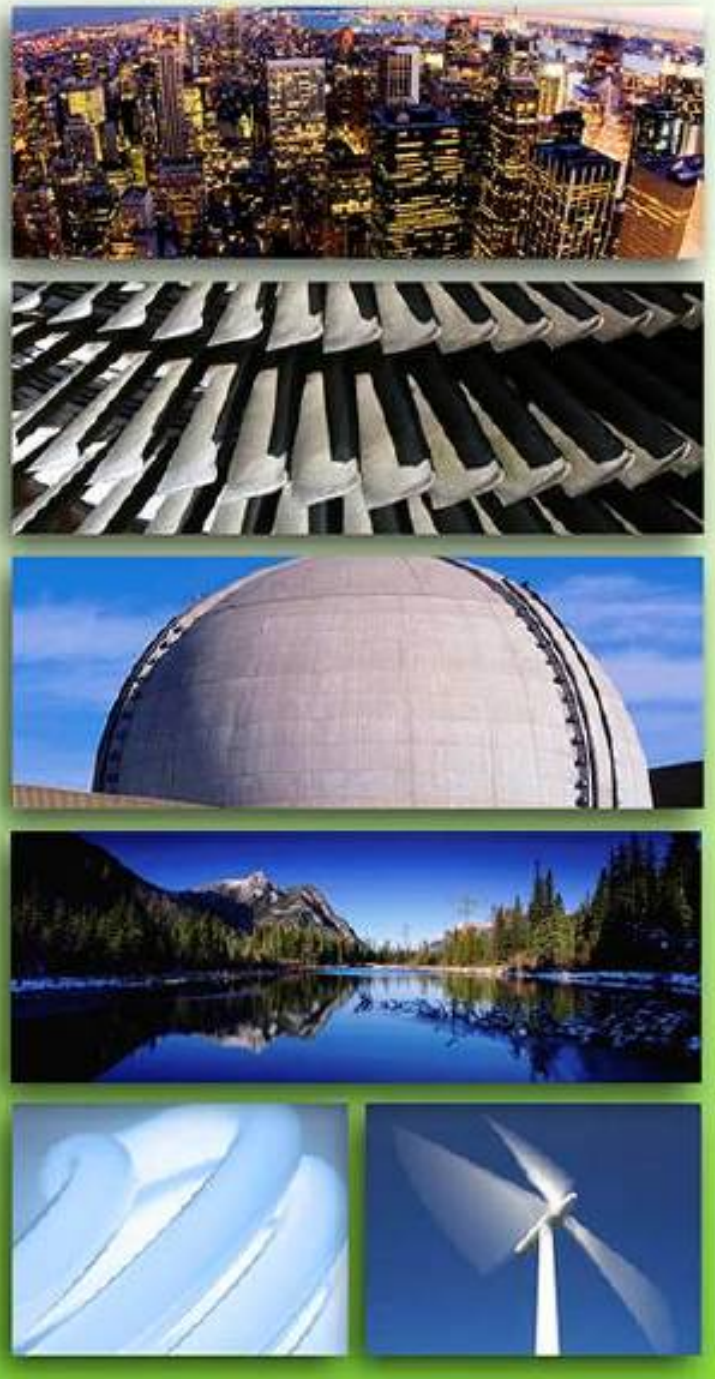

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The Electricity Technology Challenge

Surface Transportation Board
Rail Energy Transportation Advisory Committee
Washington, DC
December 1, 2009

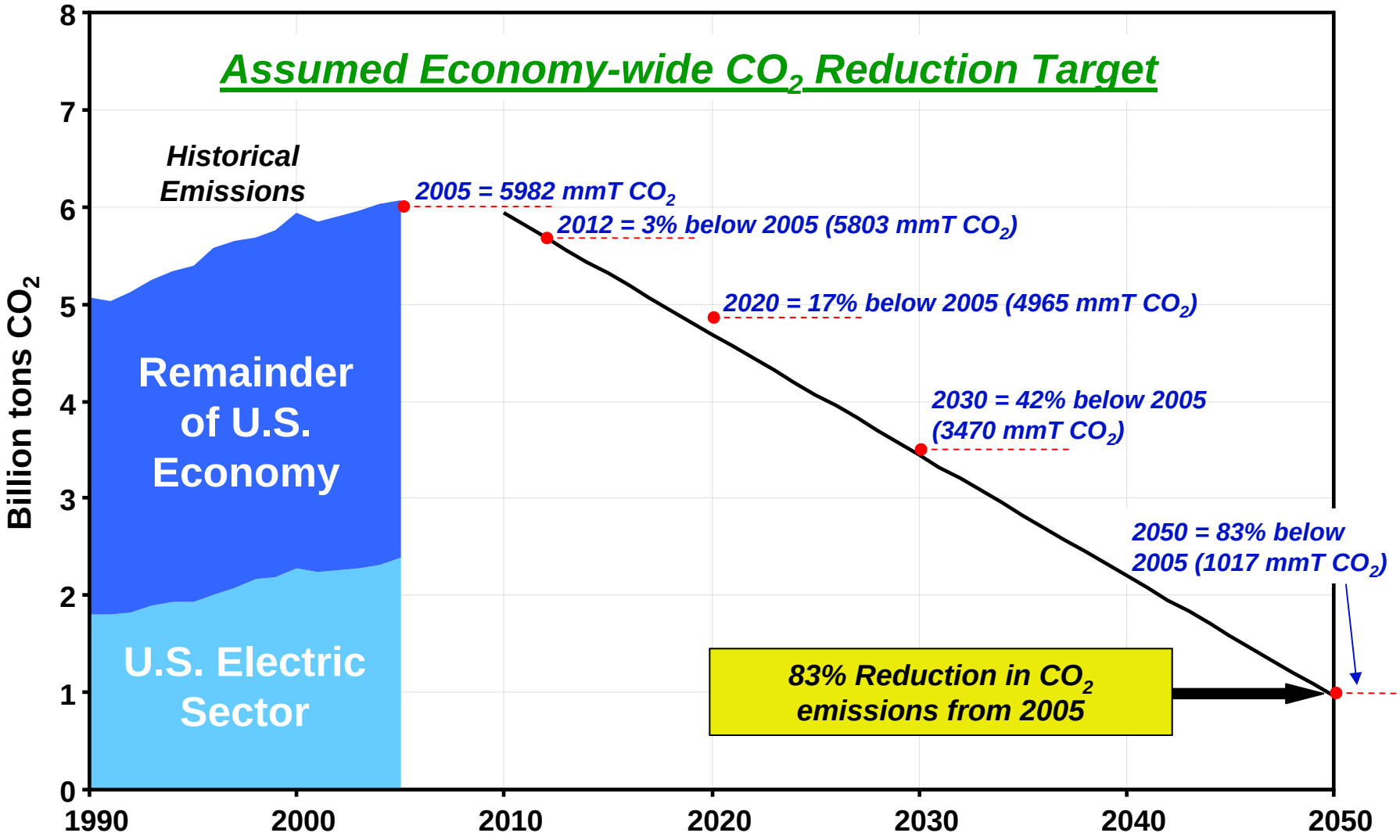
Henry A. “Hank” Courtright
Senior Vice President

Defining the Electricity Technology Challenge

- ***De-carbonize the electricity infrastructure***
- ***Provide reliable, affordable, and environmentally responsible electricity to consumers***

Two Key Metrics: CO_2 Emissions and Cost of Electricity

The CO_2 Challenge



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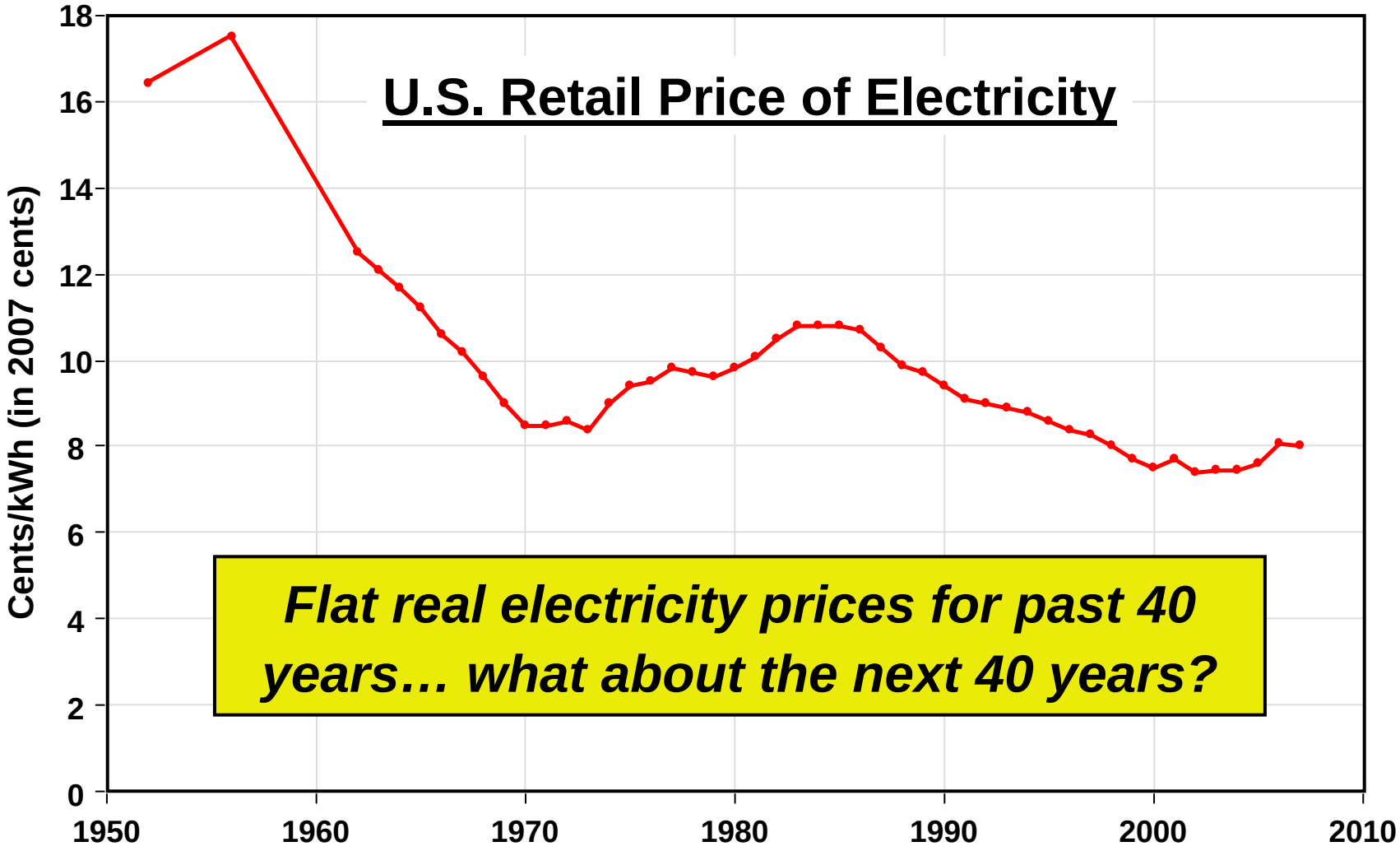
The Cost Challenge



