

Nuclear R&D Strategic Planning and Resourcing

16th International Conference on

Structural Mechanics in Reactor Technology

**17 August 2001
Washington DC**

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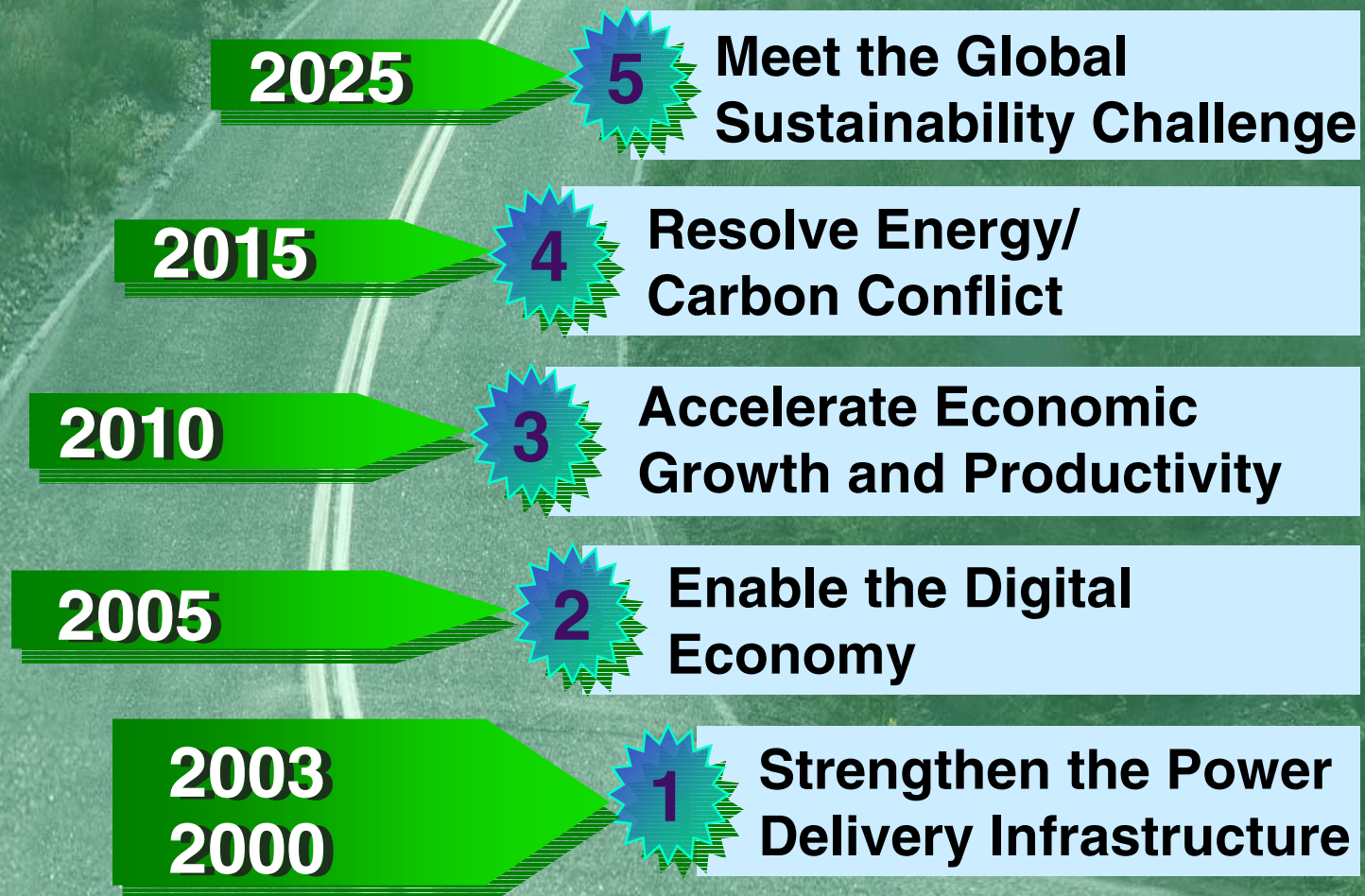
Discussion Outline

