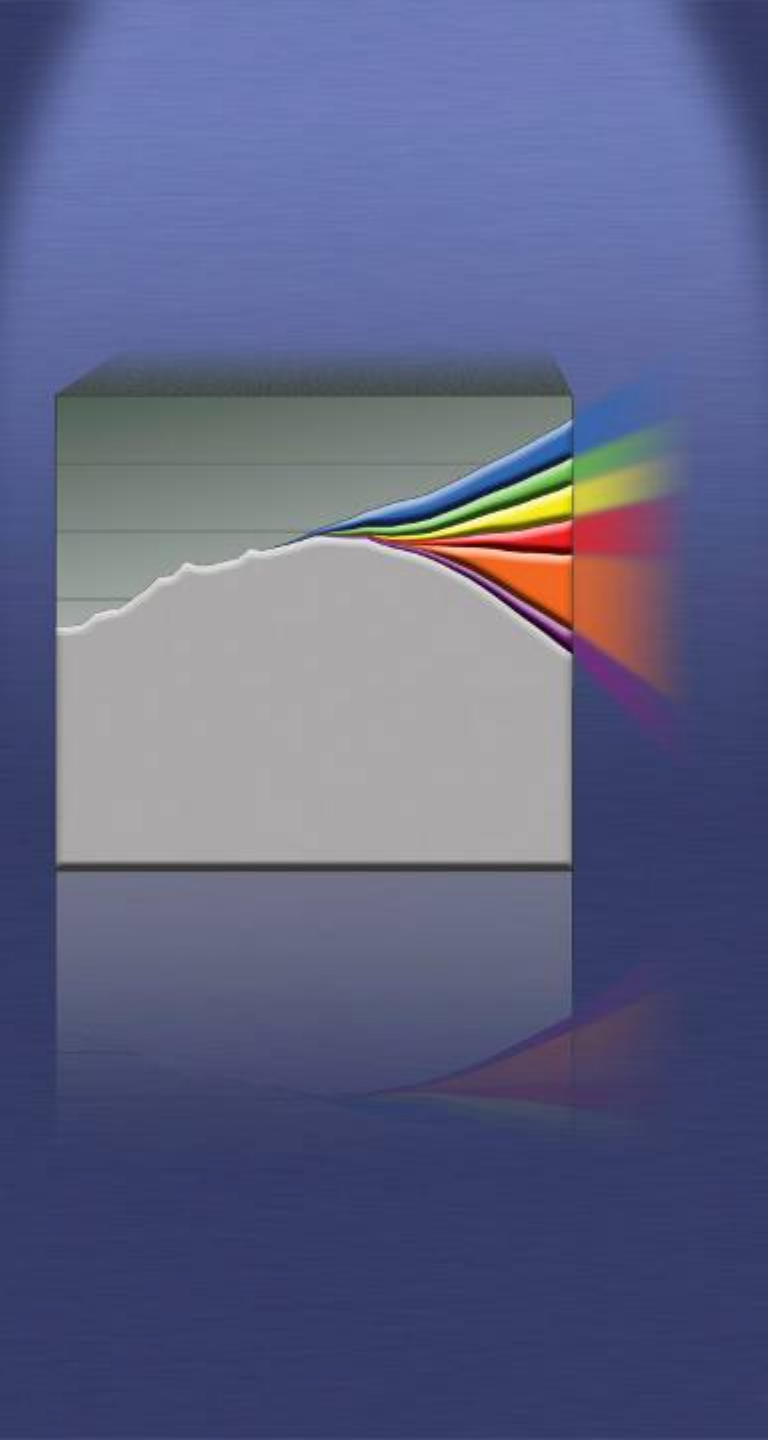

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Electricity Technologies in a Carbon-Constrained World

Ronald E. Wyzga, Sc.D

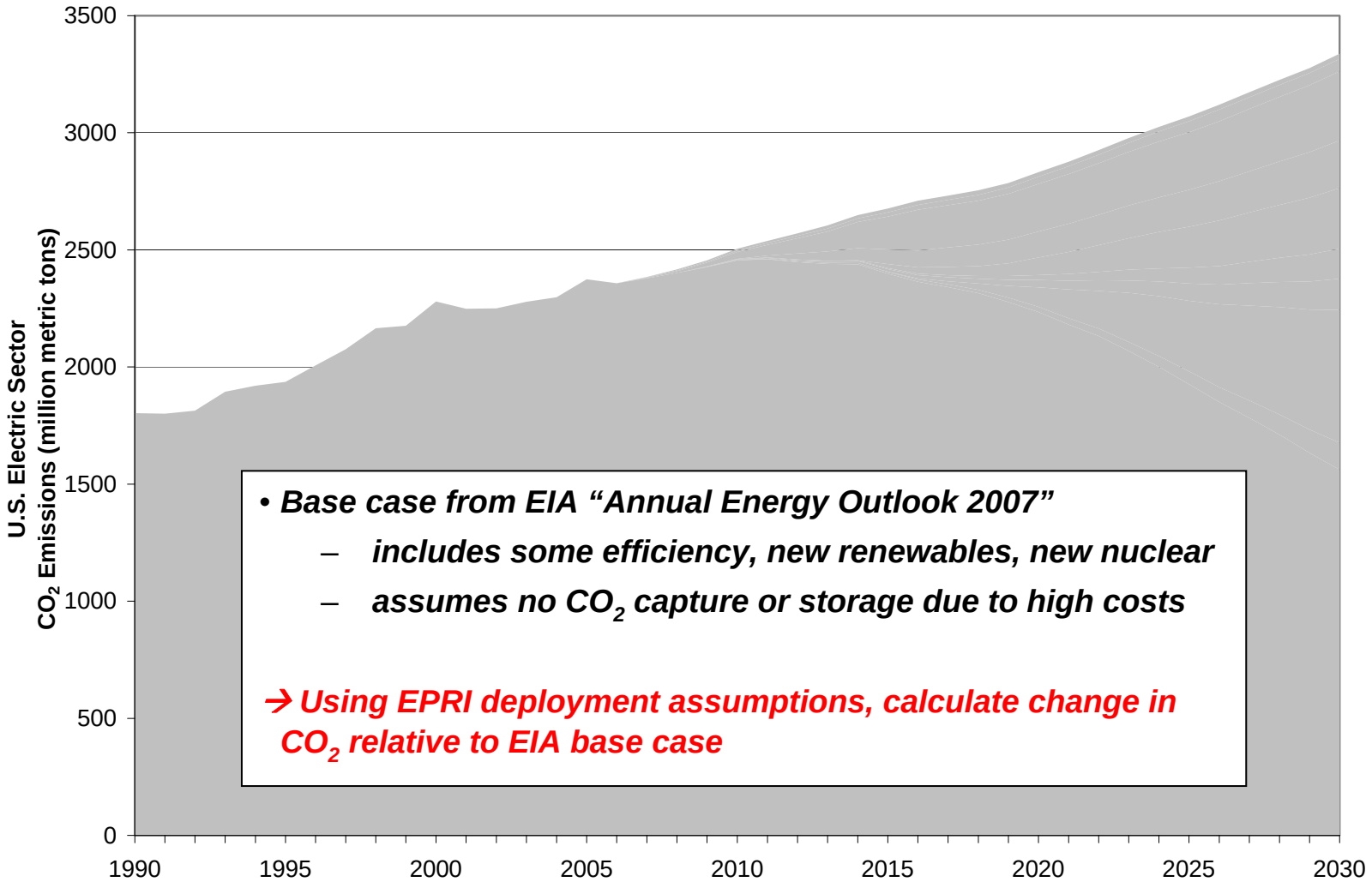
Sr. Technical Executive, EPRI

Presented to NYSERDA

November 15, 2007

With accelerated deployment of advanced electricity technologies, how quickly could the U.S. electric sector cut its CO_2 emissions?

