United States Nuclear Infrastructure Council

Special Summit: 2017

Nuclear Power Markets Status & Outlook:

UK, Europe, MENA, Africa

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Nuclear Power Outlook
Nuclear Power Under Construction Worldwide

*Source: IAEA / NEI*
Growing Markets: Under Construction & Proposed

**UK NEW BUILD**
- Operating: 15
- Under construction: 2
- Proposed: Up to 16 GWe by 2030

**AFRICA NEW BUILD**
- Operating: 2
- Under construction: 0
- Proposed: Up to 16 by 2031

**MIDDLE EAST NEW BUILD**
- Operating: 1
- Under construction: 4
- Proposed: Up to 26 by 2030

**EUROPE NEW BUILD**
- Operating: 135
- Under construction: 5
- Proposed: Up to 26 by 2030

Map Source: WNA
Middle East
United Arab Emirates

- **Leading Nuclear Construction Program in the World**
- **International Agreements**
  - “Gold Standard” 123 Agreement, 1997 Vienna, CSC
  - NPT, CSA and acceded to the Additional Protocol
- **Under Construction: 4 Units (APR1400 Design)**
  - Location: Barakah, near Abu Dhabi
  - Fleet Program
  - Contractor: KEPCO. Support at the highest levels of the S. Korean Government.
    - **On Time:** Electricity to Grid: May 2017, Fuel Load: 2016
    - **On Budget**
    - **Reference Plant:** Shin Kori 3&4
• Unit Status: All 4 Units 80% Complete
  
  • Unit 1: 95% Complete
    • Fuel On Site, Waiting for Operating License
    • Commercial Operation: 2018 to ensure safety standards and operational proficiency
  
  • Unit 2: 80%+ Complete
  
  • Unit 3: 69% Complete
  
  • Unit 4: 45%+ Complete
United Arab Emirates

• Operating Entity:
  • ENEC's nuclear operating subsidiary commenced in 2016
  • Nawah Energy Company (First Board Meeting, May 2017)

• Licensing
  • Siting License: 2010
  • Construction License Application
    • Units 1 & 2: 2012, Approved After 18 Month Review
    • Units 3 & 4: 2014
  • Operating License App. (OLA) (1&2) Submitted: Mar. 2015
Nuclear Finance Risks

State Enterprises Have an Advantage in Managing Nuclear New Build Risks:

- **Political risks** (change in government, funding, e.g., Taiwan)
- **Financial risks** (changes in interest rates and taxes, etc.)
- **Design risks** (e.g., requirement for re-design for siting conditions, aircraft impacts)
- **Construction and supply chain risks** (cost overruns, non-integrated sub-suppliers, improper & fraudulent documentation)
- **Licensing and technology** (new requirements, licensing delays)
- **Export Controls** (limitations on exports)
3 Commercial Nuclear Project Catalysts

• **International Tenders**
  - **Primarily Success:** UAE (Brakaha), S. Korea (CE & AECL), China
  - **Difficulties:** Turkey (x3), Dominion, Taiwan (Lungmen), S. Africa, Finland (Olkiluoto), Jordan, Czech Republic
  - **Unknown:** Lithuania, Poland, Horizon

• **Limited / Bilateral / Exclusive Negotiations**
  - Finland (Fennovoima), Japan, France, Argentina, Brazil, Mexico
  - U.S.: Vogtle, Summer, Luminant (STP)

• **Intergovernmental Project Agreements**
  - Turkey (Akkuyu)
  - Jordan (Qasr-Amra)
  - India (Kudankulam)
  - Bangladesh (Rooppur)
  - Vietnam (Ninh Thuan 1)
Saudi Arabia

- **Conventions**: Vienna 1997, Safeguards Agmt. (2009), no Additional Protocol

- **K.A.CARE** (King Abdulla City for Atomic and Renewable Energy) was established by Royal Decree in 2010
  - $300 Billion Program to build a “sustainable future” for Saudi Arabia to lessen the domestic oil consumption
  - Reduced Under Vision 2030 Plan Implementation
  - Solar projects no longer within K.A.CARE

- **Bilateral Agreements**
  - France (2011)
  - Russia (2015)
  - South Korea
  - United States (Only MOU)
  - Argentina
  - China
Saudi Arabia

• **Recent Deals**
  
  • **March 2015:** Agreement between K.A.CARE and **KAERI** (Korea Atomic Research Institute) to assess possibility of building **two SMART** reactors.
    
