DOE Small Modular Reactors (SMRs) Program

Presentation to the
Nuclear Infrastructure Council

Dick Black
Director, Office of Advanced Reactor Concepts
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SMRs & Advanced Reactor Concepts

Evolutionary and Transformative Technologies

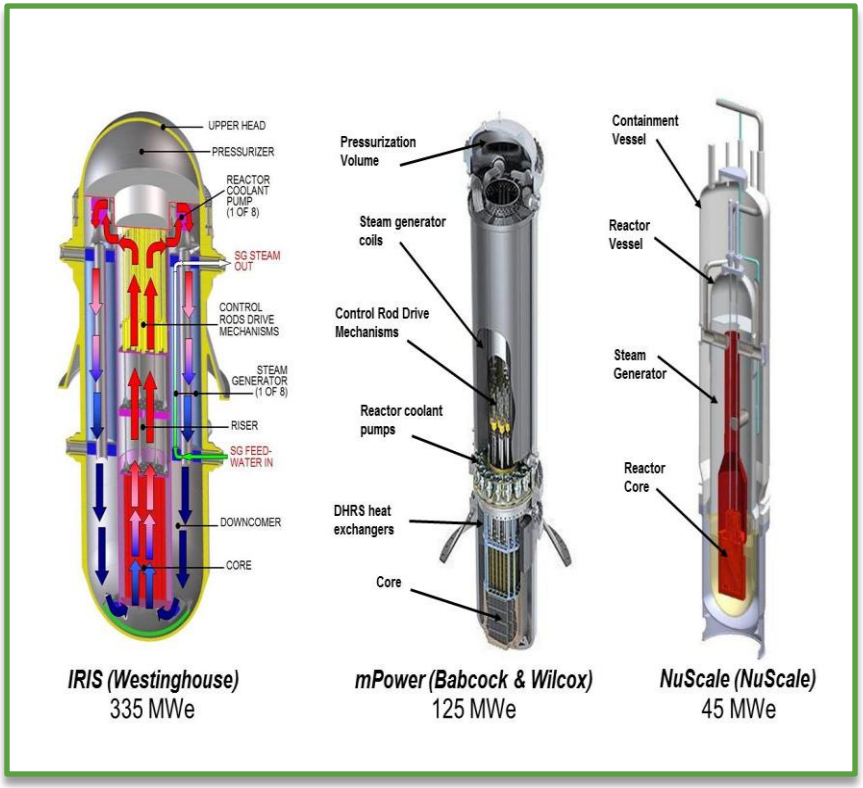
- SMRs and advanced reactor concepts can be grouped into two sets based on (a) design type, (b) estimated licensing and deployment schedule, and (c) maturity of design.
  - First-to-market Light Water Reactor (LWR) based designs
    - 5-10 years
  - Advanced, mostly Non-LWR designs
    - 10-25+ years

- Note: DOE currently defines SMRs as those reactor designs that are ≤300MWe, and fabricated in modules that are transportable from the factory to the site by rail or truck.

