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# Electricity Technology in a Carbon-Constrained World

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# Presentation Objective

Provide a factual framework for discussing:

I. Generation technologies and investment decisions in a world with carbon-constraints

II. R&D needs to achieve a low-cost, low-carbon portfolio of electricity technologies

III. Technical feasibility of using these technologies to reduce U.S. electric sector $CO_2$ emissions

# Example: Coal Generation

Levelized Cost of Electricity, $/MWh

2010 - 2015

IGCC

PC

Adjust for $CO_2$ costs:
0.8 Tons $CO_2$/MWh X $50/Ton = +$40/MWh

Determine LCOE
(capital cost, O&M, fuel)

*Rev. 1Q2007*

120
110
100
90
80
70
60
50
40
30

0
10
20
30
40
50

Cost of $CO_2$, $/Metric Ton





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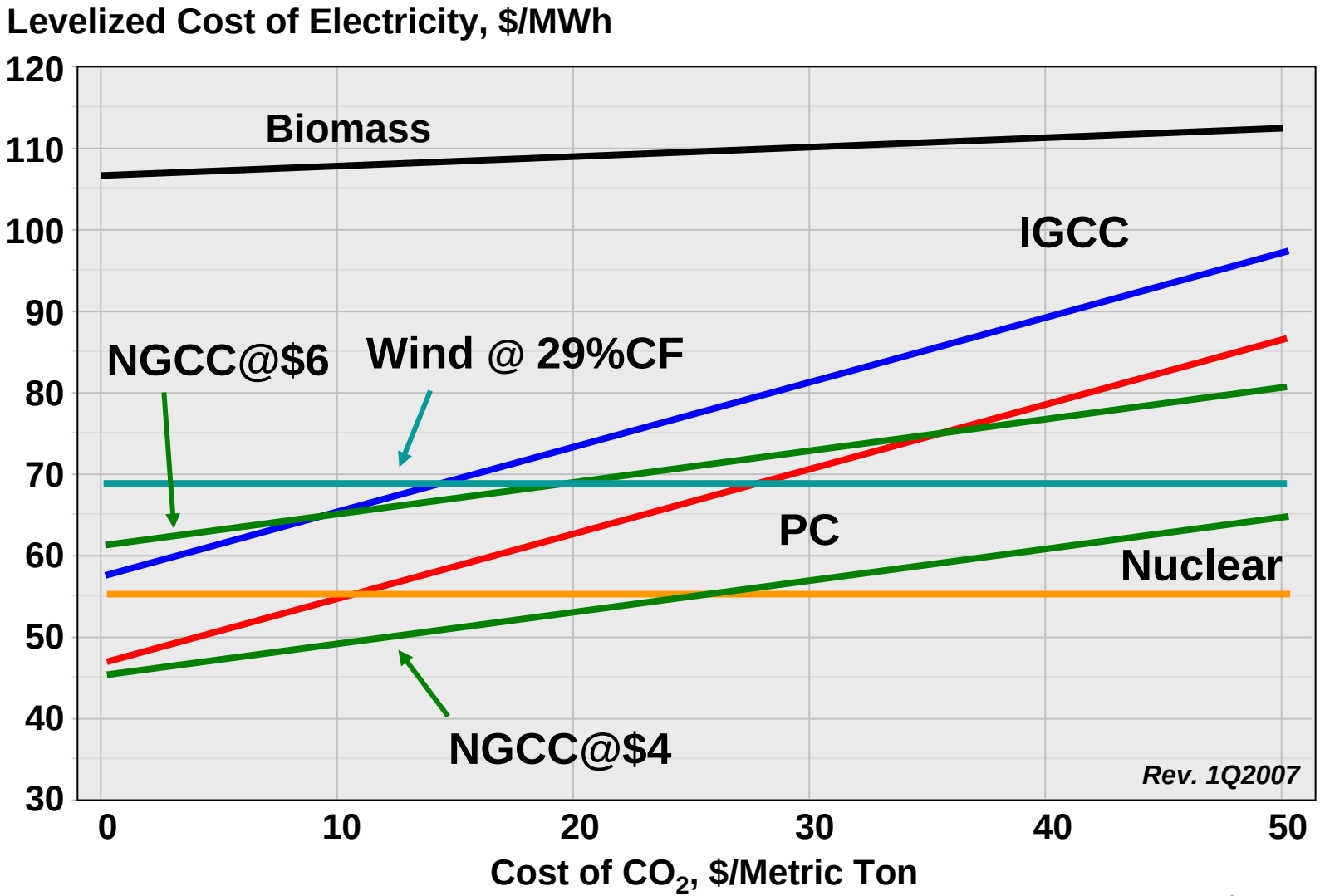
# Comparative Costs in 2010-2015

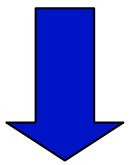


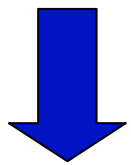
# Near-Term Implications

- New advanced light water reactors have cost advantage, but unlikely to enter operation until after 2015

- Absent nuclear, most new base-load generation will utilize fossil technologies without $CO_2$ capture and storage.
  - IGCC at present 10-20% higher than PC
  - All coal and nuclear costs escalating dramatically
  - Choice of PC vs. NGCC will depend on natural gas prices

- Renewables unlikely to extend beyond mandated requirement due to poor comparative economics





**Very limited opportunity for significant economic $CO_2$ reduction!!!**

# Key Technology Challenges

**The U.S. electricity sector will need ALL of the following technology advancements to significantly reduce $CO_2$ emissions over the coming decades:**

1. Smart grids and communications infrastructures to enable end-use efficiency and demand response, distributed generation, and PHEVs.

2. A grid infrastructure with the capacity and reliability to operate with 20-30% intermittent renewables in specific regions.

3. Significant expansion of nuclear energy enabled by continued safe and economic operation of existing nuclear fleet; and a viable strategy for managing spent fuel.

