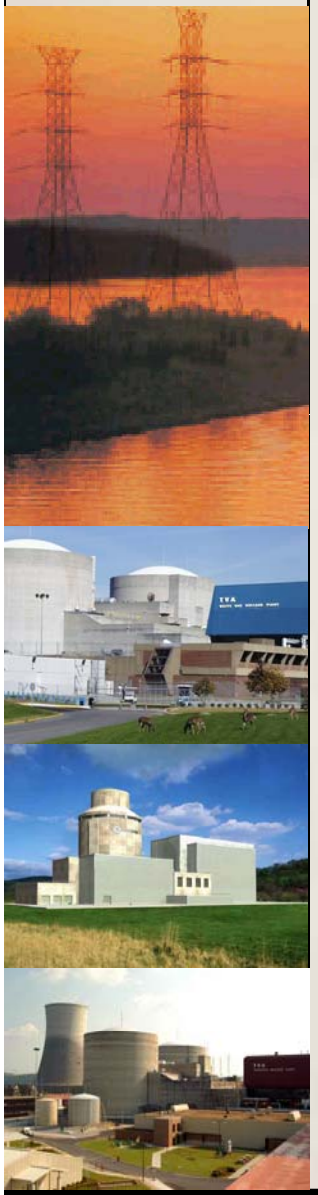
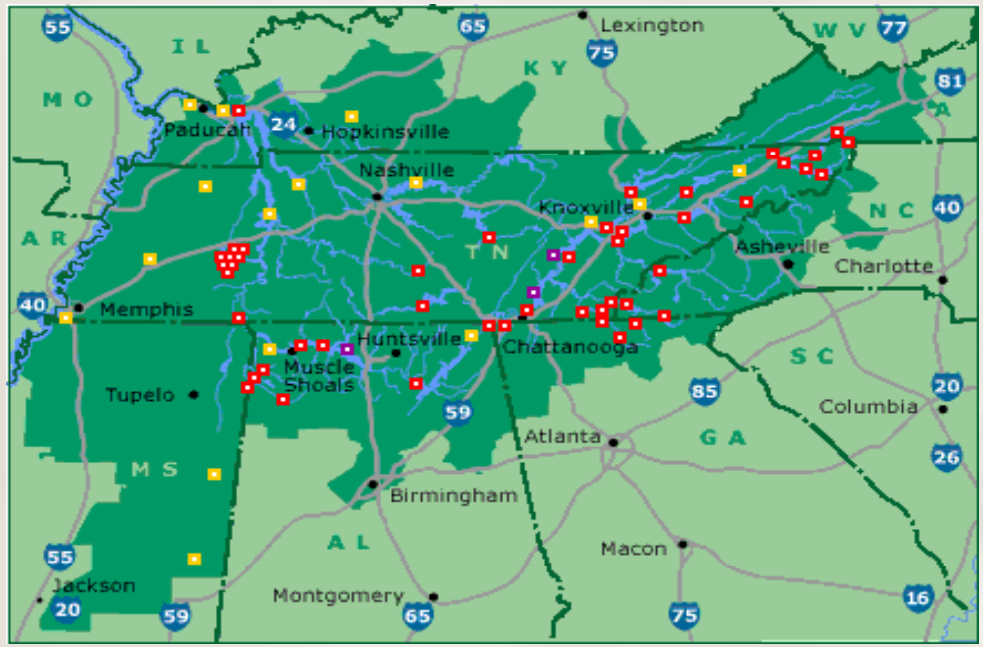