- **New Momentum**
- **Roadmaps for Expanding Nuclear Energy Supply**
 - ★ EPRI: Electricity Technology Roadmap
 - ★ NEI: Vision 2020
 - ★ EPRI: Nuclear Power Bridge Plan
 - ★ DOE: Generation IV
 - ★ DOE: Near Term Deployment
- **Industry-Government Cooperation**
 - ★ DOE
 - ★ NRC
- **Concluding Remarks**

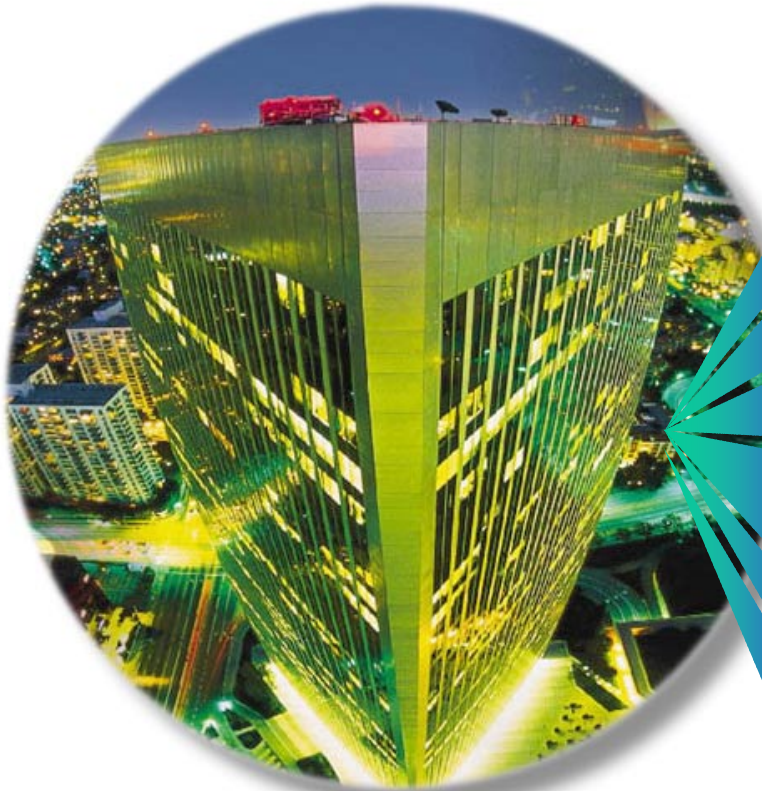
New US Nuclear Power Plants - New Momentum

- ▶ **Excellent existing nuclear plant performance**
- ▶ **Growing electricity demand; increasing awareness of the need for new generating capacity**
- ▶ **Fossil fuel price volatility, clean air constraints**
- ▶ **Improving economics of new nuclear power plants**
- ▶ **Industry consolidation = companies large enough to undertake large capital projects**
- ▶ **Significant political (and public) support**
- ▶ **Greater certainty in the licensing process**
- ▶ **Bush Administration's New National Energy Policy**

Building the Electricity Technology Road



Energy/Carbon and Global Sustainability



Limit-Breaking Technologies

Clean coal technologies

Carbon sequestration

Advanced nuclear power

Distributed renewable power systems

Advanced gas generation

Electricity/hydrogen

Need: 10,000 GW of Global Generating Capacity -- What it Means:

- **Tripling current world power plant capacity**
- **Adding 200,000 MW/yr**
- **Investing \$100 - 150 billion/yr**

It's equivalent to:

- **< 5 years of current world automobile engine production**
- **Less than 0.3% of world GDP**
- **Less than the world spends on cigarettes, etc.**

It can and must be done!

