Generation Technology Choices: Near and Long Term

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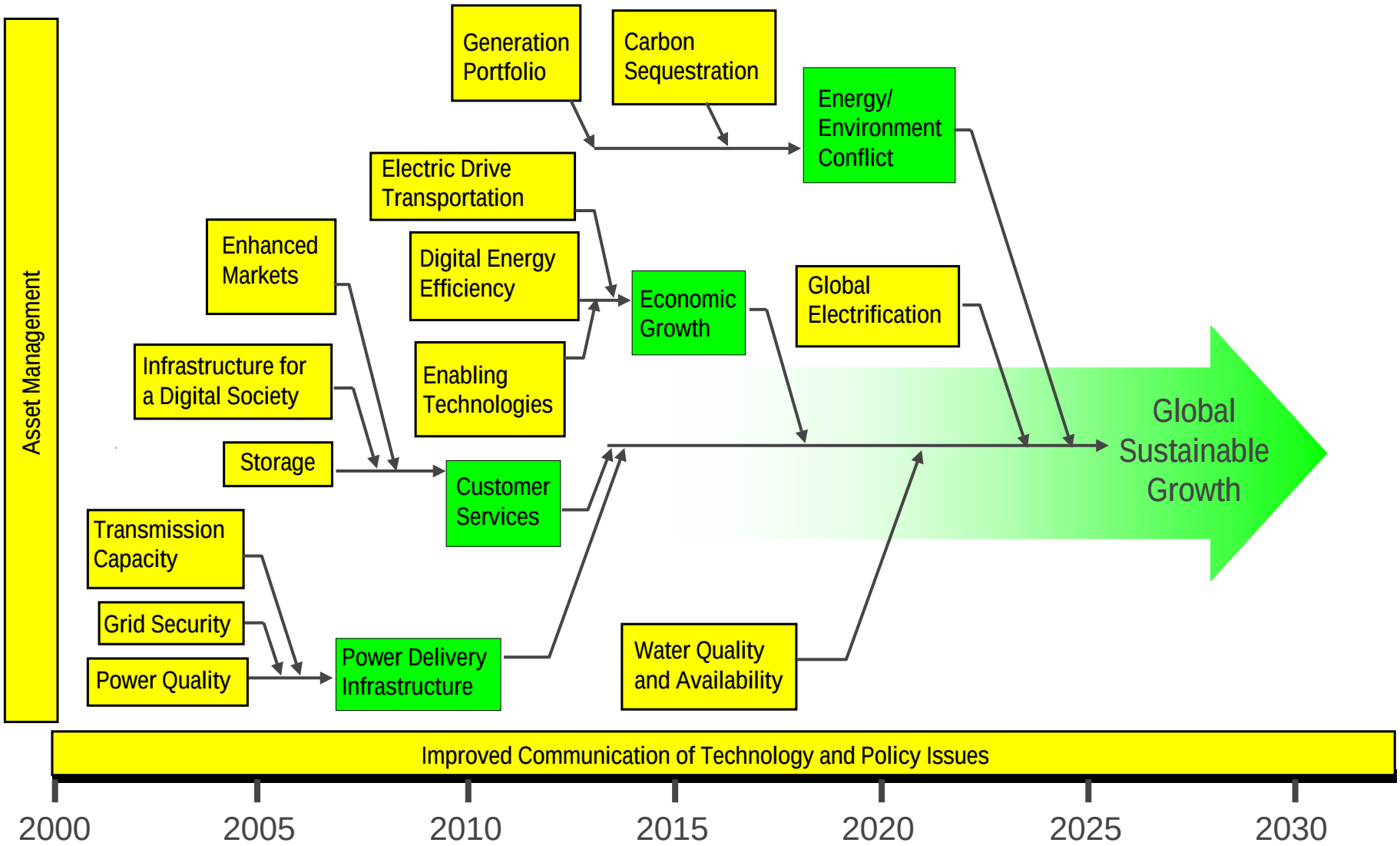
Bounding Estimate of Fossil Fuel Consumption

Fuel	Total Global Resource	Current US Consumption, per year and per capita	Projected Global Consumption, per year	Resource Lifetime
Oil	6,200 Q	37.6 Q/yr = 132 Q/B	1,580 Q/yr	3.9 years
Gas	5,500 Q	19.3 Q/yr = 67.6 Q/B	811 Q/yr	6.8 years
Coal	23,200 Q	23.3 Q/yr = 81.6 Q/B	979 Q/yr	23.7 years

