The Challenges & Promise of Small Modular Reactors

June 22, 2017

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Current Utility Environment

- Demand is flat to declining
- Customers have changed their electricity use behaviors; more energy efficiency, adjusting to time of day usage
- Gas prices are cheap and expected to stay low
- Regulations are more challenging for both coal and nuclear
- Current policies and incentives are stimulating wide-spread deployment of renewables, affecting grid requirements
- Electricity markets do not currently value many of nuclear energy's favorable attributes (grid stability, carbon-free, highly reliable, many good jobs, stable fuel supply and price)

Biggest Challenge for New Nuclear……Time

NRC

- Utility COL – 7 to 12 years
- Vendor DC – 8+ years

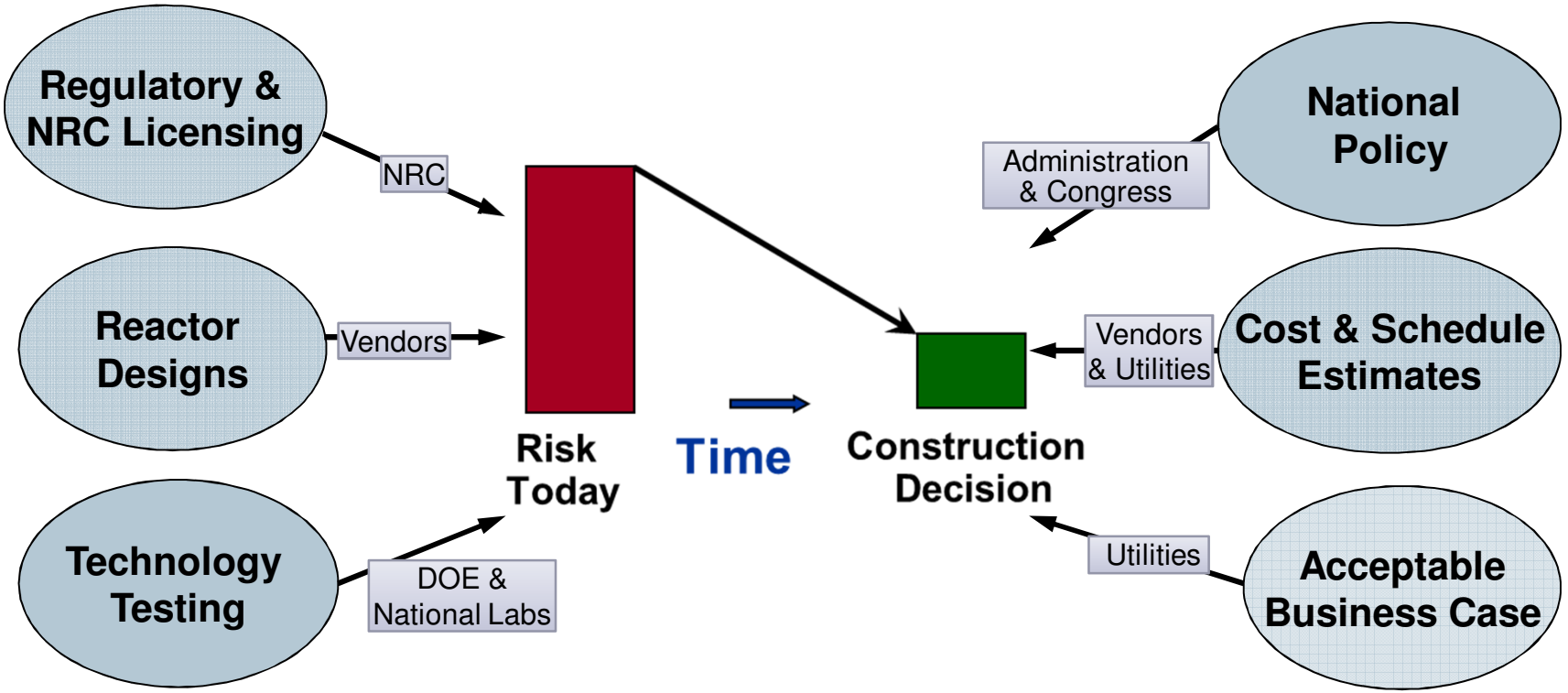
Construction Schedule

- Large – 5 to 11 years
- SMRs – 3 to 5 years
- Other Advanced – ??

The planning horizon for new nuclear generation is 10 – 20 years.

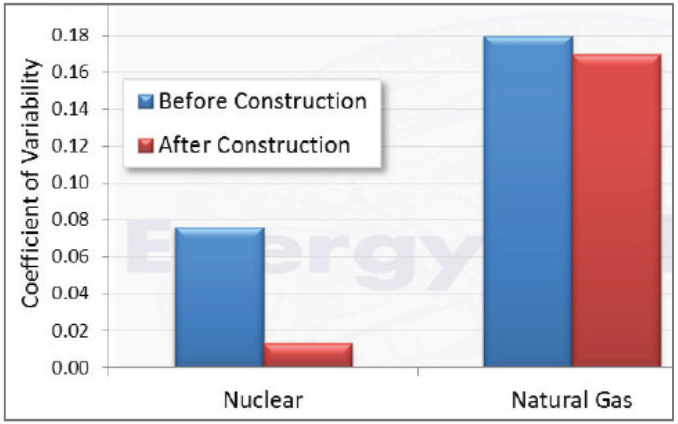
Higher degree of marketplace uncertainty that far out.