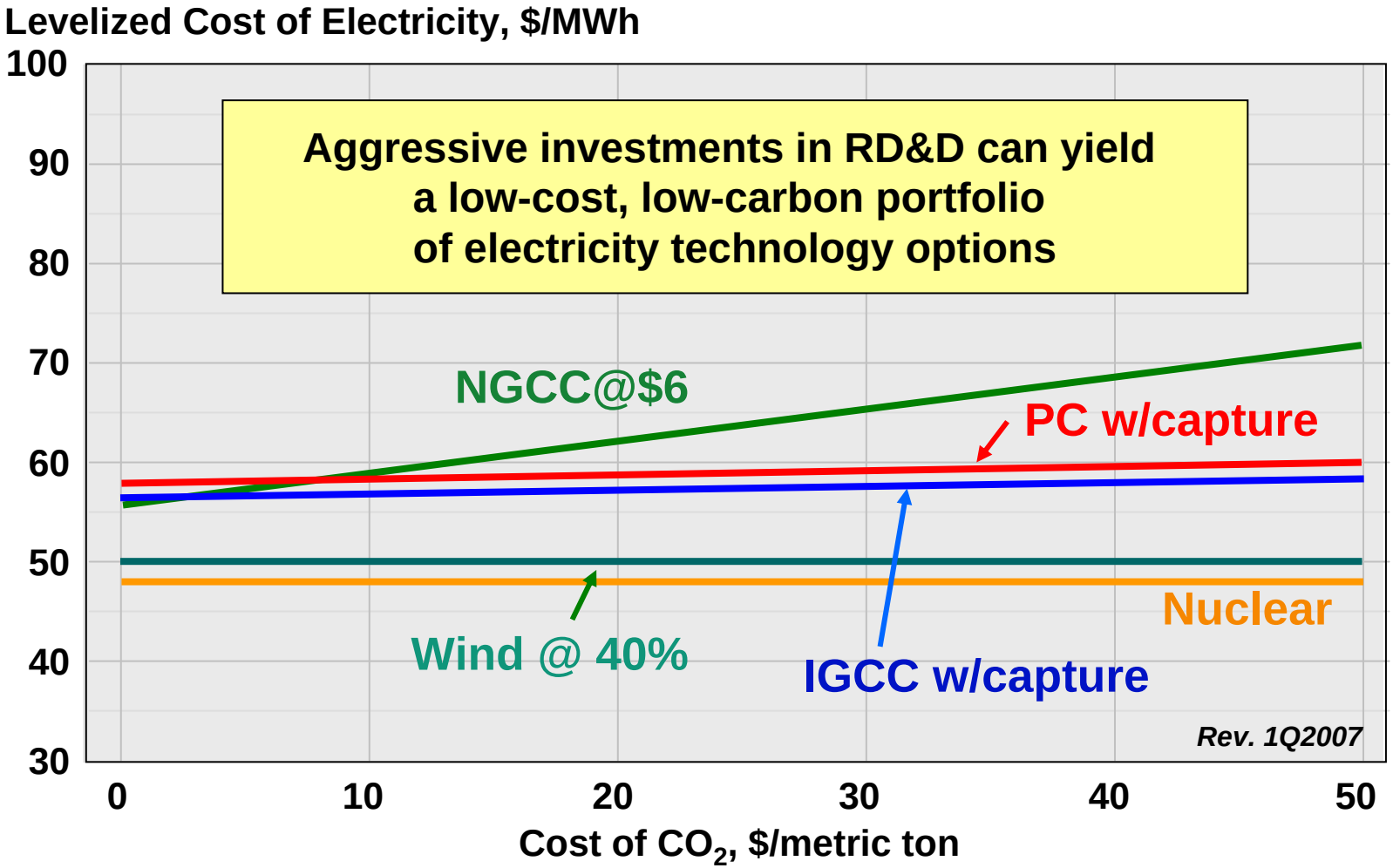
4. Commercial-scale coal-based generation units operating with 90+% $CO_2$ capture and storage in a variety of geologies.

# Average Annual Funding Needs (2005-30)

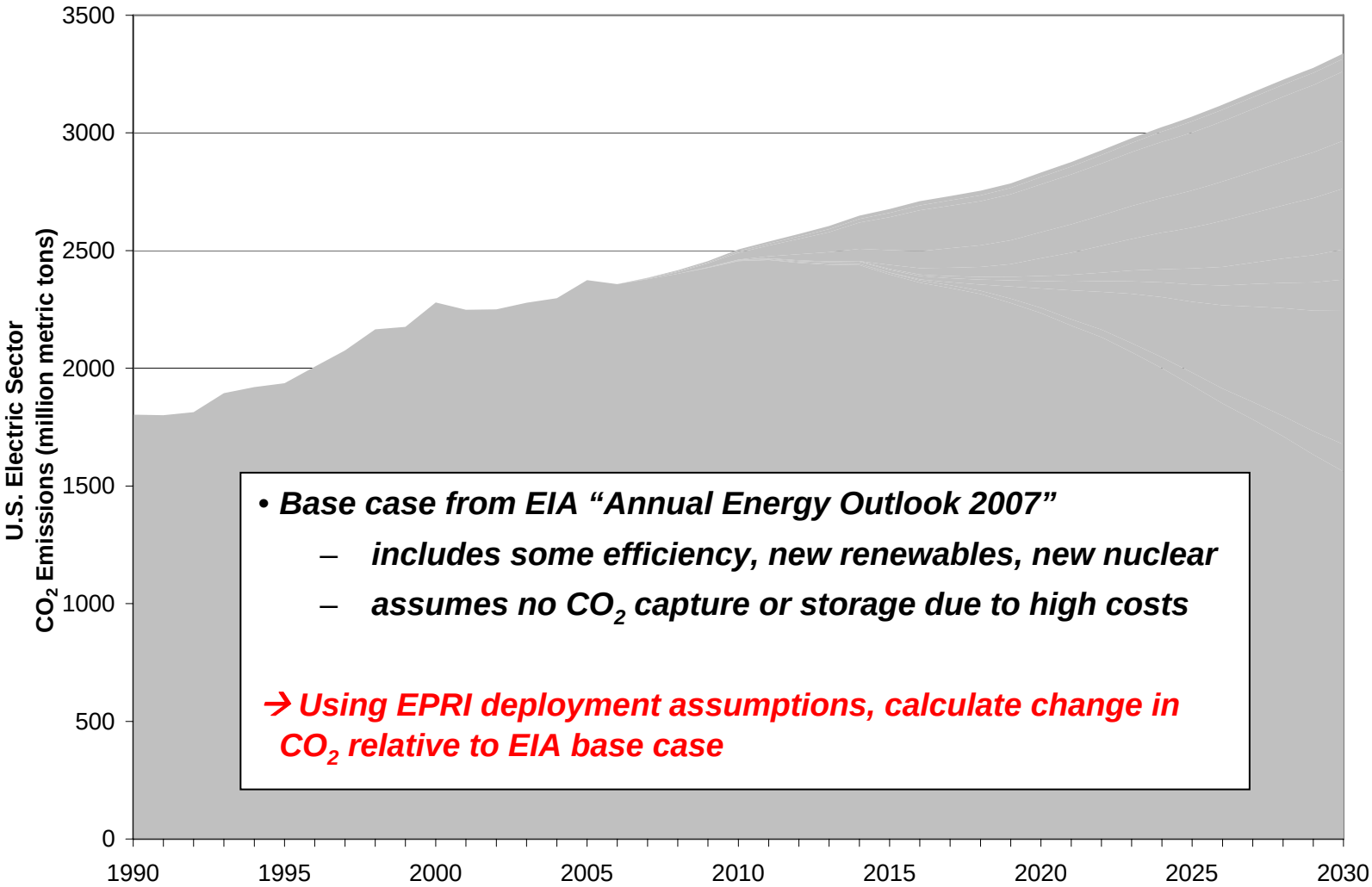
*(including nuclear closed fuel cycle, $CO_2$ storage)*

