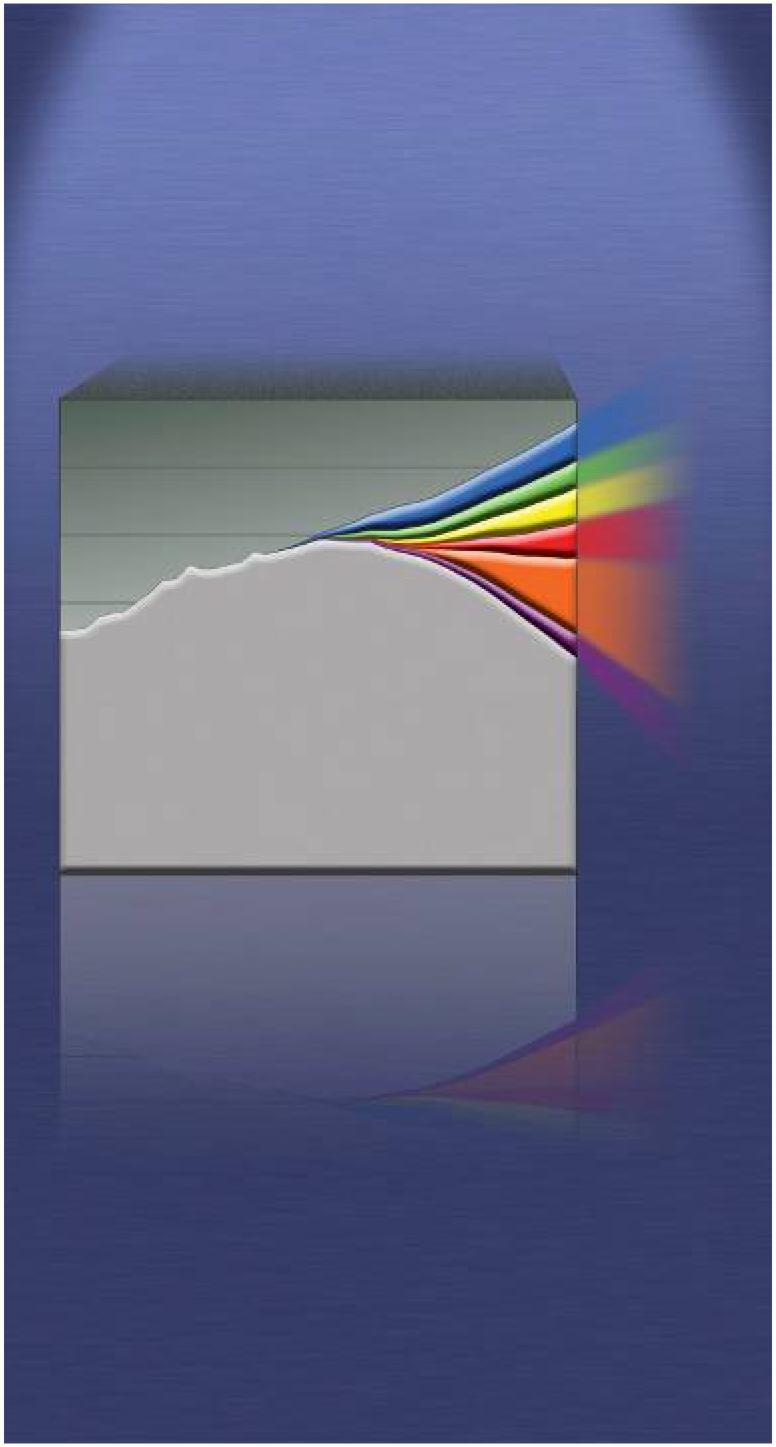

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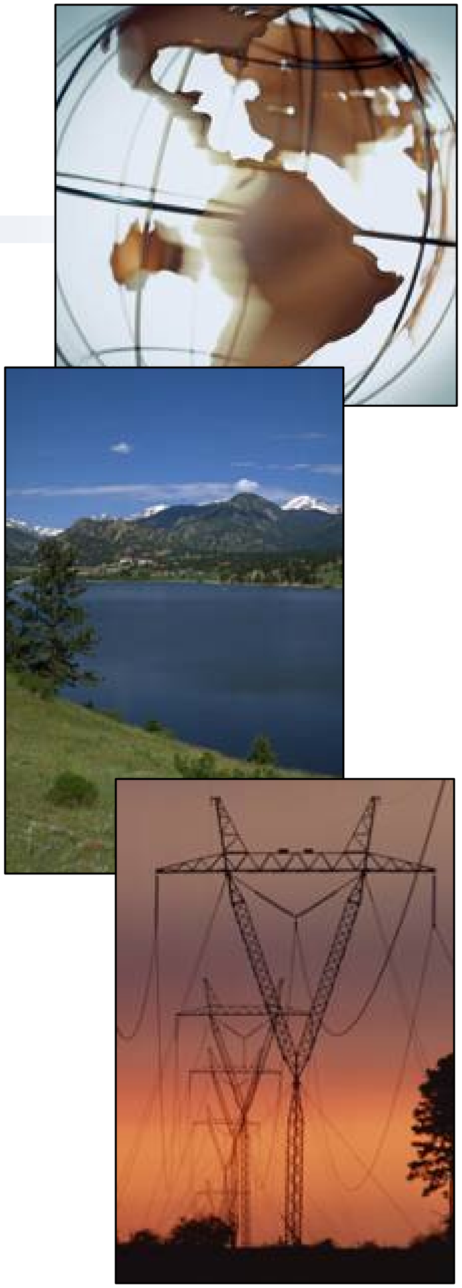
Electricity Technologies in a Carbon-Constrained World

North Carolina Legislative Commission
April 22, 2008

Bryan Hannegan
Vice President, Environment & Generation

About EPRI



Together…Shaping the Future of Electricity

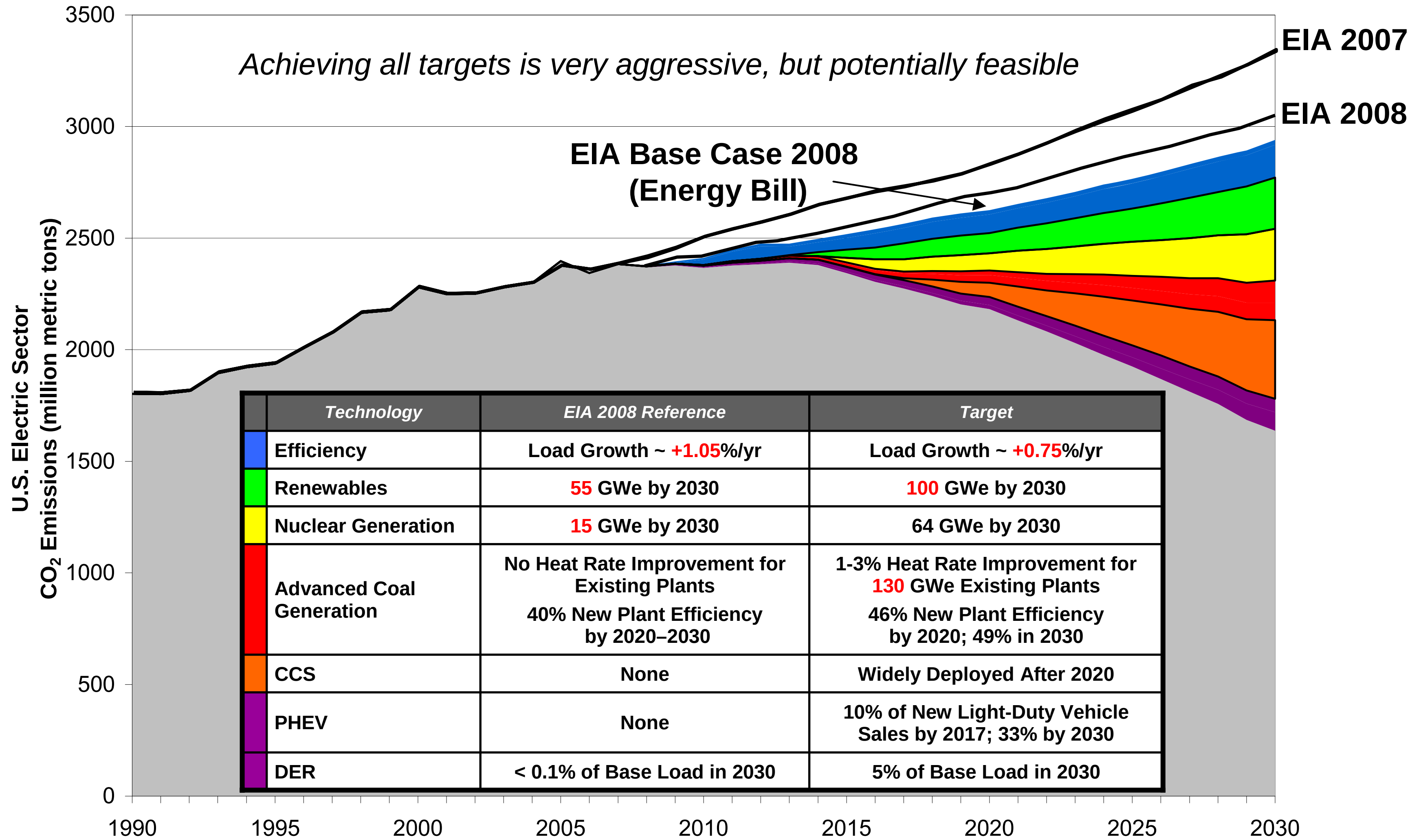
- Founded in 1973 as an independent, nonprofit center for public interest energy and environmental research.
- Objective, tax-exempt, collaborative electricity research organization
- Science and technology focus--development, integration, demonstration and applications
- Broad technology portfolio ranging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

