The Life Cycle Private and External Costs of Increased Coal Use in the United States

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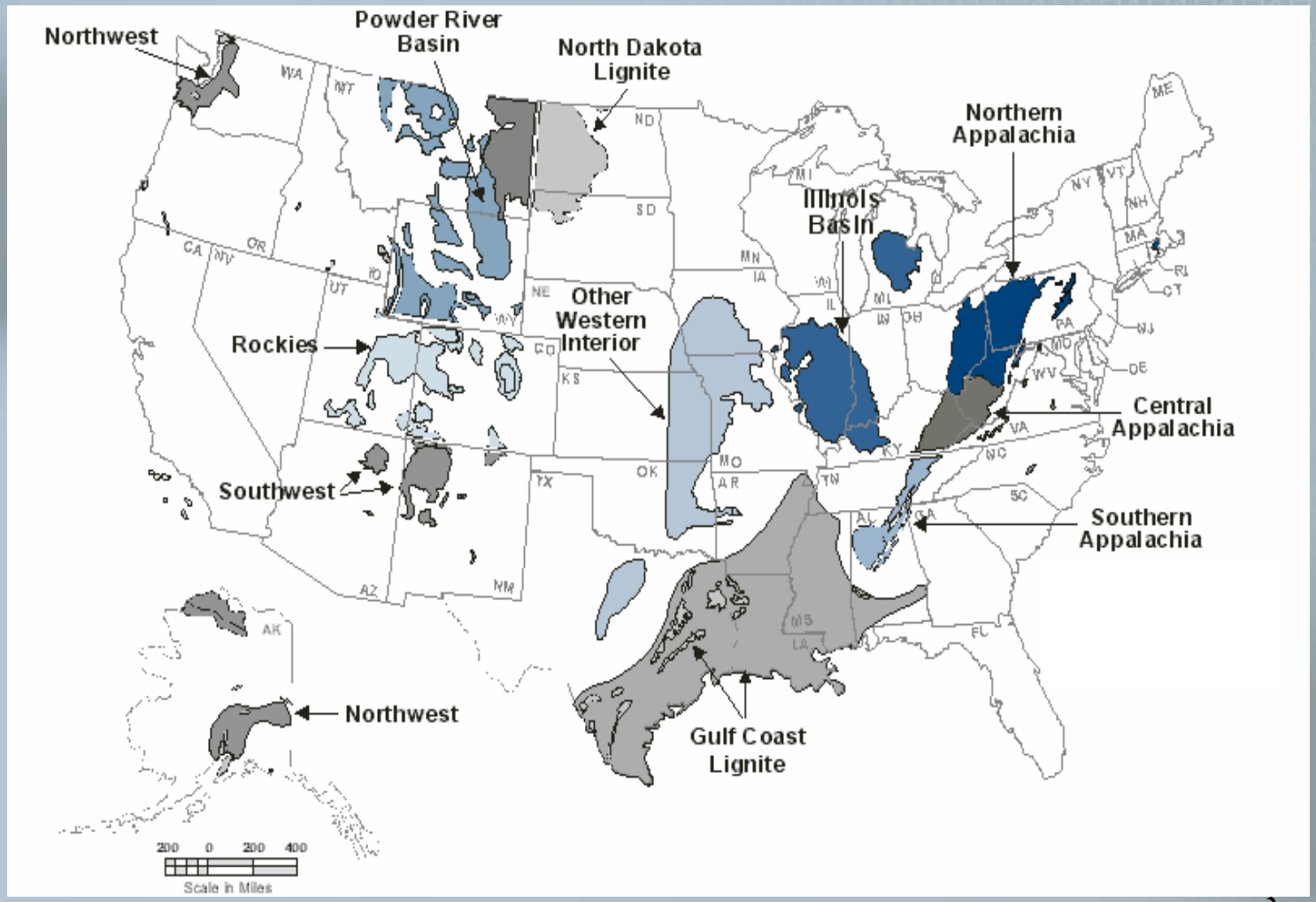
Policy Questions

- What would a high coal use future look like?
- What are the life cycle impacts associated with this use?
- Do upstream choices affect the impact associated with this use?

