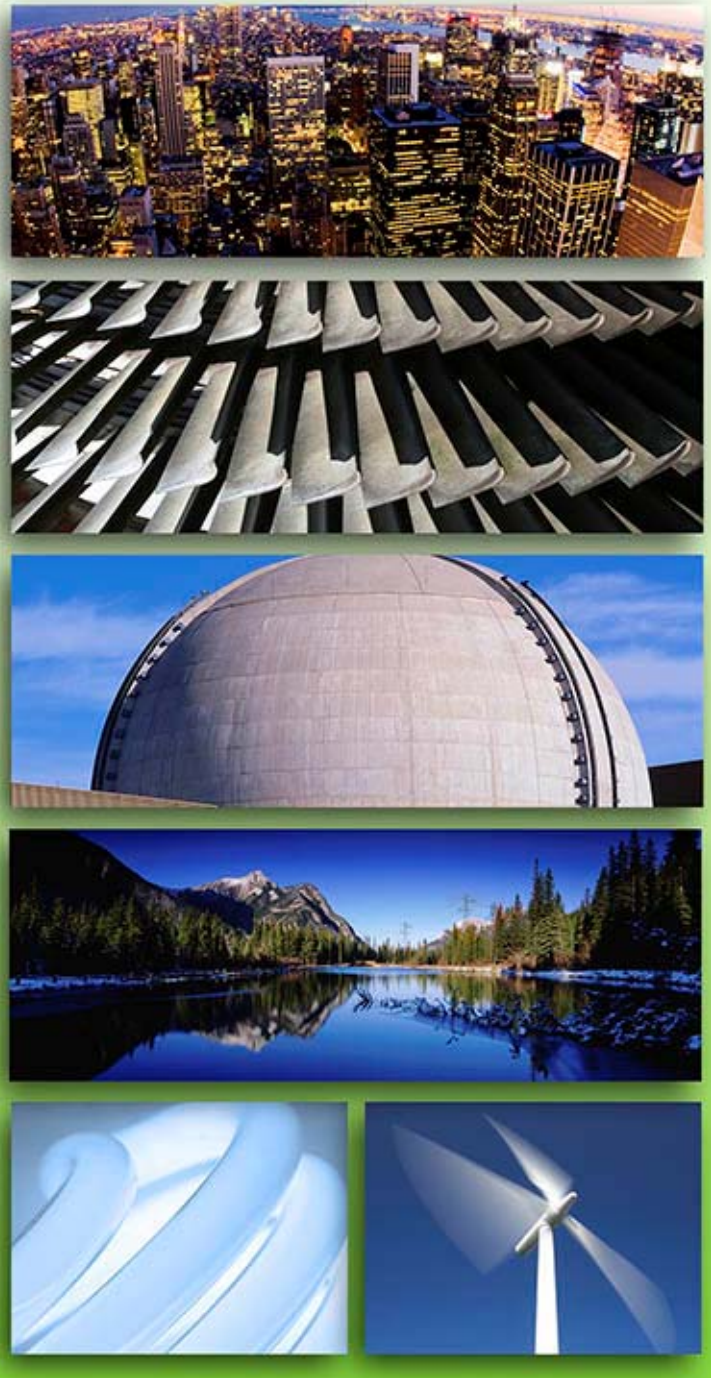

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Availability and Costs of Supply-Side Electricity Options

Revis James
Director
Energy Technology Assessment Center

EPRI Global Climate Change Research Seminar
Washington, DC
May 20, 2009

Key Messages

- **The size of the challenges**

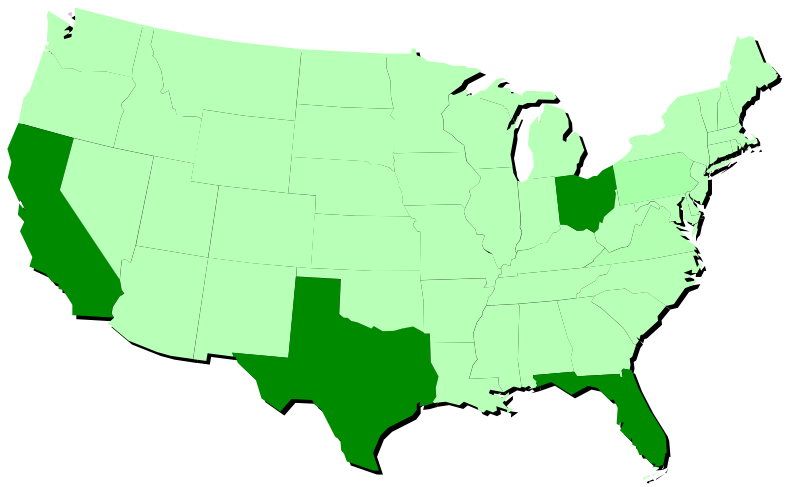
- Technology costs
  - Status
  - Trends
  - Drivers

- Technology insights
  - Full portfolio vs. “silver bullet”
  - Importance of baseload technologies
  - New challenges: renewables, efficiency

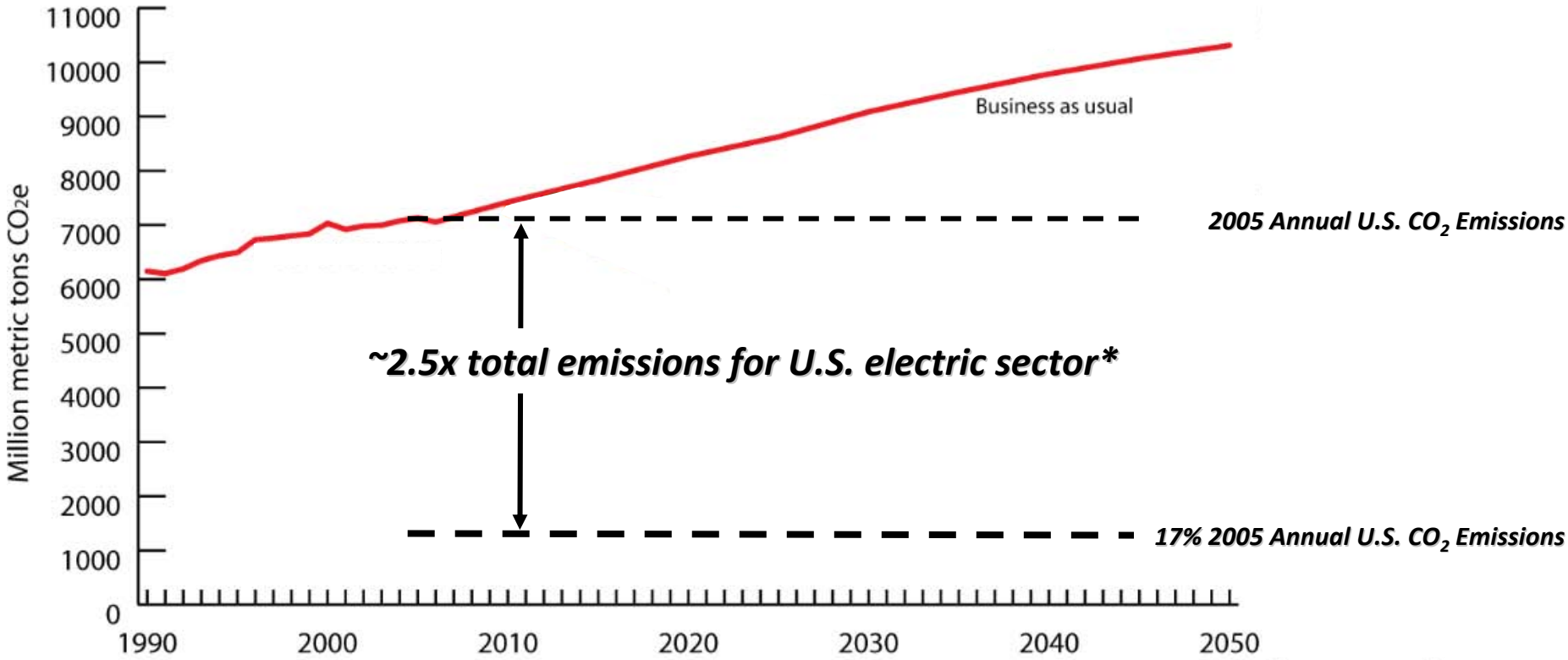
Substantial Electricity Demand

- Now: 2007 U.S. electricity consumption ~ 3800 TWh

- Future (EIA 2009 Annual Energy Outlook)
  - Final report projects **900** TWh (**24**%) increase in U.S. electricity consumption by 2030.
  - About same as addition of new load equivalent to 2006 consumption of Texas, California, Florida, Ohio.



Huge Emissions Reductions



*2007 U.S. electricity sector CO_2 emissions = 2.4B mmT CO_2

Key Messages

- The size of the challenges

- **Technology costs**
  - **Status**
  - **Trends**
  - **Drivers**

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Key Elements of Levelized Cost of Electricity

- Estimate annual cash flows from project inception through end of plant life
- Calculate net present value (NPV) of cash flows
- Calculate constant annual cash flow to produce same NPV
- Levelized cost of electricity (LCOE) = constant annual cash flow divided by annual electricity production

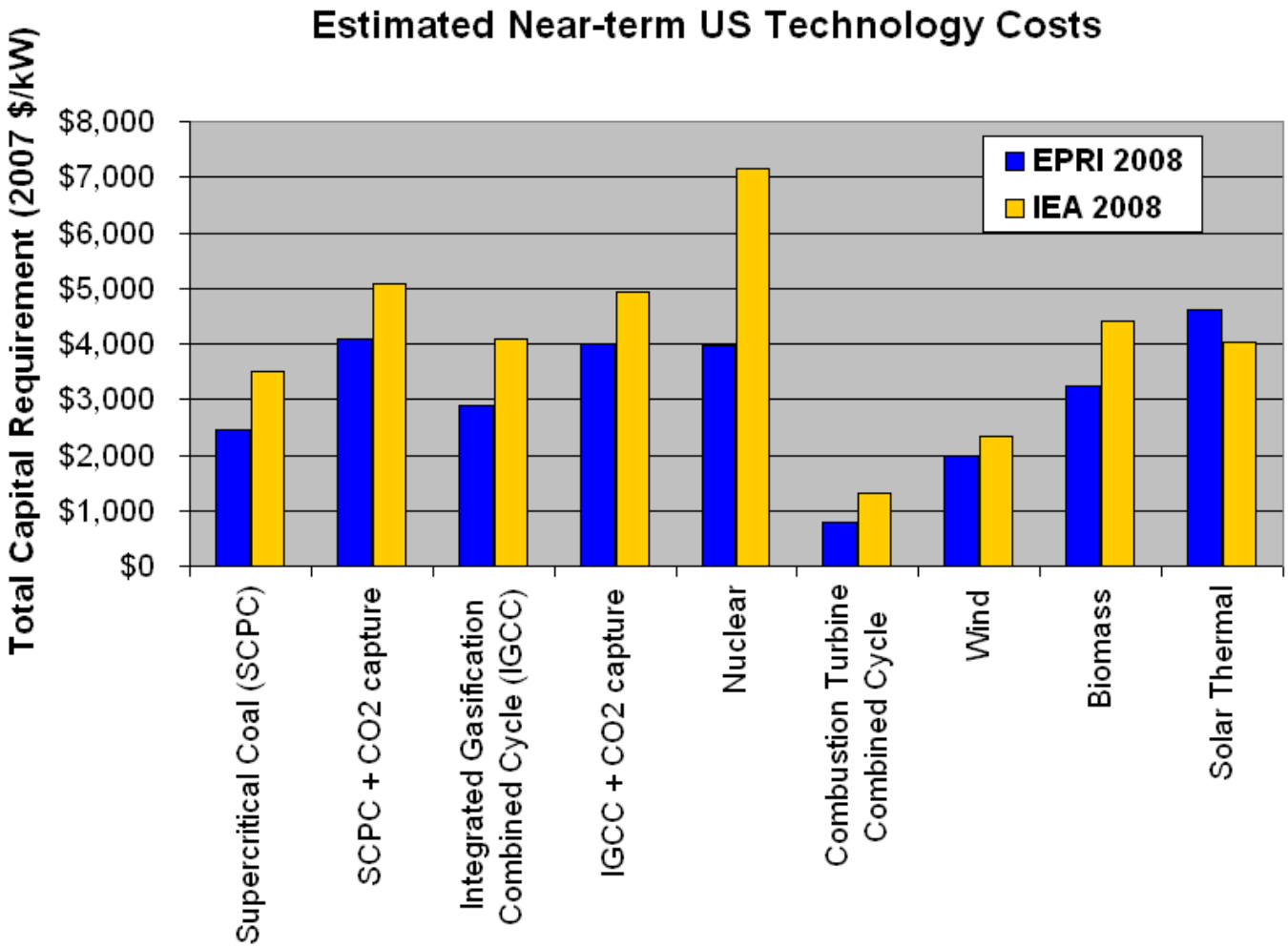
Key Elements of Capital Costs

- Total Plant Cost (TPC)
- Owners Costs
- Allowance For Funds Used During Construction (AFUDC)
- Project-specific Costs