New Nuclear Development and Advanced Fuel Cycle Uses of Simulation

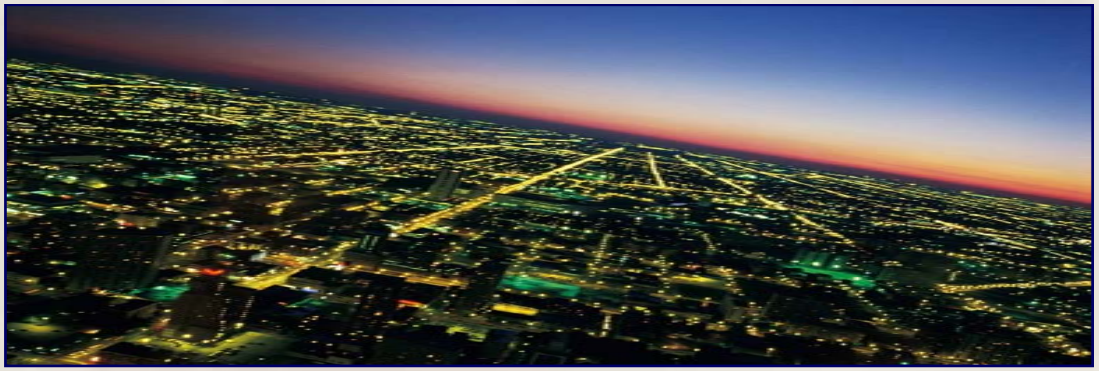
September 24, 2007

Generating Facilities and Customer Base

- 11 fossil plants (59 units)
- 3 nuclear plants (6 units)
- 29 hydro plants (109 units)
- 6 combustion turbine plants (60 units)
- 1 pumped storage station
- 17,000 miles of transmission line



- 158 power distributors
- 62 direct serve customers
- Over 8.5 million people in an 80,000 sq mile service area



