The Role of Coal in Our Energy Future

Direct Carbon Fuel Cell Workshop

July 30, 2003

Presented by:

John M. Schneider, Dr. Eng
Technology Consultant
Corporate Technology Development
American Electric Power

Acknowledgement

Manoj K. Guha
Generation Technology Consultant
manojguha@sbcglobal.net

Presentation Outline

- Electrical generation in a carbon constrained world
- The role of coal in our energy future
- Coal gasification
- Direct Carbon Fuel Cell (DCFC)

U.S. Comprehensive Energy Policy

Goals for maintaining and developing a sustainable energy system:

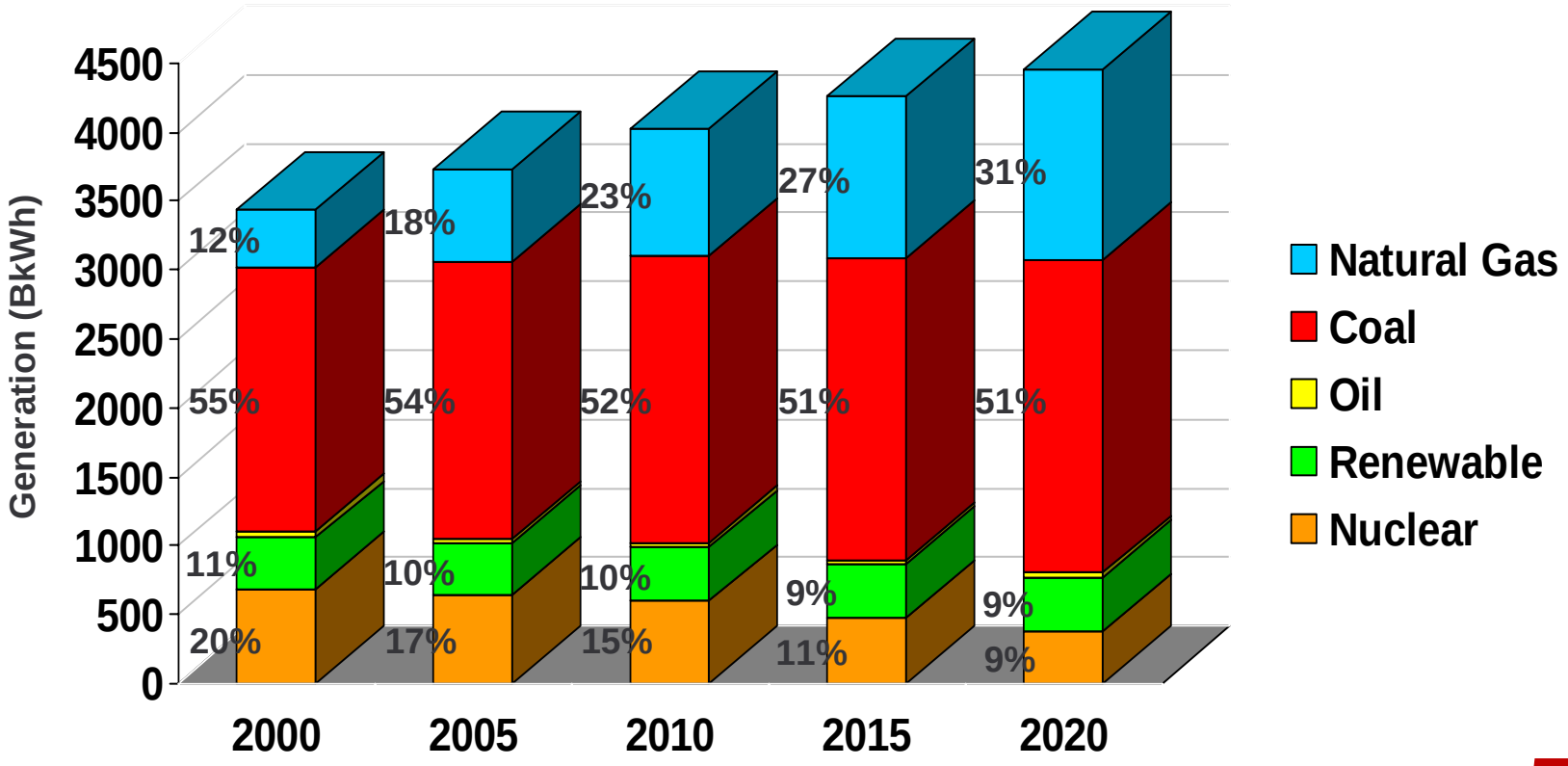
1. Minimize environmental harm
2. Improve efficiency
3. Expand future energy choices
4. Ensure against energy disruptions
5. Cooperate on international issues