Insights from Recent EPRI Work

- The technical potential exists for the U.S. electricity sector to significantly reduce its CO_2 emissions over the next several decades.
- No one technology will be a silver bullet – a portfolio of technologies will be needed.
- Much of the needed technology isn't available yet – substantial R&D, demonstration is required.
- A low-cost, low-carbon portfolio of electricity technologies can significantly reduce the costs of climate policy.
- Flexible, market-based climate policies offer significant economic advantage over sector-specific approaches

How is the electricity industry preparing for a carbon-constrained world?

Electric Sector CO_2 Reduction Potential



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

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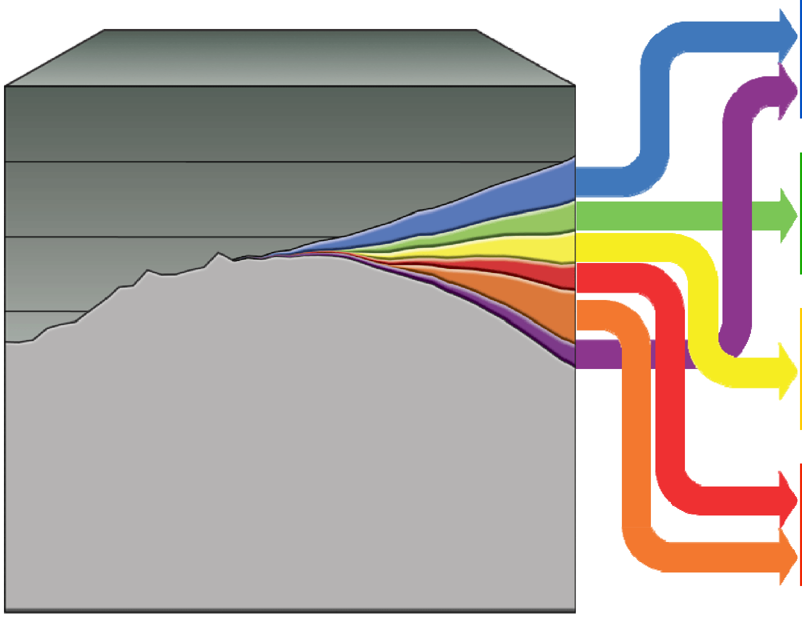
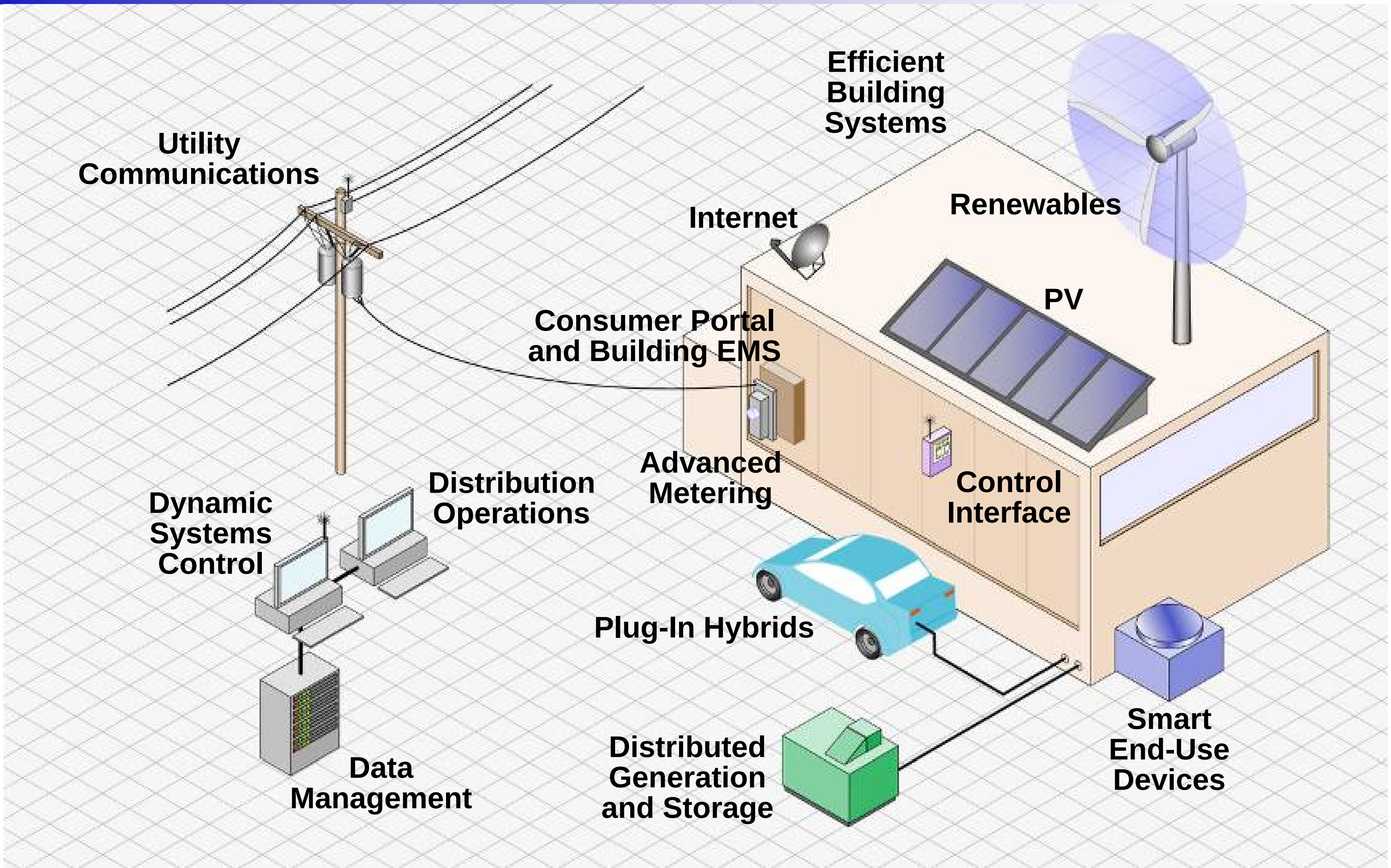
Key Technology Challenges