TVA Cautiously Developing Additional Nuclear

Browns Ferry 1
~1250 MWe

1 Complete

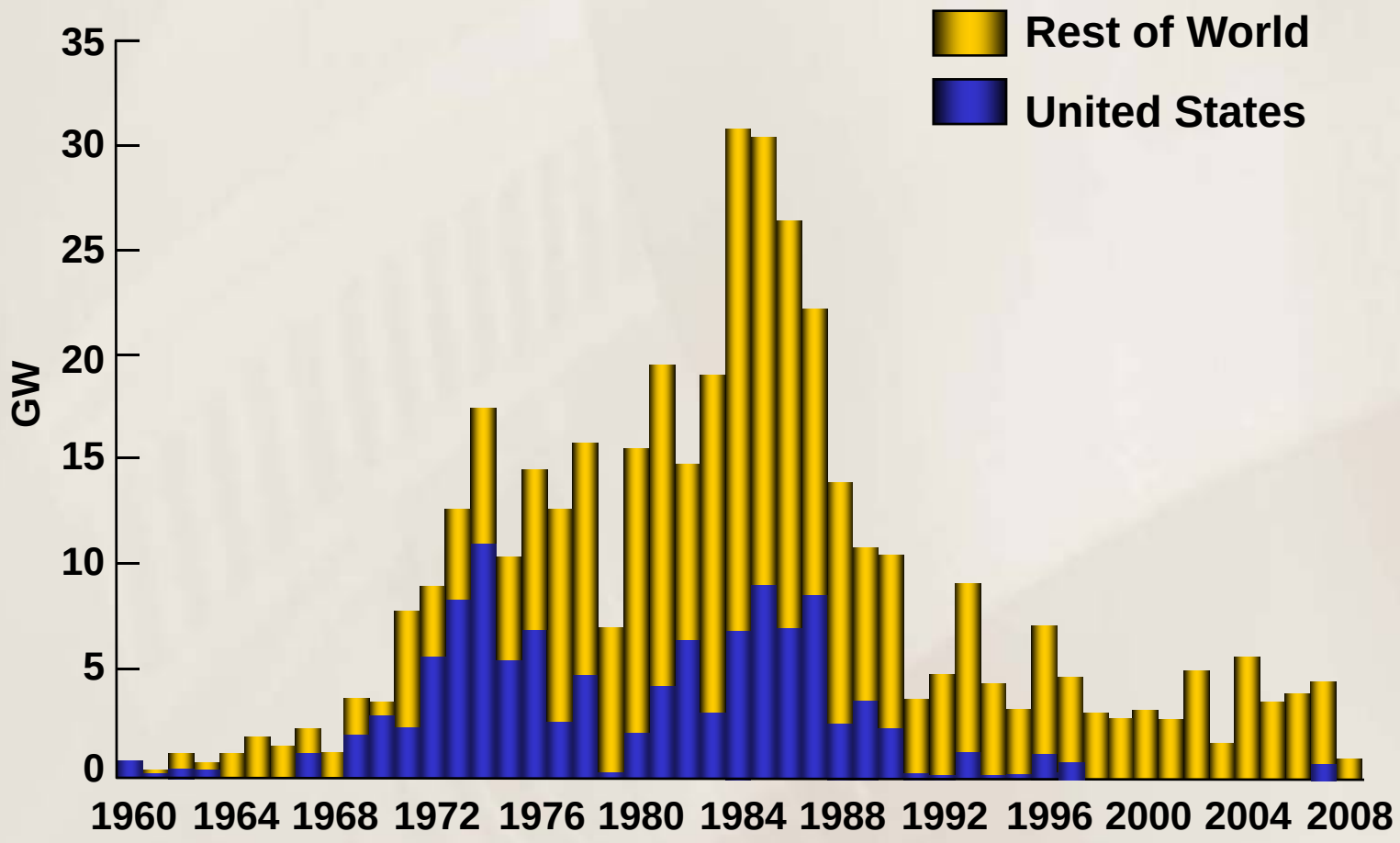
Watts Bar 2
1180 MWe

2 Approved to Finish

Bellefonte Twin
2235 MWe

3 Submitting License Application

United States vs. Global Nuclear Capacity Additions 1960-2008



Nuclear alternatives being developed for future supply needs because...

The Value of New Nuclear

Competitive Electricity

Consistent Cost of Power

Forward Price Stability

60% of Total Cost Fixed

Clean Air Value

Zero Air Emissions

Protection Against CO_2 Risk

Reliable Energy Supply

Less Dependence on Oil and Gas

Low Fuel Transportation Risk

High Capacity Factors

Even Existing Plants Need Sophisticated Computing

- Browns Ferry Units implementing 15-20% Extended Power Uprates
- Reactor steam dryers susceptible to failure due to fatigue and pressure stresses
- Finite element analysis requiring a pressure time history at 15,000 nodes performed
- Over 5 days' run time
- Combination of fluid dynamics and finite element analysis required to demonstrate satisfactory design and response

Evidence of U.S. Nuclear Revival

Congress

- Energy Policy Act of 2005
