CO_2 Capture and Storage

AEP's Perspective

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Engineering Services

American Electric Power

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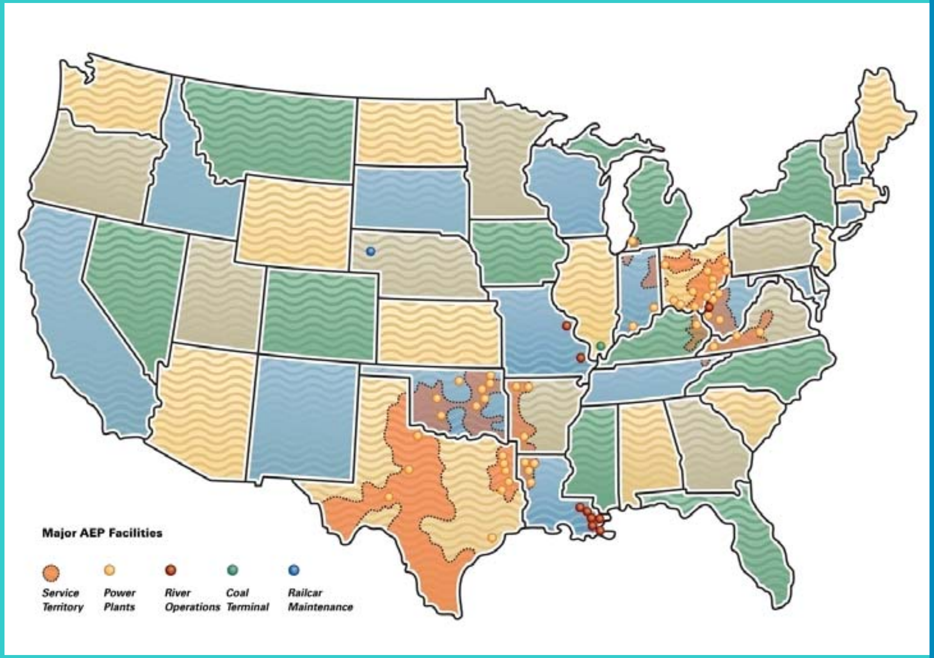
Strength & Scale in Assets & Operations

- 5.1 million customers in 11 states
- Industry-leading size and scale of assets:

Asset	Size	Industry Rank
Domestic Generation	~38,400 MW	# 2
Transmission	~39,000 miles	# 1
Distribution	~208,000 miles	# 1

Source: Company research & Resource Data International Platts, PowerDat 2005

- Coal & transportation assets:
  - Control over 8,000 railcars
  - Own/lease and operate over 2,600 barges & 51 towboats
  - Coal handling terminal with 20 million tons of capacity
- 20,000 employees



AEP Generation Portfolio				
Coal	**Gas**	**Nuclear**	**Hydro**	**Wind**
67%	**24%**	**6%**	**2%**	**1%**

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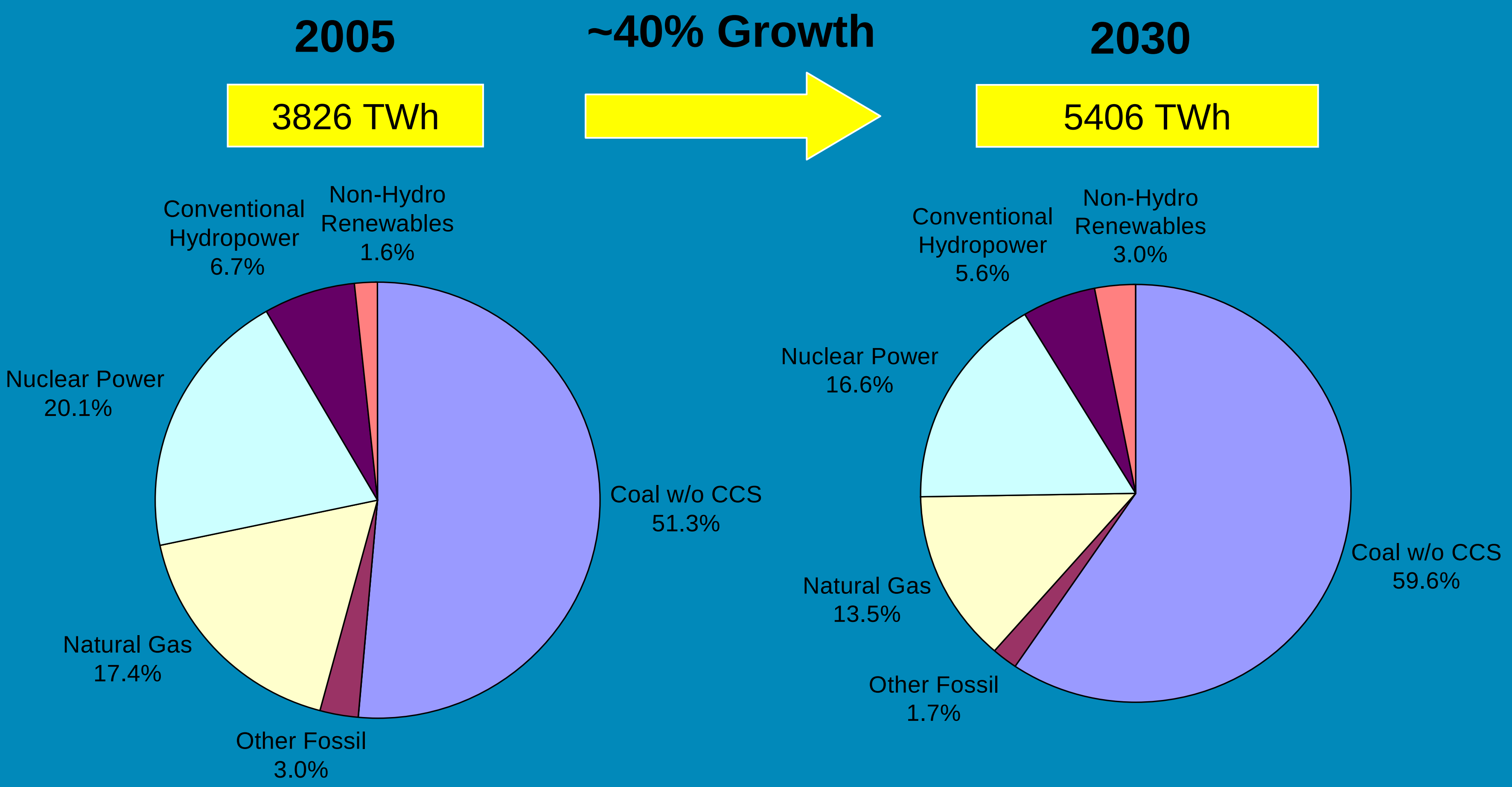
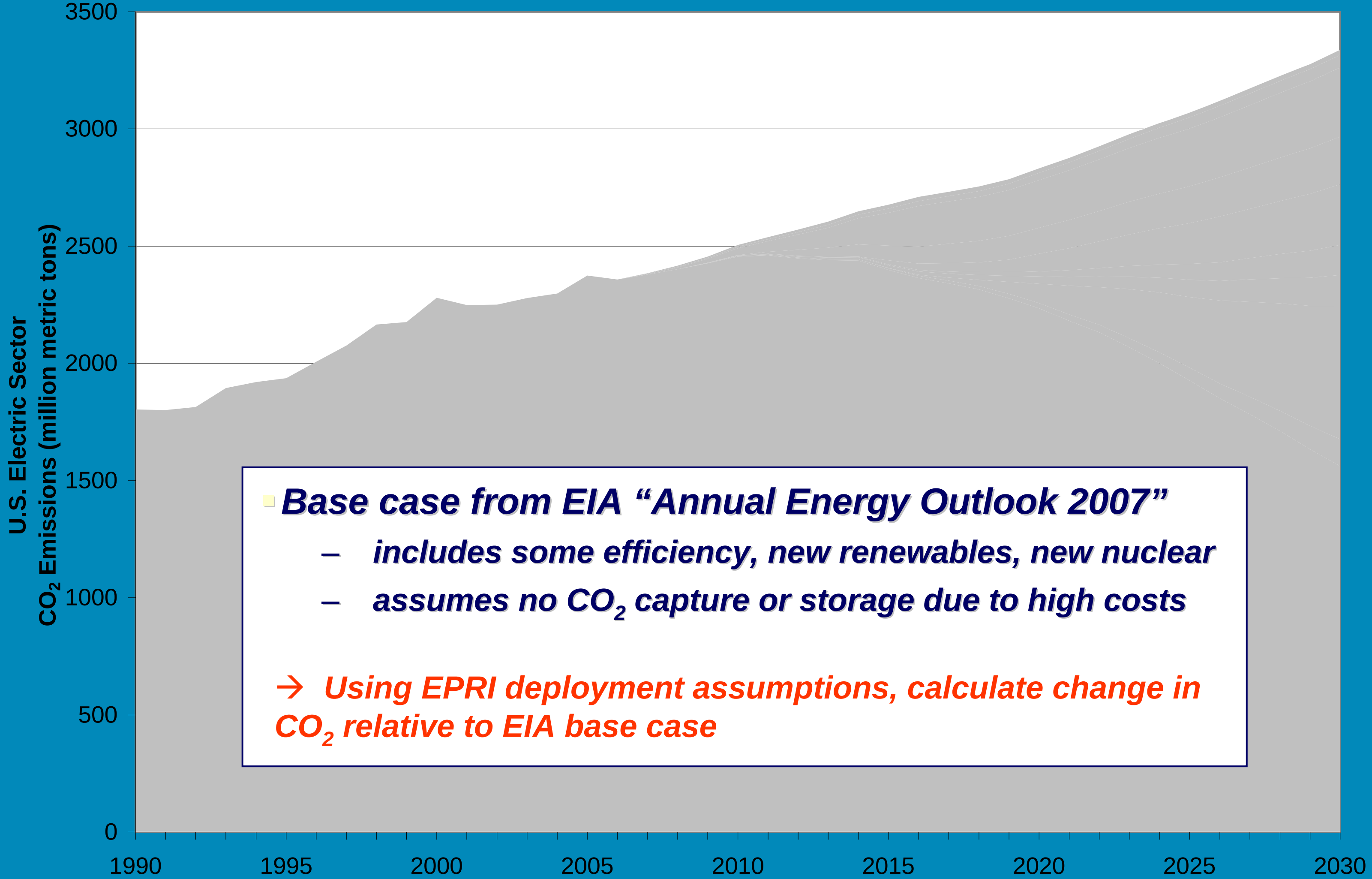
U.S. Electricity Generation Forecast*



** Base case from EIA "Annual Energy Outlook 2007"*

Forecasted U.S. Electricity Sector CO_2 Emissions



- ***Base case from EIA "Annual Energy Outlook 2007"***
  - ***includes some efficiency, new renewables, new nuclear***
  - ***assumes no CO_2 capture or storage due to high costs***

