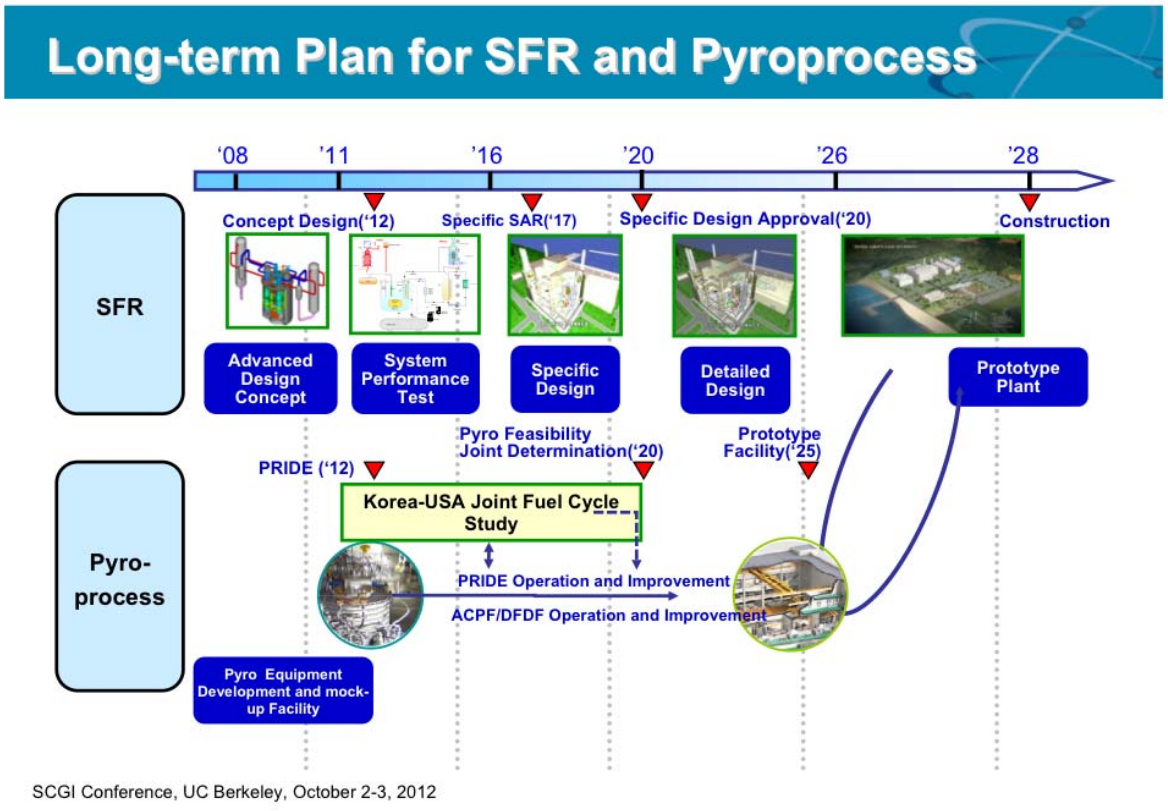
Dr. YOON IL CHANG
Argonne National Laboratory

S-PRISM Nuclear Steam Supply System



GE-Hitachi

Korea is eager to build fuel cycle by IFR under the revised 1-2-3 Agreement with US



SCGI Conference, UC Berkeley, October 2-3, 2012

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Proposal to Demonstrate IFR and Pyroprocessing at Fukushima Daini

- Melt downed fuel debris and contaminated equipments will likely stay in Fukushima, though nobody admits so.
- Pyroprocessing is the most appropriate method for treating debris.
- Pu and MA from Debris and Spent fuels be burned in IFR. Electricity is generated as by-product.
- High level waste of 300 years be stored rather than disposed geologically while decommissioning of units be cemented for years.
- Fukushima Daini (Second) Nuclear Plant of TEPCO is best located to demonstrate GE's extended S-PRISM.
- International joint project of Japan-US-Korea will provide complementing regional safeguard for global non-proliferation regime.
- Provides ground for extension of Japan-US 1-2-3 Agreement in 2018 by demonstrating complemental fuel cycle options.

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International Conference on "Sustainability of Nuclear Power and the Possibilities of New Technology" organized by the Sasakawa Peace Foundation (SPF) on November 18, 2016.