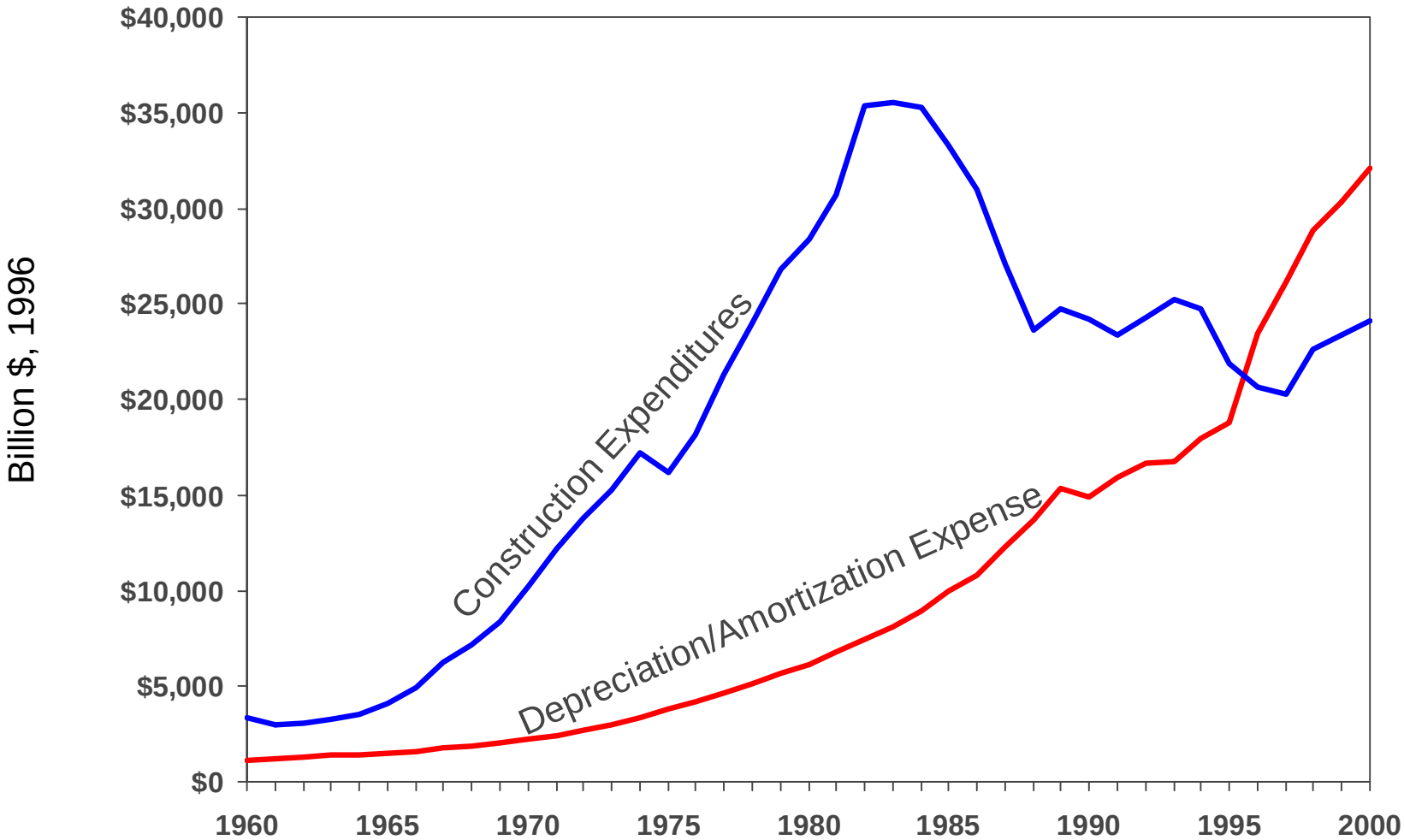
Generation Issues

- Where?
- When?
- How much?
- What kind?
- Ownership?
- Business model?
- Regulatory framework?
- Environmental concerns?
- Integration with transmission and distribution infrastructures?

Roadmap Logic Flow Diagram

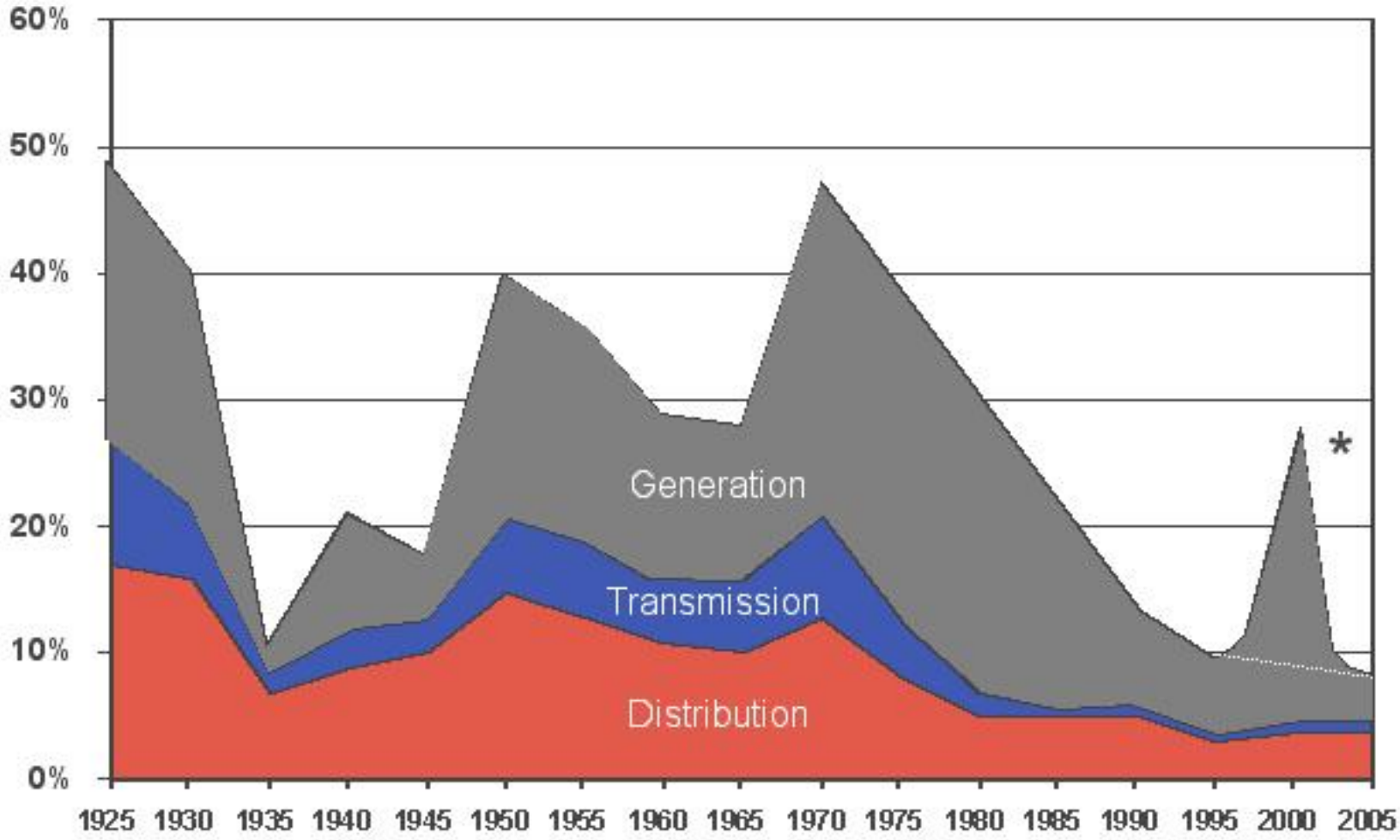


Utility Construction Expenditures and Depreciation/Amortization Expense



Source: "Historical Statistics of the Electric Utility Industry" and "EEI Statistical Yearbook" - EEI

