

Global and Domestic Nuclear Energy Outlook

Institute of Energy Economics, Japan

Tomoko Murakami
Nuclear Energy Group, Strategic Research Unit

Key Points of the Report

<Other countries>

- ✓ During a televised speech he gave on November 9, French President Emmanuel Macron confirmed his intent to relaunch the construction of new nuclear reactors in France for the first time in decades. This is illustrative of the increasing focus on nuclear energy in the face of rising energy prices.
- ✓ Over 10 nuclear power plants are being built in emerging nations such as China and India, and several of these are expected to begin operations in 2022.
- ✓ Among international nuclear energy companies, Russian state-owned nuclear energy firm Rosatom is currently building businesses in hydrogen and other such non-nuclear domains.
- ✓ Ontario Power Generation (OPG) has released an SMR construction plan on its website. GE Hitachi Nuclear Energy has signed on with OPG as a technology partner.

<Japan>

- ✓ Two nuclear power plants are expected to restart operations in FY 2022.
- ✓ A literature survey is currently being conducted for Suttsu and Kamoenai in Hokkaido, which is the first phase of the process for selecting a final disposal site for high-level radioactive waste. Most information should be compiled within FY 2022, to be followed by assessments and decisions.

1. France's President Macron declares the restart of nuclear facility construction

(Parts relating to the president's speech)

- Rising natural gas prices and electricity rates are significantly effecting people's way of life. As an urgent measure to address this, the country fixed natural gas prices.
- However, if the people want to pay reasonable energy prices and reduce their reliance on imported energy, the country needs to invest in building low-carbon energy production facilities in the country as well as continuing to save energy.
- To guarantee energy self-sufficiency, ensure a sufficient power supply, and brings CO₂ emissions to zero in real terms by FY 2050, it will need to **restart building reactor facilities** and continue developing renewable energy.

Flamanville unit 3 has been under construction since 2007.

"Restarting construction" means beginning construction on new facilities, but no concrete plan is in place. --> Lacks conviction?

2. All emerging nations that will begin supplying power in 2021

| Country | 2021 | 2022 | 2023 |
|----------|--|------|------|
| China | Tianwan-6 5/11 | | |
| | Hongyanhe-5 6/25 | | |
| | Hongyanhe-6 | | |
| | Fuqing-6 (and many others under construction) | | |
| India | KAKRAPAR-3 1/10 (and 4 under construction) | | |
| | KAKRAPAR-4 | | |
| Pakistan | KARACHI-2 3/18 | | |
| | KARACHI-3 2021/2/28 First criticality | | |
| UAE | BARAKAH-2 9/14 (and 1 under construction) | | |
| | BARAKAH-3 | | |

Some others under construction: 4 in **Korea**, 3 in **Russia** and **Turkey**, 2 in **Bangladesh**, **Belarus**, **Ukraine**, and **the U.S.** Where and how many reactors will go online in 2022?

Source: Power Reactor Information System, IAEA

3. Plant vendor competition & cooperation map

- China entering the market after Korea, joining the U.S., France, Russia, and Japan
- Competition surrounds large reactors in developed nations and medium reactors in emerging nations

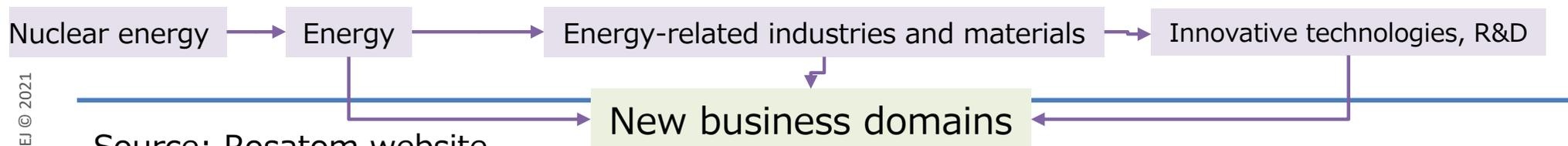
| | |
|--|---|
| | In operation, partly under construction |
| | Under construction |
| | Being planned (including on hold) |
| | No color |
| | Concept only |