Technical Feasibility of an Integral Fast Reactor (IFR) as a Future Option for Fast Reactor Cycles

-Integrate a small Metal-Fueled Fast Reactor with Pyroprocessing Facilities -

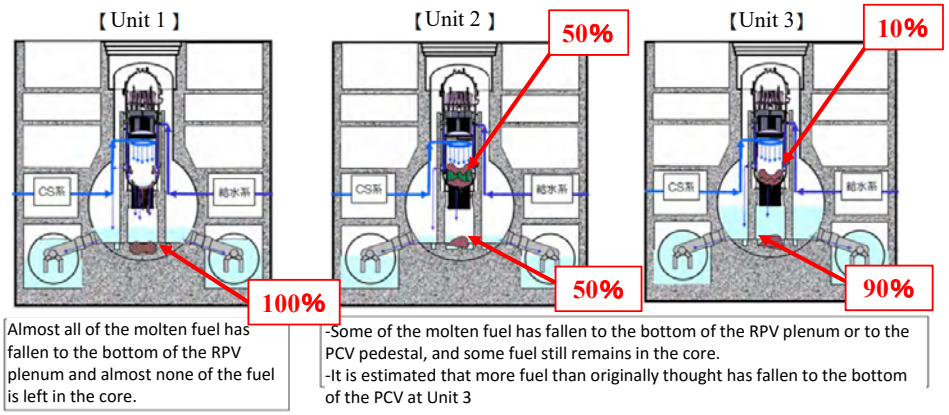
November 18, 2016

Nuclear Salon

5. Research Results

Amounts of fuel debris and nuclear materials from the TEPCO Fukushima Daiichi NPS (estimated)

The distribution fraction of heavy metals (TRU+U+FP) is estimated to be as shown by the numbers to the right in red based on analyses using the SAMPSON code*2



Assumed states of the Unit 1~3 cores/containment vessels*1

The amount of debris and primary composition has been estimated as follows based upon the amount of fuel, number of control rods, and the remaining amount*3 of structural material in each reactor.

	[Unit 1]	[Unit 2]	[Unit 3]
Amount of core region debris (Approx. 120 tons):	0	Approx. 100 tons	Approx. 20 tons
Amount of MCCI debris (740 tons):	Approx. 260 tons	Approx. 170 tons	Approx. 310 tons

•Main composition of core region debris that fused/mixed with core structure material (SUS, Zry): $(U,Zr)O_2$, SUS-Zry alloy
•Main composition of MCCI debris that fused/mixed with concrete outside the pressure vessel: $(Zr,U)SiO_4$, $CaAl_2Si_2O_8$, etc.

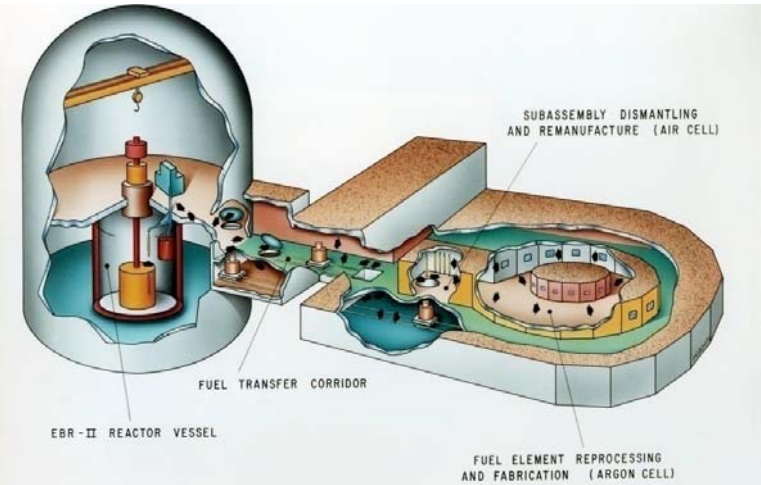
- As the average fuel composition for debris in Units 1~3, we used the composition at the time when void reactivity is the most severe, a maximum minor actinide ((MA) neptunium, americium, etc.) content rate and the largest number of years since the disaster within the published data.

