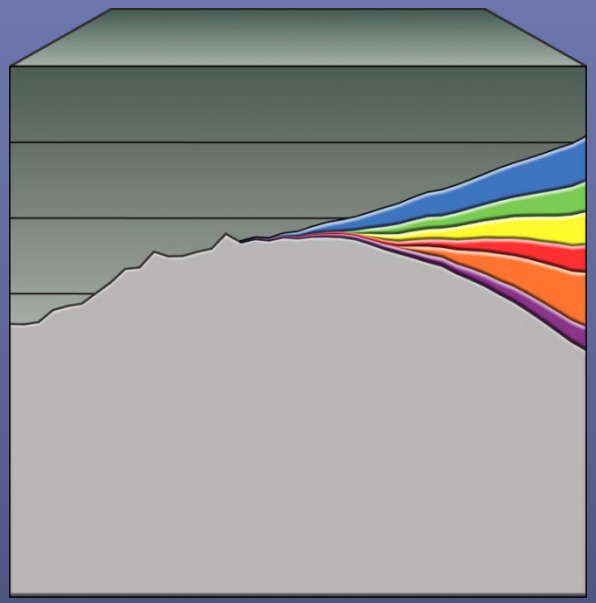


The Power to Reduce CO_2 Emissions
The Full Portfolio

Barbara Tyran

Director, Washington Relations

International Energy Agency

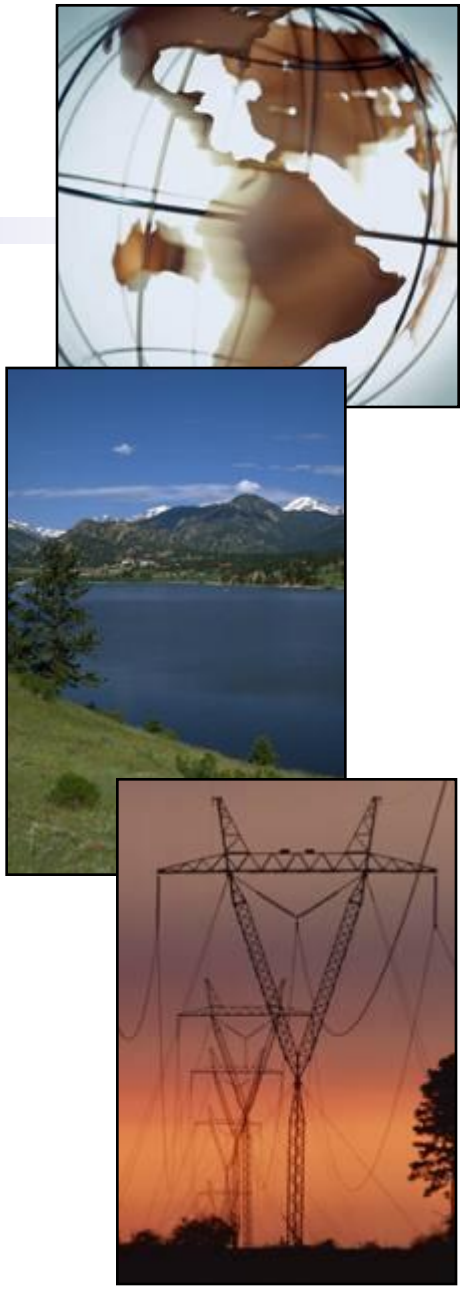
May 15, 2008

EPRI ELECTRIC POWER RESEARCH INSTITUTE

About EPRI

Together…Shaping the Future of Electricity

- Founded in 1973 as an independent, nonprofit center for public interest energy and environmental research.
- Objective, tax-exempt, collaborative electricity research organization
- Science and technology focus--development, integration, demonstration and applications
- Broad technology portfolio ranging from near-term solutions to long-term strategic research



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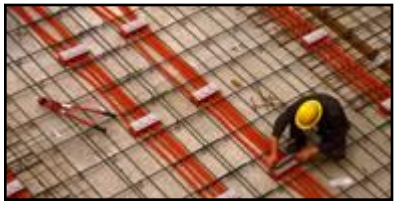
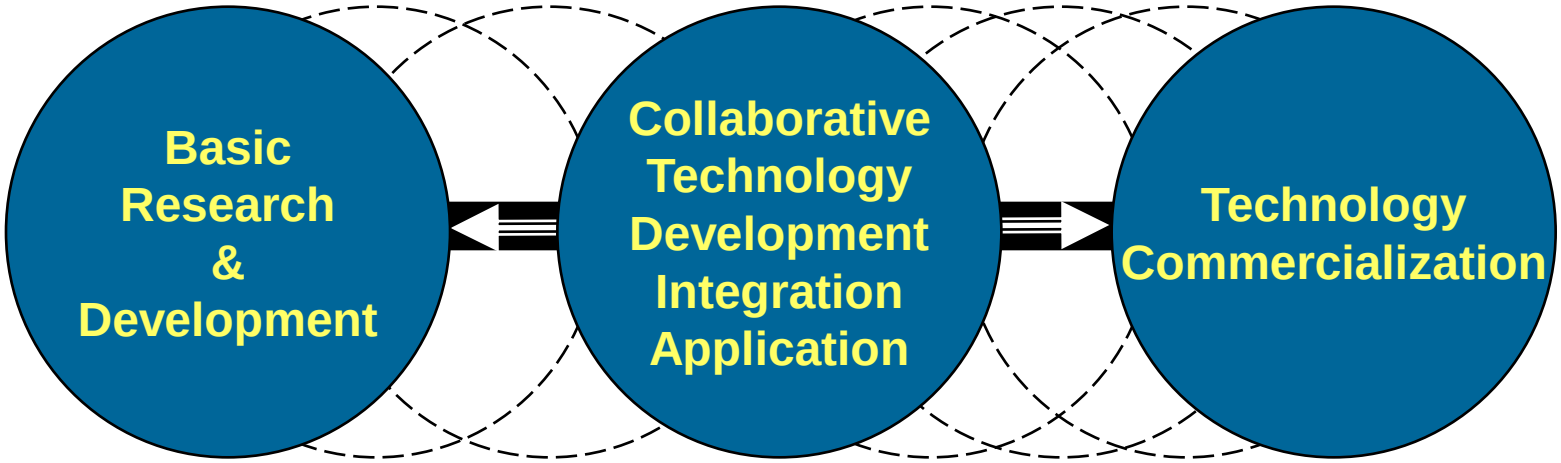
Large and Successful R&D Collaboration



- More than 450 participants in over 40 countries
  - Over 90% of North American electricity generated
- 66 technical programs
  - Generation
  - Power Delivery and Markets
  - Nuclear
  - Environment
  - Technology Innovation
- 1600+ R&D projects annually
- 10 to 1 average funding leverage
- Research is directed to the public benefit
- Limited regulatory, judicial and legislative participation

EPRI's Role



National Laboratories

Universities

EPRI

Suppliers

Vendors

Depends Upon The Specific Technology or Discipline

Context

- Growing scientific and public opinion that CO_2 emissions are contributing to climate change…
- Priority of 110th Congress …
- U.S. responsible for 1/4 of global CO_2 emissions…
- Electricity sector responsible for 1/3 of U.S. CO_2 emissions…
- General agreement that technology solutions are needed…

How can the electricity industry respond?

