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AWARIE BUDOWLANE

prevention
diagnostics
repairs
rehabilitations

West Pomeranian University of Technology, Szczecin

Polish Association of Civil Engineers and Technicians, Branch in Szczecin

ICSF 2024

Challenges & Opportunities for Nuclear Construction

Lessons Learned and Not Followed

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Outline

- Review of Past Failures
- Highlights of Success Stories
- Lessons Learned – Complexity & FOAK Not Understood
- Lessons Not Learned
- What Should Poland Do?
- Summary

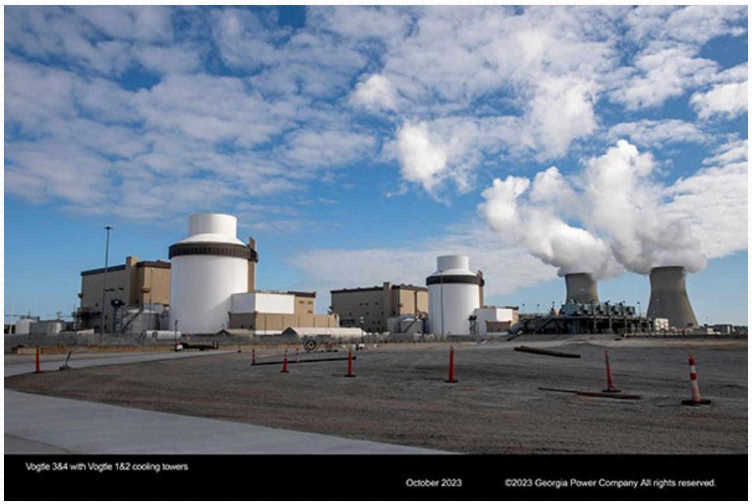
MegaProjects and Failures

- Years to build
- Billions in cost
- Complex - involving many contractors
- Mostly infrastructure (roads, bridges, tunnels, dams)

Building a Nuclear Plant is a Super-Mega-Project

- Dysfunctional Project Teams = prime drivers of failure
- Failure is not a structural or functional failure
- Failure = Not meeting budget or schedule

Vogtle 3&4 AP1000@1150 (USA)

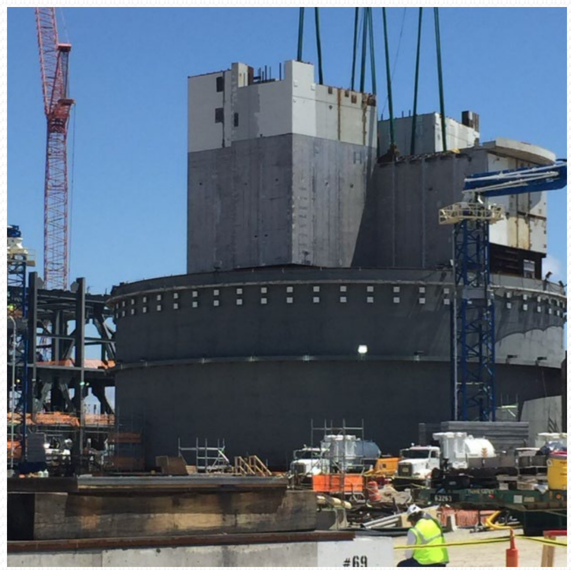


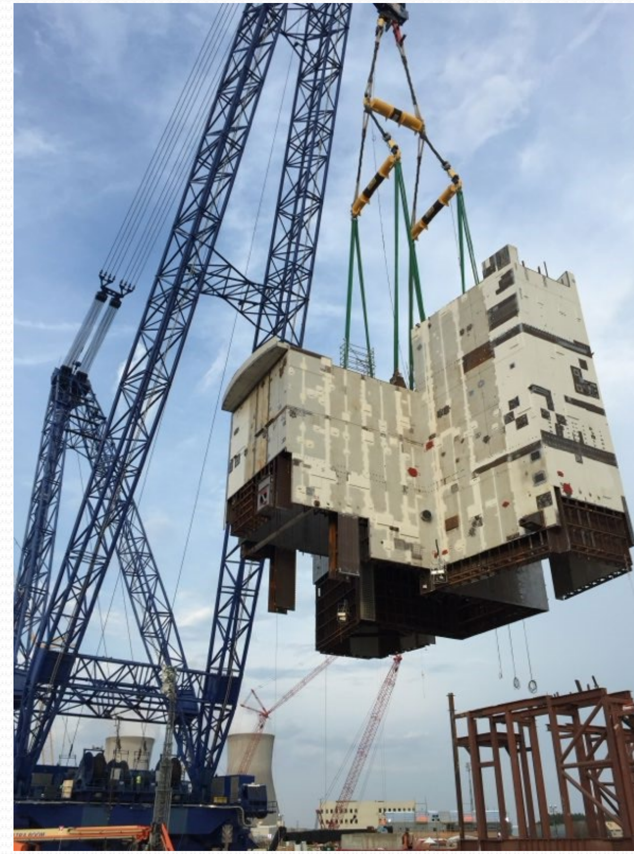
- First of a kind design
- First of a kind licensing
- First of a kind construction
- Incomplete detail design
- Not constructible – 1,000 design changes/week
- Problems with manufacturing of modules
- Problems placing foundation concrete and re-bar
- Problems with regulator
- Shortage of qualified labor

