TVA's Clinch River SMR Project

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Tennessee Valley Authority

Public power provider

- 7-state region
- 80,000 square miles
- 9 million people
- 650,000 businesses
- 155 distributors
- 56 direct-served customers

Tennessee Valley Authority

Established in 1933 as "a corporation clothed with the power of government but possessed of the flexibility of a private enterprise"

Our Mission:

- Reliable & affordable electricity
- River & natural resource management
- Economic development & technology innovation
- National defense & environmental stewardship

Our Vision:

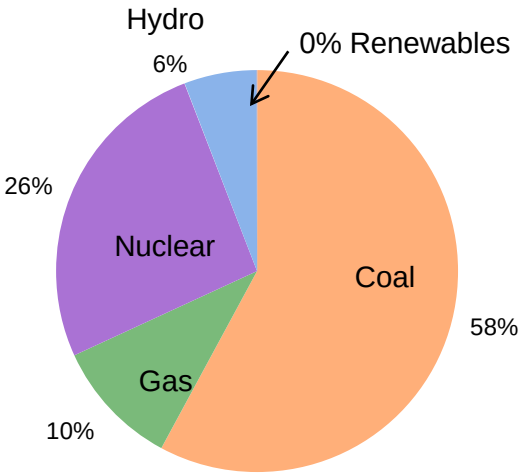
One of the Nation's leading providers of low-cost and cleaner energy by 2020

TVA's Technology Priorities:

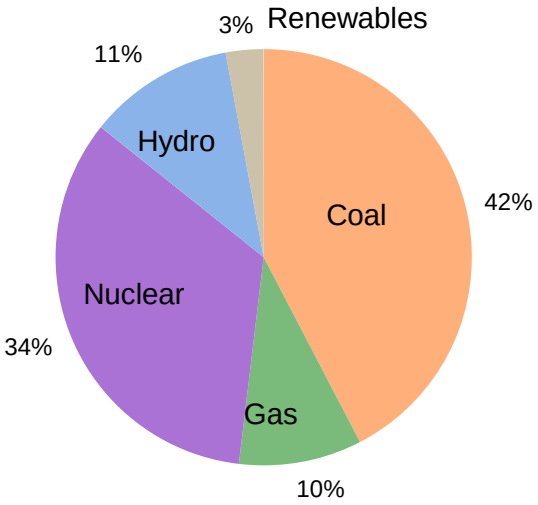
- Small Modular Reactors
- Energy Utilization
- Grid Modernization

