

United States Nuclear Infrastructure Council

pillsbury

Special Summit: Competing in the Global Nuclear Energy Market (2016)



Nuclear Power Markets Status & Outlook:

UK, Europe

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Nuclear Power Outlook



Nuclear Power Development



1960

1970



1954-1970:

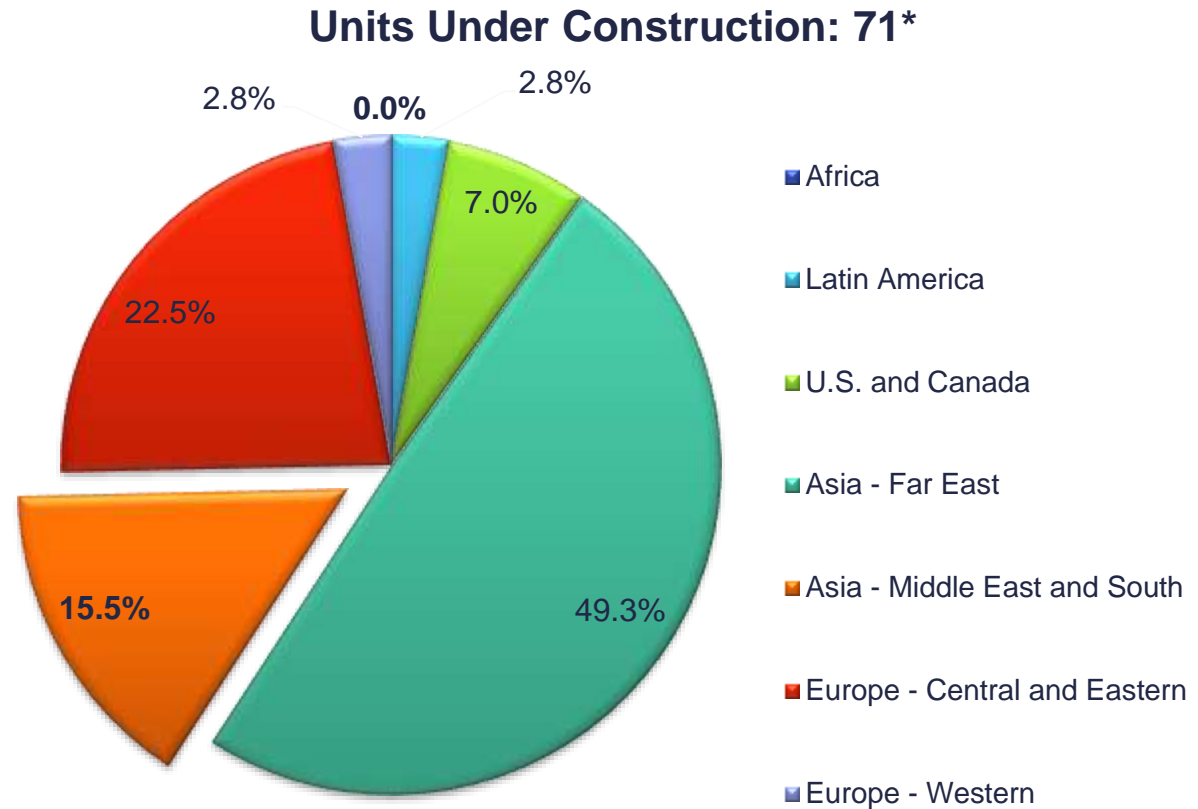
84 Power Units



1970-197