| | Research | Development | Demonstration | Early Deployment | Enhanced Performance | Total |
|---|---|---|---|---|---|---|
| **DISTRIBUTION INTEGRATION** Smart grids and communications infrastructures to enable end-use efficiency and demand response, distributed generation, and PHEVs. | $25M/yr | $51M/yr | $64M/yr | $80M/yr | $0M/yr | $220M/yr |
| **GRID INTEGRATION** A grid infrastructure with the capacity and reliability to operate with 20-30% intermittent renewables in specific regions. | $40M/yr | $80M/yr | $70M/yr | $33M/yr | $117M/yr | $340M/yr |
| **NUCLEAR** Significant expansion of nuclear energy enabled by continued safe and economic operation of existing nuclear fleet; and a viable strategy for managing spent fuel. | $247M/yr | $493M/yr | $40M/yr | $0M/yr | $40M/yr | $820M/yr |
| **ADVANCED COAL, CO2 CAPTURE and STORAGE** Commercial-scale coal-based generation units operating with 90+% CO2 capture and storage in a variety of geologies. | $52M/yr | $91M/yr | $228M/yr | $249M/yr | $0M/yr | $620M/yr |
| **Total (Public + Private Sectors)** | $364M/yr | $716M/yr | $401M/yr | $362M/yr | $157M/yr | $2000M/yr |

