



APERC Workshop at EWG53
Singapore, 24 April, 2017

2-2. Development of Nuclear Energy in APEC

Kazutomo Irie
General Manager, APERC

- **Introduction / project overview**

Nuclear power in the APEC region

- **Future scenarios and analysis**

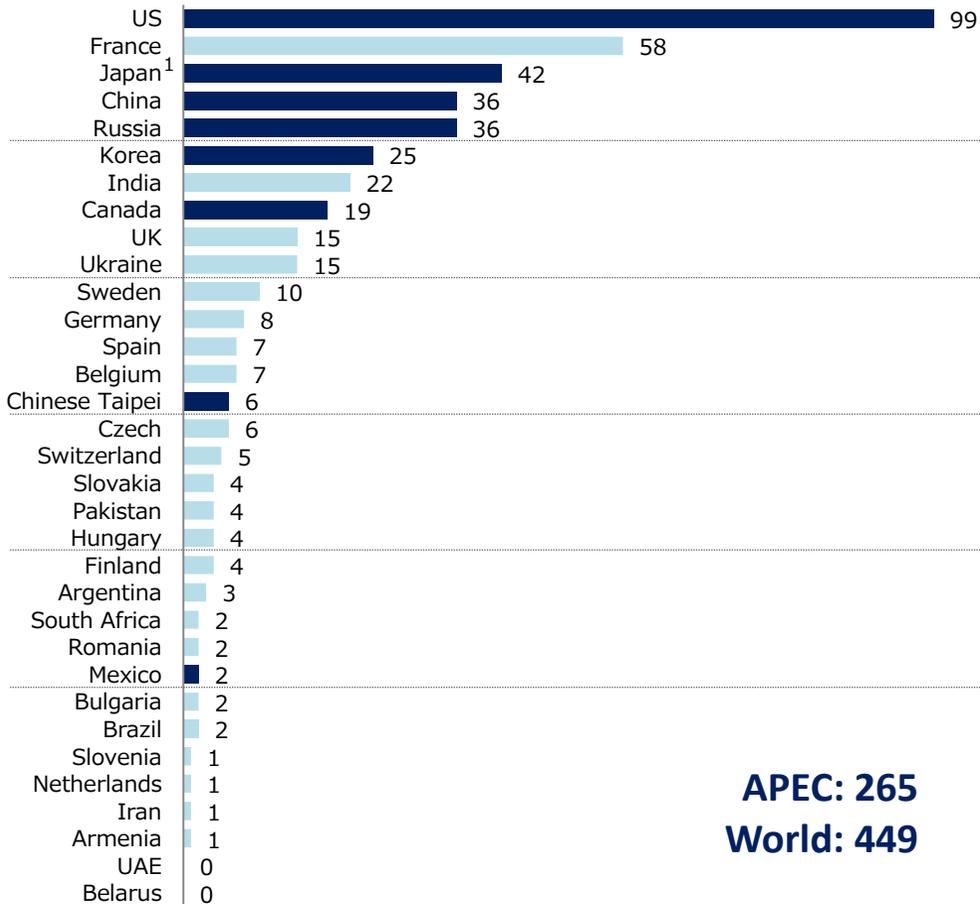
Economic modelling and analysis toward 2040

We discuss three cases: the *BAU*, *High-nuclear* and *Low-nuclear* scenarios

- **Conclusion**

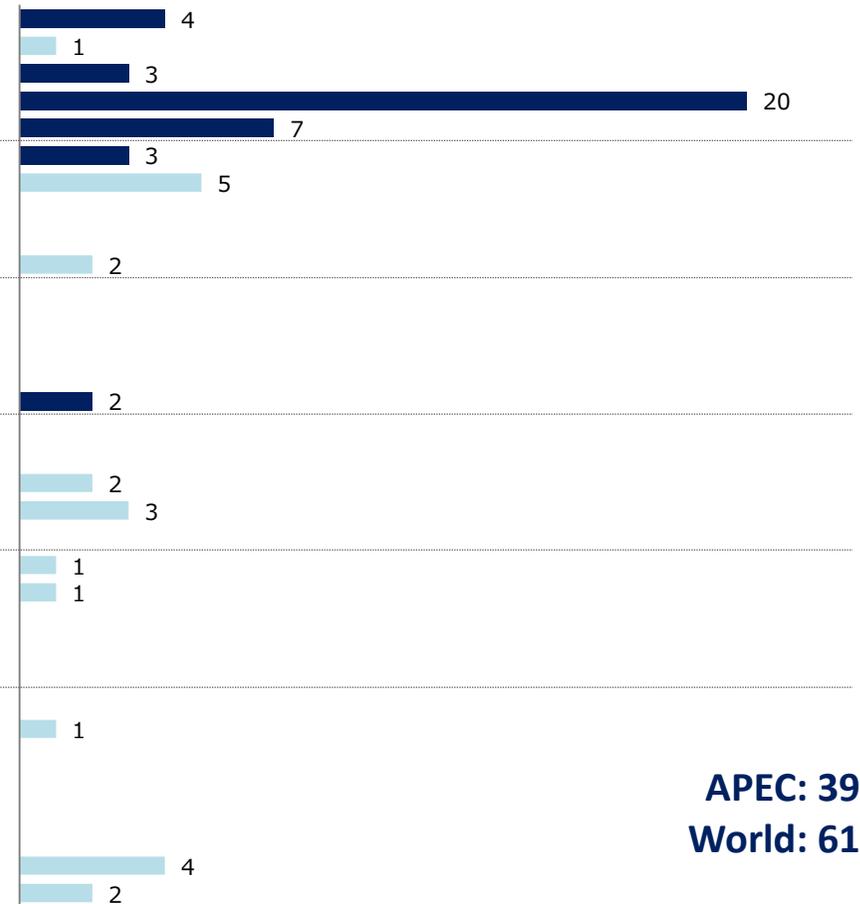
Major nuclear utilizing/expanding economies are in APEC

Number of reactors in operation (as of Nov 2016)



APEC: 265
World: 449

Under construction



APEC: 39
World: 61

1. We refer to IAEA PRIS database. We adjusted data in several economies; for example, in Japan, Ikata unit 1 is excluded from the figure in operation, and the number of reactors under construction is revised from 2 to 3.