⇒Transuranium element（TRU：Pu+MA) mass is 1.94 tons, and heavy metal (HM) mass is 251 tons

∗1：Excerpt from 1st Progress Report on the Estimate of the Status of the Fukushima Daiichi Nuclear Power Station Units 1~3 Core/Containment Vessels and the Deliberation of Unsolved Issues,"from TEPCO website.
∗2：Masanori Naito, "Analyzing Accident Event Escalation using the SAMPSON Code," Atomic Energy Society of Japan Fall Symposium, September 11, 2015.
∗3：T. Washiya et.al, Study of treatment scenarios for fuel debris removed from Fukushima Daiichi NPS, Proc. of ICONE-23, May 17-21, 2015, Chiba, Japan

Technical Feasibility of an Integral Fast Reactor (IFR)

- ✓ The concept of an integral fast reactor (IFR) consists of reprocessing the fuel debris, fabricating TRU fuel, burning it in a small MF-SFR and recycling the spent fuel by reprocessing
- ✓ Amount of heavy metals (HM), such as uranium, present in fuel debris: Approx. 250tons and **TRU elements account for approximately 1.9tons**.
- ✓ Configuration
  - A MF-SFR with inherent safety features (reactor output: 190MWt)
  - Application of a metallic fuel pyro-processing method that makes debris processing possible.

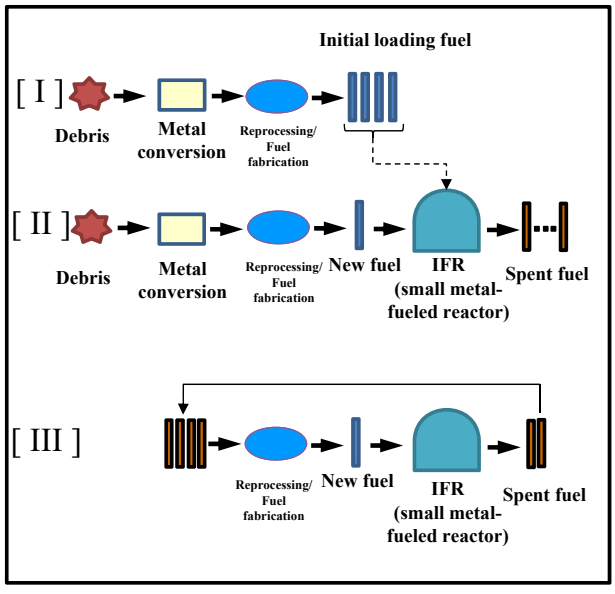


Concept diagram of an IFR that combines a fast reactor with a fuel recycling facility
(Example: Argonne National Laboratory Experimental-Breeder Reactor EBR-II and fuel cycle facility (FCF))

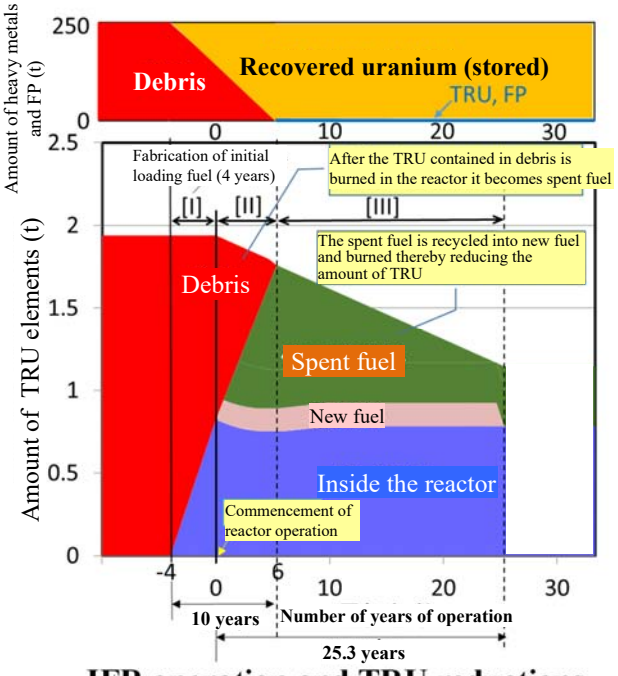
(Source: Y. I. Chang, "Integral fast reactor – a next-generation reactor concept," in Panel on future of nuclear Great Lakes symposium on smart grid and the new energy economy, Sept. 24-26, 2012.)