# Comparative Costs in 2020-2025



# U.S. Electricity Sector $CO_2$ Emissions

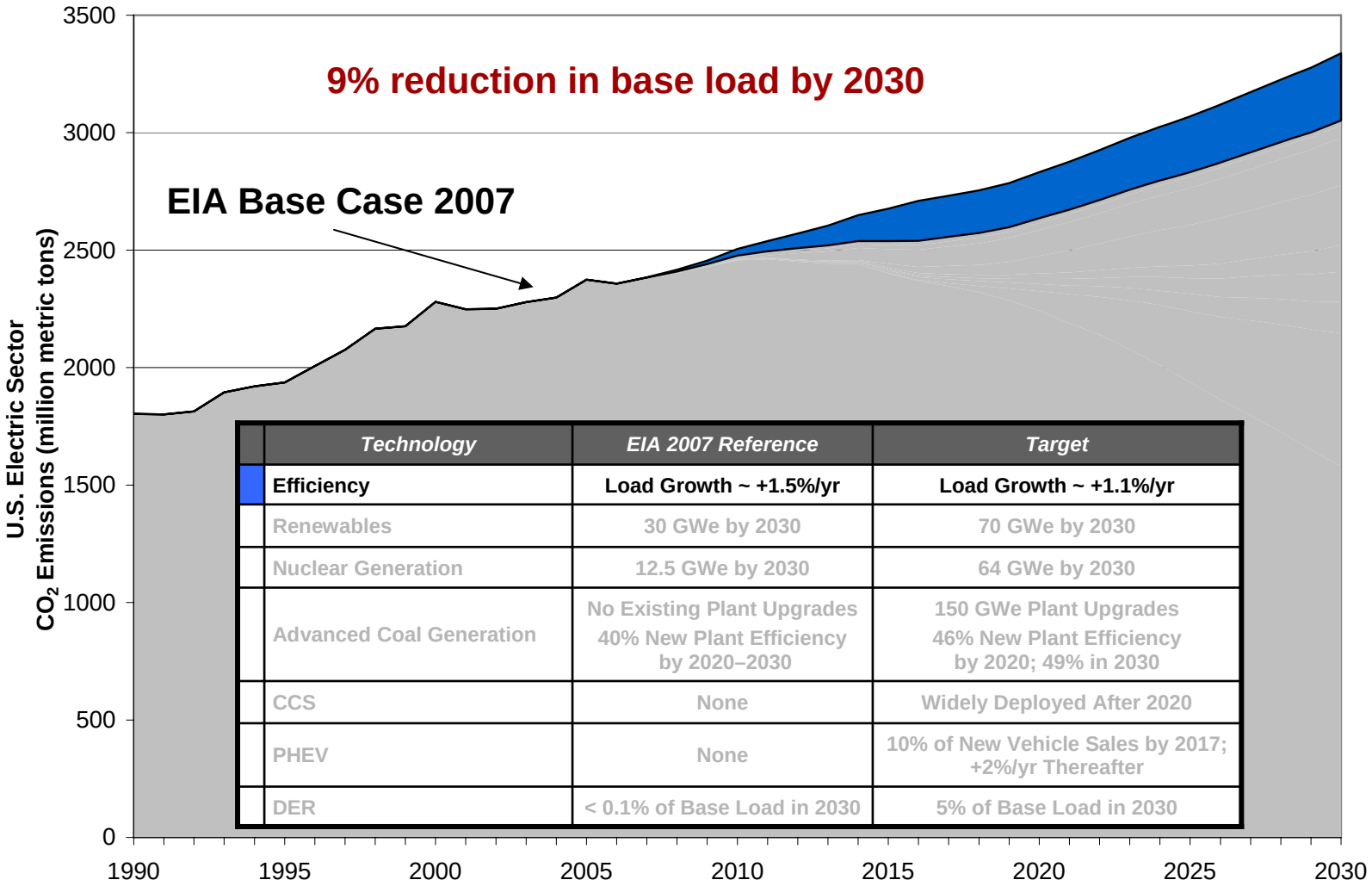


# Technology Deployment Targets

| *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**<br>**40% New Plant Efficiency by 2020–2030** | **150 GWe Plant Upgrades**<br>**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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| CCS | None | Widely Deployed After 2020 |