- ***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***

"Smart" Grid for Efficiency and Renewables

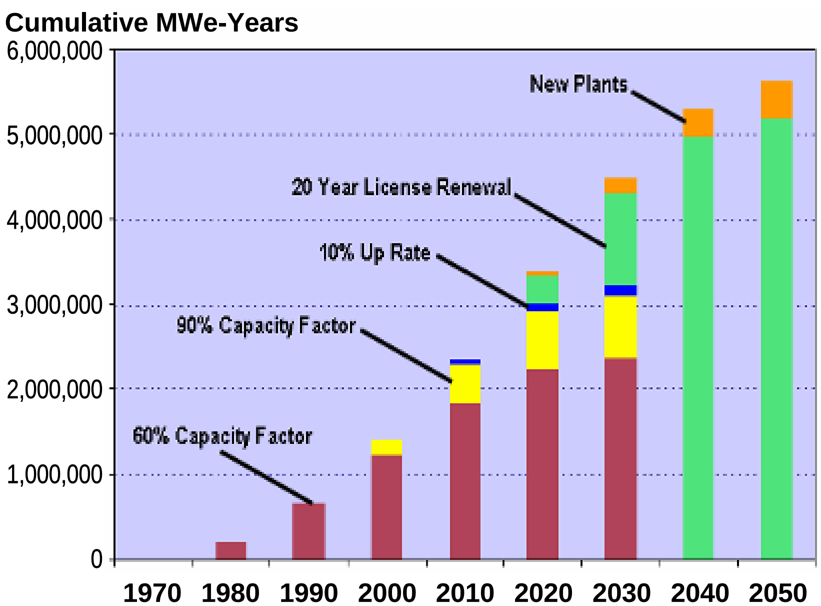


Nuclear Energy

Assumption and Necessity

- Sustained safe, reliable, economic operation
- Extended lifetimes – beyond 60 years
- Continued high capacity factors to end of life

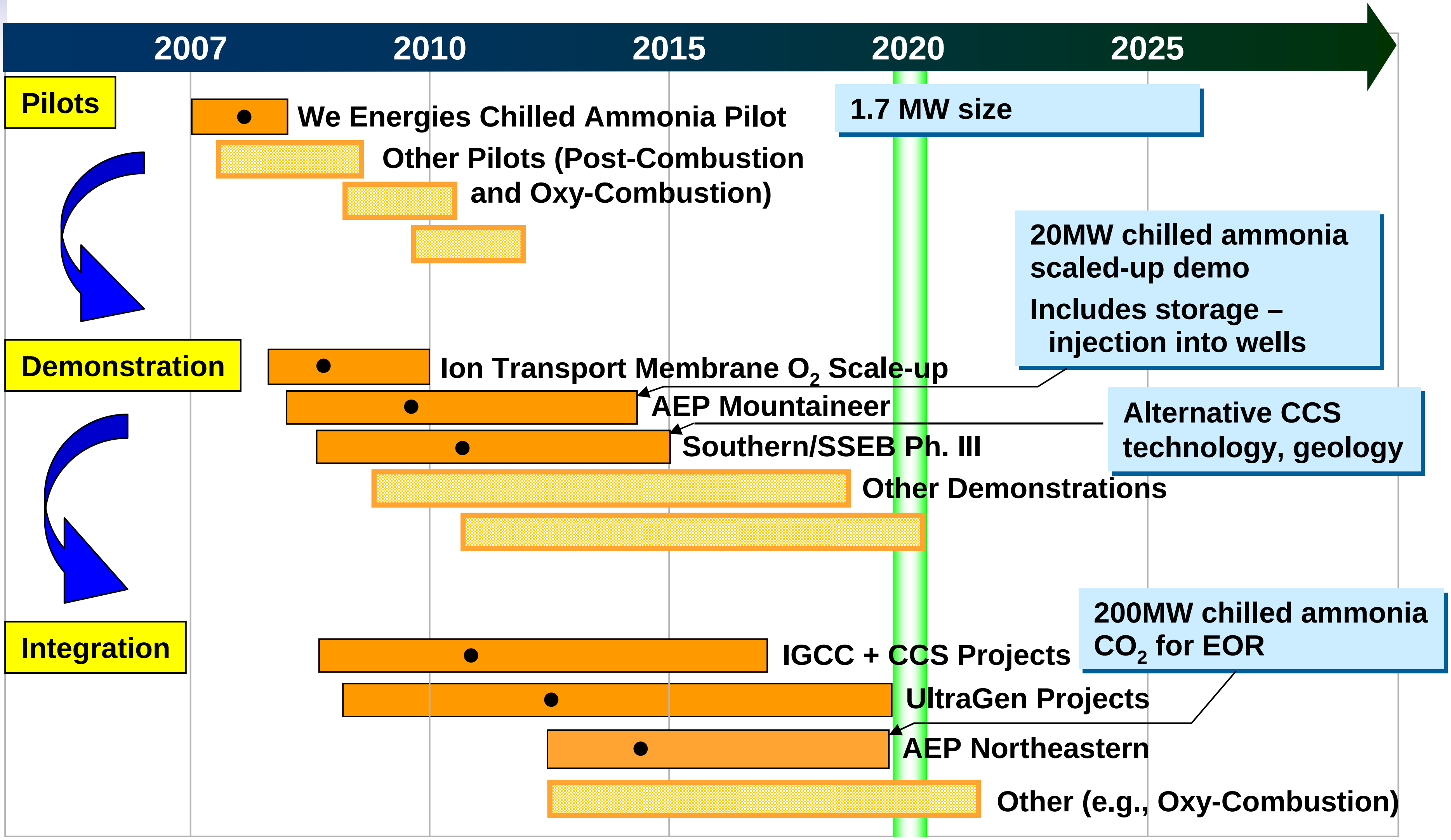
U.S. Nuclear Generation



Technological Advances Required

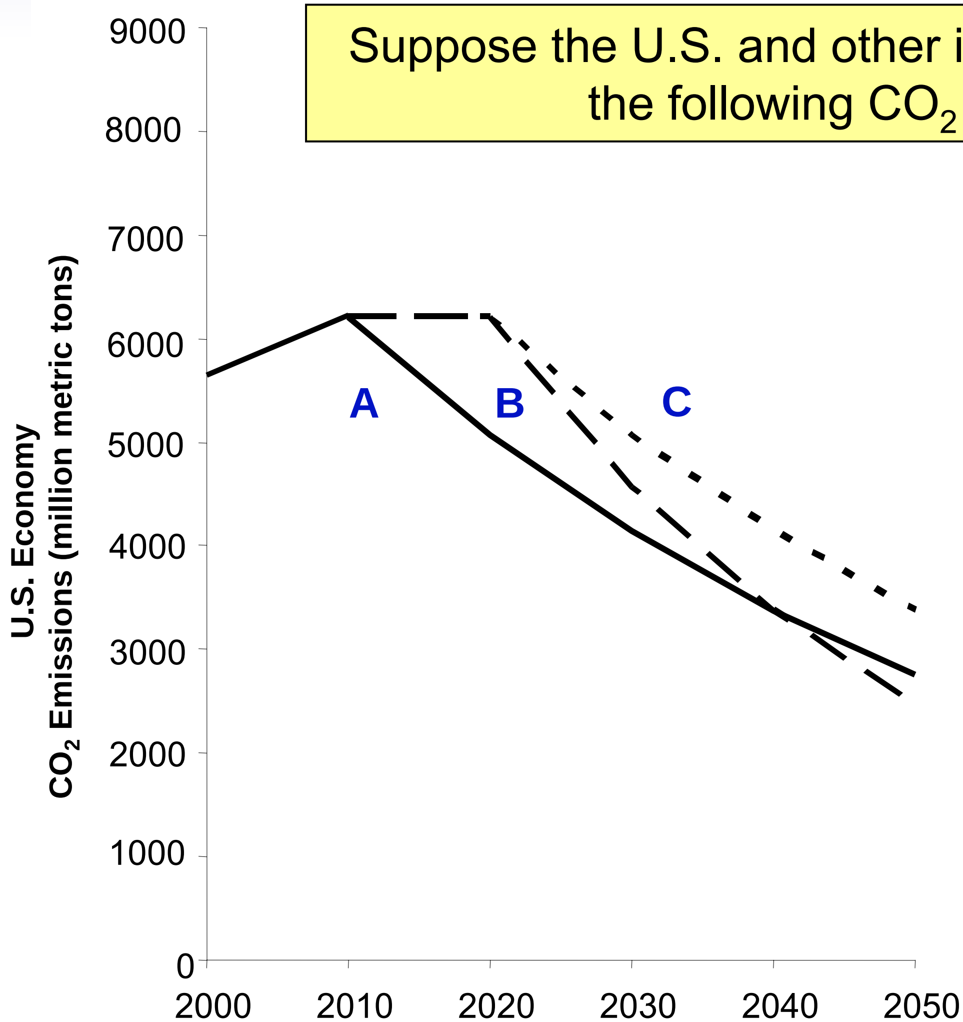
- Materials inspection, repair and replacement
- Prognostic technologies
- More extensive use of digital technology
- Cable diagnostics and alternative replacements
- Fuel performance

Coal with CO_2 Capture and Storage



How can advanced technology reduce the costs of climate policy?