Electricity, Transportation & CO_2

- Electricity accounts for about 40% of end use energy and 36% of CO_2 production
- Transportation accounts for about 37% energy consumption and 37% of CO_2

Business As Usual

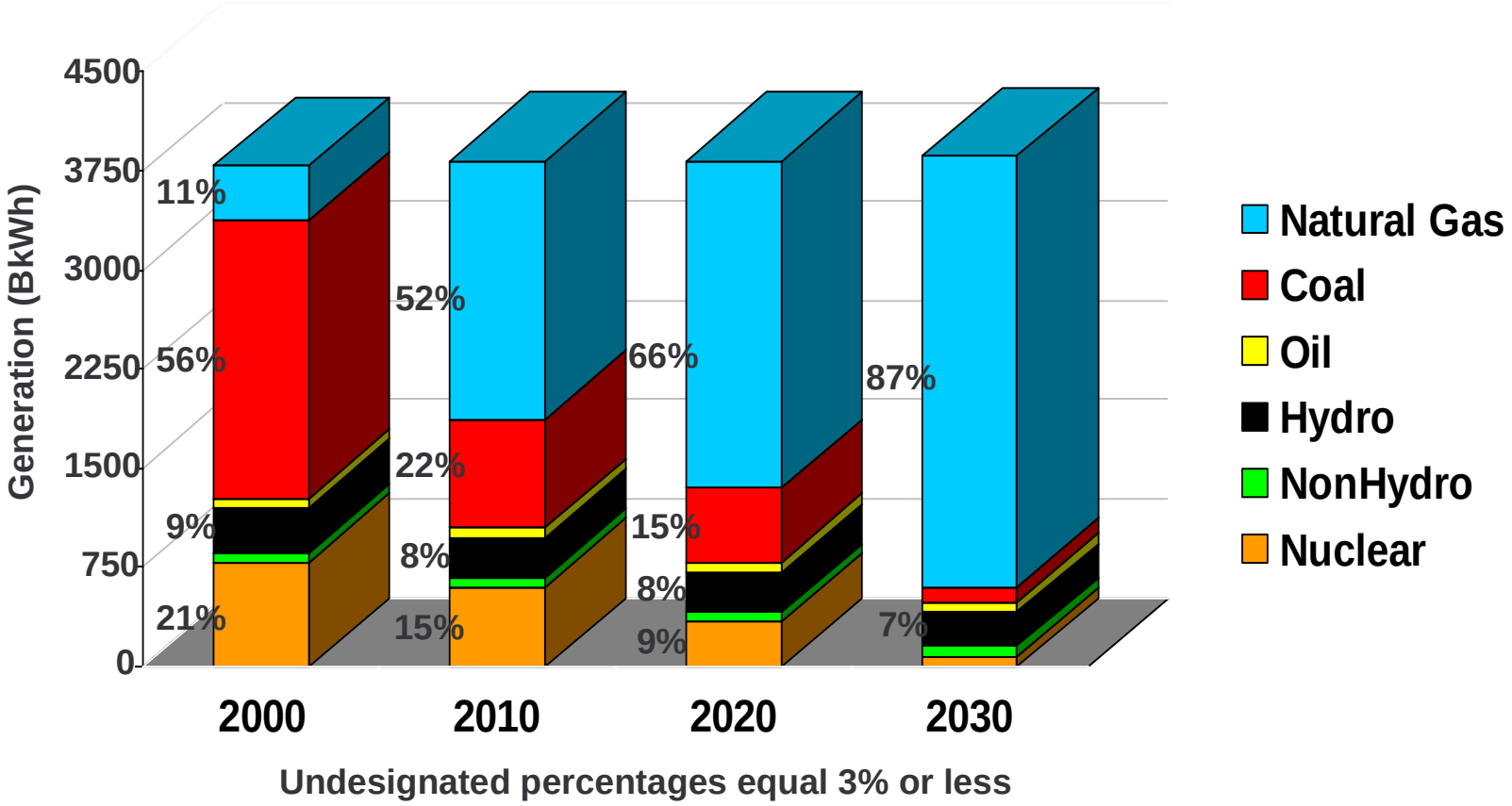
EIA AEO2001



Undesignated percentages equal 3% or less

Coal and Climate Change: Under Siege

Conservation, 7% Below 1990 Levels by 2010, w/o CO_2 Trading Credits
AEP Projection