| PHEV | None | 10% of New Vehicle Sales by 2017; +2%/yr Thereafter |
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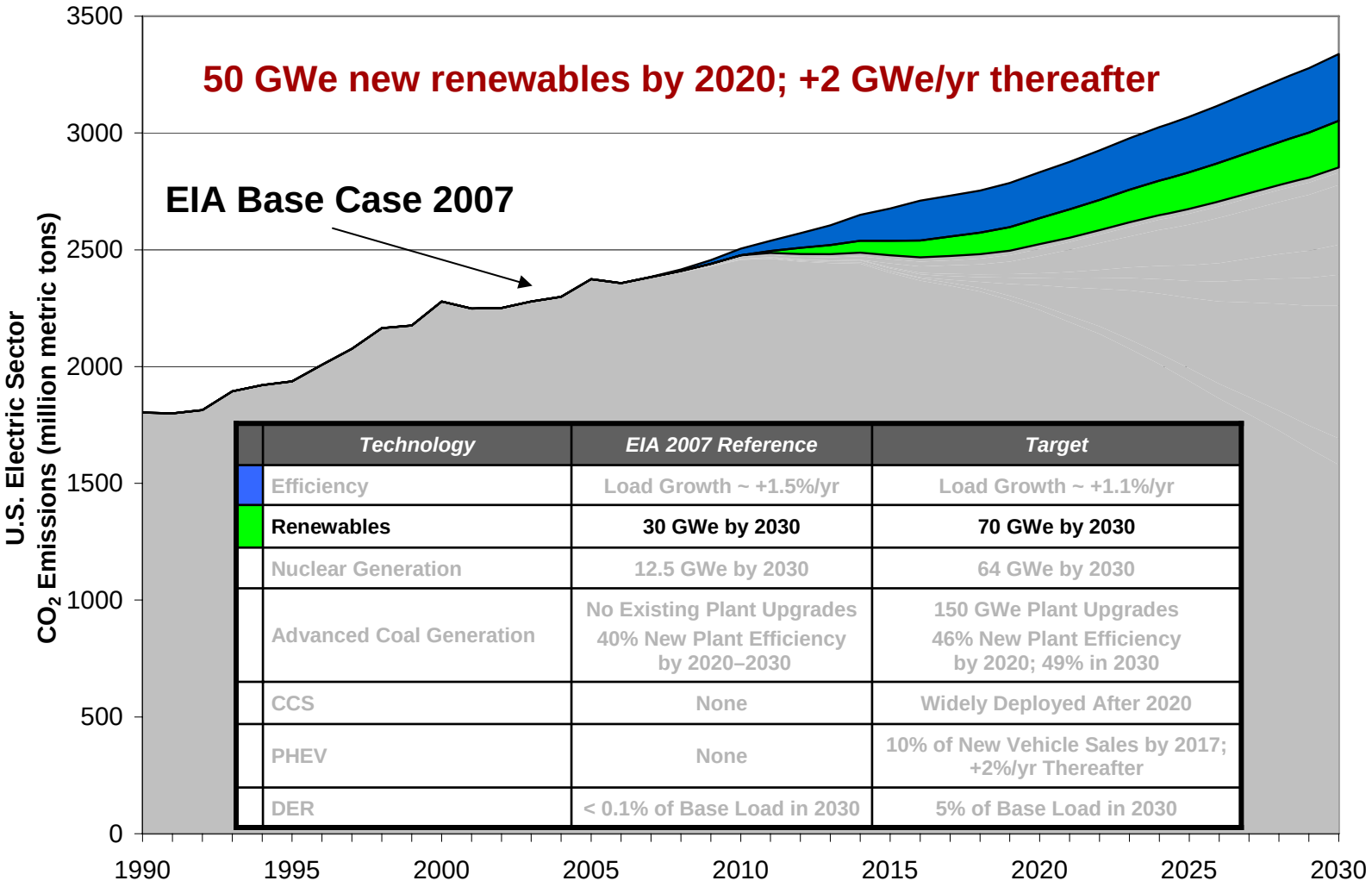
# Benefit of Achieving Renewables Target

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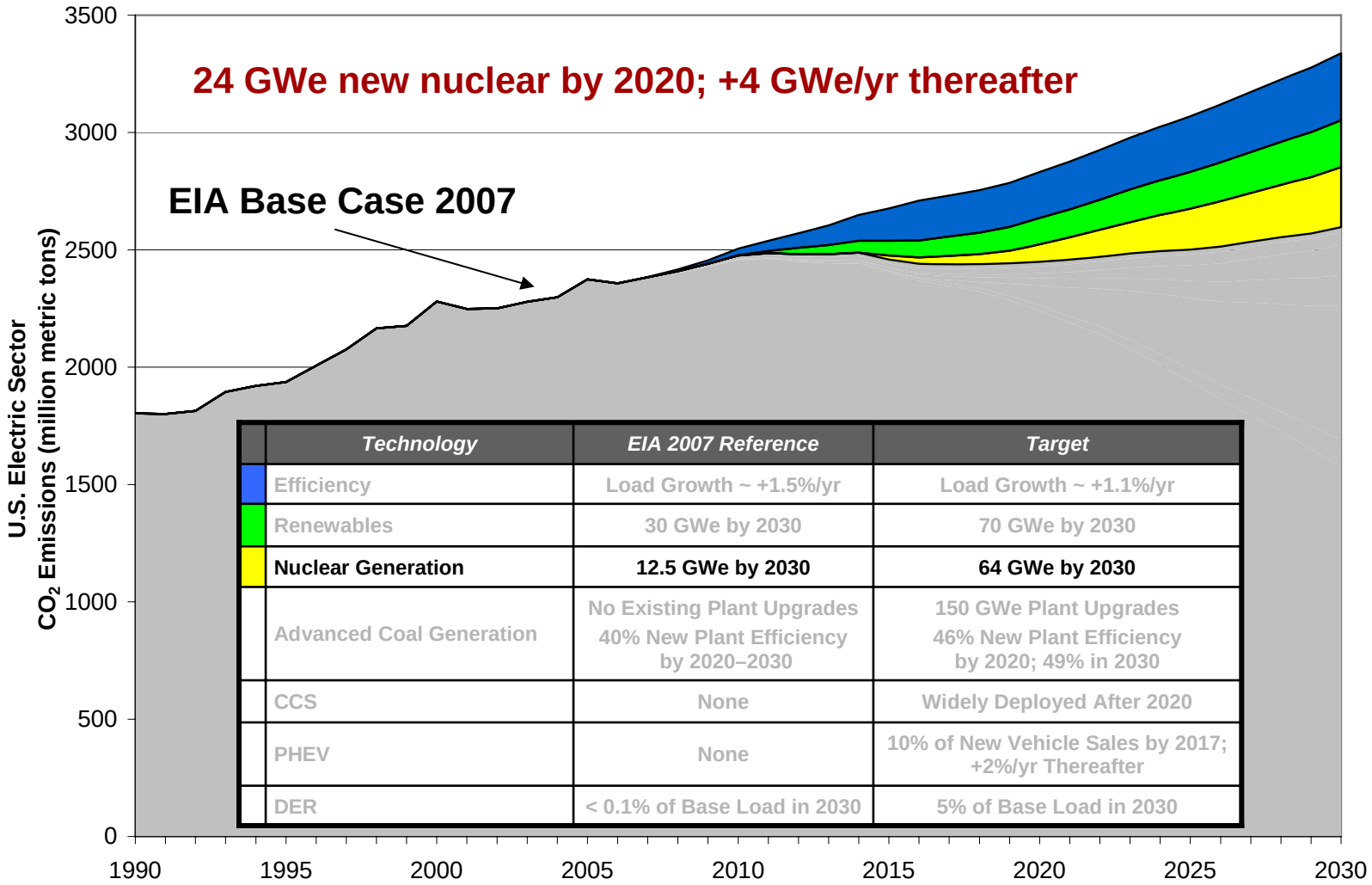
# Benefit of Achieving Nuclear Generation Target