Future CO_2 Emissions Scenarios



Suppose the U.S. and other industrialized nations adopt one of the following CO_2 emissions constraints:

Policy Scenario A:

- 2%/yr decline beginning in 2010

Policy Scenario B:

- Flat between 2010 - 2020
- 3%/yr decline beginning in 2020
- Results in "prism"-like CO_2 constraint on electric sector

Policy Scenario C:

- Flat between 2010 - 2020
- 2%/yr decline beginning in 2020

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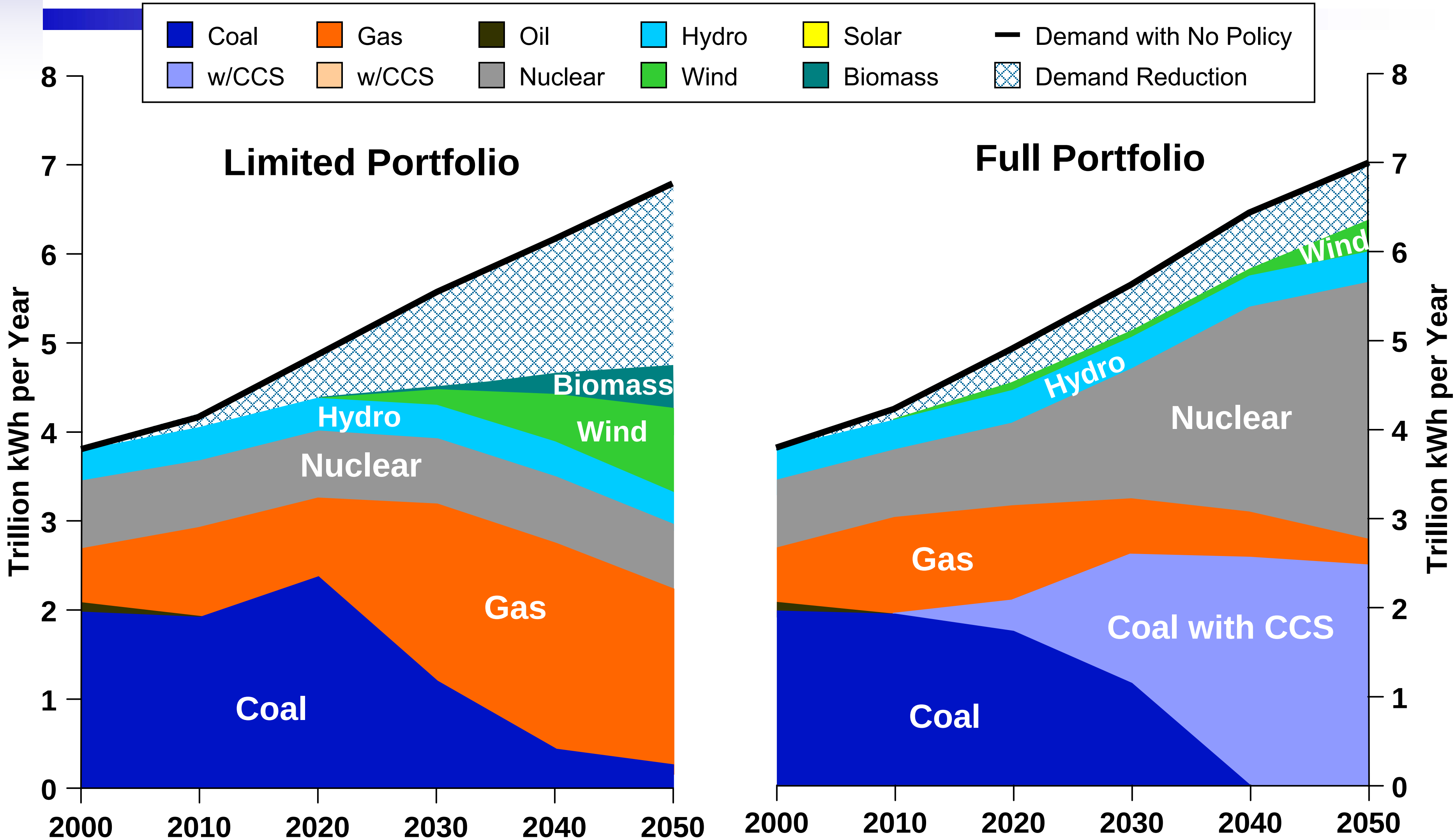
Electricity Technology Scenarios

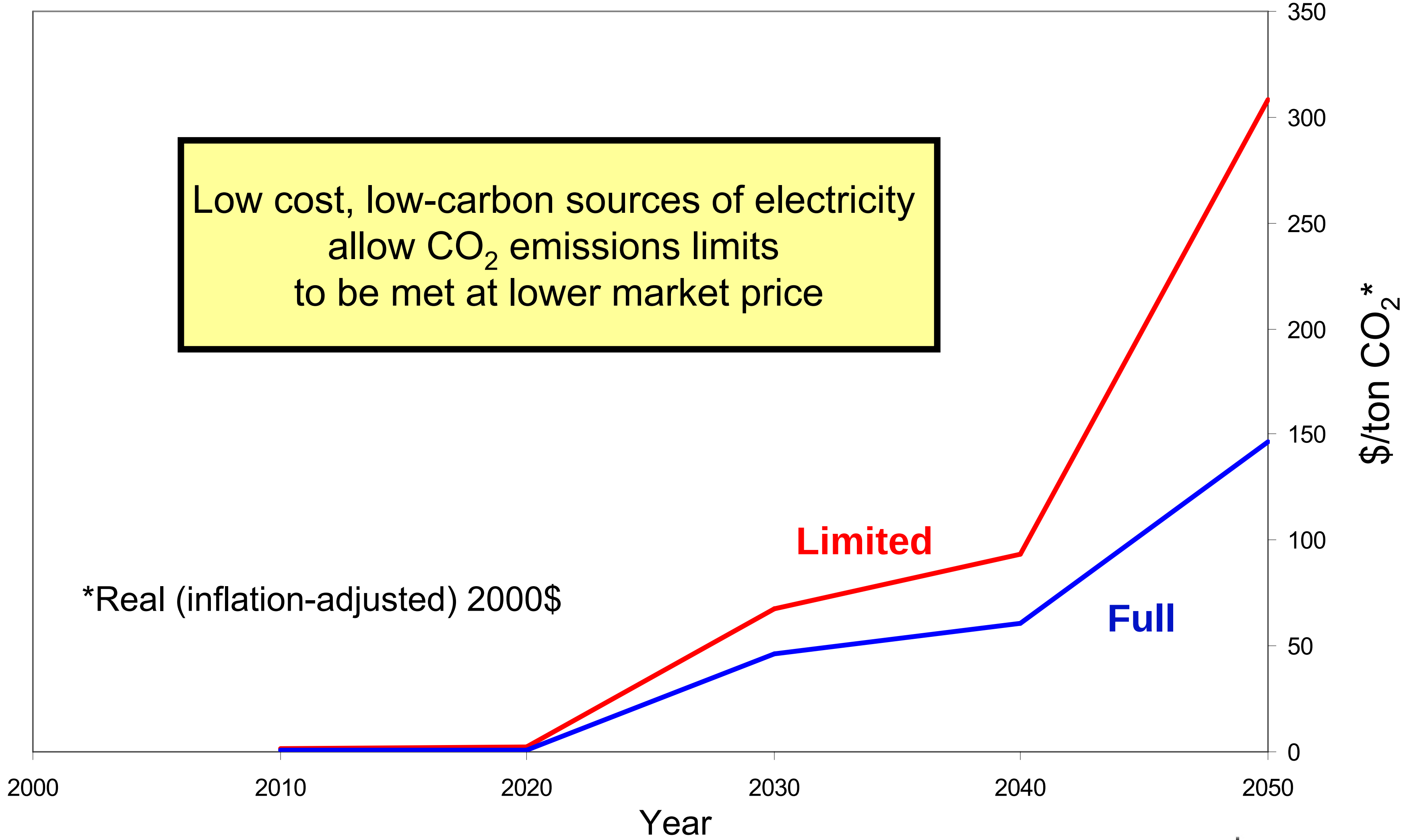
Supply-Side	Limited Portfolio	Full Portfolio
Carbon Capture and Storage (CCS)	Unavailable	Available
New Nuclear	Existing Production Levels ~100 GW	Production Can Expand
Renewables	Costs Decline	Costs Decline Further
New Coal and Gas	Improvements	Improvements