| | China (CNNC/CGN) | EDF/Framatome | Mitsubishi Heavy Industries | Westing house | Toshiba | GE | Hitachi | Canada | Russia | Doosan Heavy Industries (South Korea) |
|-------------|---|---|---|---|-------------------|---|---------|--------|---|---------------------------------------|
| Over 1.4 GW | | EPR Commissioning in Finland, France and China | Japanese 3.5+ PWR EU-APWR US-APWR | Brookfield acquired | Japanese 3.5+ BWR | ESBWR Suspended in the US | | | | APR-1400 Commissioning in UAE |
| | Agreement on cooperation June 2015 | | | | | JV in US and in Japan since April 2008 | | | | |
| 1-1.3 GW | Hualong-1 Under construction in Pakistan | ATMEA1 Proposing to Czech, Turkey etc | | AP-1000 Commissioning in the US, China | ABWR | ABWR Construction suspended in Taiwan/UK | | | VVER-1200 AES-2006 Commissioning in Belarus, Turkey, Bangladesh etc | |
| | PWR | KERENA PWR | PWR | | ACR-1000 | ACR-1000 | | CANDU | | OPR-1000 |
| | | | | | ABWR/BWR | | | | | |
| | | | | | | | | | | |

Are there markets only in emerging nations?

4. Rosatom business structure

| | | | |
|---|---|---|---|
| Nuclear Energy Nuclear Fuel Cycle Uranium Mining Fuel and Enrichment Machine Building Engineering Power Generation Nuclear Services and Maintenance <div style="border: 1px solid black; border-radius: 15px; padding: 5px; display: inline-block; margin-top: 10px;">Fully integrated nuclear energy business</div> | | Nuclear medicine Production of isotopes to effective medical treatment | Non-nuclear equipment manufacturing Desalination Thermal power Hydro-electric power Oil&gas, chemical industry Shipbuilding Composite materials NPP automated control systems |
| Wind energy Consolidation of platforms of wind power generation | Nuclear icebreaker fleet Operation of nuclear icebreakers | Metallurgy Zirconium, titanium, calcium, hafnium and niobium items for high-technology industries | Digital products Center of competences of the Federal Project Digital Technologies within the National Program Digital Economy |
| Hydrogen energy Planning and implementing pilot projects in Russia and abroad | Energy storages Lithium-ion traction batteries | Automated process control systems and electrical engineering | Additive technologies Design and 3D-printers production, additive powders, complete sets, software and 3D-printing services |
| Electricity supplies Electricity supplier in Kursk, Tver, Smolensk and Murmansk Regions >50,000 legal entities & 2 million households | New business areas Materials and services Transport storage containers/Transportation Security systems/Composite materials Innovation businesses | | R&D Scientific research activities Automated process control systems and electrical engineering |



Source: Rosatom website

5. Topic: SMR development trends

- On December 2, 2021, Canadian electric utility Ontario Power Generation (OPG) made the decision to use [the BWRX-300 small modular reactor \(SMR\)](#) for a new reactor it will build at its Darlington Nuclear Power Plant.
- With BWRX-300 vendor GE Hitachi Nuclear Energy as a technology partner, OPG is doing design and engineering work for SMR construction while formulating plans and preparing to apply for permits.
- The SMR is slated to be completed in 2028 and will be Canada's first commercial SMR.

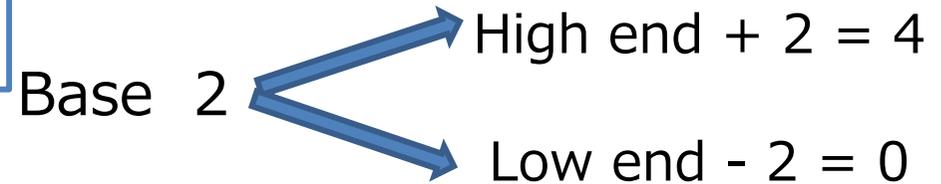
What about the business environment?