However, future direction varies by economy and uncertainties exist

- **Existing “nuclear” economy:** China, Korea and Russia hold their policy to expand nuclear, while Chinese Taipei shifts to a “phase-out” policy and uncertainties exist in Japan and US (e.g., due to existing reactors’ retirement decisions).
- **Newcomers:** Thailand considers nuclear as an option. Whereas, the accident in 2011 and recent macroeconomic/energy-market situation negatively impacts several other economies, incl. Viet Nam

Nuclear plans and targets, selected economies

China	Target by 2020: 58GW in operation and 30GW under construction
Japan	Amended reactor regulation act to limit lifetime of reactors, yet the government aims a share of 20-22% in generation by FY2030.
Korea	Planned addition by 2029: 18.2GW and retirements of KORI-I in 2017
Chinese Taipei	Nuclear phase out policy by 2025
Russia	Rosatom plans to expand nuclear mainly in the west part of Russia
United States	NRC is preparing guidance for an 80-year lifetime (Subsequent License Renewal)
“Newcomers”	Thailand: PDP2015 plans to install 2GW by 2036. Viet Nam: Halt to Ninh Thuan project.

Project overview

- *In April 2016, we launched a project on nuclear power in the Asia-Pacific region*
- *Main research agenda*
 - Survey on current nuclear policy
 - Future scenario analysis
“BAU”, “Low-nuclear” and “High-nuclear”
- *Final report to be published in mid-2017 (after peer-review process)*



Workshop on Nuclear Power Development in the APEC region, November 13-15, Tokyo

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Three scenarios to discuss the future of nuclear in Asia-Pacific

• Business-As-Usual (BAU)

Current policy exists over the projection period (2013-2040).
Recent nuclear construction/retirement trends considered.
Proposed projects are not included in most of the economies.

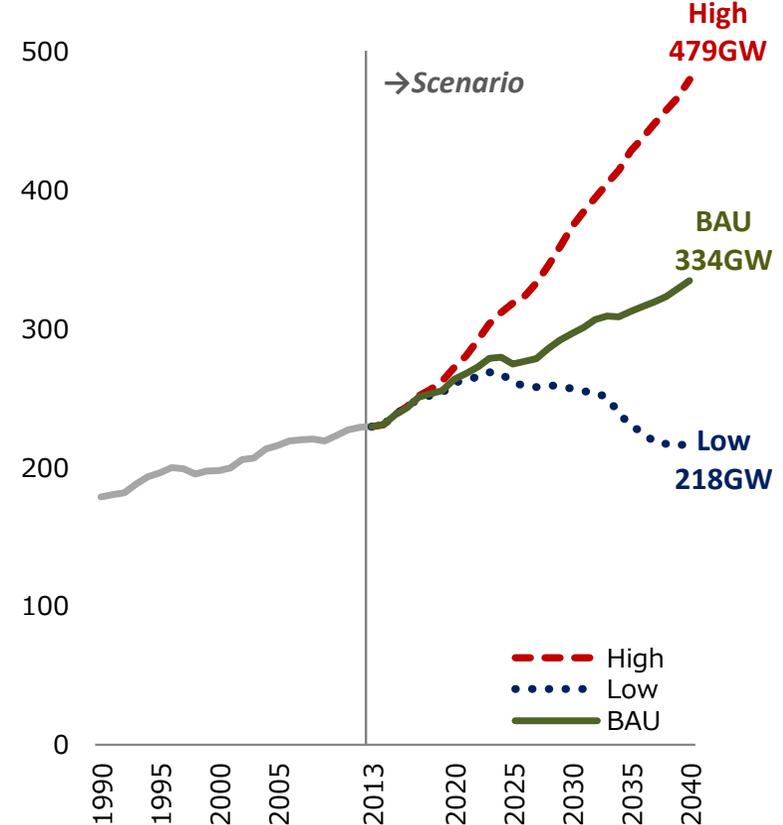
• High-nuclear (High)

Proposed projects are included in addition to BAU projects driven by energy security, environmental and economic reasons.
License extensions applied to most of the existing reactors.