  - Supports nuclear energy as a major component of national energy policy

DOE

- Nuclear Power 2010 program
  - Cost-sharing initiative between industry and government for new deployment
- GNEP - Closed Fuel Cycle Future

Utilities

- Several utilities developing Early Site Permits and Combined License Applications for new reactors

Four New Designs ... Almost Ready to Go and Too late to Make Major Changes

ABWR

- Design Certified
- Construction demonstrated
- U.S. support limited at present
- **1370-1460 MW**

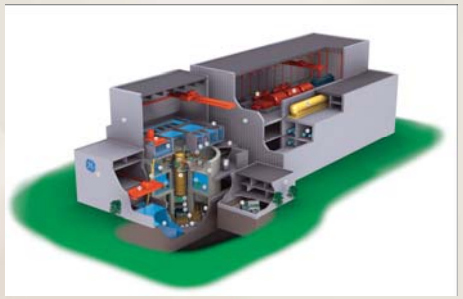
AP1000

- Final Design Approved
- Engineering incomplete
- **1117 MW**

EPR

- Design Certification not yet submitted
- Construction underway overseas
- **Large 1600 MW**

ESBWR



- Design Certification submitted late 2005
- Engineering incomplete
- **Large 1550 MW**

Computational Areas For Reactors Supported by NuStart

ESBWR

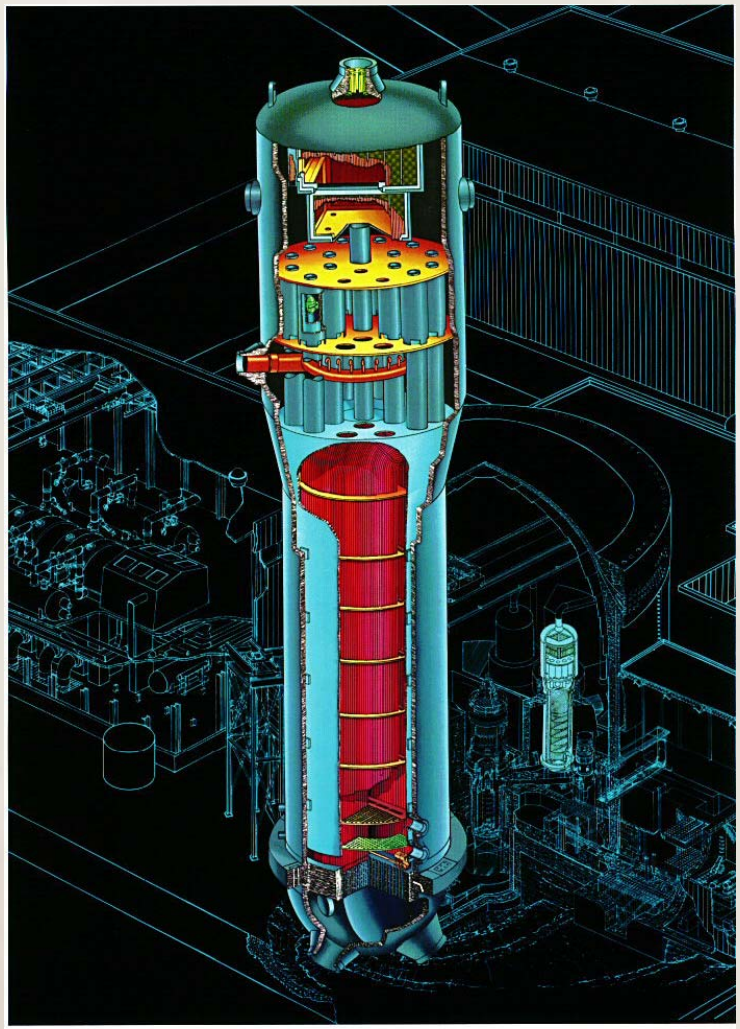
- 4500 MW thermal/1550 MWe utilizing natural circulation
  - Temperature distributions
  - Plant transient behavior
  - Core flow performance analysis
- Newly Applied Internals
  - Flow-induced vibration for Chimney