Initial start: 2009
Operation: 2023/2024
Initial Budget: $ 14 Billion
Final Cost: $ 30 Billion

Modules – **HUGE!**

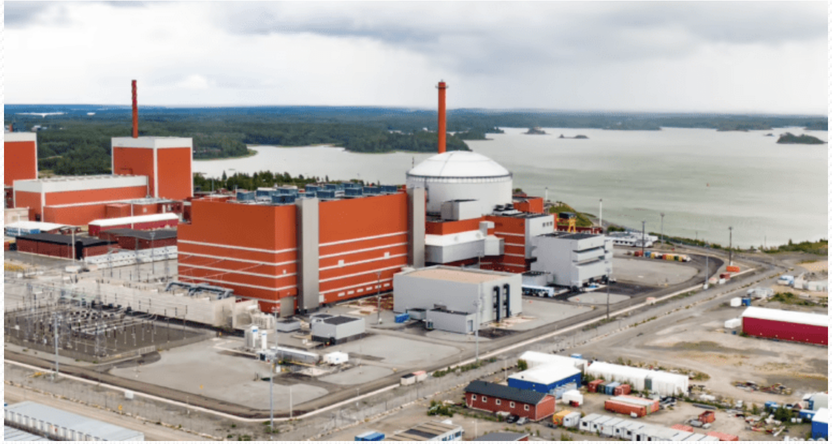
Vogtle





Issues: Deformation, tight tolerances, access, fit up, quality of welds, very heavy

Olkiluoto 3 – 1600 EPR (Finland)



Initial start: 2005
Operation: 2023
Initial Budget: $ 3 Billion
Final Cost: $ 14 Billion

- First of a kind design
- First of a kind licensing
- First of a kind construction
- Constructor lacked nuclear construction experience
- Incomplete design
- Not constructible
- Different country standards
- Reactor vessel fabrication problems
- Welding qualified work force
- Concrete issues
- Turnkey project –contract disputes

Flamanville 3 - 1600 EPR (France)

Initial start: 2007
Operation: 2024
Initial Budget: $ 3.3 Billion
Final Cost: $ 13 Billion

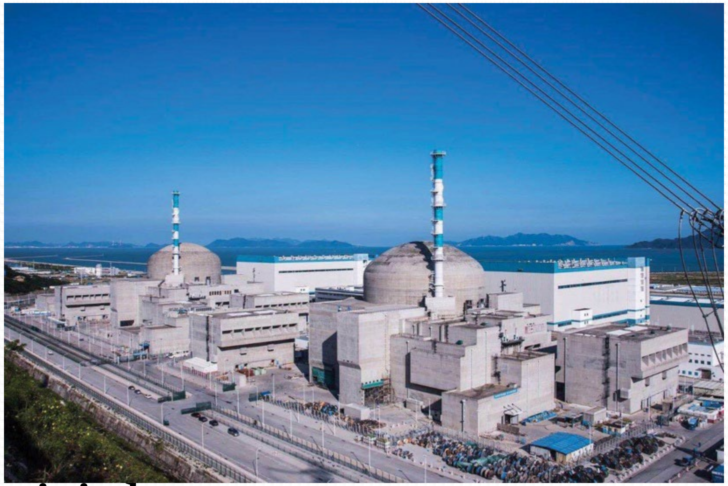
- Problems similar to Olkiluoto
- Poor quality workmanship
- Many regulatory stops
- Manufacturing problems with steam generator
- Reactor vessel anomalies
- Difficulties placing containment concrete & rebar
- Poor management oversight

Barakah – 4 Units APR @1400 (UAE)

Initial start: 2005
Operation: 2023
Initial Budget: $ 20 Billion
Final Cost: $ 24 Billion

- Not First of a Kind
- Design complete
- New Flexible Regulator
- Proven Contractor Team
- Owner engagement
- Strong management Oversight
- Repairs in Containment
- Delay to lack of operational readiness

Taishan 2 units EPR @ 1750(China)