    - **June 2016:** SK E&C Agreement for the design, EPC for the SMART Reactor
  
  • **March 2015:** **INVAP** to develop nuclear technology for Saudi Arabia (e.g., for CAREM 27 MWe small reactor for desalination).
  
  • **June 2015:** **Rosatom** -- cooperation in the field of nuclear energy, including the design, construction and operation of nuclear power reactors.
  
  • **March 2017:** **China** -- MOU to build HTR (Jan.) March: Agmt. to study feasibility to construct & **finance** HTGRs; review of site selection in KSA.
  
  • **March 2017:** MOU with **Jordan** on feasibility of constructing 2 SMRs in Jordan & mining exploration

• **HRH Prince Mohammed Bin Salman:**
  
  • 2016: Vision 2030, NTP 2020
Jordan

- **Good International Legal Infrastructure**
  - Vienna 1997

- **International Agreements**
  - No 123 Agreement with the United States. No agreement on E&R.
  - Many bilateral agreements, including Korea, France, etc.

- **Research Reactor: Jordan Research and Training Reactor (JRTR)**
  - 5 MWt
  - Construction declared complete in 2016 by Korea
  - Full Power achieved in 2016
Jordan

- **New 2-Unit Nuclear Project (Qasr Amra)**
  - Technology: VVER AES-92
  - BOO (Build, Own, Operate) Project, similar to Akkuyu
  - Ownership: Jordan Govt. (50.1%) / Russian (49.9%)

- **Main Priority: Mining (May 2017)**

- **2 Project Agreements**
  - March 2015: The Intergovernmental Agreement (“IGA”) between Russia and Jordan

- **Jordan considering a U.S. 123 Agreement**
  - According to press reports in **July 2016**
  - Jordan joined the NSG in May 2017
• **International Legal Infrastructure**
  - Needs Improvement: 1963 Vienna, CSA, No Additional Protocol

• **Current Program:**
  - **2 MW** Russian Research Reactor (1961)
  - **22 MW** Argentinian Reactor (ETRR-2) (1997)

• **Project: El-Dabaa**
  - Long History -- Since 1983
  - Plan: 4 Units to generate 4,000-6,000 MWe.
  - Plan to construct by 2022
  - Largest joint project between Egypt and Russia since the construction of the High Dam in Aswan
• **Project: El-Dabaa – 2 Units + 2 Units**
  
  • **Russia** MOU Signed Feb. 2015.
    
    • **4 Units**: VVER-1200 AES-2006 Design
    
    • Two completed documents: (1) MOU and (2) Project Development Agreement. Not binding.
    
    • Pending Documents: Construction and Financing
    
    • **Documents to be signed after approval of the State Council of Egypt later in 2017 (delayed by 1+ year).**
  
  • **Others:**
    
    • **Korea**: KEPCO & KHNP: Will submitted a proposal in 2015 to win bids to construct nuclear power reactors.
    
    • **China**: 2015: MOU - CNNC and Egypt’s Nuclear Power Plants Authority (NNPA) for cooperation. Potentially China’s Hualong One nuclear power technology.
• **Iran**

  • **Not a party to nuclear liability conventions.** Party to the NPT. Signed an Additional Protocol but has not been implementing it. Now will.

  • Rosatom: 1 Unit: **Bushehr 1**.

  • **2017: Rosatom: Starting Construction on 2 Additional Units in Bushehr.**
    - Others planned, including VVERs and an indigenous 360 MWe LWR at Darkhowin.

  • **July 2015 Joint Comprehensive Plant of Action, Vienna**
    - No Heavy Water Reactors (Arak).
    - Over 15 years, will not enrich U235 above 3.67% and will reduce LEU from 9,000 to 300 kg.
    - Centrifuges reduced from 19,500 to 6,100 (only 5,000 spinning).
    - Agreed to implement AP to CSA.
• **Akkuyu**
  • *Partly un-stalled*
  • May be operational by 2023 according to 2017 statements

• **Sinop**
  • EDF and MHI signed a MOU to develop the ATMEA Reactor
  • April 2015: Turkey ratified an IGA with Japan to construct the Atmea nuclear power plant design.
  • Technical feasibility studies that determine the site suitability will be completed by the end of 2017
  • Turkey may own 49% of the project

• **Kırklareli**
  • SNPTC in 2015 signed an agreement with EUAS for a 4-unit CAP1400 plant
  • Chinese firms and Westinghouse are potential bidders for the project. Japanese firms also may have an interest in the third nuclear plant.
The United Kingdom
• **Current Status**
  
  • *15 Nuclear Reactors* (9 GWe) generate 21% of electricity (down from 25% in the 1990s).
    