U.S. Coal Supply



Why build more Coal Plants?

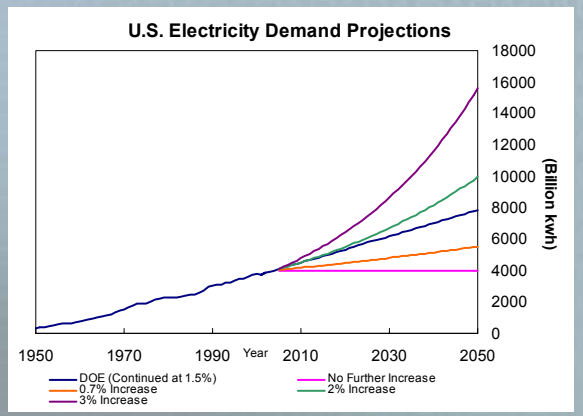
- >50% current power generation in the U.S.
- Large Reserves
- Technological Advances
  - Reduce Envt'l Impacts
- Baseload Alternatives Unclear
  - Natural gas (expensive and volatile)
  - Nuclear (uncertain)
  - Renewables (limited)
  - Conservation (?)
- Energy Policy Act 2005 - provides incentives for large scale commercial deployment of IGCC systems (some advanced PC as well)

Analytical Tools & Frameworks

- Future Energy Scenario Analysis
- Environmental Life Cycle Assessment
  - EPA/SETAC Process
    - Layout all stages, assess all energy and material inputs and outputs
    - Other models available to help model important parameters (IECM)
  - Input-Output
    - Accounts for supply chain impacts
    - Quick and easy
- Externality Valuation

14 Future Coal Scenarios

- Electricity Demand Supplied by coal
  - "BAU" – 1.5% annual growth, 50% from coal - 4 trillion kWh
  - High Growth -2% annual growth, 80% from coal - 8 trillion kWh
- Generation Technology
  - Pulverized Coal Plant
  - Coal Gasification Combined Cycle
  - Natural Gas Combined Cycle
- CO_2 Control
- Proportion of Coal Type Used
  - 51% Bituminous, 41% Subbituminous, 8% Lignite
  - 80% Bituminous (eastern), 20% Subbituminous (western)
  - 20% Bituminous (eastern), 80% Subbituminous (western)
- Current policies are maintained
  - NSPS, Title IV, Clean Air Interstate Rule



Extraction and Processing of Coal

- Total GWP (CO_2 eq) from this stage:

  10 – 70 ton/GWh

- Methane emissions from mining
  - Surface – 0.0162 tons of CO_2 eq/ton of coal
  - Underground – 0.144 tons of CO_2 eq/ton of coal
- Methane emissions are ~77% of GWP for total GWP from "coal mining" sector
- Variability
  - Coal type (amount, age, rank)

Transport of Coal

- Total GWP (CO_2 eq) from transport:

