Nuclear Power Markets Status & Outlook:

UK, Europe

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Nuclear Power Outlook
Nuclear Power Development

1954-1970:
84 Power Units

1970-1979:
162 Power Units

Source: WNA
Nuclear Power Under Construction

Units Under Construction: 71*

- **Africa**: 2.8%
- **Latin America**: 0.0%
- **U.S. and Canada**: 7.0%
- **Asia - Far East**: 22.5%
- **Asia - Middle East and South**: 49.3%
- **Europe - Central and Eastern**: 15.5%
- **Europe - Western**: 2.8%

*Based on IAEA Power Reactor Information System (PRIS) Database
Growing Markets: Under Construction & Proposed

UK NEW BUILD
- Operating: 15
- Under construction: 0
- Proposed: Up to 16 GWe by 2030

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

Map Source: WNA
The United Kingdom
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)
  - 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

Source: Telegraph
• **UK Nuclear Power Plants**

![UK nuclear power plants chart](chart_image)

Source: Telegraph
• **Only Four Key Issues**
  
  • **Financing** (Outside Investors)
  
  • **Financing** (Value of the British Pound)
  
  • **Financing** (Implications of Brexit)
  
  • **Financing** (Obligations to Support the EU)
Nuclear Finance Funding Sources

Key Funding Sources for New Build
**Funding Advantage: State-Supported Nuclear Companies**
• **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
      
      • **Sept. 2016: Final Investment Decision (FID)**
        
        • Originally to be made in May 2016
        
        • Reports that the EDF board may be divided
        
        • EDF workers have “no opinion” on the project (July 2016)
• **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 – will announce status after Hinkley C FID Announcement

  • **Bradwell B** (Essex)
    - Current in the pre-planning stages with CGN
United Kingdom

- **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 (July 2016)
• **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

  • **New Sheriff (May 2016)**

    • Duncan Hawthorne – Previously CEO of Bruce Power
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**
    • In discussions with ECAs, **structuring EPC & finance model**
    • Not in discussions yet with the UK Government for CfD and Guarantees
    • FID by end of 2018
Europe
Finland

- **Two Projects**
  - **Fennovoima** (VVER)
    - Rosatom: 34%; Finnish Investors: 77%
    - Capital cost: €6-7 billion including financing
    - Construction Contract Signed in 2013
    - Status: STUK Discussions, Early Work
  - **Olkiluoto** (TVO-Areva) (EPR)
    - Unit 3 EPR Under Construction since 2005
      - Fixed-Price Turnkey Contract
      - Original Arbitration Dispute – Called Off in May 2016
        - 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 (will sell to EPH) and Slovakia
  - **Electricity to Grid:** 2017
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
  - **January 2016: new committee** headed by the **prime minister** to coordinate the development of nuclear power in the country.
  - 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
Nuclear Power Markets Status & Outlook:

MENA, Africa

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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)
United Arab Emirates

• **Lead Nuclear Program in the GCC**

• **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

- Unit 1: 88% Complete
  - Successfully completed Safety Tests (July 2016)
- Unit 2: 72% Complete
- Unit 3: 50% Complete
- Unit 4: 31% Complete
United Arab Emirates

- **Operating Entity:**
  - ENEC's nuclear operating subsidiary commenced in 2016
  - Nawah Energy Company

- **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
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 consumption of oil for electricity generation
    - $200 Billion for Solar (41 GWe Solar)
    - $100 Billion for Nuclear (16 Units)
  - Currently, these milestones have been revised

- **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.

- **January 2016:** China - MOU to build HTR

**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)**
  - Under construction
  - Expected to be operational by June 2016
• **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%)

• **2 Project Agreements**
  - 2014: The Project Development Agreement ("PDA") between JAEC and Rosatom.
  - March 2015: The Intergovernmental Agreement ("IGA") between Russia and Jordan

• **Jordan now seeks a U.S. 123 Agreement**
  - According to press reports in July 2016
  - For SMRs
• **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.**
    
    • **2 Units:** VVER AES-2006 Design
    
    • Two completed documents: (1) MOU and (2) Project Development Agreement. Not binding.
    
    • Pending Documents: Construction and Financing
    
    • **Documents to be signed in the Summer of 2016.**
  
  • **Others:**
    
    • **Korea:** KEPCO & KHNP: Will submit 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.**

- **Rosatom: Pledged 2 Additional Units. May begin construction in 2016. 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).
  - Nuclear R&D restricted to Natanz.. Used fuel shipped out to Russia.
  - Agreed to implement AP to CSA.
Turkey

- Akkuyu
  - Stalled
  - May be unfrozen – Russian sanctions are to be reduced on a “gradual basis” according to Medvedev – June 2016

- 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
  - Turkey may own 49% of the project

- China
  - SNPTC in 2015 signed an agreement with EUAS for a 4-unit CAP1400 plant
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 2016 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)
• **International Instruments**
  - Not a signatory to any international nuclear liability convention.

• **Operational units**: None

• **Current Status**
  - 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
• **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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