EPRI's Energy Supply Roadmap

- **Priority R&D: Circa 2020:**

- ★ close gaps and implement spent fuel management systems
- ★ replace deterministic regulations with risk-informed, performance-based regulations
- ★ extend high performance of existing plants; reduce costs, extend life
- ★ adapt advanced IT to plant management over full life cycle
- ★ adapt advanced modular construction technologies to new plants

- **Priority R&D: Circa 2050:**

- ★ achieve higher fuel utilization and associated fuel cycles
- ★ pursue breakthroughs in high temperature helium-cooled reactors
- ★ determine cost-effective & practicable features of nuclear fusion

National Energy Policy Report: Nuclear Energy Recommendations

- **Support expansion of nuclear energy in the U.S.**
 - ★ Encourage NRC to expedite applications for licensing new reactors
 - ★ Encourage NRC to facilitate uprating existing plants safely
 - ★ Encourage NRC to relicense existing plants that meet/exceed standards
 - ★ Direct DOE and EPA to assess potential of nuclear to improve air quality
 - ★ Increase resources as necessary for NRC in light of new generation
 - ★ Use best science to provide deep geologic repository for nuclear waste
 - ★ Support legislation clarifying funds for decommissioning are not taxable
 - ★ Support legislation to extend Price-Anderson Act
- **Reexamine policies to allow for R&D of fuel conditioning methods that reduce waste streams and enhance proliferation resistance**
- **Consider technologies to develop reprocessing and fuel treatment that are more efficient, less waste-intensive, more proliferation-resistant**

NEI's "Vision 2020" -- 60,000 additional MWe by 2020

- **Unveiled by NEI at Nuclear Energy Assembly, May 2001**
- **Approved/endorsed by NEI Executive Committee**
- **Centerpiece: 50,000 MWe from new NPPs in the U.S.**
- **10% efficiency improvement in current plants = 10,000 MWe**
- **Total new nuclear production of 60,000 MWe:**
 - ★ increases nuclear's share of electricity supply from ~20% to ~23%
 - ★ together with renewables, maintains non-emitting share at ~30%
 - ★ contributes ~10% of new U.S. generating capacity by 2020

Building on a solid foundation of prior & current efforts

- **Nuclear Energy Industry's Strategic Plan for Building New Nuclear Power Plants (annual updates, 1990-1998)**
- **Industry-DOE ALWR Program: ~\$1 Billion, 1985-1998**
 - ★ ALWR Utility Requirements Document
 - ★ Design Certifications: ABWR, System 80+, AP600
 - ★ FOAKE: ABWR, AP600
- **NEI's Strategic Direction for the 21st Century (1998-2000)**
- **EPRI's Electricity Supply Roadmap, 1999**
 - ★ Basis for EPRI Nuclear Energy Bridge Plan, 2001

EPRI's Nuclear Energy Strategic Bridge Plan

- **Purpose:**
 - ★ Supplement tactical with strategic planning
 - ★ Address mid-term (5-10 yrs) and long-term (10-20 yrs) strategic objectives
 - ★ Consider EPRI's Electricity Technology Roadmap and all other industry strategic plans

Why Do We Need a Bridge Plan?

- **Utility Leadership over future nuclear options**
 - ★ Maintained leadership thru ~'98 (ALWR program)
 - ★ Articulating the high level vision today thru NEI
- **However, the nuclear debate over future options and establishing the technical needs must be driven by owner/operator leadership**
 - ★ DOE strategic planning and R&D agenda strongly influenced by national laboratory and academic stakeholders
 - ★ Timing and results are not driven by the market
- **The bridge plan provides an opportunity to establish market requirements**

Strategic Objectives

1. Preclude safety event surprises
2. Allay concerns of public safety
3. Achieve maximum plant useful life
4. Improve plant capacity, reliability, and availability
5. Develop technology to address material aging
6. Add cost-effective innovation to existing plants
7. Resolve on-site spent fuel issues
8. Evaluate evolutionary and new designs including gas-cooled technology
9. Develop high-utilization fuel cycles to extend resources
10. Resolve technical high level waste issues

Strategic Objectives (cont.)