Demand-Side	Limited Portfolio	Full Portfolio
Plug-in Hybrid Electric Vehicles (PHEV)	Unavailable	Available
End-Use Efficiency	Improvements	Accelerated Improvements

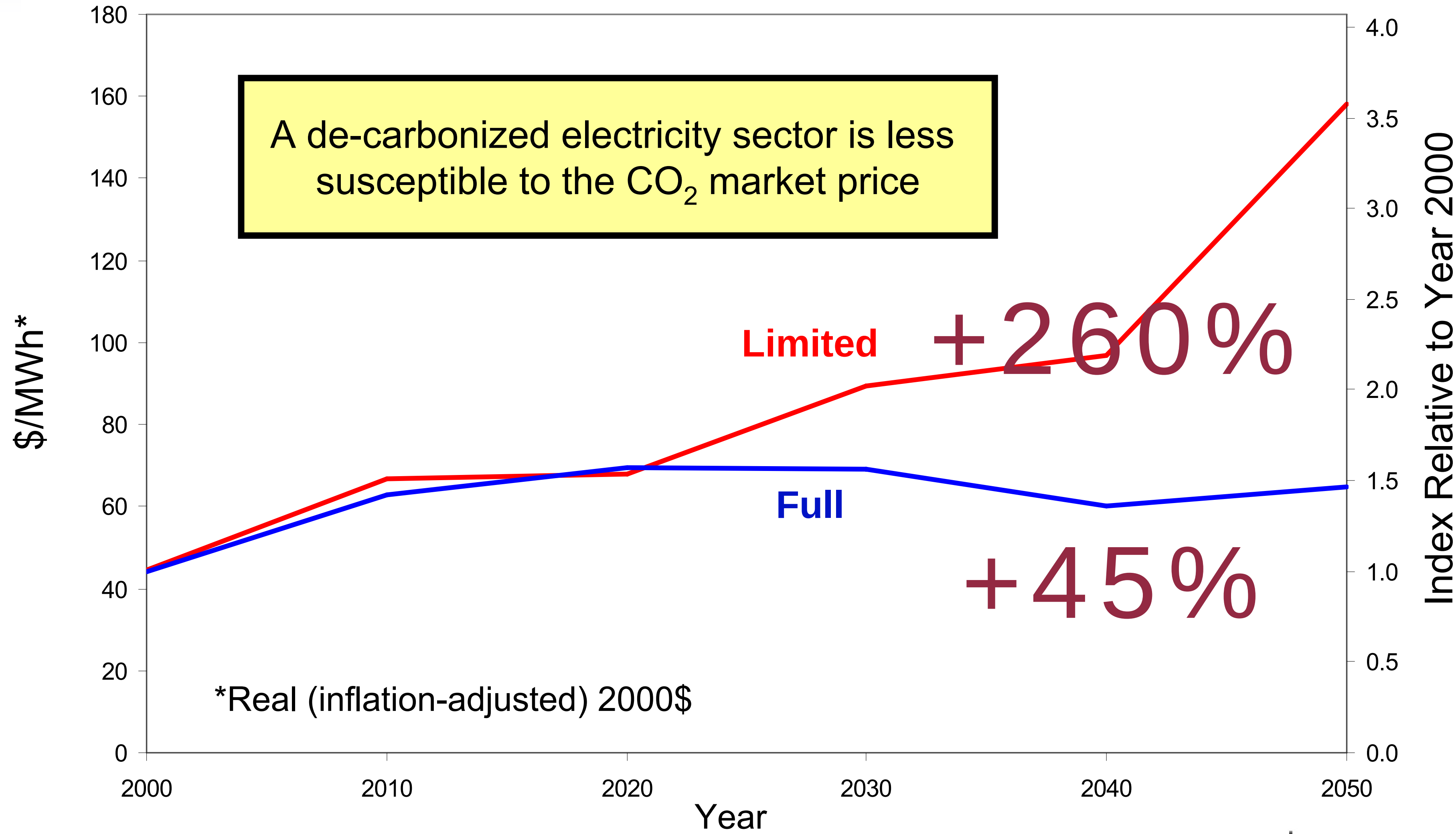
Impact on Future U.S. Electricity Mix



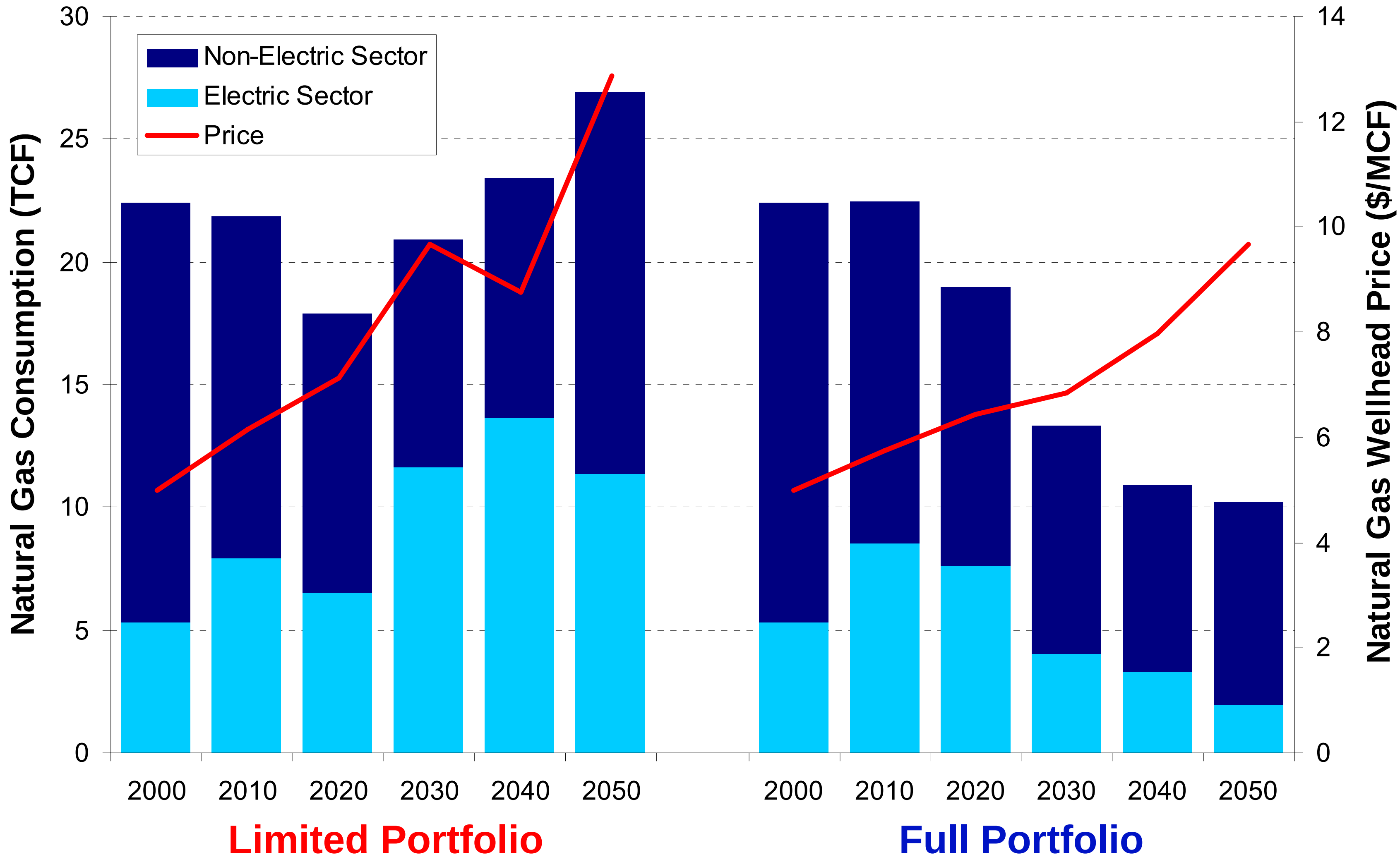