  3 – 80 ton/GWh

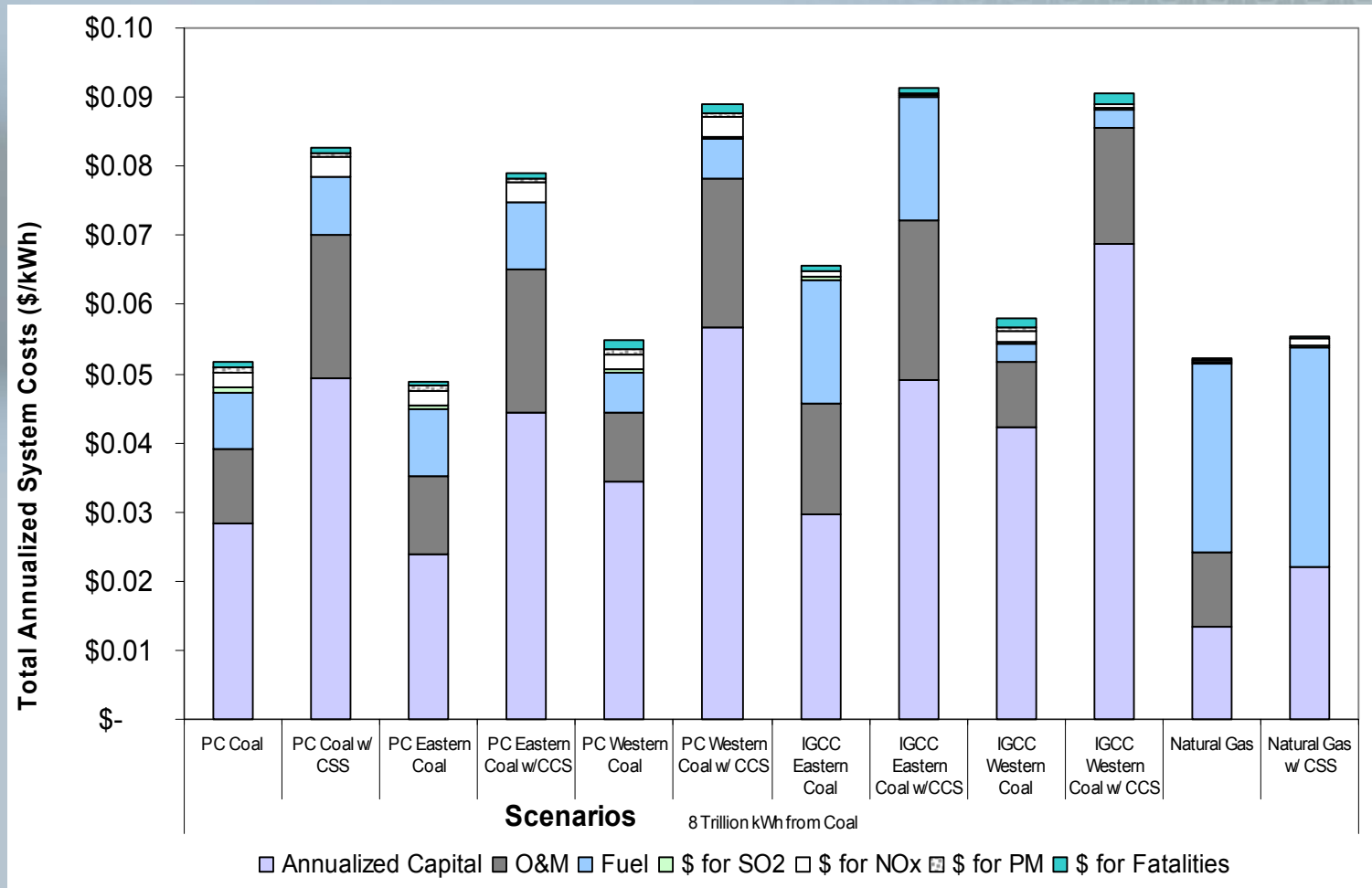
- CO_2 emissions from rail transport are ~84% of total GWP emissions from "rail transportation" sector
- Variability
  - Rail, Barge, Truck
  - Emission Factors (based on fuel type and efficiency)
  - Distance shipped