Small Modular Reactors

Near-Term LWR Designs

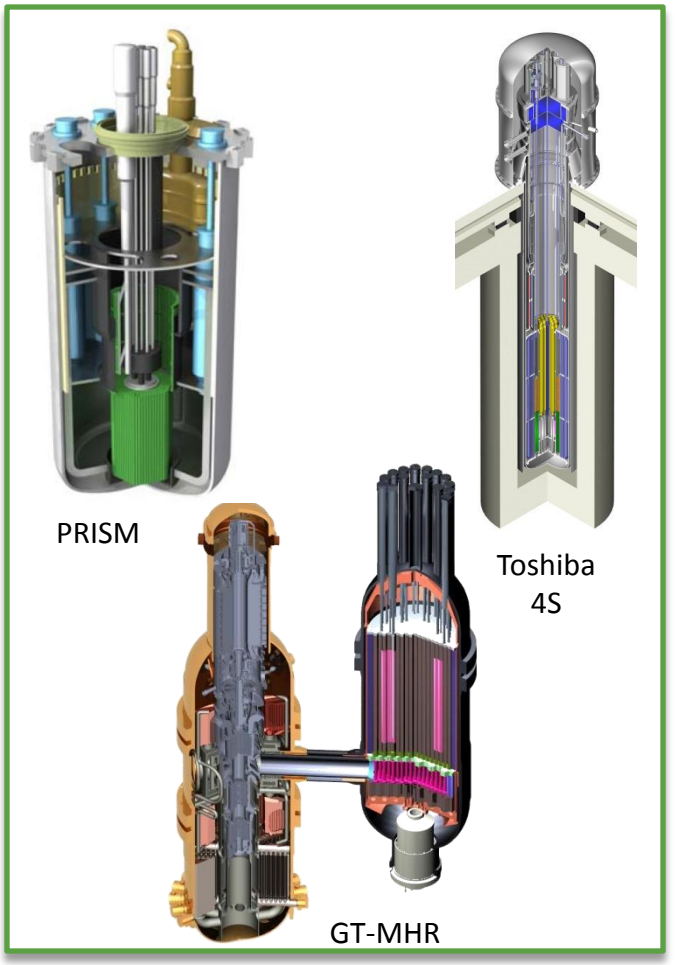
- Well-Understood Technology
  - LWR based designs
  - Standard <5% UO2 fuel
  - Regulatory and operating experience
- Commercial Interest
  - At least 2-3 credible LWR vendors
  - Vendor/Utility coalitions forming
- Manufacturing industry mobilizing
  - Revitalize US nuclear infrastructure & Navy shipbuilding industry
- Potential for operation by 2020, NRC licensed
- DOE and DoD as customers for SMR electricity
  - Private consortium constructs, owns and operates



Advanced Reactor Concepts

Longer-Term SMRs

- New innovative technologies
  - Mostly non-LWR based designs
  - Goal: Extended applications for nuclear energy
  - Characteristics: Safer, simpler, extended fuel life, proliferation resistant, higher temperature
- Broader applications
  - Distributed power production
  - Process heat applications
    - Oil refining and extraction
    - Desalination
    - Chemical and hydrogen production
    - Biofuel & Synfuel production
- Nuclear Fuel Management
  - Respond to Blue Ribbon Commission recommendations
  - Support advanced fuel cycles



Next Generation Nuclear Plant

- **Mission:** Demonstrate high-temperature gas-cooled reactor (HTGR) technology to produce electricity and high temperature process heat
- **Ongoing activities:**
  - R&D – focused on Fuel Qualification, Graphite and High Temperature Materials Qualification, and Design & Safety Methods and Validation
  - Conceptual Design – Prismatic Block (General Atomics) and Pebble Bed (technology assessment by INL)
  - Licensing Activities – working with NRC to establish regulatory framework
  - Nuclear Energy Advisory Council - Phase 1 status report due May 2011
- **Secretarial Decision:**
  - Is NGNP ready to proceed to Phase 2 (design, licensing and construction)
- **Public-private partnership and determine:**
  - Organizational structure, Milestones, Decision criteria, Cost sharing structure

Drivers for SMRs

- U.S. Economy and Environment
  - Provides a carbon-free energy source
  - Domestic manufacturing jobs
  - Global competitiveness
- Utility Demands
  - Reduce the capital cost and improve affordability
  - Repower aging fossil plants with non-emitting baseload electricity
- Federal Agency Needs
  - E.O. 13514 – Reduce emissions 28% by 2020; 83% by 2050
  - Mission cannot be curtailed to meet target
- Department of Defense Mission Surety
  - Meet strategic sustainability performance goals
  - Pursue energy security through a diversified energy portfolio
  - Surety, survivability, supply, sufficiency and sustainability
    - "Islanding" option which includes good neighbor policy

Reducing Financial Risk

Economies of Small and Modular

- Manufacturing Economies
  - Assembly line replication optimizes cost, schedule, and quality through greater standardization of components and processes
  - Analysis of shipbuilding validates "*nth*" of a kind optimization
- Production "Skill of the Craft" Economies
  - Economic learning through replication
  - Increased skilled workforce retention with order backlog and diverse jobs
- Construction "Plug and Play" Economies
  - Prefabrication optimizes on-site construction schedules and quality
  - NRC inspection at factory (ITAAC) reduces on-site inspection
  - Parallel construction of reactor building, NSSS and BOP increases labor productivity
  - Increased labor productivity reduces project management costs
  - Reduced schedule and cost uncertainties