Impact on Carbon Prices



Impact on Wholesale Electricity Prices



Impact on Natural Gas Markets



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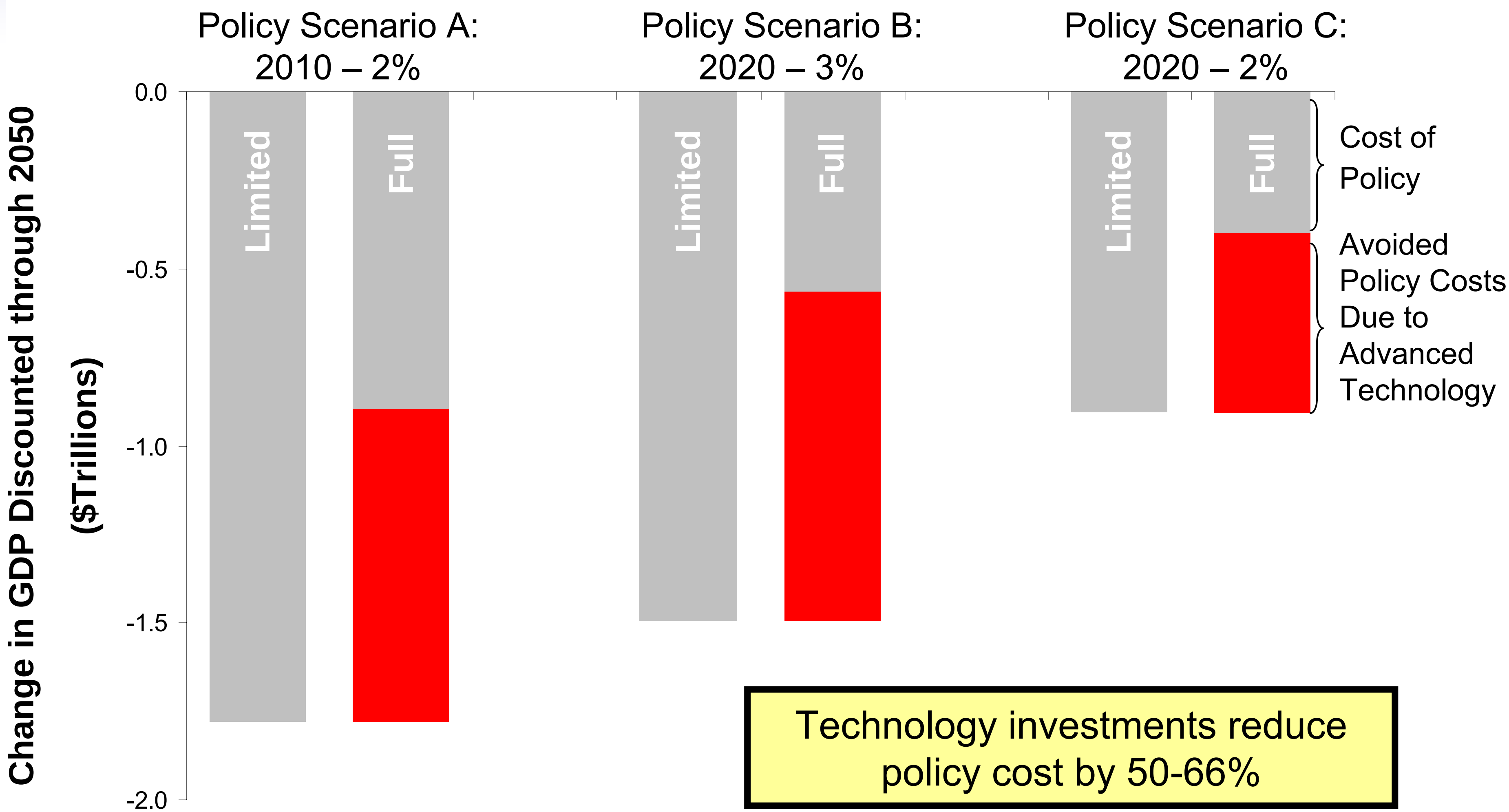
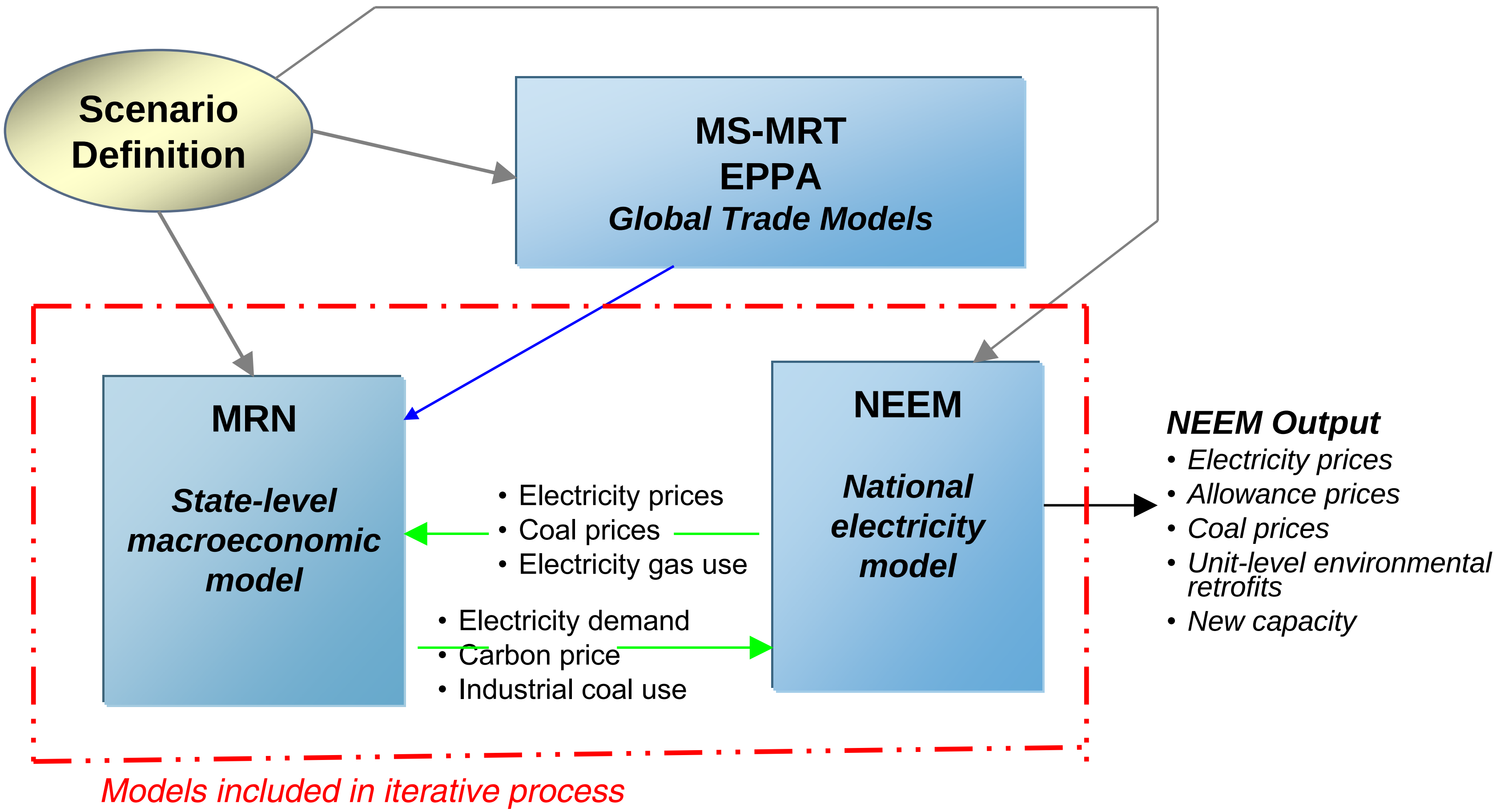
Impact on U.S. Economy