• Low-nuclear (Low)

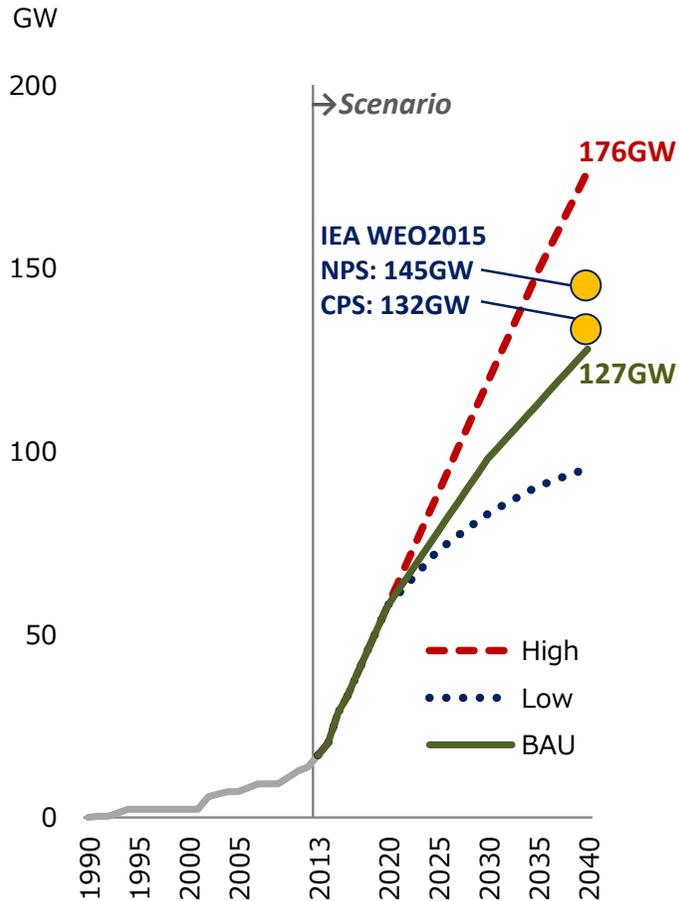
Slow down of nuclear developments and accelerated retirements of existing reactors due to various concerns, including safety and waste management.

Nuclear capacity in APEC [GW]



Note: The figure shows the year-end capacity.

Source: APERC.



Current status (as of 1st Nov 2016)

- 36 reactors in operation
- 20 reactors under construction
- Target: 58GW in operation and 30GW under construction by 2020 (“Energy Development Strategy Action Plan (2014-2020)” and The 13th Five-Year Plan)

Scenario assumptions

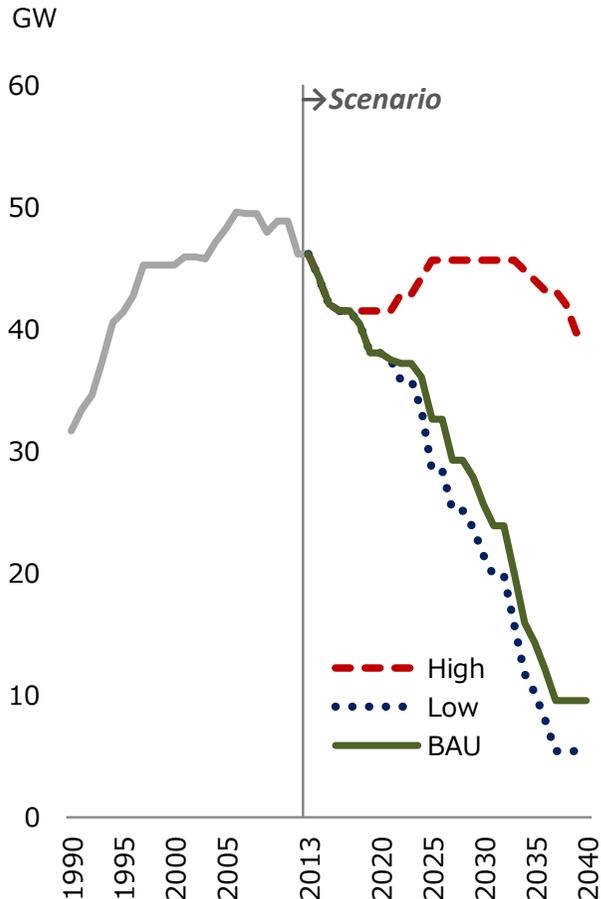
	2020 operation target (58GW)	New additions after 2020
High	Achieved	5-6 reactors/year (projected trend in the late 2010s continues)
BAU	Achieved	3-4 reactors/year (The annual average number of reactors installed in 2012-2016 Sep.: 4 reactors/year)
Low	Achieved	1-3 reactors/year

Note: The figure shows the year-end capacity.

Sources: IAEA, State Council.

Example of economy assumption

Japan – license expiration of existing reactors has significant impacts



Note: The figure shows the year-end capacity. T

Sources: OCCTO and METI.

Current status (as of 1st Nov 2016)

- 42 reactors in operation
- 3 reactors under construction (Shimane-3, Oma-1, and Higashidori-1)
- Lifetime: 40 years, and an extension of maximum 20 years allowed under nuclear reactor regulation act
- Strategic Energy Plan (published in April 2014):
“Dependency on nuclear power generation will be lowered to the extent possible”

Scenario assumptions

	Lifetime of existing reactors	New reactor additions
High	60 years	3 units currently under construction
BAU	40 years (except for the reactors approved/examined for extension)	3 units currently under construction
Low	Same as BAU	No new reactors

2. Scenario analysis

China's increasing presence in APEC nuclear generation

APEC nuclear capacity [GW]

