

Recent experience of Dukovany tender participants

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Presentation to Nuclear Energy Conference 2022
May 18 2022

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Outline

- Criteria to evaluate bidders
- Framatome EPR 1200
- Westinghouse AP1000
- KHNP APR1000
- Common issues for all designs

Criteria

- Vendor credibility
- Price
- Availability of finance. France, USA & Korea unwilling to offer loan guarantees
- Construction experience
- Operating experience
- Ability to satisfy European safety requirements

Framatome EPR: Experience with EPR 1600

- EPR1600 reviewed by Finnish, French, UK & Chinese safety authorities
- Olkiluoto (Finland), first European Pressurised Reactor ordered 2003, construction start 2005 started testing in March 2022. Forecast cost €3bn, actual cost €10+bn. Areva gave fixed price contract & lost ca €5bn contributing to its financial collapse
- Flamanville (France) start construction 2007. Hoped to complete by 2024. Expected cost €3.2bn, latest estimate €12.7bn (2015 money)
- Taishan 1 & 2. Construction start 2008/09, completion 2018/19. Reportedly 60+% overbudget. Unit 1 closed since June 2021 due to fuel problem. May require fixes to reactors in operation & under construction & a design change to new orders
- Hinkley Point C (x2). Construction since 2018/19, latest completion forecast 2027/28. Expected cost £16bn, latest estimate £22-23.7bn (2016 money). EDF reviewing time & cost, new estimates due June. Expected cost increase of £2bn & 1 year delay

Framatome EPR

EPR-2

- EPR-2, also 1650MW, under development since 2010. Said to be 25% cheaper & easier to build than EPR but still some years from first order
- Costs reduced by reducing safety features, e.g., double wall containment replaced by single wall. Won't be offered for export till operating in France, after 2030

EPR1200

- EPR has 4 coolant loops, EPR1200 would have 3. Would it be based on EPR-1 or EPR-2?
- Design does not exist in detail, has not been reviewed by a safety authority & has no other sales prospects apart from Czech Rep
- Development & first-of-a-kind costs would be substantial. Who would pay them?

Framatome Reputation

- Areva collapsed in 2016 & French government (majority owner) split the company into fuel cycle company (Orano) & reactor business, taken over by EDF & renamed Framatome
- Areva found guilty in 2013 of falsifying QC records going back 50 years
- Multiple QC failures with Olkiluoto & Flamanville. Incorrect pouring of concrete, defective welds, sub-standard reactor vessel

Westinghouse AP1000: Experience

- AP1000 reviewed by US, Chinese & UK safety authorities
- China: Haiyang (x 2) & Sanmen (x 2) construction start 2009-10, completed 2018-19. Cost unknown. Operating performance mostly good
- USA: Summer (x 2) construction start 2013 when cost expected \$5.2bn, abandoned 2017 when cost about \$25bn. State regulator promised full cost recovery & consumers paid finance charges. Consumers left with \$10bn bill
- USA: Vogtle (x2) construction start 2013, expected complete 2017. Latest estimate 2023. Cost >\$35bn cf original estimate \$11bn. Guaranteed loans provided by US government. State regulator promised full cost recovery & consumers paid finance charges.

Westinghouse AP1000: Reputation

- Westinghouse filed for Chapter 11 bankruptcy protection 2017. Bought by Canadian venture capital company, Brookfields. Brookfields wants to sell
- Criminal charges against former Westinghouse execs being investigated resulting from Summer project
- Multiple QC violations found at Vogtle site (8/21)

KHNP APR1400

- Design licensed from Combustion Engineering (System 80+) -1990s design
- 2 complete in Korea (Shin Kori 3, 4) after 8-10 years, 2016, 2019. Long shutdown 2018 at unit 3 due to defective pilot-operated stress relief valve (POSRV). Generic issue for all APR1400s
- 2 under construction in Korea since 2012/13 (Shin Hanul 1, 2). Nearly complete 4-5 years late. 2 more under construction since 2017/18 (Shin Kori 5, 6), completion 2025, 3-4 years late
- 4 under construction in UAE (Barakah) since 2012-15. 1st completed 4/21, 5 years late, 2nd testing, also 5 years late. Units 3-4 under construction & late
- POSRV is safety critical & despite problem being identified, not clear if it is solved
- Design reviewed by US & Korean authorities. No safety regulator existed in UAE when Barakah ordered
- Areva CEO said APR1400 design 'like a car without air-bags & seat belts.' European design not reviewed yet