U.S. Electricity Sector CO_2 Emissions

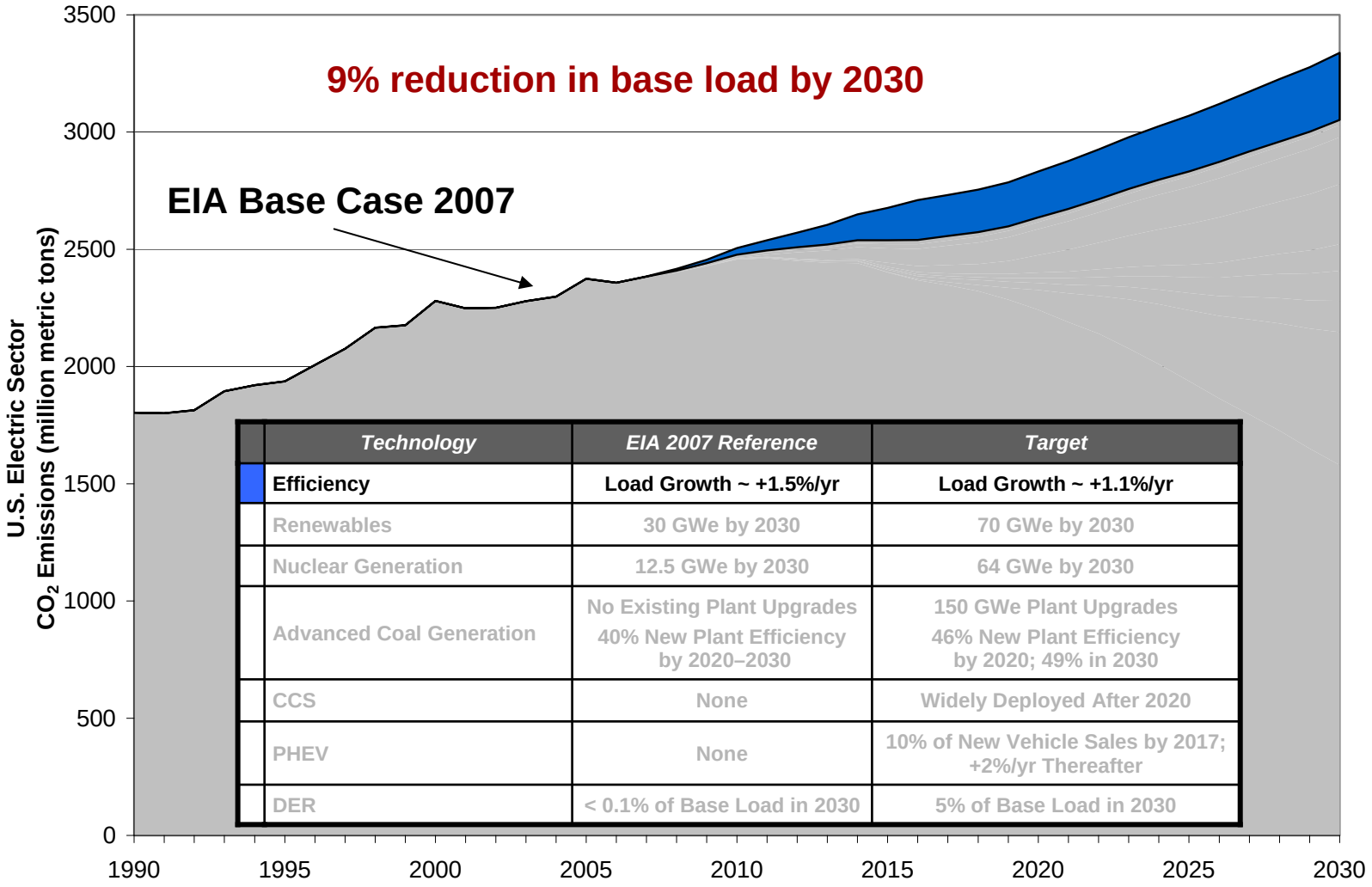


Technology Deployment Targets

Technology	*EIA 2007 Base Case*	*EPRI Analysis Target**
Efficiency	**Load Growth ~ +1.5%/yr**	**Load Growth ~ +1.1%/yr**
Renewables	**30 GWe by 2030**	**70 GWe by 2030**
Nuclear Generation	**12.5 GWe by 2030**	**64 GWe by 2030**
Advanced Coal Generation	**No Existing Plant Upgrades** **40% New Plant Efficiency by 2020–2030**	**150 GWe Plant Upgrades** **46% New Plant Efficiency by 2020; 49% in 2030**
Carbon Capture and Storage (CCS)	**None**	**Widely Available and Deployed After 2020**
Plug-in Hybrid Electric Vehicles (PHEV)	**None**	**10% of New Vehicle Sales by 2017; +2%/yr Thereafter**
Distributed Energy Resources (DER) ***(including distributed solar)***	**< 0.1% of Base Load in 2030**	**5% of Base Load in 2030**

EPRI analysis targets do not reflect economic considerations, or potential regulatory and siting constraints.

Benefit of Achieving Efficiency Target



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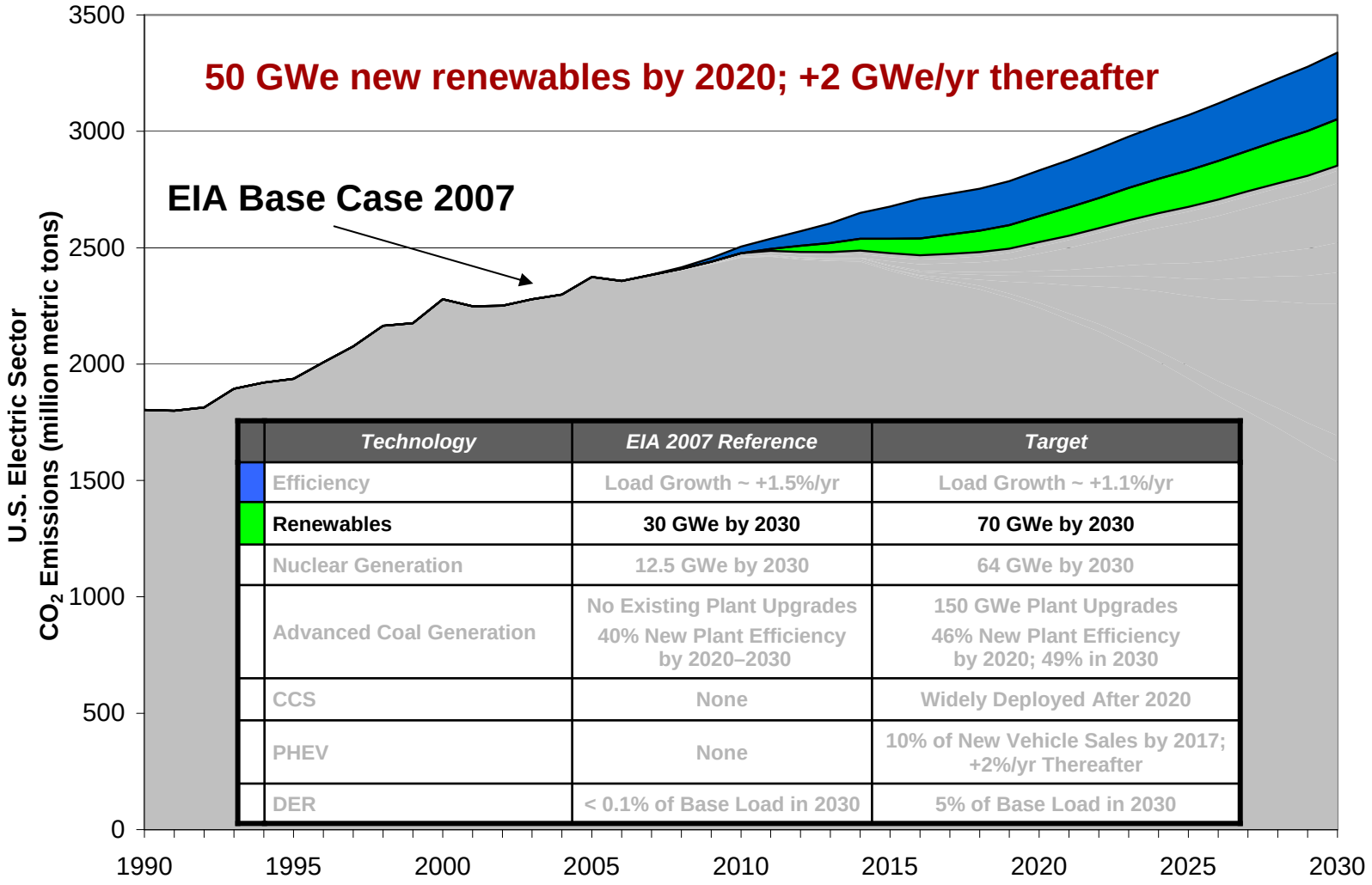
Benefit of Achieving Renewables Target



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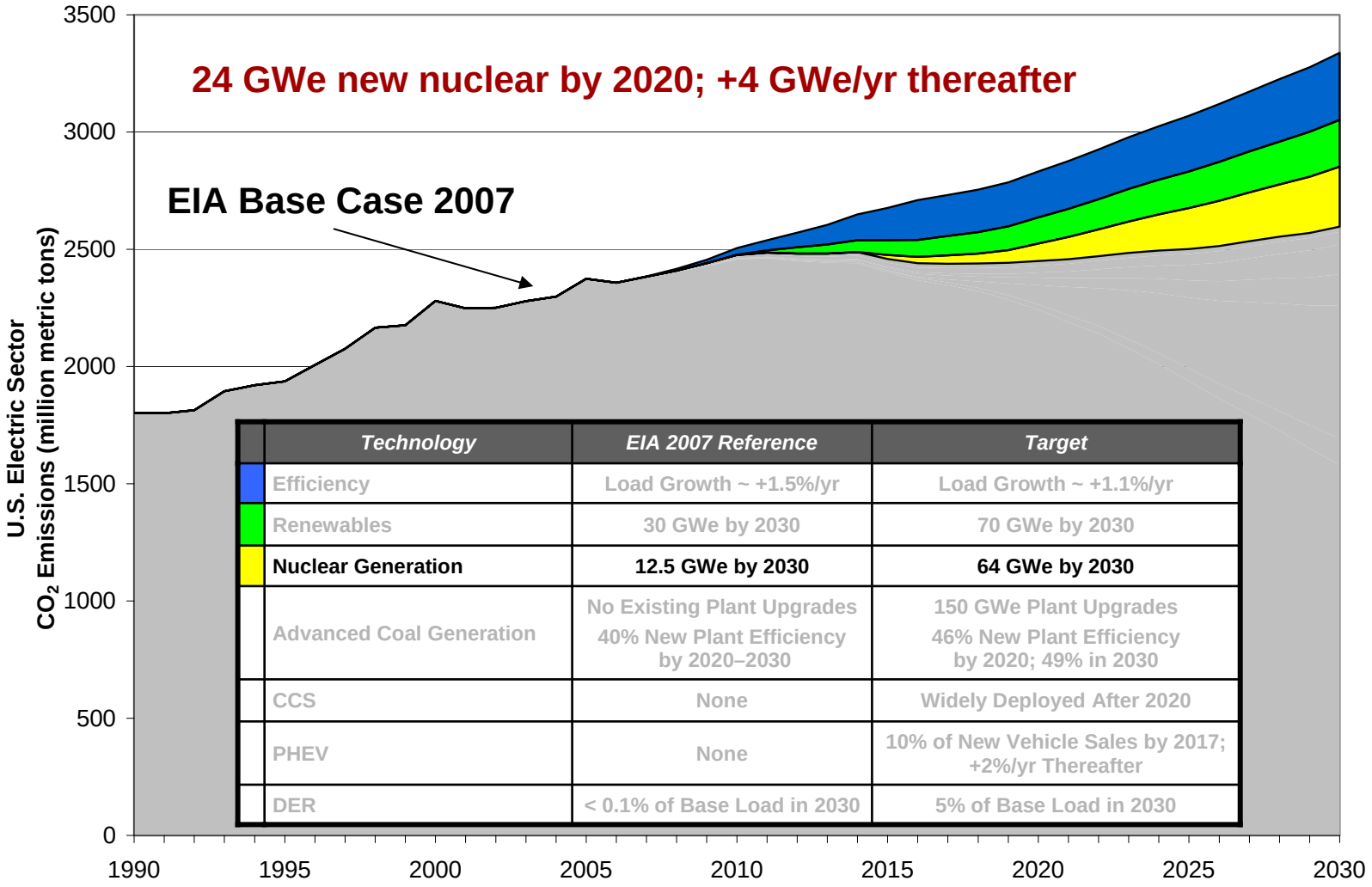
Benefit of Achieving Nuclear Generation Target