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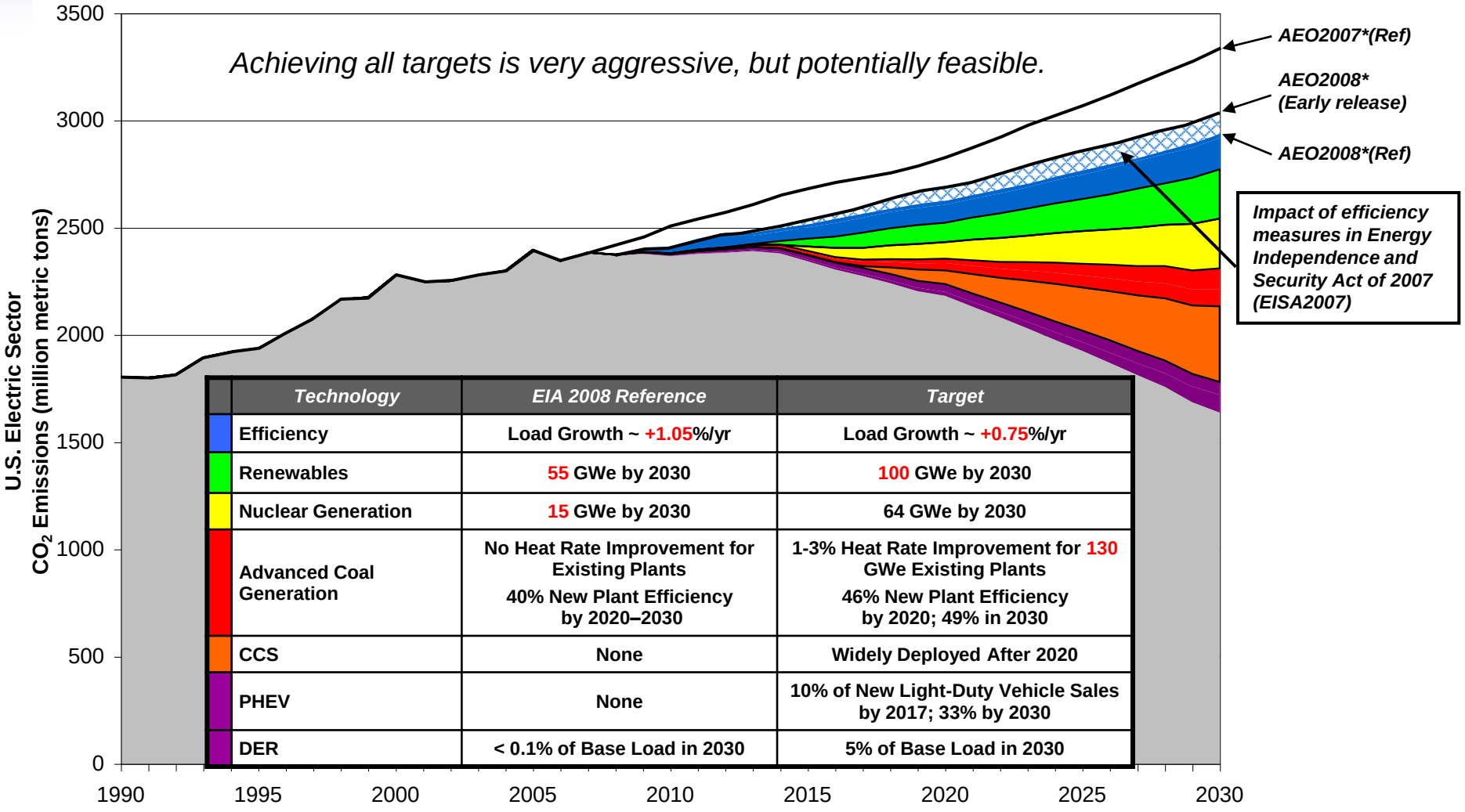
Presentation Objective…Answer Three Questions

- **What is the technical potential for reducing U.S. electric sector CO_2 emissions?**
- **What are the economic impacts of different technology strategies for reducing U.S. electric sector CO_2 emissions?**
- **What are the key technology challenges for reducing electric sector CO_2 emissions?**

2008 Prism...Technical Potential for CO_2 Reductions



Technology	EIA 2008 Reference	Target
Efficiency	Load Growth ~ +1.05%/yr	Load Growth ~ +0.75%/yr
Renewables	55 GWe by 2030	100 GWe by 2030
Nuclear Generation	15 GWe by 2030	64 GWe by 2030
Advanced Coal Generation	No Heat Rate Improvement for Existing Plants 40% New Plant Efficiency by 2020–2030	1-3% Heat Rate Improvement for 130 GWe Existing Plants 46% New Plant Efficiency by 2020; 49% in 2030
CCS	None	Widely Deployed After 2020
PHEV	None	10% of New Light-Duty Vehicle Sales by 2017; 33% by 2030
DER	< 0.1% of Base Load in 2030	5% of Base Load in 2030