Key Elements of Capital Costs

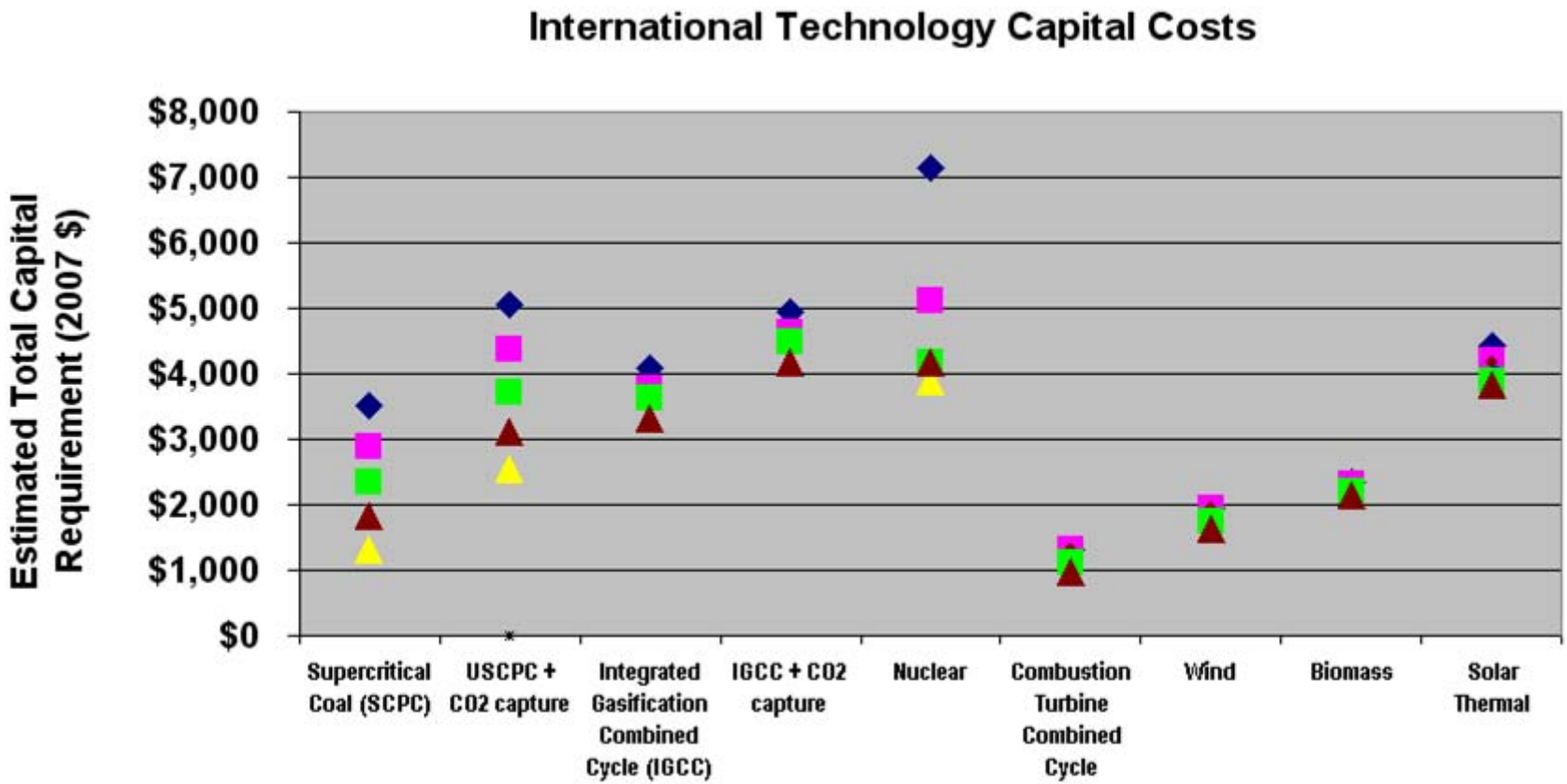
- Total Capital Requirement (TCR) = TPC + Owner's Costs + AFUDC + Project Specific Costs
- Under standard assumptions, Owner's costs+AFUDC ~ 16–19% of TPC.
- Project-specific costs ~ 10–15% of TPC

Technology Cost Estimates Vary

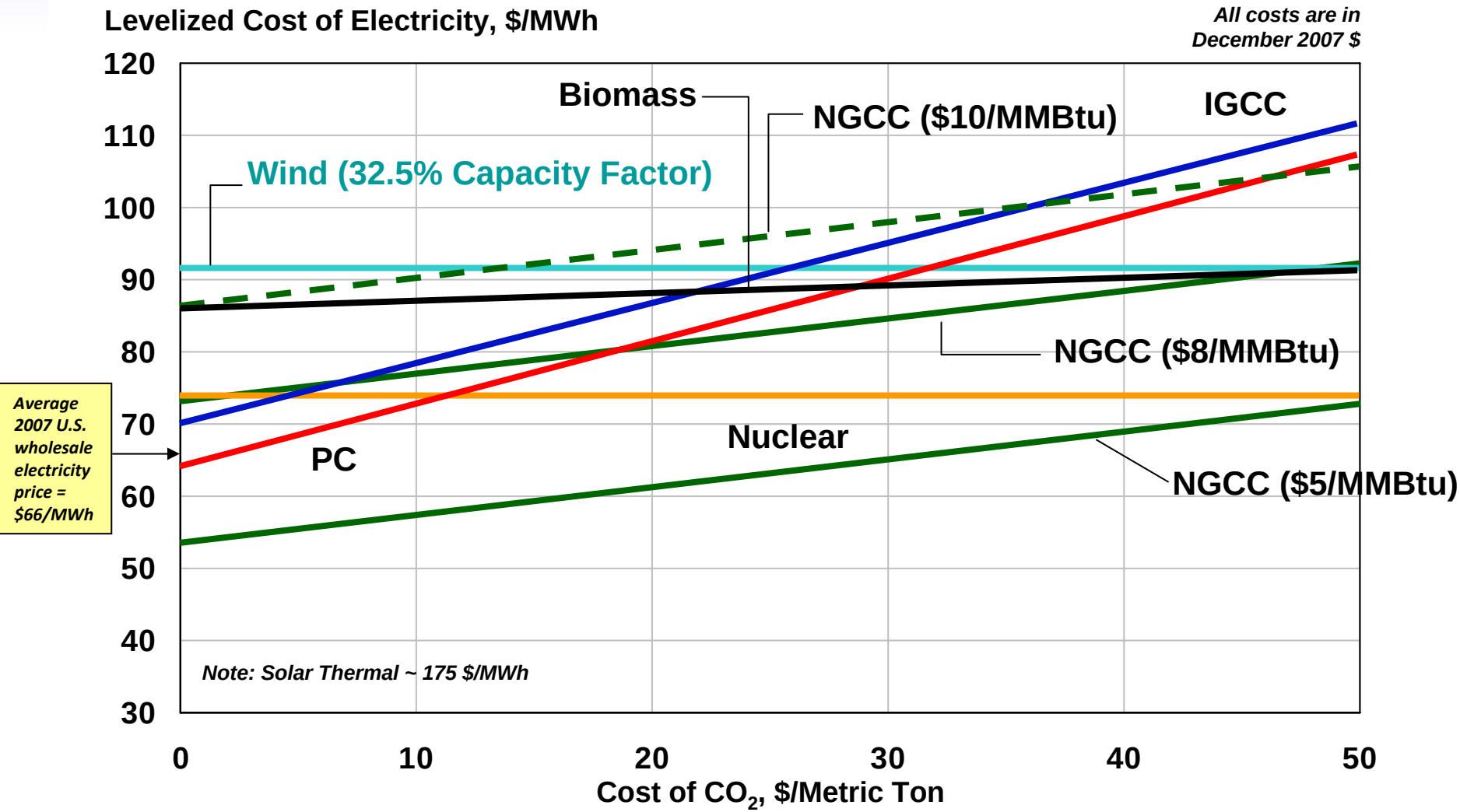


Costs Vary by Region

(IEA 2008 World Energy Outlook)



Electricity Production Cost Driven by Capital Cost, Capacity Factor



EPRI 1018329, October 2008

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Common Drivers Affect Costs

Shop load > 80%

- Boilers
- Compressors
- Motors
- Piping
- Structural steel
- Valves
- Turbine generators
- Vessels & tanks
- Wire & cable

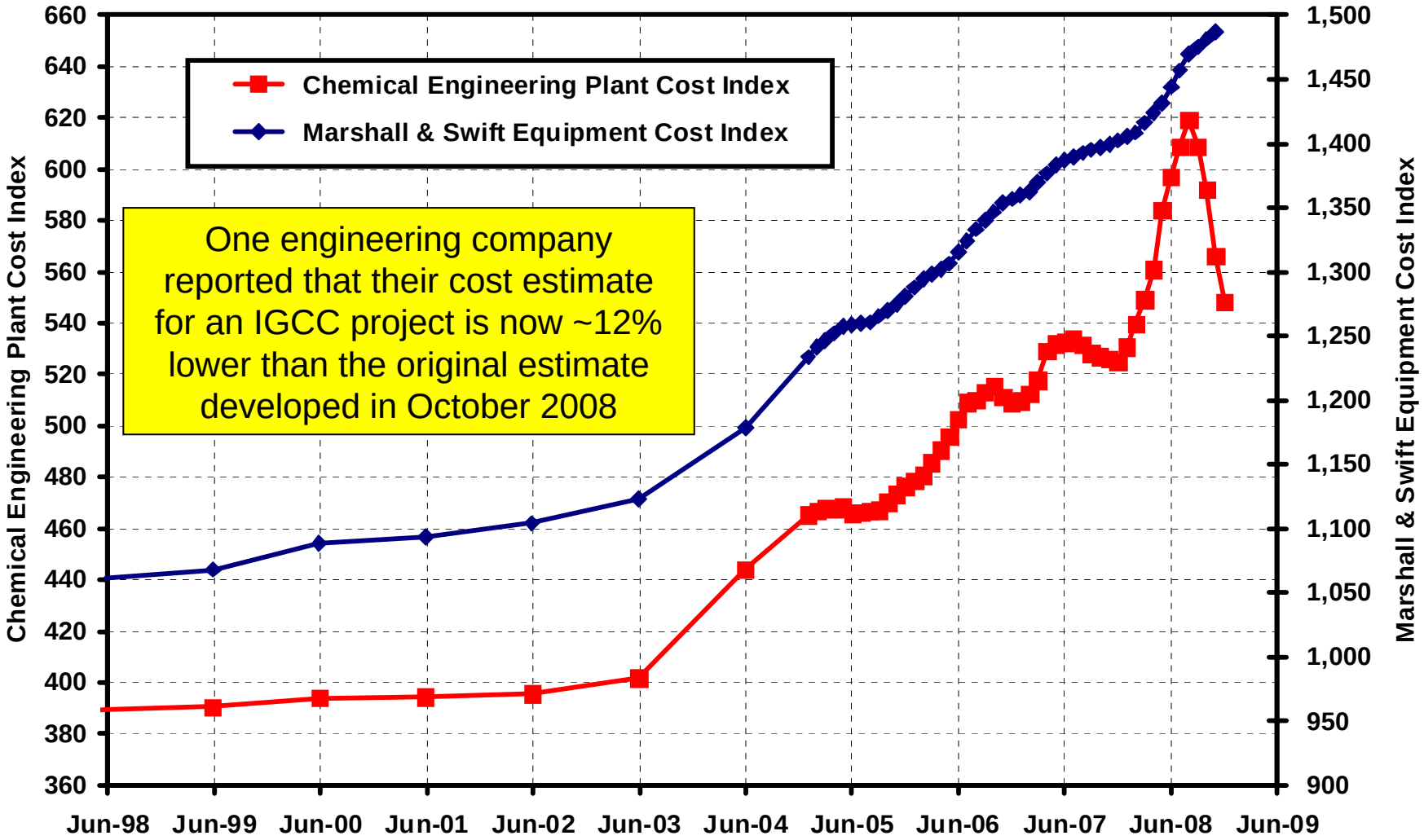
Lead times > 1 year

- Boilers
- Compressors
- Turbine-driven equipment
- Pressure vessels

Bechtel Global Supply Trends, April 2008

Effects of Recession on Cost Escalation

(Source: Chemical Engineering Magazine, March 2009)