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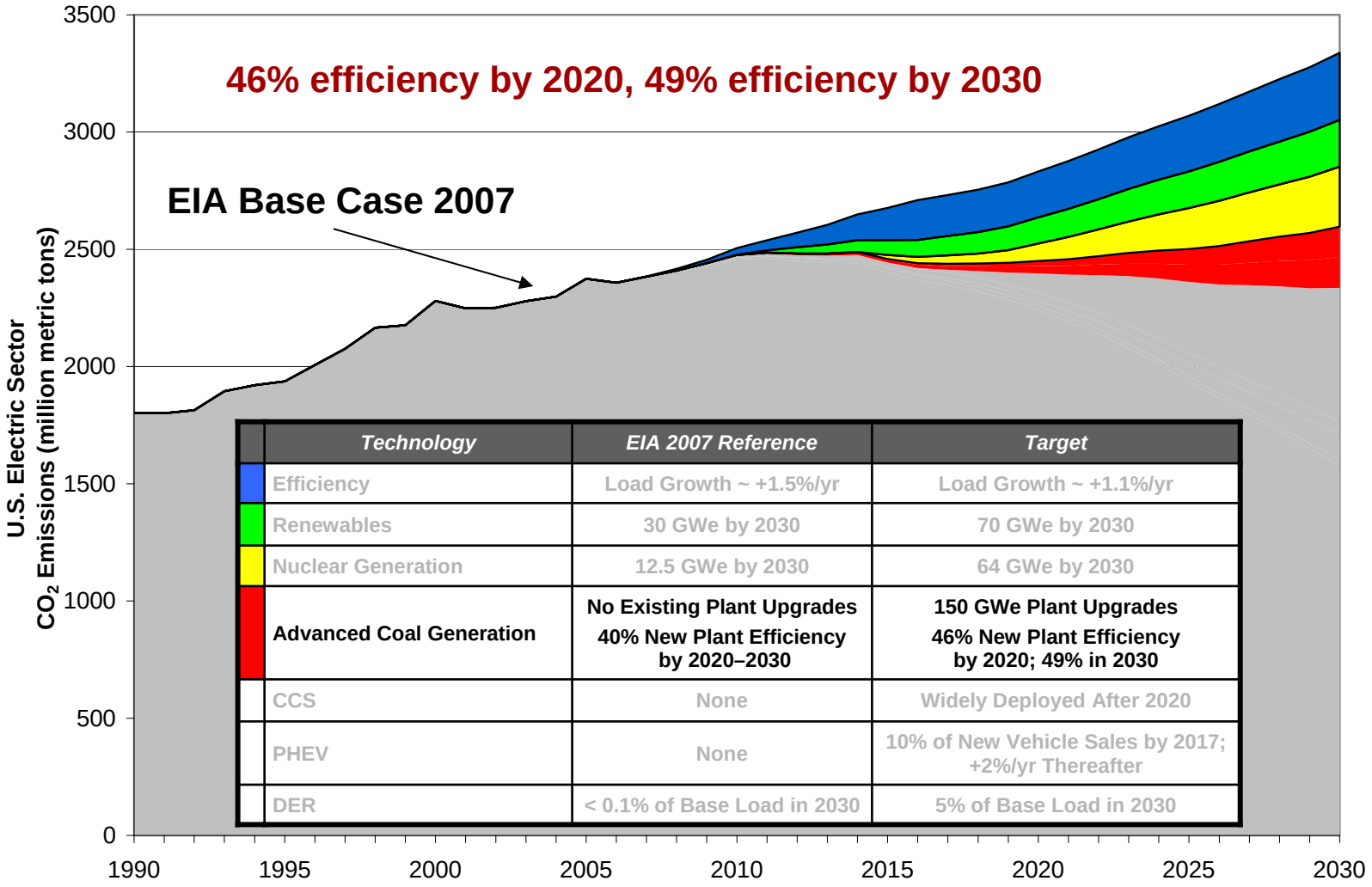
Benefit of Achieving Advanced Coal Target



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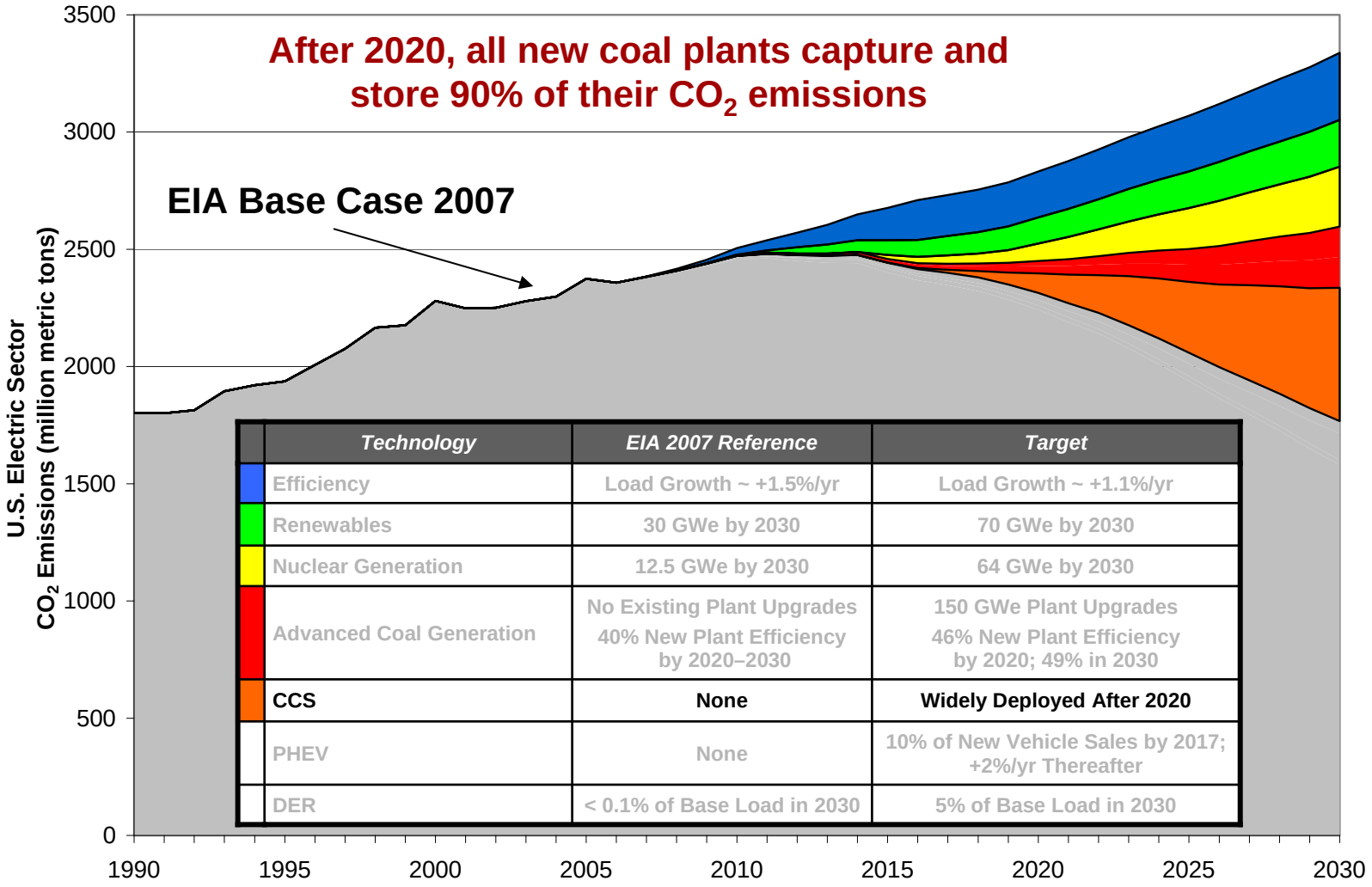
Benefit of Achieving CCS Target