**Energy Information Administration (EIA) Annual Energy Outlook (AEO)*

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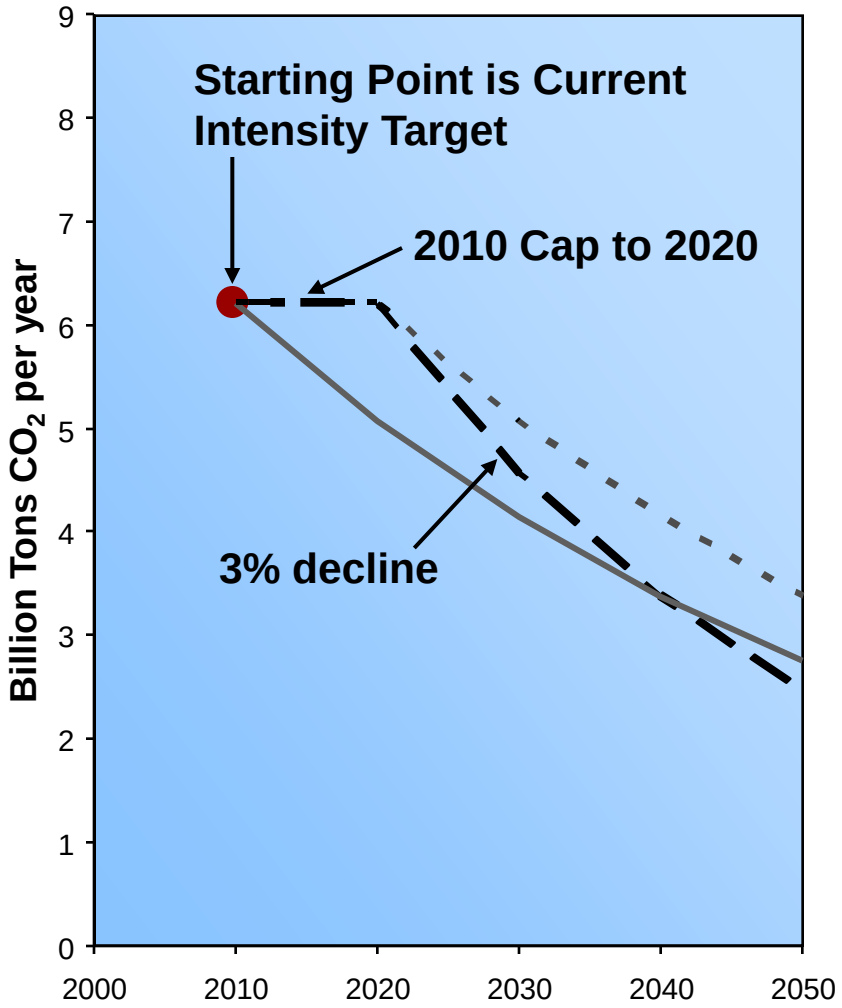
Assumed U.S. Economy-Wide CO_2 Constraint

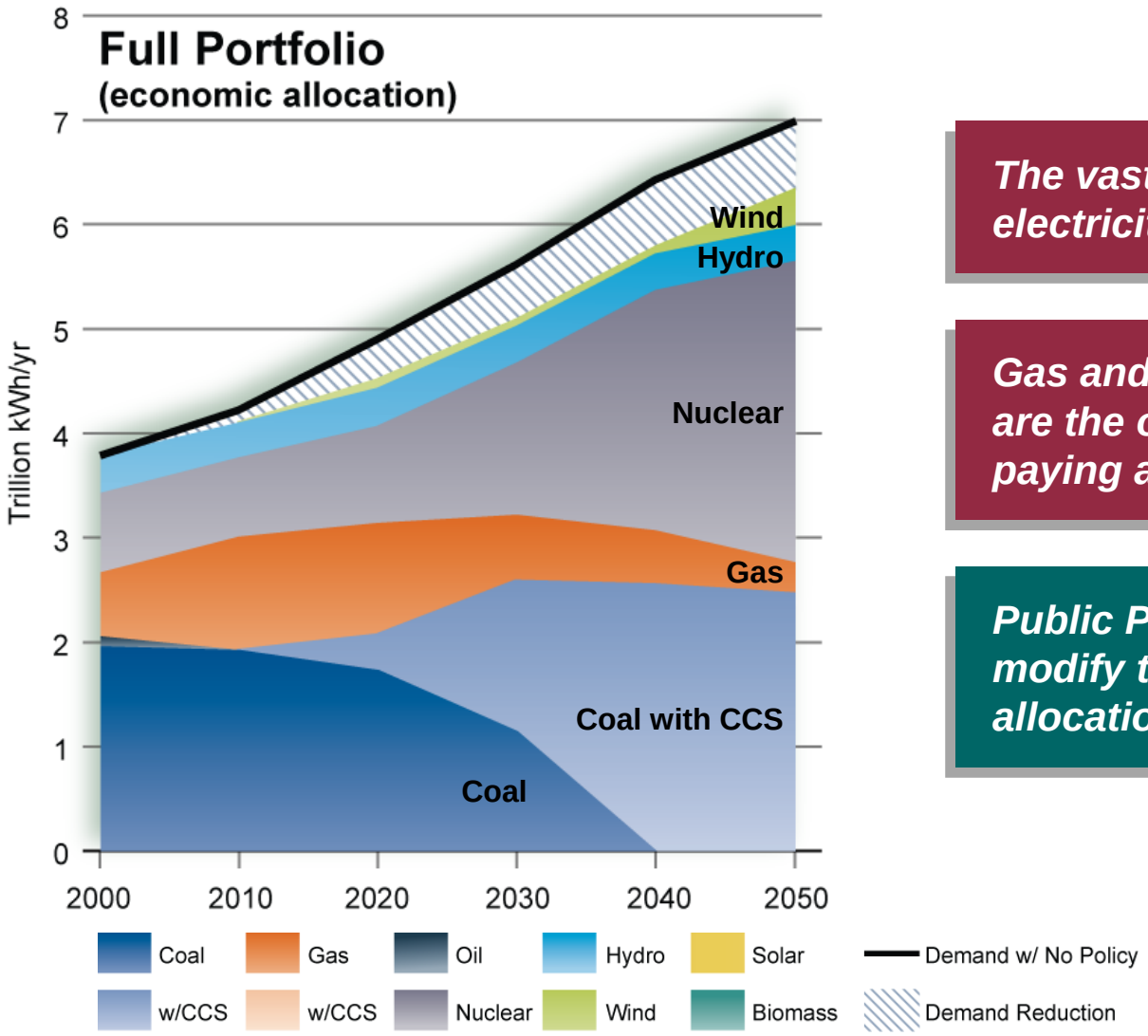


- **PRISM electric sector CO_2 profile most closely modeled by economy-wide constraint which:**
  - *Caps emissions at 2010 levels until 2020*
  - *Requires 3% decline beginning in 2020*
  - *Constraint in 2050 ~50% of 1990 emissions levels*

Electricity Technology Scenarios

	Full Portfolio	Limited Portfolio
Supply-Side		
Carbon Capture and Storage (CCS)	Available	Unavailable
New Nuclear	Production Can Expand	Existing Production Levels ~100 GW
Renewables	Costs Decline	Costs Decline Slower
New Coal and Gas	Improvements	Improvements
Demand-Side		
Plug-in Hybrid Electric Vehicles (PHEV)	Available	Unavailable
End-Use Efficiency	Accelerated Improvements	Improvements