11. Achieve cost/risk-focused decision-making in regulation, operation, and design
12. Optimize technology transfer and collaboration
13. Employ advances in information technology to design and operations
14. Meet increasing demand for skilled, productive work force
15. Advance the use of high performance fuel
16. Adopt advances in manufacturing and construction technology
17. Provide basis for simplified licensing process

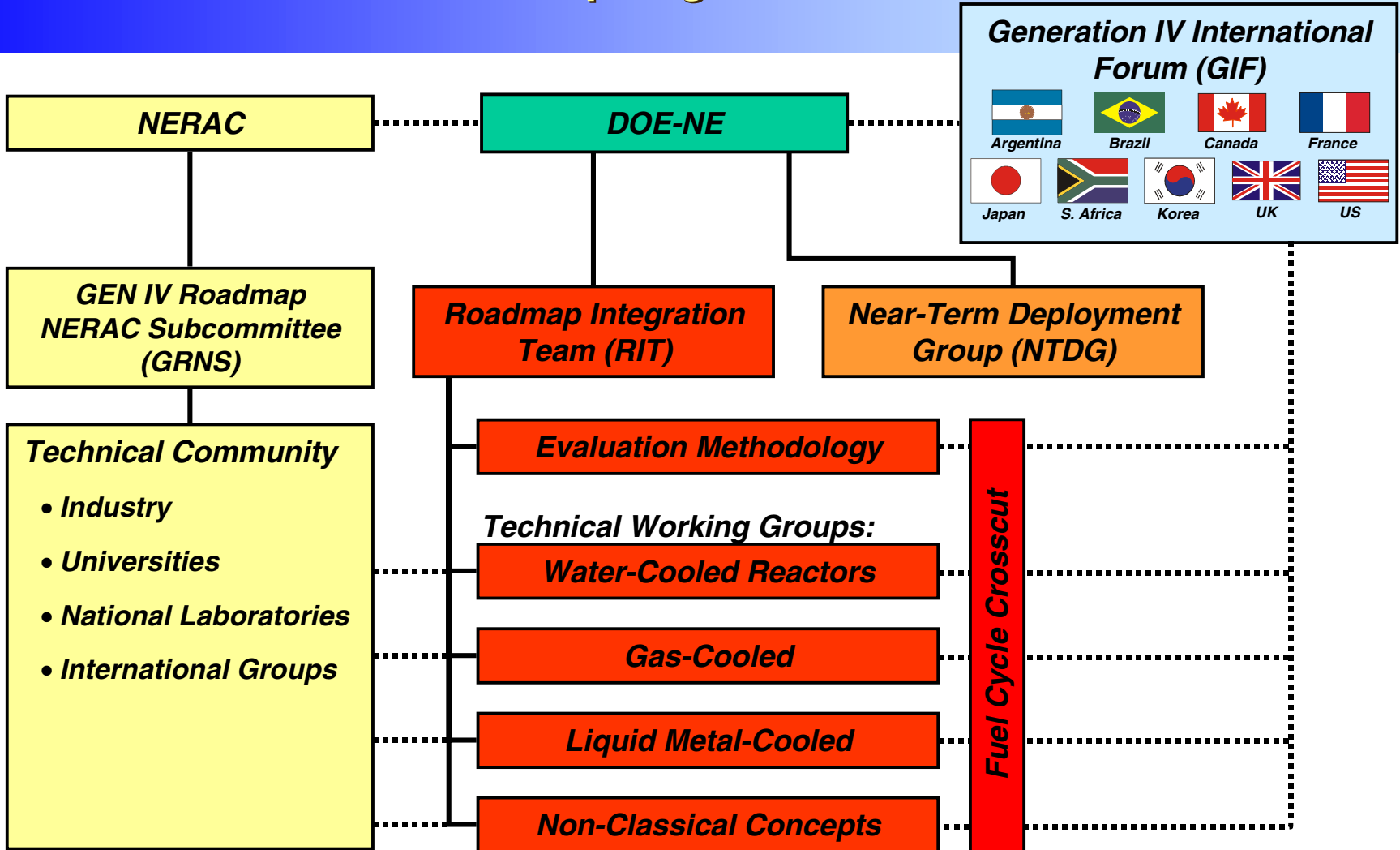
Reducing Nuclear Power Plant Capital Costs

- **New standardized US designs responsive to utility/ EPRI-defined requirements for plant simplification:**
 - ★ have much reduced hardware quantities (piping, supports, valves, pumps, cable, steel, concrete)
 - ★ are designed in detail for expedited construction (e.g. via extensive modularization), and thence reduced interest during construction
- **Industry's plant standardization policy for new plants will accrue cost reduction via detailed replication**
- **New EPRI initiatives target further construction and operating cost reductions**
- **Best hopes for achieving objective:**
 - ★ AP1000, ESBWR
 - ★ PBMR, GT-MHR