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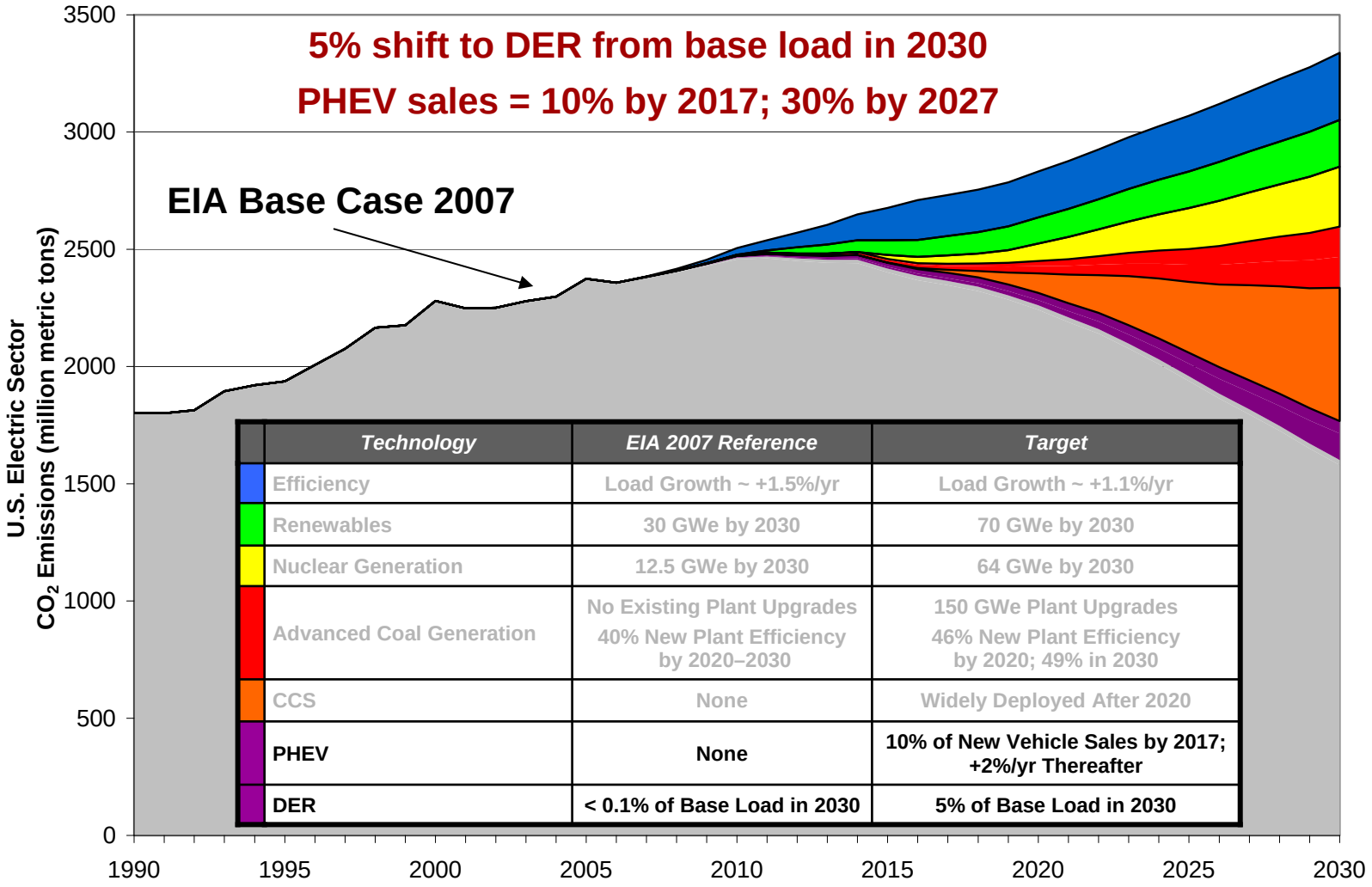
Benefit of Achieving PHEV and DER Targets



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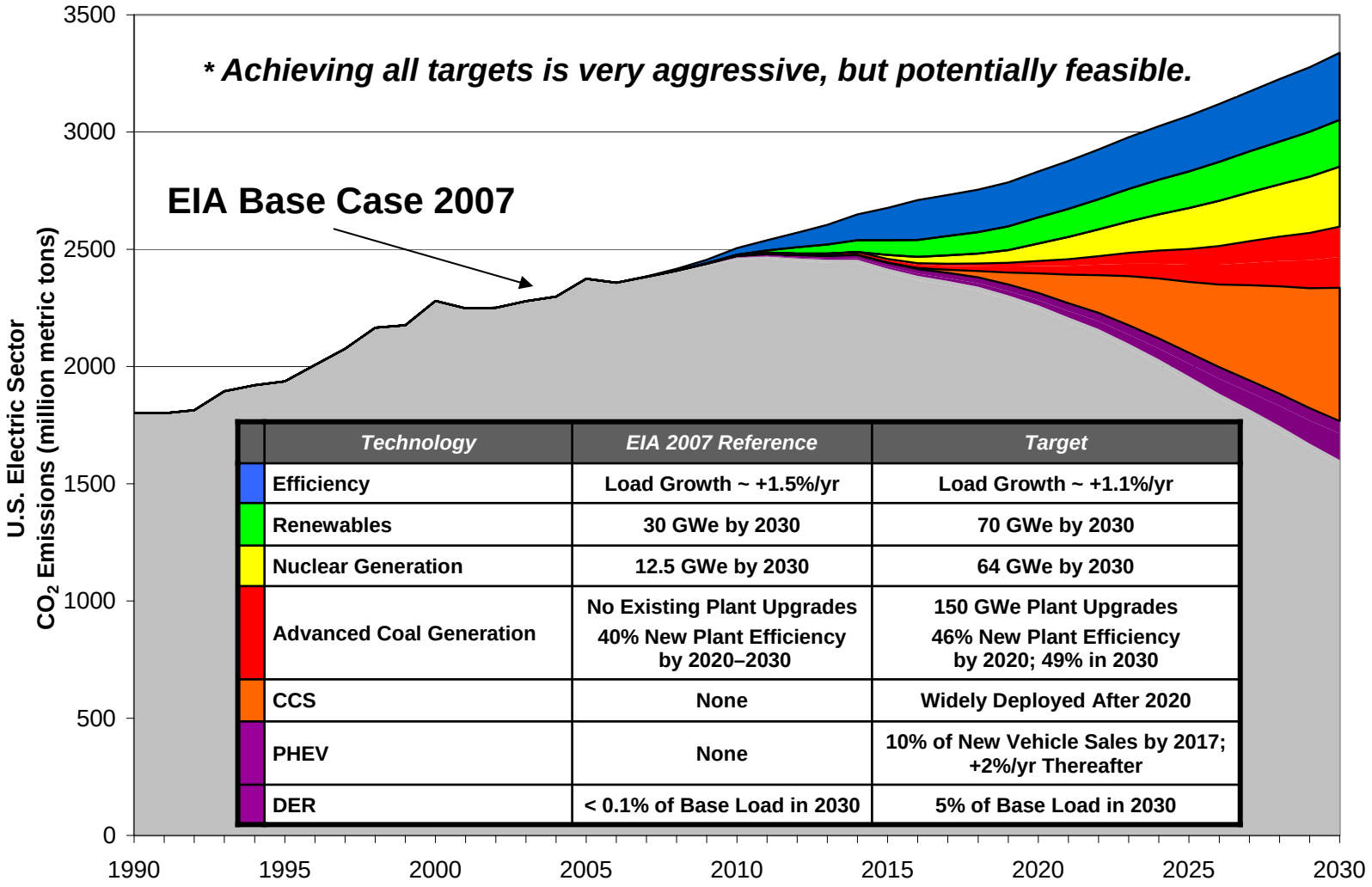
Electric Sector CO_2 Reduction Potential