U.S. Electric Generation – Full Portfolio



The vast majority of electricity supply is CO_2-free

Gas and non-captured coal are the only supply options paying a CO_2 cost

Public Policy (RPS) can modify this economic allocation

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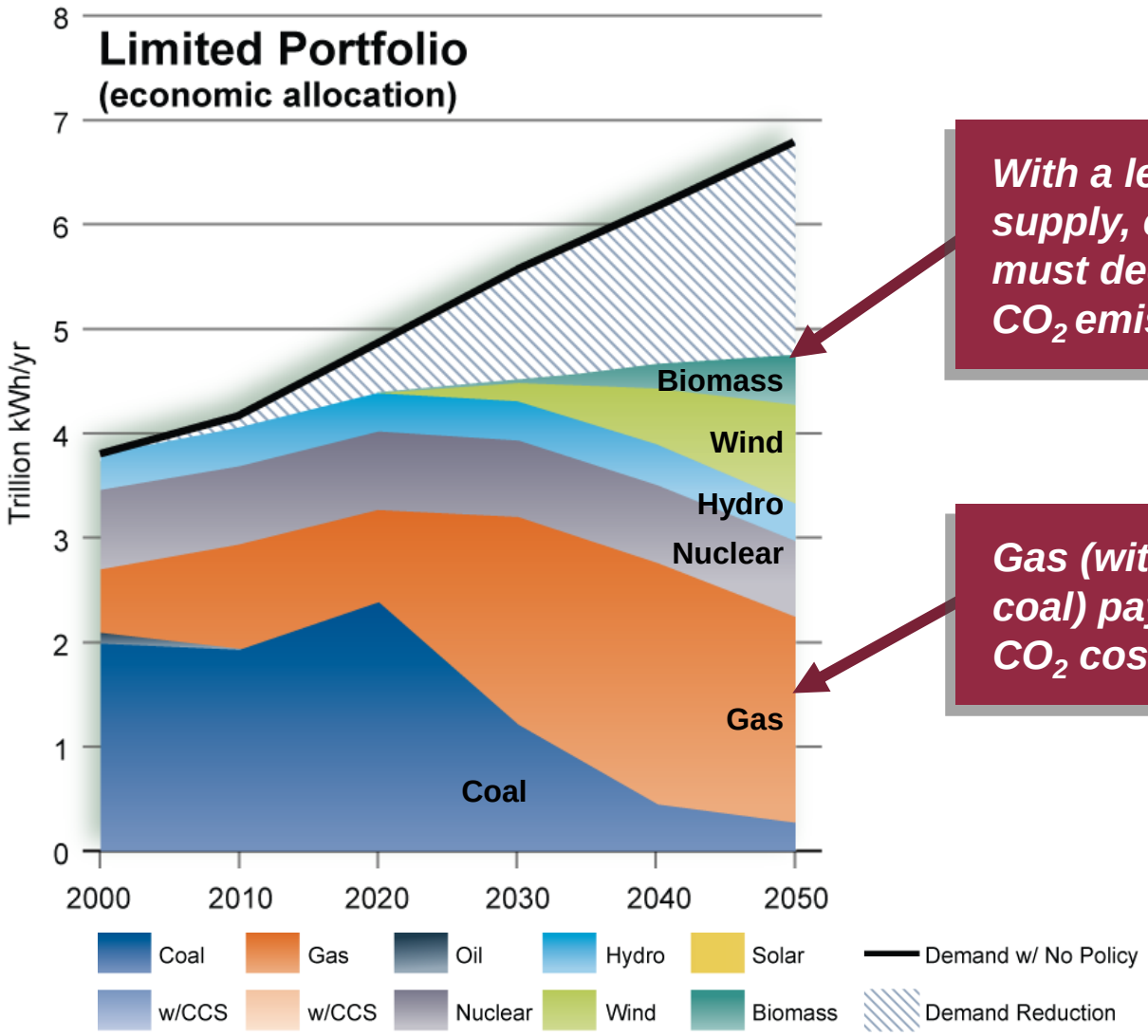
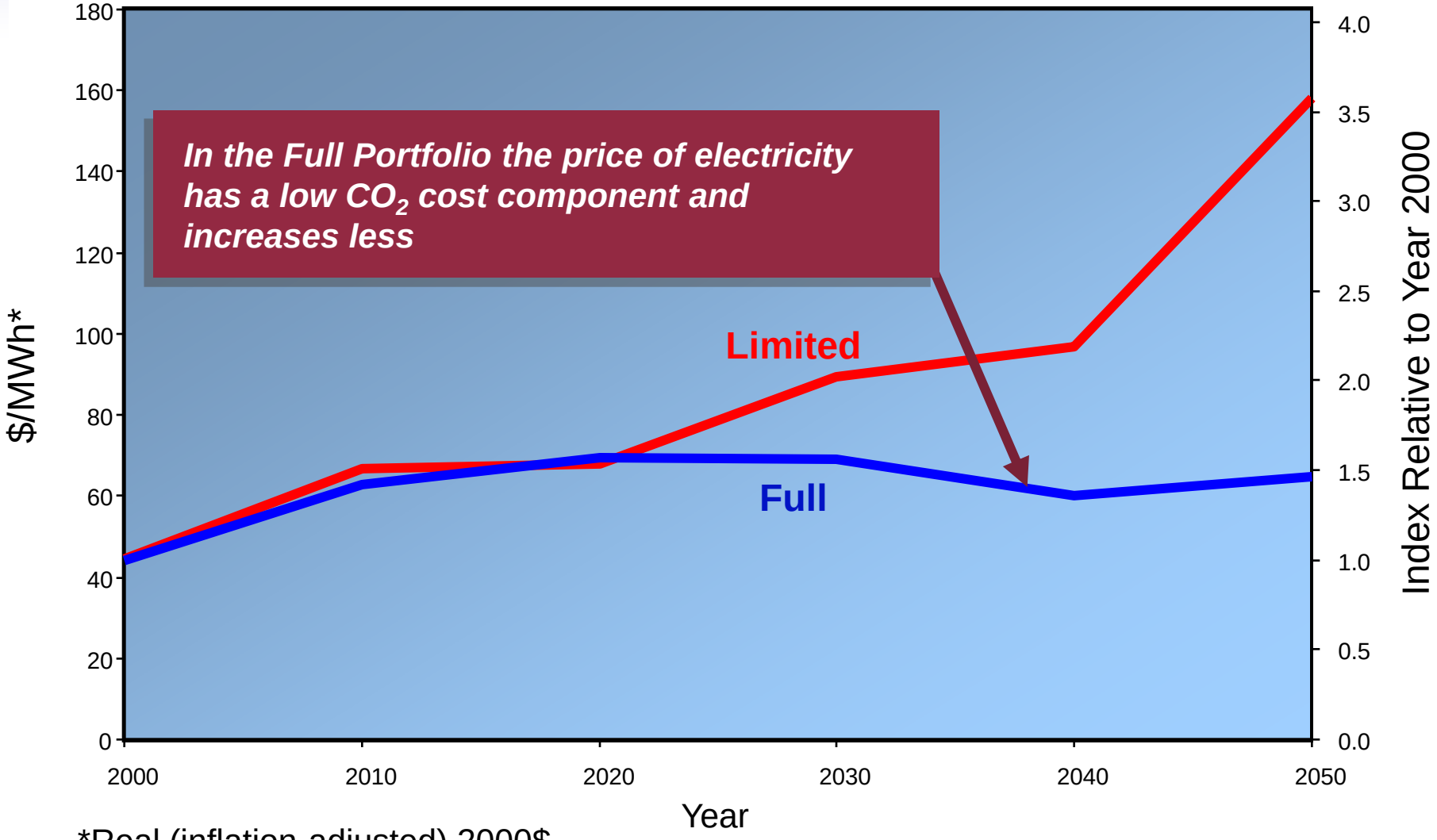
U.S. Electric Generation – Limited Portfolio