2013

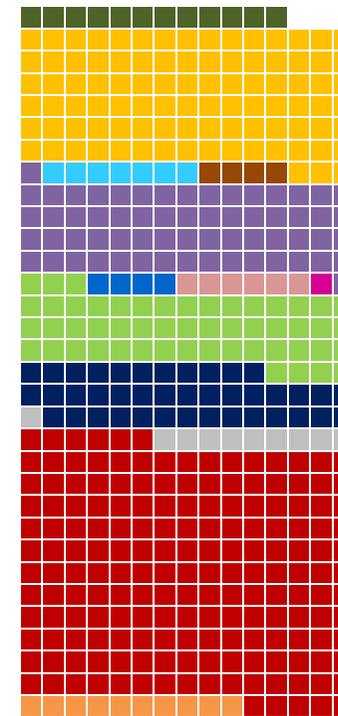
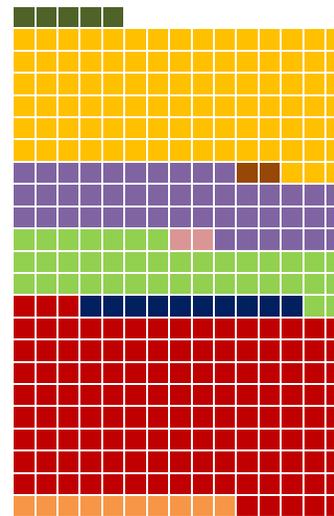
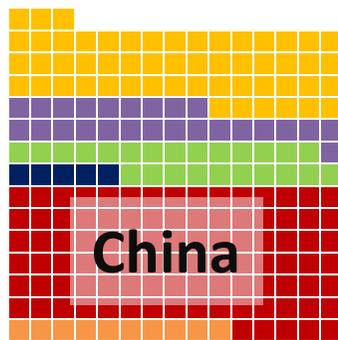
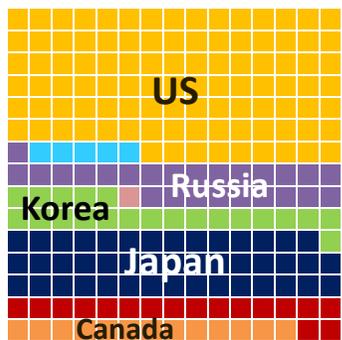
2040

Low

BAU

High

1GW

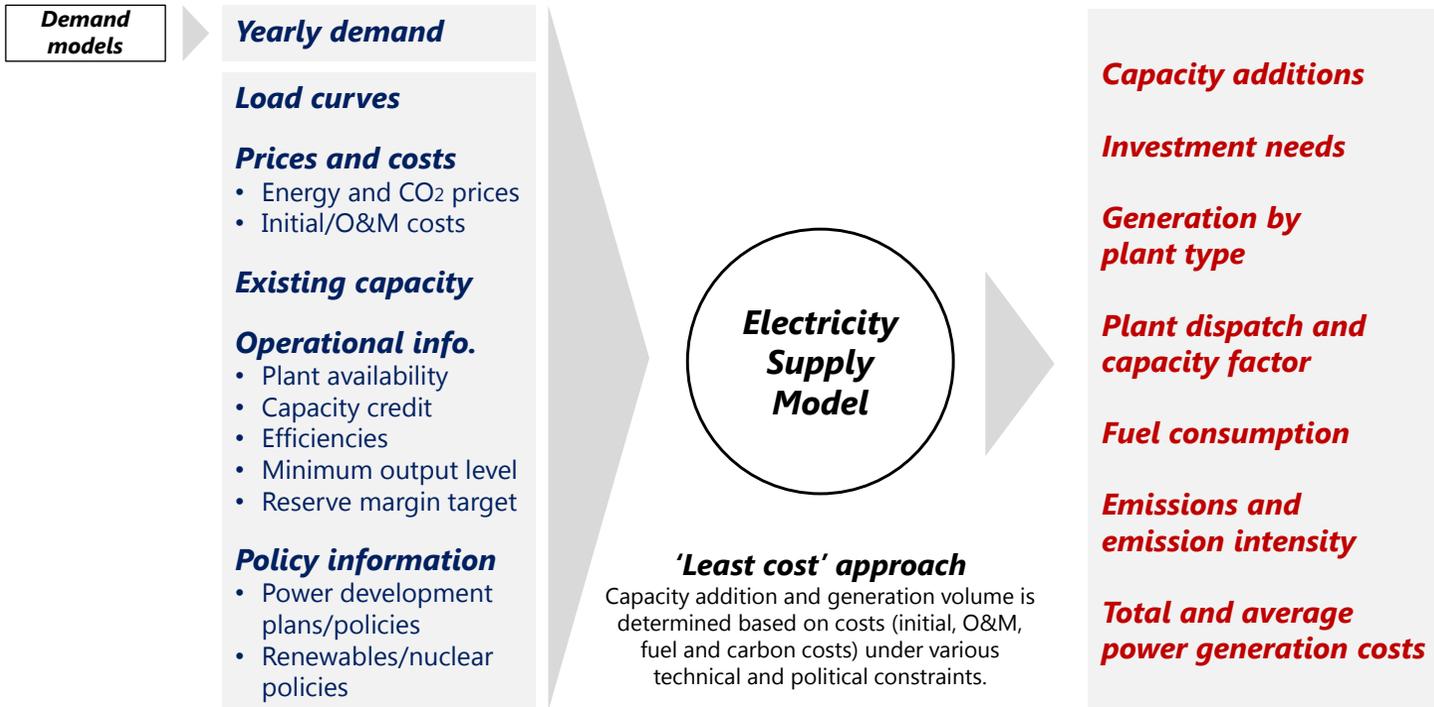


Note: Nuclear capacity in each economy is rounded. The number of block does not necessarily means the exact installed capacity. Source: APERC.