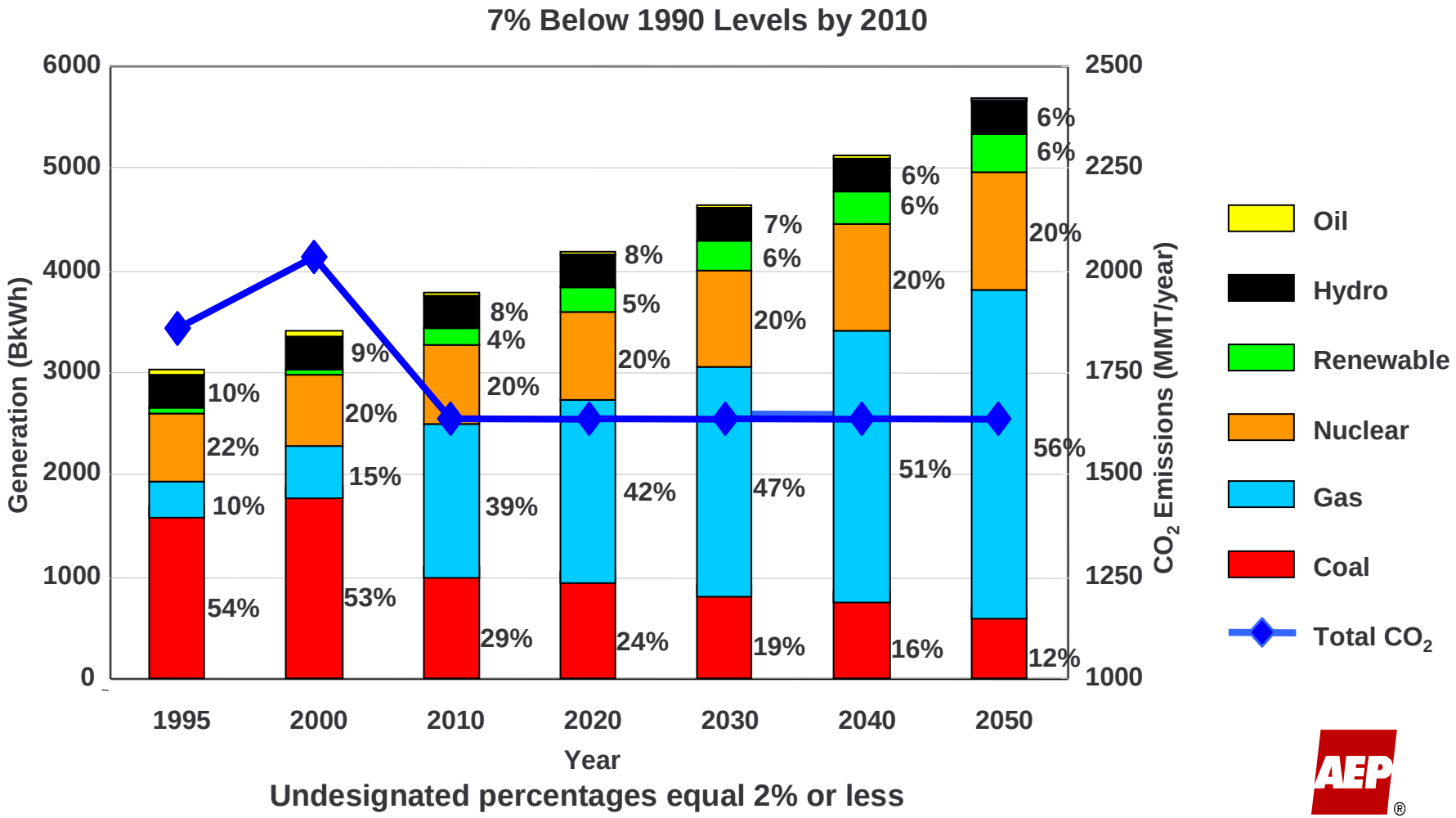


Undesignated percentages equal 3% or less

- Very challenging technically, economically & practically

CO_2 Emissions from Power Generation w/ Nuclear Additions

AEP Projection



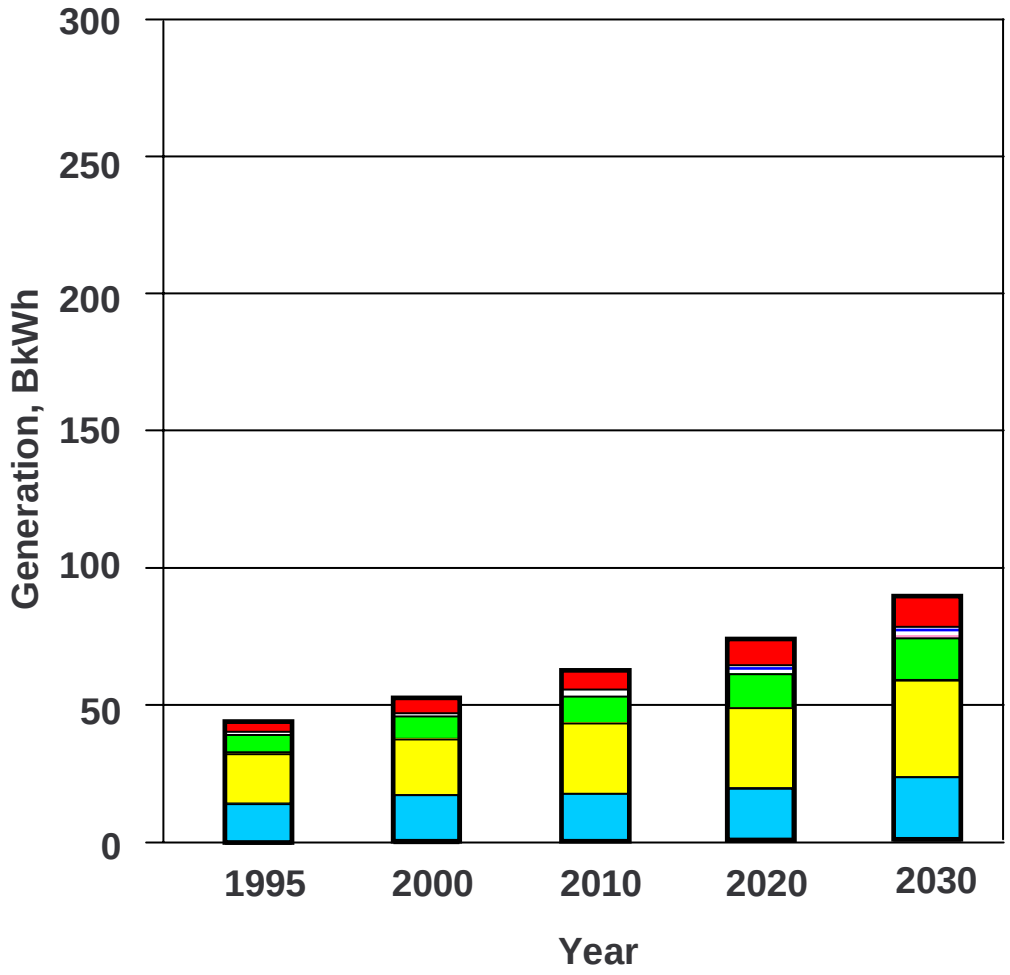
Undesignated percentages equal 2% or less

Limits to Nuclear

- Existing U.S. fleet is aging
- Public perceptions about operational safety and waste disposal constrain new additions
- High capital costs limit nuclear expansion into developing countries

U.S. Non-Hydro Renewable Generation

EIA AEO 2001 (2000-2020); AEP Projection (2020- 2030)