With a less de-carbonized supply, electricity load must decline to meet the CO_2 emissions target

Gas (with half the CO_2 of coal) pays a significant CO_2 cost

Wholesale Electricity Price



*Real (inflation-adjusted) 2000$

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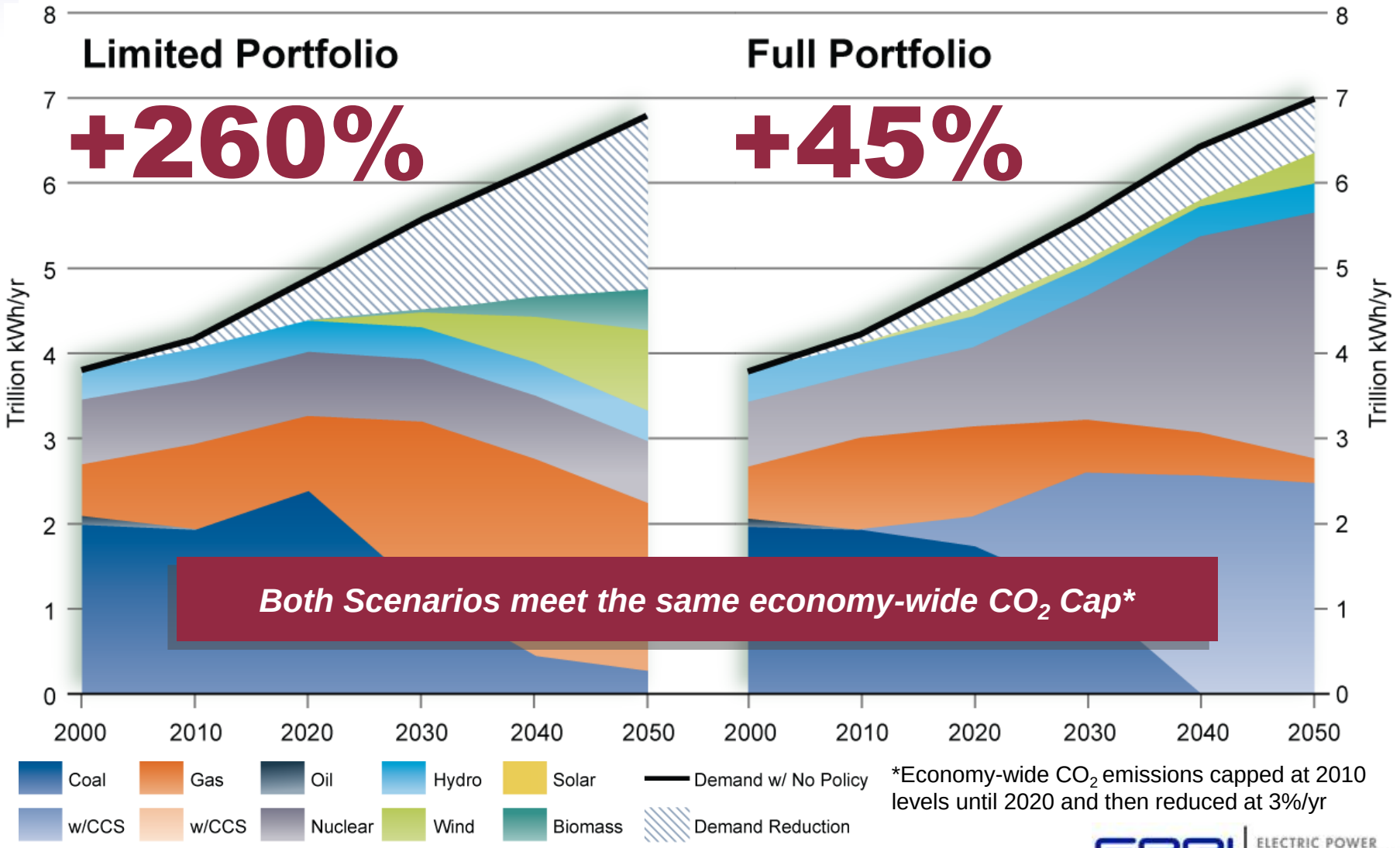
Increase in Real Electricity Prices… 2000 to 2050



*Economy-wide CO_2 emissions capped at 2010 levels until 2020 and then reduced at 3%/yr