2. Scenario analysis

APERC uses a long-term power supply model based on cost-optimization

Electricity supply model structure



Modelled technologies

Generation

- Nuclear
- Coal-fired (sub-critical)
- Coal-fired (super / ultra-super critical)
- Gas turbine
- Gas combined cycle
- Oil-fired
- Solar PV & solar thermal
- Wind (onshore, offshore)
- Geothermal
- Biomass and others

Storage

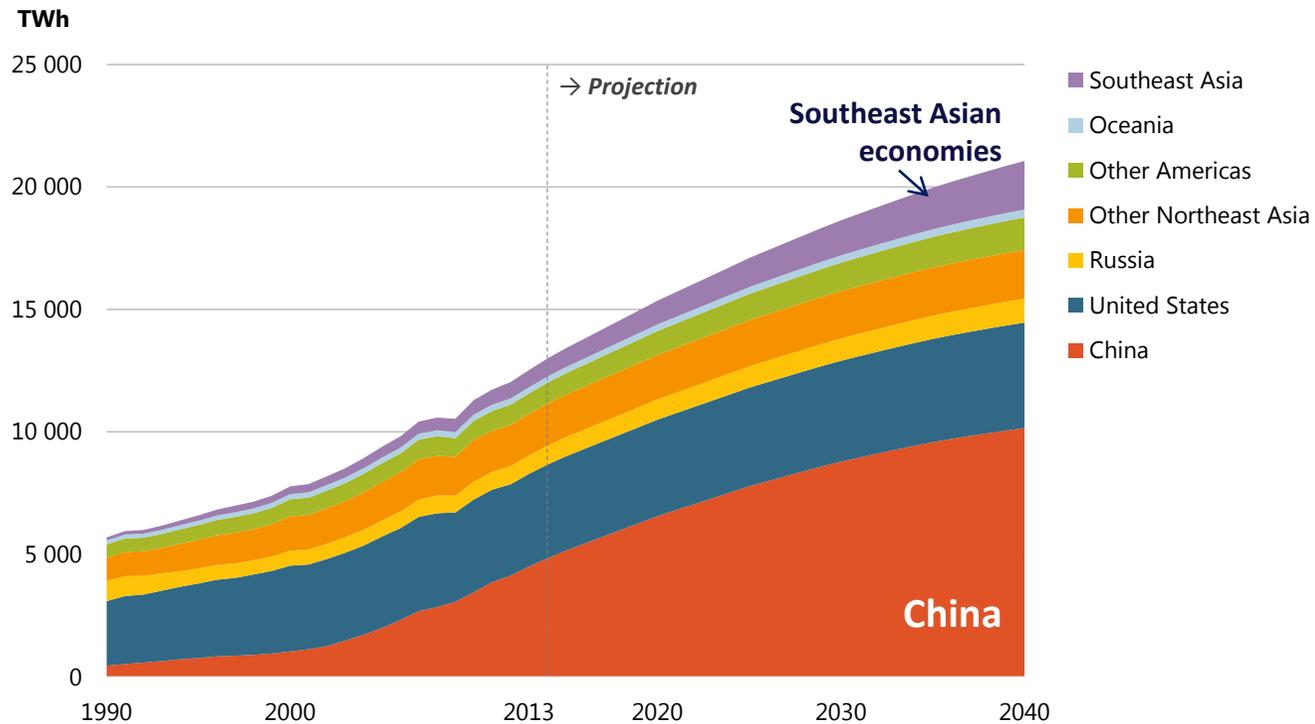
- Pumped hydro
- Battery

- Future nuclear capacity is given as the scenarios (not based on optimization)
- The model determines fossil fuel-fired capacity and operation of all technologies, considering policy directions

Source: APERC.