Capital Invested as % of Electricity Revenues



* Note – deregulated market generation

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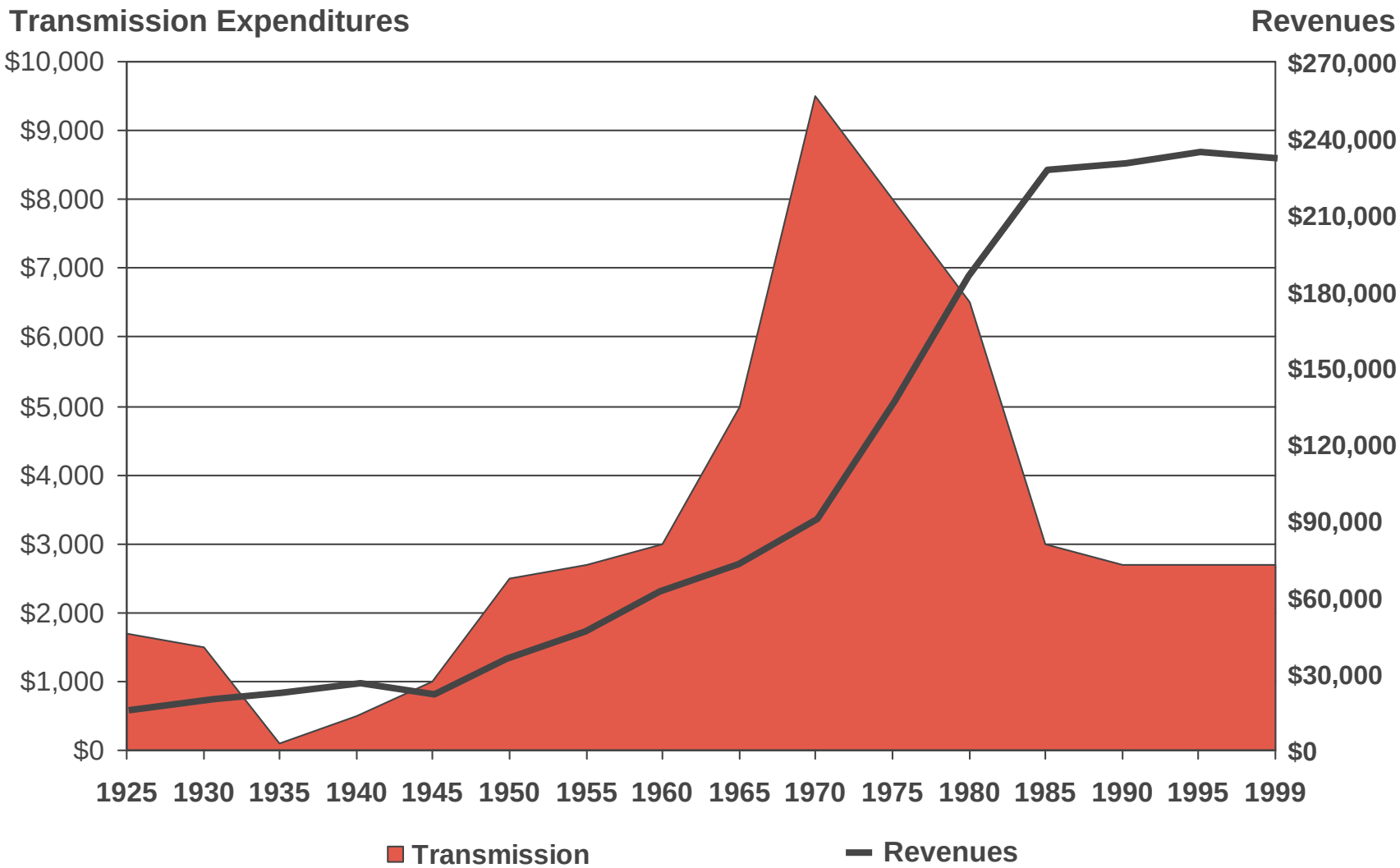
Electric Utility Revenues & Transmission Expenditures in Real 2003 $m, 1925-1999



Source: EEI, EIA

Natural Gas and Power Reliability: A Vital Concern

- Even with a reduction in planned additions, gas-fired capacity continues to grow
- It will be difficult to maintain even existing levels of production with conventional resources
- Supplies will have to increase by 8 trillion cubic ft/yr to meet post-2010 projections