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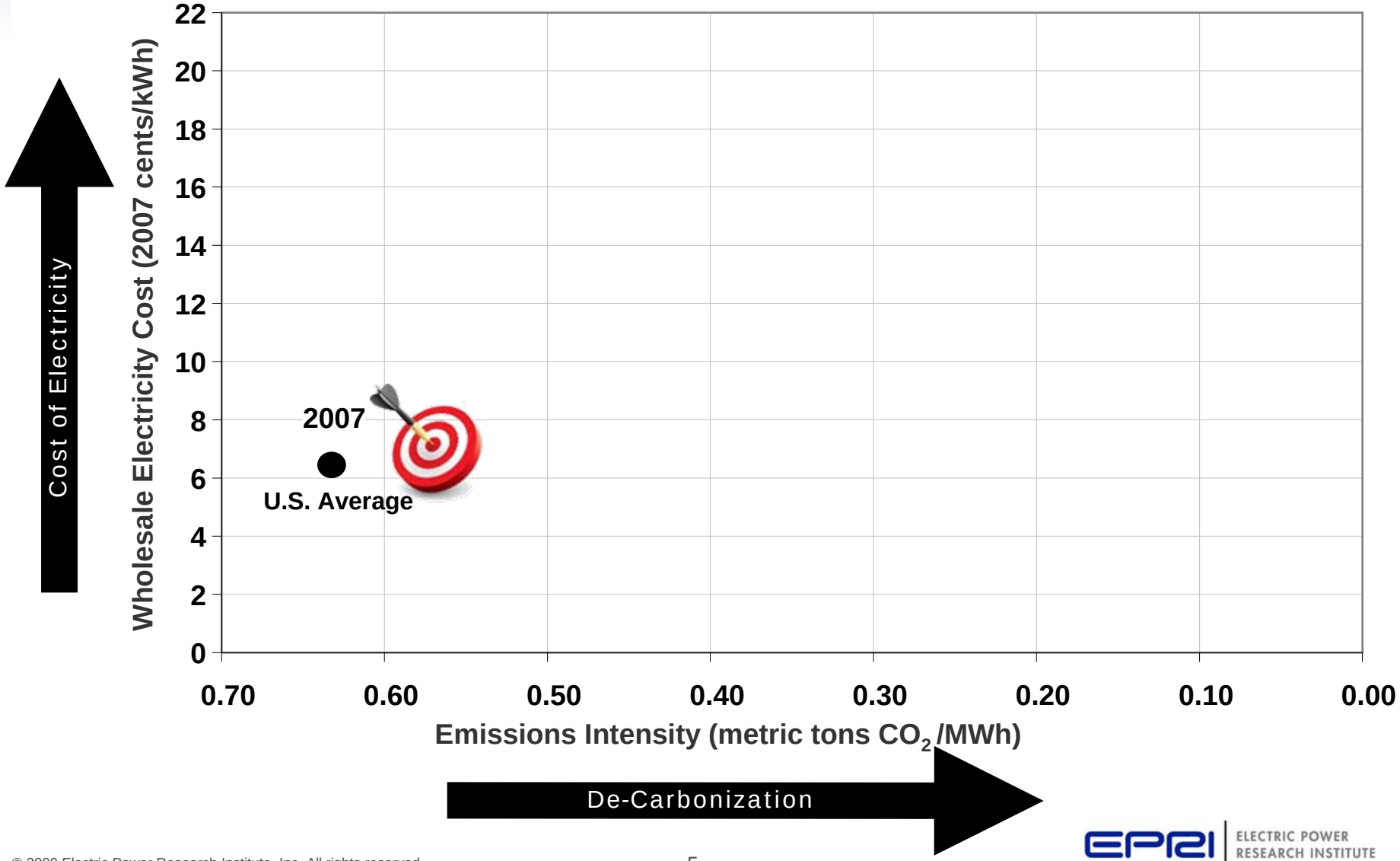
The Technology Challenge