China and Southeast Asian economies drive demand growth

Assumed electricity demand¹



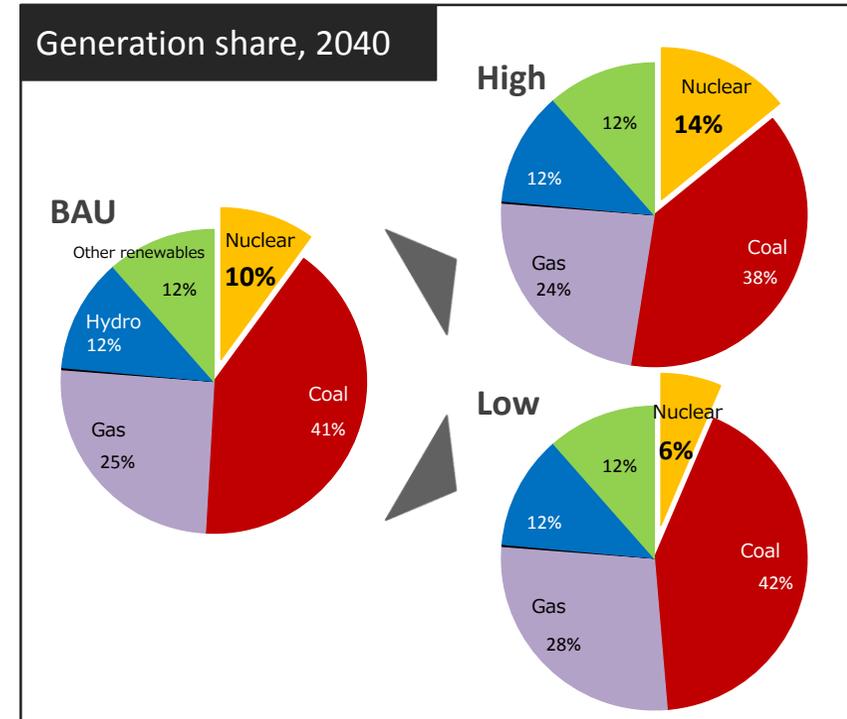
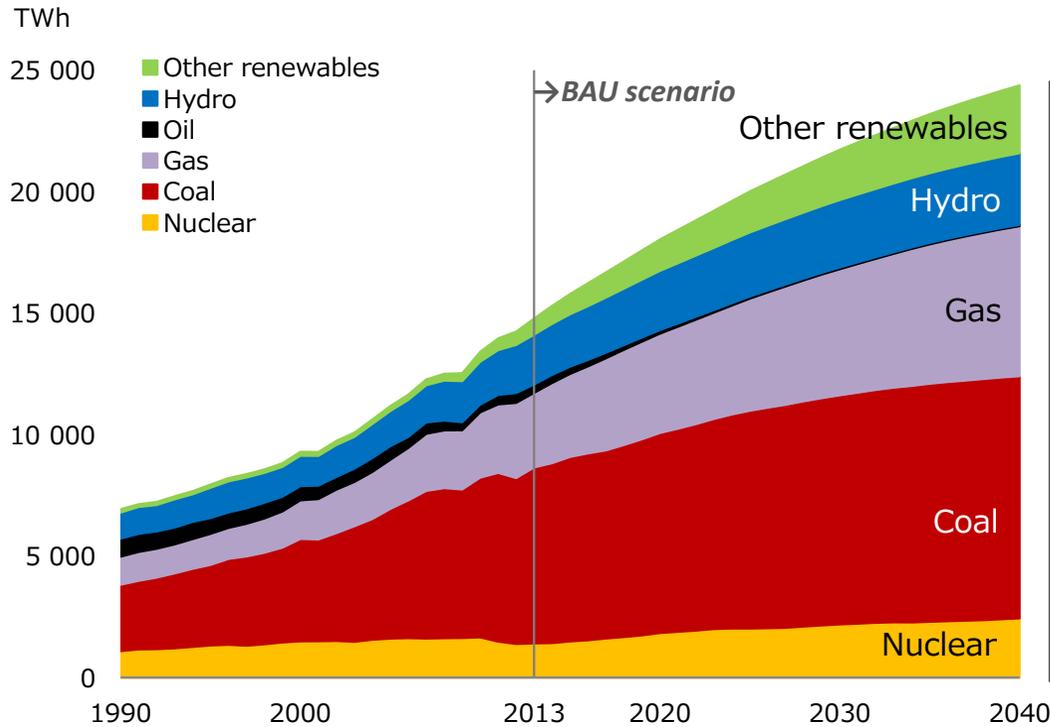
- Electricity demand in APEC grows by 70% over the outlook period
- China and Southeast Asian economies more than double their demand

¹ Source: APERC (2016) "APEC Energy Demand and Supply Outlook 6th Edition"

2. Scenario analysis

Fossil fuels dominate in the BAU and even in High-nuclear, but ...

APEC electricity generation, BAU



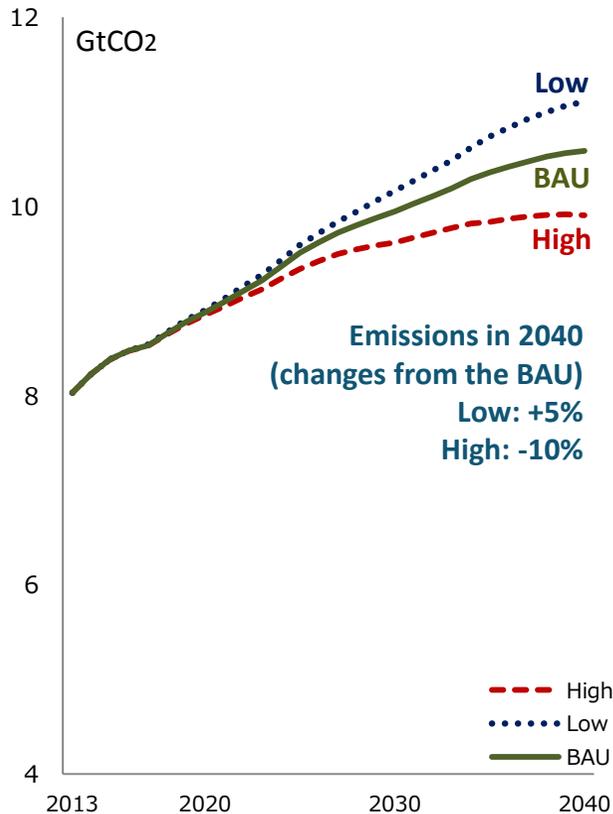
- Fossil fuel dominate in the BAU scenario, and even in the High nuclear scenario, although accelerated nuclear development contribute to reducing fossil fuel generation.

Source: APERC.