Initial start: 2009

Operation: 2018/2019

Initial Budget: $ 3 Billion

Final Cost: $ 14 Billion

- First commercial EPR
- 1000's lessons from Olkiluoto applied
- EPR difficult to build
- Construction period extended from 46 months to 88 months
- Recently had a fuel cladding problem
- China can apply experienced labor

Sanmen -2 Units AP1000 (China)

Initial start: 2009
Operation: 2018/2018
Initial Budget: $ 5 Billion
Final Cost: $ 7.7 Billion

- 2 units built essentially simultaneously
- Built a large on-site modular assembly plant
- Difficulty with suppliers
- Experienced contractors
- Localization effort reduces some risk but quality control is an issue
- Shows value of continuous nuclear construction program

Building a nuclear plant is Hard

- The plant is extremely complex, millions of interfaces, and big
- Many systems need to work together to maintain safety & operation
- Supply chain needs to be nuclear "qualified"
- Management must be vigilant about progress
- Procurement must be timely on site
- Design changes during construction cost $$$$$$$ and Time
- Design must be constructible and tested before attempting at the site – 3 D computer models
- Work force needs to have a nuclear culture
- Subcontractors need to understand the difference
- Strong, decisive leadership is vital – no confusion
- The regulator needs to be flexible and part of the solution

Summary of Nuclear Power Plant Design/Engineering/Procurement/Construction Deliverables

Managing Configuration of Millions of Data Interfaces & Revisions are Crucial for Success

Engineering & Design Products	Approx. Number		Approx. Number	Vendor Data for Detail Design
Piping, Mechanical, Electrical Systems	100		500	Specifications - Engineered Equipment
Major Equipment Components	2,000		500	Specifications - Engineered Off the Shelf
Engineering Calculations	10,000		1,000	Purchase Orders - Equipment/Material
P&ID Flow Diagrams	500		100	Contracts - Labor/Equip/Material
Control Logic Diagrams	500		16,500	Vendor Technical Submittals (average 15 submittals per P.O. & contract)
Elementary Wiring Diagrams	1,000		165,000	Vendor Detailed Data Documents (average 10 documents per submittal)
Construction Drawings	>10,000		4,125,000	Vendor Document Pages to Review, Check, & Incorporate in Design (average 25 pages per document)

3-D computer model technology assists but does not replace rigorous human review to assure fidelity

Lessons Learned

- Incomplete detailed design suitable for construction
- Poor selection of contractors, vendors that do not understand nuclear quality expectations
- Management that believes that they will catch up
- Slow response time to correct problems
- Confused leadership roles
- Lack of oversight by experienced professionals
- No plan B (risk management)
- Lack of detailed plans and schedules
- Budget controls just track costs – not prepared to adjust

Lessons Learned

Four Industry Lessons Learned Reports from Hundreds:

- Royal Academy of Engineering
- Nuclear Energy Institute (USA)
- Massachusetts Institute of Technology
- Electric Power Research Institute (EPRI)

Why are Lessons Not Followed?

- Organization and Individual Blind Spots
- Unwillingness to invest in upfront planning
- Thinking you are smarter than those who preceded you

Lessons Not Learned

- Selection is critical
  - Selection of technology
  - Selection of design engineer, constructor, subcontractors and vendors
  - Selection of workforce qualified for nuclear work
  - Selection people in the leadership team
- Importance of document control and quality assurance
- Lack of planning for the “unexpected’ contingencies
- Too aggressive/unrealistic schedule and cost estimates

What Should Poland Do?

- Before start of construction assure:
  - The detailed design is complete
  - Review detailed design to assure that it meets local and European nuclear standards for construction and operation.
  - The procurement schedule and contractors can deliver on time (requires detailed reviews)
  - Have a digital twin made of the design and construction sequence.
  - Review the qualifications of the leadership team individually
  - Do not be tempted to go “Local” unless they have nuclear qualifications.
  - Be sure design, supply chain, & construction workforce is qualified for nuclear work – training and certification.

Success Strategy:

- The key to success is knowing where you stand in the construction process and be able to adjust.
- Recommendations:
  - Establish two groups of independent experienced engineers and constructors (in addition to your QA)
    1. On-site and key offices of major contractors to monitor progress on a regular basis – Construction Review Board (CRB) -monthly
    2. Establish a Senior Construction Oversight Board (SCOB) to report quarterly to senior utility management their overall assessment based on their independent reviews of CRB and other factors.

Summary

- Success of nuclear power requires building plants on budget and schedule
- There are plenty of lessons learned.
- What is needed is good implementation
- This is the management challenge and opportunity

Thank you for your attention !

Biography

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