Both AP1000 and ESBWR

- Passive safety system accident and transient response

Steam Generator Vibration and Wear

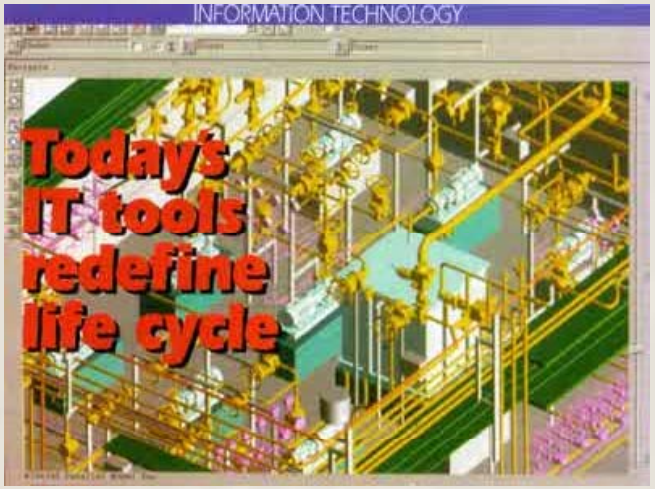
- Replacement steam generators for existing plants and new steam generators for new plants
- Enhanced modeling of thermal hydraulic conditions to predict tube vibration and wear and improve design
- Enhance safety and reduce maintenance costs
- Eliminate problems for next generation reactors