EPRI R&D In-Place to Support Nuclear Renaissance

- **Generic:**
 - ★ Licensed-basis management
 - ★ Construction modeling
 - ★ Early site permit
- **LWR Specific:**
 - ★ AP1000
 - ★ ESBWR
- **HTGR-Specific**
 - ★ Maintainability
 - ★ Graphite behavior
 - ★ Minimizing Ag contamination
 - ★ Catcher bearings

DOE Generation IV Roadmap Organization



Near-Term Deployment Group

- **Mission** - Identify the technical, institutional and regulatory gaps to the near term deployment of new nuclear plants and recommend actions that should be taken by DOE.
 - ★ Orders by 2005
 - ★ Multiple plants in commercial operation by 2010
- **Participants** - multi-disciplined nuclear industry group
 - ★ Nuclear Utilities - Duke, Southern Nuclear, Exelon
 - ★ Reactor Vendors - Westinghouse, General Electric, General Atomics
 - ★ National Laboratories - ANL, INEEL
 - ★ Academia - Penn State
 - ★ Industry - EPRI
 - ★ Government - DOE-NE
 - ★ NERAC

Near-Term Deployment: Near Term Action Paper

- **Significant FY2002/2003 Proposed DOE-funded Activities (each to be cost-shared with industry) include:**
 - ★ **Site-specific, per 10CFR 52 (cost-share with applicants):**
 - Early Site Permit Demonstrations (one for each type of site)
 - Combined Construction/Operating License (COL) Demonstration (first COL for each design referenced, with a pre-existing ESP)
 - COL without pre-existing ESP (first “fast track” applicant)
 - ★ **Generic regulatory & technical solutions to benefit specific applications (cost-share with EPRI; needs defined w/ NEI)**
 - Generic ESP and COL guidelines, generic regulatory framework
 - Improved modular construction technologies and 4-D modeling
 - ★ **Design-specific (cost-share with design teams)**
 - Design Certification of 1000+ MWe ALWR
 - Confirmatory Testing and Code Validation of Advanced Reactors Utilizing New Technology

Near-Term Deployment Group: Final Report

- **Design Specific Responses to RFI**

- ★ SWR 1000 Framatome
- ★ PBMR Exelon/PBMR
- ★ AP600/AP1000 Westinghouse
- ★ IRIS Westinghouse
- ★ GT-MHR General Atomics
- ★ ABWR General Electric
- ★ ESBWR General Electric

Near-Term Deployment Group: Final Report

- **Generic Gaps (Tentative)**

- ★ Lack of demonstrated regulatory processes to obtain permission to build a nuclear energy plant in the U.S.
- ★ Lack of an appropriate Risk-Informed, Performance-Based regulatory process for licensing decisions.
- ★ Lack of closure with NRC on major COL and construction inspection issues that can affect construction schedule and cost-effective plant operation.
- ★ Lack of assurance that new nuclear plants will be cost competitive
- ★ Lack of effective ownership and financing options for use in a deregulated electricity marketplace.