LNG – Promise and Problems

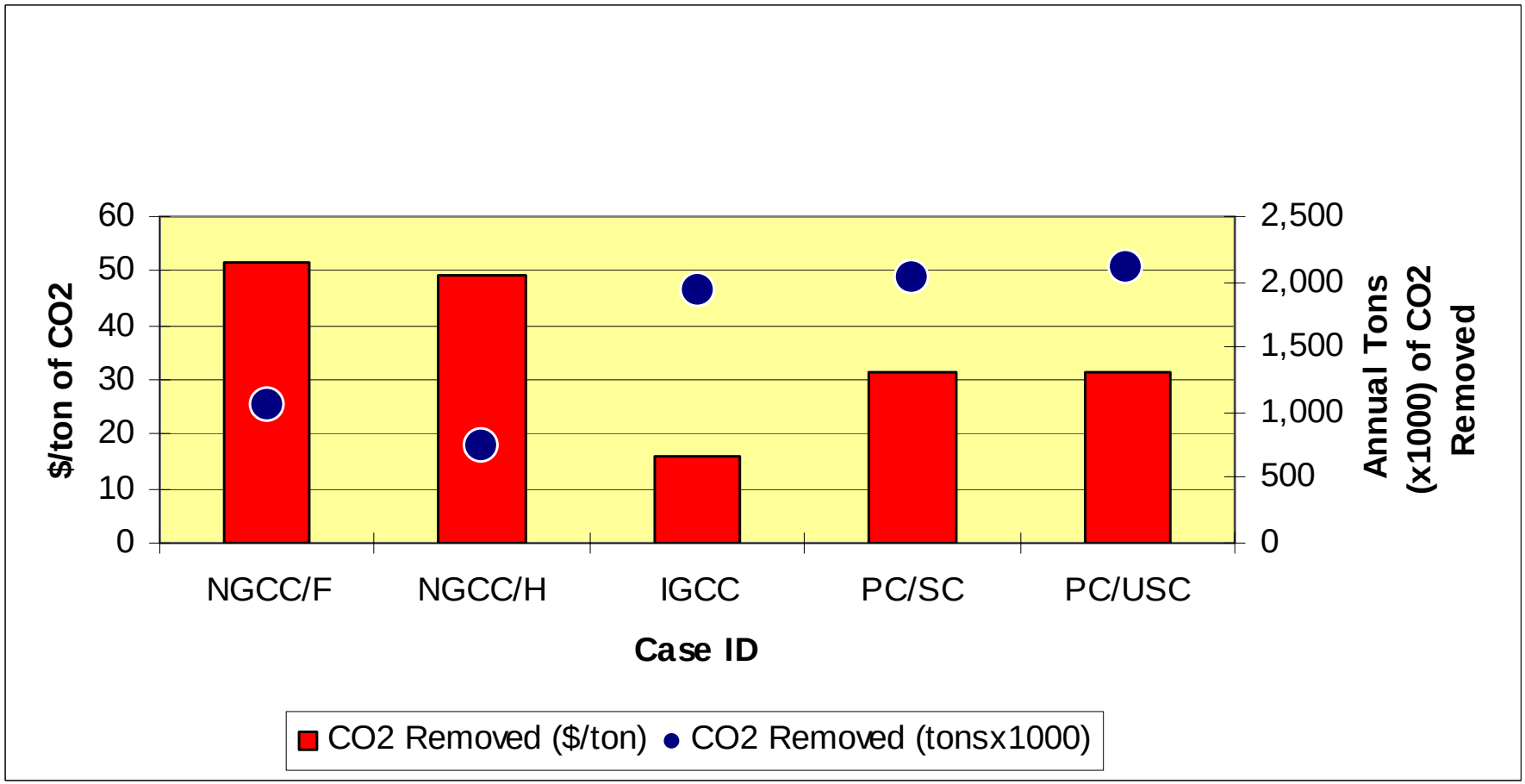
Carbon Sequestration

- Direct sequestration:
  - capture CO_2 (how?)
  - dispose of it (where?)
- Costs are high and may be difficult to reduce
- Technology breakthroughs needed

Integrated Gasification Combined Cycle

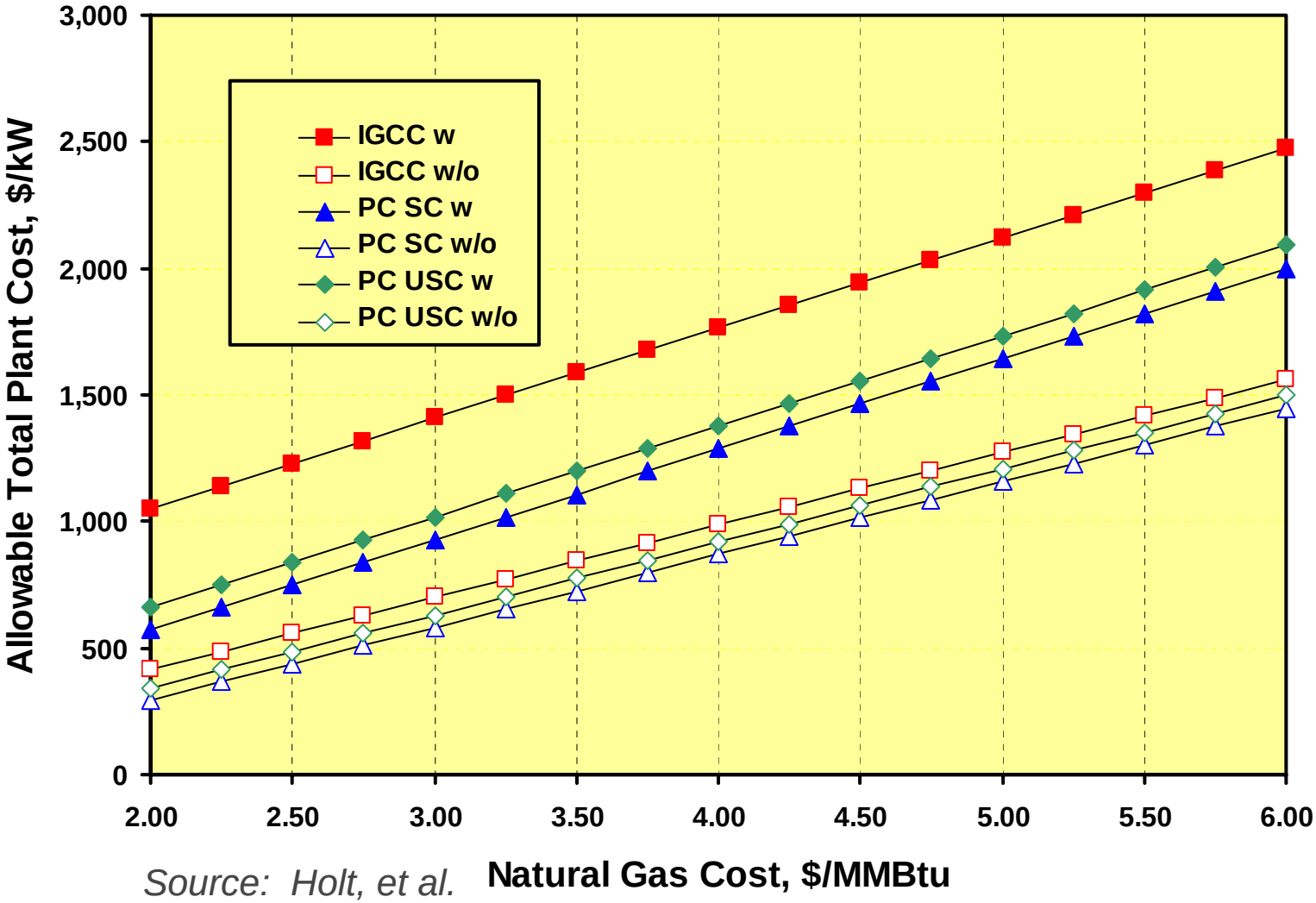
- IGCC may become the coal technology of choice
  - Low emissions
  - High efficiency
  - Ideal for CO_2 capture
- Key enabling technology for future coal-based power
  - *and other markets !!*
- Ability to co-produce hydrogen adds potential for:
  - Clean transportation fuel
  - Significant reduction of green house gas emissions