Key Messages

- The size of the challenges

- Technology costs
  - Status
  - Trends
  - Drivers

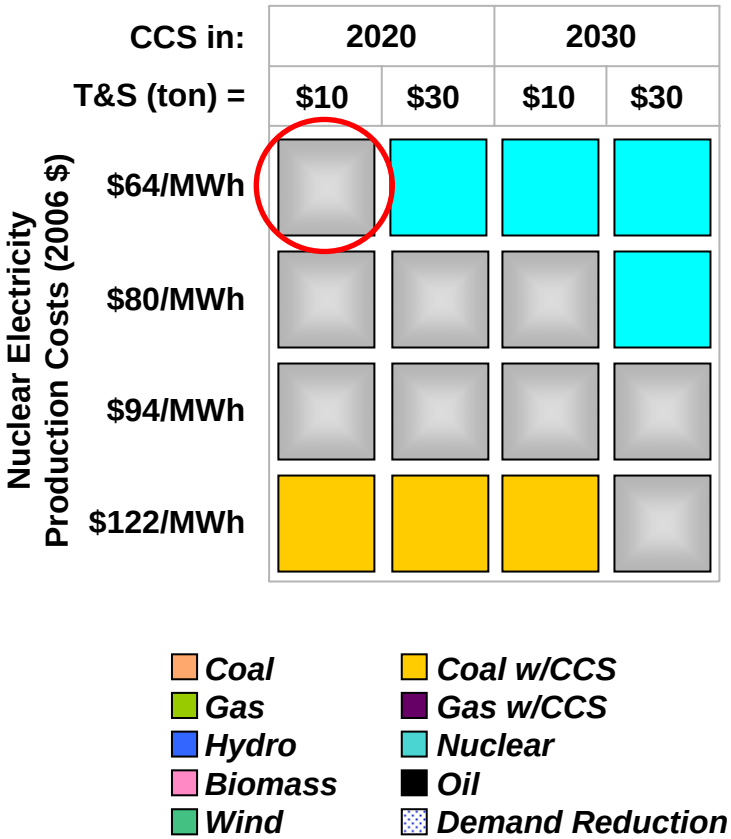
- **Technology insights**
  - **Full portfolio vs. “silver bullet”**
  - **Importance of baseload technologies**
  - **New challenges: renewables, efficiency**

Cost Uncertainty and Technology Mix

- **Vary costs, timing of key technologies: nuclear, CO_2 capture and storage**

- **Proportions of different generation technologies vary, but a diverse portfolio of technologies is optimum in all cases.**

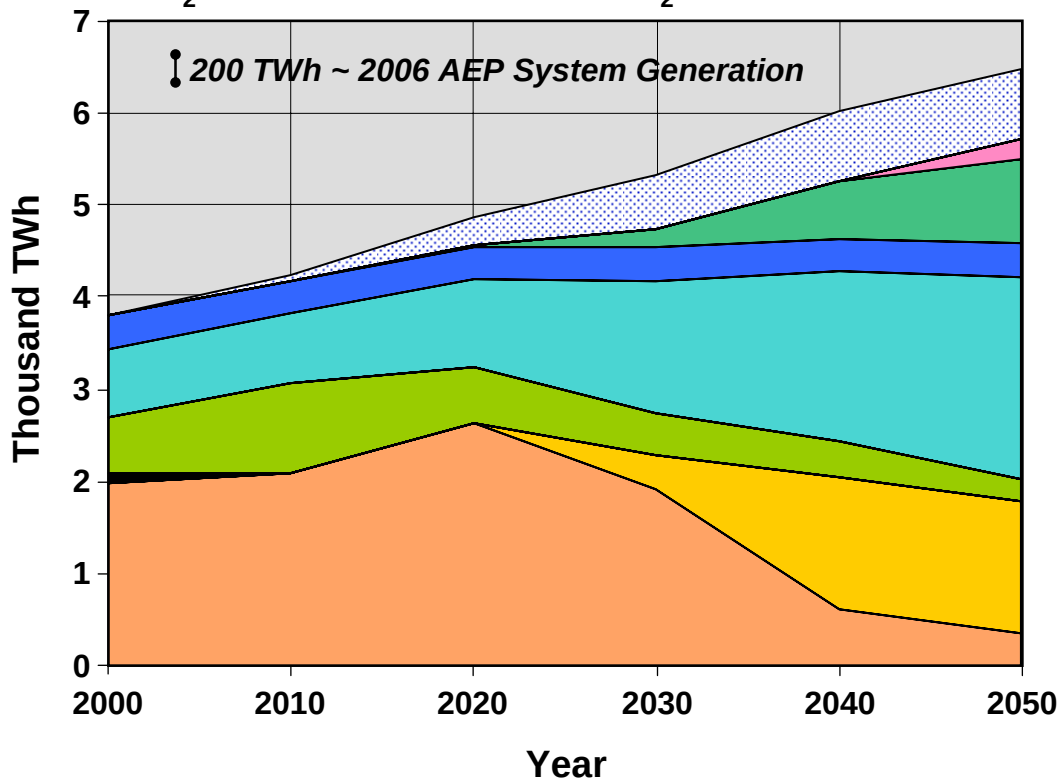
EPRI 2008 MERGE Sensitivity Analyses



Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $113/MWh

CO_2 Cost = $74/metric ton CO_2



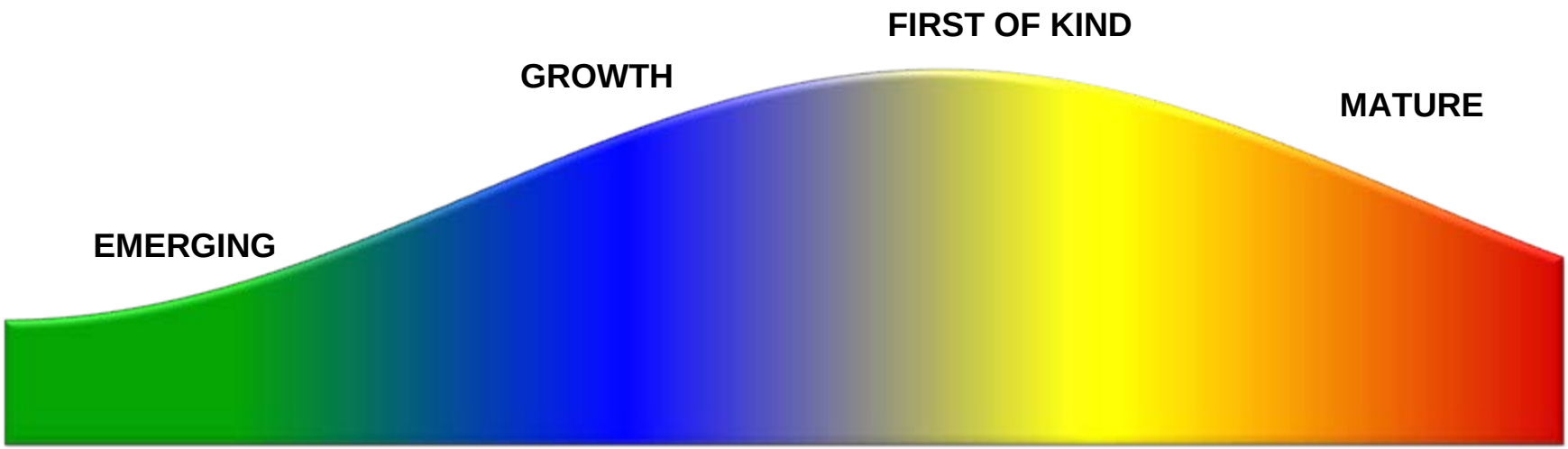
Important Technology Insights

- Together, advanced nuclear and advanced coal + CCS play a dominant role in all scenarios.
- The magnitude of demand reduction across all scenarios will likely drive increasing end-use efficiency.
- Renewables ultimately play a large role in nearly all scenarios.

Lead Times are Long for Technology Development

Basic Science, Experiments	Prototypes, Proof of Principle	Large scale demonstration, first of kind plants	Commercial technology, widespread deployment

~ 15-25 years



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Future Cost Trends

Factors leading to lower capital costs:

- Commodity, transportation and fuel costs are declining from 2008 peaks
- Reduced demand due to worldwide recession
- Currency exchange rates (country-specific; in United States, the dollar improved versus other currencies)

Factors leading to higher capital costs:

- Need for infrastructure projects in developing nations
- Increased project finance costs due to credit crisis

Procurement costs:

- Declining procurement price increases projected for 2009, 2010
- Shop loads stable in 2009, declining in 2010

Other Future Trends Affecting Technology

- Chinese commodities, components will become more focused on export, create competition

- CO_2 policy impacts on fuel markets
  - Pressure on increasing NG, LNG consumption
  - Longer term, reprocessing and breeder nuclear fuel cycles

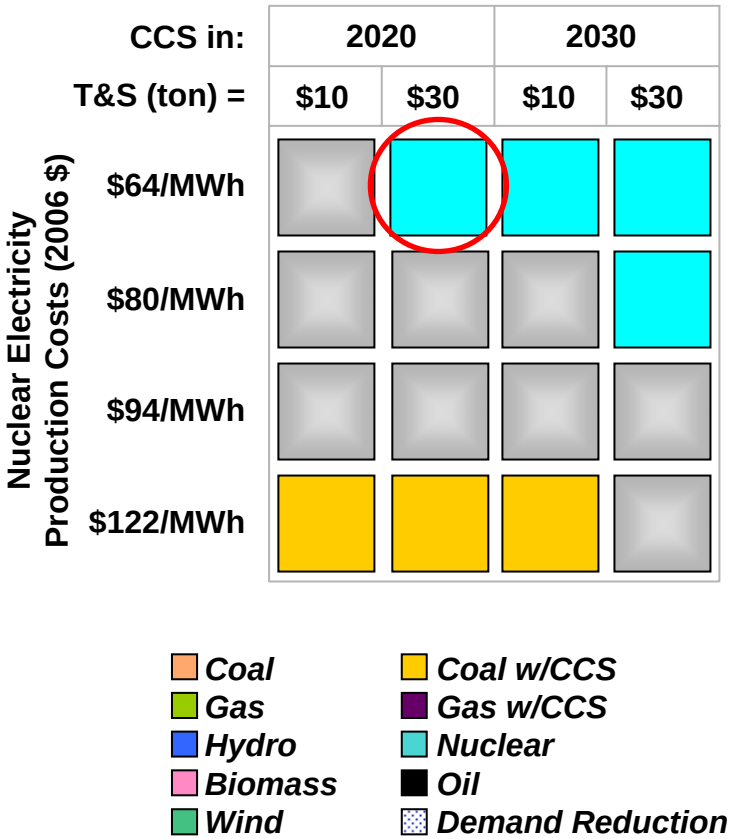
Bechtel Global Supply Trends, 2008 Mid-Year Update

Conclusions

- **Even with cost escalation and variability, we can conclude that:**
  - **The scale of technology expansion and transformation will be huge.**
  - **No one technology will be a silver bullet – a portfolio of technologies will be needed.**
  - **Baseload technologies will be needed.**
  - **Renewables and efficiency will also play a large role.**
  - **There is no time to lose – technology development lead times are long.**