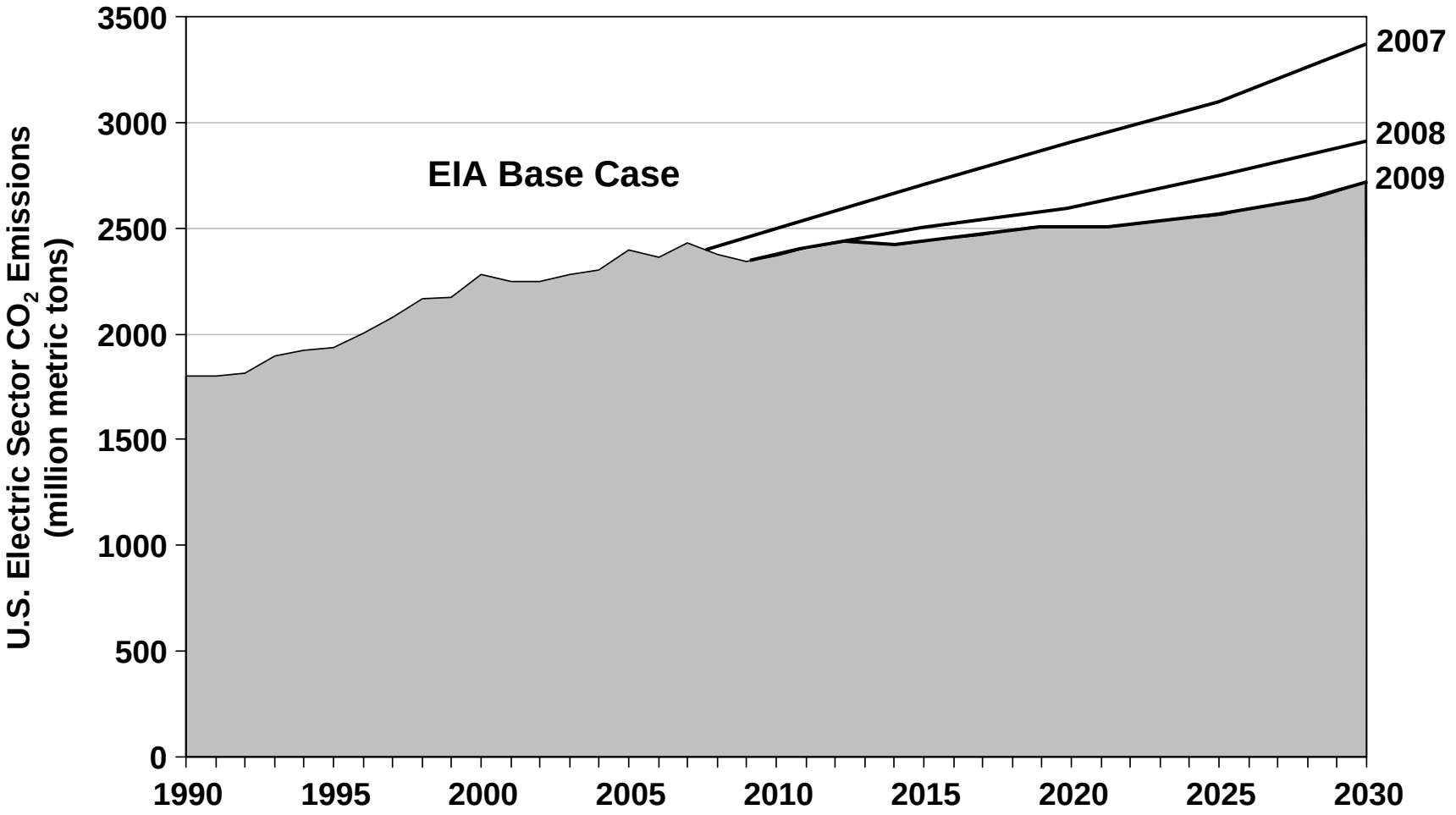


Understanding the Technology Challenge

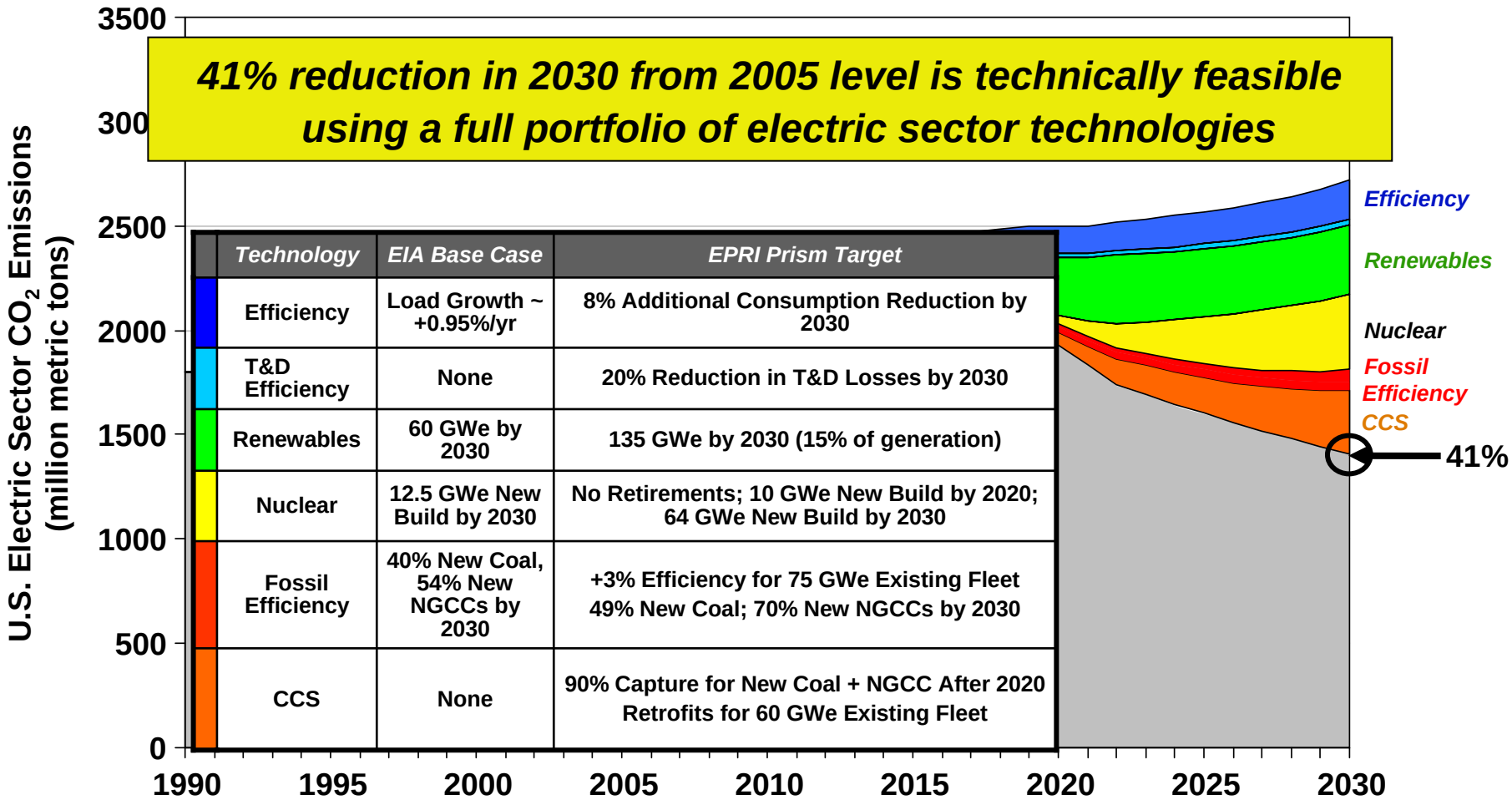
Insights Provided by Two Different Analytical Models

- **Bottoms-up "Prism" Technology Analysis**
  - *Uses Energy Information Administration's (EIA) Annual Energy Outlook as the base case*
  - *Estimates CO_2 reduction impacts relative to the base case if more aggressive technology targets could be met*
- **Tops-down "MERGE" Economic Analysis**
  - *Optimization model of economic activity and energy use*
  - *Inputs: Energy supply technologies and costs for electric generation and non-electric energy*
  - *Constraints: Carbon policy and energy resource availability*
  - *Output: Economy-wide impacts of carbon policy*

U. S. Electric Sector CO_2 Emissions



2009 Prism



Technology	EIA Base Case	EPRI Prism Target
Efficiency	Load Growth ~ +0.95%/yr	8% Additional Consumption Reduction by 2030
T&D Efficiency	None	20% Reduction in T&D Losses by 2030
Renewables	60 GWe by 2030	135 GWe by 2030 (15% of generation)
Nuclear	12.5 GWe New Build by 2030	No Retirements; 10 GWe New Build by 2020; 64 GWe New Build by 2030
Fossil Efficiency	40% New Coal, 54% New NGCCs by 2030	+3% Efficiency for 75 GWe Existing Fleet 49% New Coal; 70% New NGCCs by 2030
CCS	None	90% Capture for New Coal + NGCC After 2020 Retrofits for 60 GWe Existing Fleet

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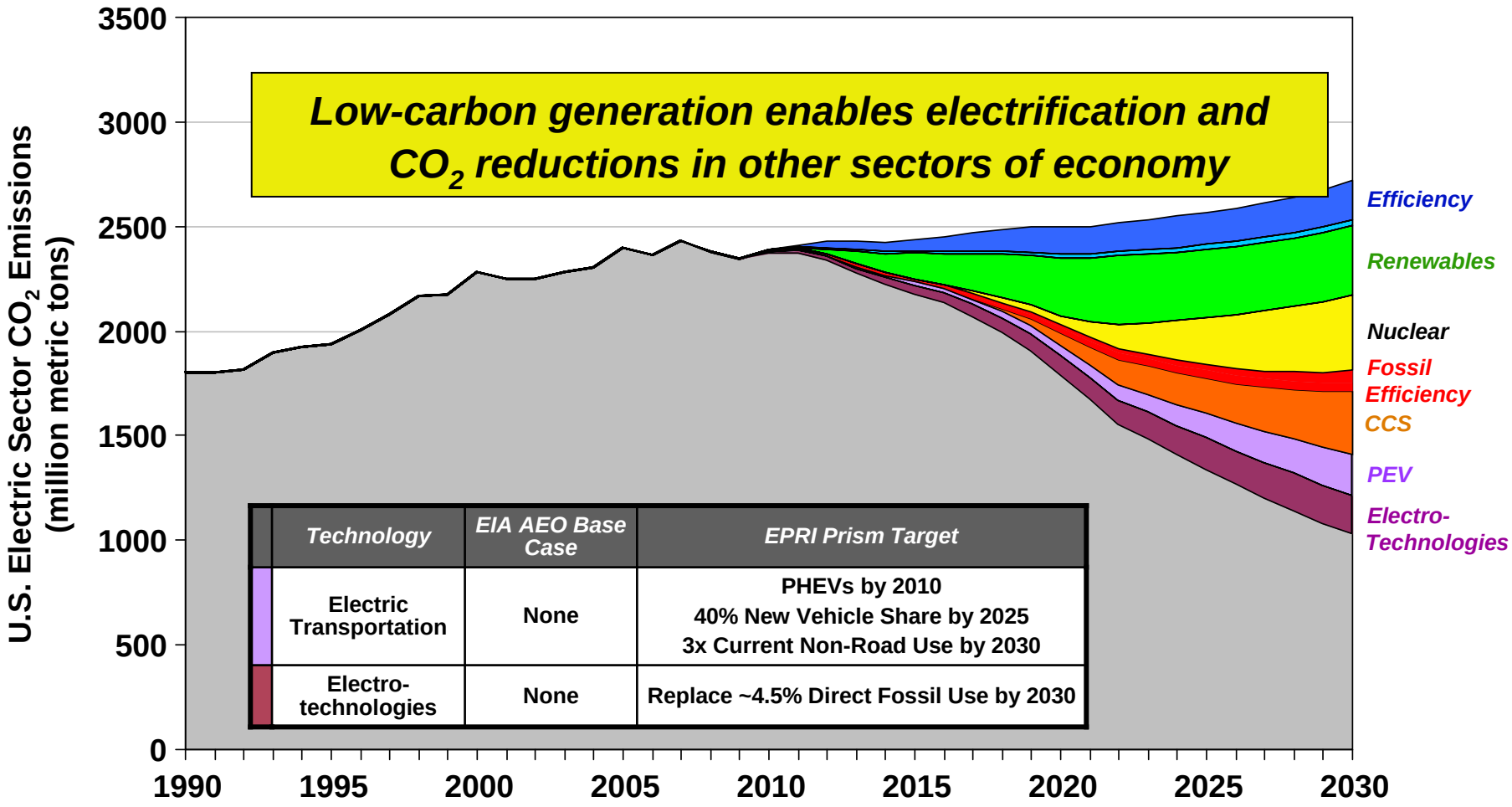
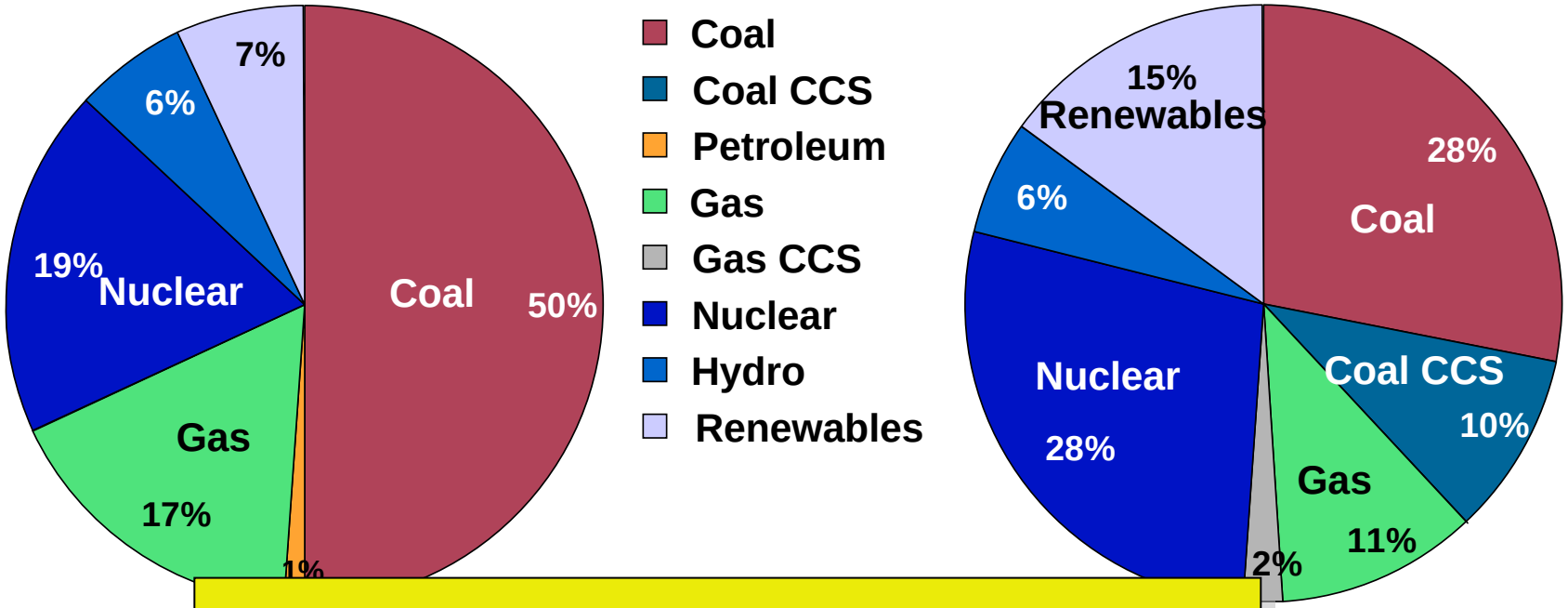
2009 Prism – PEV and Electro-Technologies



Generation by Fuel Source in 2030



What if we LIMIT the Generation PORTFOLIO?