    • 14 AGRs (Dungeness, Hartlepool, Heysham, Hinley Pt., Torness)
    
    • 1 PWR (Sizewell B)
  
  • Originally planned *16 GWe* of new nuclear to be operating by 2030 (total need for 60 GWe)

• **Government**

  • Historical under-investment in electricity generation
  
  • New 2015 Policy involving:
    
    • Possible phase-out of coal-fired generation
    
    • Construction of new gas-fired plants
    
    • **Greater reliance on nuclear power** & offshore wind
      
      • But “*nuclear must not only be low carbon but also low cost.*” - UK Energy Secretary
Three Key Projects

- **Hinkley C**
  - 2 Unit EPR (EDF)
  - Somerset

- **Horizon**
  - UK ABWR (Hitachi)
  - Wylfa

- **NuGen**
  - AP1000 (Toshiba & Engie (France))
  - Moorside
• **UK Nuclear Power Plants**

![UK nuclear power plants chart](chart.png)

Scheduled lifetimes of existing reactors and proposed new plants

Source: Telegraph
Nuclear Finance Funding Sources

Key Funding Sources for New Build

**Funding Advantage: State-Supported Nuclear Companies**
United Kingdom

- **EDF Energy New Build EPR Projects:**
  - **Hinkley Point C** (Somerset)
    - 2-unit EPR, design approval and a nuclear site license completed
    - Ownership: **33.5% CGN / 65.5% EDF Energy** (not less than 50%)
  - **Costs:**
    - Estimated Cost: £18 billion+
    - Strike Price: Fixed price of £92.50 per kilowatt hour
  - **Timeline:**
    - 2014: UK provides £2 billion Infrastructure UK Guarantee
    - 2015: EDF and CGN Sign Strategic Investment Agreement
    - **2016: Final Investment Decision (FID)**
    - 2017: Construction Started
United Kingdom

- **EDF Energy New Build EPR Projects:**
  - **Hinkley Point C** (Continued)
    - Key Suppliers:
      - France (NSSS, I&C)
      - Alstom France (turbines) and Alstom UK (operations)
      - Bouygues TP/Laing O’Rourke (main civil works) & BAM Nuttal/Kier Infrastructure (earthworks)
    - Brexit: Brexit is “no barrier” to the Hinkley Project, says EDF (4 July 2016)
  - **Sizewell C**
    - Initial planning stages
  - **Bradwell B** (Essex)
    - Current in the pre-planning stages with CGN
• **Horizon Nuclear**
  
  • **Owner**: Hitachi (2012)
  
  • 2-3 UK ABWRs
  
  • Currently receiving a Generic Design Assessment (GDA) for the ABWR (to be completed by 2018)
  
  • **EPC Joint Venture**: Hitachi Nuclear Energy Europe (Jan. 2016)
  
  • Hitachi-GE
  
  • Bechtel
  
  • JGC
  
  • Subcontractor selection will be decided by the JV, contracts will be issued by the partner companies on its behalf
  
  • Japan Atomic Power Company (JAPC) will assist
• Horizon Nuclear (Cont.)
  • Financing:
    • Negotiating with the Dept. of Energy & Climate Change (DECC) on the:
      • CfD Price
      • Government Guarantee
    • Horizon willing to cancel project if a deal is not reached
    • Deep consideration regarding financing – expertise needed
United Kingdom

• **NuGen Project (Moorside)**
  
  - **Owner:** Toshiba (60%) and Engie (40%) (2012)
  - 3 AP1000 Units Planned
  - Currently receiving a Generic Design Assessment (GDA) for the AP1000 (delayed but estimated to be completed by Q1 2017)
  - Plan to submit nuclear site license application in Q2 2017
  - **Leadership:**
    - New Chairman: Takeshi *Yokota* (July 1, 2016)
    - CEO: Tom *Samson* (formerly ENEC CEO)
  - **Financing**
    - *Chinese Power Firm in Investment Talks with NuGen* (May 2017)
Europe
• **Two Projects**
  
  • **Fennovoima (VVER)**
    * Rosatom: 34%; Finnish Investors: 77%
    * Capital cost: €6-7 billion including financing
    * Construction Contract Signed in 2013
    * Some delays
    * Status: STUK Discussions, Early Work
  