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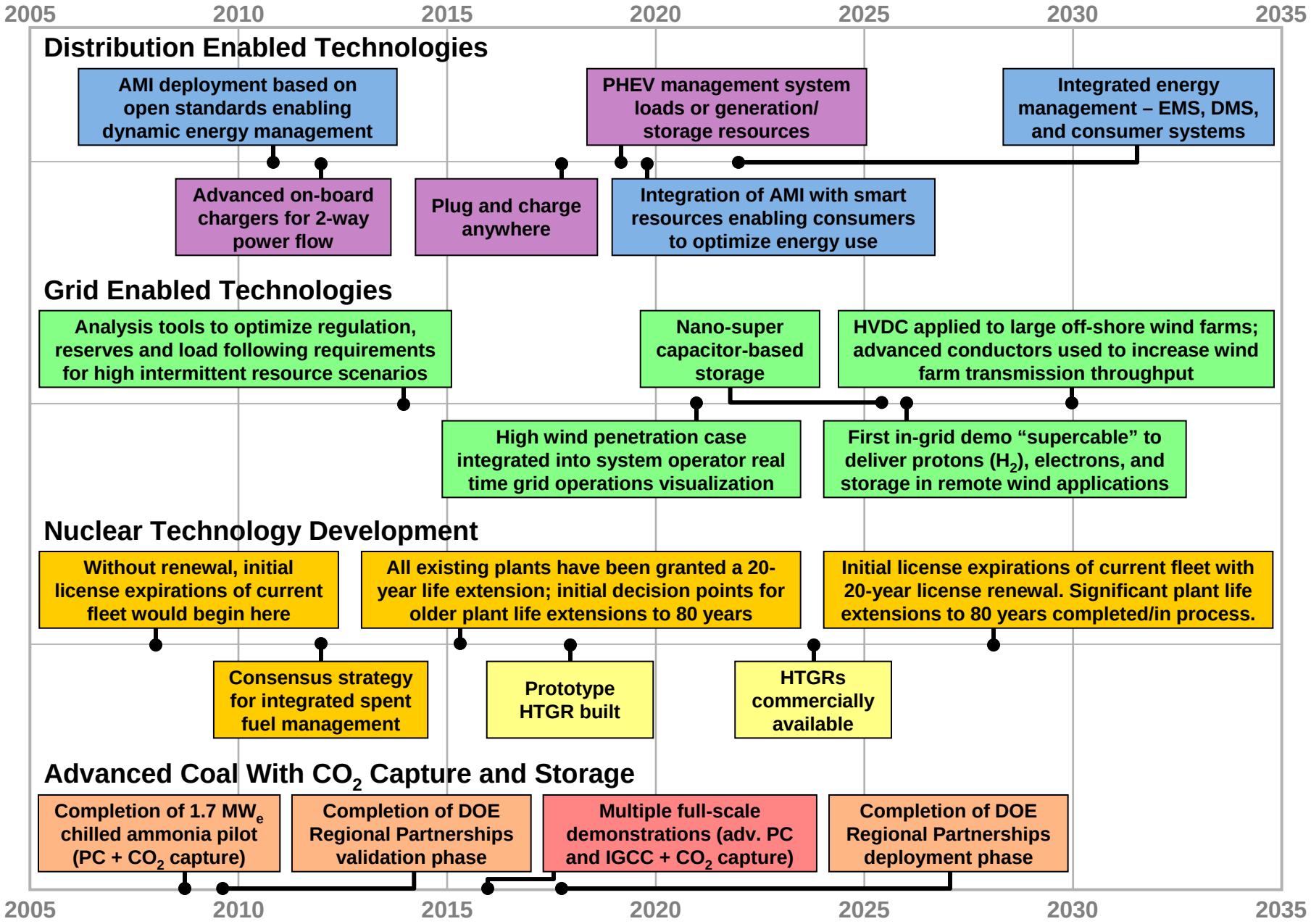
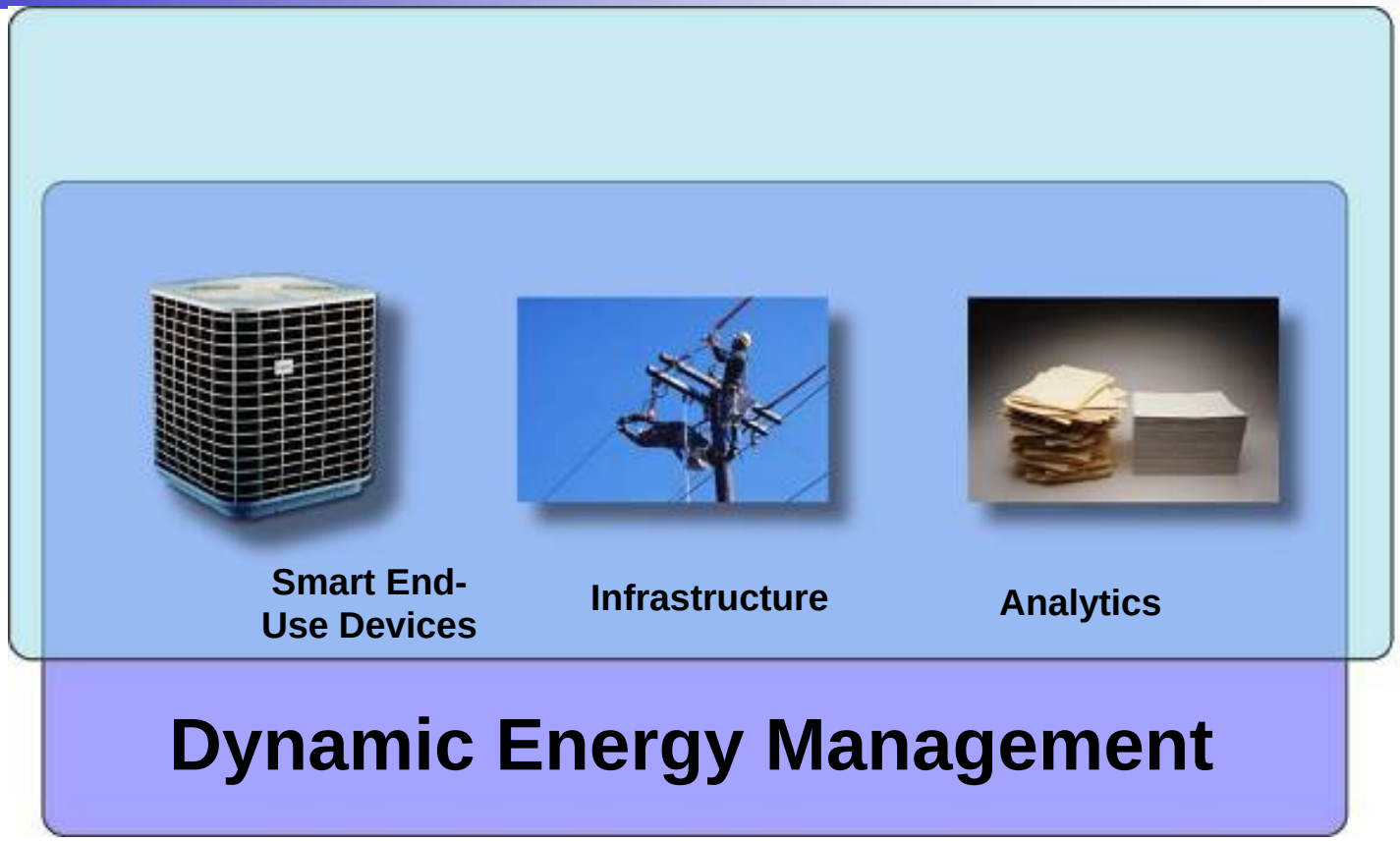
Key Technology Challenges

- ***Smart grids and communications infrastructures*** to enable end-use efficiency and demand response, distributed generation, and PHEVs.
- ***Transmission grids and associated energy storage infrastructures*** with the capacity and reliability to operate with 20–30% intermittent renewables in specific regions.
- ***Advanced light-water reactors*** enabled by continued safe and economic operation of the existing nuclear fleet; and a viable strategy for managing spent fuel.
- ***Coal-based generation units with CCS*** operating with 90+% CO_2 capture and with the associated infrastructure to transport and permanently store CO_2.