Moving to a More Balanced Portfolio

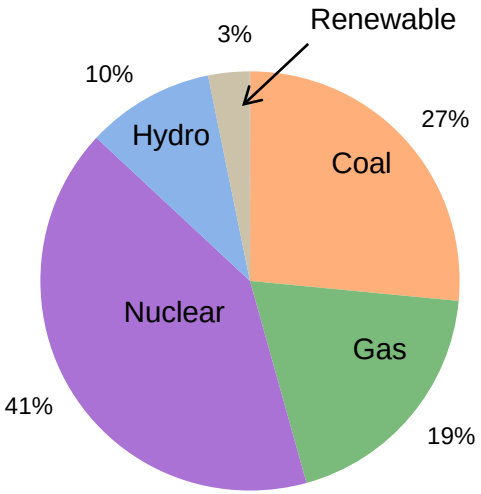
2007 Sources



2014 Sources

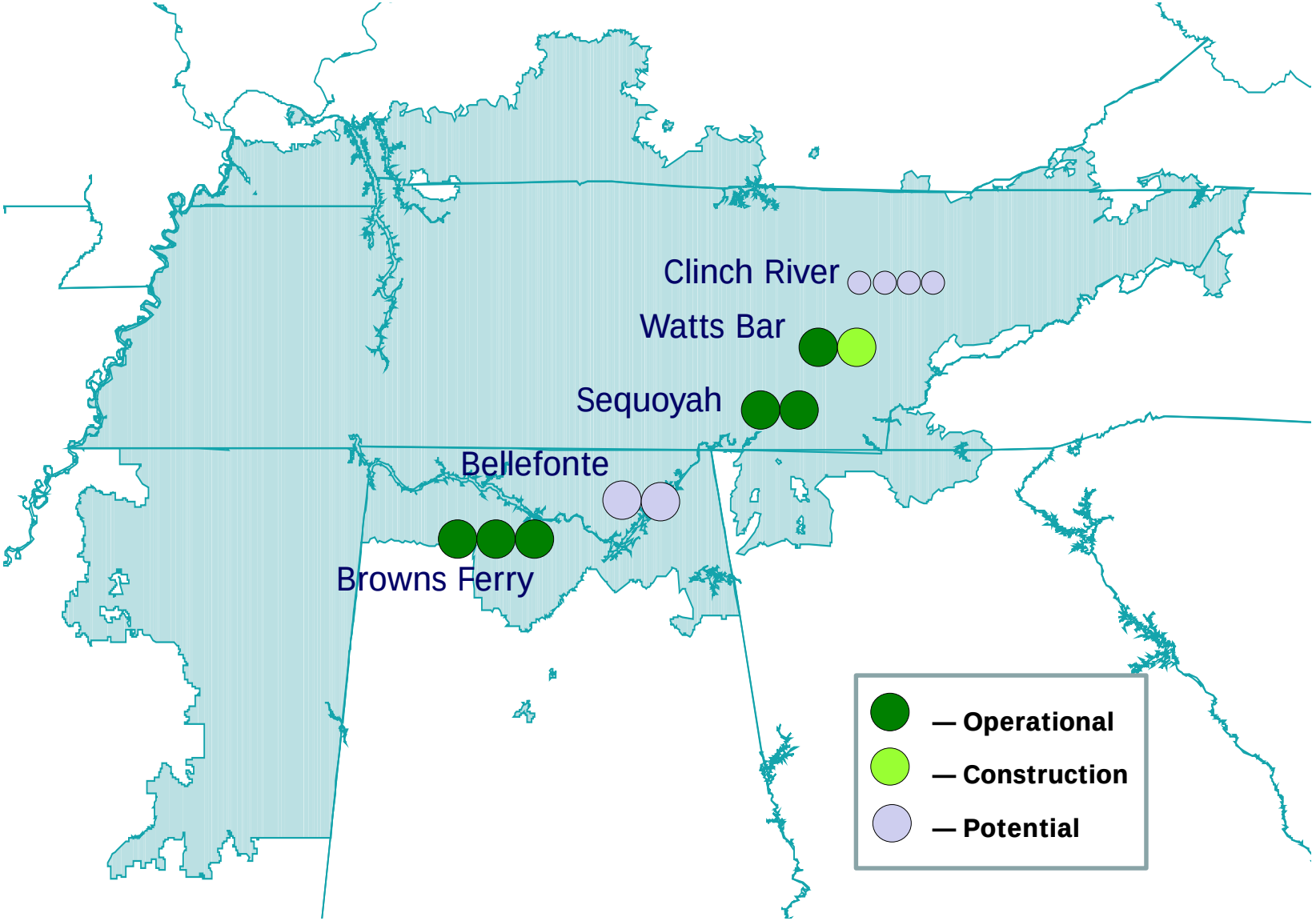


2024 Sources

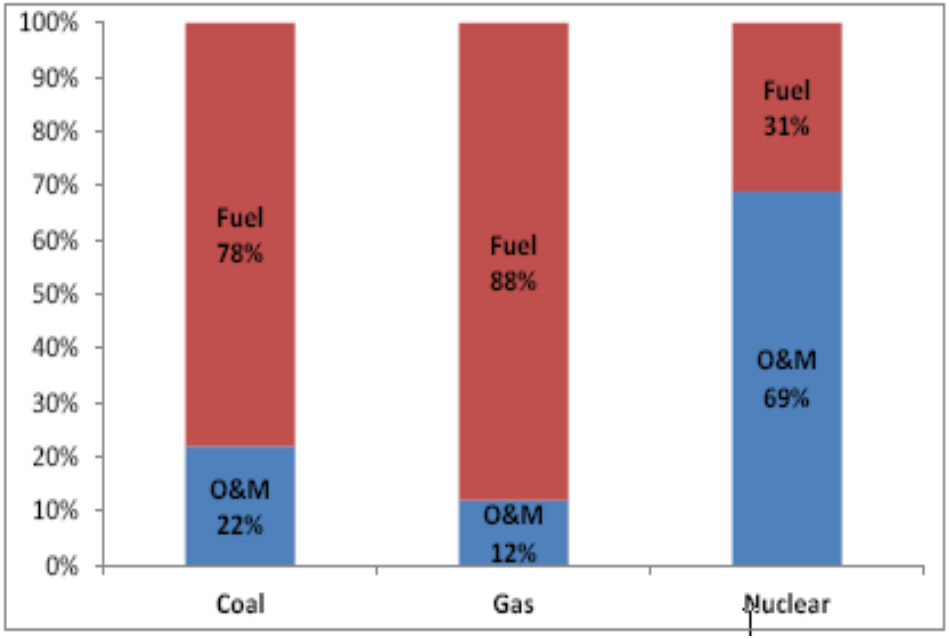


Fuel Diversity Enhances Reliability

TVA's Nuclear Fleet



Nuclear Provides Bigger Economic Stimulus



Tech-nology	Size (MW)	Direct Jobs	Ave. Pay ($/hr)	Direct Income
Coal	1000	187	28	$11M
Gas	630	34	28	$2M
Nuclear	1000	504	31	$32.5M

Source: Assessment of the Nuclear Power Industry - Final Report, Navigant Consulting, Inc., Funded by the U.S. Department of Energy, June 2013

Compared to fossil generation, nuclear generation projects employ more people at higher wages!

Challenges Facing TVA and Most Utilities

- Demand is flat and recession recovery is slower than expected
- Customers have changed their electricity use behaviors and are taking advantage of energy efficiency and demand response programs
- Gas prices are cheap and expected to stay low
- Regulations are making older and smaller coal plants uneconomical
- Current policies and incentives are resulting in wide-spread deployment of renewables that take away market share from utilities
- As coal plants are shut down and more highly-variable renewables are deployed, the grid becomes stressed getting generation to consumers

It is difficult to justify funding technology innovation and large capital expenditures in an uncertain demand, revenue & regulatory environment

Why is TVA Evaluating SMRs?

- The need for a more diversified generating fleet with increased use of reliable, cleaner, low-cost energy generation
- Potential for next generation nuclear technology that is more flexible and has improved safety margins
- SMRs could help TVA and the nation improve energy security with clean and reliable new nuclear technology

Option for clean and reliable energy in lower cost increments

Why Should TVA be First to Deploy SMRs?