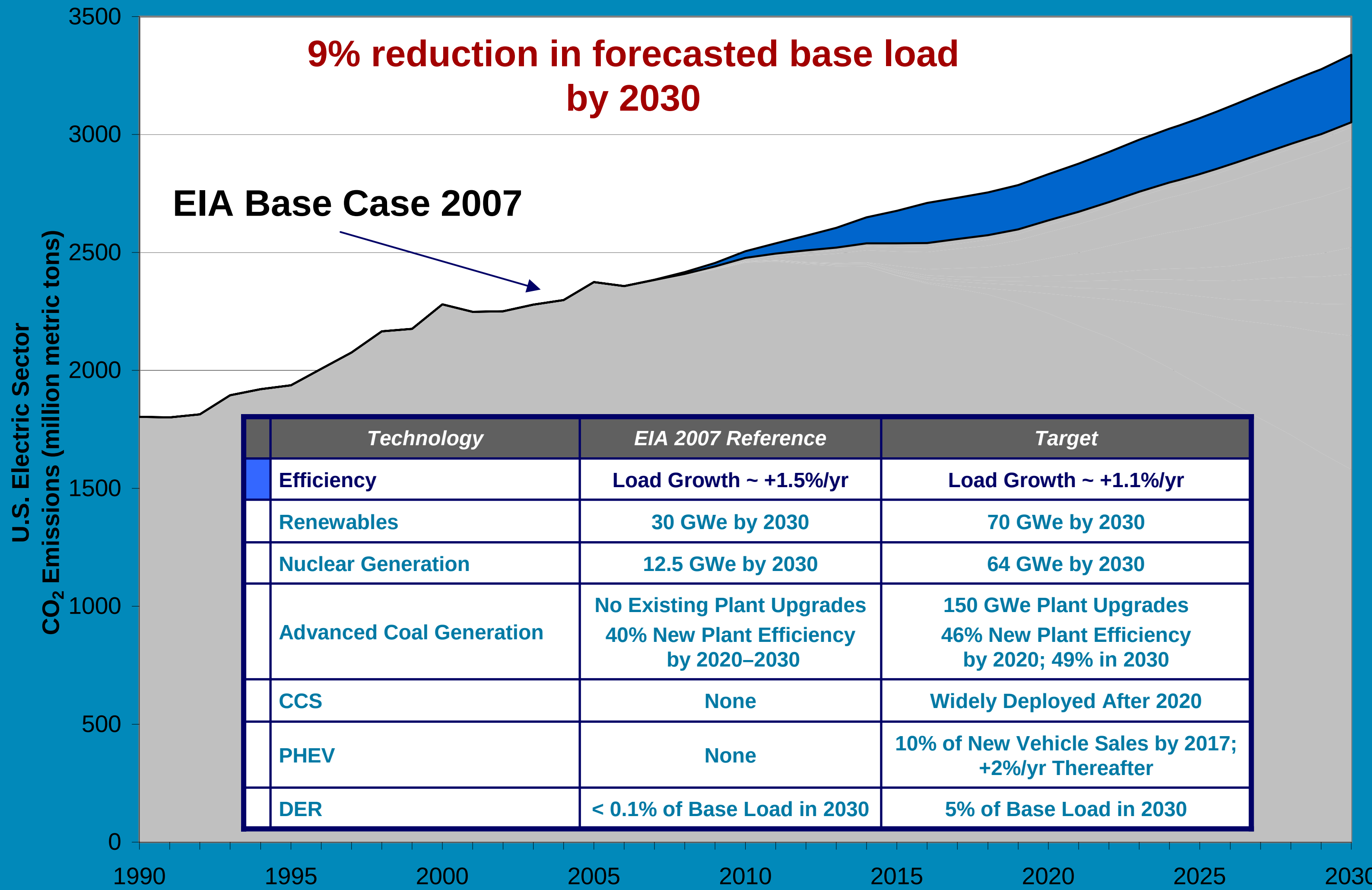
→ Using EPRI deployment assumptions, calculate change in CO_2 relative to EIA base case

EPRI Technology Deployment Targets

Technology	*EIA 2007 Base Case*	*EPRI Analysis Target**
Efficiency	Load Growth ~ +1.5%/yr (includes historic rate of efficiency improvement)	Load Growth ~ +1.1%/yr (doubles rate of historic efficiency improvements)
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



	Technology	EIA 2007 Reference	Target
	Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
	Renewables	30 GWe by 2030	70 GWe by 2030
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	CCS	None	Widely Deployed After 2020
	PHEV	None	10% of New Vehicle Sales by 2017; +2%/yr Thereafter
	DER	< 0.1% of Base Load in 2030	5% of Base Load in 2030

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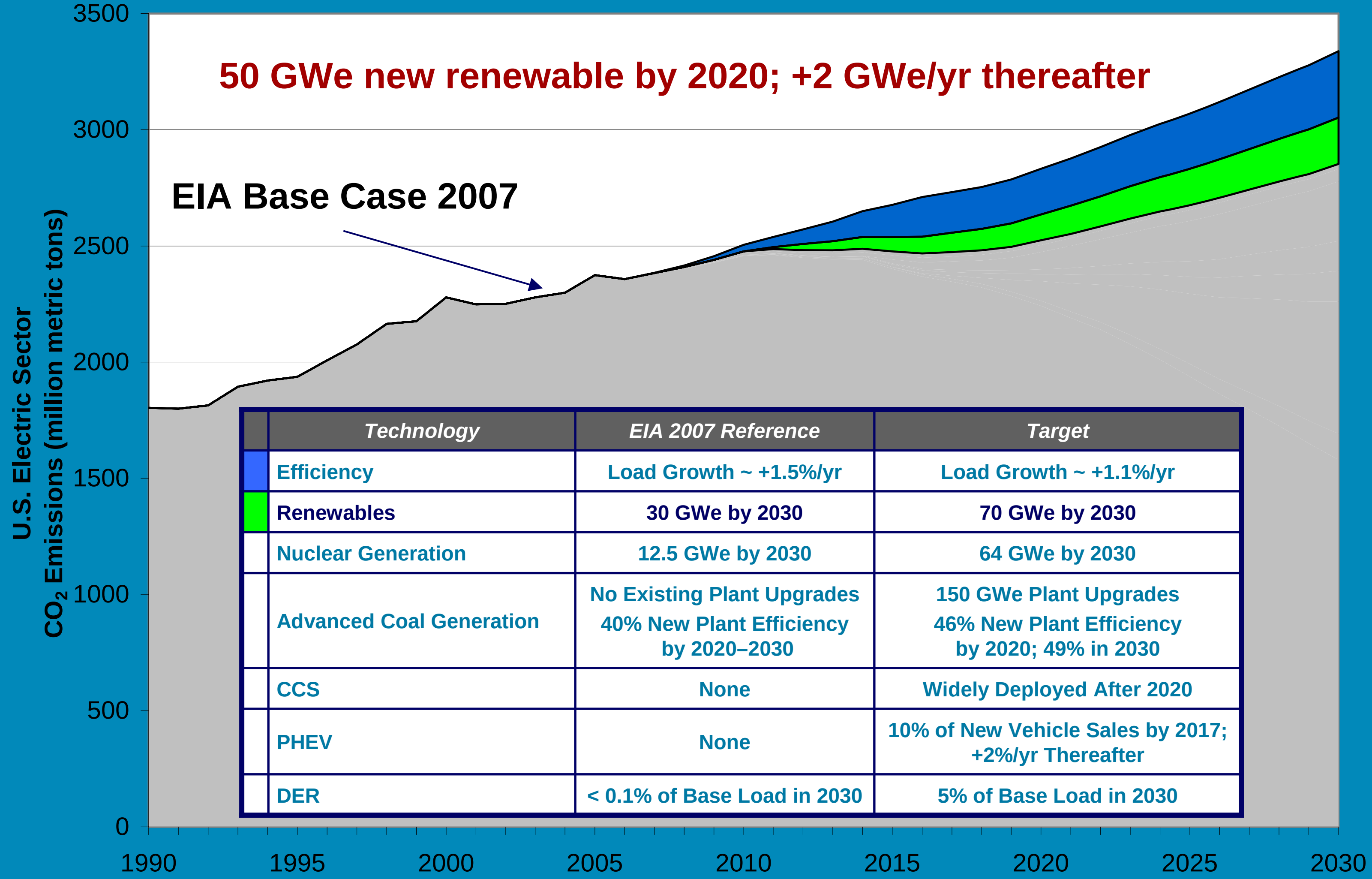
Benefit of Achieving Renewables Target



	Technology	EIA 2007 Reference	Target
	Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
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	PHEV	None	10% of New Vehicle Sales by 2017; +2%/yr Thereafter
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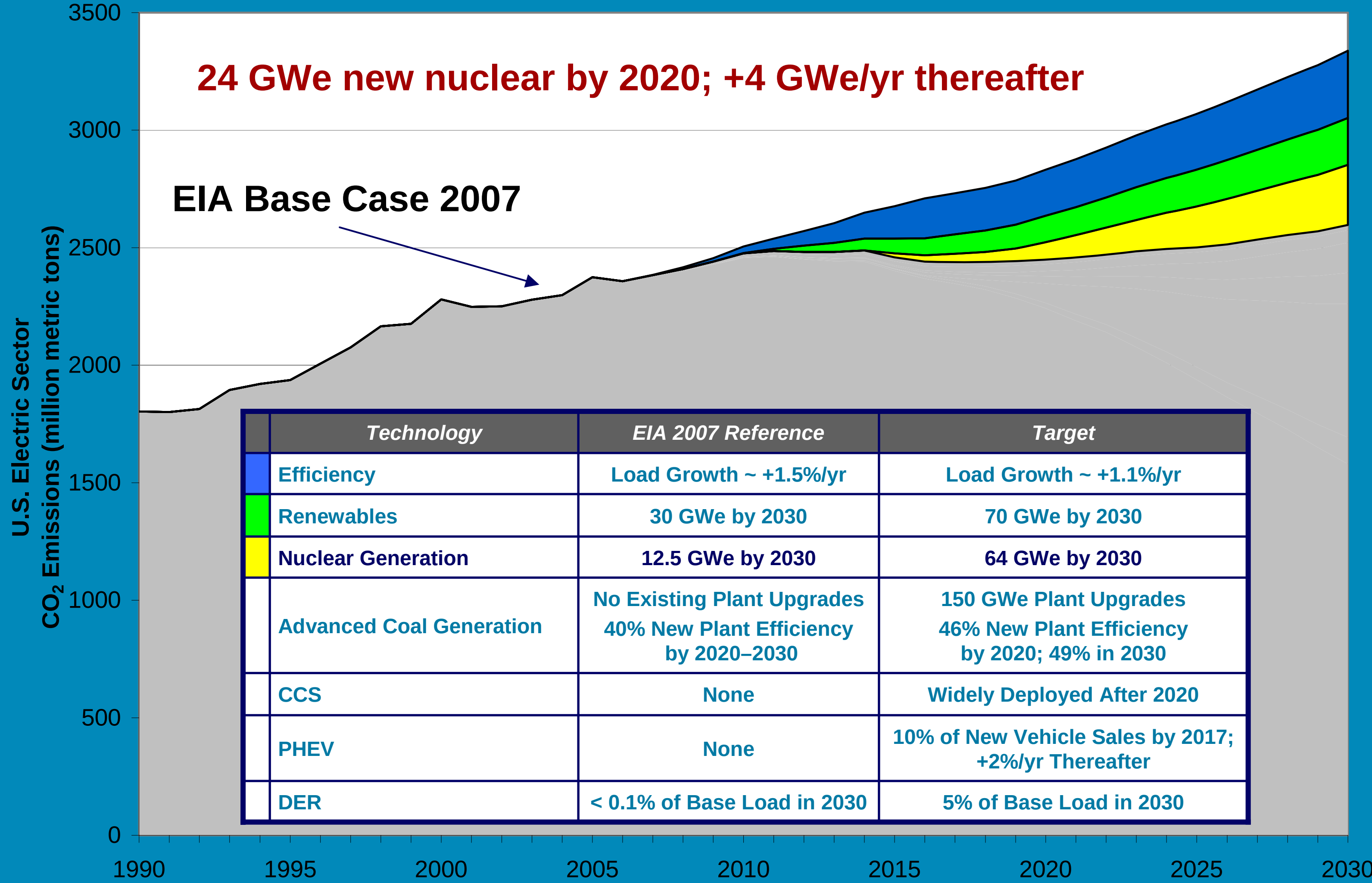
Benefit of Achieving Nuclear Generation Target