Together…Shaping the Future of Electricity

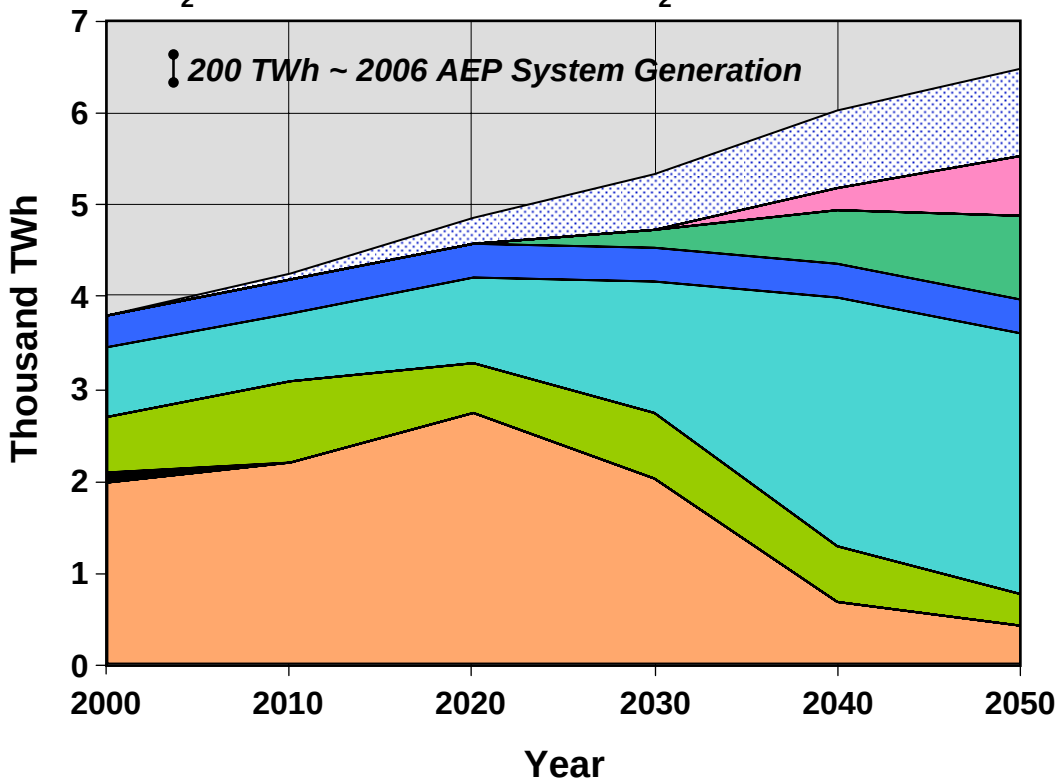
EPRI 2008 MERGE Sensitivity Analyses



Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $112/MWh

CO_2 Cost = $76/metric ton CO_2



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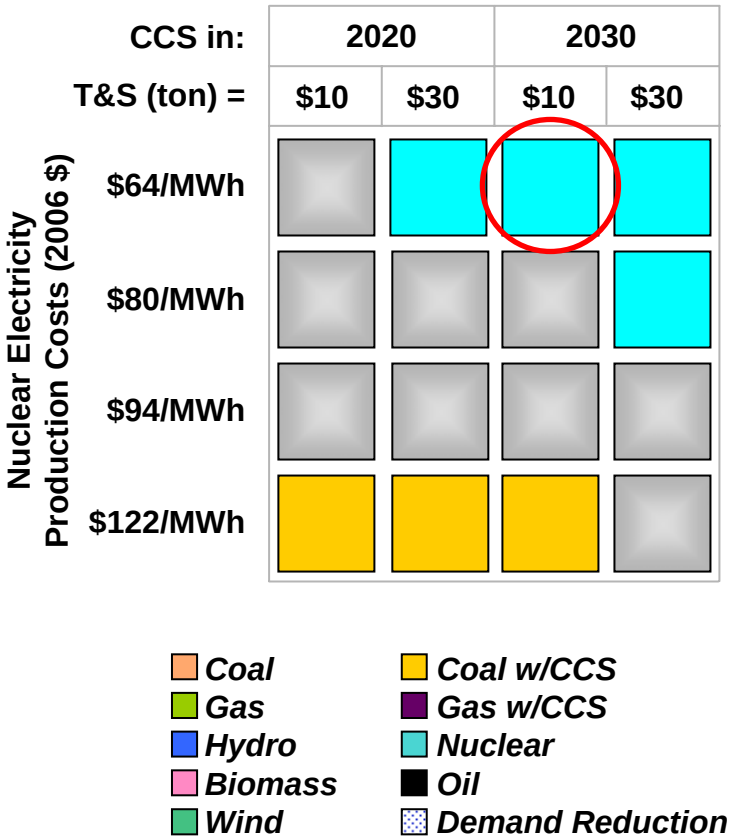

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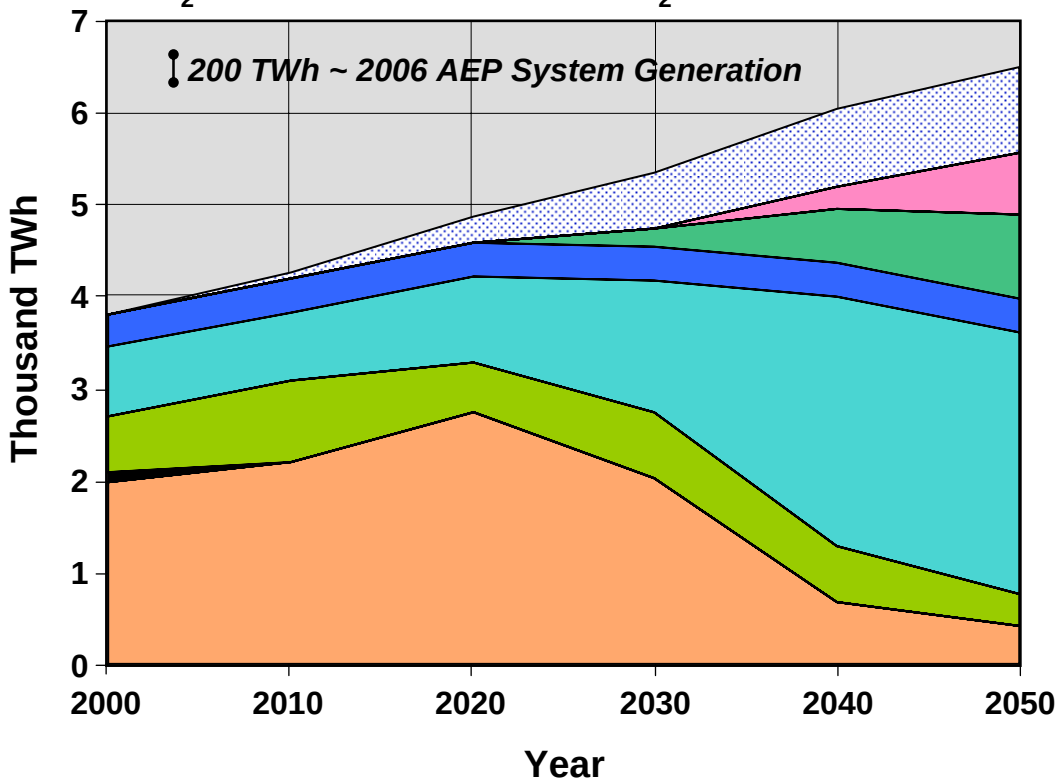

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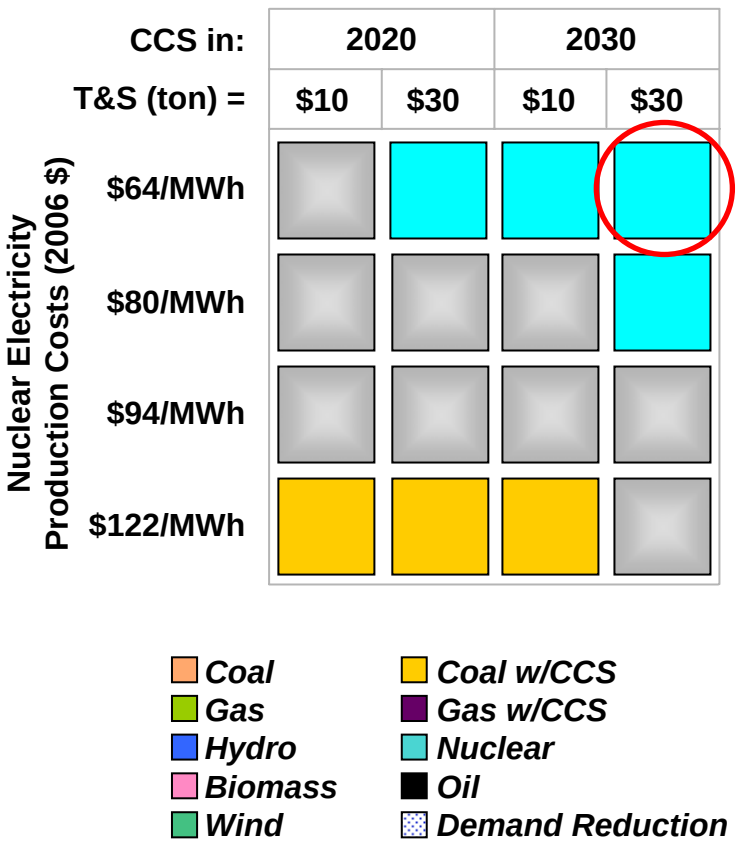

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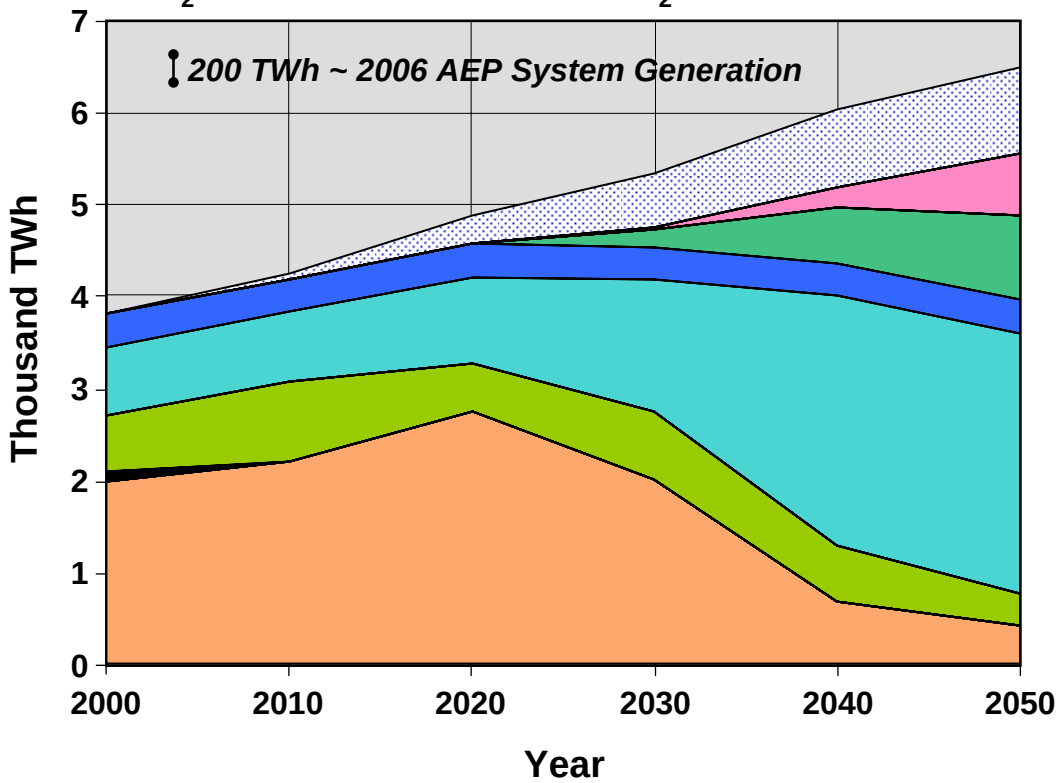

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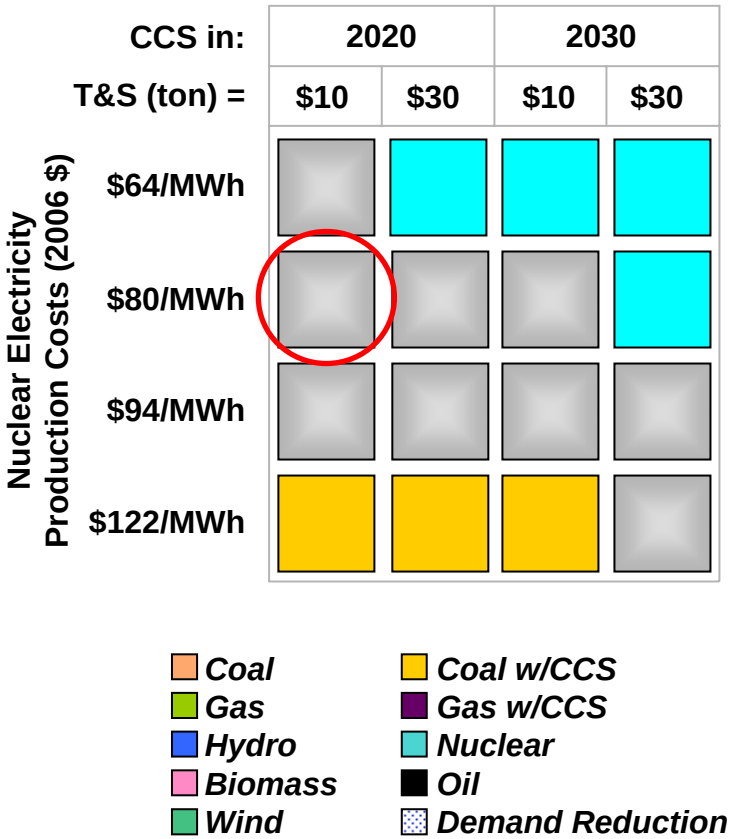
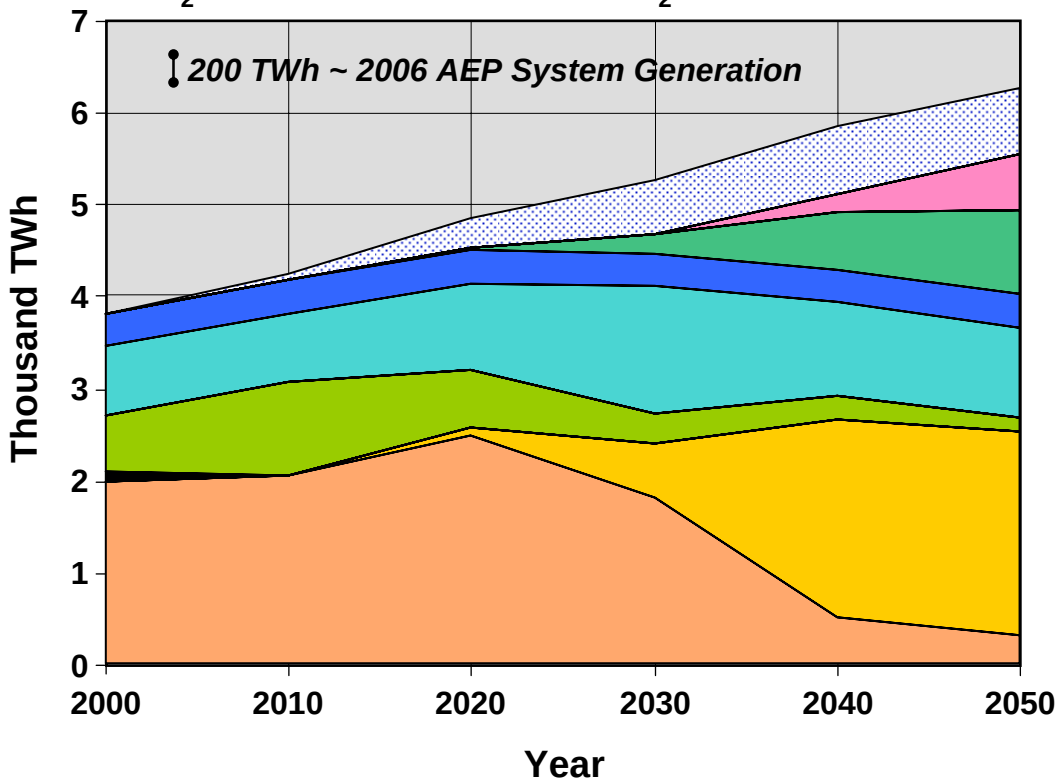


Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $116/MWh

CO_2 Cost = $81/metric ton CO_2



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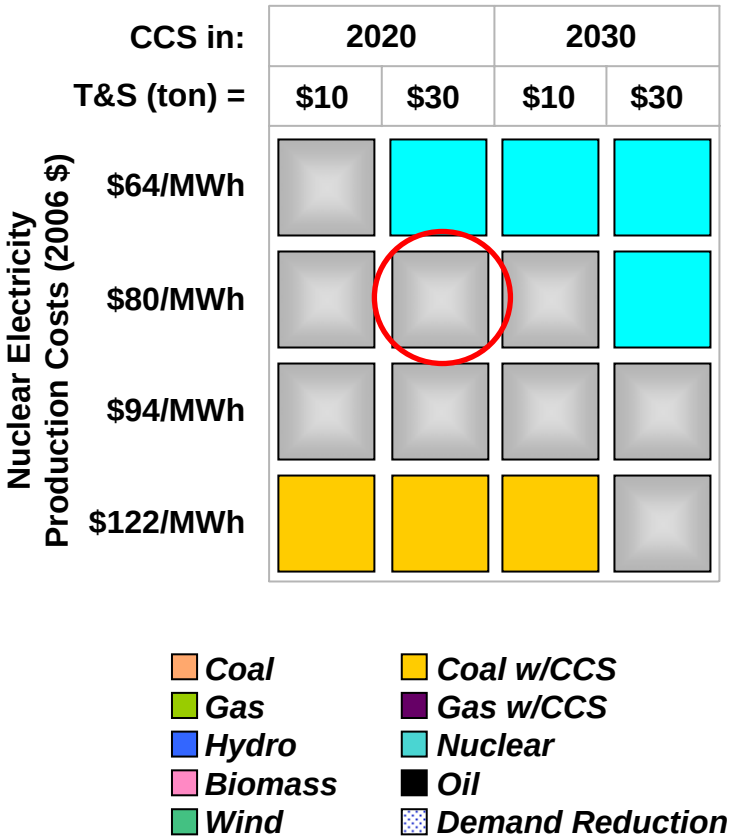
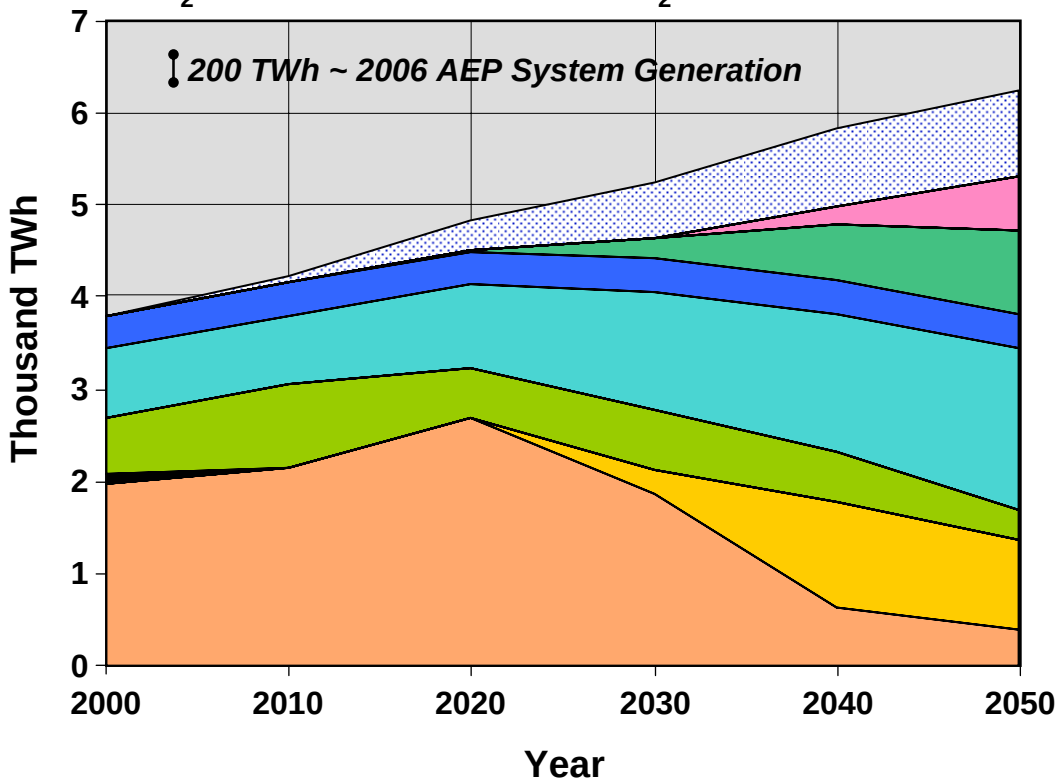


Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $114/MWh

CO_2 Cost = $89/metric ton CO_2



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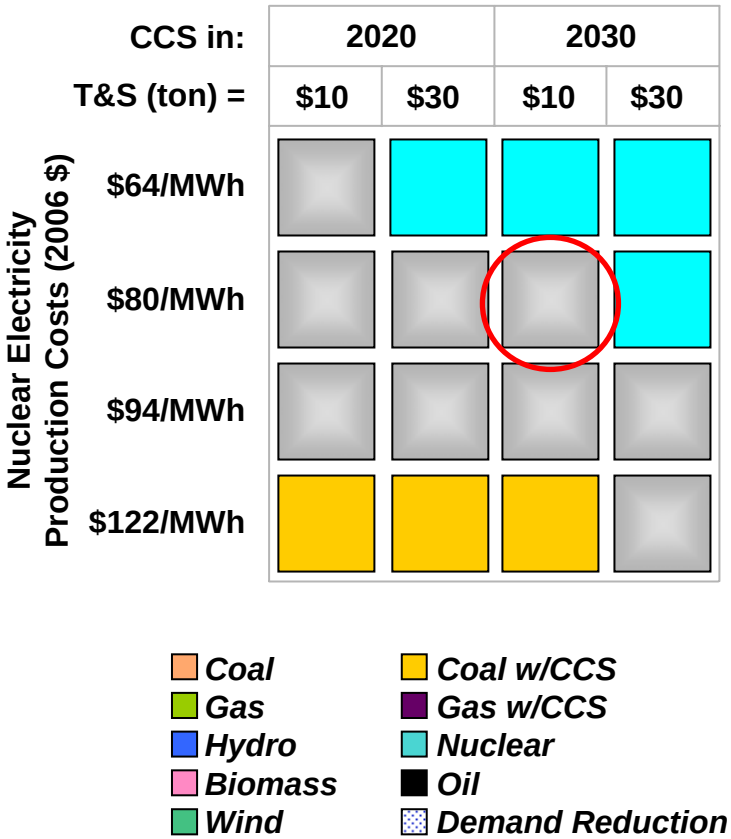

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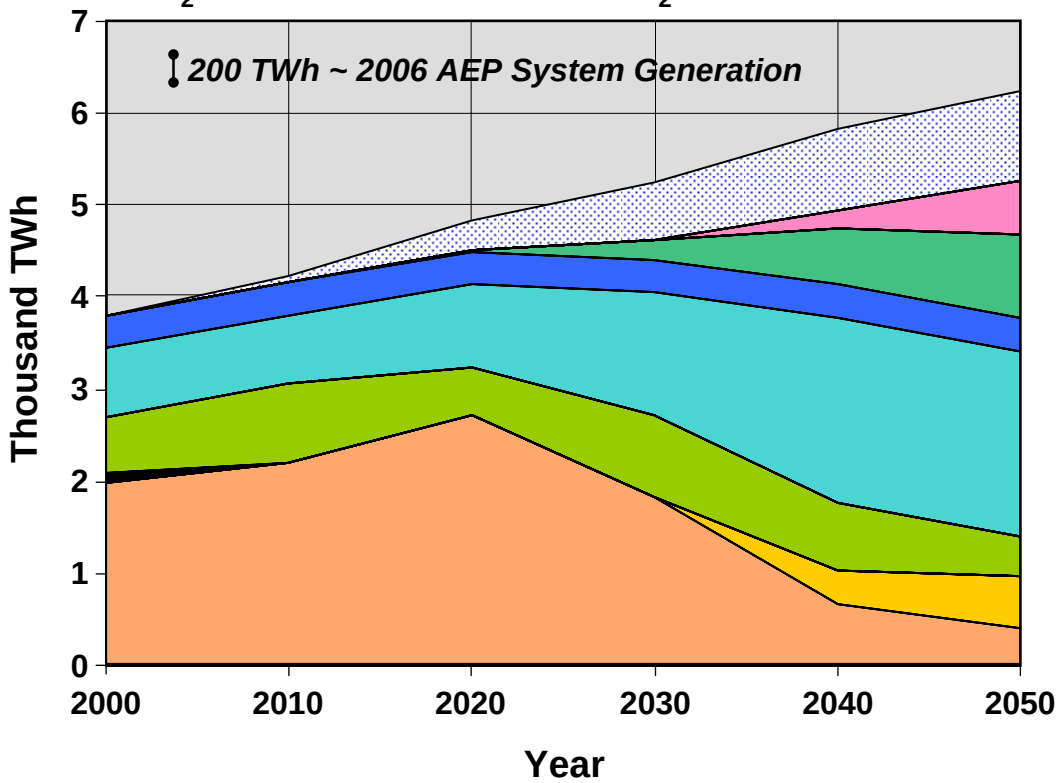