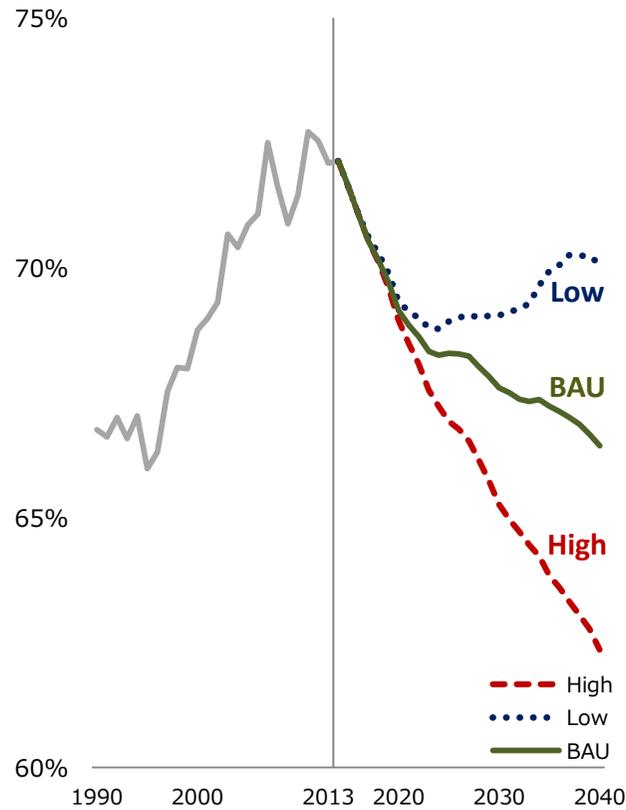
2. Scenario analysis

... but, nuclear contributes to APEC from the “3E” perspective

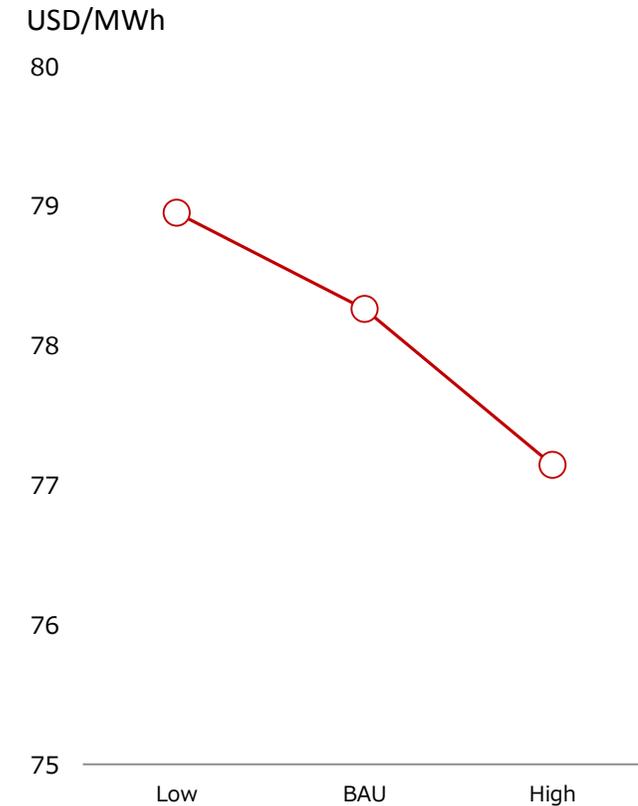
Annual emissions¹



Fossil fuel dependencies²



APEC average cost in 2040



1 Emissions from electricity generation in APEC

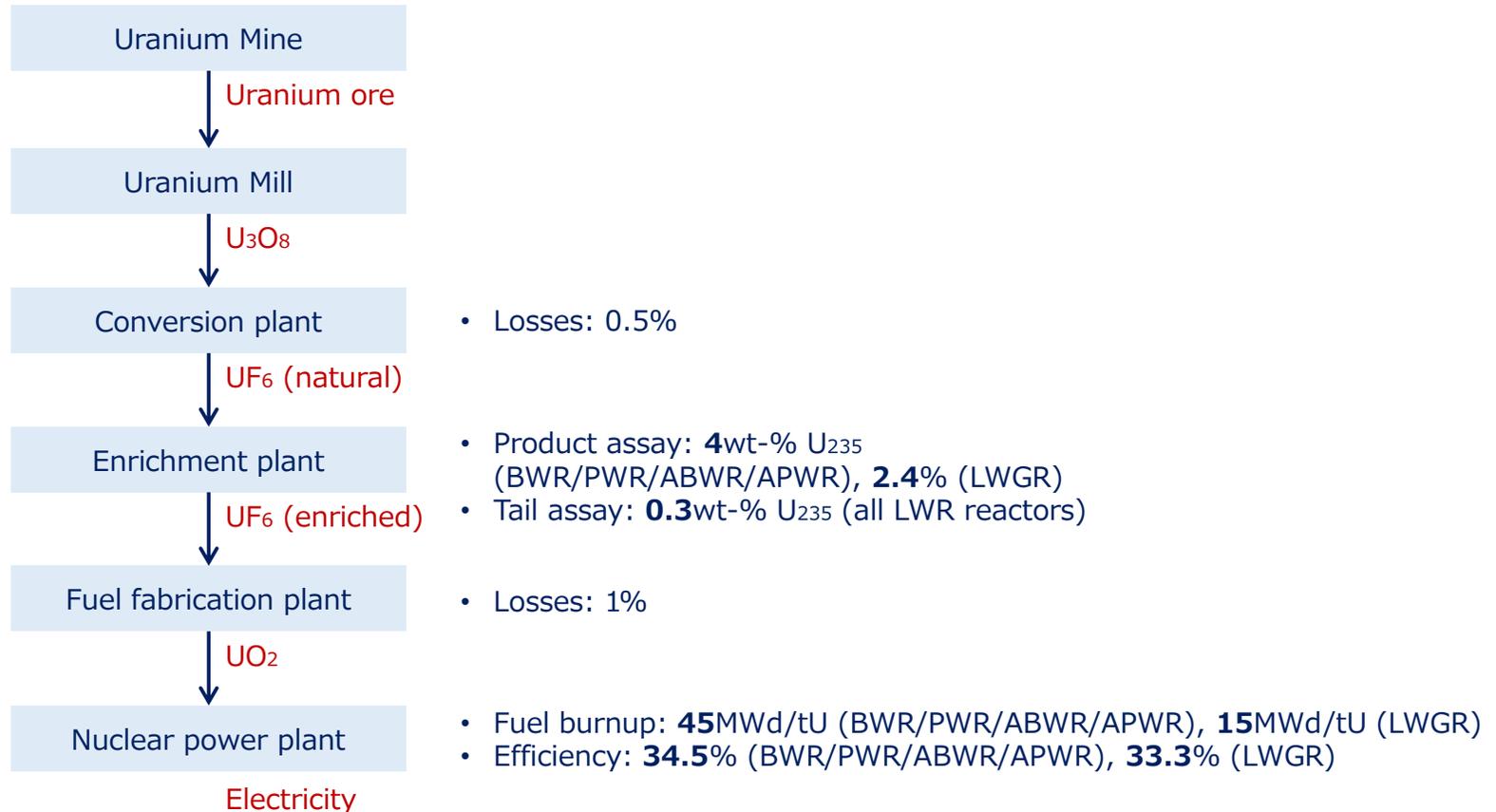
2 The share of fossil fuel in electricity generation in APEC