	Technology	*EIA 2007 Reference*	*Target*
(blue)	Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
(green)	Renewables	30 GWe by 2030	70 GWe by 2030
(yellow)	**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
	CCS	None	Widely Deployed After 2020
	PHEV	None	10% of New Vehicle Sales by 2017; +2%/yr Thereafter
	DER	< 0.1% of Base Load in 2030	5% of Base Load in 2030

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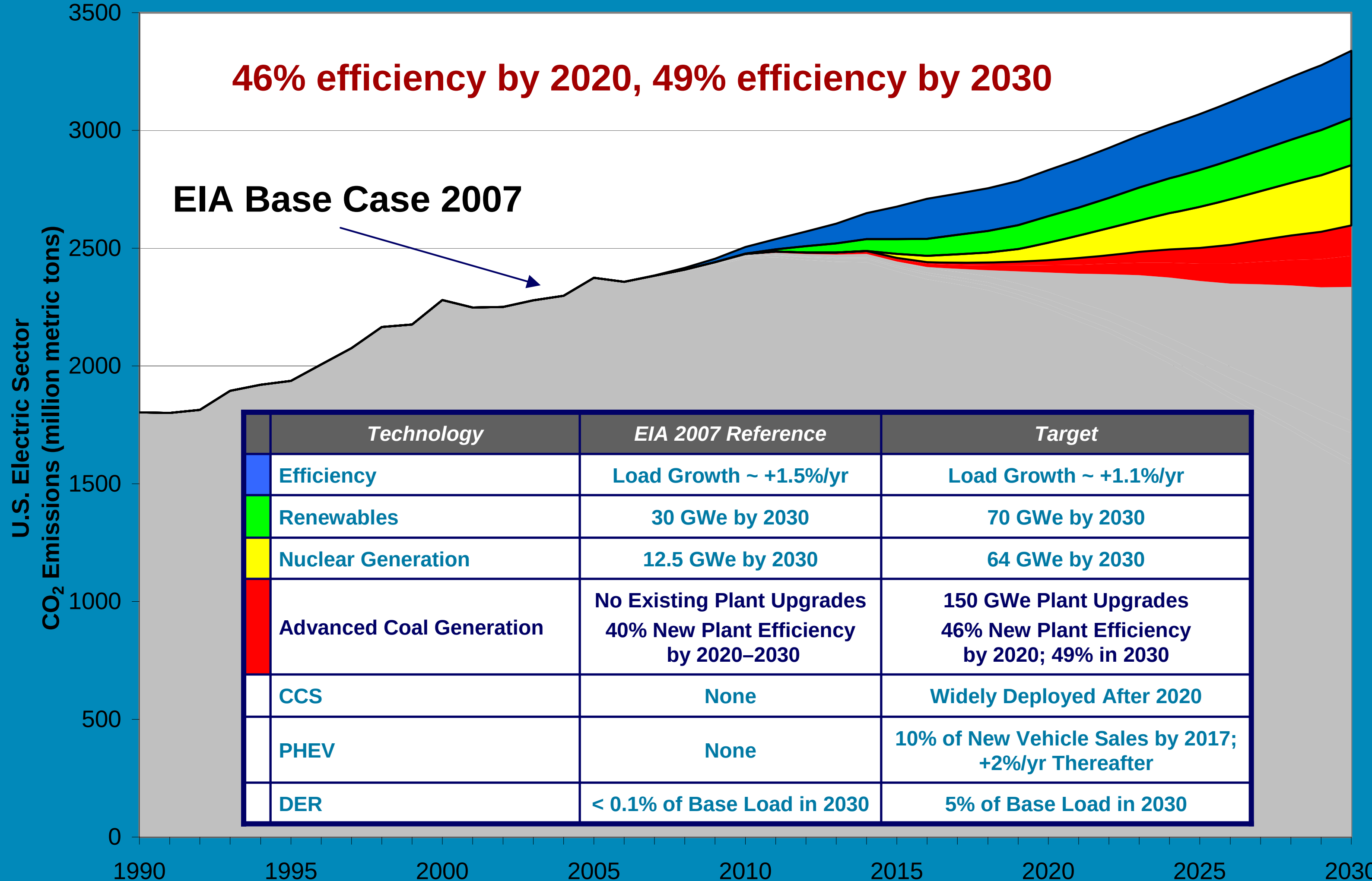
Benefit of Achieving Advanced Coal Generation Target



	Technology	EIA 2007 Reference	Target
	Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
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	PHEV	None	10% of New Vehicle Sales by 2017; +2%/yr Thereafter
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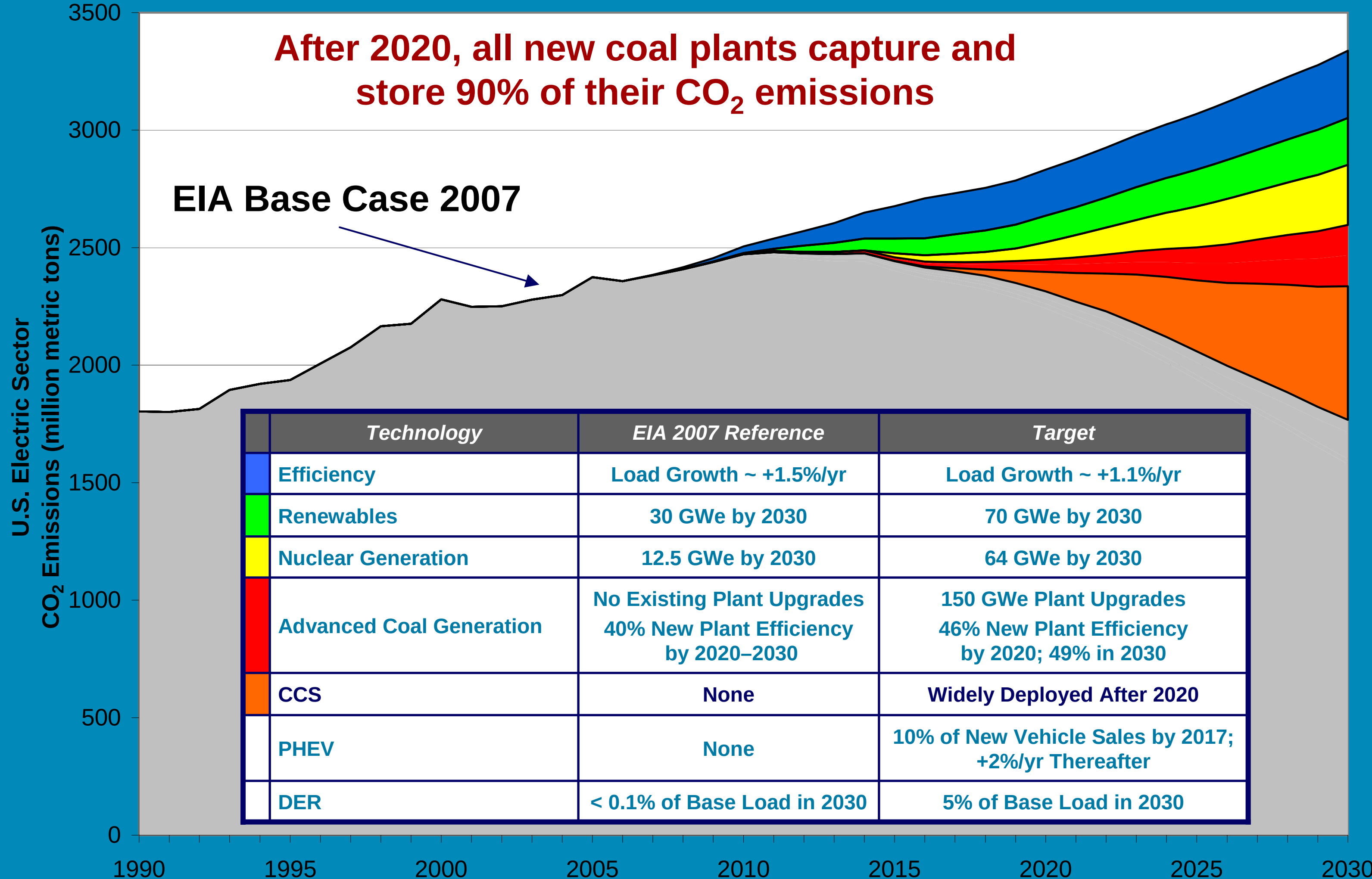
Benefit of Achieving the CCS Target