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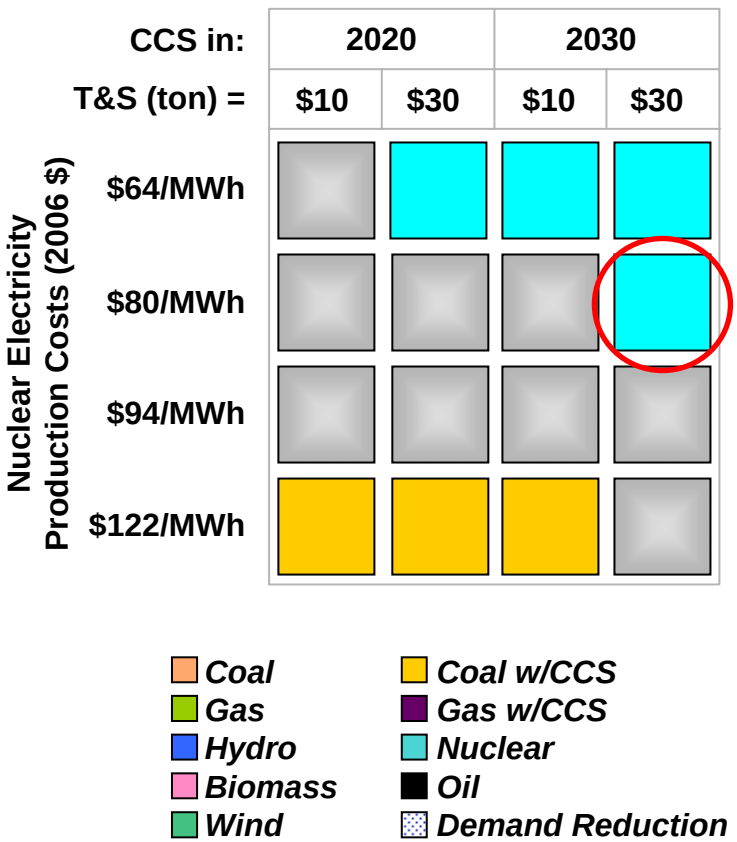
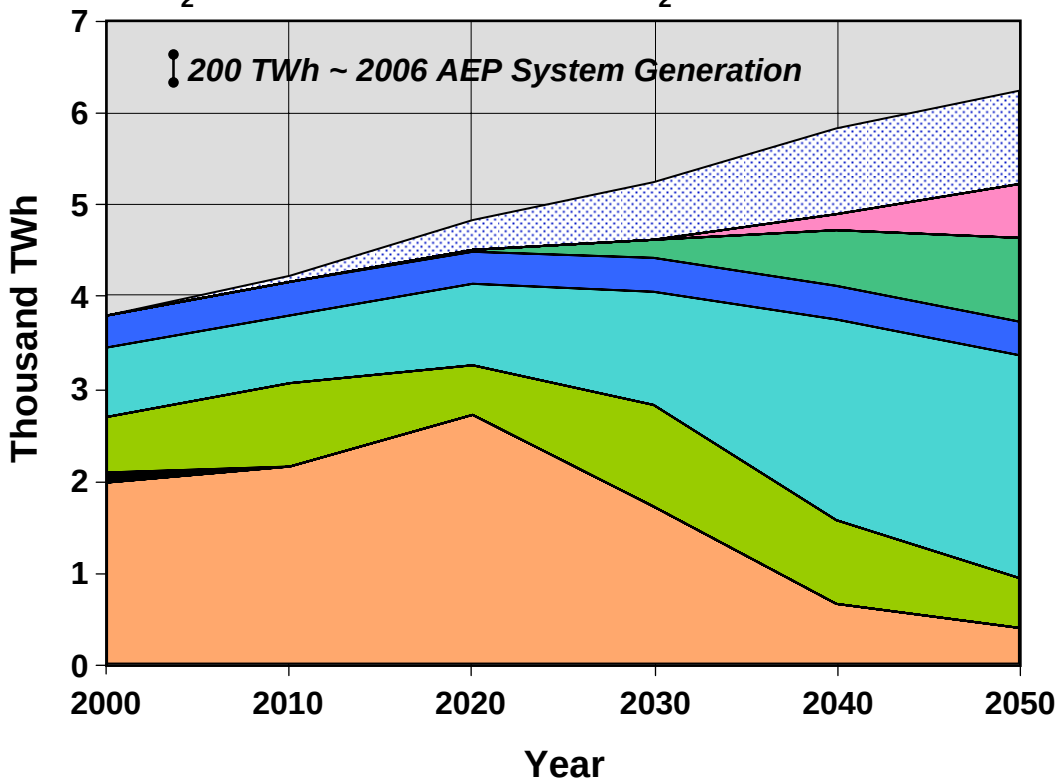


Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $112/MWh

CO_2 Cost = $85/metric ton CO_2



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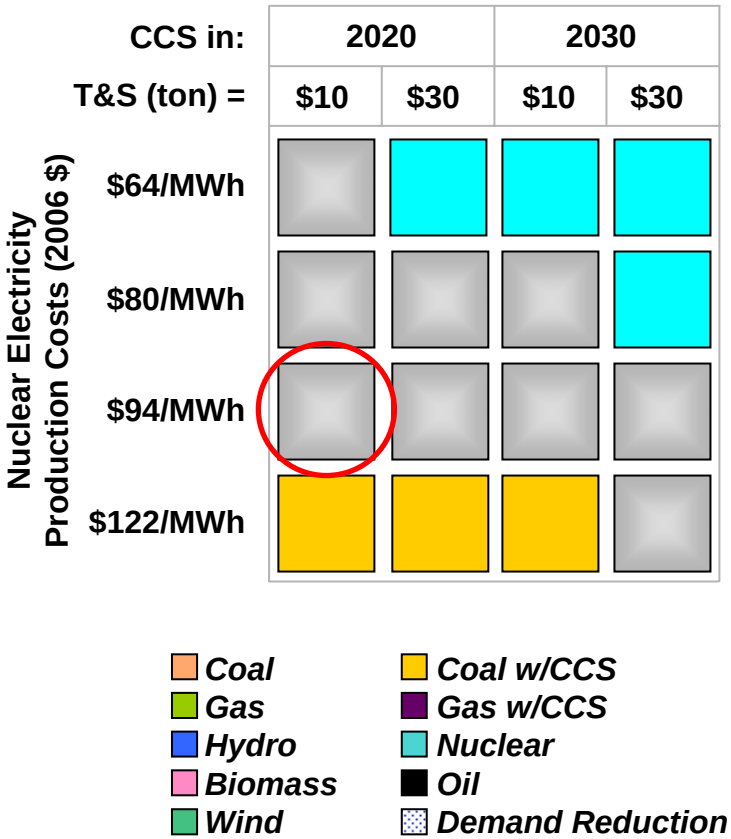
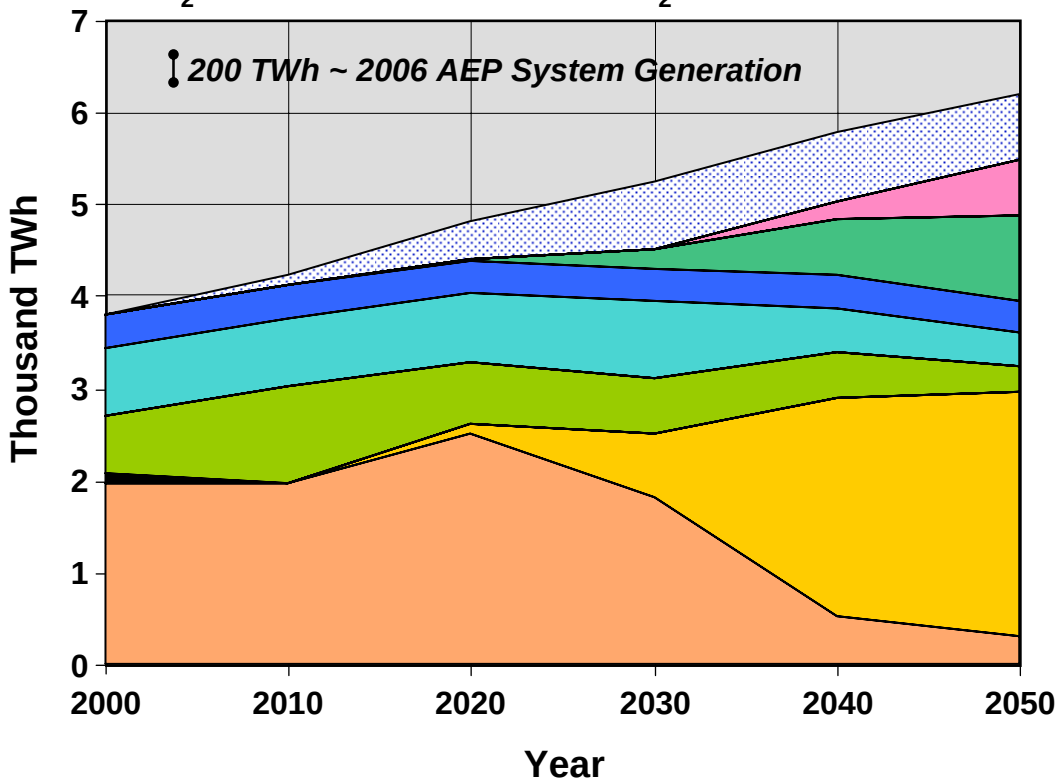


Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $124/MWh

CO_2 Cost = $95/metric ton CO_2



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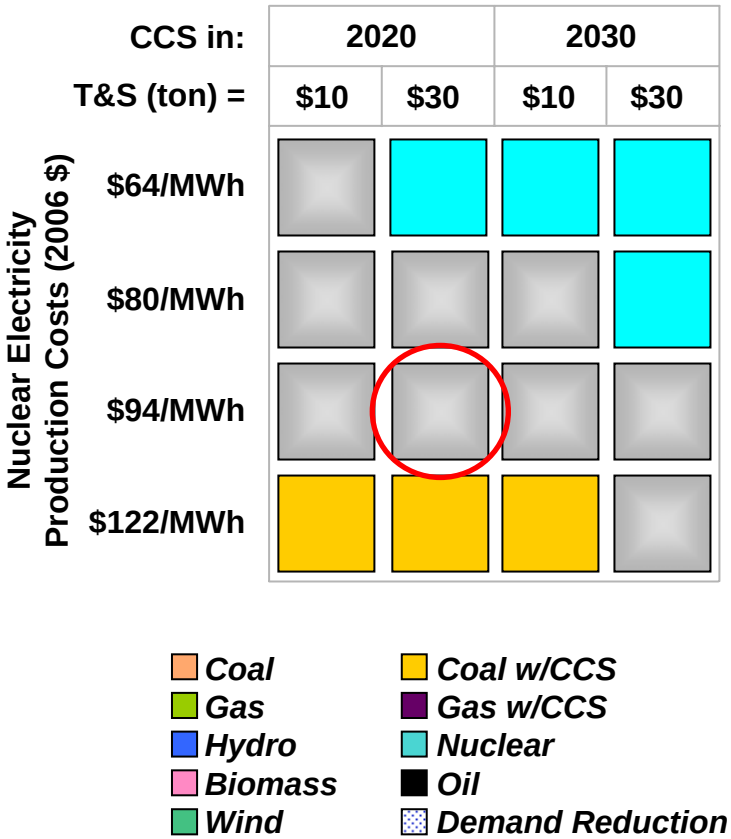
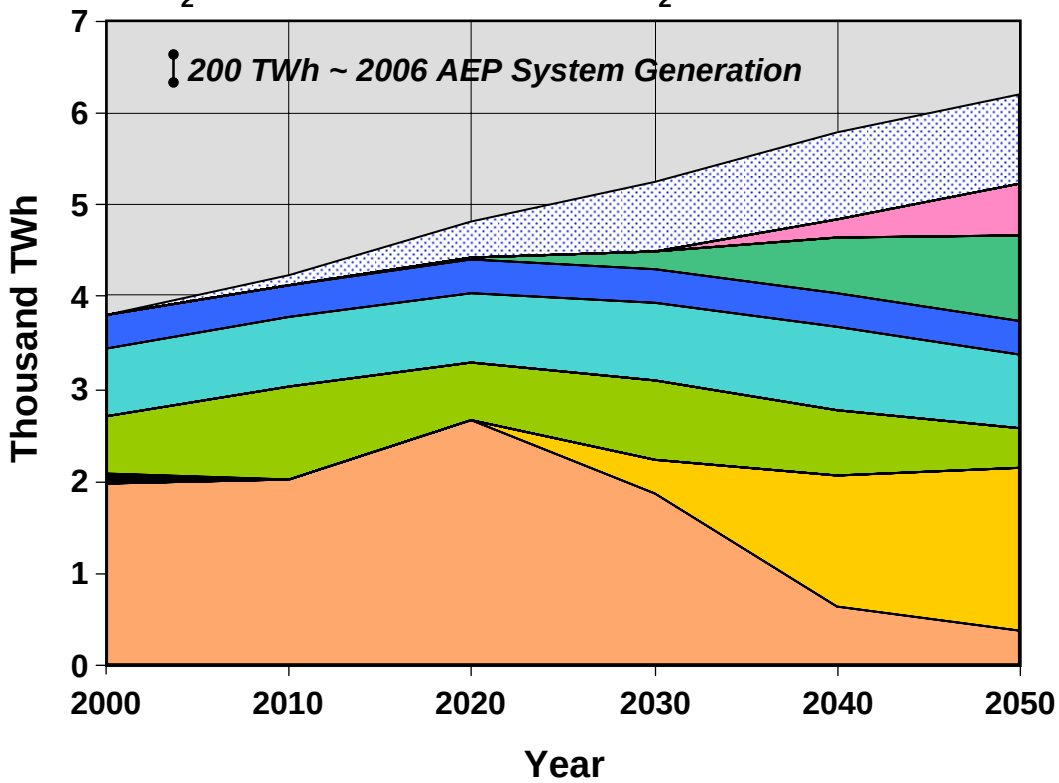


Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $123/MWh

CO_2 Cost = $96/metric ton CO_2



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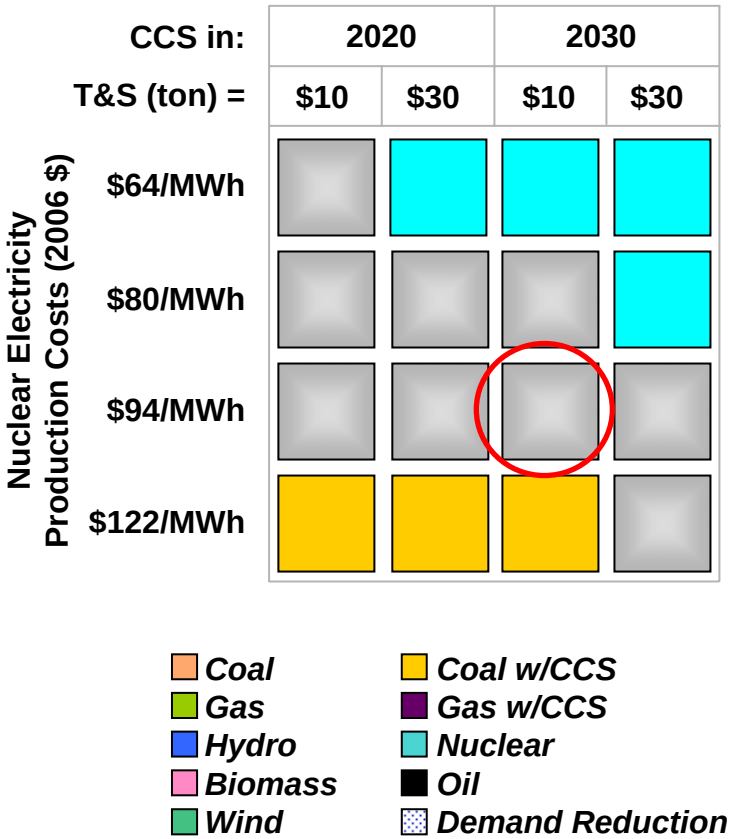

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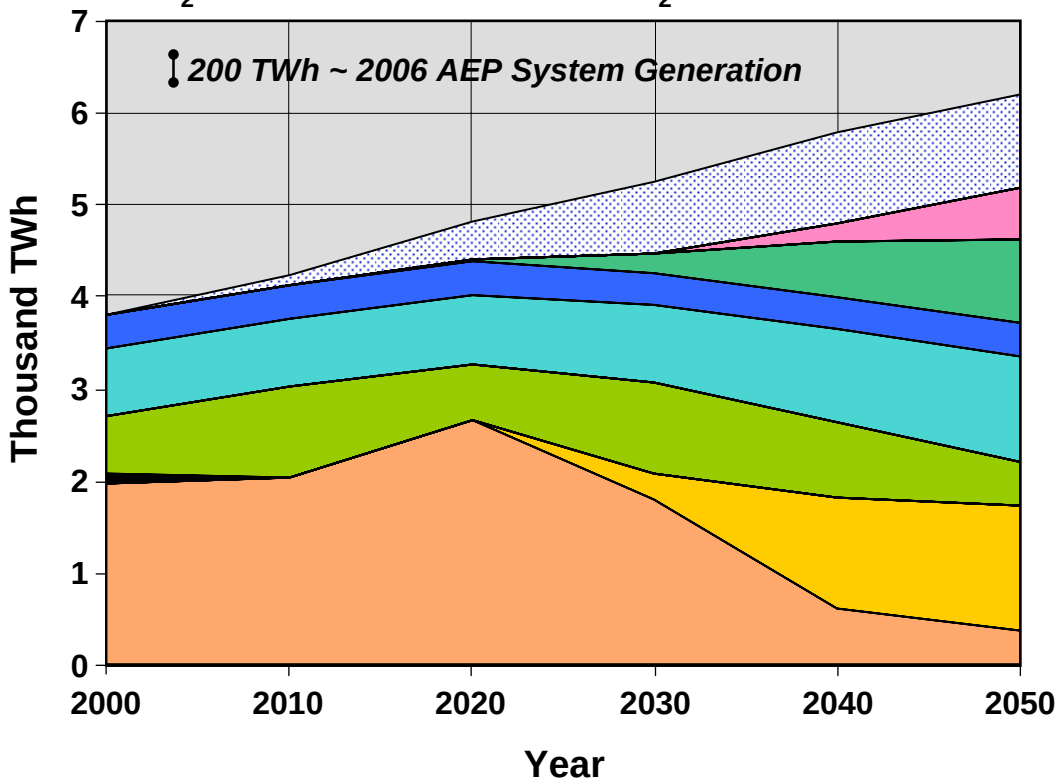

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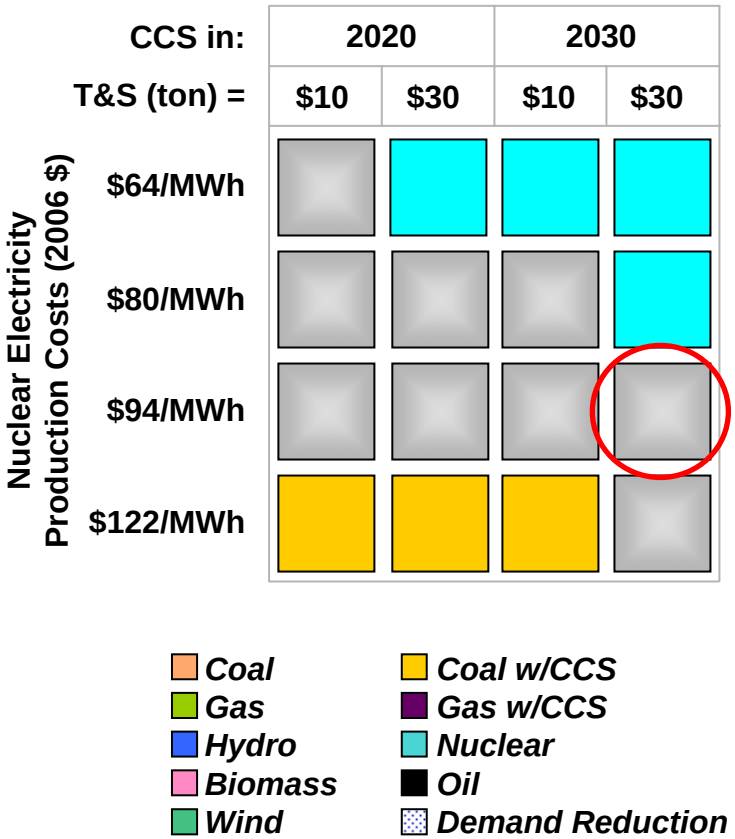
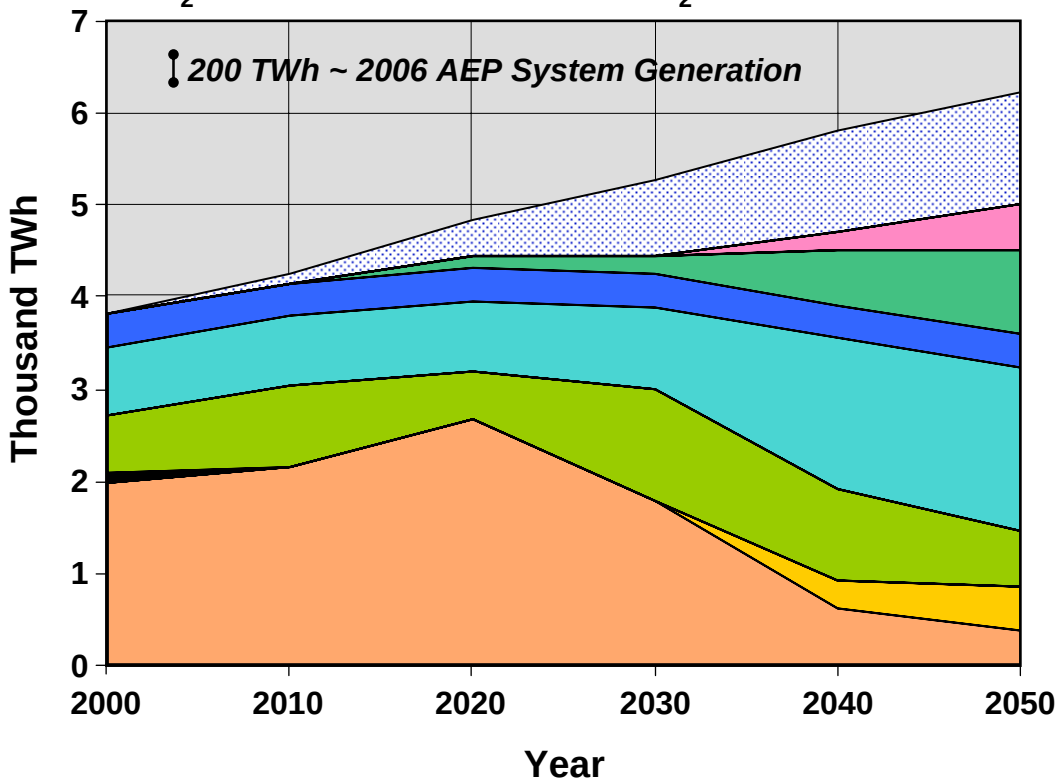


Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $125/MWh

CO_2 Cost = $100/metric ton CO_2



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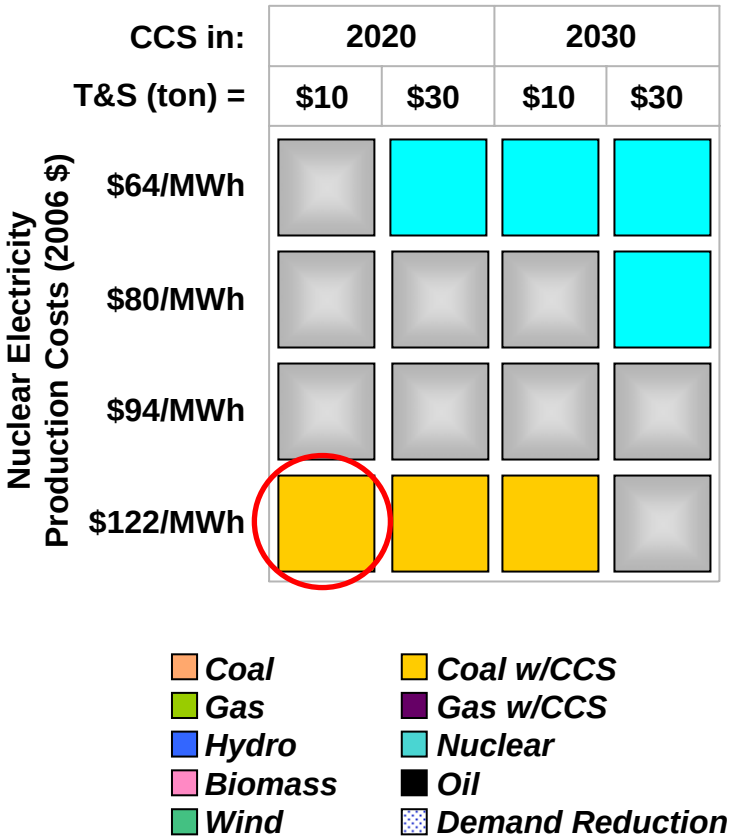