Cost of CO2 Removal -- A Strong Function of Generation Technology



Source: Delallo, et al.

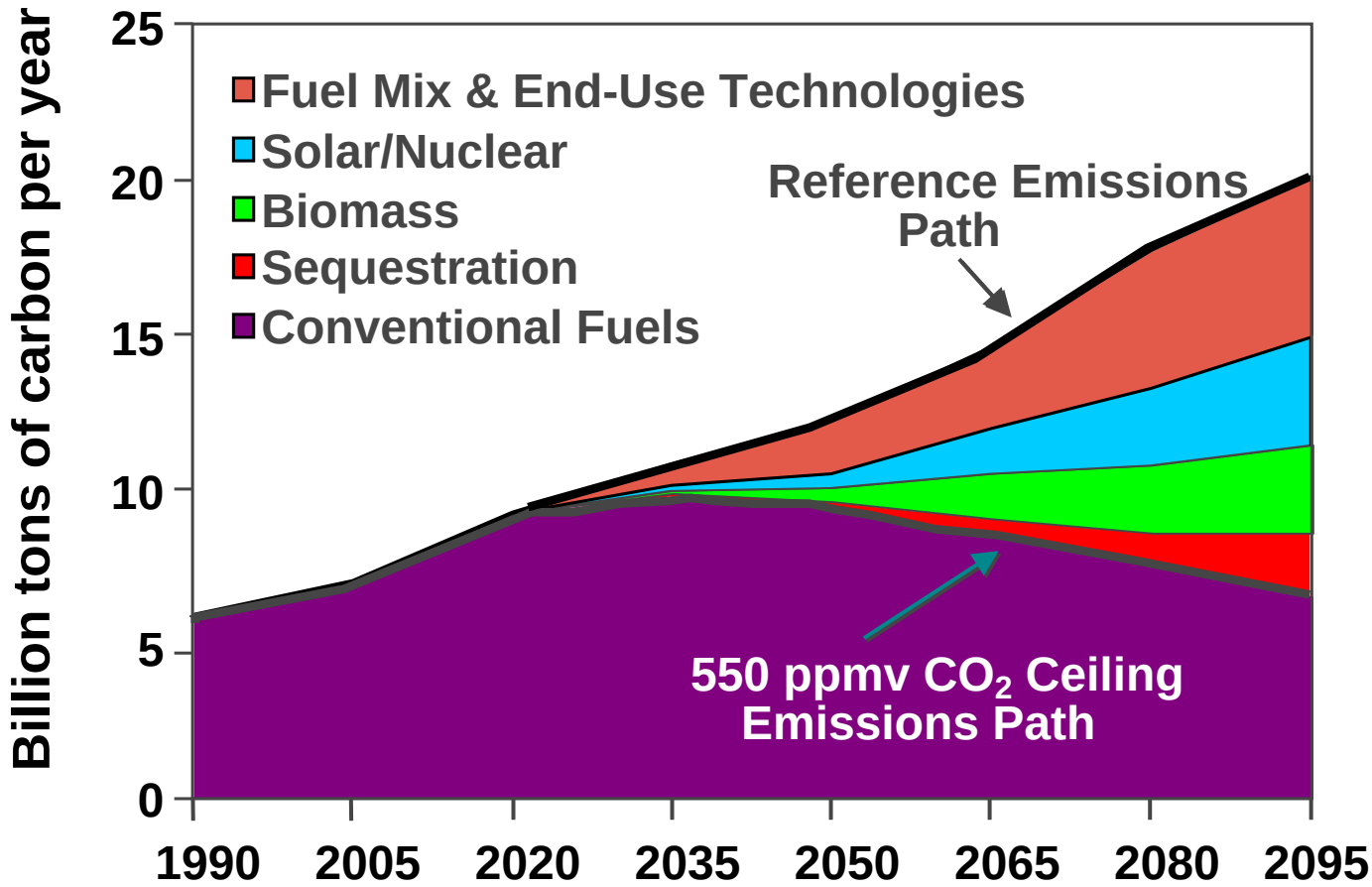
Break-Even COE – Coal and Natural Gas Comparison



Source: Holt, et al.