	Technology	*EIA 2007 Reference*	*Target*
Blue	Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
Green	Renewables	30 GWe by 2030	70 GWe by 2030
Yellow	Nuclear Generation	12.5 GWe by 2030	64 GWe by 2030
Red	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
Orange	CCS	None	Widely Deployed After 2020
	PHEV	None	10% of New Vehicle Sales by 2017; +2%/yr Thereafter
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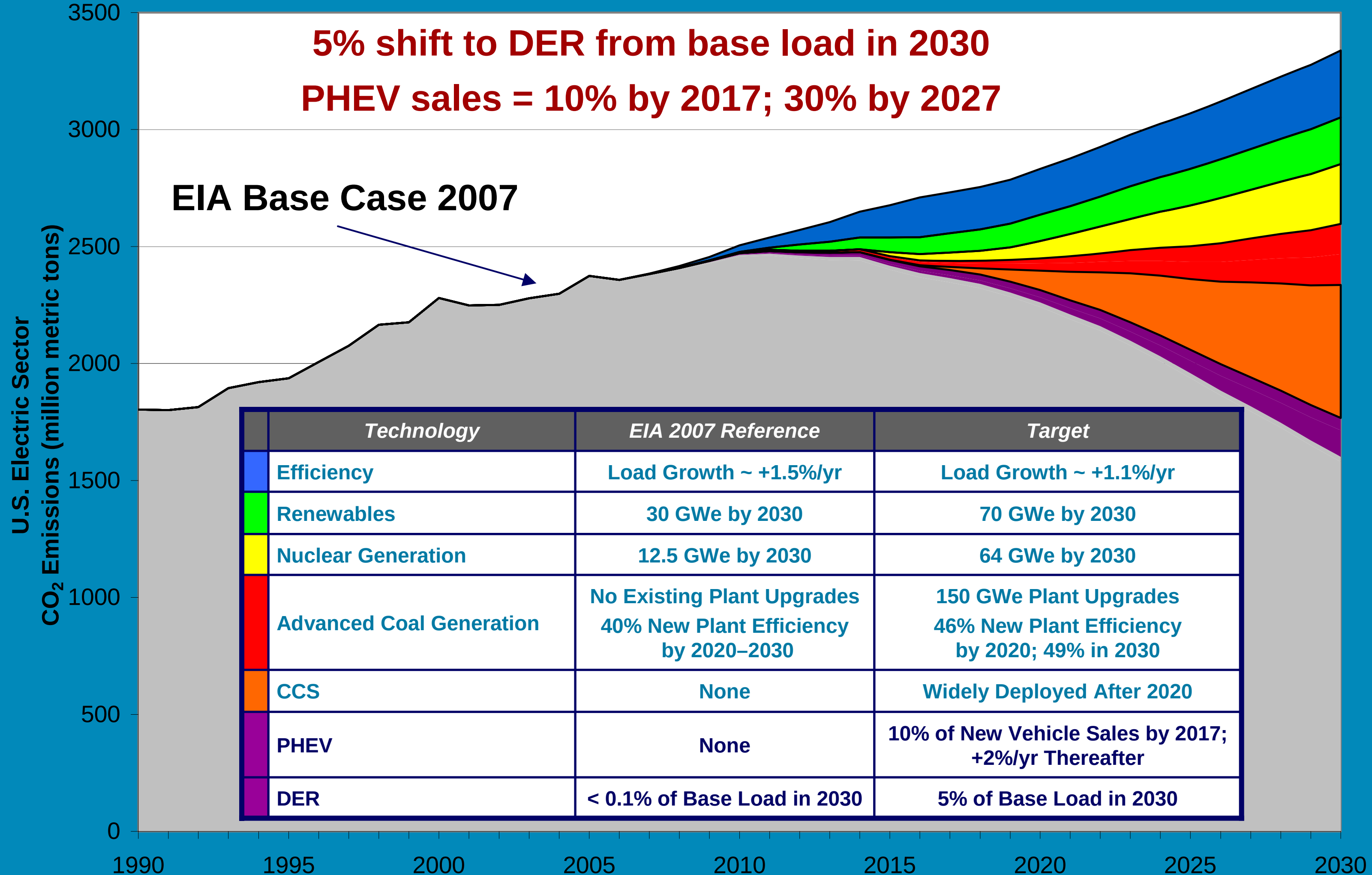
Benefit of Achieving PHEV and DER Targets



	Technology	EIA 2007 Reference	Target
	Efficiency	Load Growth ~ +1.5%/yr	Load Growth ~ +1.1%/yr
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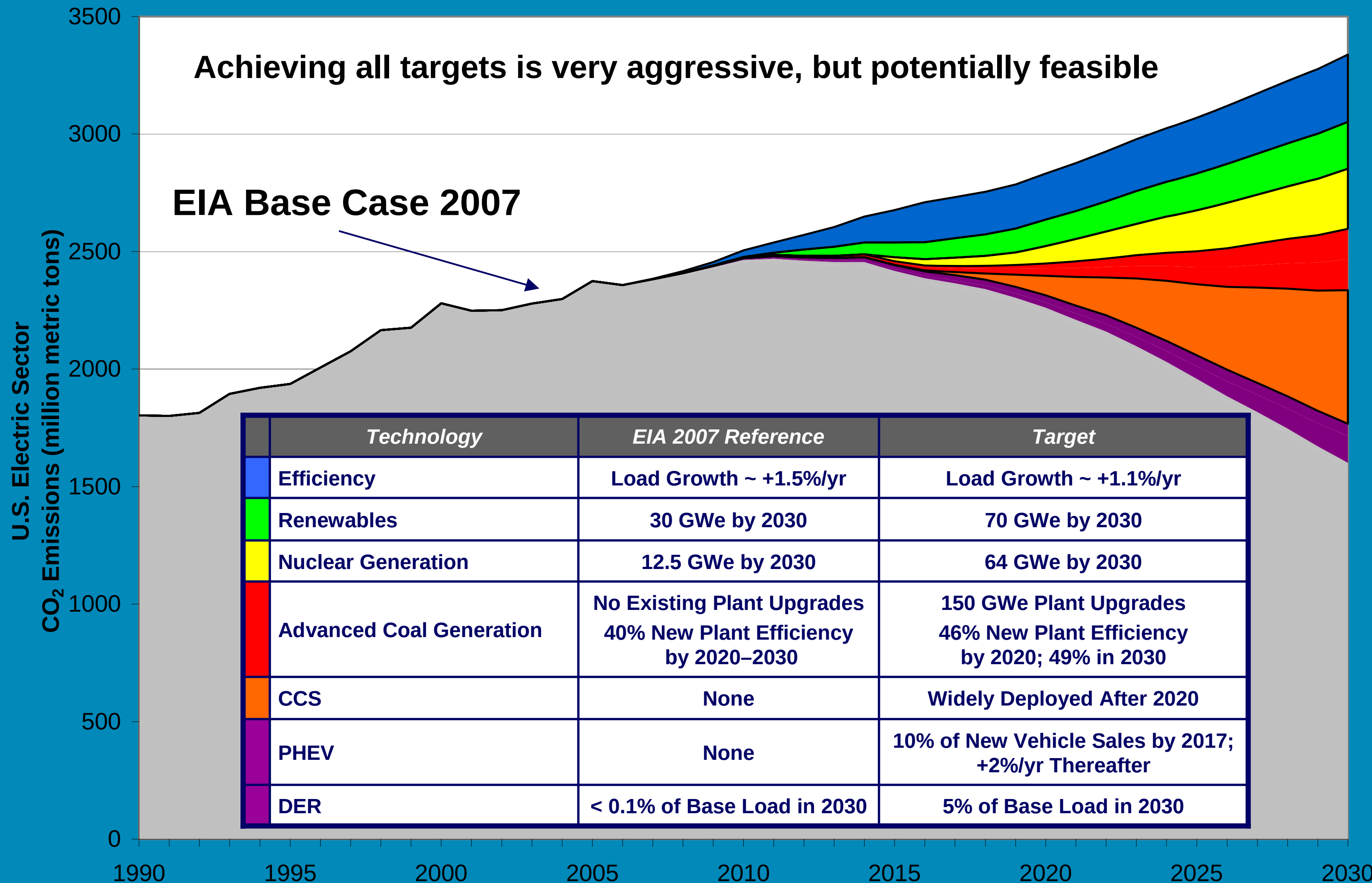
EPRI CO_2 Reduction "Prism"



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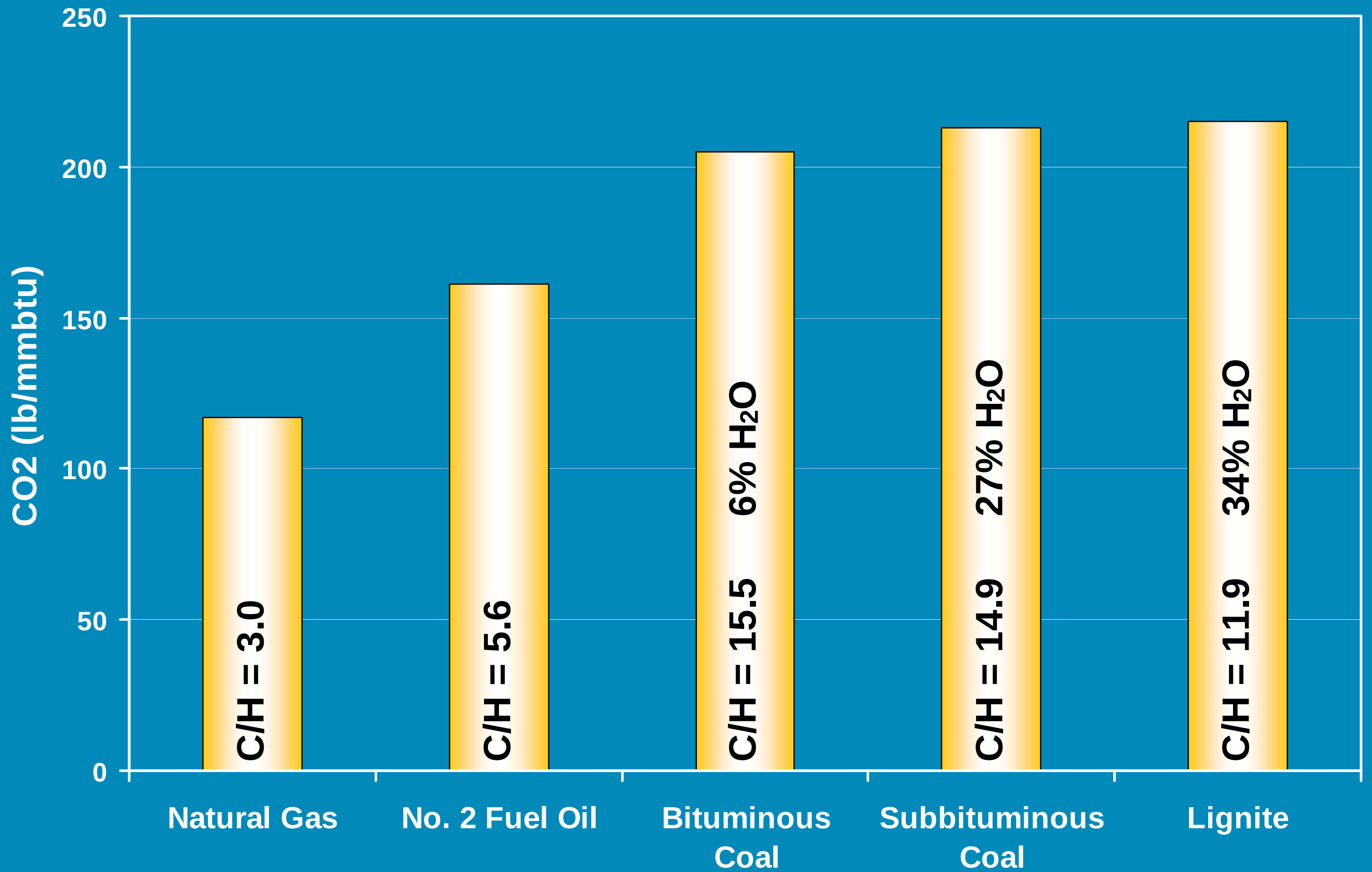
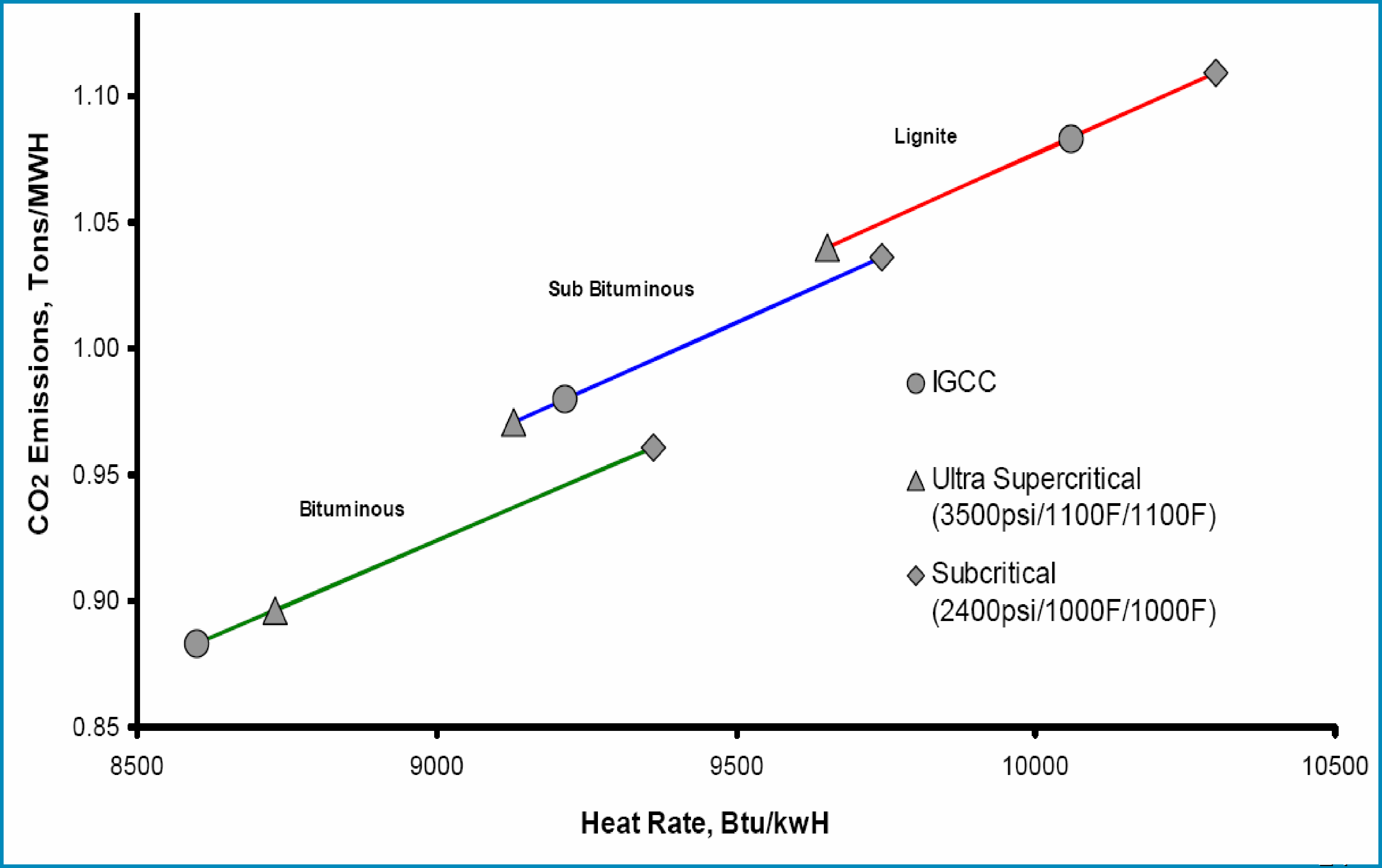
Fuels and CO_2 Emission Rates