Critical Technology Pathways – Much to be done

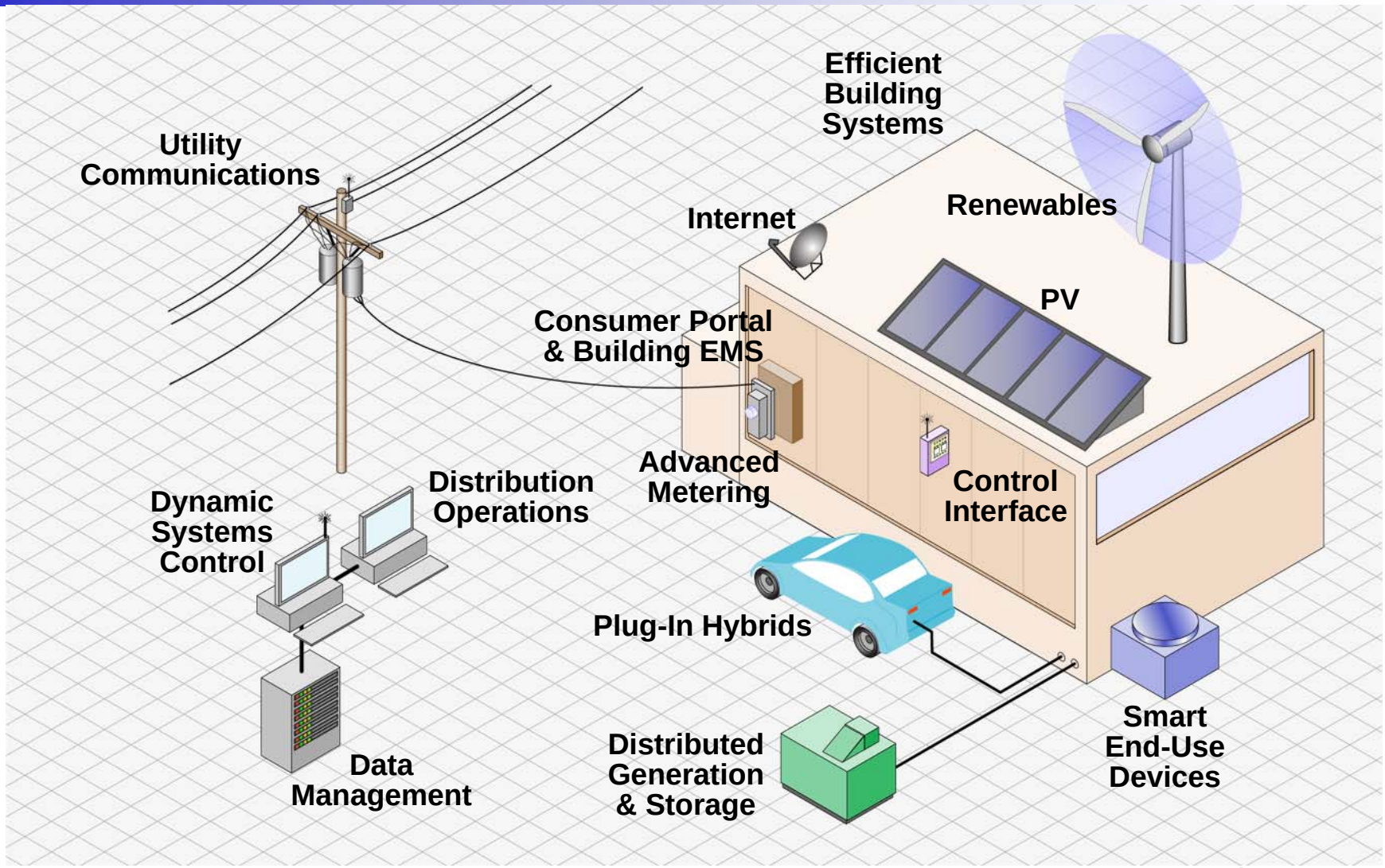


Energy Efficiency Initiative Update



- **Successful launch on January 31, 2007**
- **40 utilities joined or pending**

Dynamic Energy Management Vision: Enable Utilities and Consumers to Optimize Energy Use



What is the potential value of these advanced electricity technologies to the U.S. economy and to consumers?

Economic Assessment

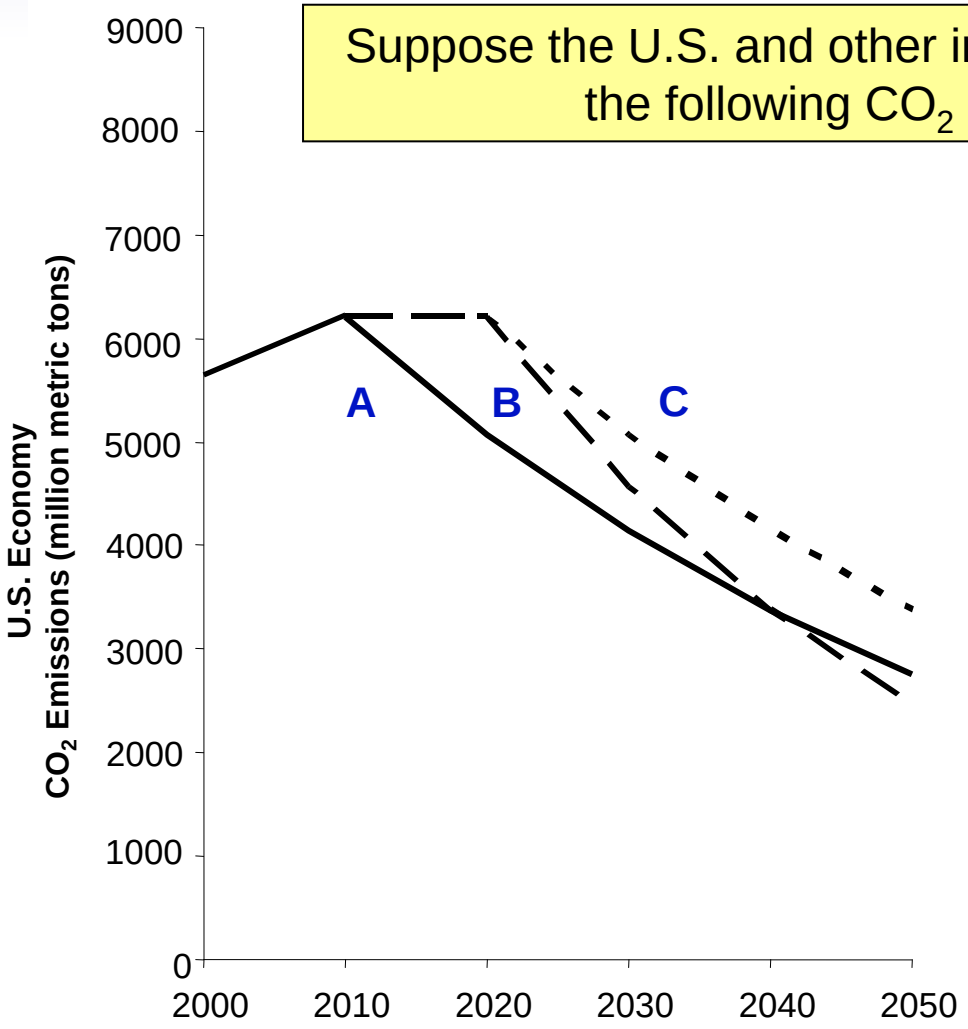
EPRI Economic Analysis Model (MERGE)

- Economy-wide analysis of economic growth using a general equilibrium macro-economic model
- MERGE seeks lowest-cost technology mix able to meet specified emissions requirement

One of three models used by U.S. Climate Change Science Program and in many international and domestic studies.

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

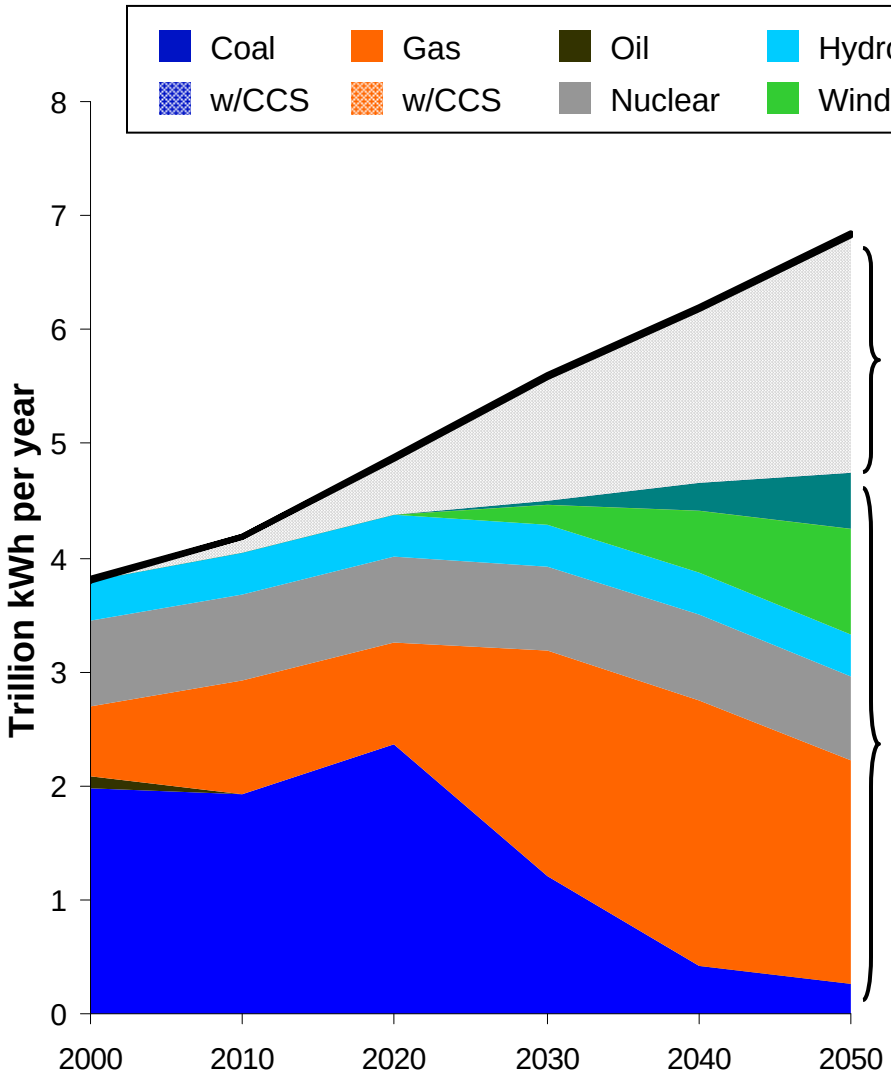
Policy Scenario C:

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

Electricity Technology Scenarios

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

U.S. Electric Generation: Limited Portfolio

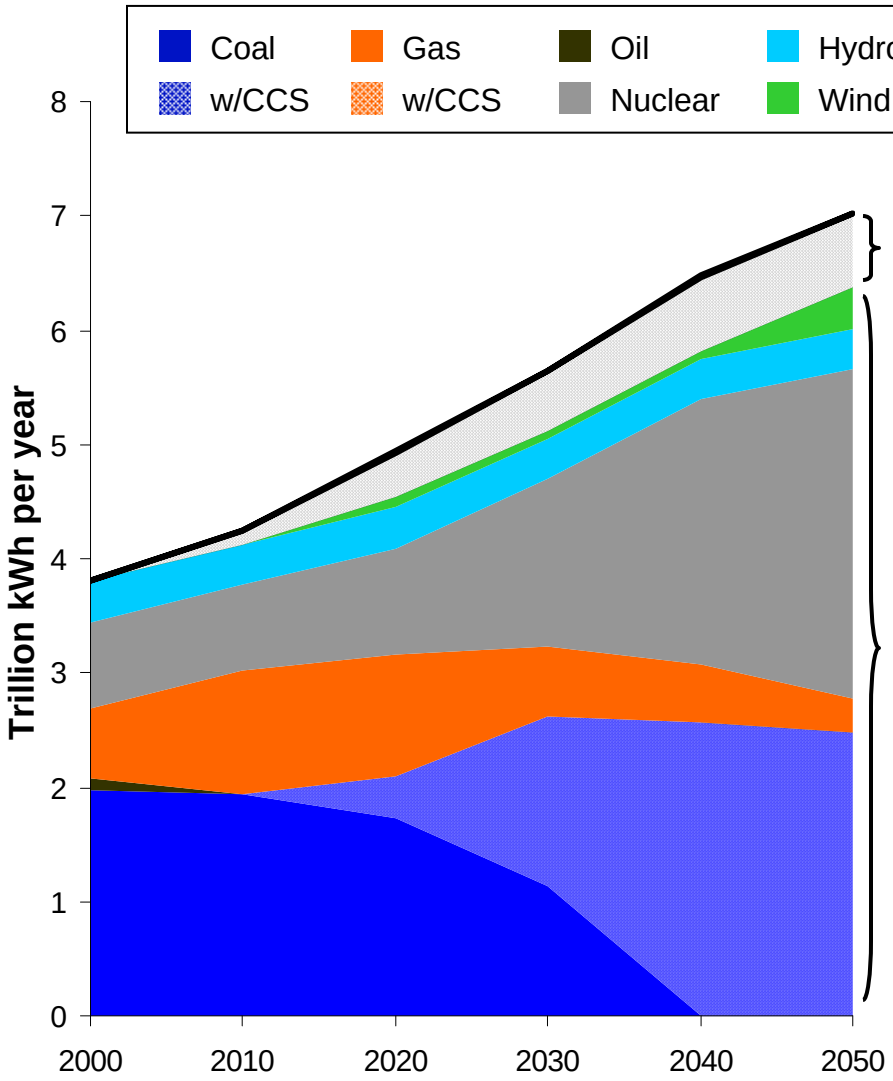


Emissions are reduced in two ways:

- Carbon penalty drives price up, demand down

- Supply shifts to less carbon-intensive technologies

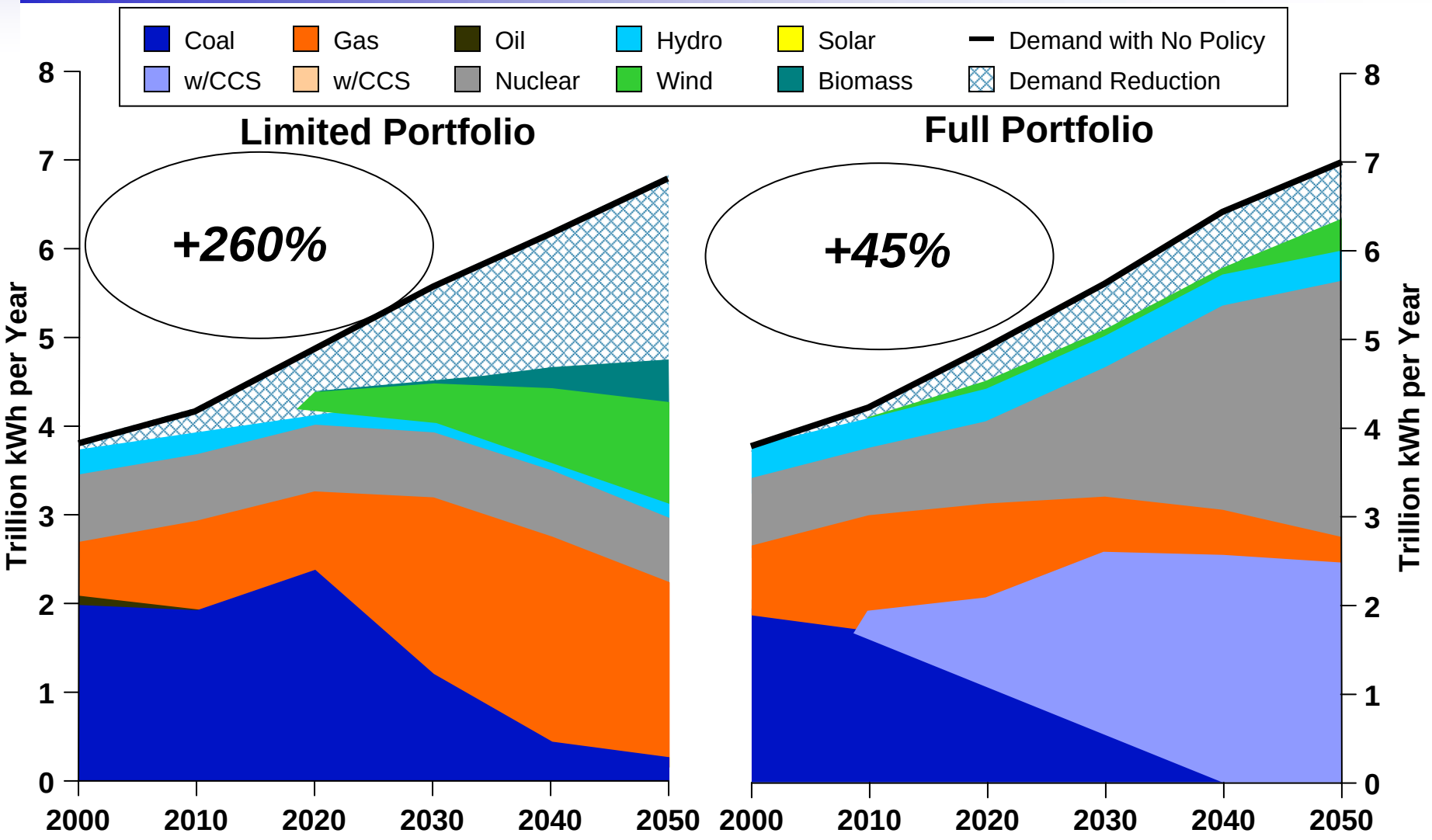
U.S. Electric Generation: Full Portfolio



- Demand reduction is limited, preserving market and managing cost to economy

- Availability of CCS and expanded nuclear allow large-scale low-carbon generation

Increase in Real Electricity Prices…2000 to 2050



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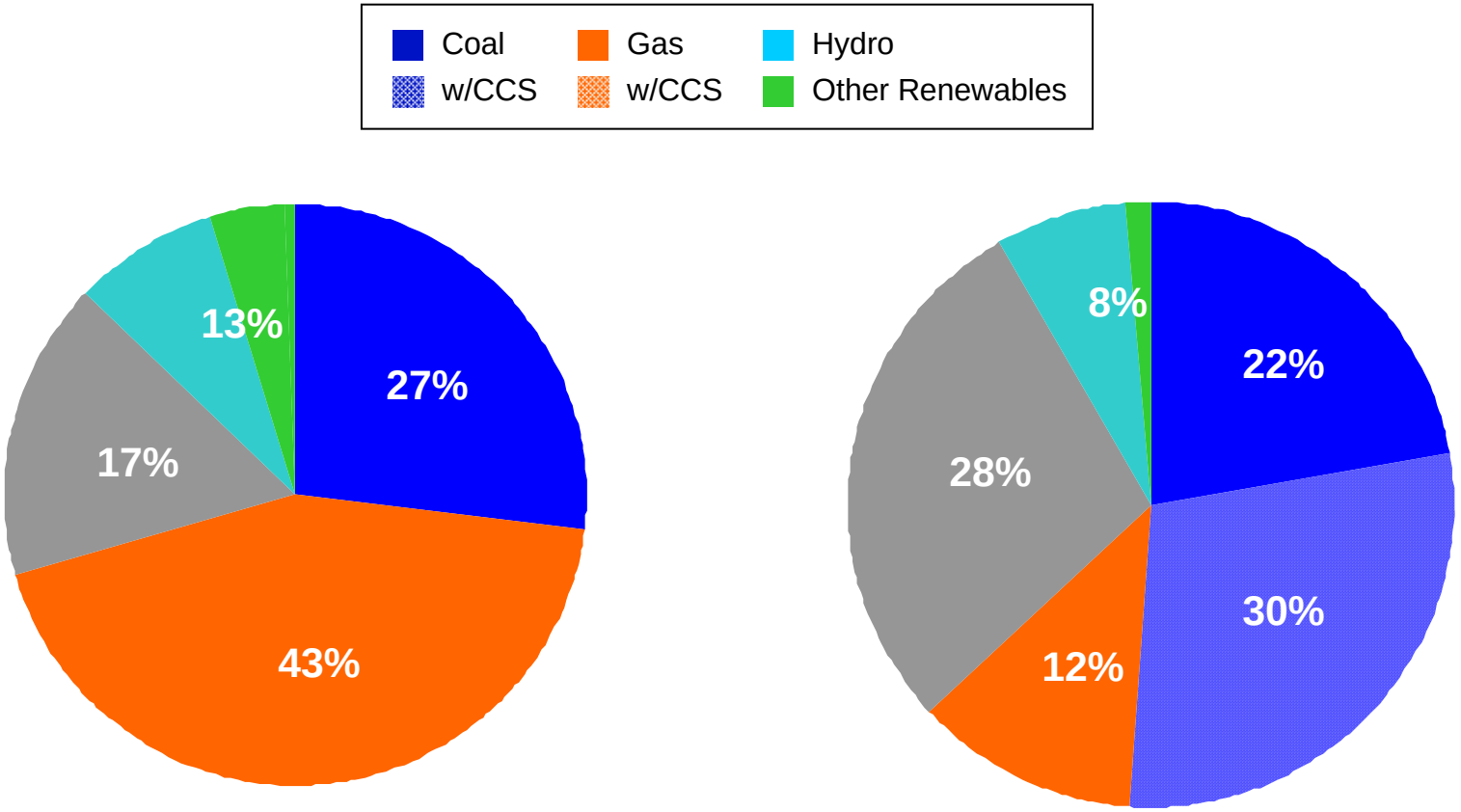
U.S. Electric Generation in 2030