Debris Processing Scheme and TRU Reductions

- An assessment of TRU burn-up performances showed the originally estimated debris processing period of 15 years could be shortened to 10 years.
- The 1.9 tons of TRU present in the debris will be reduced to a total of 1.2 tons in 25 years after the launching the IFR including that remaining in the reactor and that existing in the spent fuel. Since the amount of TRU required to constantly fabricate fuel after this point will be insufficient, it will be necessary to procure TRU from external sources in order to continue continuous operation of the reactor.



Concept diagram of debris processing scheme



IFR operation and TRU reductions

Evaluation of Construction Costs for Reactor and Fuel Cycle Facilities

[Reactor]

●A small MF-SFR with the **thermal output of 190MWt (electrical output: 70MWe)** was estimated:

•Decision on the major plant specifications, created general main-circuit system schematics, conceptual diagrams for reactor structures, and conceptual diagrams for the reactor building layout
•Estimated plant commodity with referencing commodity data from past designs.
•JAEA's evaluation code for construction cost is adopted.

●Results: **Approx. 110 billion yen** (construction unit cost: Approx. **1.6 million yen/kWe**) (However, there is much uncertainty in these values since the system design has not yet been performed.)

[Fuel Cycle]

- A tentative assessment of the overall construction costs of pyroprocessing facilities capable of **reprocessing 30tHM/y** and **fuel fabricating 0.72tHM/y** was done as follows:
  - The number of pieces of primary equipment were estimated based upon the processing capacity of primary equipment after determining a general process flow and material balance.
  - A general assessment was made by referencing recycle plant cell volume and building volume from past researches
- Assessment result: Whereas the construction cost of these facilities may be able to be kept at approximately **several tens of billions of yen**, there is much uncertainty in regards to reprocessing facilities and since design aspects have not been examined, it is necessary to refer to assessment values made during other design research into facilities with similar processing capabilities.