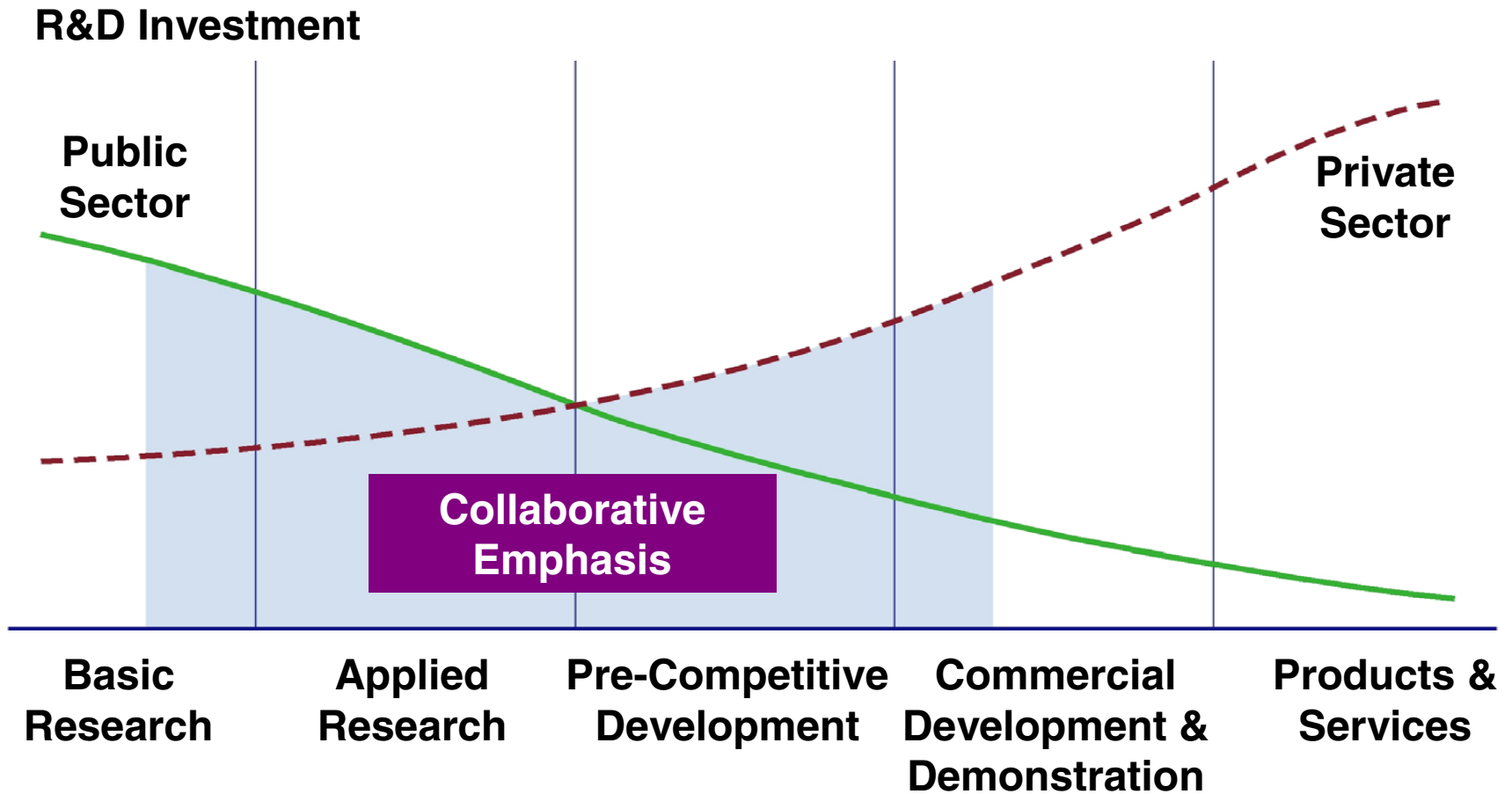
- **Generic Issues (Tentative)**

- ★ Spent fuel management and nuclear weapons proliferation
- ★ Establishing a level playing field among energy supply options
- ★ Public acceptance of Nuclear Energy
- ★ Robust infrastructure to support major component fabrication, plant construction, maintenance and operation of multiple new plant deployment

Imperatives for Industry-Government Cooperation

- **Leverage dwindling resources**
- **Avoid duplication, overlap, counterproductive efforts**
- **Responsive to organizations' leadership & sponsoring bodies**
 - ★ Utilities encourage EPRI to collaborate with NRC, DOE
 - ★ Congress, PCAST, SEAB encouraged DOE to expand public-private partnerships
 - ★ Commission encouraged collaboration under DSI-22
- **Value to society -- cooperation enhances ability to:**
 - ★ sustain/improve nuclear safety, reliability, affordability
 - ★ maintain a viable nuclear option to address environmental problems with fossil fuels
 - ★ maintain global leadership in safety, regulations, advanced designs, operations, non-proliferation, etc.