Technology investments reduce policy cost by 50-66%

How might the specific details of climate policy design make a difference?

EPRI/CRA Study of CA Climate Policy



California AB 32 Implementation Study

- **AB 32 sets emissions limit of 1990 levels by 2020; look at 20 different implementation scenarios, e.g.**
  - **Pure Trade –** Comprehensive cap-and-trade program with standard assumptions about technology, except no new nuclear and renewables-only imports
  - **LCA –**low-cost-assumptions: high end energy efficiency, lowest capital costs for renewables, rapid introduction rate of non-emitting transportation backstop, doubling DSM benefits of "DSM Benefit" case
  - **SV-LCA –** Same as Pure Trade but with price safety-valve set at CO_2 price in scenario with low-cost-assumptions (LCA)
  - **Trgt40 –** In 2050, achieve 40% emissions reduction below 1990 levels, with no new nuclear and renewables-only imports
  - **Trgt80 –** In 2050, achieve 80% emissions reduction below 1990 levels, with no new nuclear and renewables-only imports
  - **Nuclear80 –** Same as Trgt80, but allow unrestricted imports of nuclear
  - **RPS 20 –** Meet State Renewable Portfolio Standard (RPS) of 20% renewable energy by 2020, but don't impose an overall emissions cap

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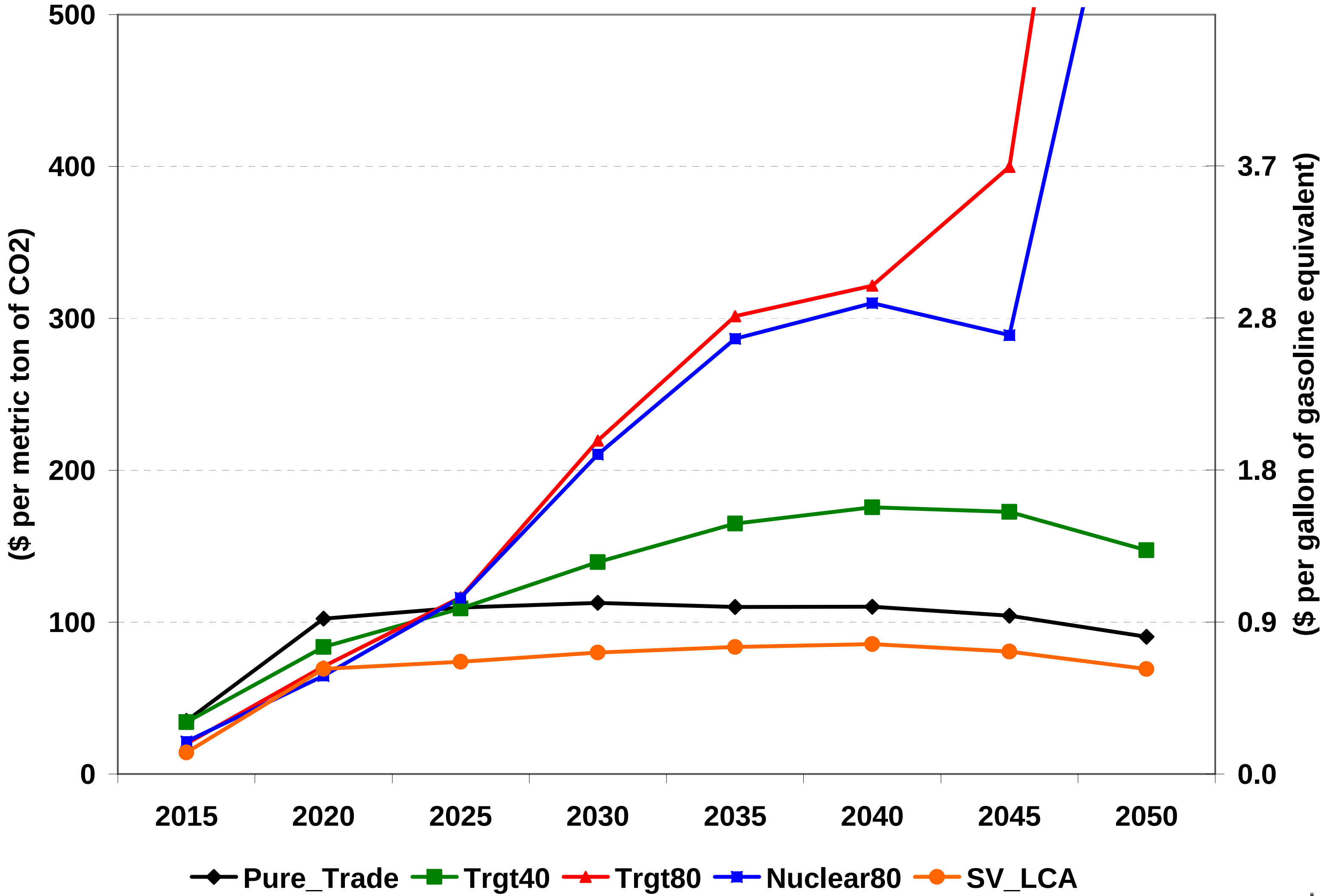
California CO_2 Permit Prices