SMR Industry Benefits

Creating an Industry for Growing Markets

- Overarching
  - Support domestic economic, energy security and environmental goals
  - Respond to increasing energy demands
- Secondary
  - Establish a U.S. supply chain infrastructure for emerging SMR technology
  - Create high-quality manufacturing, construction, and engineering jobs
    - Prototypical (100 MWe) SMR has the potential to (*):
      - Create 7,375 manufacturing/operating jobs
      - Generate $1.4 billion in sales
      - $695 million value-added
      - $431 million in earnings (payroll)
      - $44 million indirect business taxes
  - Global leader in SMR technology based on mature nuclear infrastructure and NRC certified designs
  - U.S. industry exporting to meet global demand

**The Energy Policy Institute – Economic and Employment Impacts of Small Modular Nuclear Reactors; June 2010*

DOE SMR Program

Responding to the Market

- Program Mission (Beginning in FY2011):
  - Conduct research, development, and demonstration (RD&D) activities supporting the deployment of small modular reactors (SMRs)
  - Support technologies that enable the accelerated licensing and deployment of near-term light water based SMR designs
  - Support continued R&D activities for innovative, longer-term designs
- Key Program Objectives:
  - Build financial assistance partnerships with industry with a goal of certifying, licensing and deploying at least 2 LWR-based SMRs by FY2020
  - Establish a RD&D program that supports the licensing and deployment of both near- and long-term SMR designs
  - Establish domestic fleet manufacturing capability
  - Collaborate with NRC and Standards Developing Organizations (SDO's) to address gaps in codes and standards to support SMR designs
  - Conduct evaluations of advanced SMR designs for commercialization potential
  - Consider SMR first movers for DOE/DoD siting

SMR Cost-Share Focus Area

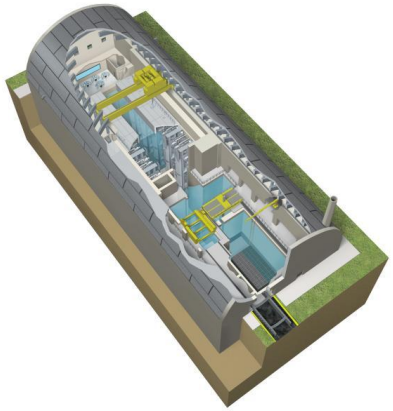
- Industry Partnerships
  - Cost-share first-of-a-kind (FOAK) development and licensing costs to advance at least two LWR SMR designs toward Design Certifications and Operating Licenses
  - Pursue business model(s) that promise a return on investment or other value proposition to the U.S. Government
    - Proposed TVA/B&W/ORNL example discussed in subsequent slides
    - Cost-shared first-mover SMRs are a performing asset that will return value to the Government
    - Cost-shared projects advance U.S. strategic missions and goals
  - Pursue business model(s) that advance U.S. commercial interests

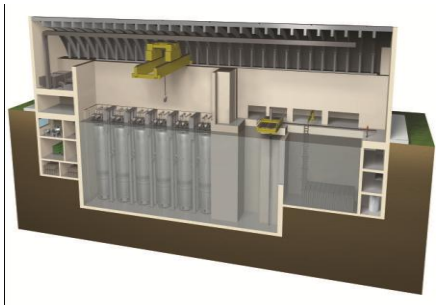
SMR Technical Focus Areas

- Advanced SMR RD&D – Will focus on development of technologies that address issues unique to SMRs:
  - SMR Instrumentation and Control/Human Machine Interface
    - Develop techniques to improve measurements, diagnostics and controls for SMR-specific environments (e.g., low flow, inaccessible internals, multiple modules, etc.)
  - SMR Assessment Methods
    - Develop PRA capability to verify reduced risk of simpler, safer designs
    - Advanced economic models for near and long-term needs
    - Integrated visualization tools for site screening studies
  - SMR Materials, Fuels and Fabrication Technologies
    - Examine ways to achieve higher fuel burn up with less dependence on control rods and boron injection
    - Support a project to advance integrated manufacturing of SMR module
    - Examine potential for coolant blockage of SMR fuel elements under unique operating conditions