Prism → 60% no- or low-carbon electricity by 2030

Technology Portfolios

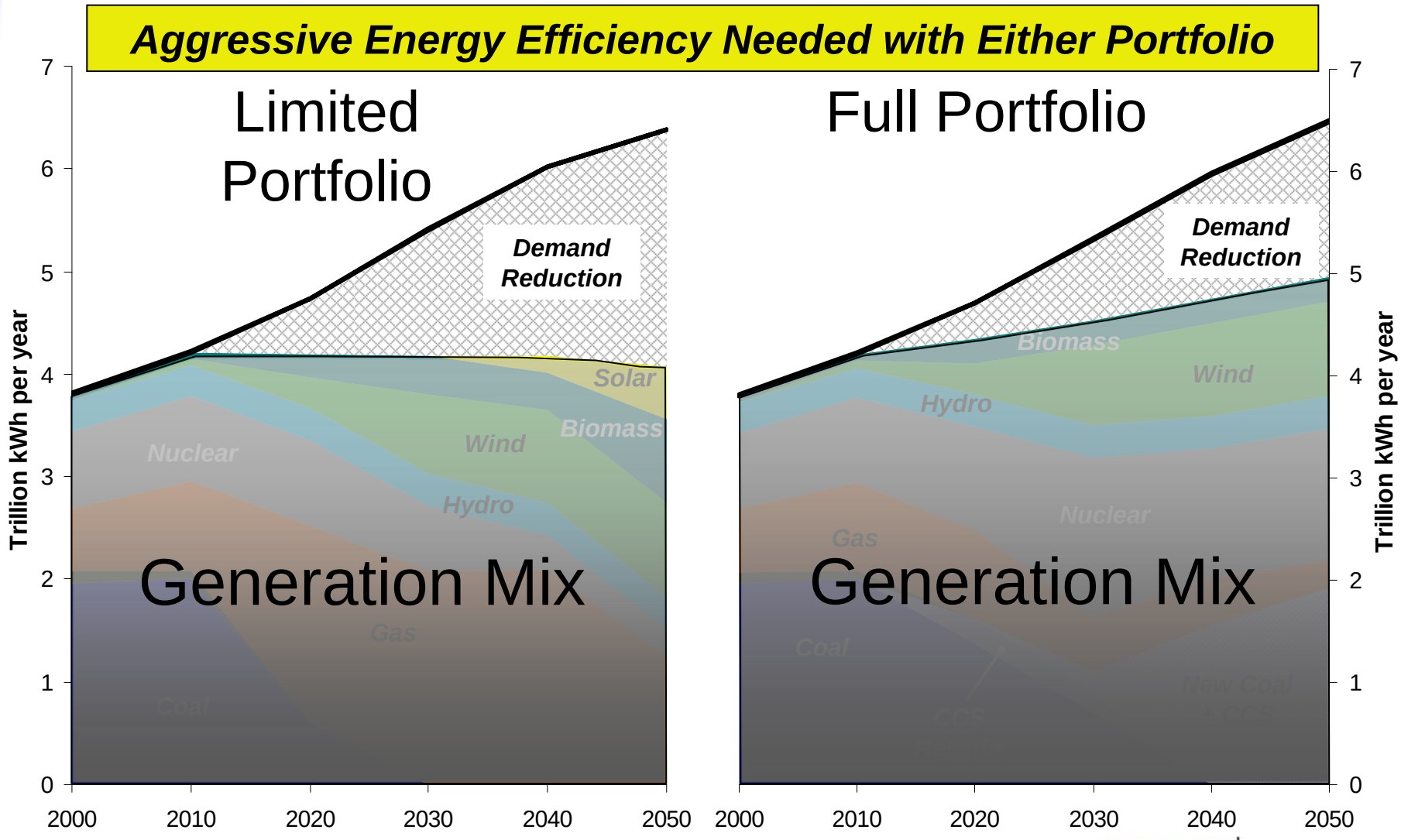
- **Limited Portfolio**
  - No CO_2 capture and storage (CCS)
  - Nuclear generation does not expand
  - No plug-in electric vehicles (PEV's)

- **Full Portfolio**
  - Coal and Gas CCS available
  - Accelerated end-use efficiency
  - PEV's can expand
  - Nuclear production can expand

MERGE Economic Model

- Optimization Model of Economic Activity and Energy Use through 2050
  - Maximize Economic Wealth
- Inputs
  - Energy Supply Technologies and Costs for Electric Generation and Non-Electric Energy
- Constraints
  - Greenhouse Gas Control Scenarios
  - Energy Resources
- Outputs
  - Economy-wide Impact of Carbon Policy

MERGE U.S. Electric Generation Mix



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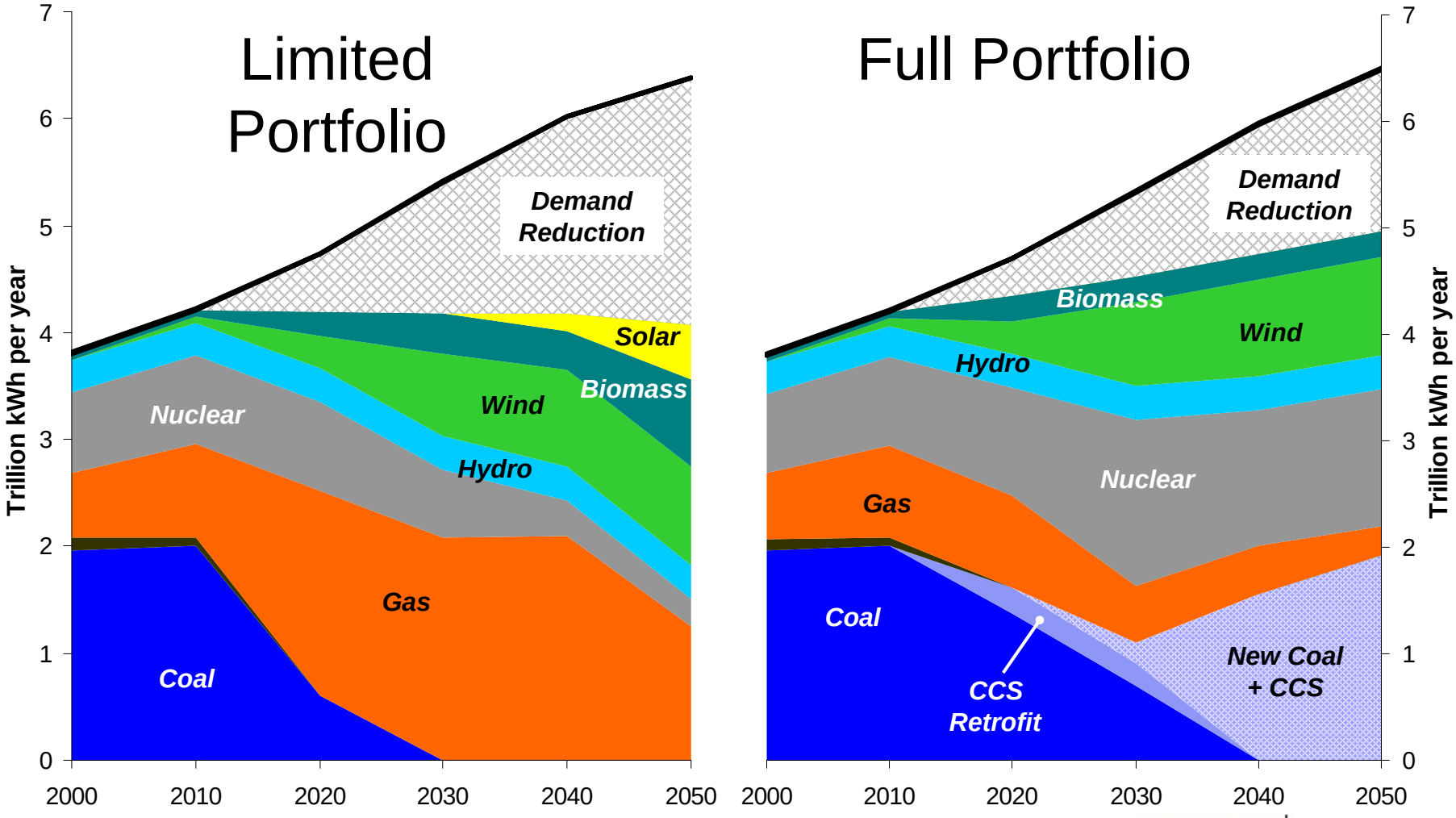
MERGE U.S. Electric Generation Mix