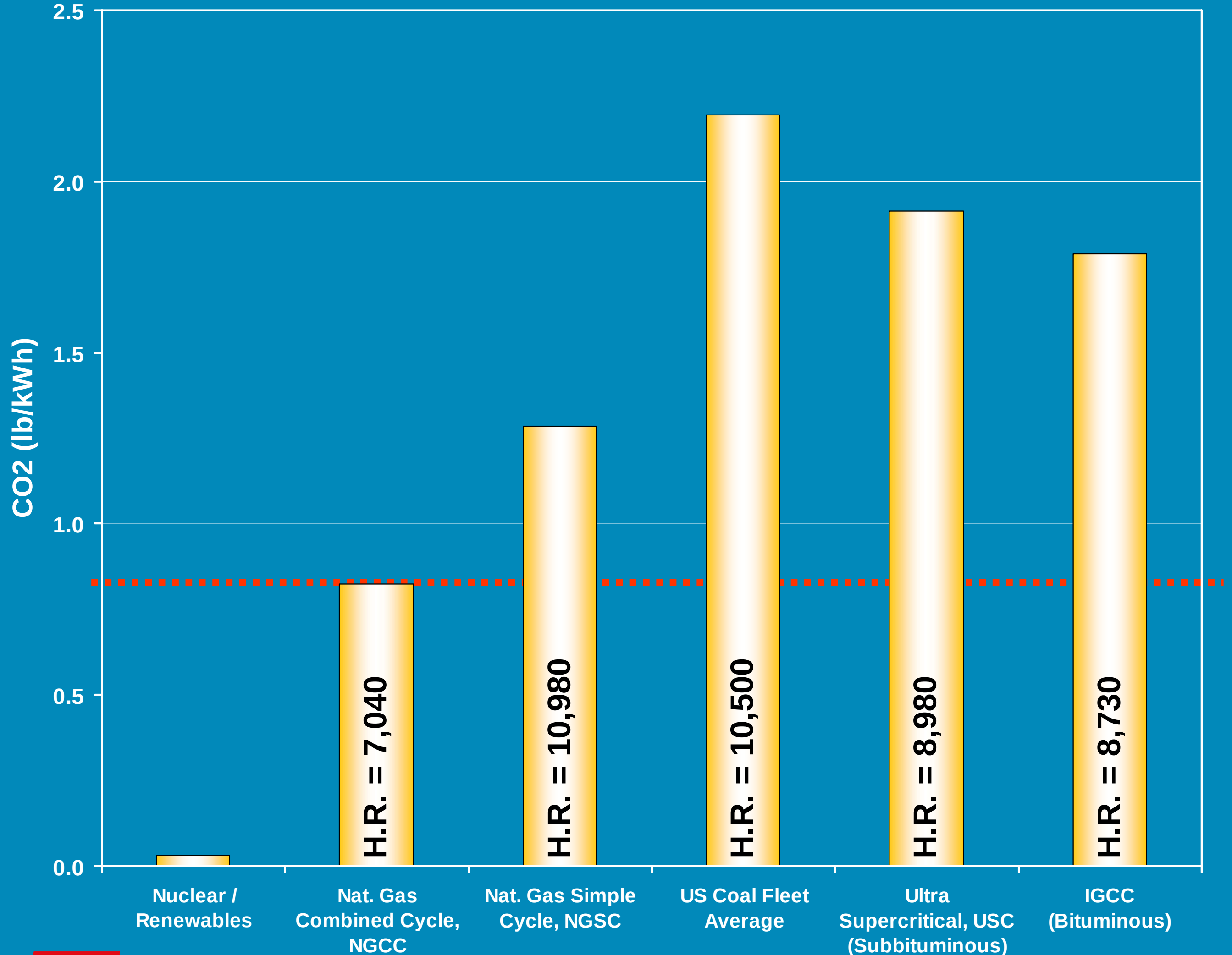


Note: C/H is the mass ratio of carbon to hydrogen

Coal Technology Efficiency and CO_2 Emission Rates



Carbon Intensity for Different Systems



CO_2 Reduction Necessary to Achieve NGCC Emission Levels

- NGSC – **36%**
- US Coal Fleet – **62%**
- USC/IGCC (subbitum) – **57%**
- IGCC/USC (bituminous) – **54%**

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Note: "H.R." = Heat Rate (efficiency). Values represent typical heat rates, used here for illustrative purposes only.

CO_2 Capture Techniques

- Post-Combustion Capture – Existing Units & Possible on New Units
  - Conventional or Advanced Amines, Chilled Ammonia
  - *Key Points*
    - Amine technologies commercially available in other industrial applications
    - Relatively low CO_2 concentration in flue gas – More difficult to capture
    - High parasitic demand – reduced unit output
      - Conventional Amine ~25-30%, Chilled Ammonia target ~10-15%
    - Amines are require **very** clean flue gas
- Modified-Combustion Capture – Oxy Coal Firing
  - *Key Points*
    - Technology not yet proven at commercial scale
    - Creates stream of very high CO_2 concentration
    - High parasitic demand, >25%
- Pre-Combustion Capture
  - IGCC with Water-Gas Shift – FutureGen Design
  - *Key Points*
    - Most of the processes commercially available in other industrial applications
      - Have never been integrated together
    - Turbine modified for H_2-based fuel, which has not yet been proven at commercial scale
    - Creates stream of very high CO_2 concentration
    - Parasitic demand (~20%) for CO_2 capture - lower than amine or oxy-coal options