Energy Technologies Filling the Global CO_2 Emissions Gap

(an illustrative example)



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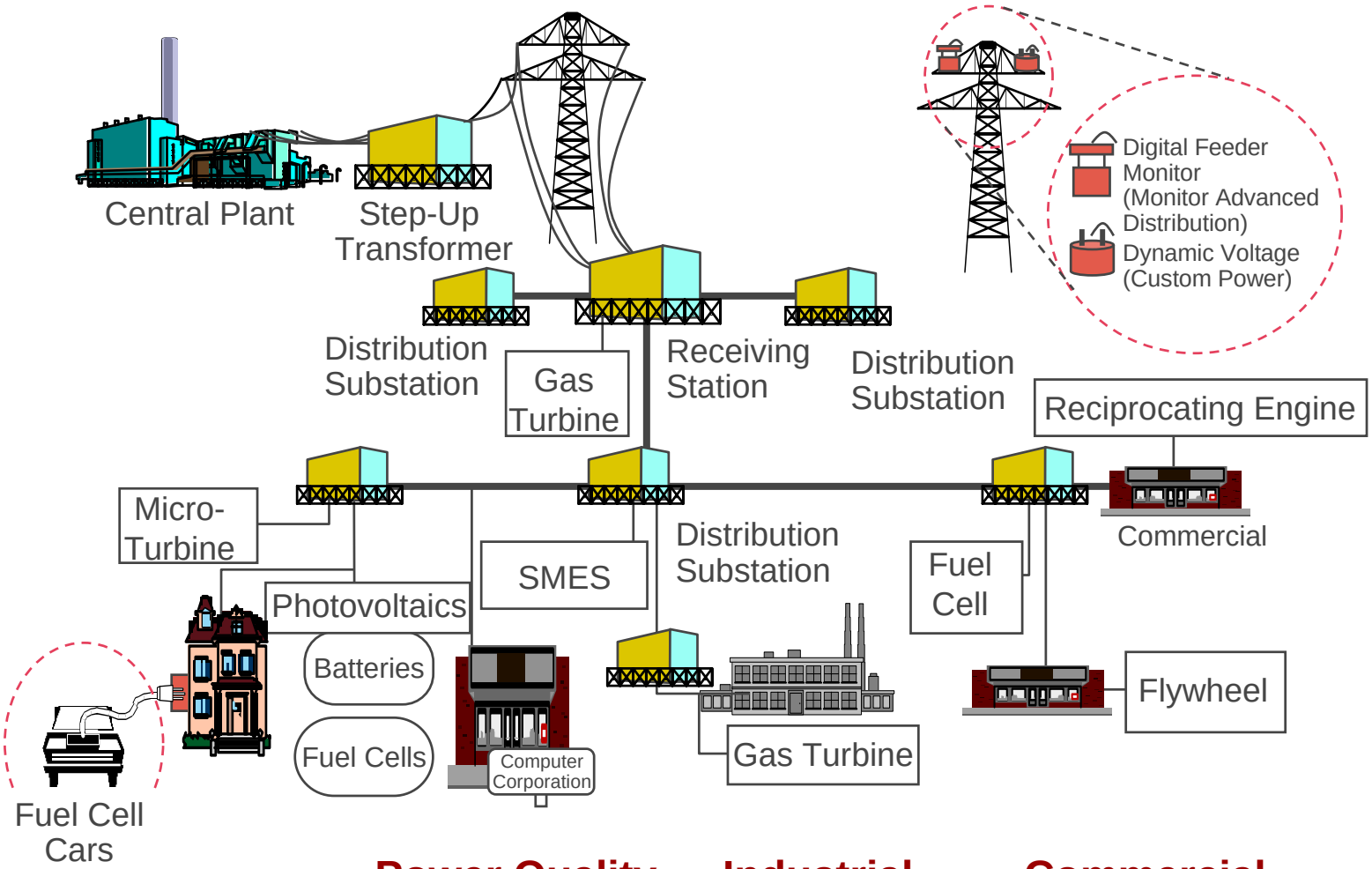
Energy/Carbon and Global Sustainability