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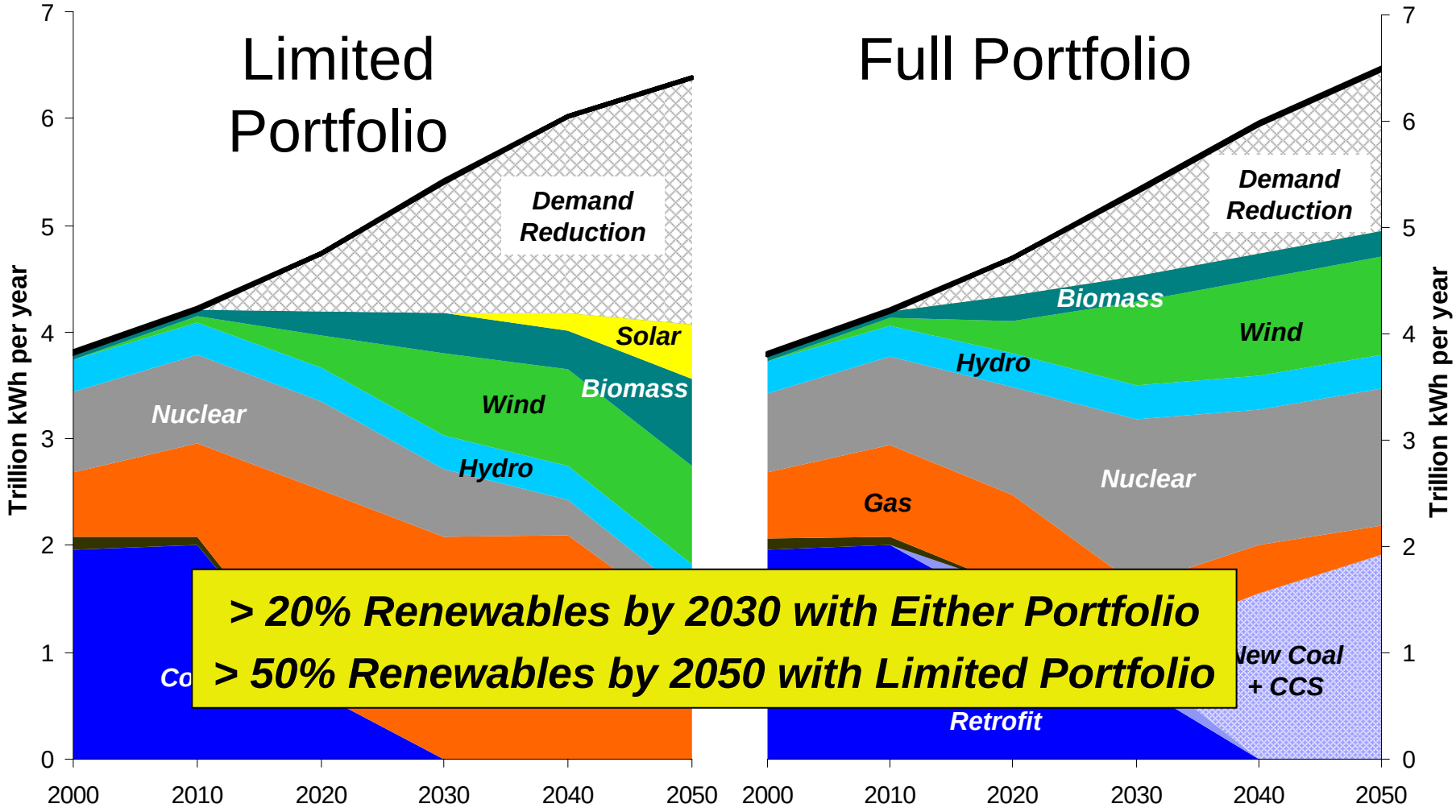
Insights – Renewables



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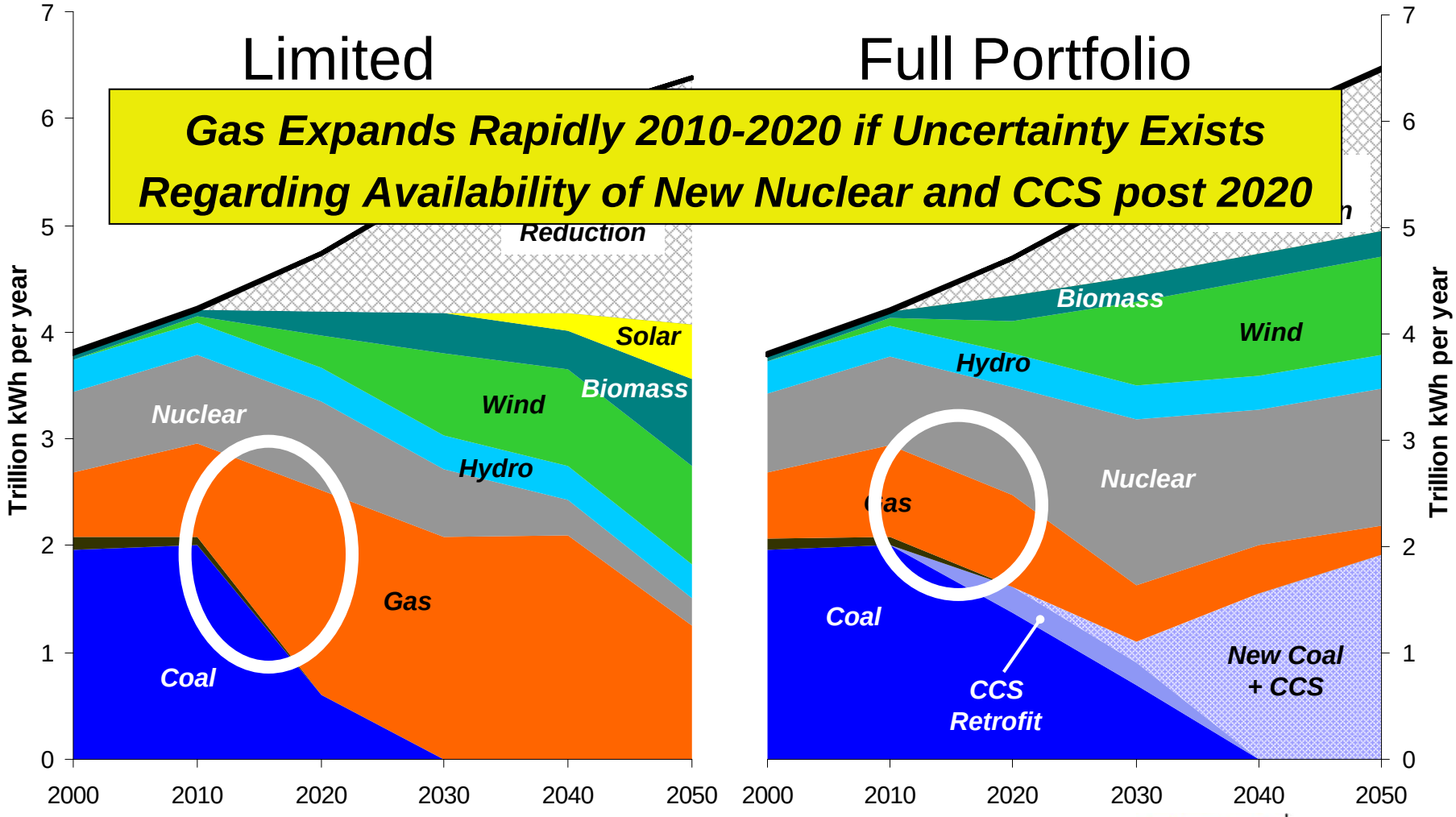
Insights – Nuclear and CCS



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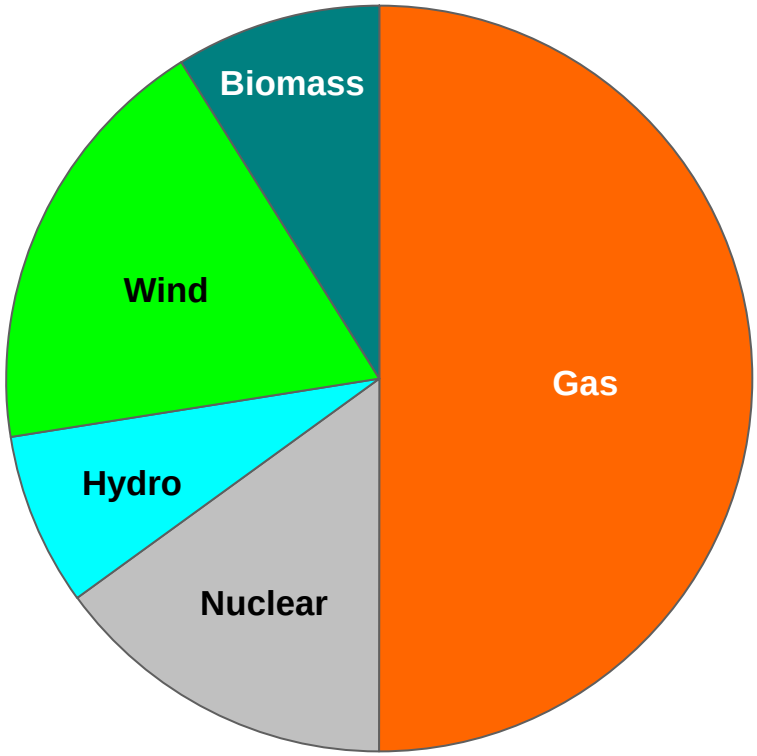
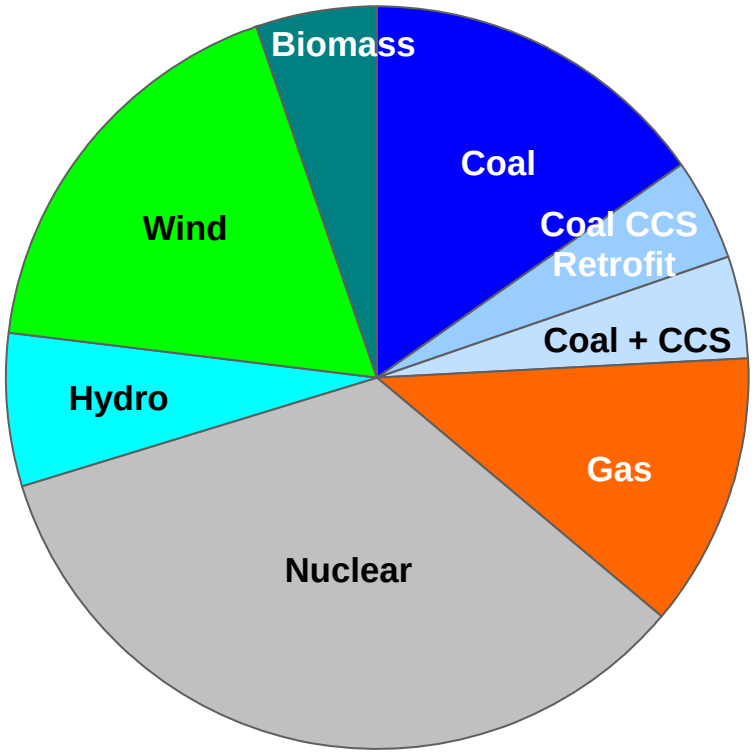
2030 Generation Mix

Remarkably different futures…and only 20 years away!