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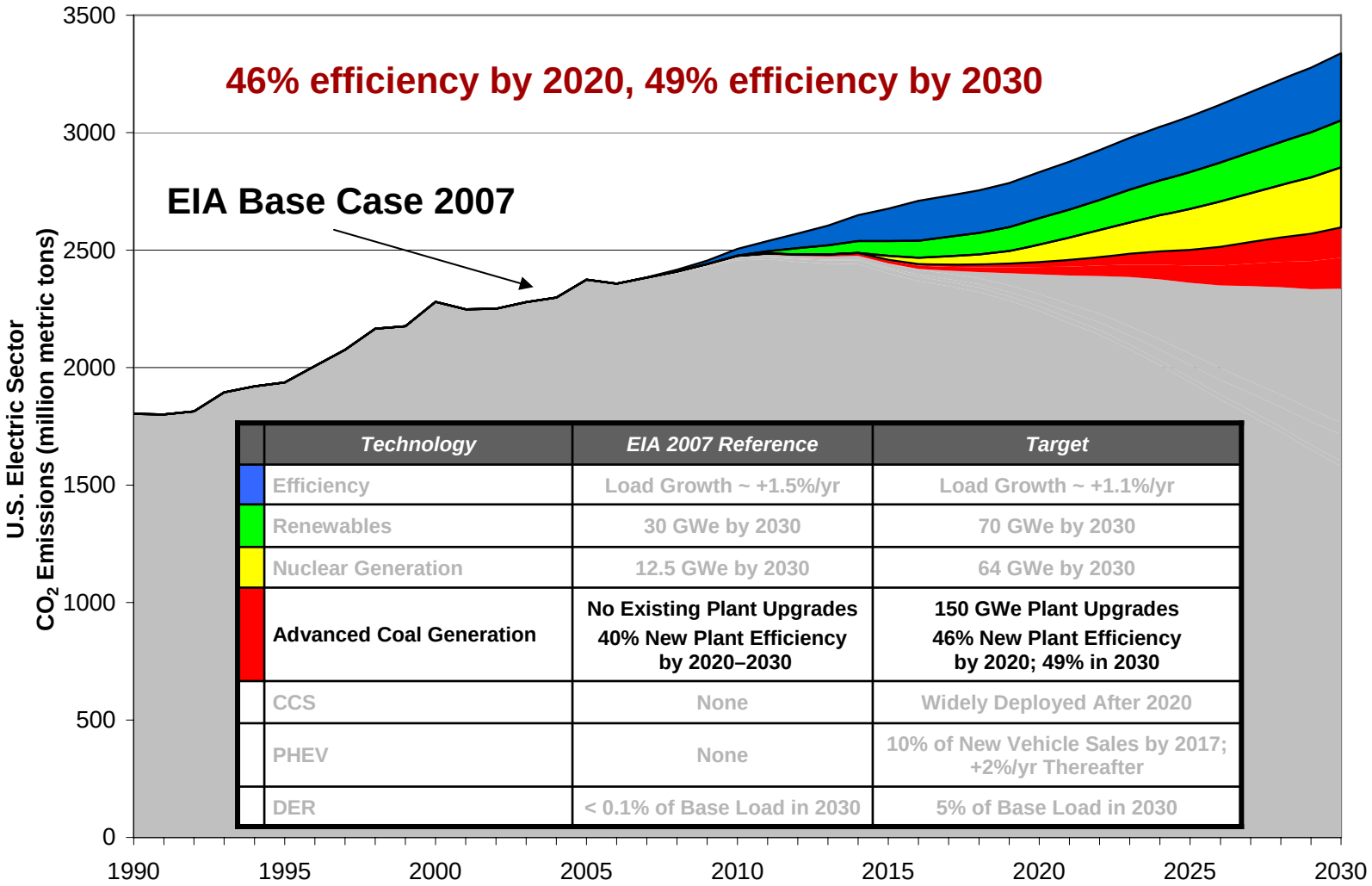
# Benefit of Achieving Advanced Coal Target




| 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 |
| 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 |
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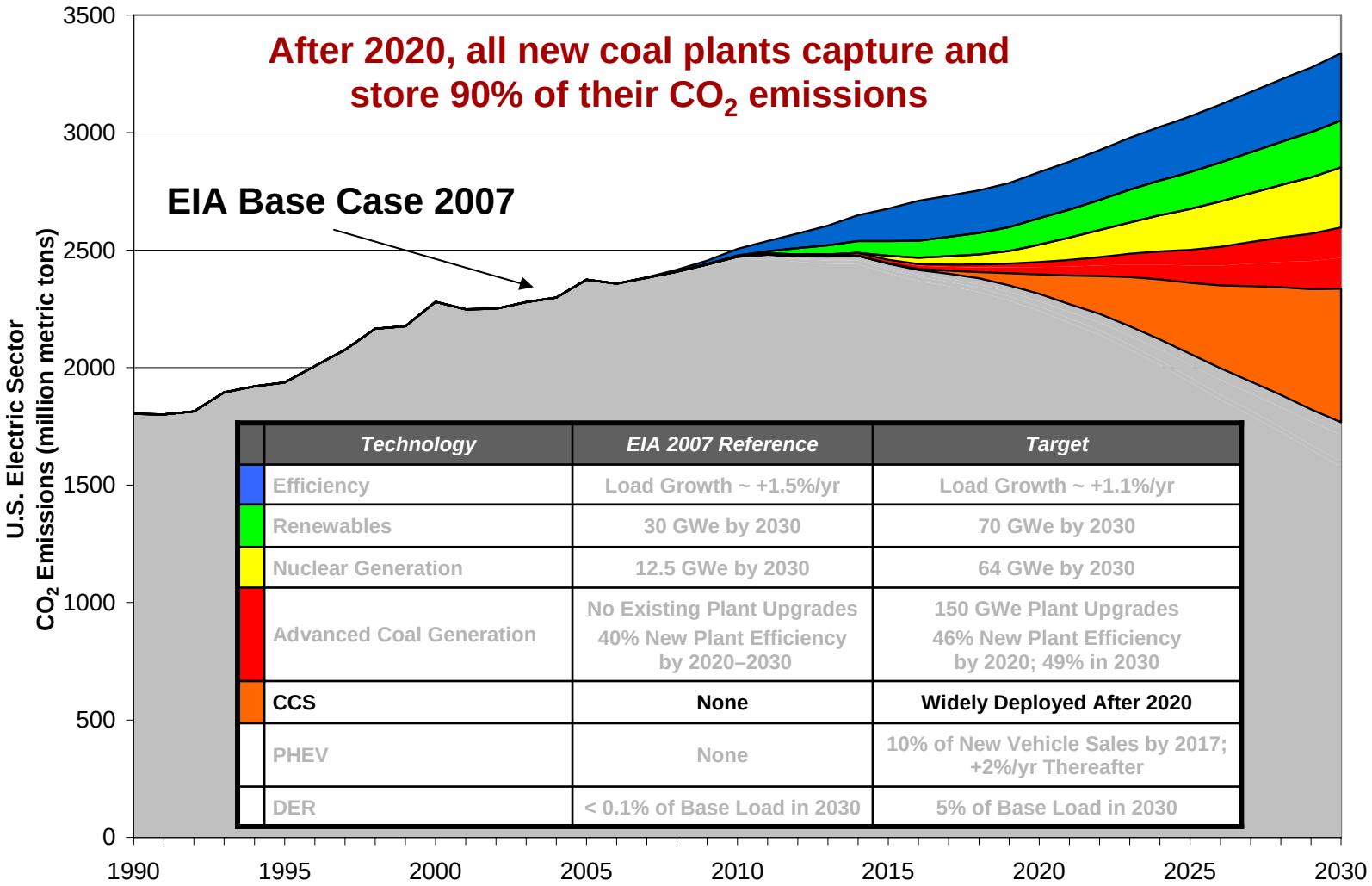
# Benefit of Achieving the CCS Target