Aligned with our Purpose & Needs

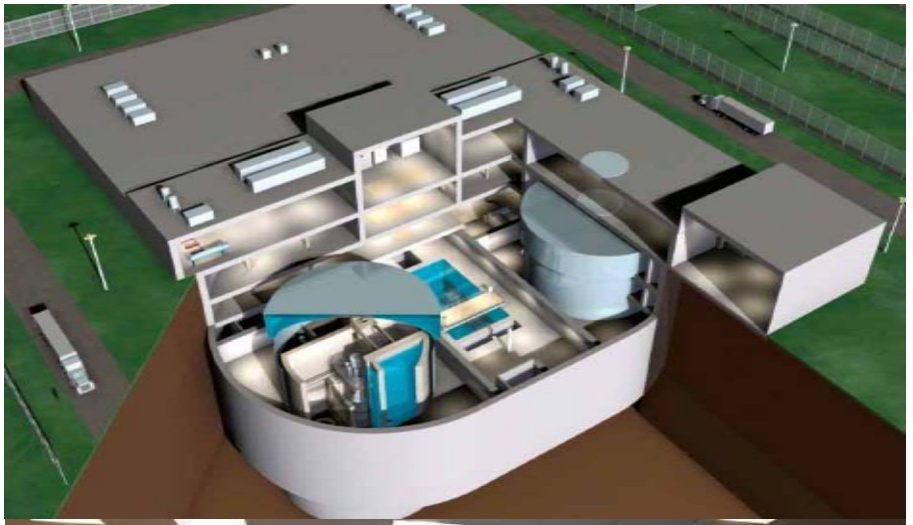
- We are committed to keep nuclear as part of our balanced generation portfolio and want an option besides large LWRs
- Technology Innovation is part of TVA's mission and charter
- We have a good site next to a large DOE customer that needs clean and reliable energy

TVA is Uniquely Qualified

- Build on other successful DOE and DoD programs/support
- Relevant recent WBN2 experience can transfer to the SMR project
- Advantages from being a Government Corporation

Operating SMRs: Changing Paradigms

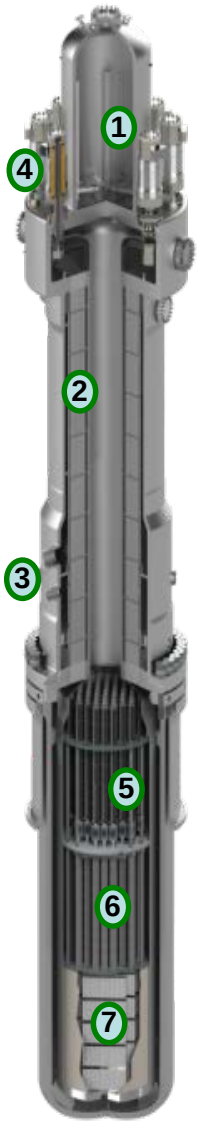
- Simple design
- Slow accident progression
- Long coping time
- Fast load following
- Automatic “Island Mode”
- Small EPZ
- Reduced plant staffing
- Standardized operator training & licensing



Economical fleet of standardized SMRs in U.S. and abroad

B&W mPower™ Reactor Design

- 530 MWt reactor results in 180 MWe
  - Core, CRDMs, SG, Pressurizer, and Coolant Pumps
  - No penetrations below top of core
- 4-Year fuel cycle with “standard” PWR fuel
  - 69 fuel assemblies with <5% ^{235}U enrichment
  - Reactivity controlled with Rods, not boron chemistry
- Simple, fully “passive safety” design
  - Core remains covered during design basis accidents
  - No power required for emergency core cooling

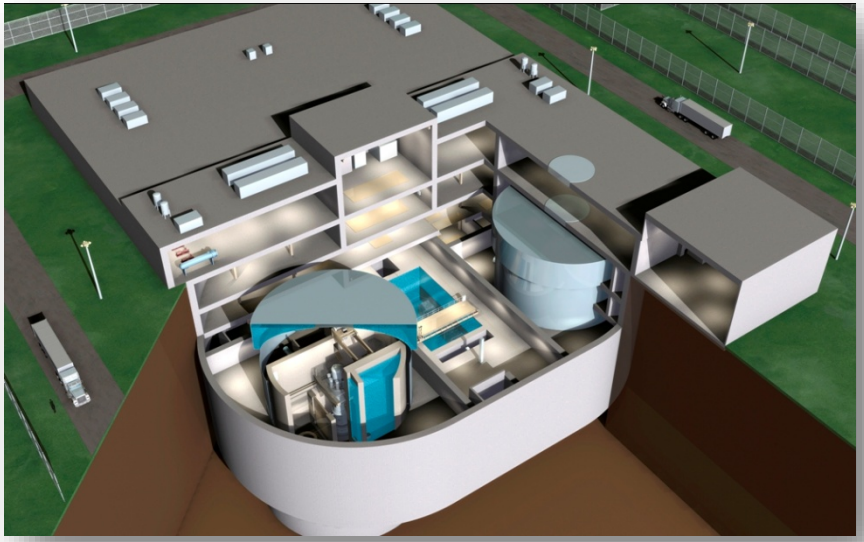


1. **Pressurizer**
2. **Once-Through Steam Generator**
3. **Feedwater Inlet / Steam Outlet**
4. **Reactor Coolant Pumps**
5. **Electro- Hydraulic CRDMs**
6. **Upper Internals**
7. **Reactor Core**

Nuclear Island Features

Fully underground

- Protected from external threats
- Enables security-informed architecture
- More efficient seismic design
- Steel containment, with space for O&M activity



“Passive safety” design

- No safety-related emergency AC power
- 72-hour safety-related control/monitoring battery
- No shared active safety systems between units
- 14-day underground ultimate heat sink
- Defense-in-depth layers deliver ~10^{-8} core damage frequency

Enhanced Spent Fuel Pool (SFP) configuration

- 20-year wet storage capacity
- SFP inside reactor building
- Large heat sink with 30-day “coping time”

Simple, robust architecture could enhance safety, lower licensing risk

Plant Site Layout

mPower “Twin Pack” Site Layout

- 2 x 180 MWe units
- ~40 acre standard plant
- Low site profile
- Safety systems underground
- Smaller security boundary