IEE JAPAN

Application of an IFR cycle to the existing Japanese nuclear fuel cycle

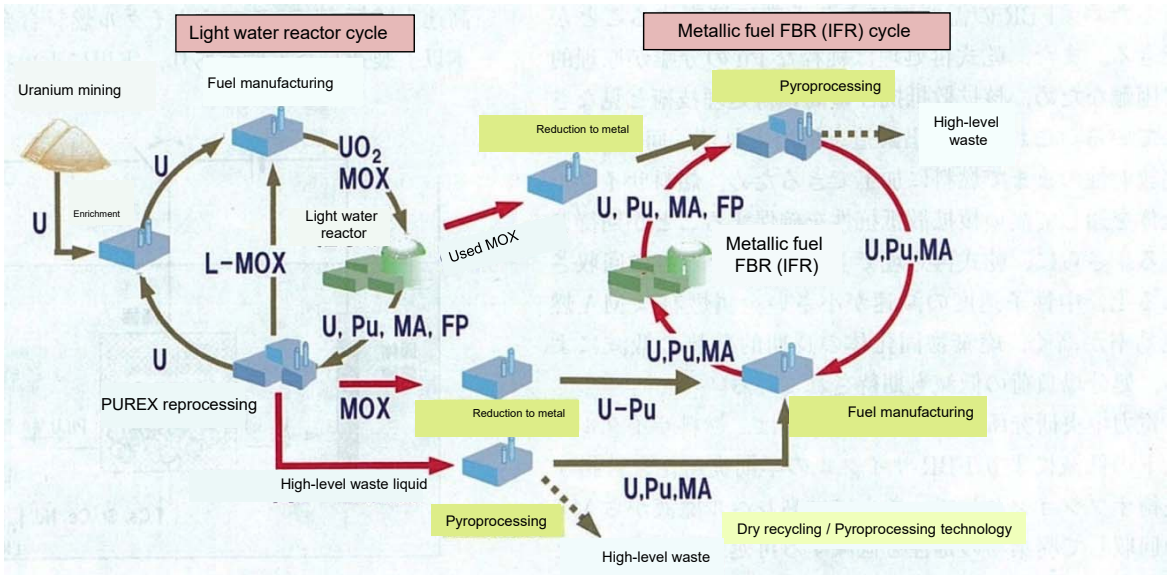


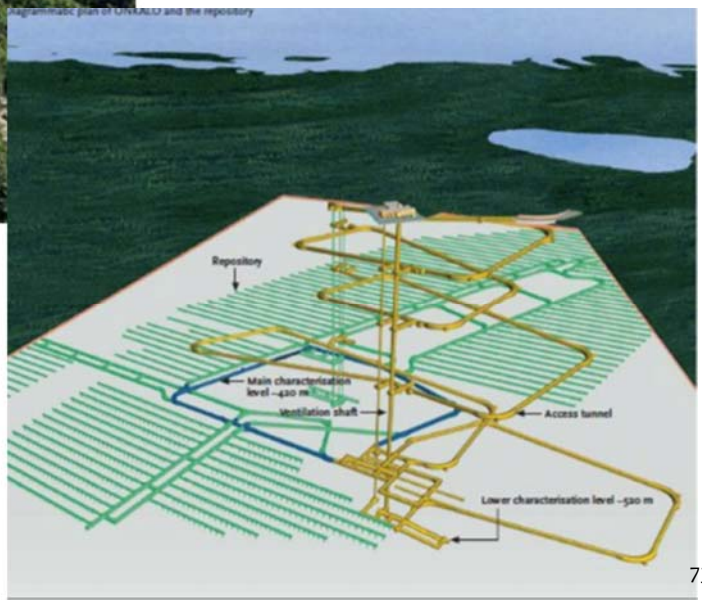
Figure 6: Fuel cycle concept using Pyroprocessing technology

(30) Journal of the Atomic Energy Society of Japan Vol. 52, No. 7 (2010)

Central Research Institute of Electric Power Industry: Tadafumi Koyama, Takanari Ogata

Radioactive High-level Waste Disposal or Storage

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.

Legend of Admiral Rickover: Success of LWR for nuclear submarine has crowded out Fast Reactors

Does Japan desire to continue to be a tier-one nation, or is she content to drift into tier-two status?

U.S.-Japan Alliance Report by Nye & Armitage (2012/8/10）

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.

うつくしま、福島
(Fukushima, the Beautiful)

昨日はとても勉強になりましたし、何よりも明るい気持ちになりました。福島は日本の科学技術のために使っていただいた場所なのですから。 思いがけない傷を負ってしまった福島ですが、これからも技術者たちの挑戦を見届け、世界の技術発展と人類の未来のために使っていただく地になること、それこそが福島の前向きな選択であると感じました。
5年間悲観的な感情論を山ほど聞いて、どちらに向けて顔を上げていったらいいのか、福島の人間はずっと模索してきたのだと思います。
昨夜、田中様のお話しを聞いて、私は原発が街に初めてやってきた子供の頃のことを思い出しました。田中様のお話は、私にその時と同じ気持ちを思い出させるものでした。そのようなお話を聞いたのはの初めてです。ありがとうございます。
事故の前まで、福島県のキャッチコピーは、美しい島という意味で、「うつくしま、福島」だったのです。事故後に、そのポスターも言葉も消えました。私は科学技術に尽くすという意味で、「つくすしま、福島」でいいのではないか、これは決して後ろ向きの決意ではなく、福島の誇りだと思います。是非とも実現に向けて頑張っていただきたいし、ご協力できることがあればやらせていただければ嬉しく思います。私は身体障害者ですが、自由な時間はたくさんありますので、社会のお役に立てることがあるなら、身体が動く限り何でもやってみたいと思っています。

Statement by Dr. Takashi NAGAI after Nagasaki atomic bomb. "How to turn the devil to the fortune."

Dr. Takashi Nagai, a Professor at Nagasaki University in 1945 when the atomic bomb was dropped, exemplifies the resilience, courage and believe in science of the Japanese people. Despite having a severed temporal artery as a result of the bomb, he went to help the victims even before going home. Once he got home, he found his house destroyed and his wife dead. He spent weeks in the hospital where he nearly died from his injuries. But just months after the atom bomb dropped, he said:

"Everything was finished. Our mother land was defeated. Our university had collapsed and classrooms were reduced to ashes. We, one by one, were wounded and fell. The houses we lived in were burned down, the clothes we wore were blown up, and our families were either dead or injured. What are we going to say? We only wish to never repeat this tragedy with the human race. We should utilize the principle of the atomic bomb. Go forward in the research of atomic energy contributing to the progress of civilization. Devil will then be transformed to fortune.(Wazawai tenjite Fukutonasu) The world civilization will change with the utilization of atomic energy. If a new and fortunate world can be made, the souls of so many victims will rest in peace."