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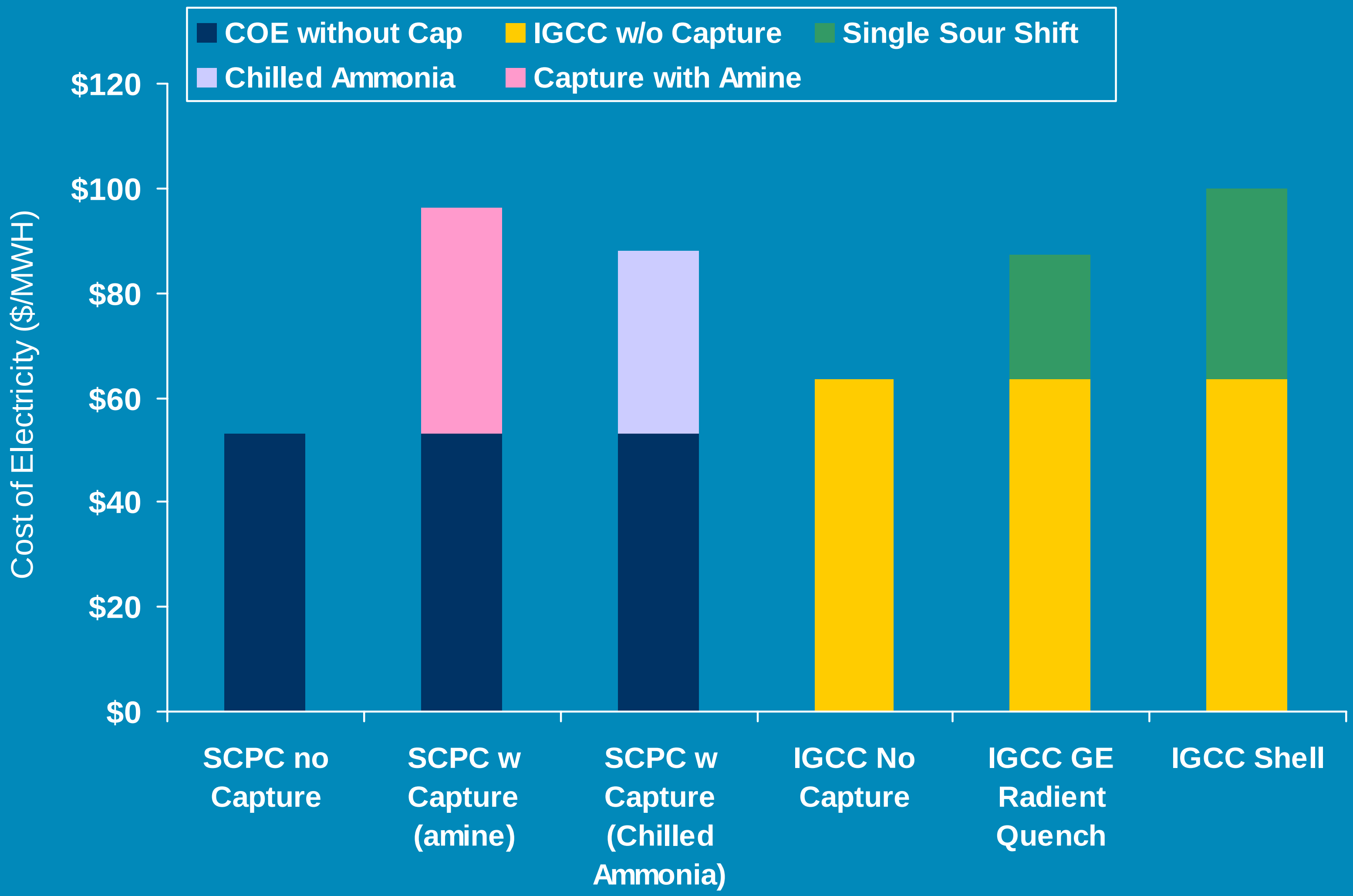
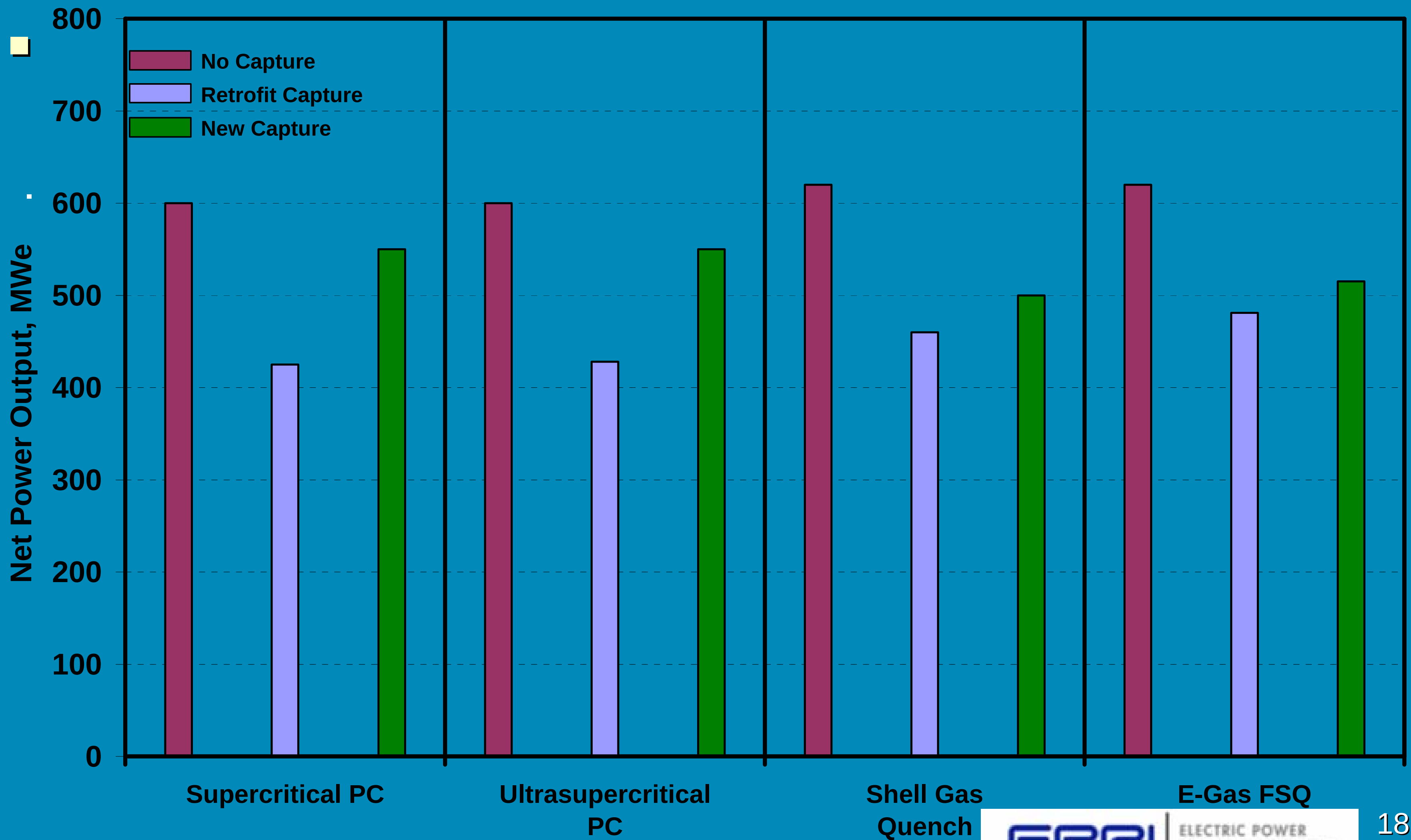
Approximate Cost of Electricity for SCPC and IGCC without and with 90% Carbon Capture[1]



Source
1. Updated Cost and Performance Estimates for Clean Coal Technologies Including CO_2 Capture – 2006, EPRI, Technical Update,# 1013355, March 2007.

EPRI PC and IGCC Net Power Output With and Without CO_2 Capture (PRB Coal)



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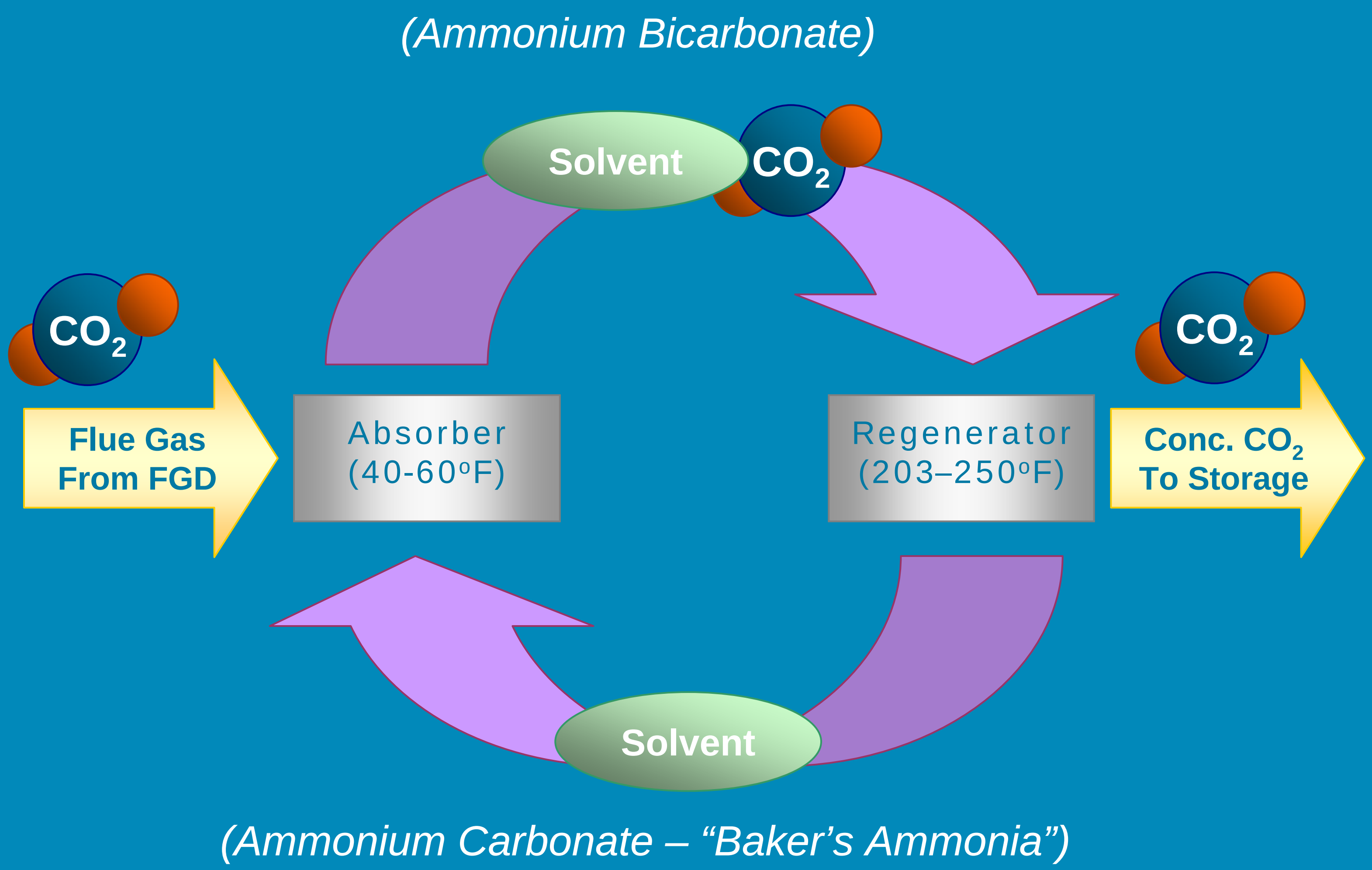
Alstom's Chilled Ammonia Process