Technical Focus Areas (continued)

- Advanced SMR Research and Development (cont.)
  - SMR Regulatory Technology Support
    - Conduct evaluation and analysis on issues related to SMR source term quantification, decay heat curves, and human factors impacts
    - Address issues identified in Nuclear Regulatory Commission SECY10-0034
      - Collaborate with the NRC, Nuclear Energy Institute (NEI) and American Nuclear Society (ANS) committees
    - Develop advanced design tools and techniques for security integration
  - SMR Advanced Concept Evaluation
    - Identify and assess the characteristics, capabilities, technologies and economic viability of advanced SMR designs
    - Early focus on co-generation and load-following capability





FY 2010-11 Budget Summary

dollars in thousands

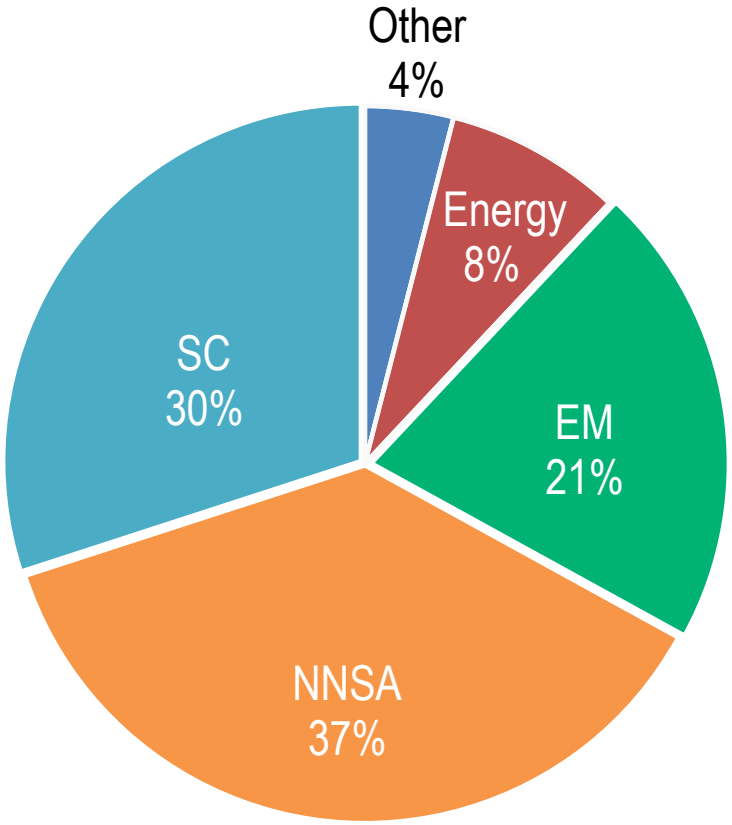
Activity/Sub-Activity	FY 2010 Approp.	FY 2011 Request	FY 2011 House	FY 2011 Senate
Management and Integration	**0**	**600**		
Light Water Reactor SMR Cost Share	**0**	**20,000**		
Advanced SMR Research and Development	**0**	**18,840**		
SBIR/STTR	**0**	**560**		
Total – Small Modular Reactors	0	40,000	55,000	50,000