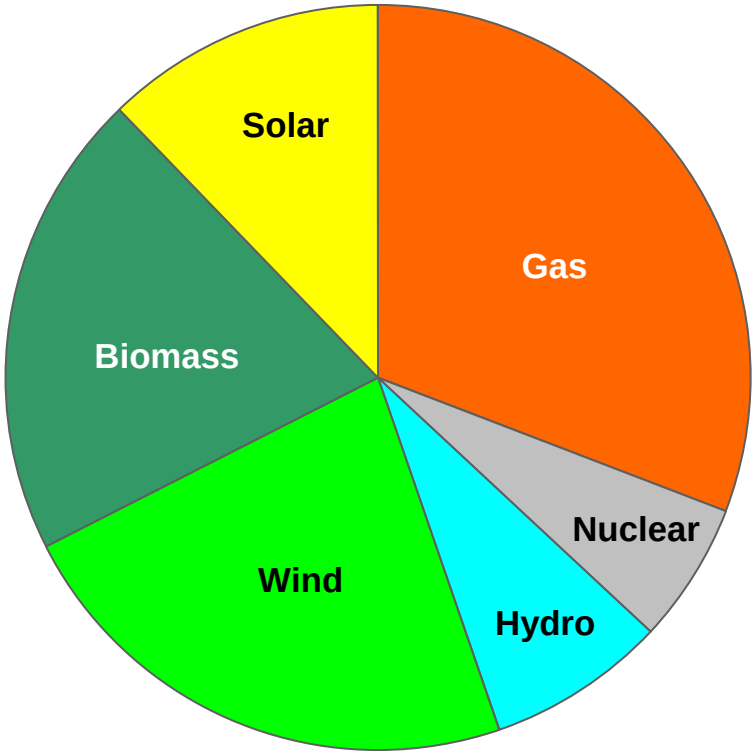
Limited Portfolio



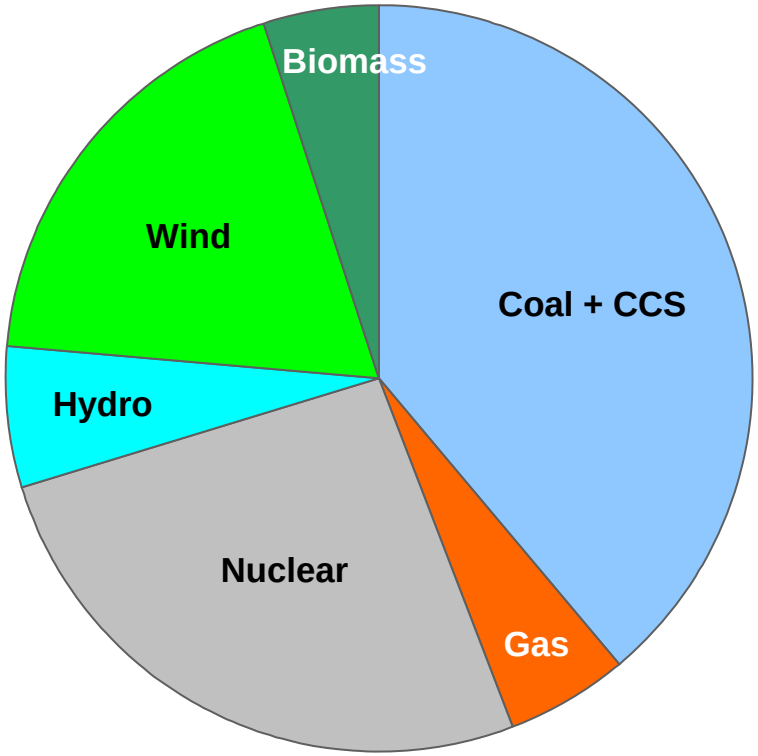
Full Portfolio

2050 Generation Mix

Totally different futures in 2050

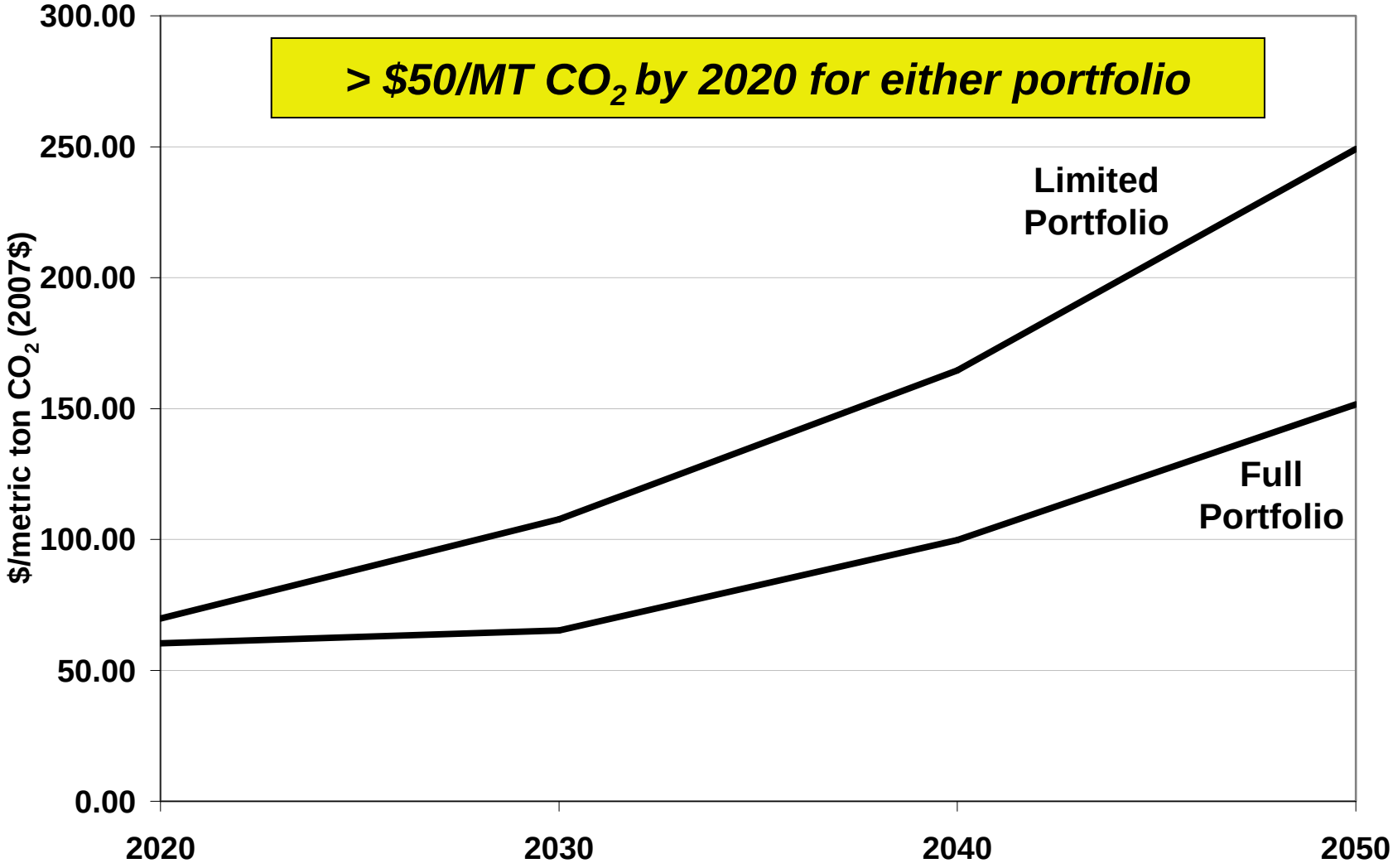


Limited Portfolio

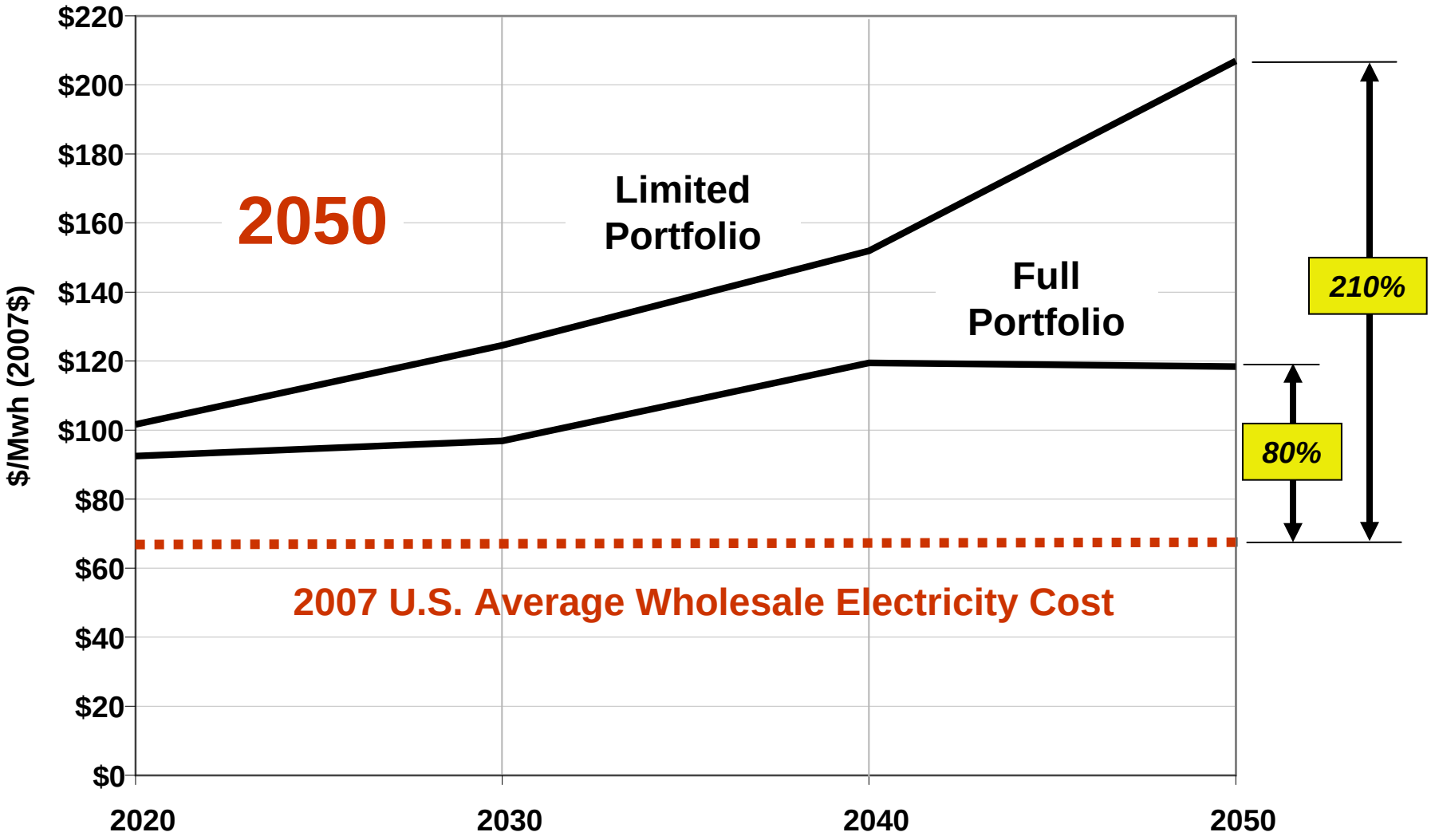


Full Portfolio

MERGE CO_2 Price Results