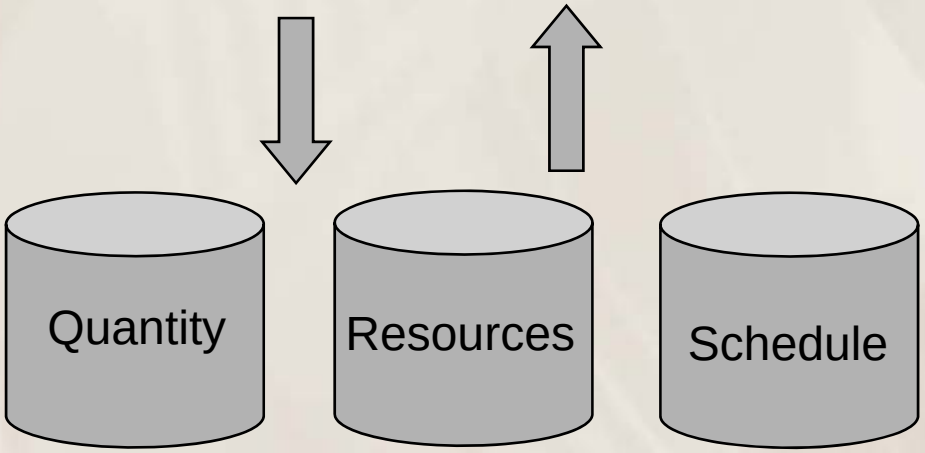


Westinghouse STEAM GENERATOR

Better Simulation Needed for Next Wave

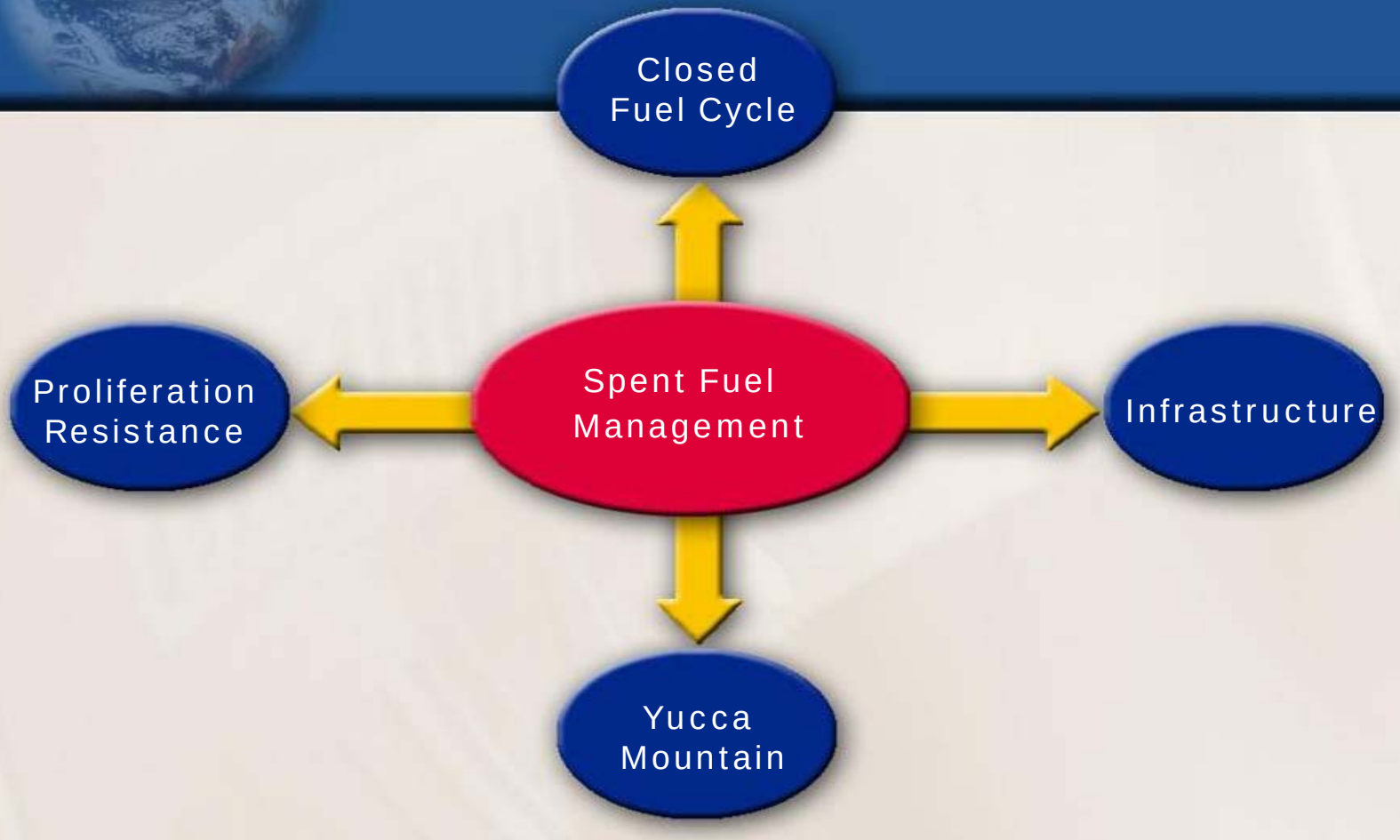
Design, Construction, and Enhanced Operations