Generation Phase

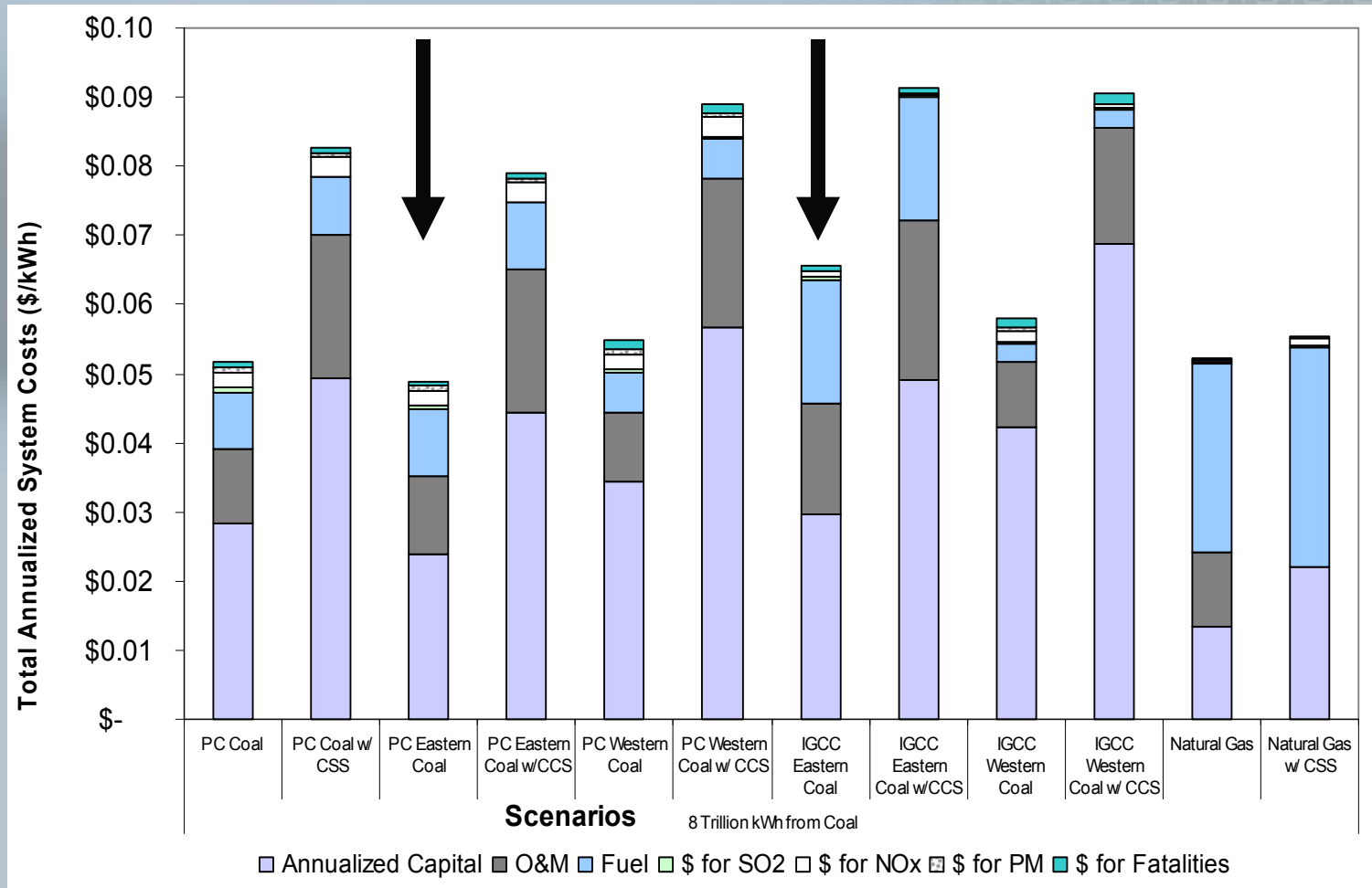
- Total GWP (CO_2 eq) from this stage (w/o CCS): **900-1100 ton/GWh**

- Variability
  - Technology (efficiency)
  - Control Technologies
  - Coal Type
  - Carbon Capture and Sequestration