Small, low-impact footprint could offer more siting options

Modular Manufacturing & Construction

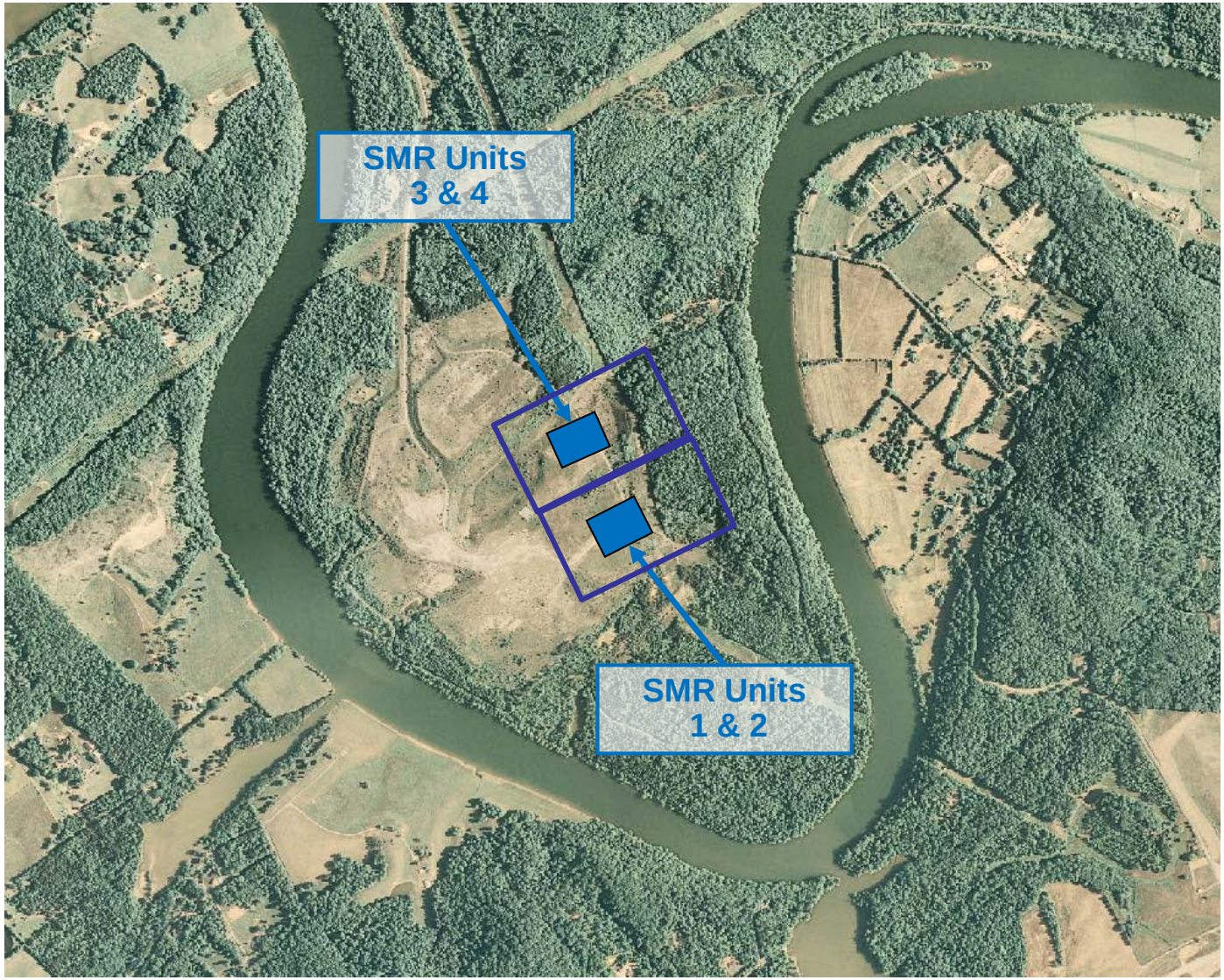
Modularization Attributes:

- Modularity part of the design process
- Goal of > 70% of construction to be modular
- Design optimization through “area design”
- Strong attention to tolerances, interfaces, & integration
- Repeatability through automation and common tooling
- Robust quality assurance in fabrication facilities