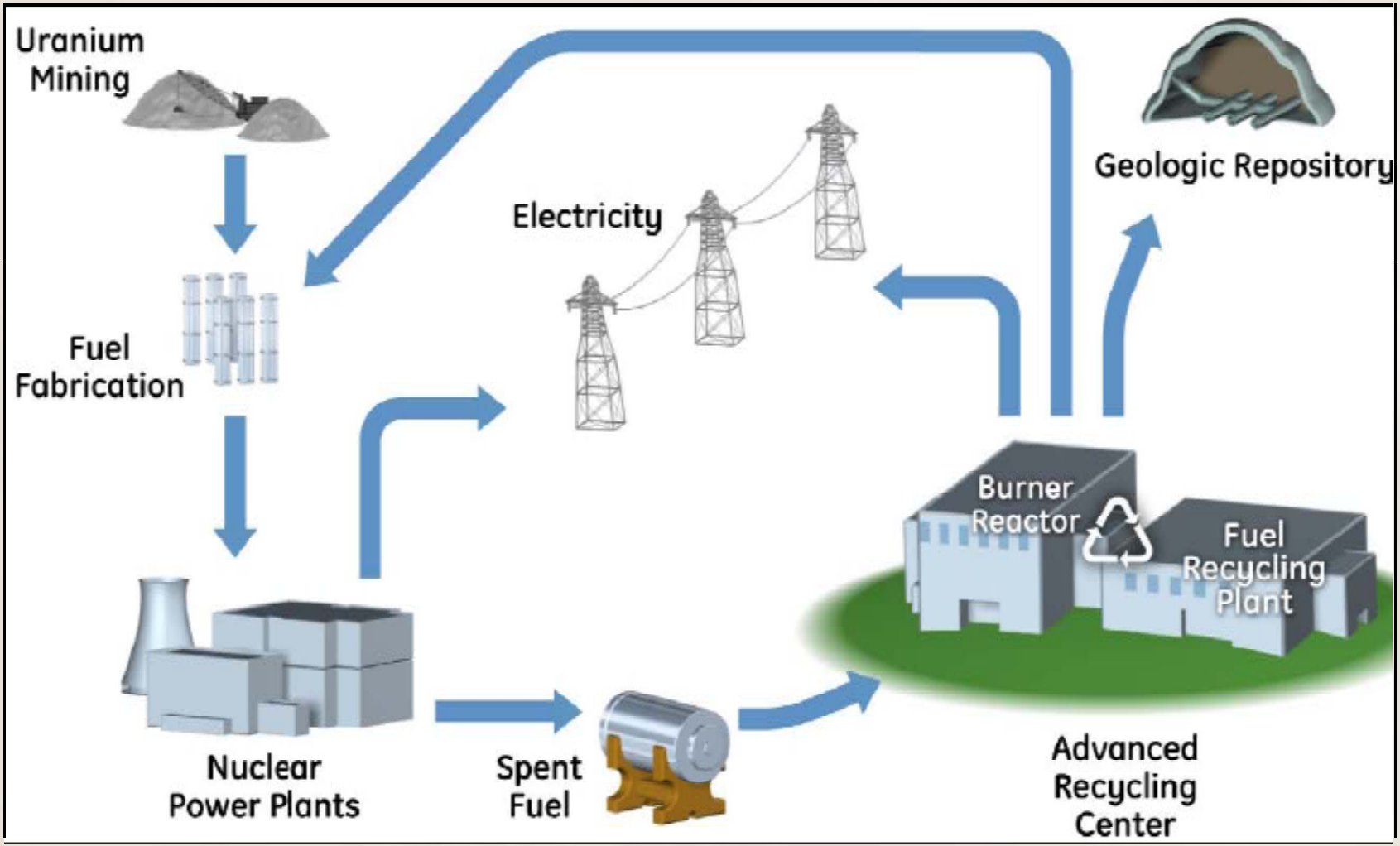


- Faster/cheaper design
- Quicker/better planning
- Improved operations

Let's Move GNEP Forward



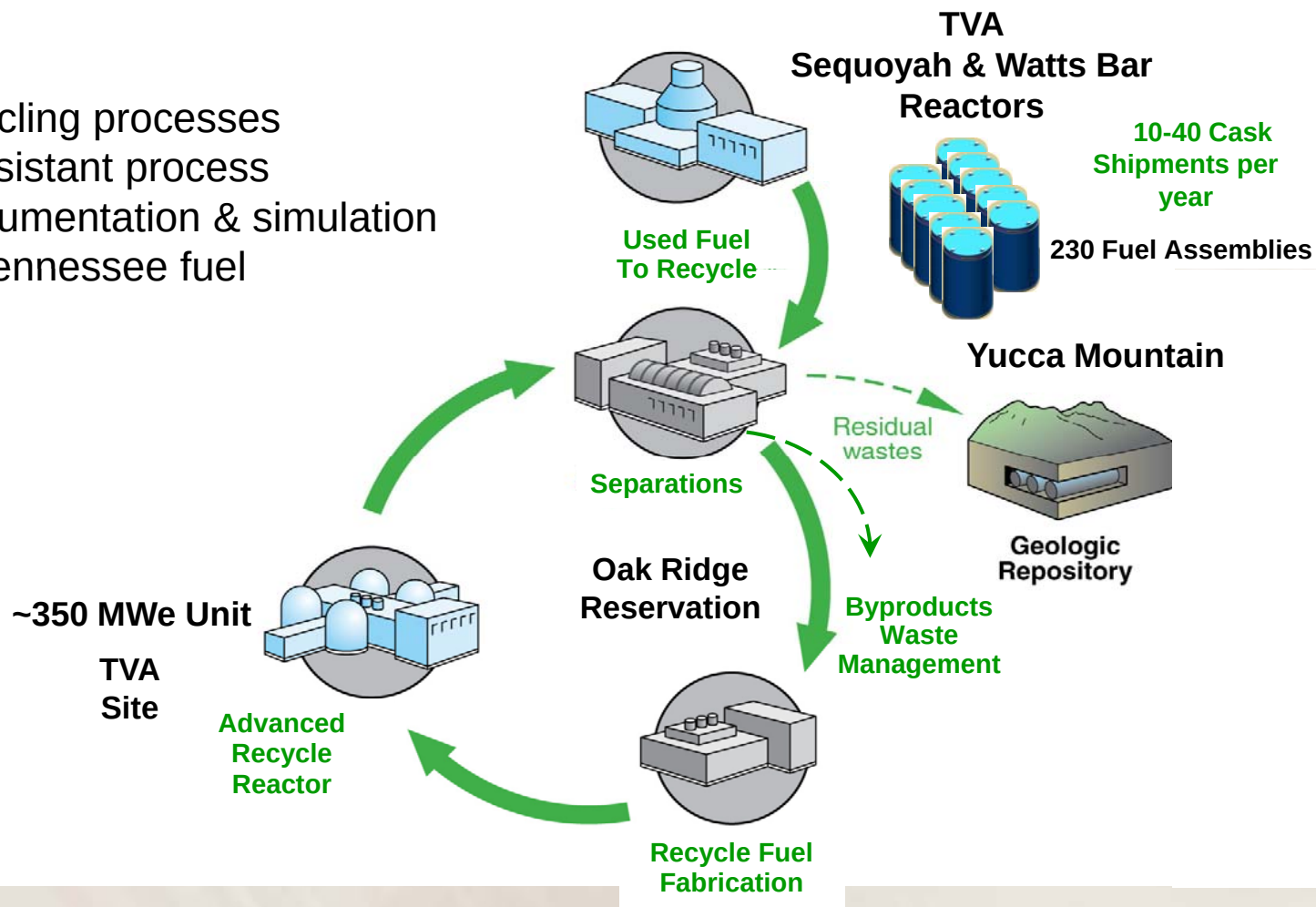
A Closed Nuclear Fuel Cycle Recycles Spent Nuclear Fuel & Reduces High Level Waste



Proposed Closed Fuel Cycle Demonstration in Tennessee

Key features:

- Advanced recycling processes
- Proliferation resistant process
- Advanced instrumentation & simulation
- Accepts only Tennessee fuel