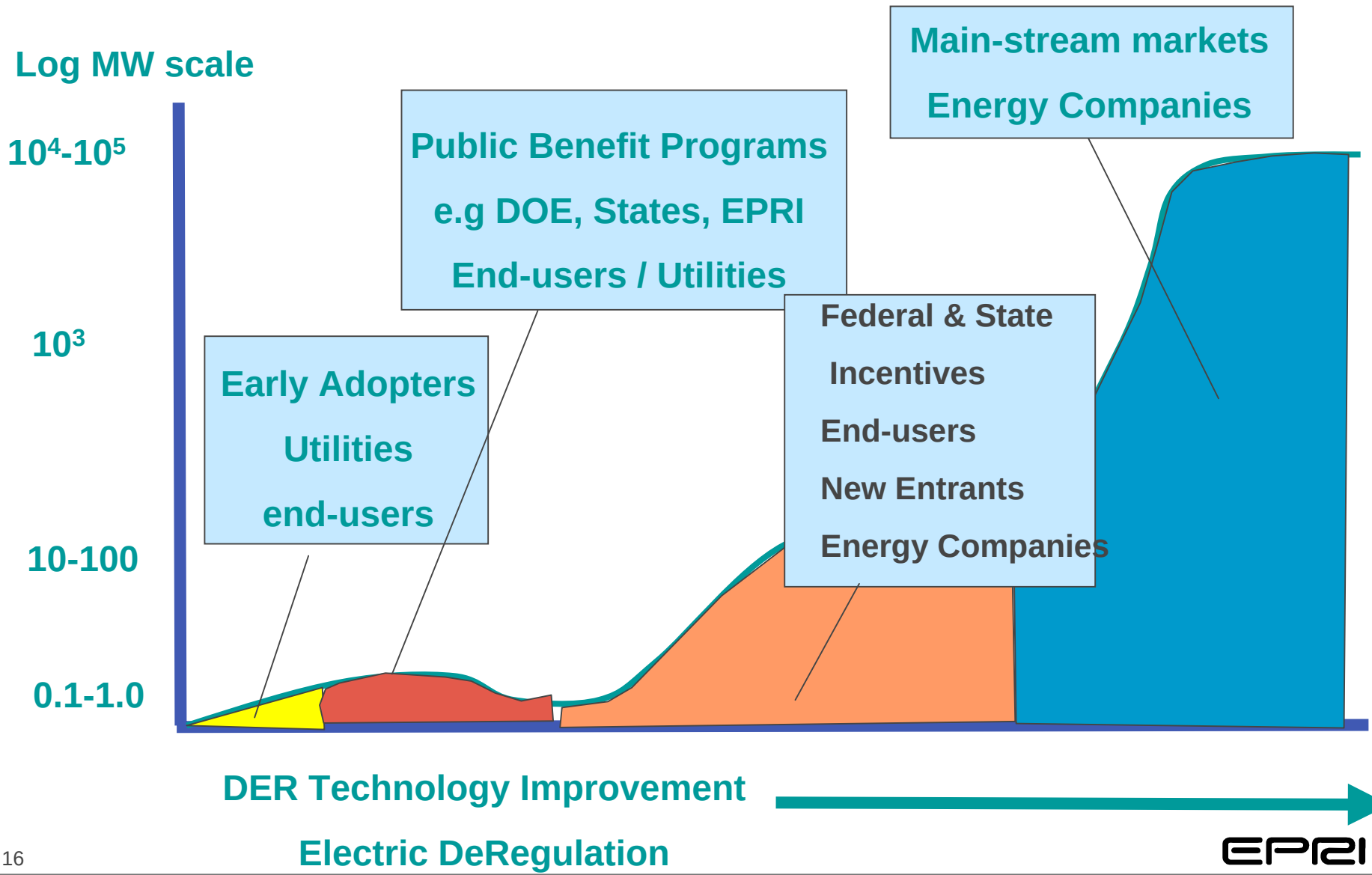
Limit-Breaking Technologies

- Clean coal technologies
- Carbon sequestration
- Advanced nuclear power
- Distributed renewable power systems
- Advanced gas generation
- Electricity/hydrogen

Tomorrow's Grid May Bear Little Resemblance to Today's



One View of DER Adoption

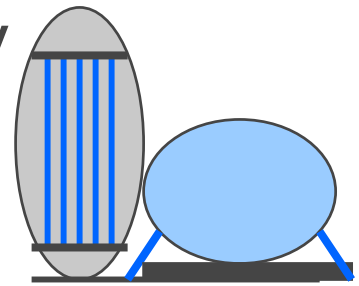


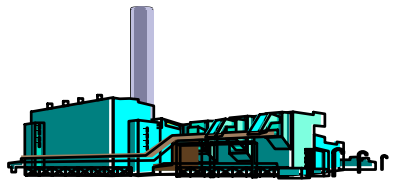
EPRI Hydrogen Roadmap

Utility Business Models and R&D Needs will drive the opportunity for public/private partnerships.

Distributed
H_2 Production

Centralized Production
Storage & Delivery





Nuclear

Coal Complex

Biomass

Near-term opportunity
Central H2 production
and delivery to Refilling Stations
NG Reformation at Refilling stations
Electrolysis at Refilling Stations