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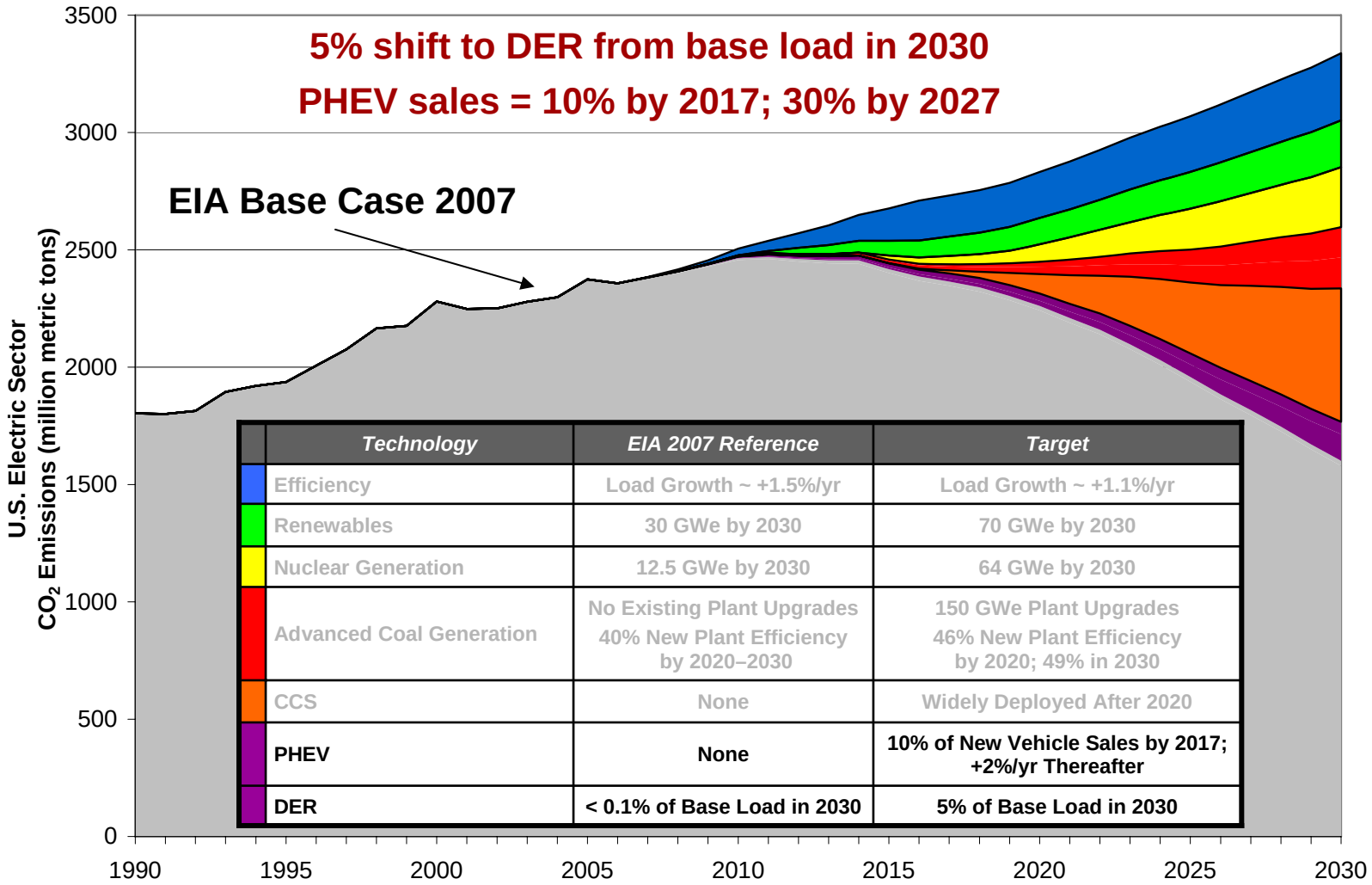
# Benefit of Achieving PHEV and DER Targets

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| **PHEV** | **None** | **10% of New Vehicle Sales by 2017; +2%/yr Thereafter** |
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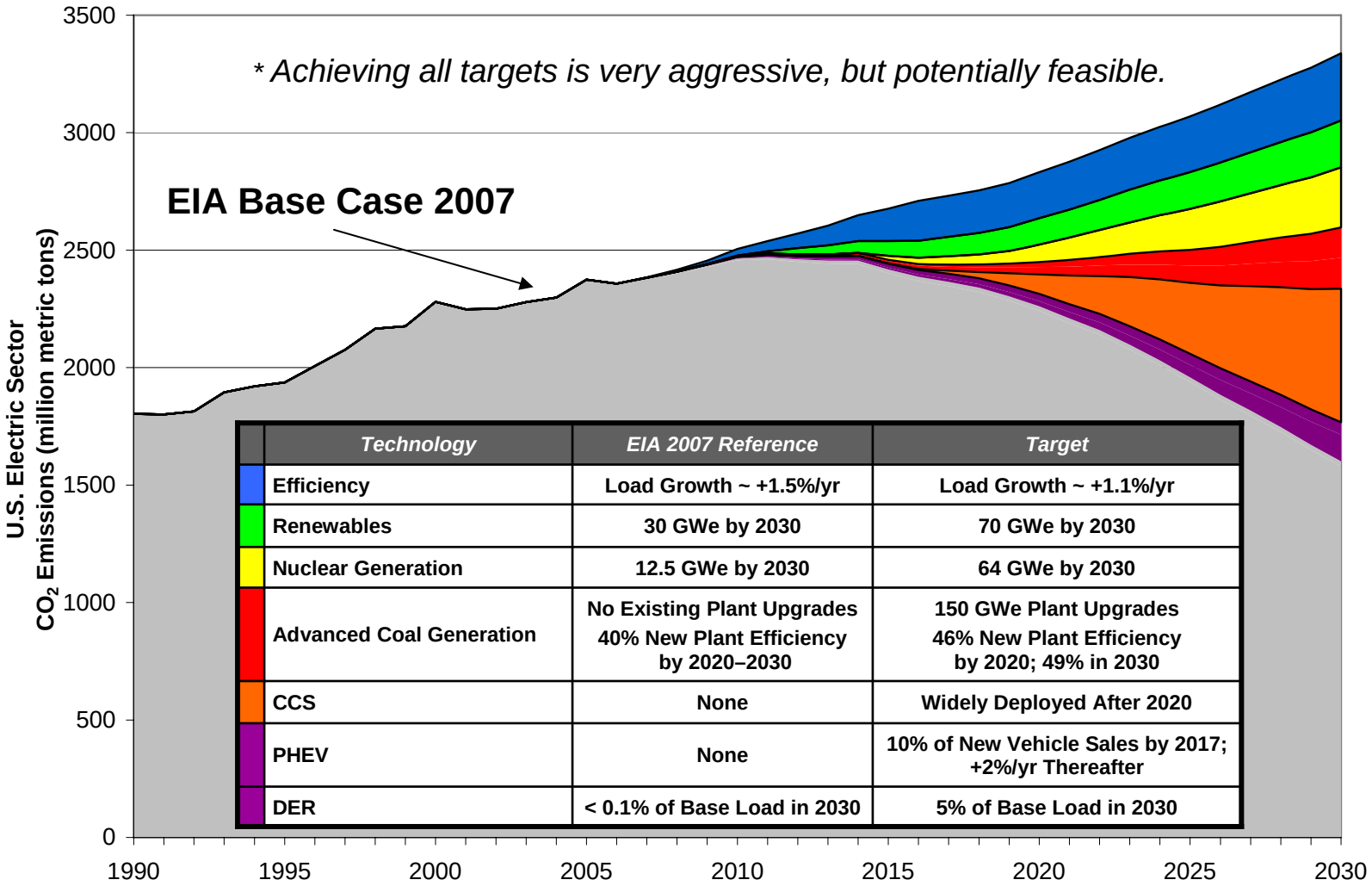
# $CO_2$ Reductions … Technical Potential*