*

DOE Goal for Reducing Greenhouse Gas Emissions

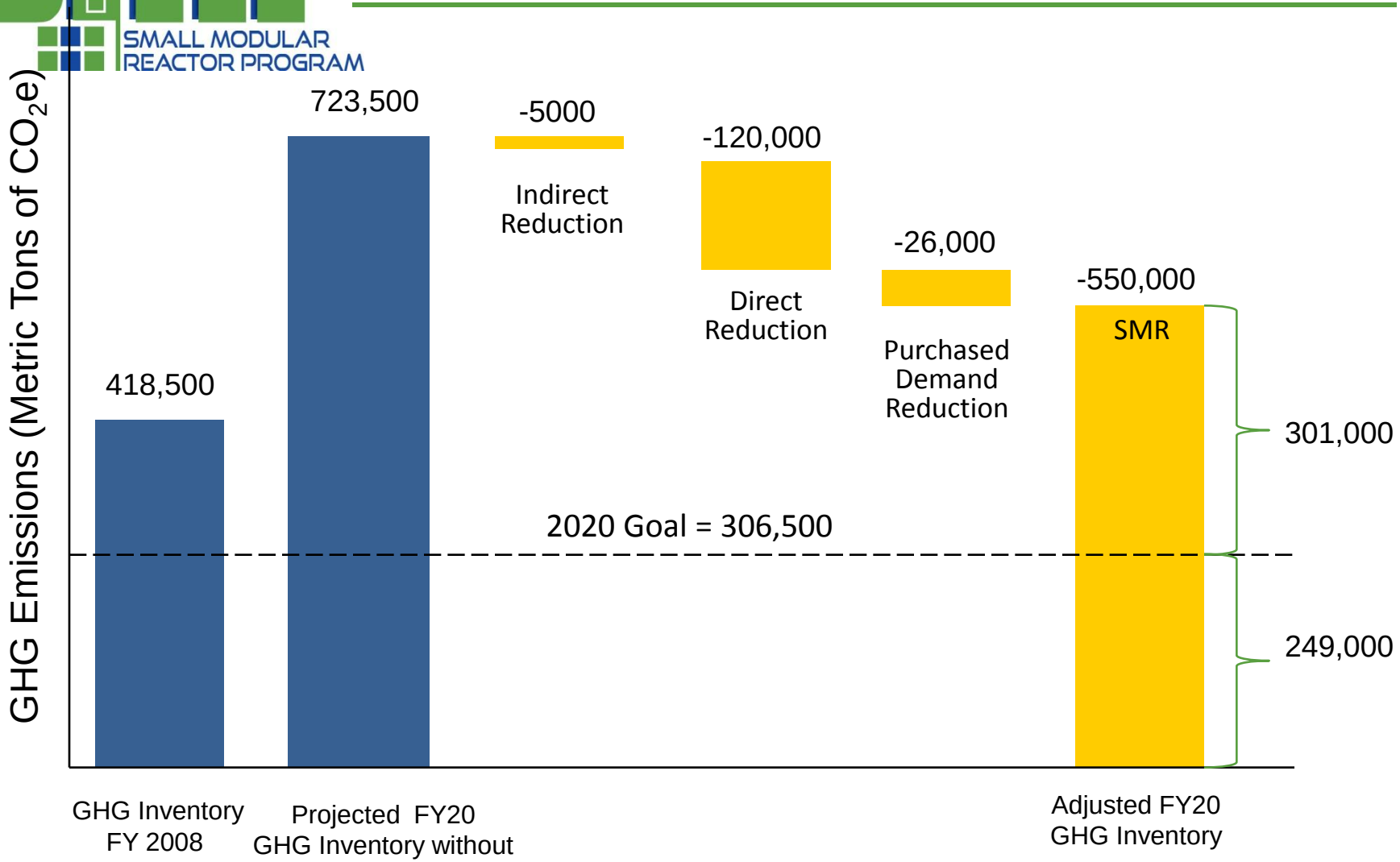
- Preliminary 2008 baseline: 4,600,000 $MtCO_2$
- DOE goal for 2020 (28% reduction): 1,290,000 $MtCO_2$