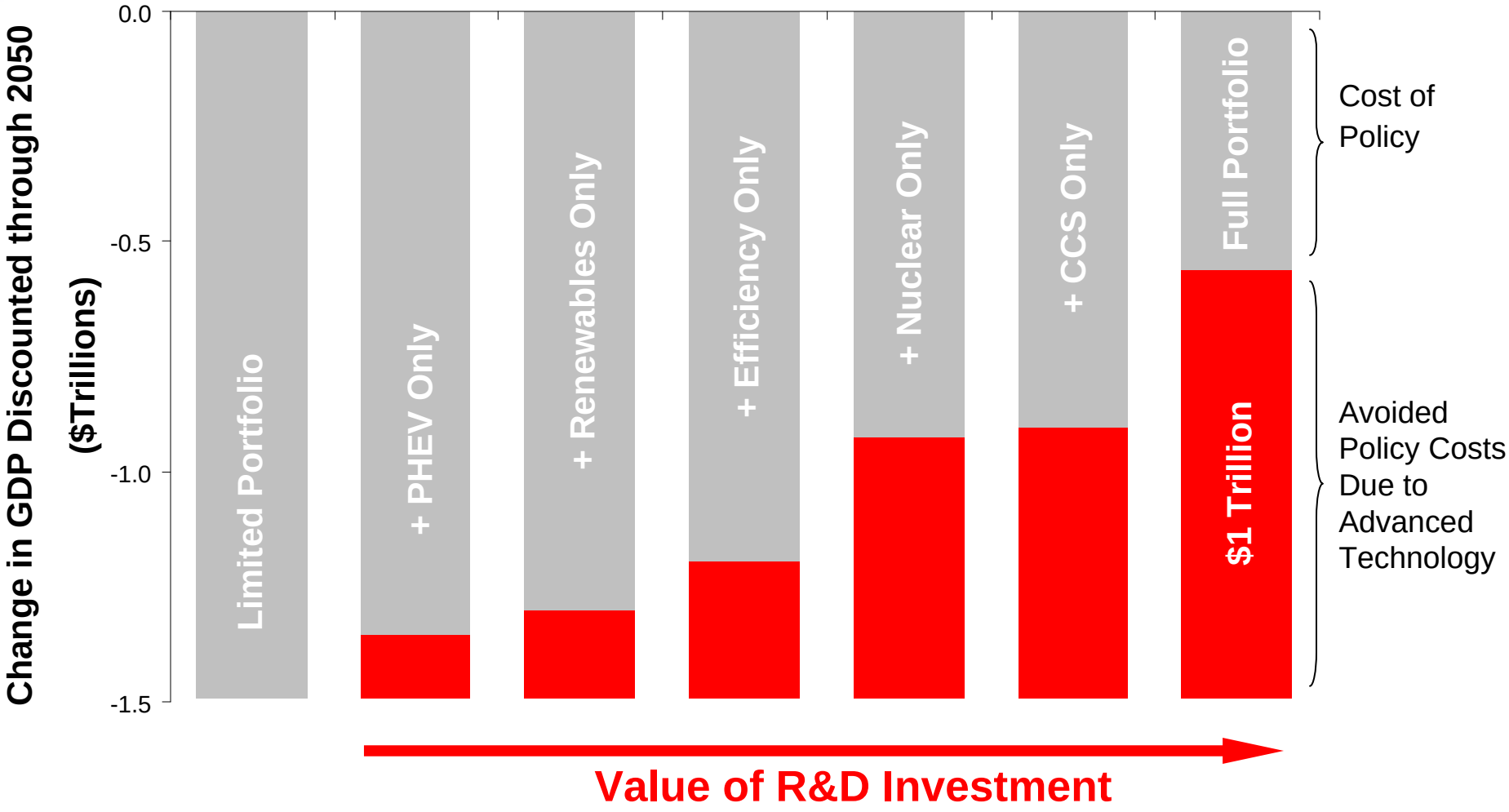
Limited Portfolio

Total: 4,500 TWh

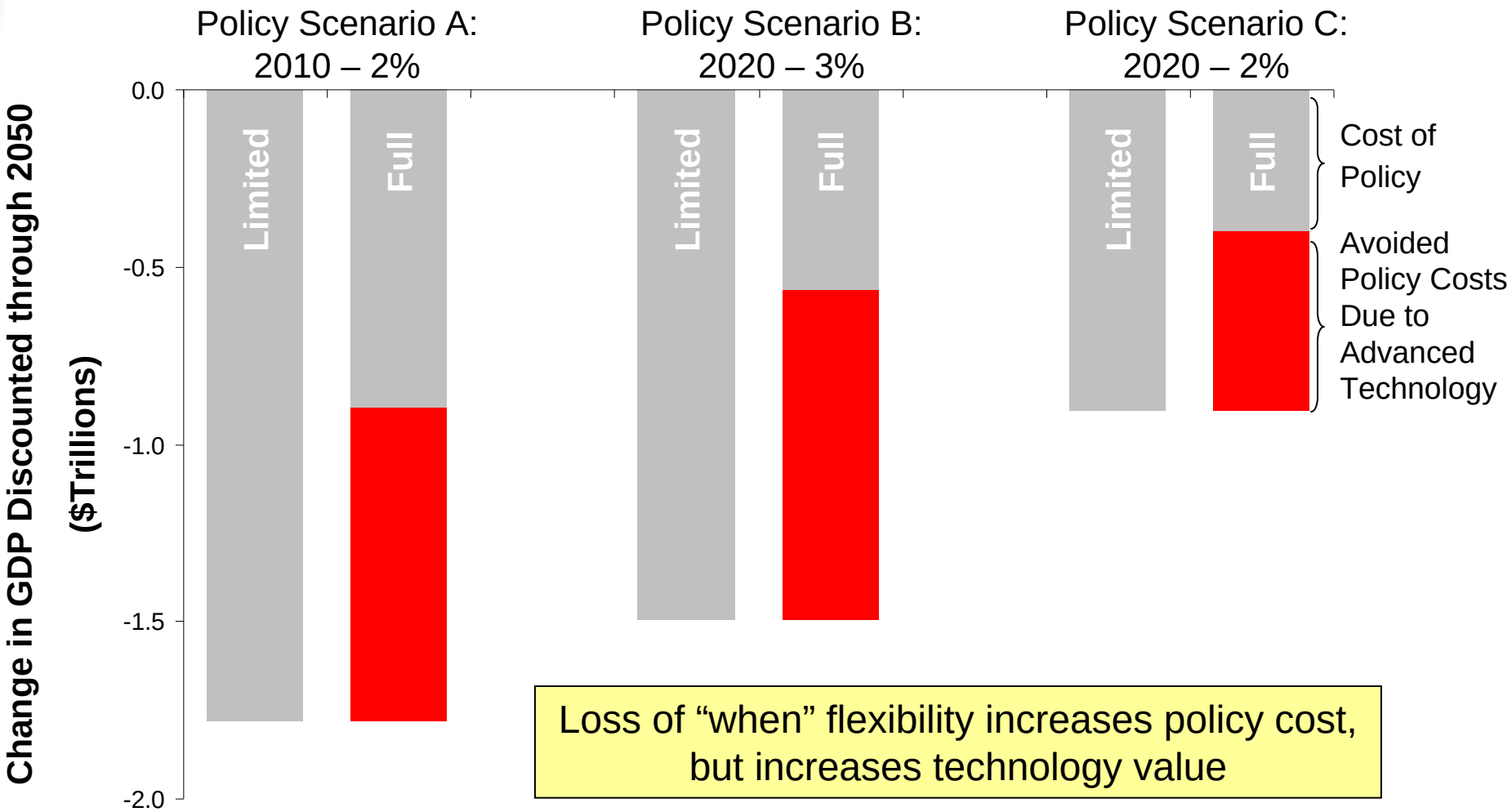
Full Portfolio

Total: 5,125 TWh

Impact on U.S. Economy



Economic Cost Sensitivity



Summary of Economic Analysis

Absent advanced electricity technologies, CO_2 constraints result in:

- *Price-induced "demand reduction"*
- *Fuel switching to natural gas*
- *Higher electricity prices*
- *High cost to U.S. economy*

With advanced electricity technologies, CO_2 constraints result in:

- *Growth in electrification*
- *Expanded use of coal (w/CCS) and nuclear*
- *Lower, more stable electricity prices*
- *Reduced cost to U.S. economy*

The Bottom Line

- **The electricity sector's overall carbon footprint can be substantially reduced**
- **A decarbonized electricity sector enables other sectors to reduce emissions**
- **Technology enables this while minimizing impact on economy**

EPRI Study Conclusions

- 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.
- **Time to act is NOW!**