Source: APERC.

2. Scenario analysis

A sub-model to estimate uranium consumption and spent fuel

Front-end model (LWR¹ model as an example)



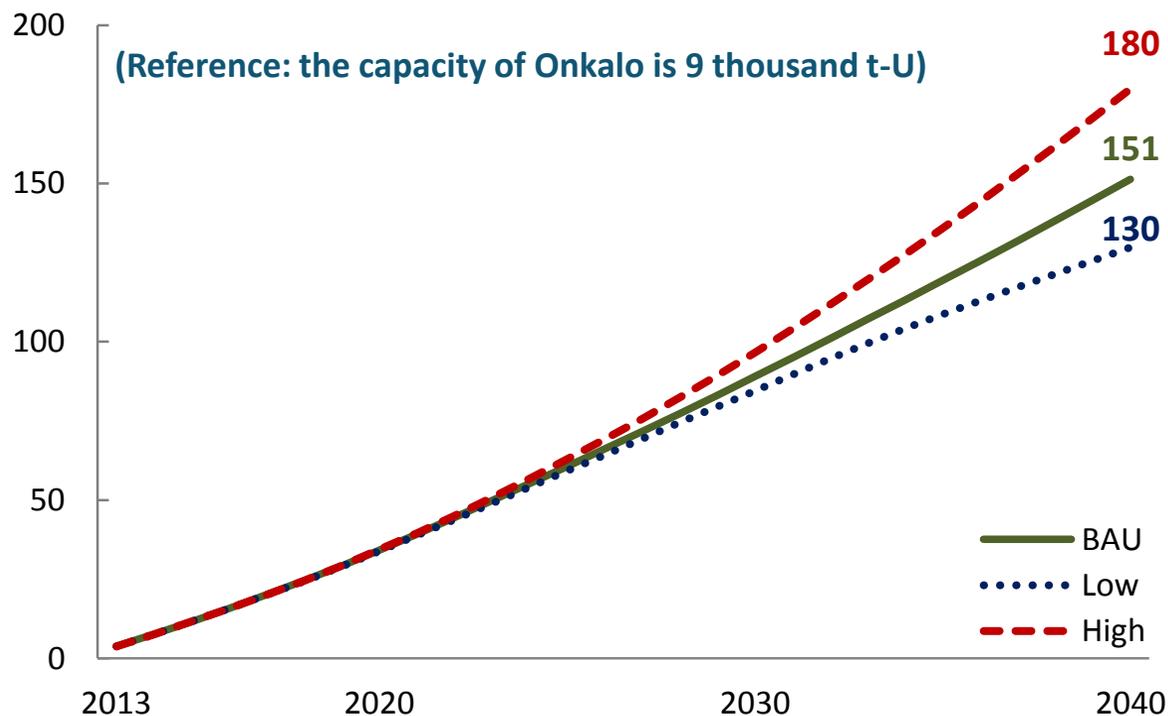
¹ LWR=Light Water Reactors. APERC also developed another model for heavy water reactors.

Source: World Information Service on Energy and APERC,

Waste management : headache for nuclear utilizing economies

Spent fuel (cumulative from 2013, APEC)¹

thousand-tU



- Estimated amount of spent fuel reaches 130-180 thousand tons of Uranium; even Low-nuclear scenario reaches 70% of the level in High scenario
- Economies need to construct sufficient intermediate storage and final disposal facilities

¹ This estimation assumes a once-through fuel cycle for all economies.

Source: APERC.

Conclusion and future research agenda

- Nuclear power contributes to the APEC region from the “3E” perspectives, especially in terms of Environment and Energy security.
- Despite the capacity growth in the BAU, the share of nuclear remains around the current level due to increasing demand; accelerated installation and license extension of existing reactors are important to increase the share, as shown in the High Scenario.
- A large amount of spent fuel is estimated even in the Low Scenario. Economies need to implement policies to construct sufficient facilities for storage and/or disposal.
- For the “two-degree” scenario in the next outlook, comprehensive analysis on low-carbon generation sources—not only nuclear but also energy efficiency, renewables, CCS and so on—would be important.



Thank you for your kind attention!

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