MERGE Wholesale Electricity Cost Results



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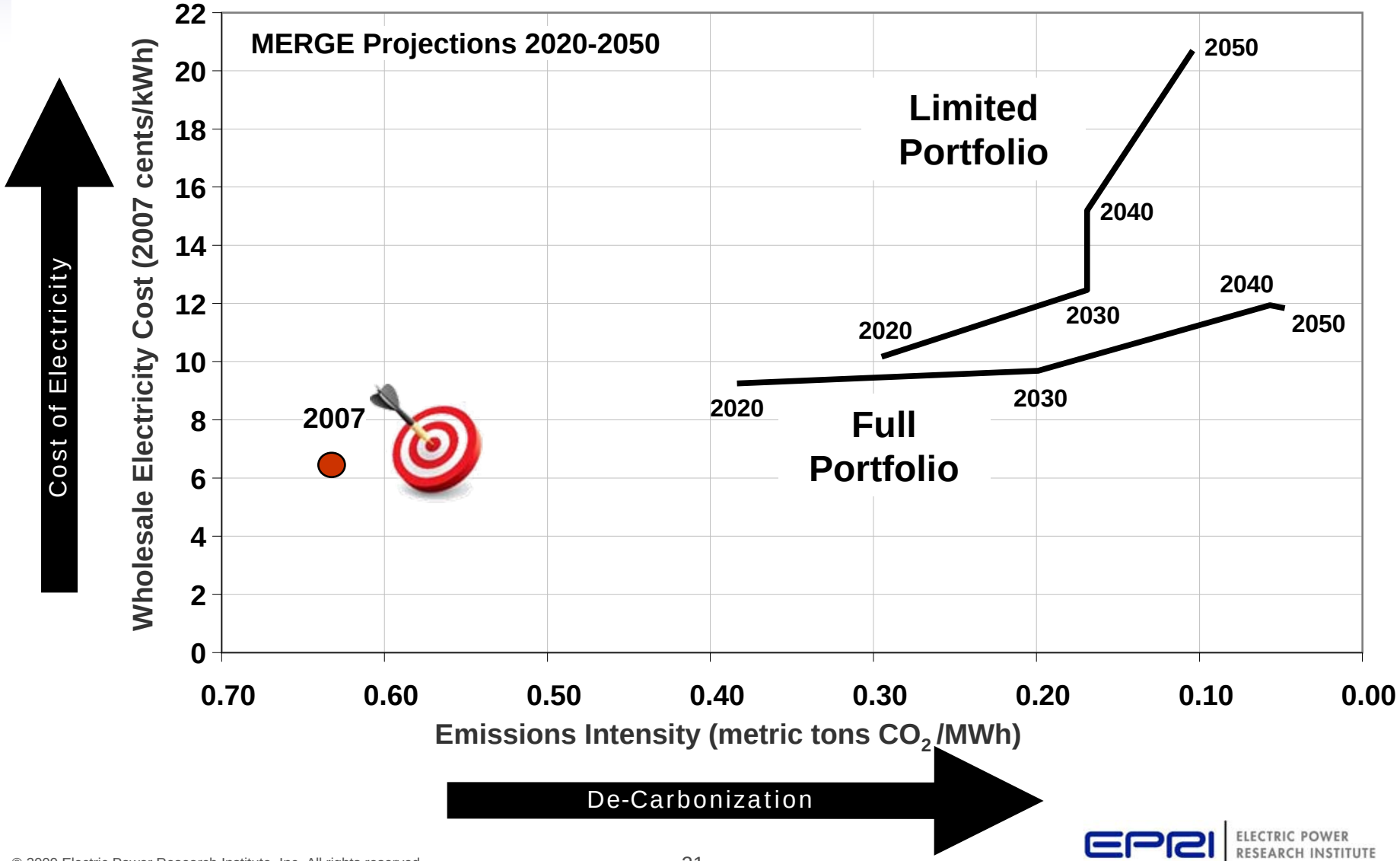
MERGE De-carbonization Results



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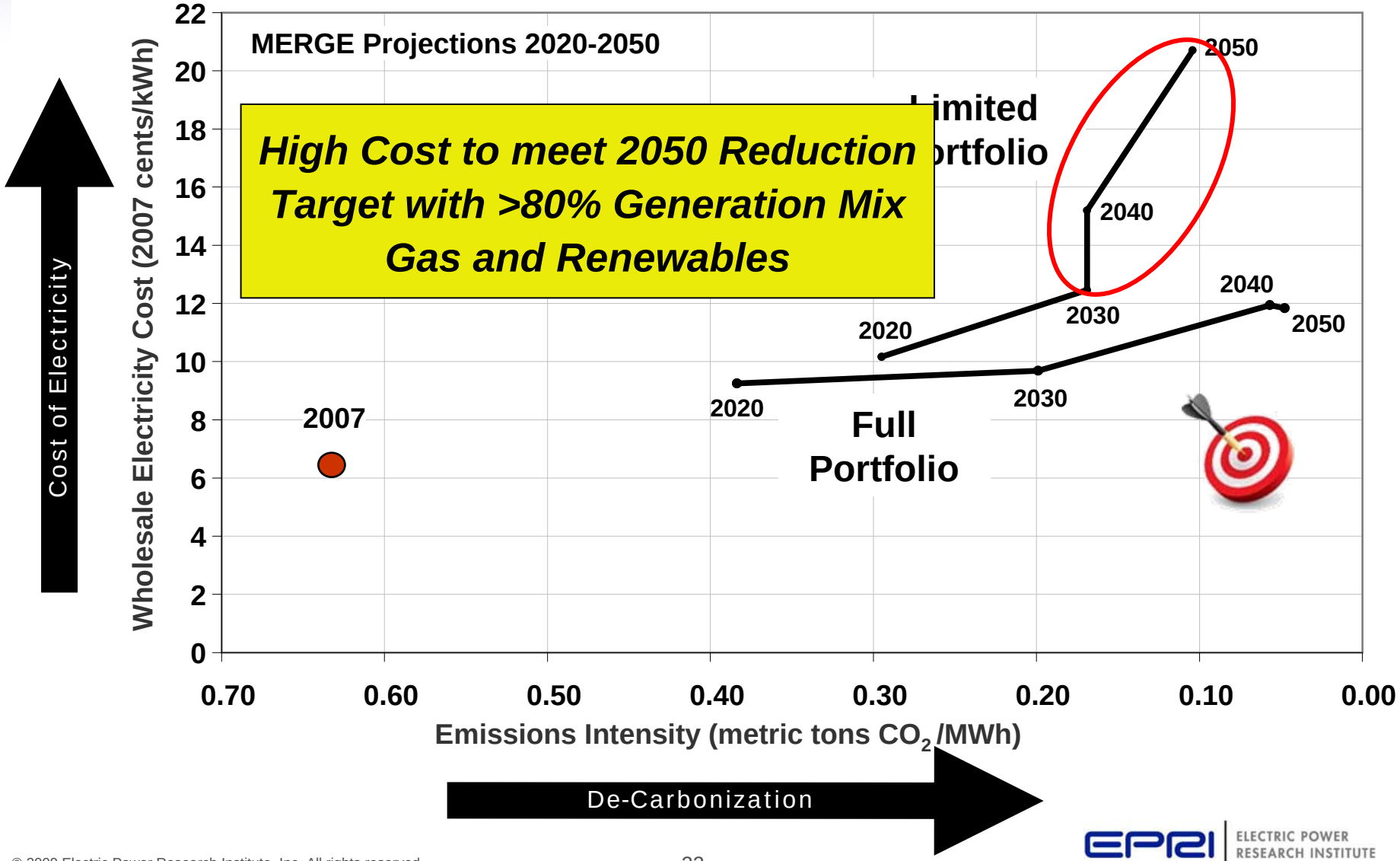
MERGE De-carbonization Results