Purchased electricity is the biggest contributor to DOE GHG emissions



DOE GHG emissions: FY08 baseline

ORNL can Meet/Exceed GHG Goal in 2020 with 125MWe SMR



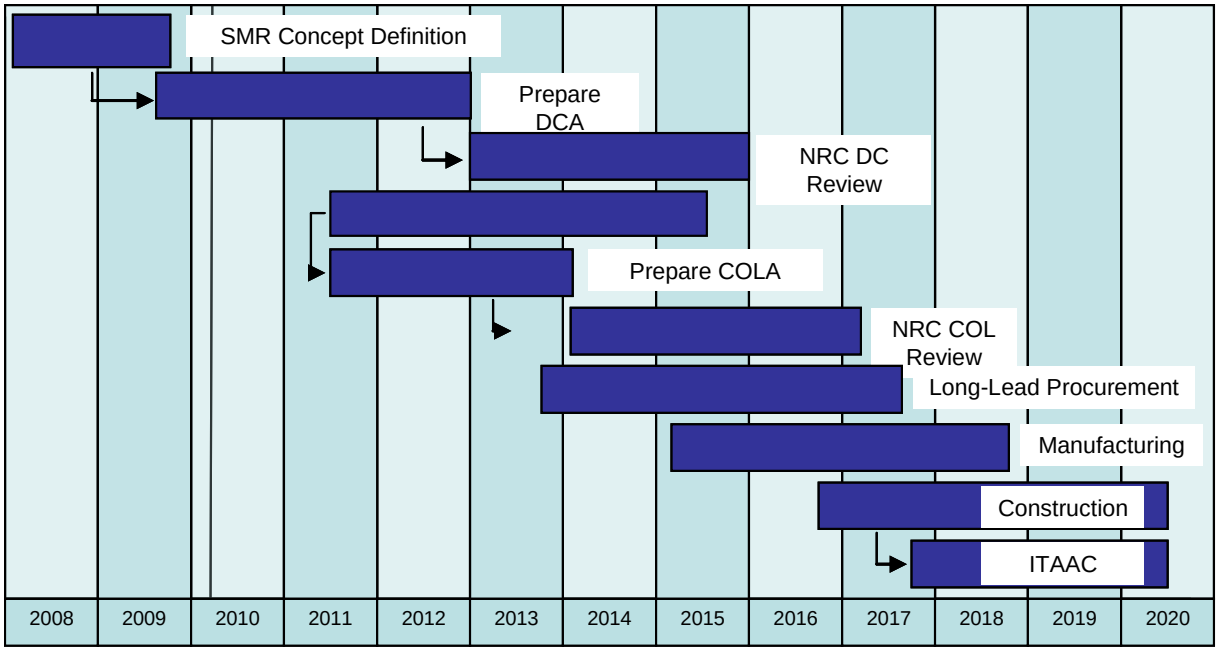
Federal Role in SMR Commercialization

Value Proposition in a Private-Government Proposal

Department of Energy	Vendor	Federal Facility	Public Utility
▪ Achieves substantial progress in meeting its complex-wide GHG reduction goal ▪ DOE: Exceeds its GHG reduction goal with additional room for mission growth ▪ DOE-NE: Demonstrates commercial viability of SMR design and deployment models ▪ Reduces risk of volatility in electrical rate for high energy mission specific facilities	▪ Achieves accelerated demonstration of SMR design ▪ Demonstrates fully domestic supply chain ▪ Demonstrates economy-of-replication business model ▪ Builds strong position for domestic and international markets	▪ Substantially reduces carbon footprint to support DOE GHG reduction goals ▪ Demonstrates site-wide net-zero energy model ▪ Provides test-bed for power islanding technologies ▪ Secures long-term predictable power costs	▪ Increases mix of clean energy generation ▪ Demonstrates viability of incremental capacity model for future generation growth ▪ Demonstrates viability of SMRs for repowering of fossil sites

Deployment by 2020

Nominal SMR Licensing Schedule



- NRC responding to SMR interest
  - SECY 10-0034 identified issues with SMR licensing
  - Office of New Reactors includes SMR certification & licensing
  - FY2011 budget request calls for doubling NRC staff to support SMR review and licensing
  - NRC and industry (NEI) currently working on SMR licensing/regulatory issues

Summary

Mobilization is crucial to winning the nuclear race

- Nuclear power remains a key element of the U.S energy strategy and portfolio
- DOE is ready to invest resources to address and resolve challenges that confront the U.S. commercial nuclear industry
  - Technical
  - Licensing
  - Nuclear supply chain
- Government role - Invest in clean energy
  - Prove innovative technologies through RD&D
  - Enable clean "nuclear" energy competitiveness
  - Reduce risk to investors and industry
- Reestablish U.S. leadership
  - Nuclear technology
  - Nuclear supply chain
  - Manufacturing and fabrication

"**Most importantly, investing in nuclear energy will position America to lead in a growing industry ….. Our choice is clear: develop these technologies today or import them tomorrow" – *Secretary of Energy Steven Chu***