Post-Combustion Capture



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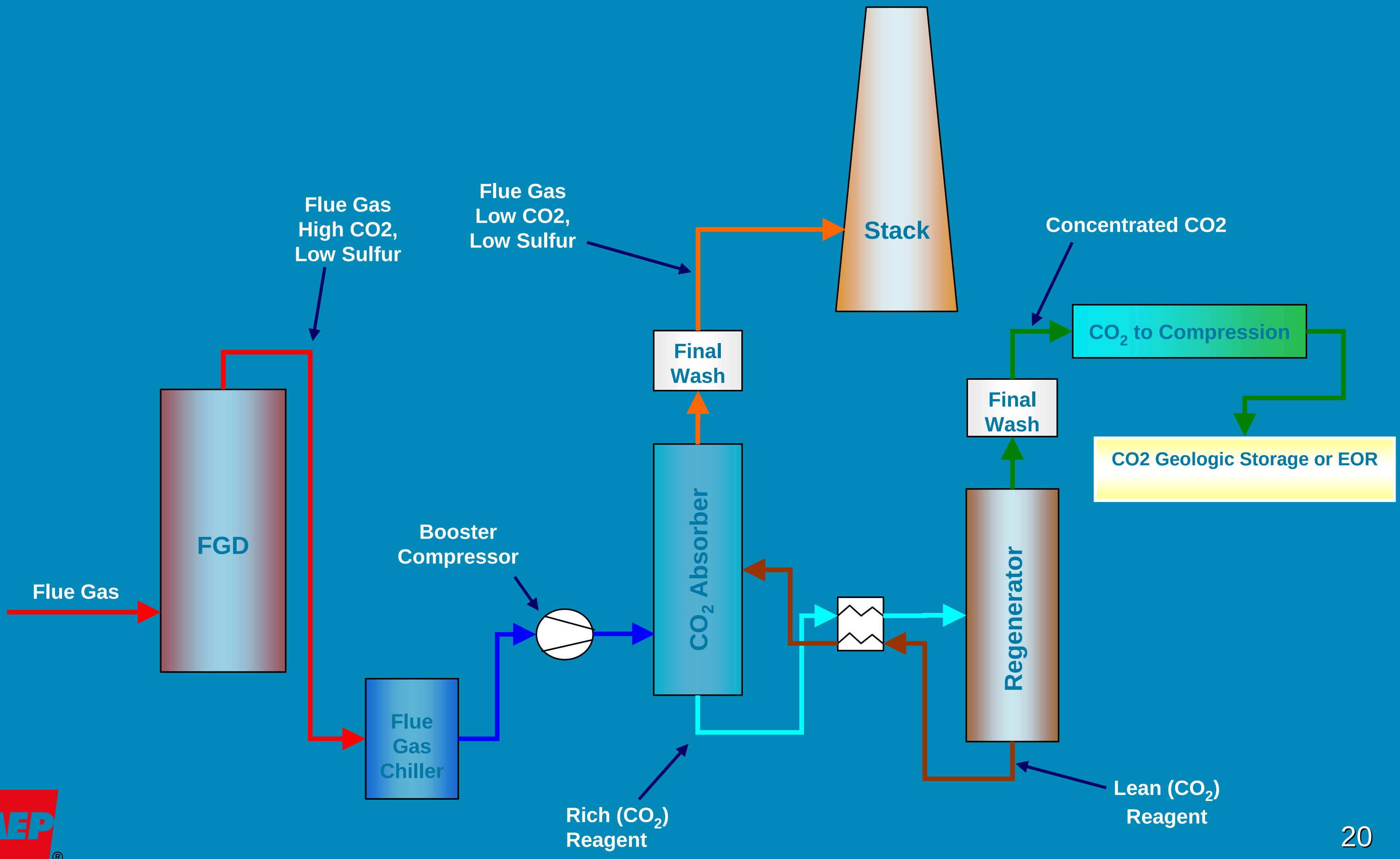
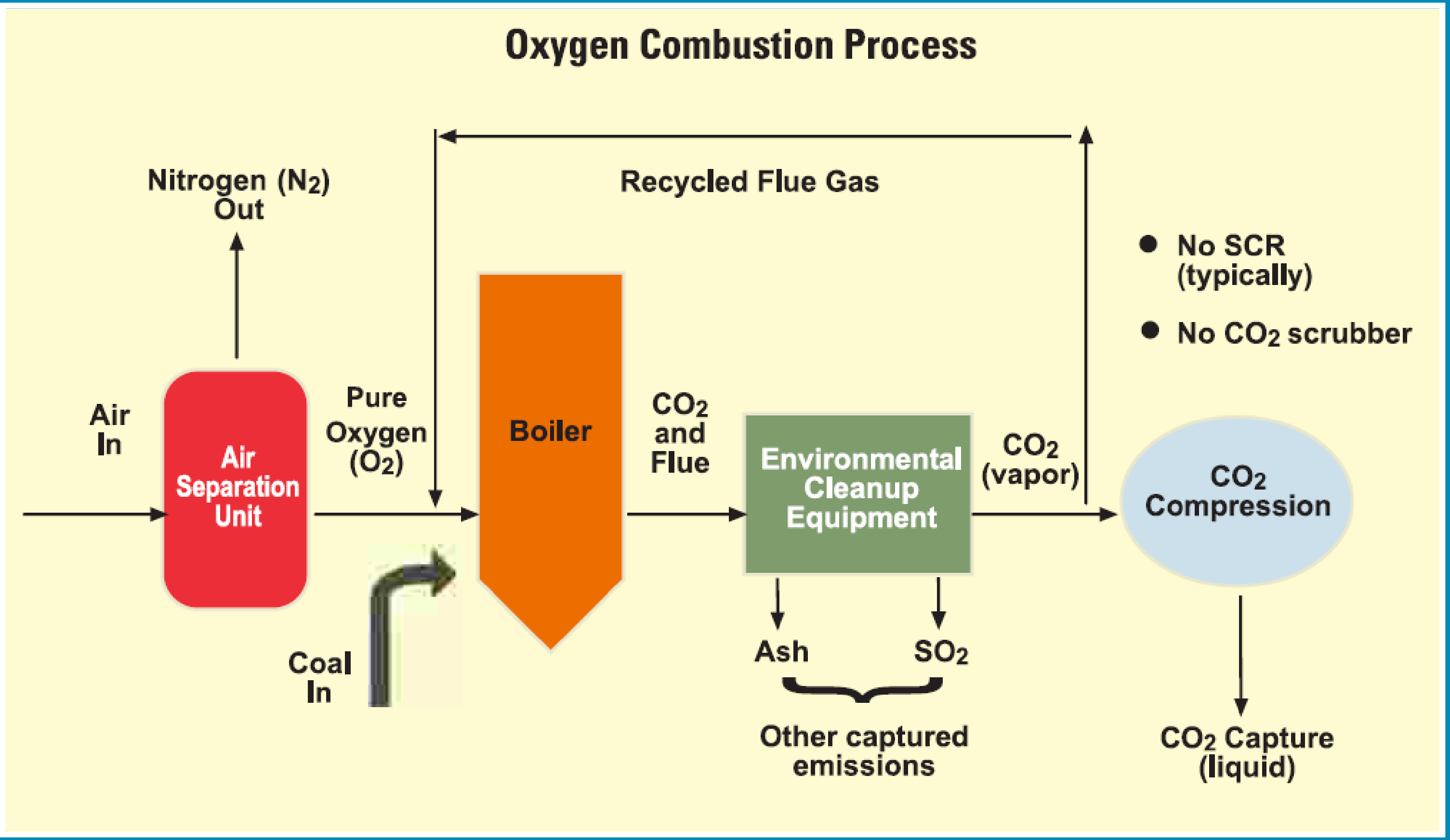
Post-Combustion Capture



B&W's Oxy-Coal Process

Modified Combustion Capture



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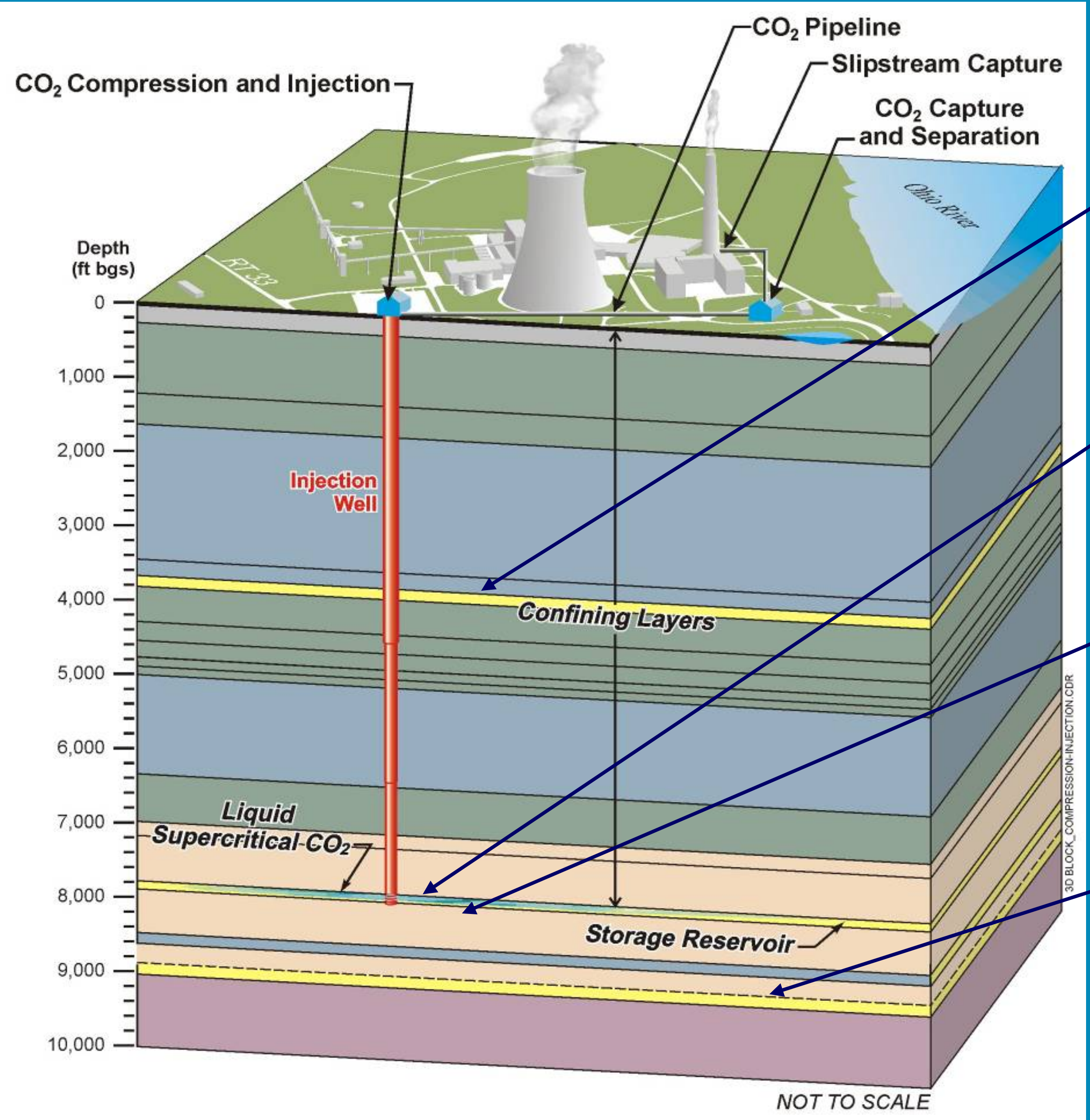
CO_2 Injectivity in the Mountaineer Area



CO_2 injection should also be possible in shallower sandstone and carbonate layers in the region

Rose Run Sandstone (~7800 feet) is a regional candidate zone in Appalachian Basin

A high permeability zone called the "B zone" within Copper Ridge Dolomite has been identified as a new injection zone in the region

Mount Simon Sandstone/Basal Sand - the most prominent reservoir in most of the Midwest but not desirable beneath Mountaineer site

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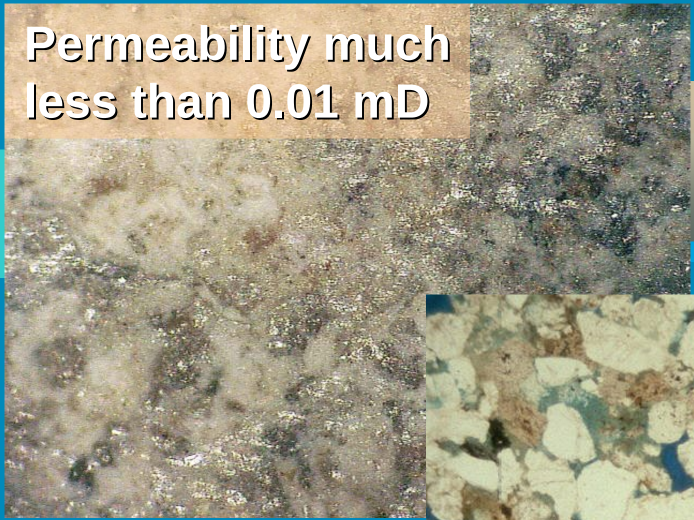
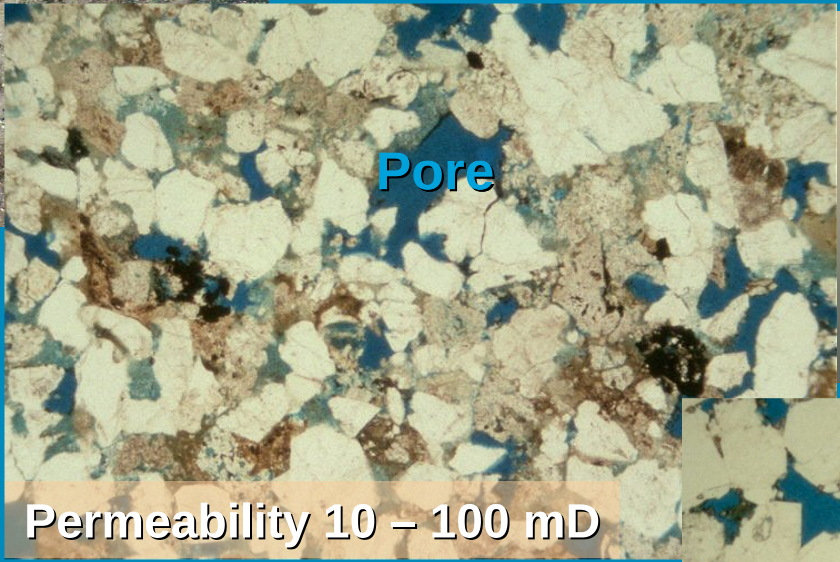
The Business of Innovation