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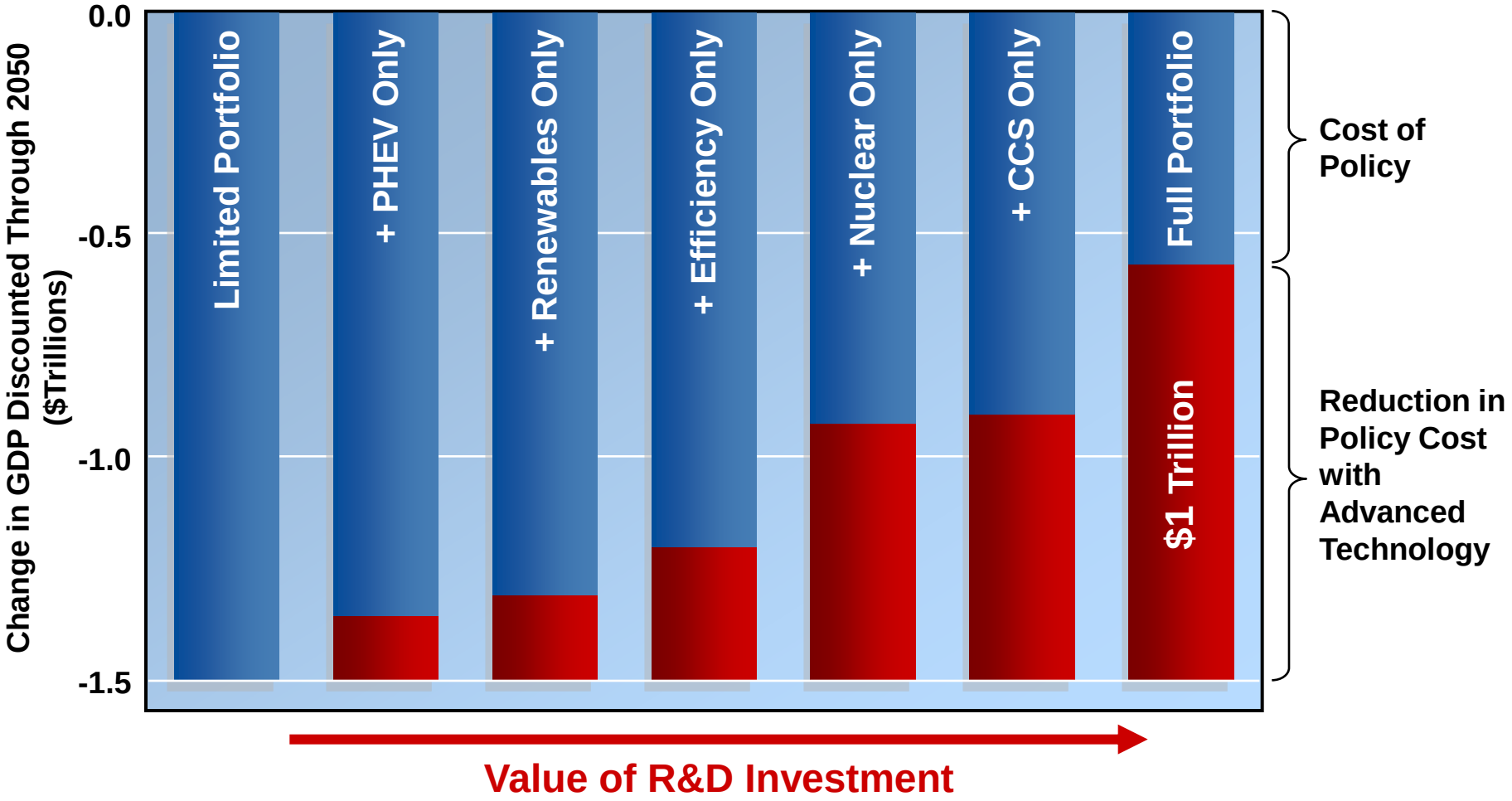
Full Technology Portfolio Reduces Costs of a CO_2 Emissions Reduction Policy by 60%



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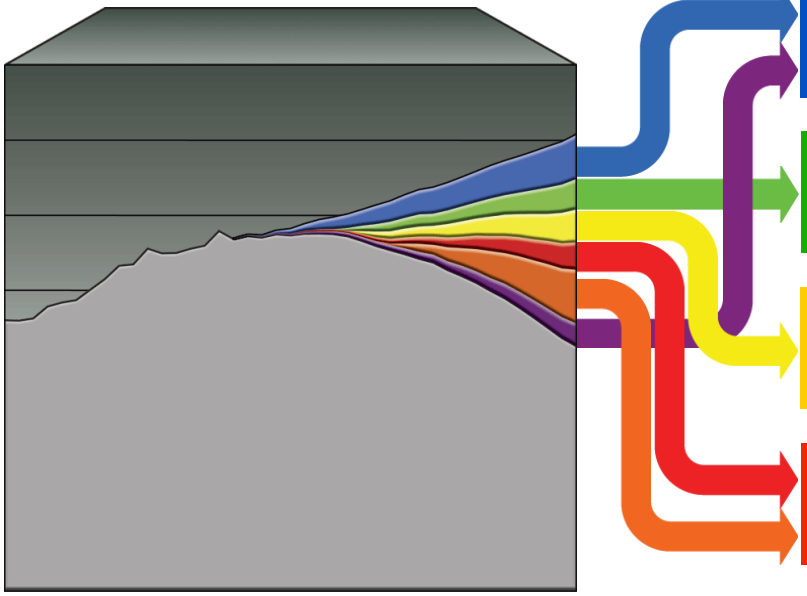
Presentation Objective…Answer Three Questions

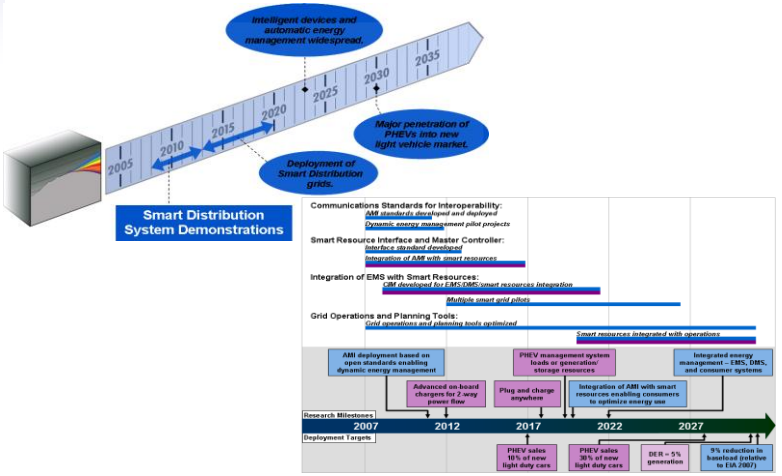
- What is the technical potential for reducing U.S. electric sector CO_2 emissions?
- What are the economic impacts of different technology strategies for reducing U.S. electric sector CO_2 emissions?
- **What are the key technology challenges for reducing electric sector CO_2 emissions?**

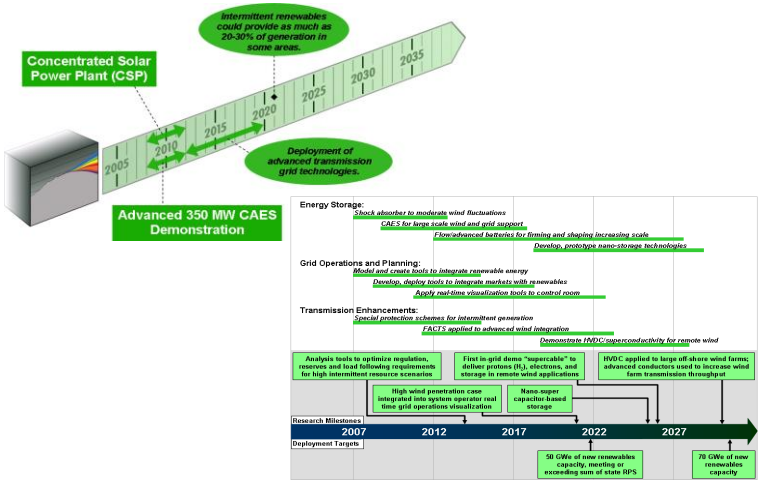
Transition to Low-Emissions Technologies