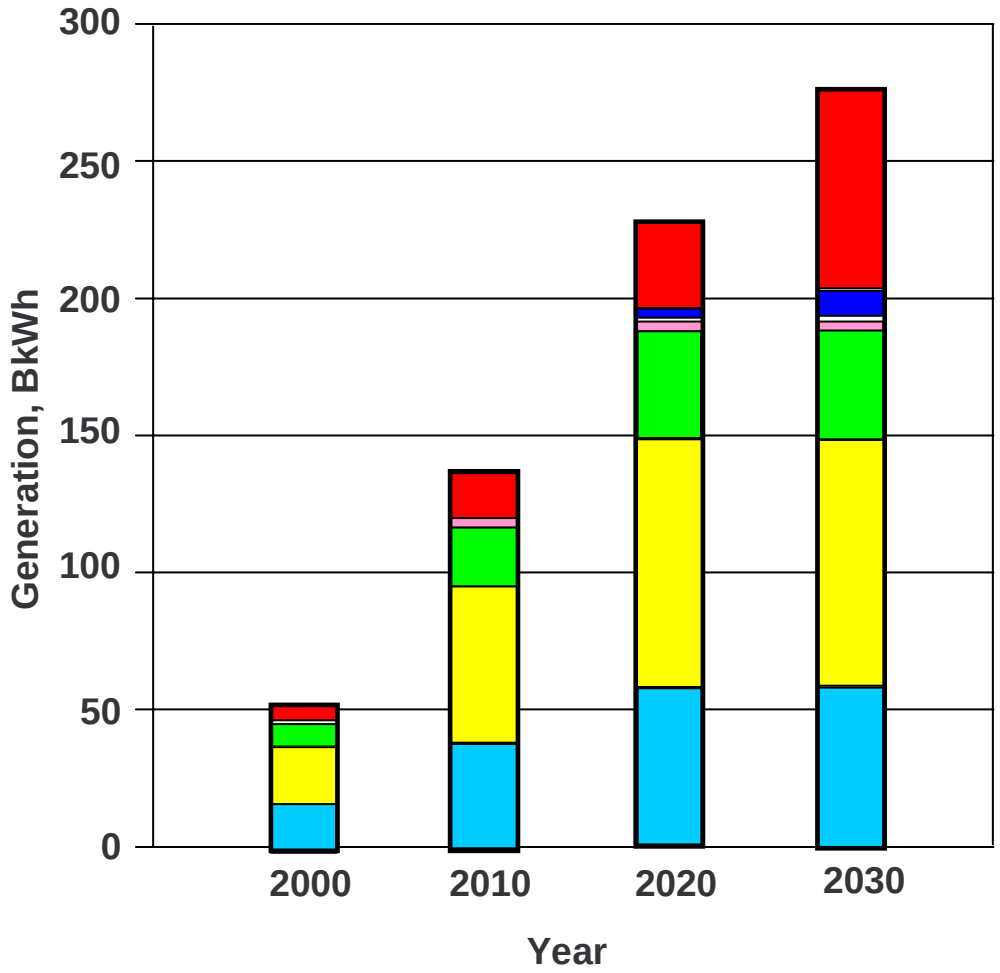
	Annual Growth Rates 2000 - 2030
Wind	2.6%
Solar Photovoltaic	12.6%
Solar Thermal	2.4%
Wood / Biomass	1.8%
Municipal Solid Waste	1.8%
Geothermal	1.0%

Non-Hydro Renewables % Total Generation

1995	1.4%
2000	1.6%
2010	1.6%
2020	1.7%
2030	1.8%

Maximum Potential of Non-Hydro Renewable Generation

Extension of production credits to all Renewables past 2010
AEP Projection (2020- 2030)



	Annual Growth Rates 2000 - 2030
Wind	9.0%
Solar Photovoltaic	19.6%
Solar Thermal	5.7%
Wood / Biomass	5.1%
Municipal Solid Waste	5.0%
Geothermal	4.2%

Non-Hydro Renewables % Total Generation

2000	1.6%
2010	3.7%
2020	5.5%
2030	6.0%

Limits to Renewables

- Even with accelerated expansion of non-hydro Renewables, potential market penetration remains small in near- to mid-term in the U.S.
- Prohibitively high capital costs continue to constrain renewable deployment in developing countries

Can Coal Continue As The Dominant Energy Source?

- Abundant
- Affordable
- A domestic resource
- Improvable
- Key developing countries are coal-rich, with every intent of using it

Near to Mid-Term

- **Gasification**
  - **Coal + H_2O + $O_2 \rightarrow$ Syngas (H_2, CO) + CO_2 + …**
  - **Syngas can fuel combustion turbines and SOFC's**
  - **Syngas can be further processed to pure H_2**