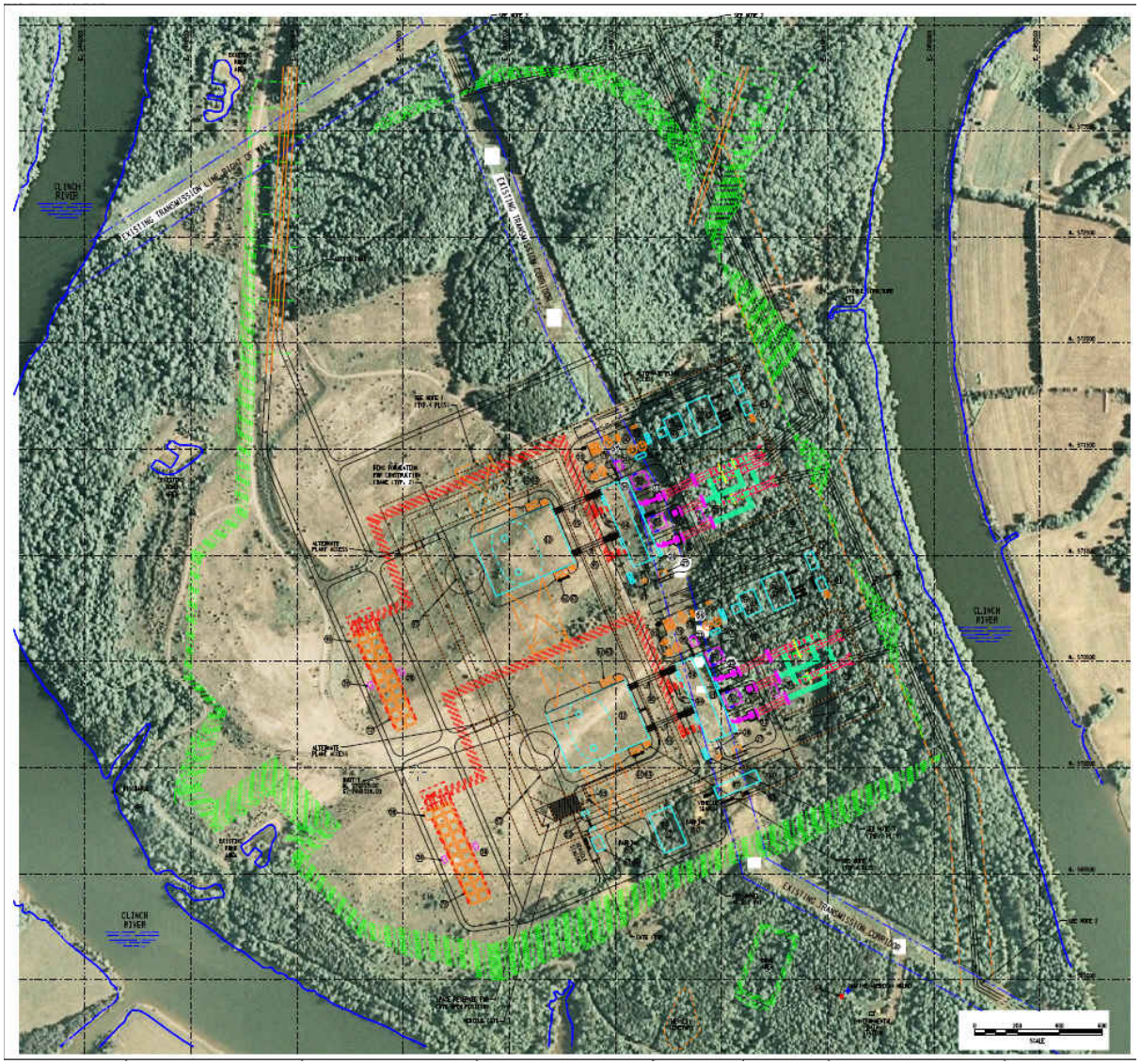
“Economies of Mass Production vs. Economies of Scale”

Clinch River Site

Reactor Locations on Site



Clinch River Site Plot Plan



Rendering of Plant Appearance

Rendered View of Clinch River SMR from Speers Road looking north-northeast

Site Characterization Completed

- Core Borings
- Ground Water Wells
- Meteorology
- Biology
- Botany
- Wetlands
- Cultural Resource Surveys
- Numerous Studies

Site Characterization Work Remaining

- Groundwater Analysis
- Hydrothermal Analysis
- Flood Analysis
- Establishment of Environmental Baseline