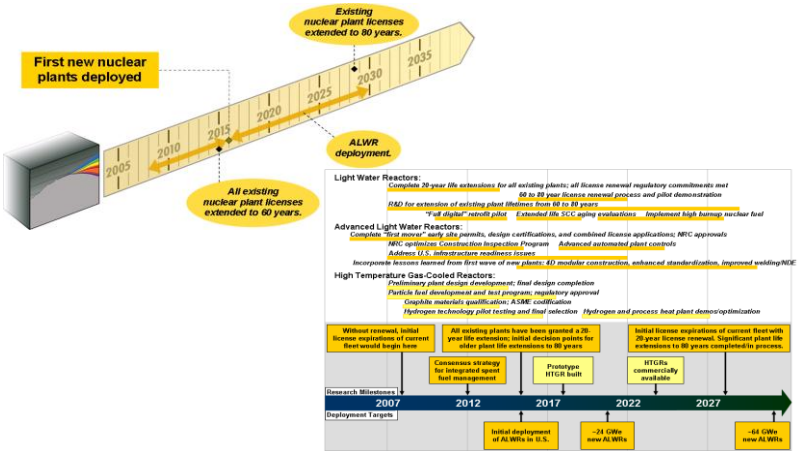


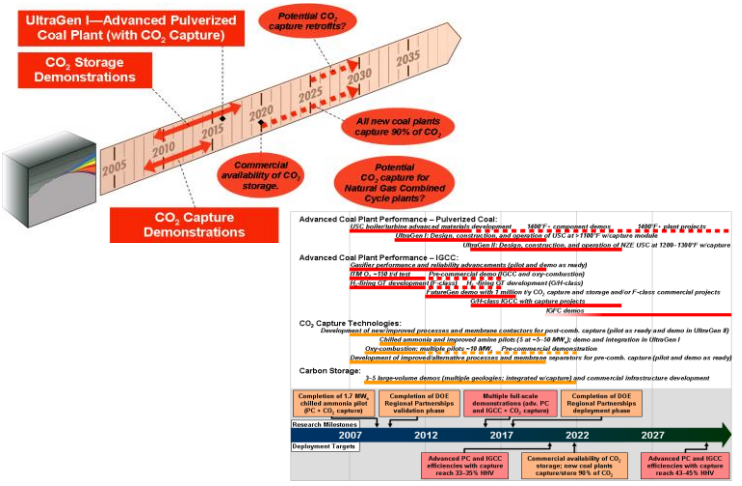
- ***Enabling Efficiency, PHEVs, DER via the Smart Distribution Grid***
- ***Enabling Intermittent Renewables via Advanced Transmission Grids***
- ***Expanded Advanced Light Water Reactor Deployment***
- ***Advanced Coal Plants with CO_2 Capture and Storage***

Developing Detailed RD&D Action Plans









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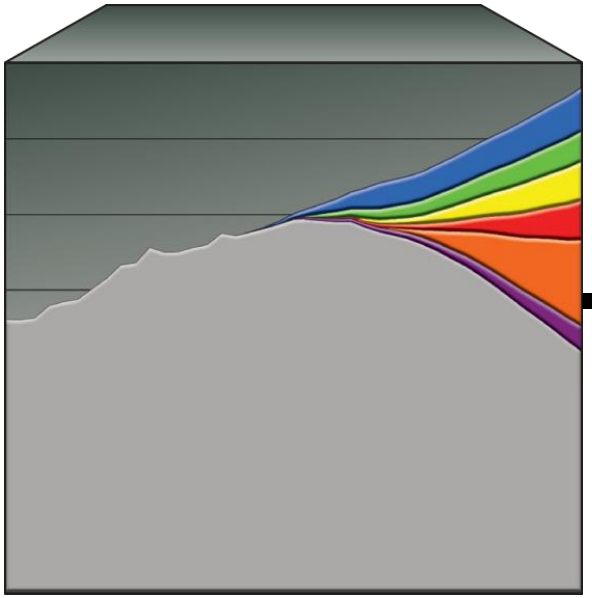
2008 EPRI Priority…Analysis to Action



Technology Challenges	*Demonstration Projects*
1. Enabling energy efficiency with efficient end-use technologies and smart grids	Hyper-efficient electric end-use technologies Smart grids
2. Enabling intermittent renewables with advanced transmission and energy storage	Compressed air energy storage
3. Deploying advanced light water reactors	PC with partial CCS Two alternate capture technologies
4. Deploying CCS by 2020	IGCC with partial CCS Lower-cost O_2 production

Electricity demand will grow…

- **EIA 2008 Annual Energy Outlook**
  - Preliminary report projects **1150** TWh (**30%**) increase in U.S. electricity consumption by 2030.
  - Greater than addition of new load equivalent to 2006 consumption of Texas, California, Florida, Ohio, Pennsylvania

~13 New York metro areas!

Challenges in End-Use Efficiency

Growth in Electronic Load

- Increase in electricity use by adding a 46” plasma and a set-top box: **~860 kWh/yr/household or 2.7% of US electricity Consumption**

Plasma TV (~300W),
Set-top Box (~30W)

- Increase in electricity use by adding one digital photo frame per household: **~Five 250MW generation plant**

Digital photo frame
(6W-15W)

By 2030 almost 30% of residential load will be “plug connected”
(DOE/EIA Annual Energy Outlook 2007)

Growth in Electronic Load

PLASMA TV

42”
250W

vs.