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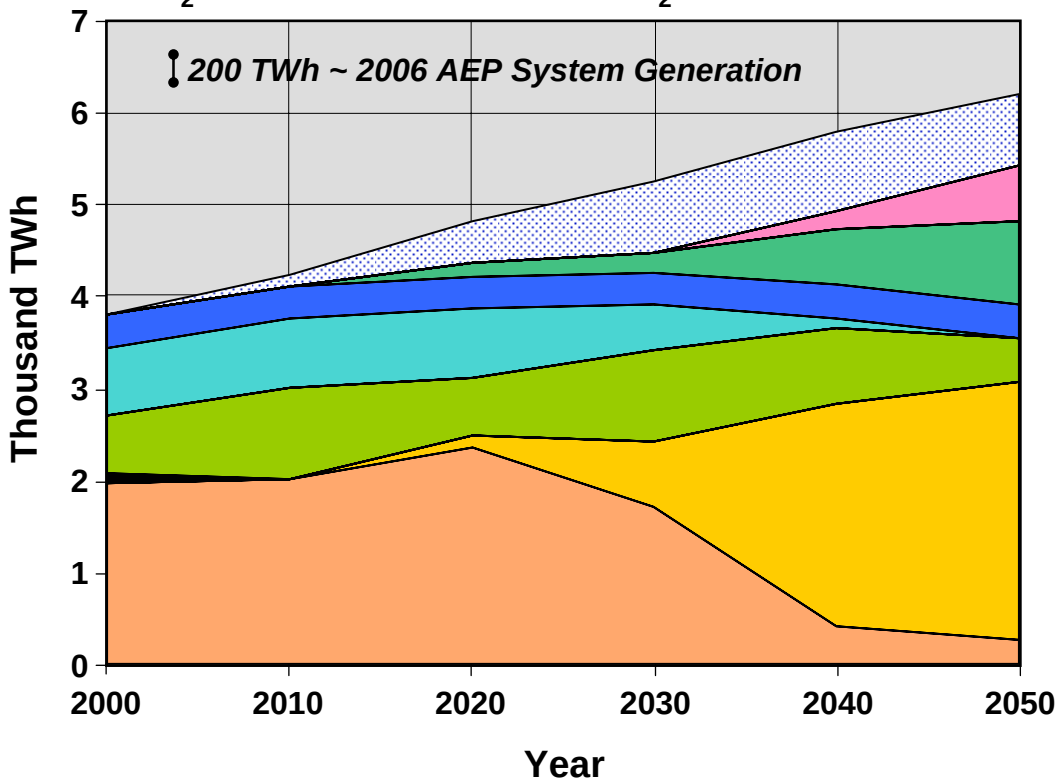

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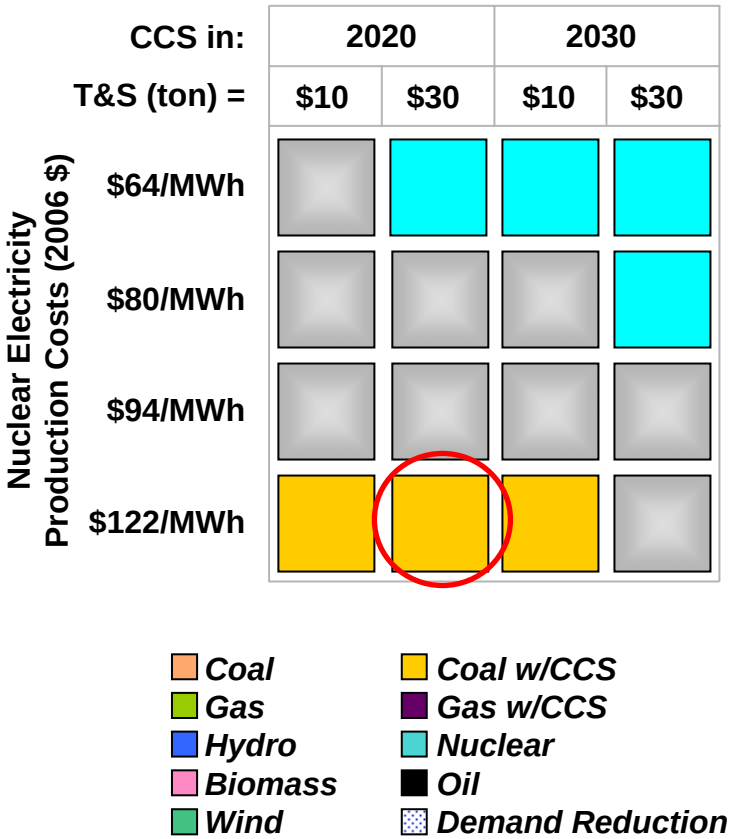
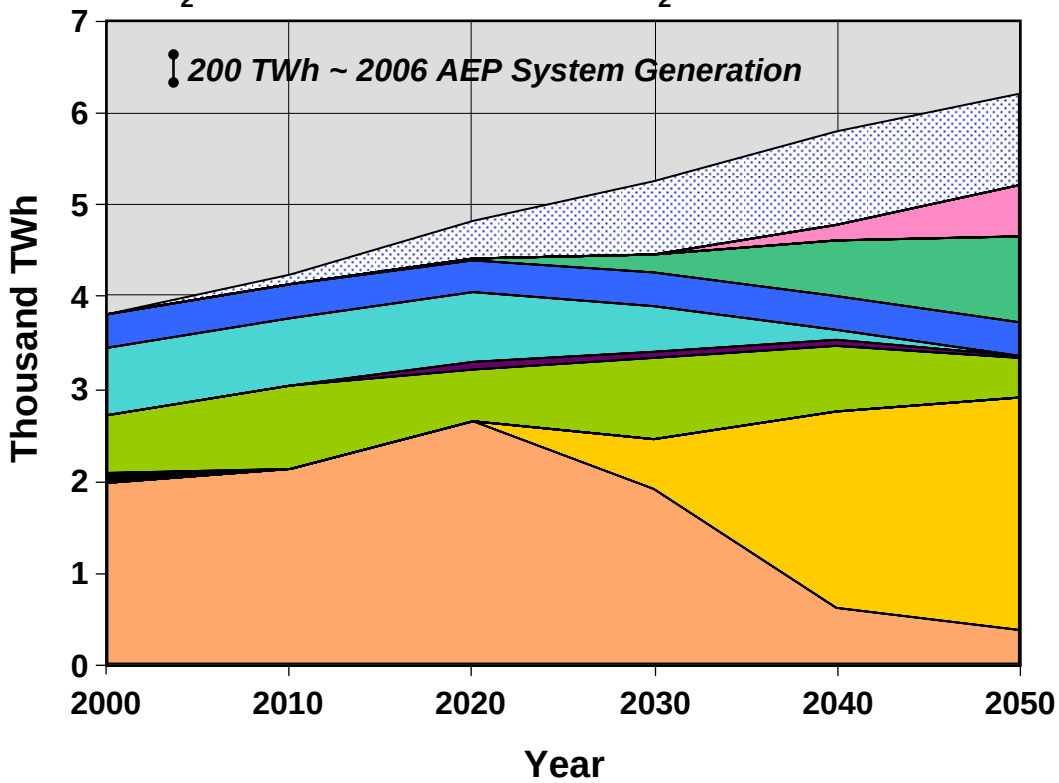


Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $125/MWh

CO_2 Cost = $98/metric ton CO_2



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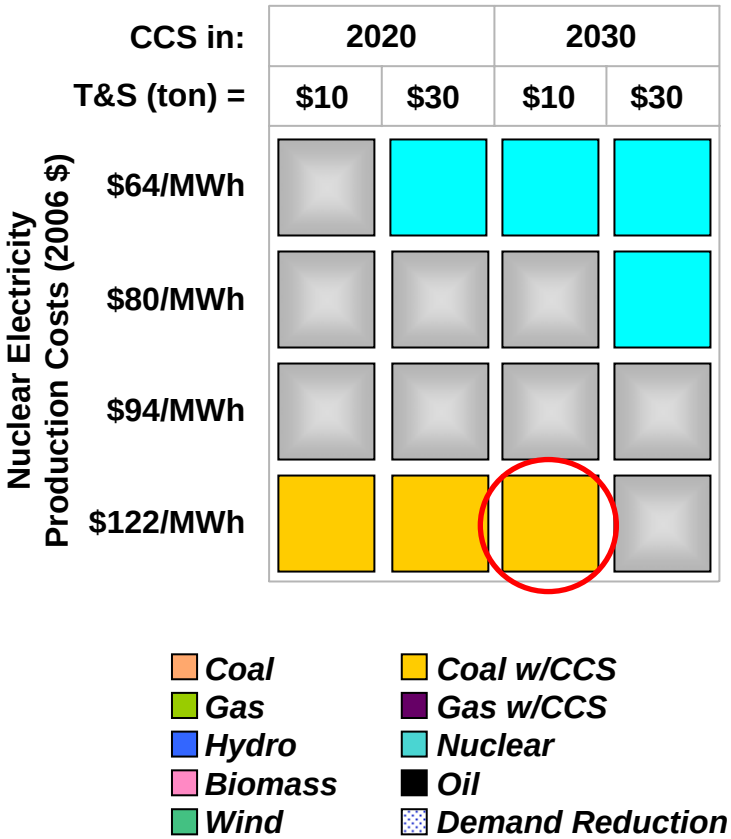

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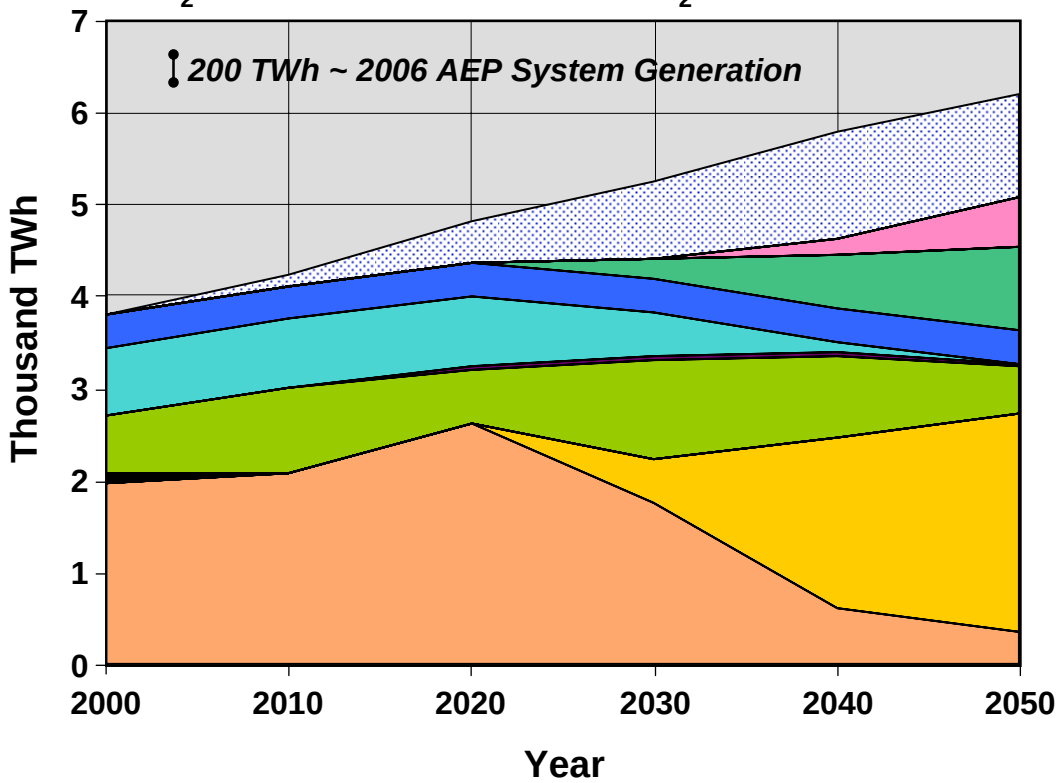

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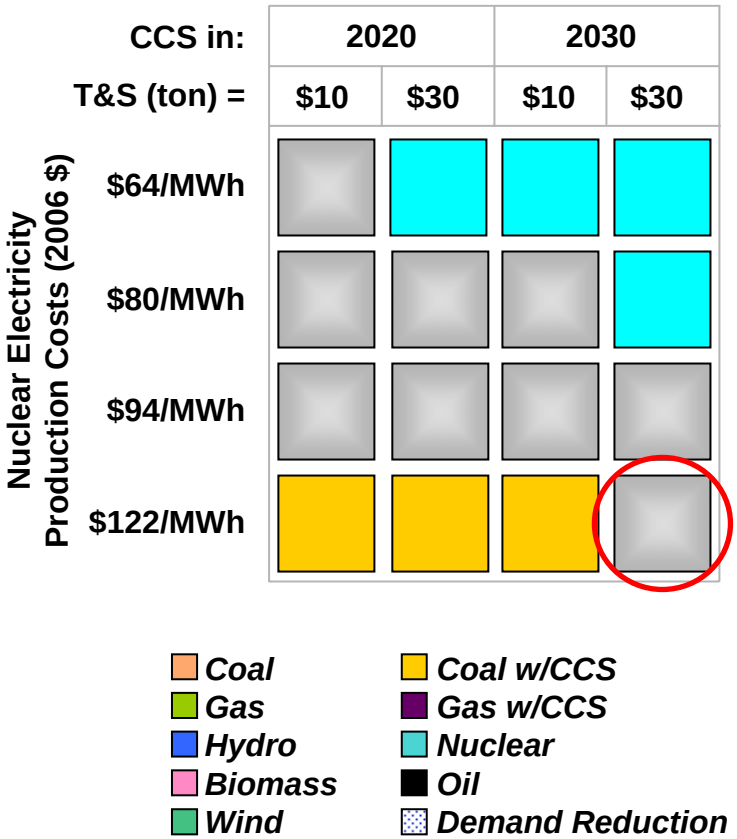

Key parameters in 2030 (2006 $)

Wholesale Electricity Cost = $129/MWh

CO_2 Cost = $103/metric ton CO_2