KHNP APR1000 & reputation

APR1000

- Design does not exist in detail, has not been reviewed by a safety authority & has no other sales prospects apart from Czech Rep
- Development & first of a kind costs would be substantial. Who would pay them?
- KHNP's only export experience to UAE. Delays & quality issues

Reputation

- Large scale QC falsification in Korea discovered in 2012 delaying 4 APR1400s. All suspect components had to be replaced

Issues: Construction cost

- Real overnight (excluding finance) nuclear costs have consistently gone up
- Standardisation, bulk ordering & factory production, the standard nuclear industry prescription to lower costs, have not worked. Even in France, the real cost of the standardised large-scale programme went up significantly over time
- The Nuclear Renaissance of ca 2000 promised construction costs of \$1,000/kW. Latest costs about \$10,000/kW
- Contract costs are not a good indicator of actual costs so no sane vendor will offer a fixed price (turnkey) contract. So buyer is signing a blank cheque. Fixed price contracts a major element in the financial failure of Areva & Westinghouse

Issues: Finance (1)

- China & Russia would offer low-cost finance but they are politically unacceptable
- Whether nuclear is categorised as 'green' under the EU taxonomy does not change the risk for financiers so won't make a significant difference
- Cost of finance during construction of the same order as construction cost
- Nuclear projects are risky so banks won't lend money if any risk falls on them
- Vendors will not accept the risk via turnkey contracts,
- If nuclear is to be financeable, the risk has to fall on consumers who will have all costs incurred passed on to them in electricity bills

Issues: Finance (2)

- New schemes aim to reduce cost by forcing consumers to pay the finance costs as a surcharge on their bills
- Consumers would pay the interest costs from final investment decision till commercial operation
- Adopted for Summer & Vogtle with very bad results (see below) & proposed for UK (Regulated Asset Base model)
- Only feasible if consumers guaranteed to meet whatever costs are incurred

Issues: Power purchase price – fixed price

- Two main options: fixed price or variable price
- Under the UK Contract for Differences (CFD) model, the power purchase price is fixed at the start with the plant owner taking the risk of cost overrun.
- For Hinkley (UK), the power purchase price was set at £92.5/MWh (2012 money, ~€110/MWh) when the construction cost was expected to be £14bn. Construction cost is now forecast to be £22-23.7bn (under review & expected to rise) but the power purchase price cannot increase.
- Seems likely EDF will lose heavily & EDF has said it won't use the model again

Issues: Power purchase price – variable price

- Most projects have a variable power purchase price reflecting costs incurred
- If all costs can be recovered from consumers, the risk on financiers is less, but consumers are signing a blank cheque

Issues: Vulnerability

- Browns Ferry (1975), Three Mile Island (1979) & Chernobyl (1986) have exposed how vulnerable NPPs are to operator error, but can weaknesses be designed out (at what cost)?
- 9/11 (2002), Fukushima (2011) & Ukraine invasion (2022) have exposed how vulnerable nuclear reactors are to external events. Can we conceive of all possible risks or are we just solving yesterday's problem?

Conclusions

- Of the 3 designs under consideration:
 1. EPR1200 & APR1000 would be untested designs based on scaled-down designs with poor history with first of a kind costs falling on Czech Rep
 2. Construction experience with AP1000 & EPR poor, operating experience with EPR poor, major problem with fuel not resolved
- Serious quality issues during construction have occurred with all designs
- Outturn cost impossible to predict. Reactors are always late & overbudget
- Design issues with, eg, fuel (EPR), reactor coolant pumps (AP1000), pilot operated stress relief valve (APR1400)
- Reputation of all 3 vendors poor. Framatome & Westinghouse recovering from financial collapse. KHNP & Framatome guilty of large-scale QC falsification.