162 Power

Nuclear Power Under Construction



*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





- **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**



United Kingdom



• Three Key Projects

• Hinkley C

- 2 Unit EPR (EDF)
- Somerset

• Horizon

- UK ABWR (Hitachi)
- Wylfa

• NuGen

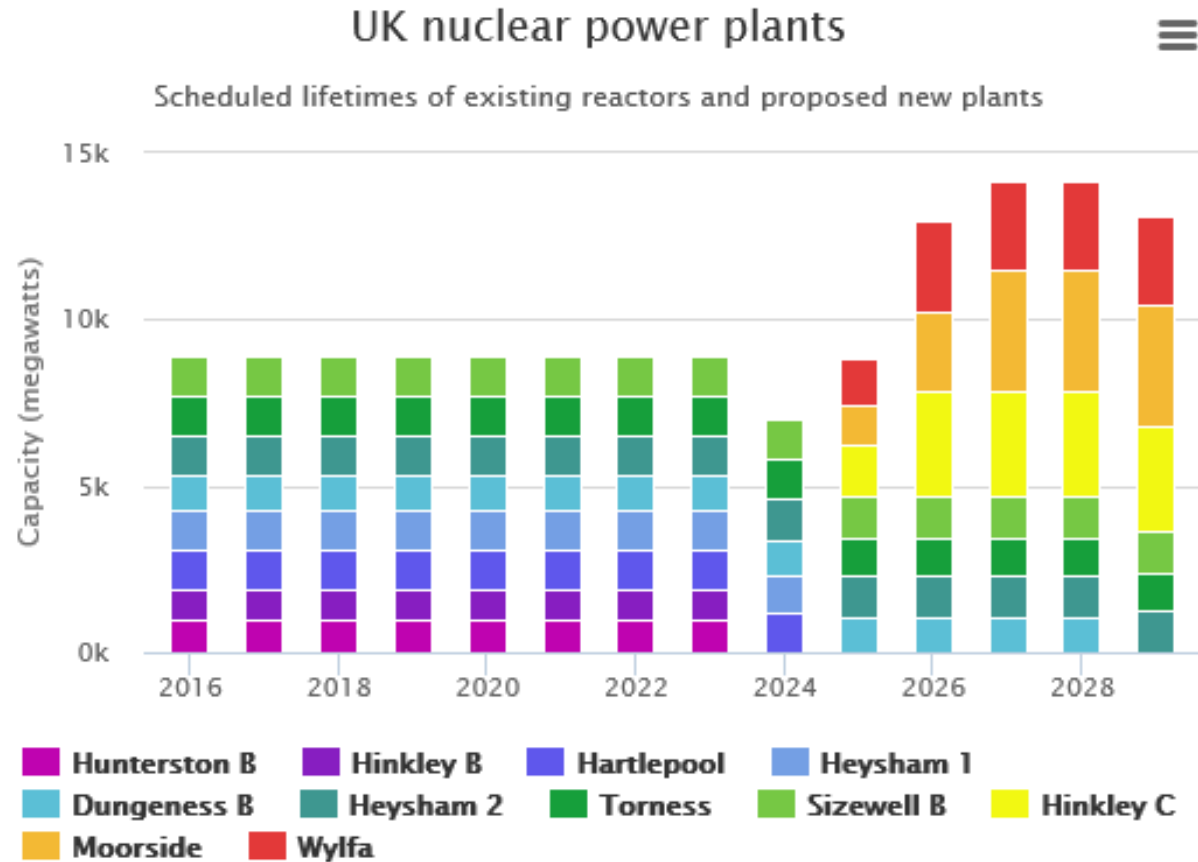
- AP1000 (Toshiba & Engie (France))
- Moorside