SMR Option Development

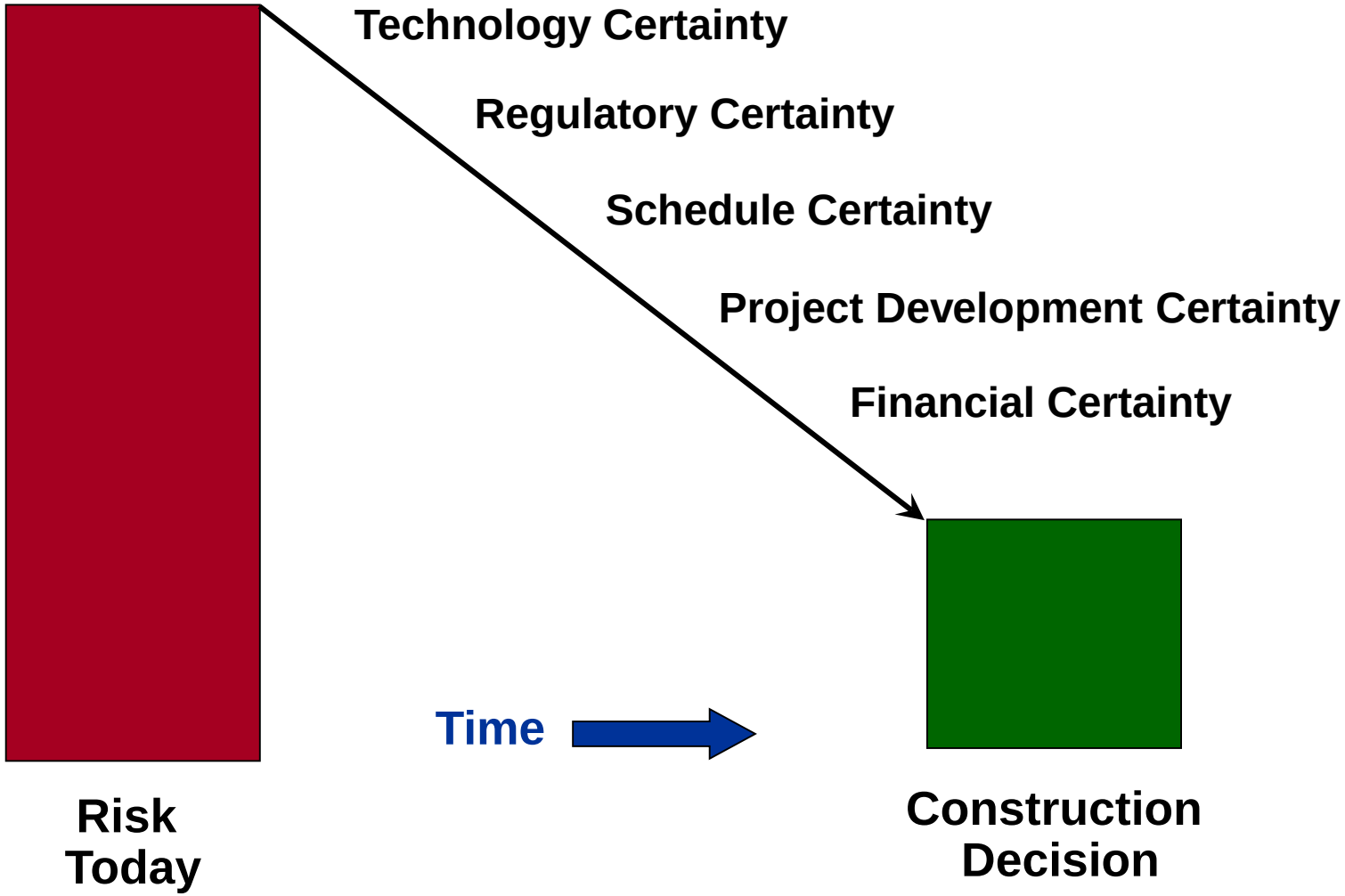
Licensing

Engineering

Planning

- ✓ Establish NRC License and Perform Environmental Reviews
  - Site Characterization
  - Resolve key regulatory uncertainties needed to improve the business case
  - Prepare and submit license application to NRC, support NRC's review & approval
- ✓ Evaluate Design
  - TVA participates in mPower standard plant design reviews along with other utilities
  - Evaluation of engineering and licensing documents and reports supporting DCA
- ✓ Establish Viability of the SMR option
  - Define deployment scope, cost and schedule
  - Establish success criteria
  - Pursue agreements for SMR electricity supply
  - Evaluate business case
- ✓ Operator training program development and accreditation
- ✓ Develop Plan for Next Phase
  - Detailed engineering
  - Long lead procurements
  - Operator training

Risk Management



A Different Approach to Engineering

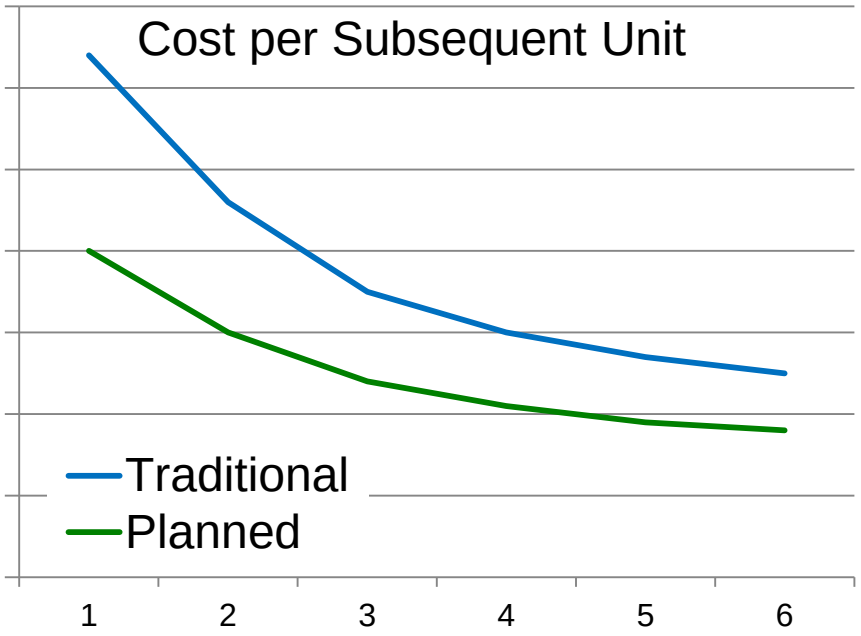
✓Reactor and construction vendors integrated early

✓GmP business entity formed for integrated plant EPC

- Detailed Design of Standard Plant includes bid-evaluate-award of component subcontracts and subsequent detailed system engineering
- Area-Based Design Optimization includes:
  - Optimization and modularization of integrated plant design after detailed design complete
  - Design for manufacturing and construction
    - Safer, faster, leaner
    - Some systems de-optimized for overall optimization of plant economics

❖Increased standardization should result in:

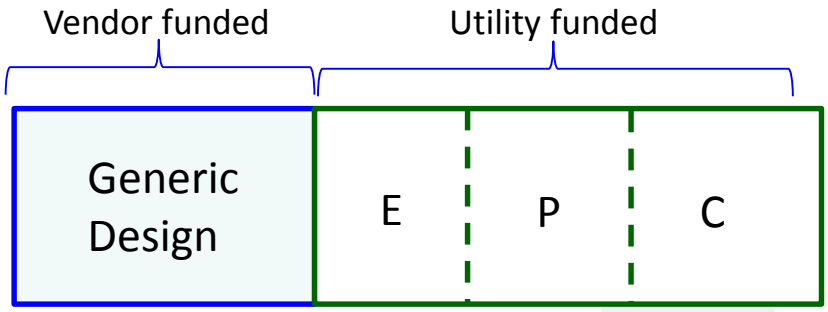
- Fewer utility options, but lower cost
- Lower engineering cost for subsequent utilities
- Increased O&M efficiency (e.g. fleet training, spare parts, etc.)