27”
100W

Consumes 2.5x more energy

SET TOP BOX

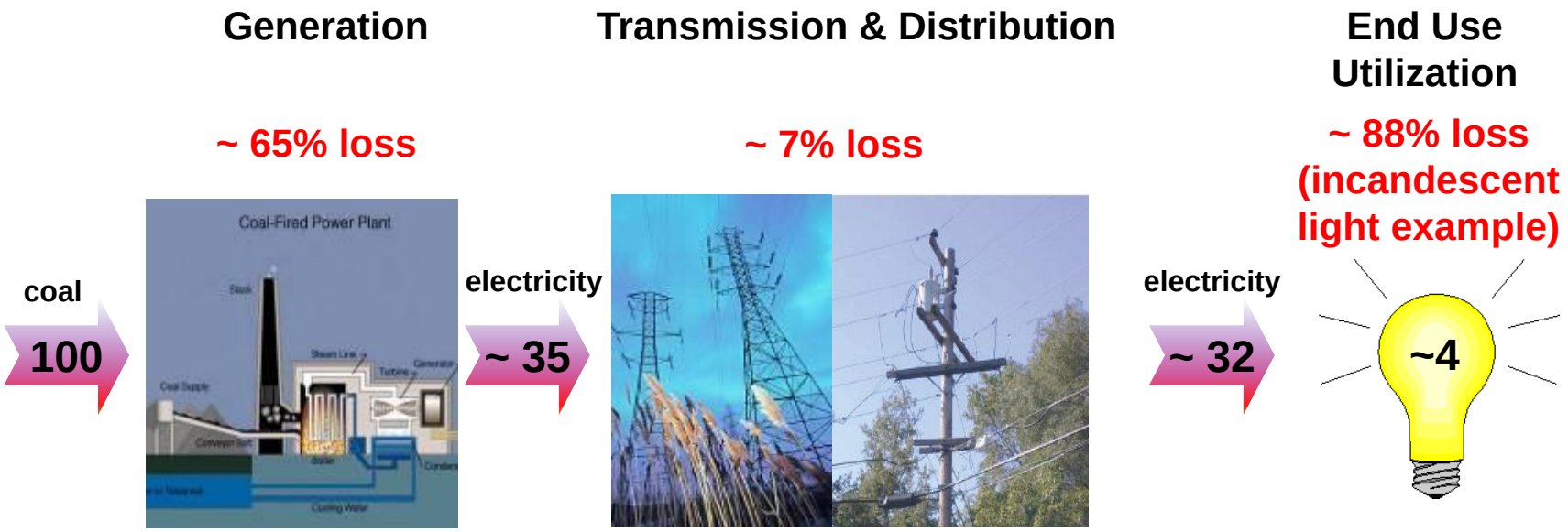
30W

30W

=

2 set top boxes consume as much energy in one year as a refrigerator

Opportunities for End Use Efficiency



Example of T&D Loss Reduction Measures

kWh saved by Reducing T&D Losses by 10% is Equivalent to the kWh generated by 11GW of wind capacity @ 25% capacity factor

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Opportunities for End Use Efficiency

CFL as an Example

Generation	Transmission & Distribution	End Use Utilization
~ 65% loss	~ 7% loss	50%-60% loss (CFL example)

coal **100** → 

→ electricity **~ 35** →  → electricity **~ 32** → 

Replacing all incandescent bulbs with CFLs in a US household: ~1200 kWh/yr/household or 3.7% of US electricity Consumption

Hyper-Efficient Technologies

Variable Refrigerant Flow Air Conditioning

Ductless Residential Heat Pumps and Air Conditioners

LED Street and Area Lighting

Heat Pump Water Heaters

Efficient Data Centers

Hyper-Efficient Residential Appliances

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Together...Shaping the Future of Electricity

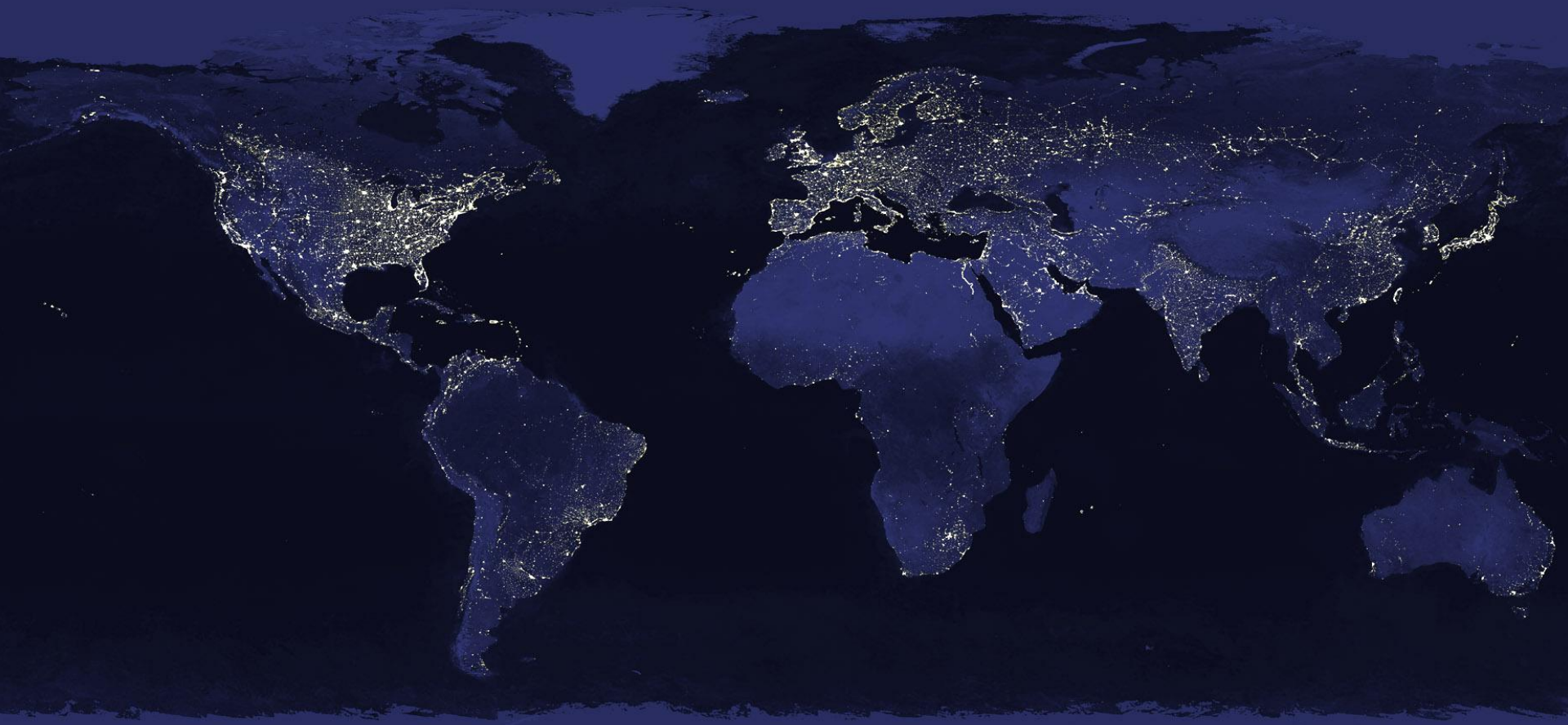

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Image courtesy of *NASA Visible Earth*