● Confirmed new sites ● Sites currently generating ● Shut-down sites



Source: Telegraph

- UK Nuclear Power Plants



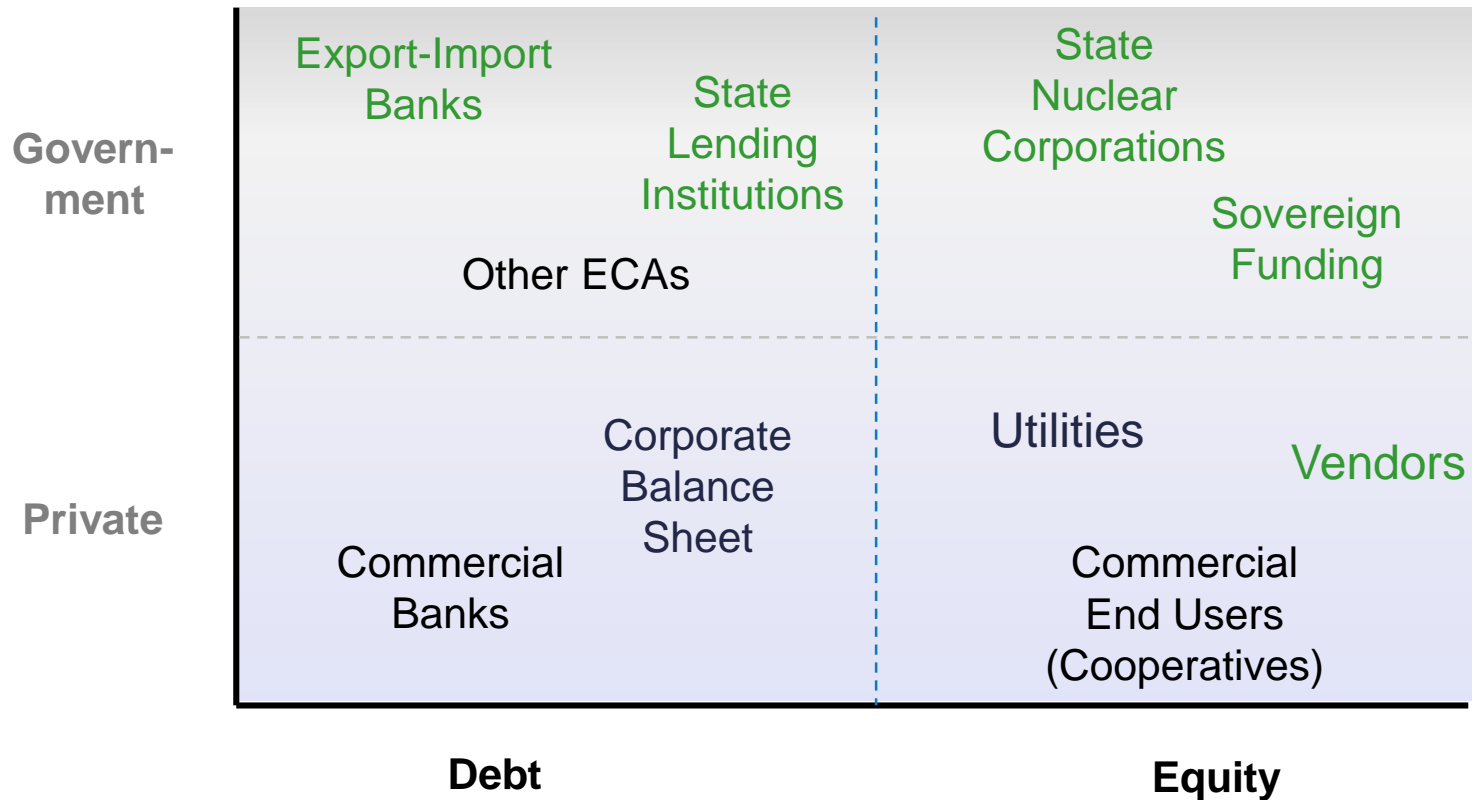
Source: Telegraph

- 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

- **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



- **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



- **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

Nuclear Power Plants in Czech Republic



Source: World Nuclear Association

Europe Thoughts

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





Nuclear Power Markets Status & Outlook:

MENA, Africa

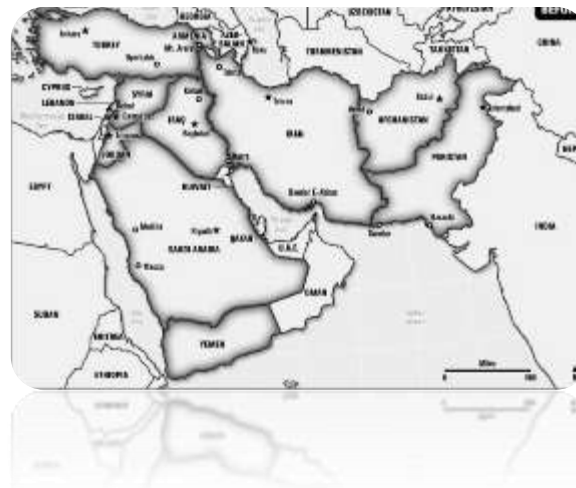
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Middle East



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**



مؤسسة الإمارات للطاقة النووية
Emirates Nuclear Energy Corporation



United Arab Emirates

- **Unit Status**

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



مؤسسة الإمارات للطاقة النووية
Emirates Nuclear Energy Corporation





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





- **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

- **Good International Legal Infrastructure**
 - Vienna 1997
 - Safeguards Agreement (1978) and Additional Protocol (1998)
- **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 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.**
 - VVER-1000. Operating in 2011. Entered Commercial Operation in 2013.
- **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 Plan 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)





- **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**

- 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





Nigeria

- **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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