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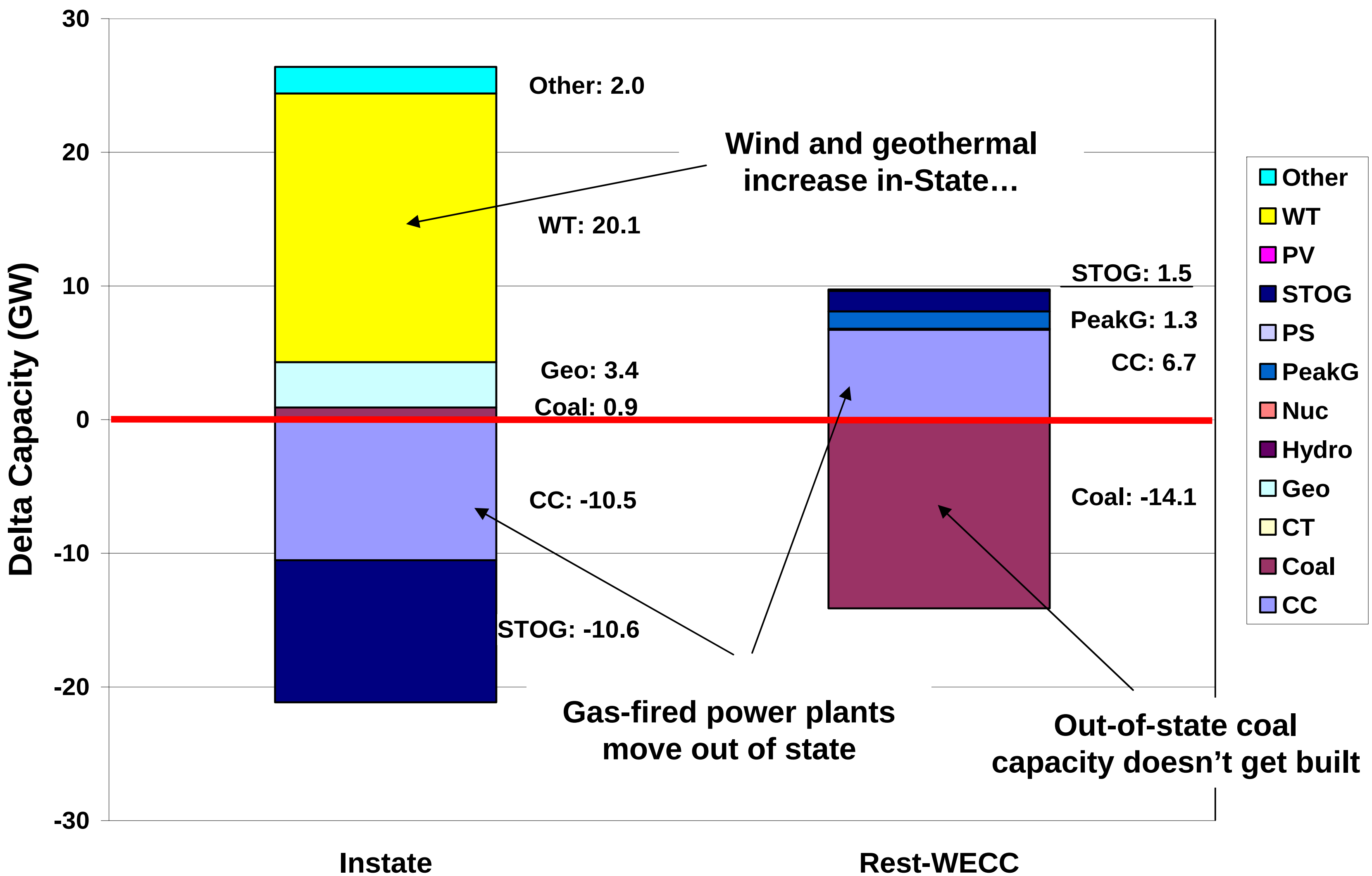
Regional Generation Mix Changes



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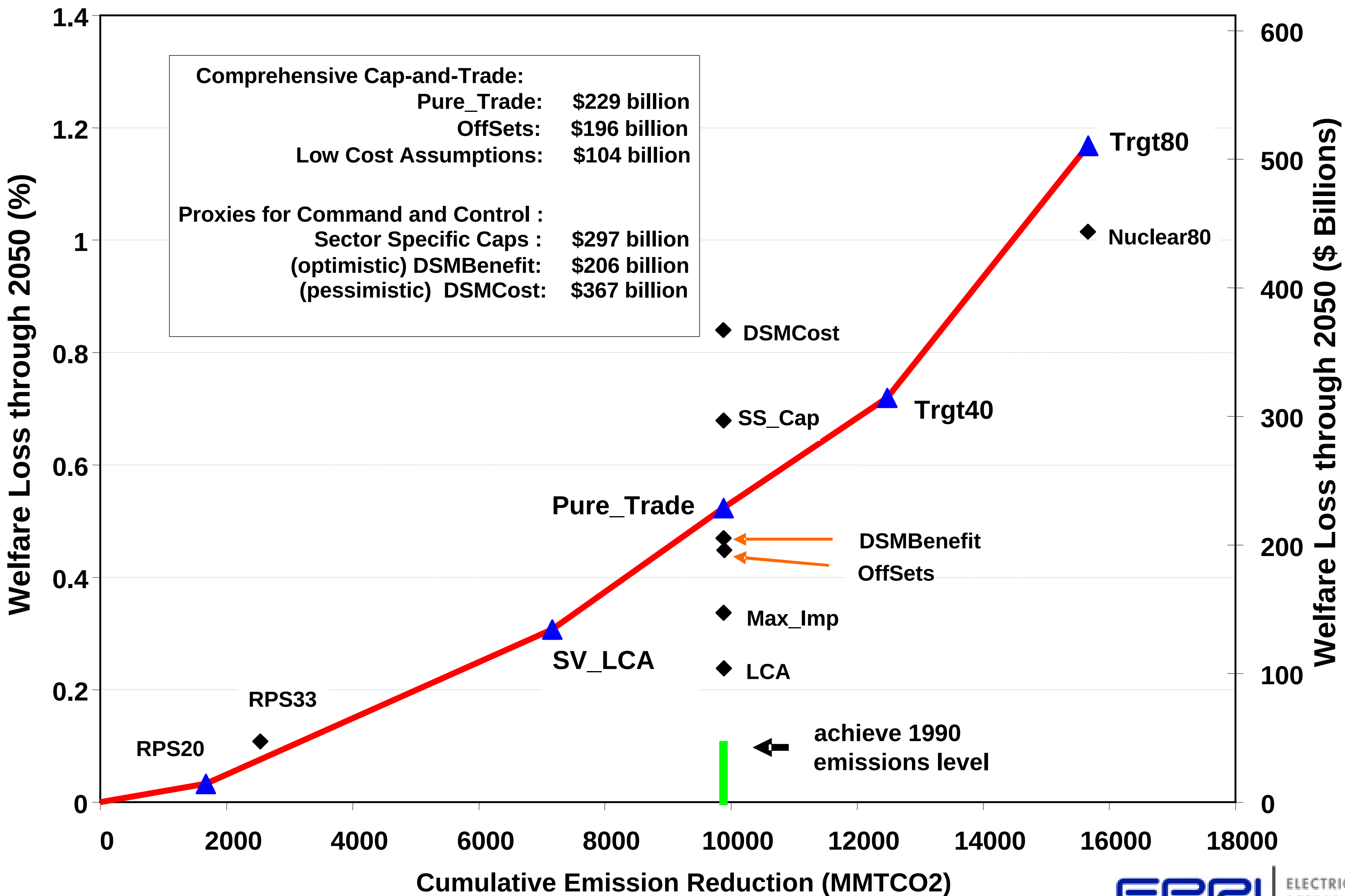
Economic Costs to California Economy



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Implementation Details Make a Difference

All potential scenarios show real economic costs to state

- Costs ranged from -0.24% to -1.17% through 2050

Broad, market-based cap-and-trade policies are most cost-effective

- Command-and-control or sector-specific caps are more costly
- Allowance price "safety valve" would limit costs, but limit CO_2 reduced

Electric sector plays a pivotal role in achieving CO_2 targets

- Changes in power imports, in-state generation mix result
- Electrification of other sectors enables them to meet their CO_2 goals
- Cost estimates do not include "system stability" costs

Several elements of State policy need careful examination

- CAT estimates of in-state forestry offsets → $33 billion savings
- Stronger rules to prevent "leakage" would drive up costs

Insights from Recent EPRI Work

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- No one technology will be a silver bullet – a portfolio of technologies will be needed.
- Much of the needed technology isn't available yet – substantial R&D, demonstration is required.
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- Flexible, market-based climate policies offer significant economic advantage over sector-specific approaches

Implications for State Policy Design

1. You get what you pay for; higher cuts = higher costs
   – Non-emitting sources of energy by definition more expensive

2. Traditional regulatory approach unlikely to be effective by itself
   – Not “end-of-pipe”; requires transformation of energy system
   – Not short-term, specific; is long-term (100 yrs), global, economy-wide

3. Timing of low-carbon technology availability is a key cost driver
   – Necessary technologies are NOT at hand, <u>if you care about cost</u>
   – Need full range of “market pull” and “technology push” activities

4. Electric sector plays primary role in broader de-carbonization
   – Provides low-cost, low-carbon fuel to replace direct fossil use
   – Can be inhibited by sector-specific approaches

5. States alone cannot drive climate change policy
   – Linkage to national, international policies must be kept in mind

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