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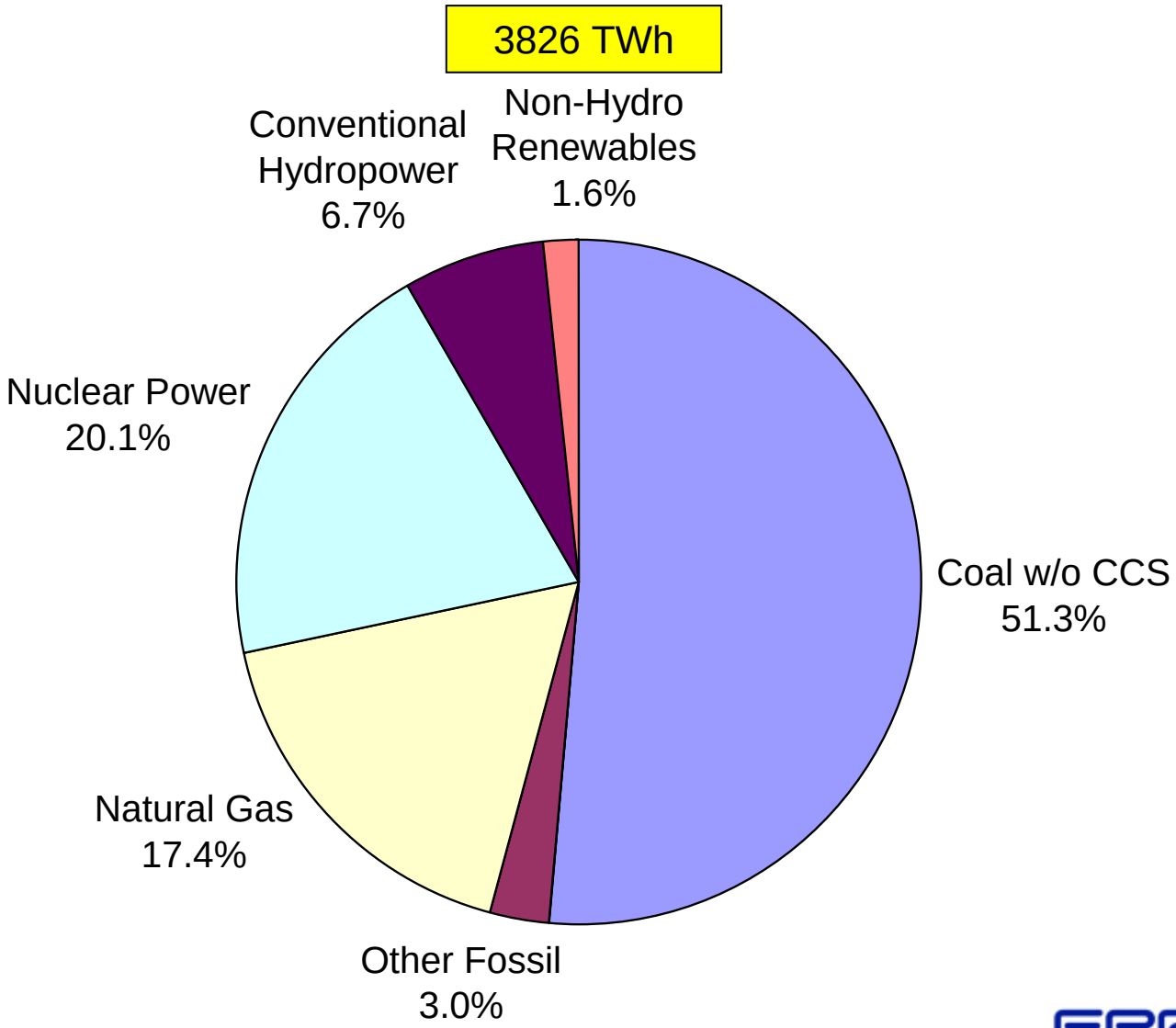
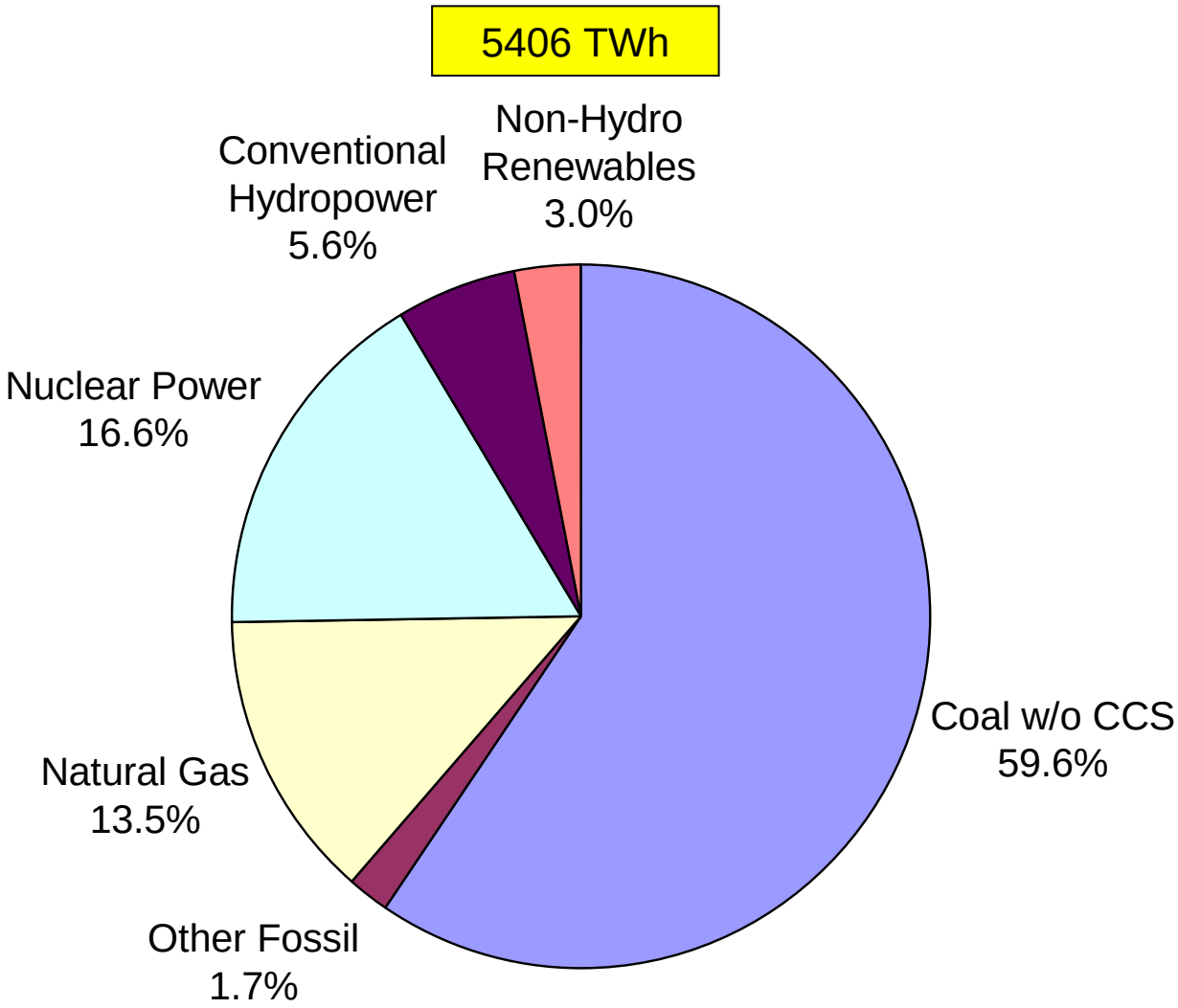
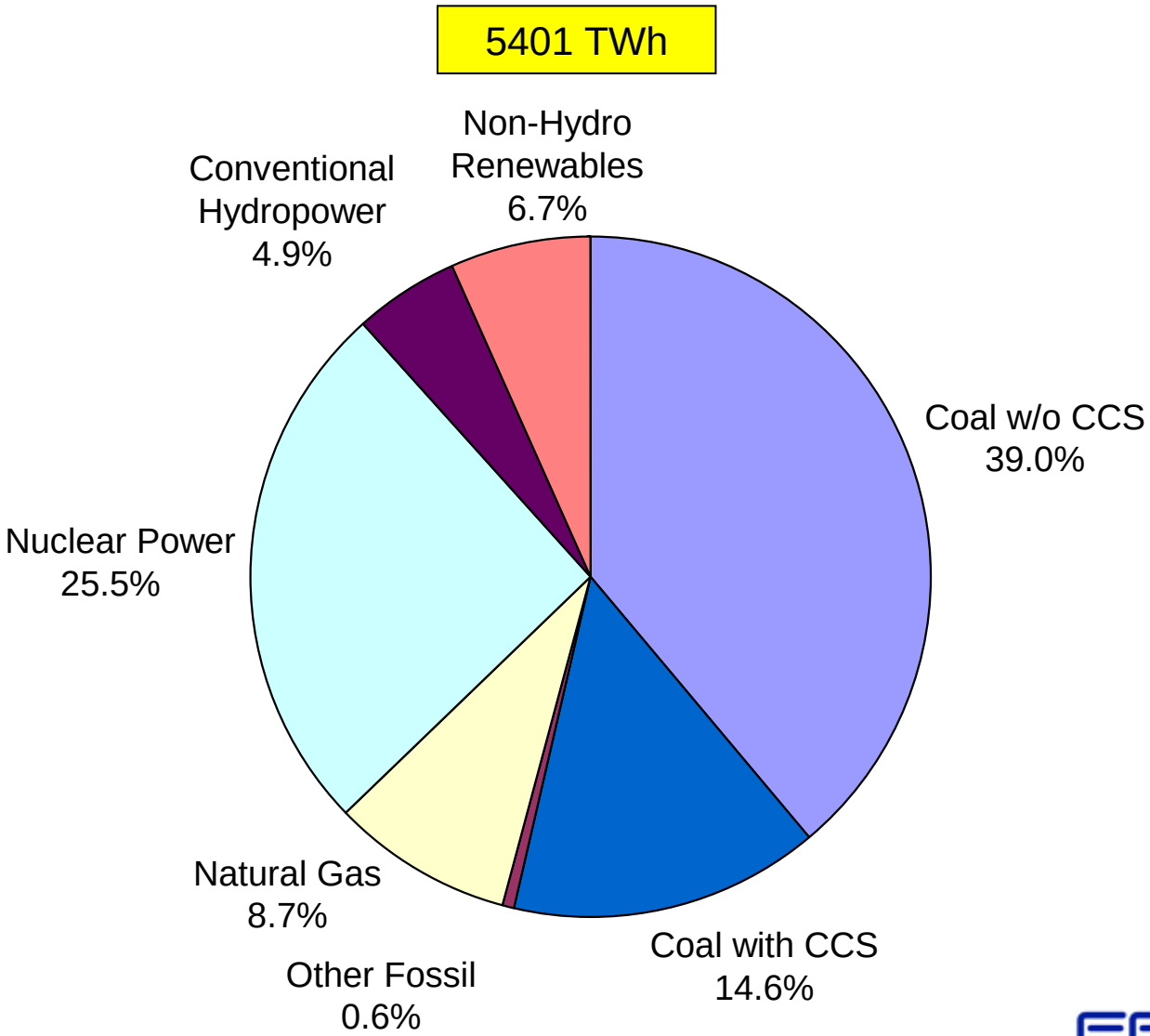
# Total U.S. Electricity Generation: 2005 EIA



# Total U.S. Electricity Generation: 2030 EIA Base Case



# Total U.S. Electricity Generation: 2030 Advanced Technology Targets



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