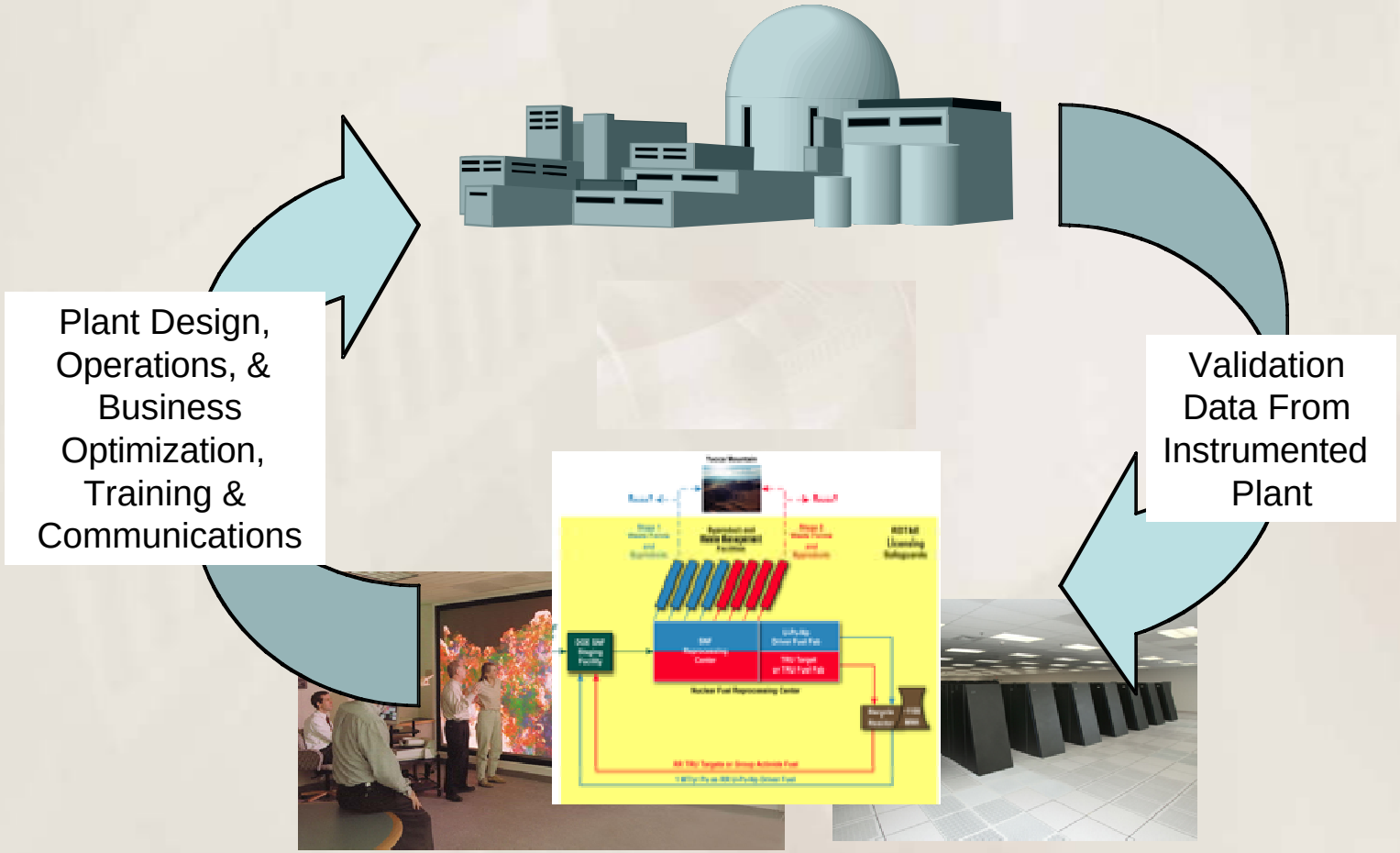
Demonstration Physical Elements

- **Heavily instrumented spent nuclear fuel recycle center**
  - Receive, store, stage spent fuel from Sequoyah and Watts Bar
  - Process 100-200 metric tons heavy metal per year spent nuclear fuel and recycle reactor spent fuel and targets
  - Fabricate light water reactor and/or recycle reactor fuel
  - Separate, stabilize, store waste streams for decay or transport to Yucca Mountain

- **A 300-400 MWe flexible recycle reactor**
  - Capable of utilizing a variety of fuels and targets produced by the recycle center
  - Capable of achieving full transmutation fuel cycle
  - Heavily instrumented

A Tightly Integrated Physical and Virtual Demonstration

Physical Demonstration



Virtual Demonstration

Virtual Elements of Demonstration

- **An integrated set of models and simulations of the physical processes and phenomena**
  - Sophisticated sensory and control network that couples the physical and virtual elements
  - Fuel cycle enterprise simulation to address economic and environmental performance
  - Requirements-driven testing and early application of modeling and simulation tools
  - Fuel cycle-specific verification and validation tools
  - Recycle facility and recycle reactor simulator for predicting performance, operator training, and public education

- **Provides a validated foundation for evaluation, design, and implementation of closed fuel cycle**
  - Provides capability for scaling studies to help shape GNEP

Summary Messages

- TVA's primary near-term focus is the completion of Watts Bar Unit 2 and the longer term planning for a new advanced reactor at Bellefonte.
- Existing Plants and New Plants have opportunities for increased computational solutions and computing power.
- Spent Fuel Management needs focused research to support the closed fuel cycle demonstration.
- Industry, vendors, and utilities can benefit by collaborating on needed solutions.