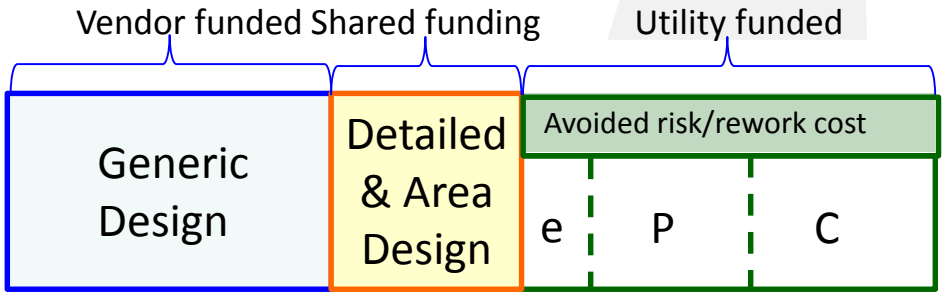
Area-based design optimization following detailed design leads to lower cost of lead plant and flatter learning curve

Potential Engineering Cost/Risk Approach

Traditional Model: Final detailed engineering in EPC Contract, design not optimized



Potential Model: Detailed engineering and area design before construction starts



Optimized design benefits all plants!

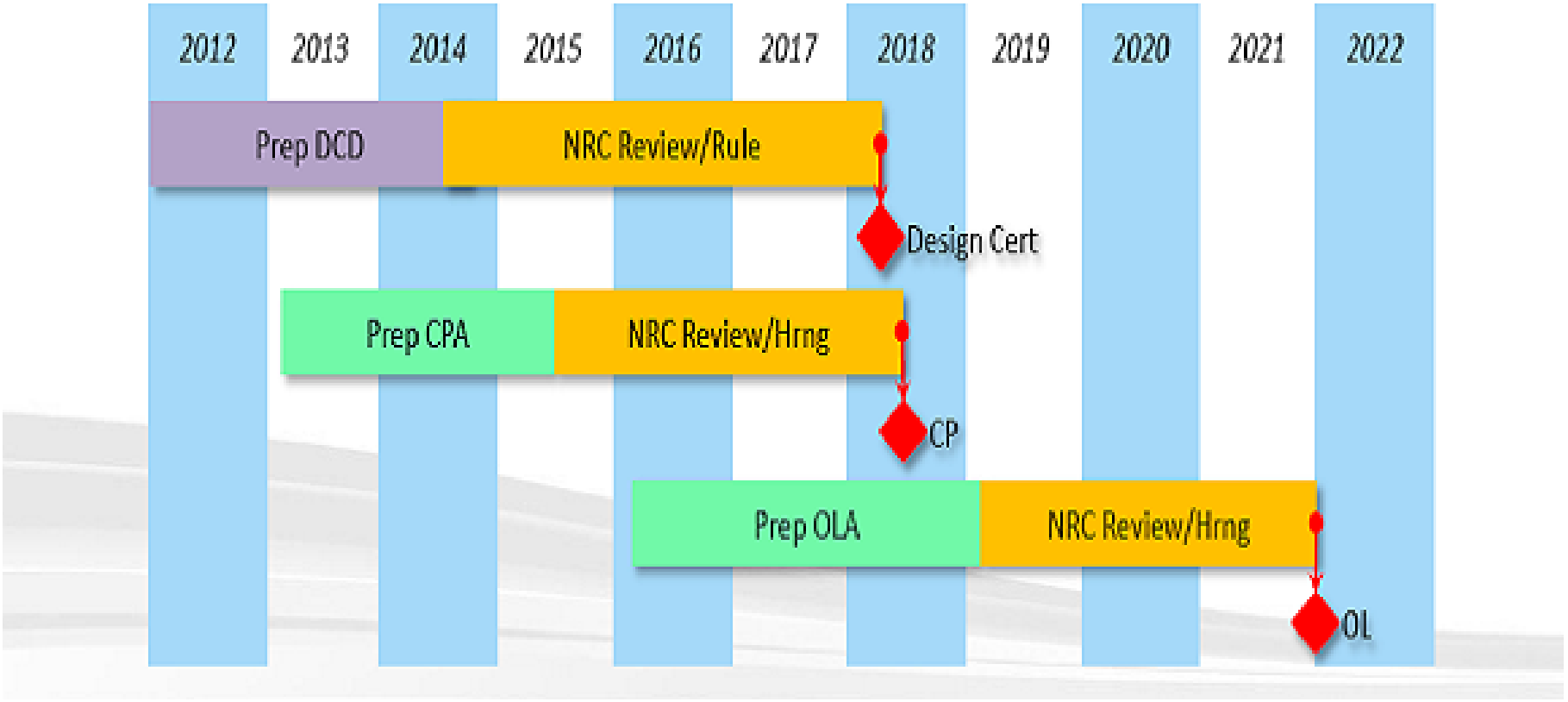
NRC Licensing/Design Approach

- 10 CFR Part 50 approach for first nuclear plant, subsequent plants would be licensed under Part 52
- Anticipate design changes for improved constructability/cost savings
- Certified Design will be updated to be the Clinch River design
  - TVA does not want a “one-off design”
  - B&W wants its Standard Design to be informed by lessons learned during construction of the first plant