  • **Olkiluoto (TVO-Areva) (EPR)**
    * Unit 3 EPR Under Construction since 2005
      * Fixed-Price Turnkey Contract
      * Arbitration Dispute
        - TVO: $3.96 billion Euros
        - Areva: $3.4 billion Euros
    * Unit 4 Cancelled
France, Slovakia

- **Flamanville, France**
  - **Unit 3:** 1 EPR
  - **Issues:**
    - 2015: Areva informed ASN of weak spots in the steel pressure vessel
    - 2015: Cooling system safety faults
  - **Planned startup:** 2018
    - Pressure vessel may cause further delays
    - **Cost:** at least $11.5 billion (from $3.5 billion)

- **Mochovce, Slovakia**
  - VVER Units 3&4: Under construction, restarted construction in 2008
    - Unit 3: 92% Complete
    - Unit 4: 75% Complete
  - Owned by ENEL (Italy) and EPH (Slovak) & State (34%)
  - **Electricity to Grid:** Perhaps 2018
Poland, Czechia

- **Poland**
  - Nuclear project pushed back to **after 2030** according to PGE (July 2016) – Sited financing
  - May consider small nuclear
  - PGE canceled a site characterization consultancy contract

- **Czechia (also known as the Czech Republic)**
  - Considering new nuclear power
  - A **new nuclear envoy** is to serve as the main coordinator for new construction, supply chain, wastes, and legislation to move the nuclear sector forward
Europe Thoughts

- Some Construction Continues
- Growth Contract Areas for be in Decommissioning Nuclear Plants
Africa
South Africa

- Only country in Africa with an operating nuclear power plant.

- International Agreements
  - Not a party to nuclear liability conventions, CSA and Additional Protocol (2002)

- 2 Operating Units
  - 2 PWR units at Koeberg NPP (5% of country’s electricity)
**South Africa**

**Winding Process**

**2013:**

- **Westinghouse:** Agreement with the Sebata Group for potential NPP development

- **Rosatom:** Nuclear Energy Corp. of South Africa (NECSA) agreement with Russia’s ASE & Nukem to build the entire chain of NPP construction and operation.

**Sept. 2014:** **Rosatom** MOU with S. Africa’s Energy Minister for up to 9.6 Gwe of nuclear capacity by 2030

**Oct. 2014:** Nuclear Coop. Agreement with **France** signed.

**Nov. 2014:** IGA with **China** – the “preparatory phase for a possible utilization of Chinese nuclear technology in South Africa”
South Africa

• **Current 2017 New Build Procurement Process**
  
  • **Targets:**
    
    - 9.6 GWe
    
    - First unit on line in 2023

  • In 2015 Eskom ceded control of the new build program to the **Department of Energy**.
    
    - **Advisor to South Africa’s Dept. of Energy: Worley Parsons (2016)**

  • **2016:** Court ruled the government failed to allow adequate public consultation for preliminary agreements with Russia, S. Korea, and the US

  • **2017:** South Africa will relaunch nuclear power plants by signing new agreements.
• **International Instruments**
  • Not a signatory to any international nuclear liability convention.

• **Operational units: None**

• **Current Status**
  • Kenya Nuclear Electricity Board (Nuc. Energy Prog. Impl. Org.)
  • **2015:**
    • **Pre-feasibility Study Completed**
    • Plan to have four units, with the first unit operating by 2023, completed by 2031.
    • Discussing with numerous vendors, including Chinese
    • Signed MOU with Russia in 2016
• **International Instruments:**
  - 1963 Vienna Convention, CSA and Additional Protocol

• **Operating Research Reactor**
  - Nigeria Research Reactor-1
  - Chinese-Origin Research Reactor (Ahmadu Bello University)

• **Actively Considering Nuclear Power**
  - **2012**: Signed a cooperation agreement with Rosatom based on 2009 IGA
  - **2014**: Statement by President to develop nuclear power (4,000 MWe by 2030 Planned).
  - **2015**: Nigeria was in talks with Rosatom and others.
Concluding Thoughts

- Financing and Delivery Matter
- Commercial participants in competition:
  - China
  - U.S.
  - Russia
  - South Korea
  - France
- State funding will continue to lead development
Competition can be Effective

- Let each vendor bid as they usually do
  - Priority for a requirements contract
  - Priority for fixed price
  - Priority for single bidder
- Make financing part of the bid
- Make technology transfer part of the bid only if it is required
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