Annualized System Costs



Annualized System Costs



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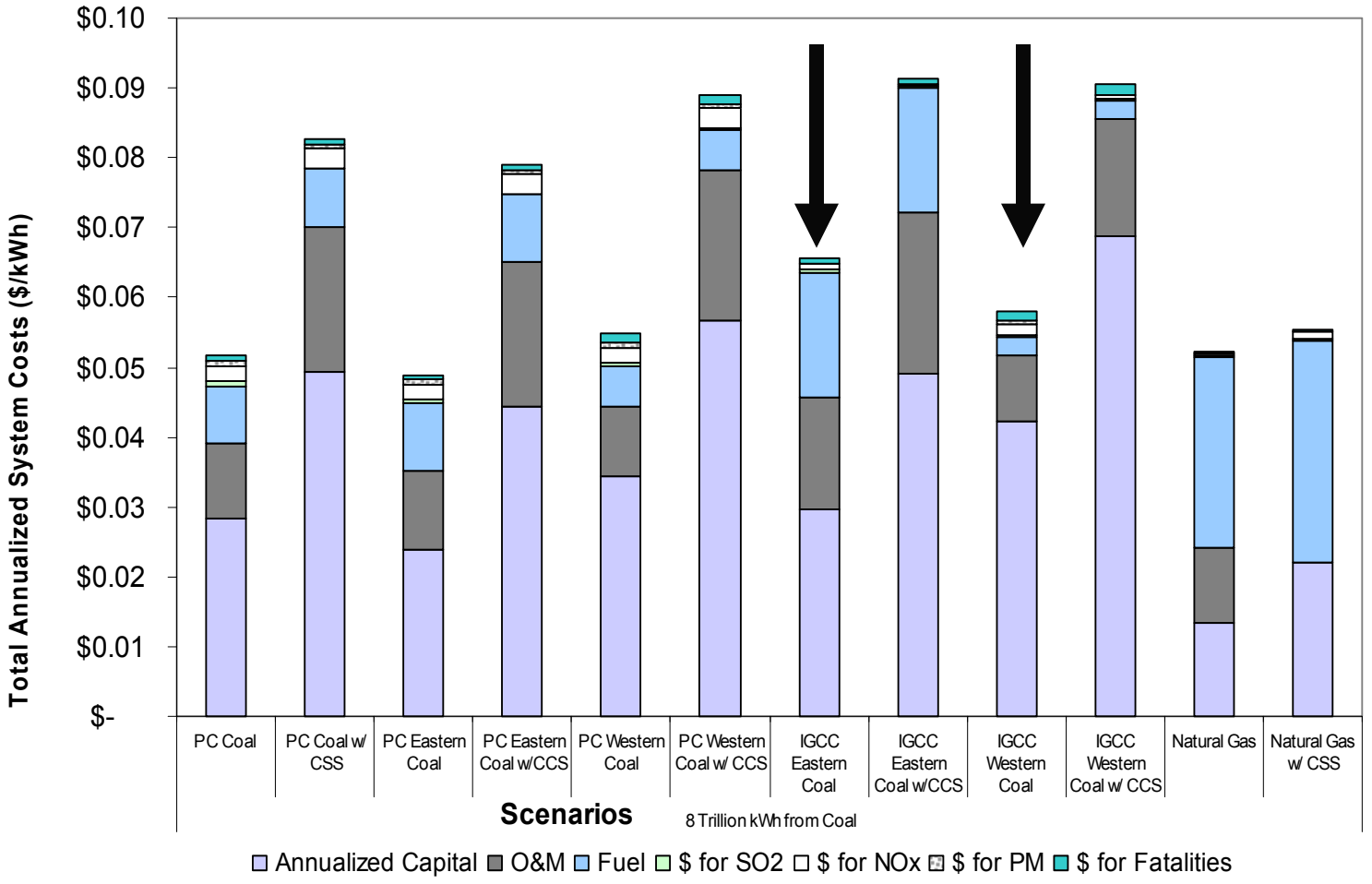