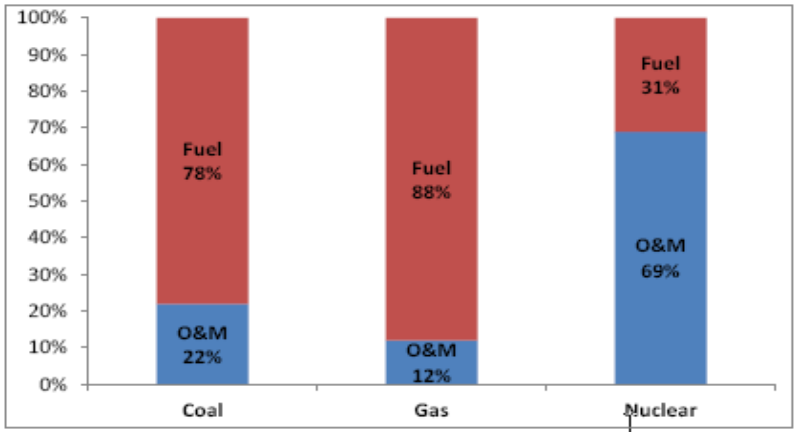
Challenges to an SMR Build Decision



Why Would A Utility Choose Nuclear?

Price Stability





Reliability >90% Capacity Factor Grid Stability Portfolio Diversity

Clean Zero Carbon Emissions

Attractive Features of SMRs

- Enhanced safety and security
- Lower capital cost capacity additions
- Little or no fuel cycle risk
- More flexibility to meet electricity demand; more distributed and more incremental
- More operational flexibility; load-following and continued operation during loss of off-site power
- Smaller footprint and reduced emergency planning zone lead to more siting options; opportunity to repower coal plants

Option for reliable and carbon-free electricity generation in affordable increments!

Work is Underway to Reduce Uncertainties for SMRs

- Maturing designs (NuScale spend >$500M so far)
- Changing regulations (working with NEI to drive NRC)
- Addressing licensing risks in step-wise manner
- Risks analyzed and prioritized
- Sharing risks with DOE and others
- TVA is viewing Clinch River as a demonstration – to reduce uncertainties – to increase viability of option
- Seeking Federal support on Clinch River SMR to keep TVA customer's rates unaffected

Economic Considerations

- Traditional Large Light Water Reactors
  - Average for 2 AP 1000 reactors (Vogtle/Summer) Wikipedia
  - ~ $12B - $14B for 2250 MW
  - ~ 2013: nuclear construction start, 2019 - 2020: forecast completion
- NuScale – current vendor estimate
  - ~ $3B for 570 MW
  - ~ 3 years to construct
- SMR Value Considerations
  - Modular construction
  - Reduced construction period
  - Reduced financing costs
  - Potential for reduced transmission interconnect costs

TVA Early Site Permit Application

- Docketed by NRC on December 30, 2016
  - Submitted May 12, 2016
  - Supplemented later in 2016
- >8000 pages
- Next Steps
  - Support NRC Requests for Additional Information (RAIs)
  - Support NRC Audits
  - Respond to Atomic Safety and Licensing Board
  - Received NRC schedule in March 2017
  - Review expected to take about 3 years

TVA Presenting Application to NRC

QA - Requirements

- Nuclear Safety Related
  - 10 CFR 50 App B
  - ASME NQA-1 2008/2009
  - 10 CFR 21
  - “N” Stamp per ASME Code Section III
  - Nuclear Safety Culture
- Augmented Quality – A quality classification used to identify non-safety related items or services designated that perform functions that are important to safety. Example: Highly reliable electrical equipment (switchgear, MCCs, PDCs, inverters, VFDs)

QA – Nuclear Safety Related

- An item/component becomes a Nuclear Safety Related item when it is controlled under a suppliers nuclear QA program that is implemented for design, manufacture, testing, and inspection.
- The process by which a commercial item becomes a Nuclear Safety Related item is known as “Commercial Grade Dedication”.

QA – Oversight

- Reactor vendor QA is required to evaluate the supplier's QA program prior to placing an order.
- Purpose is to evaluate a supplier's ability to provide items or services in accordance technical and QA requirements.
- Monitoring supper performance through periodic review using annual evaluations, audits, commercial grade surveys, surveillances, and/or the owner acceptance review process.

QA – Lessons Learned from Industry

- Implement improvements in the oversight of suppliers
- Effectively validate procurement (design and testing) requirements including adequate qualification testing.
- Ensure suppliers and sub-suppliers are suitable qualified for and capable of performing the contracted scope.
- Improve the rigor in the development, implementation and assessment of qualification testing to establish or ensure adequate component design.
- Implement a robust Corrective Action Program.

QA – Observations from the Utility

- Not getting quality right the first time is very costly.
- Assign the correct quality requirements to items/components (don't apply NQA-1 if Commercial Grade Dedication meets requirements).
- Begin the design process with the end quality requirements in mind.
- We are all in this together. Help vendor audit program, utility audit program, and NUPIC audits to be successful and we are all successful.

Summary

- Market conditions difficult for new nuclear builds
- SMR facilities would provide utilities with significant benefits
- Licensing and regulatory progress is being made, but more progress is needed
- QA in nuclear construction will make the difference between a project that is successful and one that is not.
- TVA continues leadership role in SMR development as SMR option remains attractive and continued investment is warranted.

Acknowledgment: "This material is based upon work supported by the Department of Energy under Award Number DE-NE0008336."