- Policies: The government announced an SMR development roadmap in 2018 and national action plan in 2020. The Canadian government has pledged to establish the necessary regulations and legal system.
- Regulations: Nuclear regulatory agency CNSC will support better business operator predictability through pre-licensing vendor design reviews.
- Province-level: In April 2021, Ontario, New Brunswick, and Saskatchewan announced the results of their SMR development feasibility studies. The results found that the development, commercialization, and proliferation of SMR would not only reduce greenhouse gas emissions but also contribute to local economies. [SMR development will benefit not only development vendors but also power producers and local communities.](#) **Might have conviction**

Source: "Zero Carbon Energy Essential for Energy Security: About Generation IV Nuclear Power Technologies" (Yomiuri Online), OPG website, etc.

6. Outlook for reactor restarts in Japan

10 reactors were restarted as of the end of 2021.
FY 2020 restarts:



| | 2021 | | | | | | | | | | | | 2022 | | | | | | | | | | | |
|-----------------------|------|---|---|---|---|---|----|----|----|---|---|---|---|---|---|---|---|---|----|----|----|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| Tokai 2 | | | | | | | | | | | | | Safety measures to be completed by JAPC in Dec. 2022 | | | | | | | | | | | |
| Onagawa 2 | | | | | | | | | | | | | Safety measures to be completed by Tohoku Electric Power in Mar. 2023 | | | | | | | | | | | |
| Kashiwa zaki-Kariwa 7 | | | | | | | | | | | | | Safety measures to be completed by Tokyo Electric Power in Jan. 2021 (but were not) | | | | | | | | | | | |
| Shimane 2 | | | | | | | | | | | | | Safety measures to be completed by Chugoku Electric Power in Mar. 2023 | | | | | | | | | | | |
| Takahama 1 | | | ▲ | | | | | | | | | | [Blue bar] | | | | | | | | | | | |
| Takahama 2 | | | ▲ | | | | | | | | | | [Blue bar] | | | | | | | | | | | |



▲ : Transitional measure deadline for specialized safety facilities

Must keep an eye on the fact that there are limits to reactor restart forecasting as a result of political factors

(Reference) Installed capacity needed to achieve "20-22%"

FAQ: What installed capacity will be needed to make nuclear energy 20–22% of the energy mix by 2030?

$$\text{Annual nuclear power output (GWh)} = \text{installed capacity (GW)} \times 8,760 \text{ (h)} \times \text{capacity factor (\%)}$$

| Total power output (100 million kWh) | Nuclear share | Nuclear power output (100 million kWh) | Nuclear capacity factor | Nuclear installed capacity (GW) |
|--------------------------------------|---------------|--|-------------------------|---------------------------------|
| 9340 | 20% | 1868 | 70% | 30.5 |
| | | | 80% | 26.7 |
| | | | 90% | 23.7 |
| | 22% | 2055 | 70% | 33.5 |
| | | | 80% | 29.3 |
| | | | 90% | 26.1 |

Reference: Number of reactors in Japan
 10 restarted reactors 10.0 GW
 27 reactors that have applied for permits 27.6 GW

Reference:
 Top five 10-year average capacity factors
 (2010–2019)

| Country | Capacity factor (%) | Reactor type |
|----------|---------------------|--------------|
| Romania | 93.1% | CANDU |
| Slovenia | 92.2% | PWR |
| Finland | 92.1% | VVER/BWR |
| U.S. | 90.6% | PWR/BWR |
| Hungary | 89.9% | VVER |

7. Topic: Literature surveys

- November 2020 saw the launch of a "literature survey" (the first phase of the process for selecting a final disposal site for high-level radioactive waste) in Suttsu and Kamoenai.
- Four dialogue sessions each have been held with residents in Suttsu and Kamoenai.

Notes on progress concerning geological disposal business and literature survey progress

- Recap information from 3rd session
- Will cover geological disposal business safety, the situation in countries involved, and additional information not provided at the 3rd session, and discussions will be held.
- Respond to requests and questions from sessions 2 and 3
- Field comments and questions based on the above discussions

Source: NUMO (Nuclear Waste Management Organization)

↑ "Today's Agenda" from NUMO's materials at the 4th "Dialogue Session" (November 14, 2021, Suttsu)
Record of dialogue between participants and NUMO -->

Literature survey and dialogues will continue in 2022.

A different is being taken than with other kinds of energy - how will it play out?