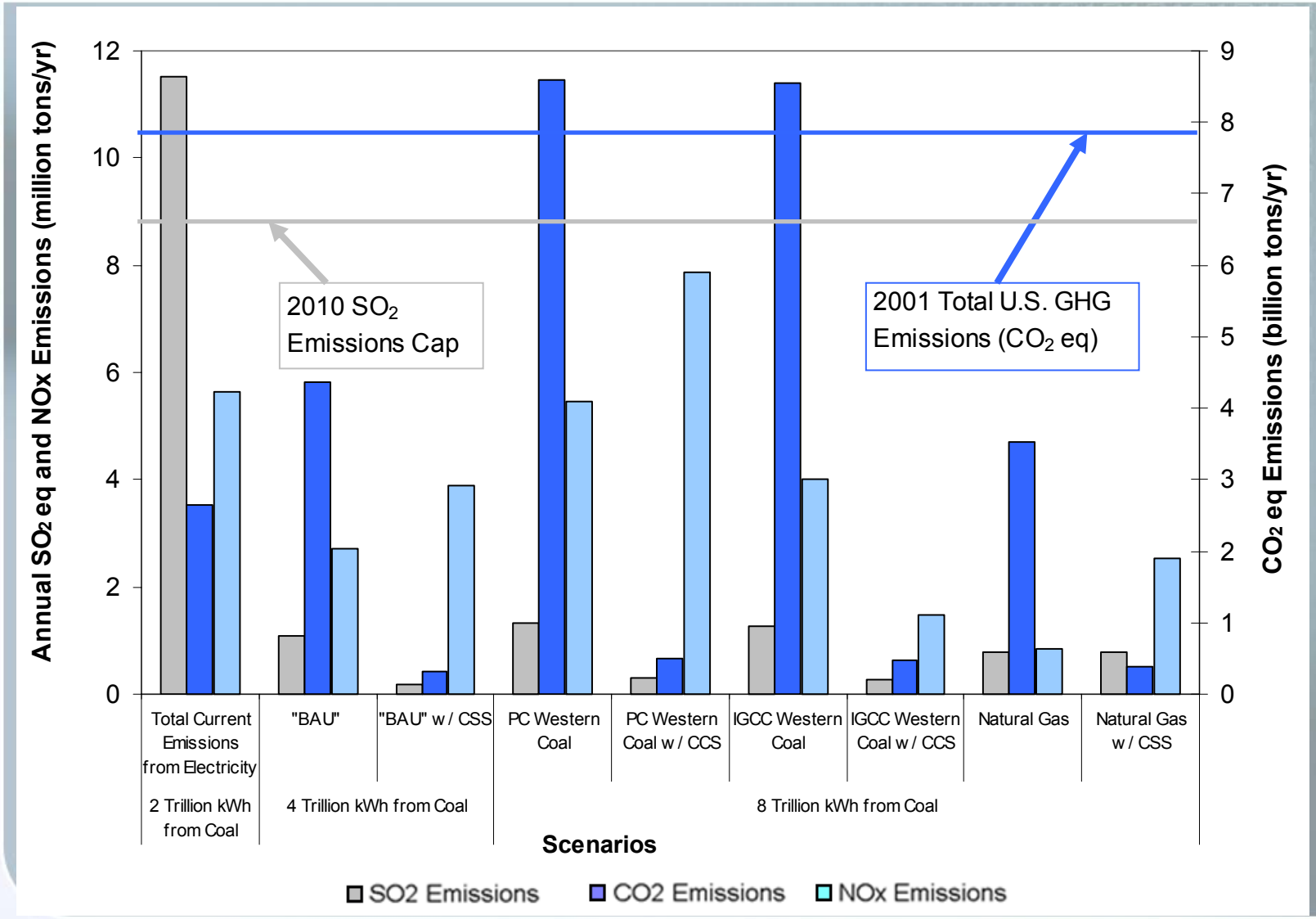
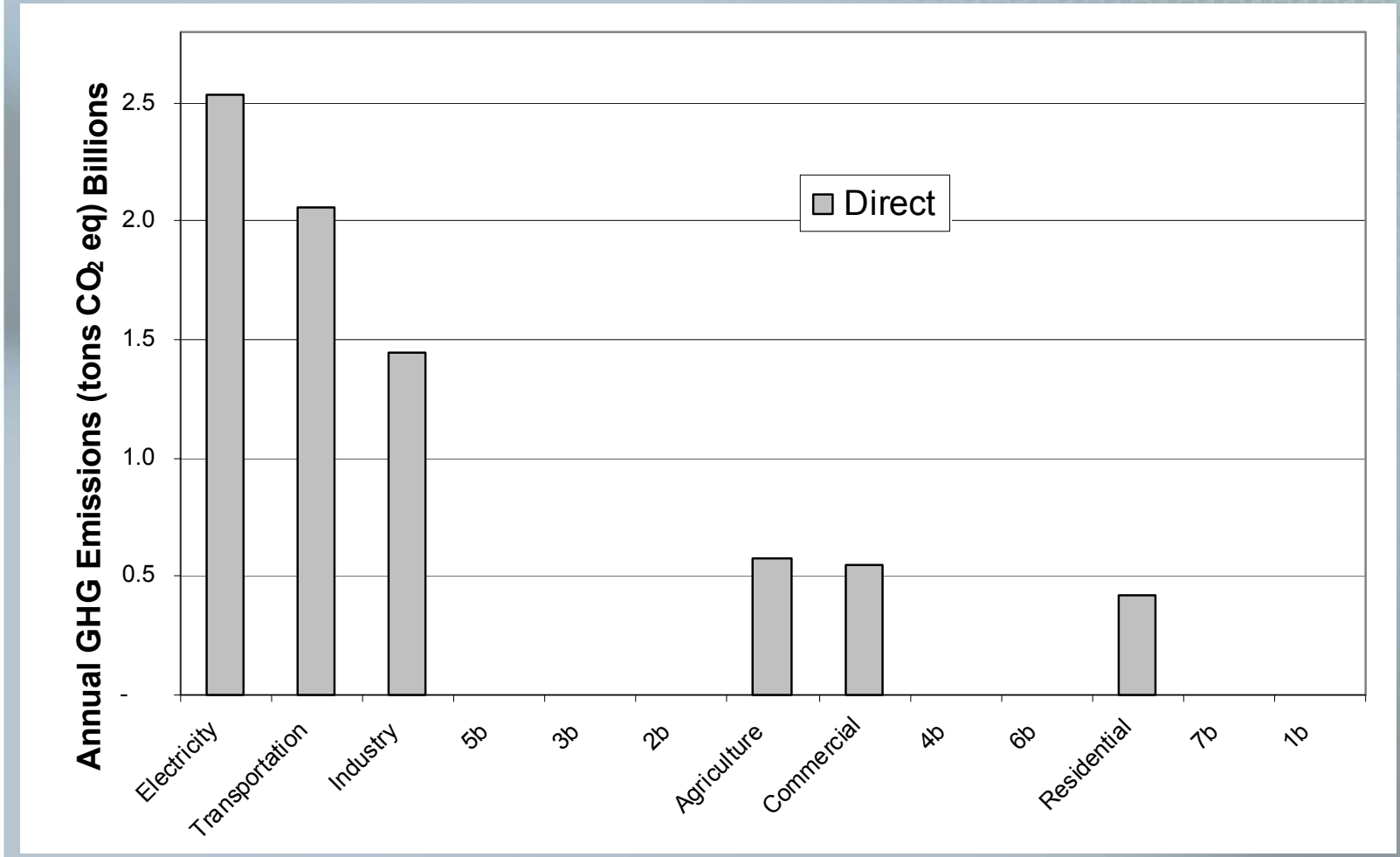