Go/NoGo by auto companies

2005 2010 2020 2050

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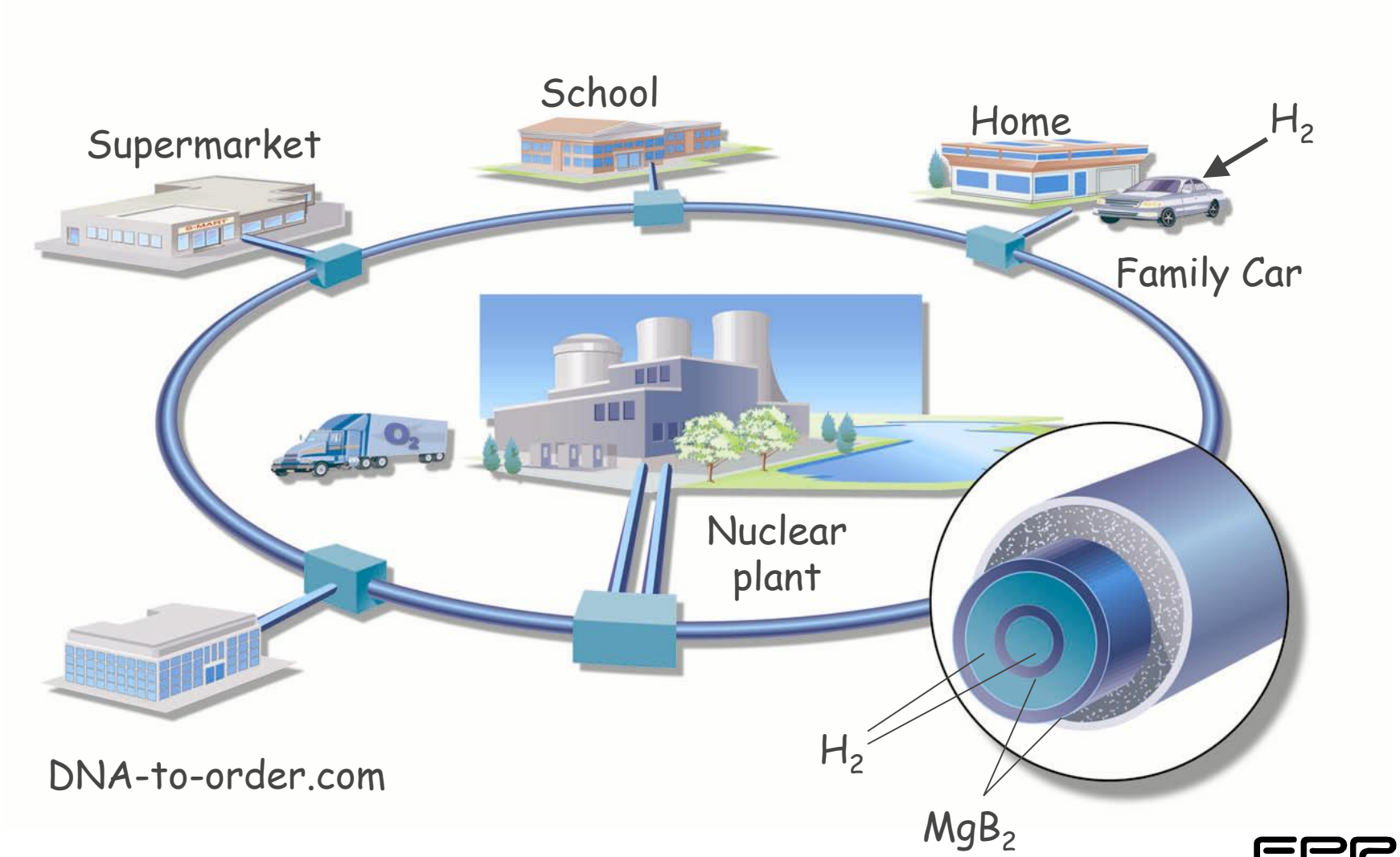
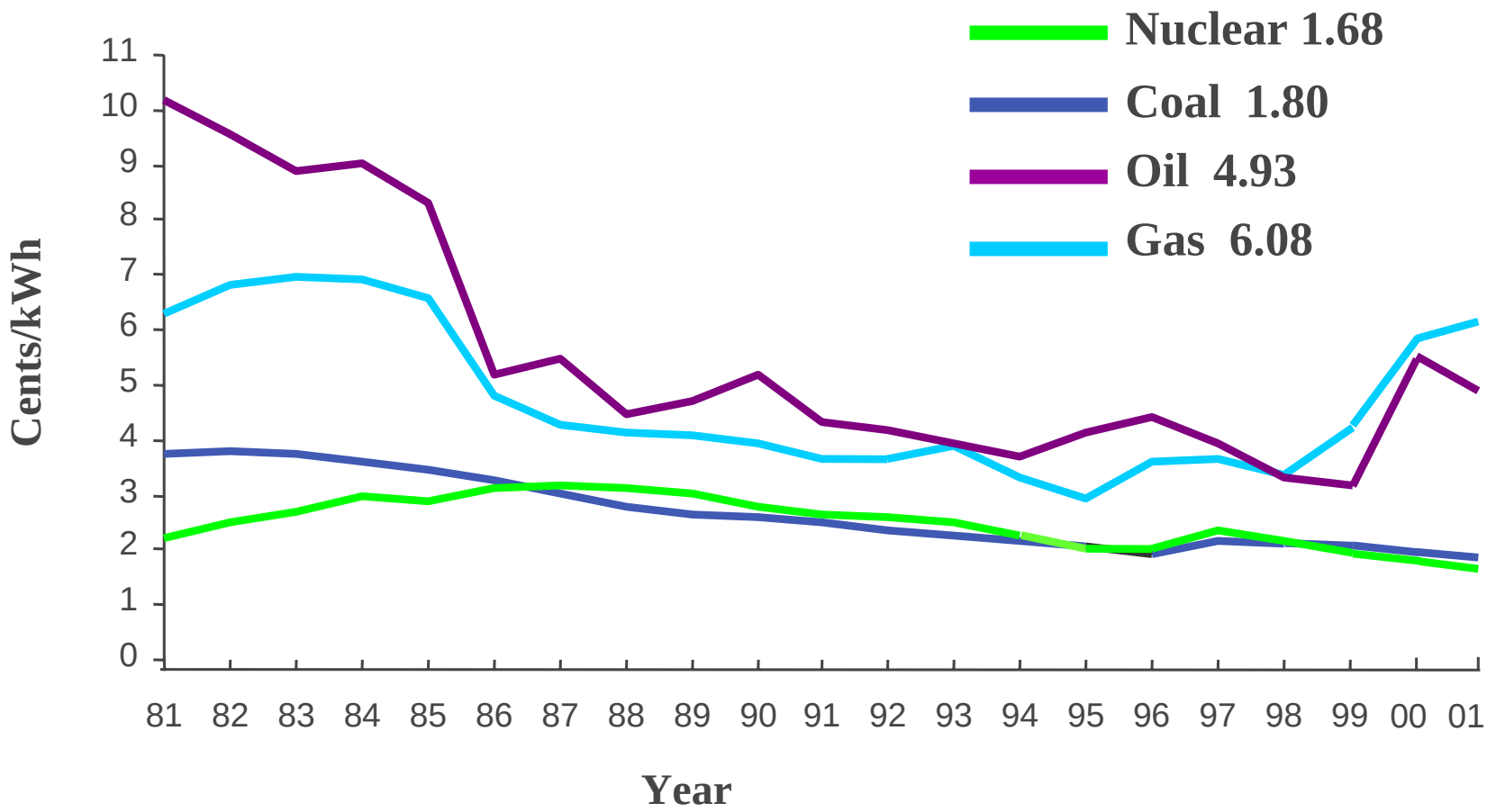
Super Grid of the Future Integrates Superconducting Transmission with H_2 Energy Carrier



Electricity Production Costs



Source: RDI /EUCG for Nuclear data, RDI/EUCG for Fossil Fuels. Converted to 2001 dollars by NEI

The Prospects For Nuclear Energy

- Business climate reinforces value of nuclear plants
  - Reliable, low-cost supply of electricity
  - Secure, stable cash flows
  - Hedge against fossil fuel price/supply volatility
  - Safeguard against escalating environmental requirements
  - Additional cash flow potential of $4 billion annually through cost savings, higher output
- Continued support of RD&D efforts (e.g., funding of one-time engineering and licensing costs) is critical near term imperative
  - DOE's NP2010 program and nuclear industry must jointly fund

Renewables Breakthrough Challenges

Technologies that change the business proposition

- 25% efficiency for PV (copper indium diselenide) at 30 to 50$/$m^2$
- Biomass -- low-cost, dedicated gasification facilities
- Wind -- low-cost diurnal (or longer) storage
- Wind -- siting issues

Resolving the Global Energy/Carbon Conflict

Technologies that may make sense anyway:

- End-use efficiency
- Plant improvement
- Nuclear
- Renewables
- Biomass

Technologies for a carbon-constrained world:

- Capture and disposal
- Tree planting and soil carbon

Technology Breakthroughs

- Zero Emission Power Plants (ZEPPs)
- Low-temperature water splitting

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