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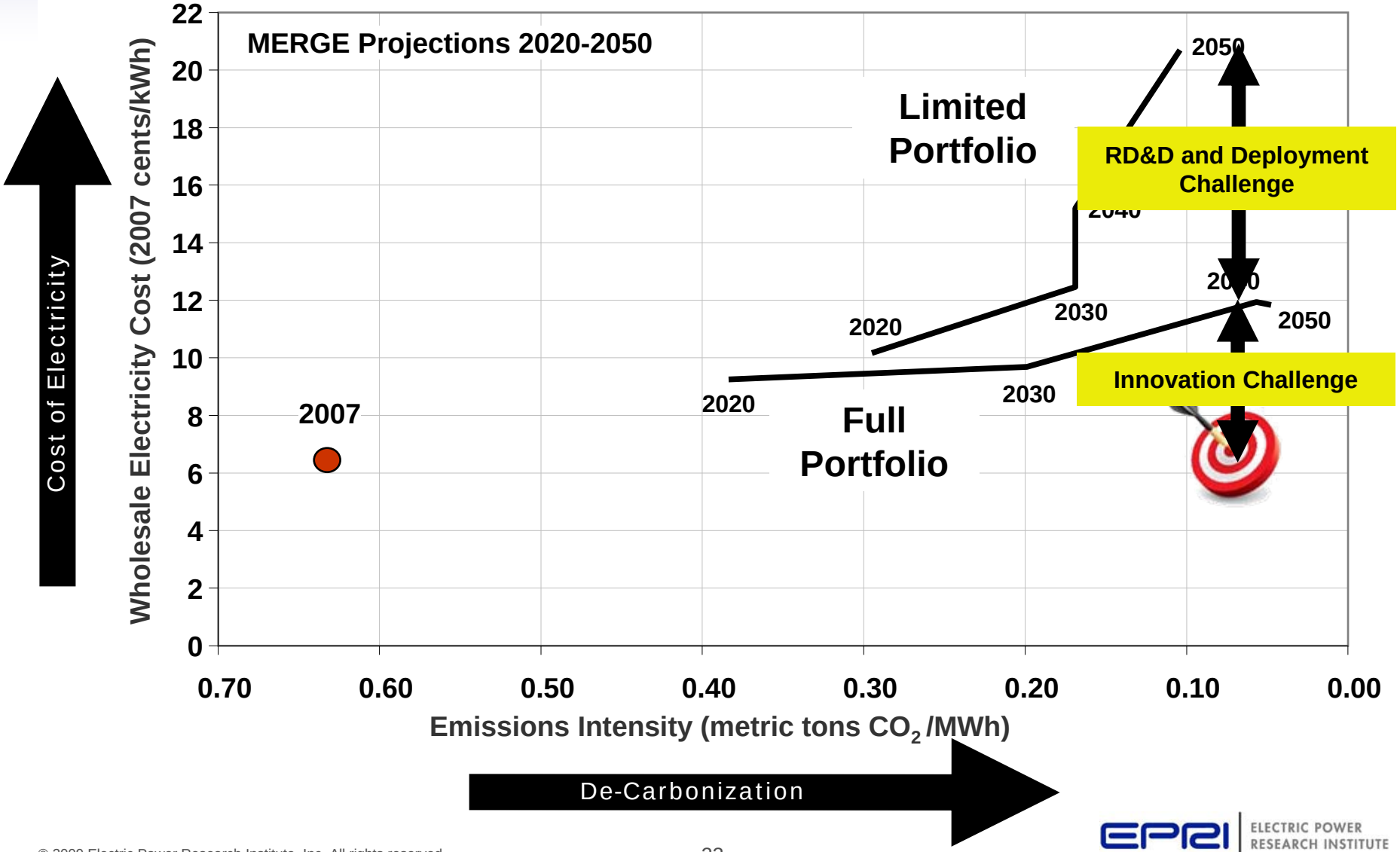
Meeting the Challenge



Together...Shaping the Future of Electricity

Electricity policy and technology actions over the next decade will to a great extent shape the electricity future of 2050

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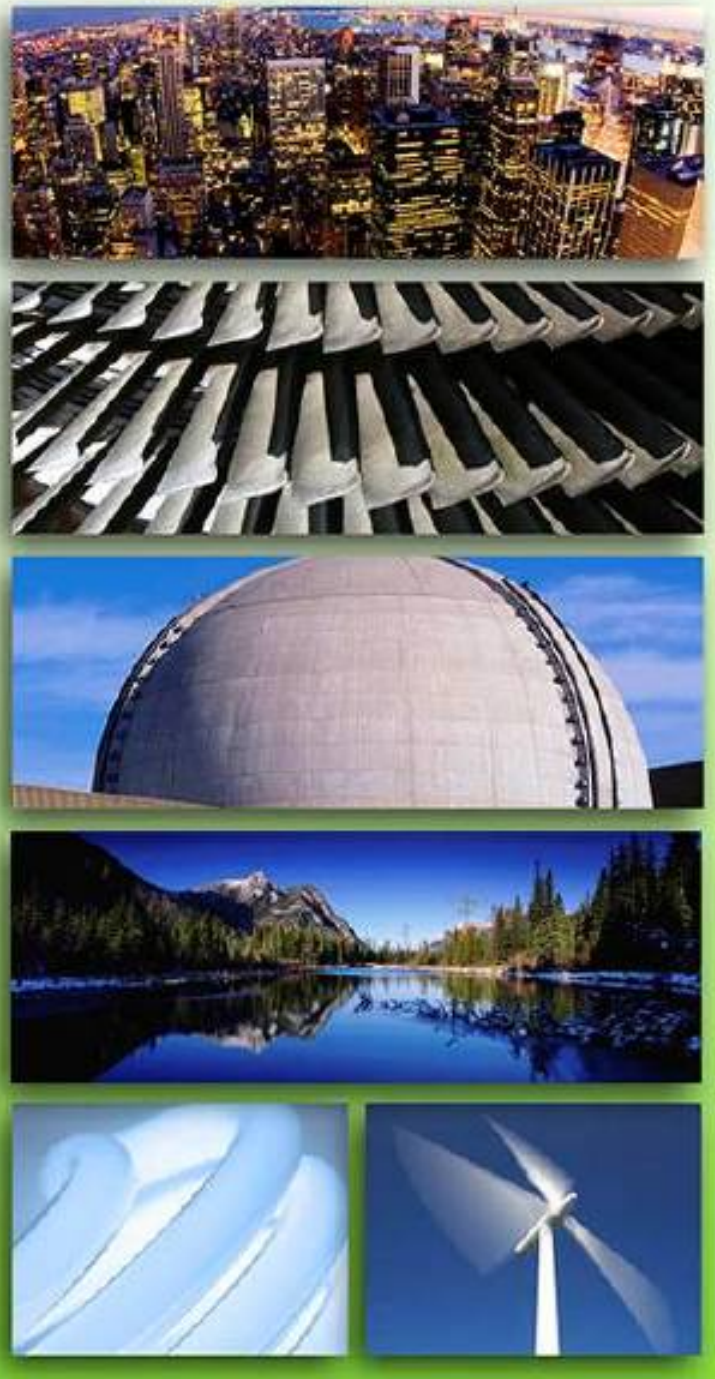
Image from *NASA Visible Earth*



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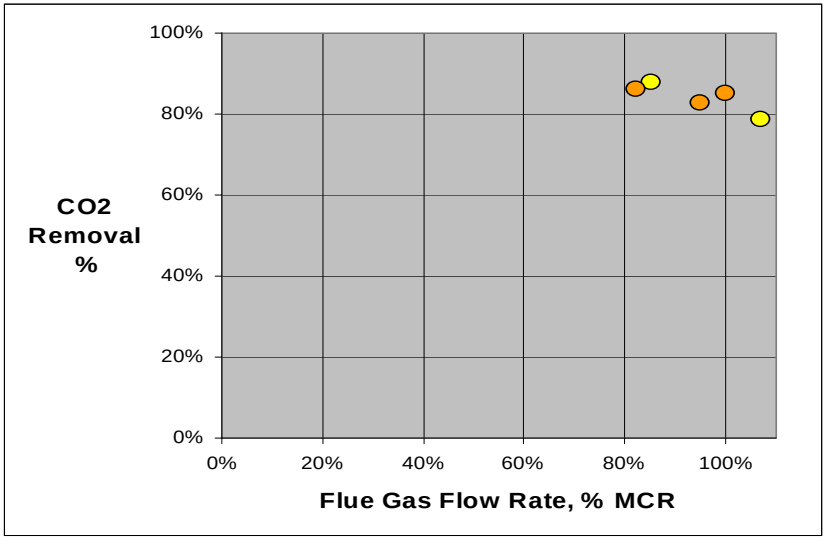
Industry / EPRI Demonstration Projects

Carbon Capture and Storage

Alstom / We-Energies / EPRI Chilled Ammonia Pilot

Achievements:

- High CO_2 removal ~90%
- High purity CO_2 ~99%
- Low ammonia emissions
- Energy use as predicted



Declared Success!!!

Pilot Concluded

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PC with CCS: AEP/Alstom

- ~20 MW capture module at AEP's Mountaineer plant. CO2 injection into on-site storage wells
- Mountaineer started capturing CO_2 on Sept 1 and injecting CO_2 on Oct 1
- Formal dedication October 30
- Several years of planned operation & testing

Alstom's Chilled Ammonia Process at AEP's Mountaineer Plant, 5-21-09

All pictures of the Mountaineer CO_2 Capture and Storage Project are the property of Alstom Power and/or AEP

PC with CCS: Southern/MHI

- ~25 MW capture module at Southern Company's Plant Barry (Alabama)
- MHI KS-1 advanced amine process
- Injection and storage test conducted by DOE "SECARB" regional partnership with EPRI technical leadership

Status

- Site characterization under way
- Start-up scheduled for 1Q 2011

Low-Cost Oxygen via Membrane Technology

DOE – Air Products - EPRI

- Progress to date
  - Initial testing of 0.5 tons O_2/day with over 600 days of cumulative operation
  - Initial testing of 1.0 ton O_2/day modules planned this year
  - **Engineering & design completed for 150 tons O_2/day test unit**