Annual Emissions of SO_2, CO_2, NOx



Comparison of GHG Emissions
(w/100% CO_2 Removal from Generation)



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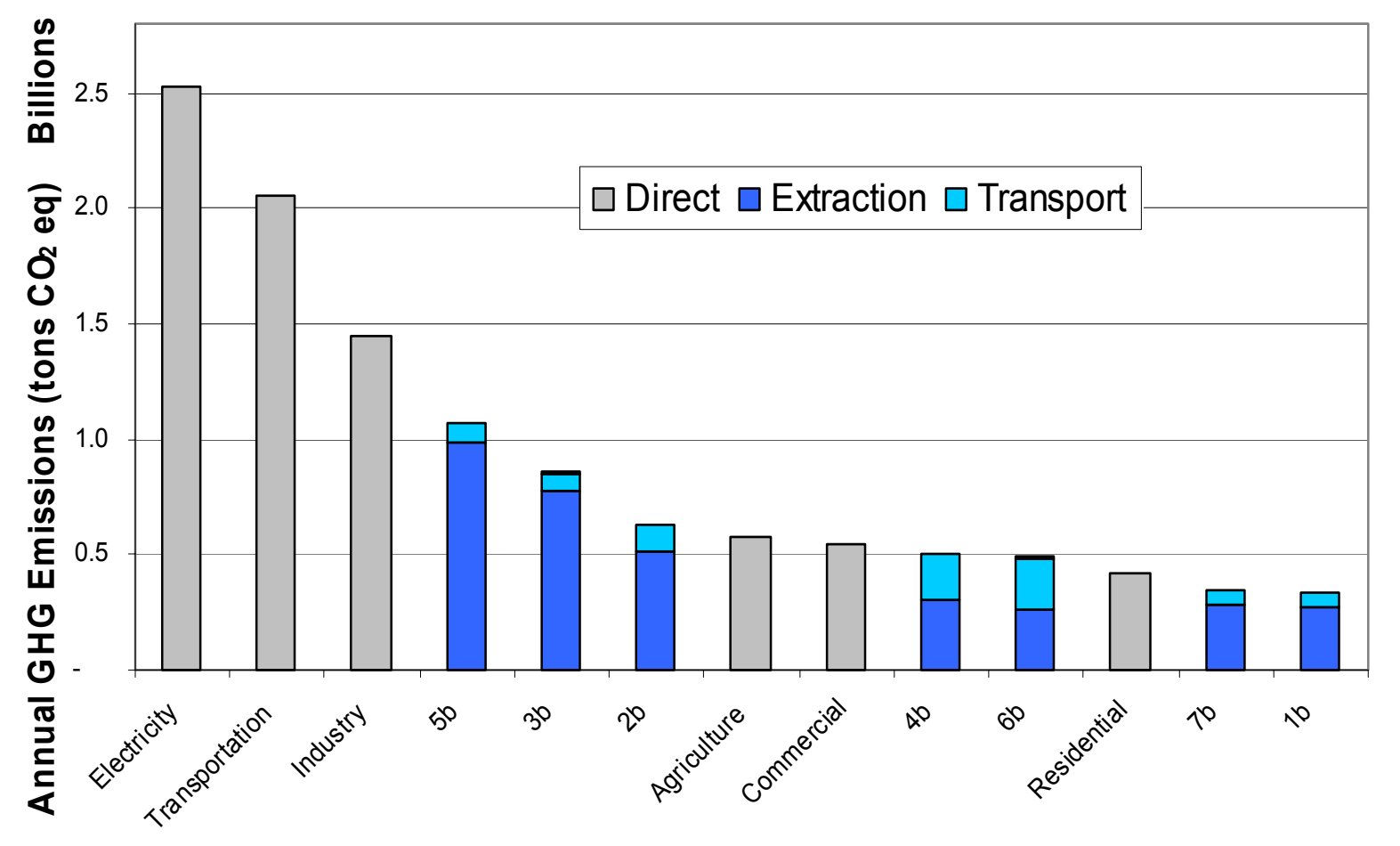

Local Impacts – Western Scenarios

- Currently 350 million tons/year produced
- 80% of 8 trillion kWh from PRB coal requires 3.5 billion tons/year production
  - Requires a 5% annual production increase (average increase in Subbituminous coal since 1969 is 11%)
  - Exceeds current demonstrated *reserve* from producing surface mines in Wyoming
  - However, if 3.5 billion tons/yr it would take until the end of the century to exceed the *resources* identified for the Northern Rocky Mountains and Great Plains
- If shipped by rail, this would require significant upgrades for congestion management

Local Impacts cont'd…

- Water
  - If 80% of 8 trillion kWh were from gasification in PRB
  - Dry cooling towers would be required
    - Significantly increasing cost of plants
  - Water consumed in the gasification process
    - ~ 800 billion gallons/year
    - 1.4 times the total flow of the Big Horn River
    - Or up to 3% of the flow of the Columbia River
- Local Air emissions
  - Potential hot spots?

Long-Term Implications

- A high coal future could pose considerable environmental challenges
- Advanced technologies for generation and control of pollution and greenhouse gases can offset these impacts and leave us better off than we are today
- Even with 100% CO_2 removal from the generation phase, the CO_2 emissions from the rest of life cycle are comparable to the other major sources of CO_2 in the economy today

Future Work

- Expand upstream impacts
  - Localized generation
  - Potential for upstream reductions of CO_2
- Other Generation Options
  - Renewables
- Potential for integration of life cycle assessment with large system level models?

Contact Information

- Carnegie Mellon University Electricity Industry Center

  www.cmu.edu/electricity
- Economic Input-Output Life Cycle Assessment

  www.eiolca.net
- Integrated Environmental Control Model

  www.iecm-online.com

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