R&D: Supporting the Transition



The Resource Picture over the last 15 Years

- **For Perspective: ALWR Program spent ~\$1B, 1985-1998**
- **Today:**
 - ★ DOE: \$7.5M + \$ few M (NERI): mostly long term focus
 - ★ EPRI: ~\$4M
 - ★ Vendors: less than investments during ALWR program
- **Federal Investments in Energy Supply R&D (last 5 years, avg.):**

| | |
|-----------------------------|--------|
| ★ Fossil energy: | \$415M |
| ★ Solar & Renewable Energy: | \$345M |
| ★ Energy Efficiency | \$521M |
| ★ Fusion | \$235M |
| ★ Nuclear Energy | \$26M |

Why U.S. Govt. Should Support a Strong NE R&D Program at DOE

- **Essential part of national energy strategy: strong R&D program needed to underpin strategic objectives**
 - ★ 1995 Yergin Report articulated national goals
- **Signals federal government recognition that NE is an essential part of future U.S. “clean energy”, diversified fuel portfolio**
- **Signals U.S. intent to remain global leader in NE**
 - ★ Supports U.S. firms in growing international NE competition
 - ★ Demonstrates US will remain reliable provider of peaceful NE
 - ★ Preserves U.S. “Seat at the Table” on nuclear-related policy matters (safety, nonproliferation, trade)
 - ★ Supports need to replace aging NE workforce

Memoranda of Understanding to Support Industry / Government Cooperation

- **NRC, DOE, and EPRI have executed bilateral MOUs with each other**
- **NRC-EPRI MOU:**
 - ★ Executed Nov. 1997
 - ★ Basis for cooperation of data phase of R&D
- **DOE-EPRI MOU:**
 - ★ Executed Sept. 1999
 - ★ Basis for cooperation on all LWR R&D
 - ★ Initial focus: NEPO Program
- **DOE-NRC MOU executed in 1999**

Joint DOE-EPRI Strategic Plan

- **Primary Objective: Maintain & improve operation of current NPPs via coordinated R&D planning**
- **Scope: R&D needs supporting joint DOE and industry interests for commercial nuclear energy**
- **Shared roles: Industry (near-term), DOE (mid-term)**
- **Strategic Goals & Plan Organization:**
 - ★ Aging Management
 - ★ License Renewal
 - ★ Generation Optimization

NRC - Industry Cooperation in R&D -- a Perspective

- **Extensive collaboration among NRC, DOE, EPRI, NSSS Vendors on nuclear R&D in 1970s, early 80s**
- **R&D collaboration rare during last decade**
 - ★ Legal concerns with “independence”
- **Independent R&D became obstacle to issue closure**
 - ★ Lack of agreement up-front on definition/scope of issue
 - ★ Lack of agreement on R&D needs, assumptions, data
- **What has changed?**
 - ★ Greater appreciation of common R&D goals
 - ★ Diminished resources for R&D suggests leveraging
 - ★ Risk-informed regulation encourages convergence on R&D assumptions, data, models, etc.

Research Cooperation under the EPRI/NRC MOU

- **Formal Addenda to MOU on:**
 - ★ Testing of High Burnup Fuel
 - ★ Fabrication Flaw Distribution in RPVs
 - ★ Fire Risk
 - ★ Treatment of Proprietary and Commercial Info.
 - ★ Welding of Highly Irradiated Materials
 - ★ Dry Cask Storage Project at INEEL
 - ★ Steam Gen. Tube Pull Specimen Library (pending)
- **Other areas of cooperation:**
 - ★ RIR: RI-ISI, PSA Standards, other RI issues
 - ★ Aging Issues for License Renewal
 - ★ Decommissioning Dose Models
 - ★ Digital I&C, SA close-out, etc.

Concluding Remarks

- **Strategic objectives outlined in EPRI Bridge Plan show importance of new technology:**
 - ★ high strength, corrosion resistant materials; high temp. applications
 - ★ modern I&C and information technology applications
 - ★ equipment reliability is key to economic performance
 - ★ PRA evolution to risk management tool to optimize safety & cost
- **New technologies, including risk-informed, performance-based methods, must be applied to regulations and reg. guidance**
- **Strategic planning is critical to focusing resources**
 - ★ public-private partnerships essential to success
 - ★ “technology pushers” need to listen to “market pullers”
 - ★ ultimately, policy leaders and investors will appreciate good planning that reflects marketplace needs and assures success