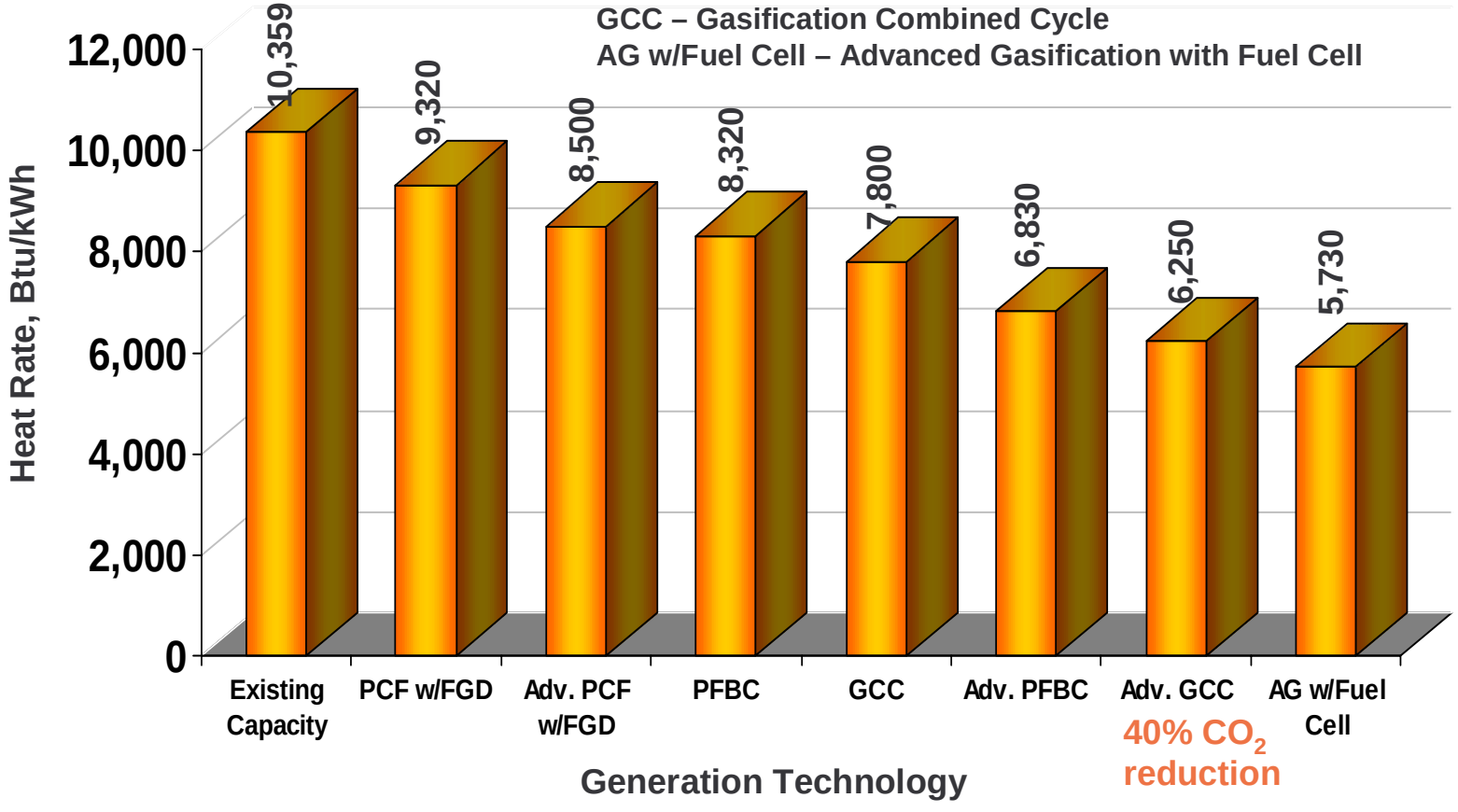
Coal Gasification Needs

- For coal gasification to play a major role we must:
  - Improve hot gas clean-up (particulates, H_2S, …)
  - Develop high efficiency gas turbines
  - Develop carbon capture techniques
  - Create carbon storage options

Heat Rates Comparison

Coal-Based Technologies - Conventional and Advanced

PCF w/FGD – Pulverized Coal-fired with Flue Gas Desulfurization
PFBC – Pressurized Fluidized Bed Combustion
GCC – Gasification Combined Cycle
AG w/Fuel Cell – Advanced Gasification with Fuel Cell



Mid to Long-Term

- **Direct Carbon Fuel Cell**
  - **$C + O_2 \rightarrow CO_2$**
  - **Molten salt electrolyte (400 °C)**
  - **Molten Carbonate electrolyte (800 °C)**
  - **Coal (hydrocarbon, biomass, …) feedstock**
  - **~80% theoretical efficiency**

DCFC Needs

- **For DCFC to play a major role we must:**
  - Accelerate development/demonstration of fundamental technology
  - Develop technologies necessary to deal with chemical complexity of coal (fuel prep, electrolyte reprocessing, …)
  - Address scale-up issues
  - Develop carbon capture techniques
  - Create carbon storage options

Conclusions

- Fossil fuels will remain the dominant energy source in foreseeable future
- Environmental constraints demand cleaner, more efficient utilization
- Near to mid-term answer for coal is gasification
- Mid to long-term answer for coal could be the DCFC