Battelle
The Business of Innovation

Sedimentary Rocks
A Microscopic View

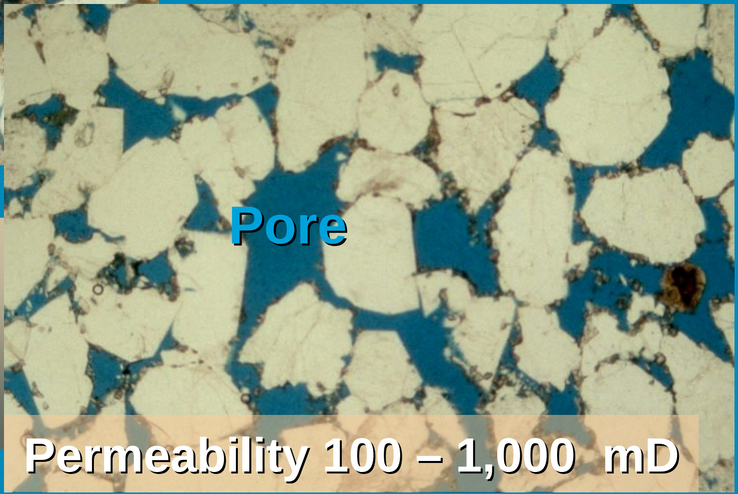


Shale with Extremely Low Permeability Forms Good Caprock

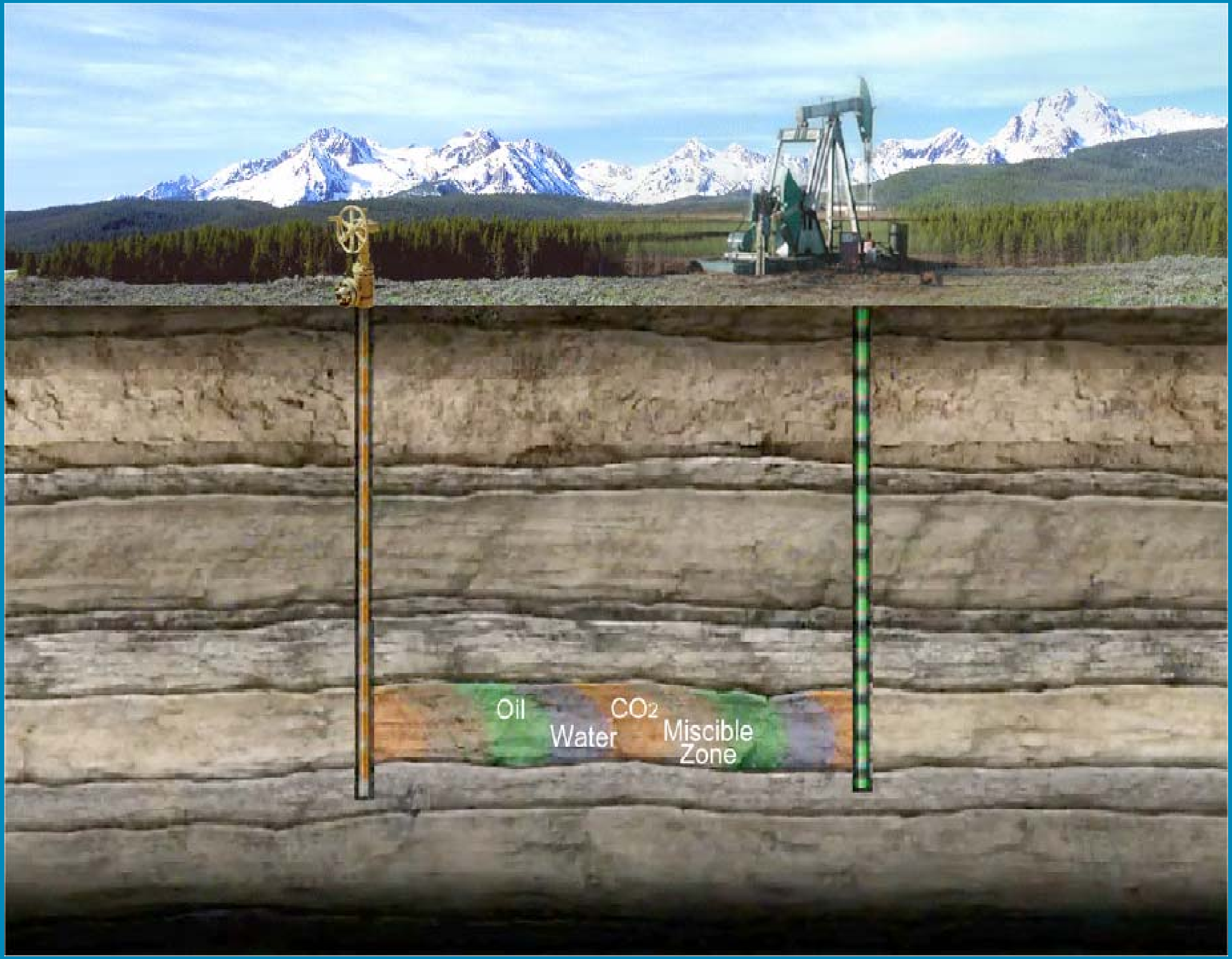


Sandstone with Medium Permeability Forms Good Host Reservoir Medium Cost

Sandstone with High Permeability Forms Excellent Host Reservoir at Low Cost



Enhanced Oil Recover (EOR)



Graphic courtesy of USDOE National Energy Technology Laboratory

CO_2 Storage Key Points

- Will require multiple wells
  - Very geology-dependent
    - A 500 MW power plant could require a dozen or more wells at a spacing of several thousand feet or more
- Deep saline vs. EOR
  - Deep Saline = Permanent storage
  - EOR => CO_2 recycle and store…how much stays put?
- Challenges with storage
  - Not yet proven in large , long-term scale
  - Capacity and injection rates very site-specific
  - Long-term liability and legal ownership are points not yet resolved on federal or state level

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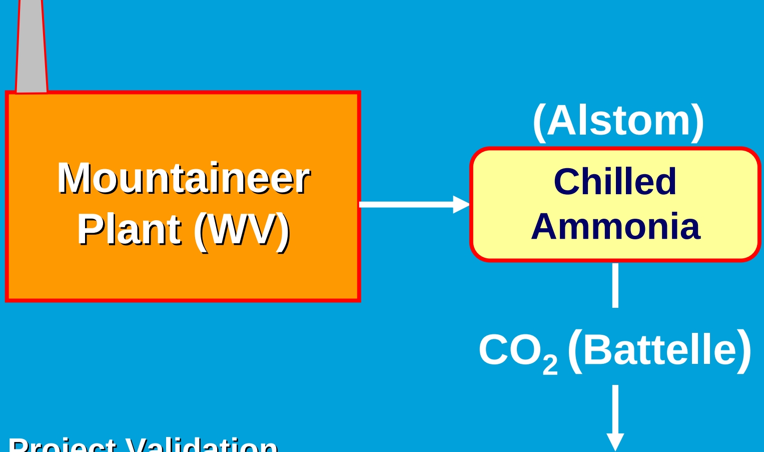
Chilled Ammonia Technology Program

Phase 1
2009 Commercial Operation

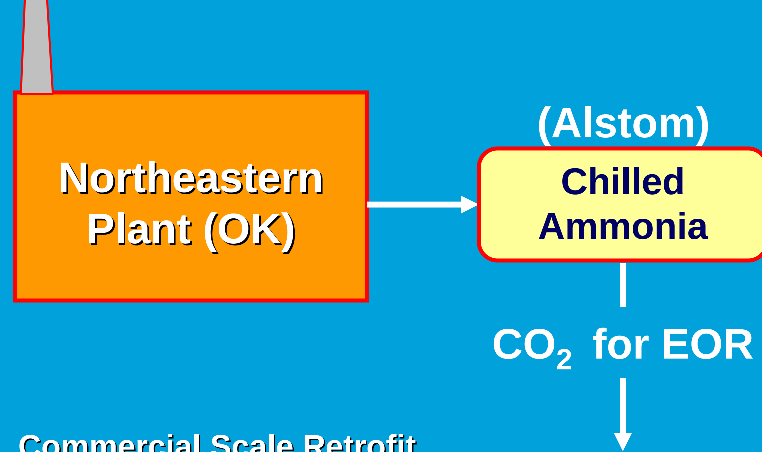


Project Validation

- 20 MW_e (megawatts electric) scale (a scale up of Alstom/EPRI 5 MW_t (megawatts thermal) field pilot, under construction at WE Energies)
- ~100,000 tonnes CO_2 per year
- In operation 2Q 2009
- Approximate total cost $80 – $100M
- Using Alstom "Chilled Ammonia" Technology
- Located at the AEP Mountaineer Plant in WV
- CO_2 for geologic storage

Phase 1 will capture and sequester 100,000 metric tons of CO2 / year

Phase 2
2012 Commercial Operation



Commercial Scale Retrofit

- ~ 200 MW_e scale (megawatt electric)
- ~1.5MM tonnes CO_2 per year
- In operation 2012
- Approx. capital $250 – $300M ($CO_2$ capture & compression)
- Approx. O&M cost $12M per year
- Retrofit NOx Controls and Wet FGD Required: ~$225 – $300M (required for CO_2 capture equipment)
- Located at AEP's Northeastern Plant Unit 3 or 4 in Oklahoma
- CO_2 for Enhanced Oil Recovery (EOR) or geologic storage

Phase 2 will capture and sequester 1.5 Million metric tons CO2 / year

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Oxy-Coal CO_2 Capture & Storage Project

Demonstration Scale

- 10 MW_e scale
- Teamed with B&W's Alliance Research Center and 16 other utilities
- Demo completion 4Q 2007
- AEP funding of $50k

Commercial Scale

- Retrofit on existing AEP sub-critical unit (several available)
- 150 – 230 MW_e scale retrofit
- 4,000 – 5,000 tons CO_2 per day
- Teamed with B&W
- AEP funding of ~ $200k – $3M for feasibility study
- Feasibility study completed 2Q 2008

Combustion conversion technology for existing coal fleet -- longer lead time with enhanced viability and long-term potential

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CHILLED AMMONIA PROCESS

POWER SYSTEMS ALSTOM

Questions ?