Part 50 Provides Flexibility for New Technology Deployment

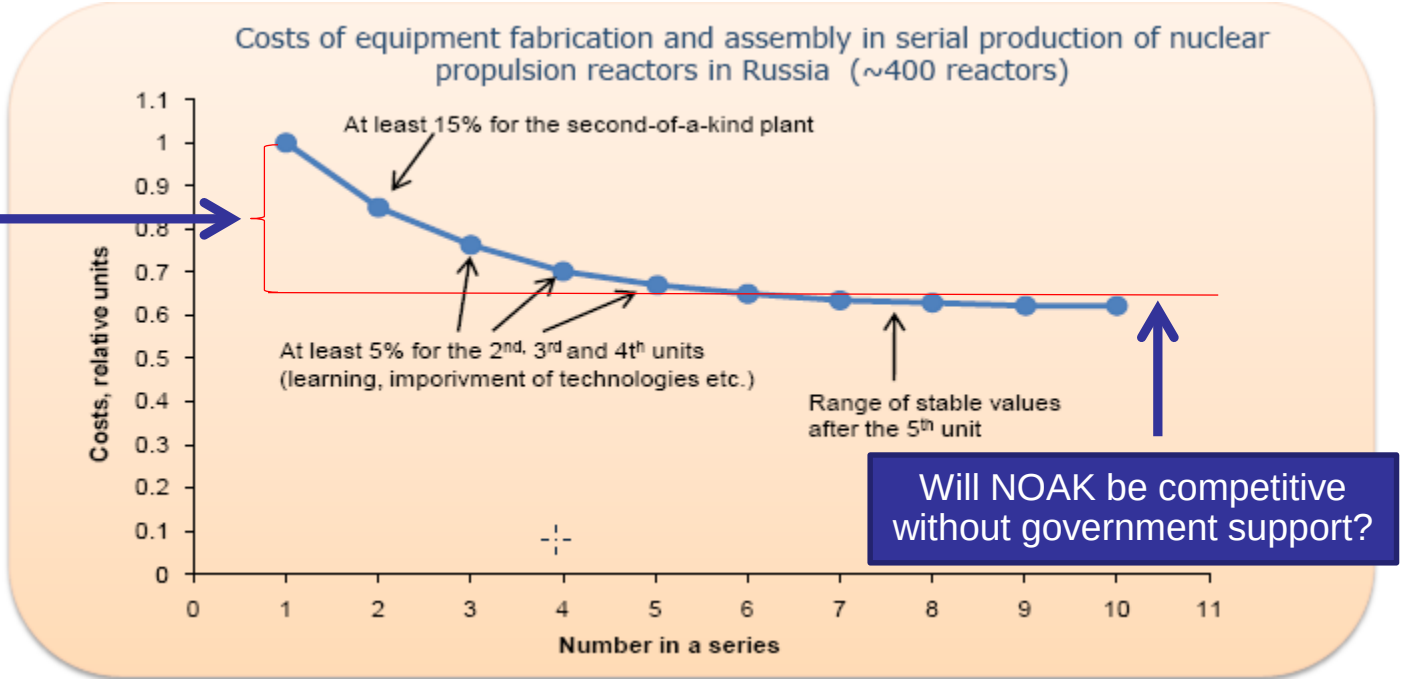
Licensing Schedule

Coordinated Part 50/Part 52 Process:



The Learning Curve

Will FOAK risks be addressed by the Federal Government?



Will NOAK be competitive without government support?

First-of-a-kind factors and economy of subsequent units on the site/ multi-module plants:

- Factory fabrication is also subject to “learning”
- FOAK plants are reported to be 15-55% more expensive than the second one
- For serial units, the reduction of the effective (per unit) SMR capital cost could be 10-25%.

DOE's Strategic Vision for SMR Deployment

Presented by Asst. Secretary Lyons at ANS on 11/12/13

- **Our long term goal is to enable deployment of a fleet of SMRs, not just 1 or 2 units**
- **Envision need for >50 GWe capacity in coming decades based on coal plant replacements alone**
- **Long term vision is that SMRs would evolve through anticipated deployment phases**
  - Regulatory *(where we are today)*
  - Early adopters *(first 20 units)*
  - Full-scale factory production *(20 – 40 units/year)*

Federal Support Programs & Timing

2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

Enabling Legislation

Licensing Technical Support (6-year, $452M, cost-sharing)

- Supports reactor design
- Proves out licensing process

- FOA
  - Selection
    - Cooperative Agreement
    - 2nd FOA
      - 2nd Selection
        - 2nd Cooperative Agreement?

First Movers & Early Adopters

- Serve as "model homes"
- Reduce uncertainties
- Move down the learning curve
- Enables creation of order books

Policy tools for first movers and early adopters may involve

- Power purchase agreements
- Loan guarantees
- Production tax credits
- Clean energy credits

Full-scale Factory Production

- Creates manufacturing infrastructure
- Achieve Nth-of-a-kind costs
- Significant job creation & U.S. leadership
- Sustainable without government support

Source: DOE at ANS on 11/12/13

U.S. Government as Customer for First Several SMRs

- SMRs Could Meet DOE & DoD Critical Facility Electricity Needs
  - Only available option that is both reliable and clean
- Supports Mission Critical Loads
  - Self supporting (SMR does not require offsite power)
  - Less vulnerable to terrorist / cyber threats / natural phenomena
  - Can provide power long term during an extended event
  - Provides DOE/DoD with clean energy, helping to meet Federal directives
- Clinch River SMRs could provide “enhanced reliability” to DOE’s facilities in Oak Ridge, which DoD could observe/support
  - “Smart Grid” applications (Uninterruptable Power Supply type features)
  - Operational limitations (never schedule both units off at the same time)
  - Acceptable voltage and frequency tolerance during shift to Island Mode
  - Robust transmission (e.g. armored transformers)

Conclusion

- SMRs are consistent with TVA's Vision and Mission of having a cleaner, balanced electricity generation portfolio
- TVA has a suitable site with an interested key customer
- Design and licensing costs are being supported by the Government, and there appears to be support to share FOAK risks
- Work is underway to mature the design, test key components, obtain an NRC license, and better understand cost, schedule and economic projections before making a construction decision

Attractive SMR Features and Potential Government Support Warrant Continued Investment to Develop a Unique Nuclear Generation Option

Acknowledgement and Disclaimer

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