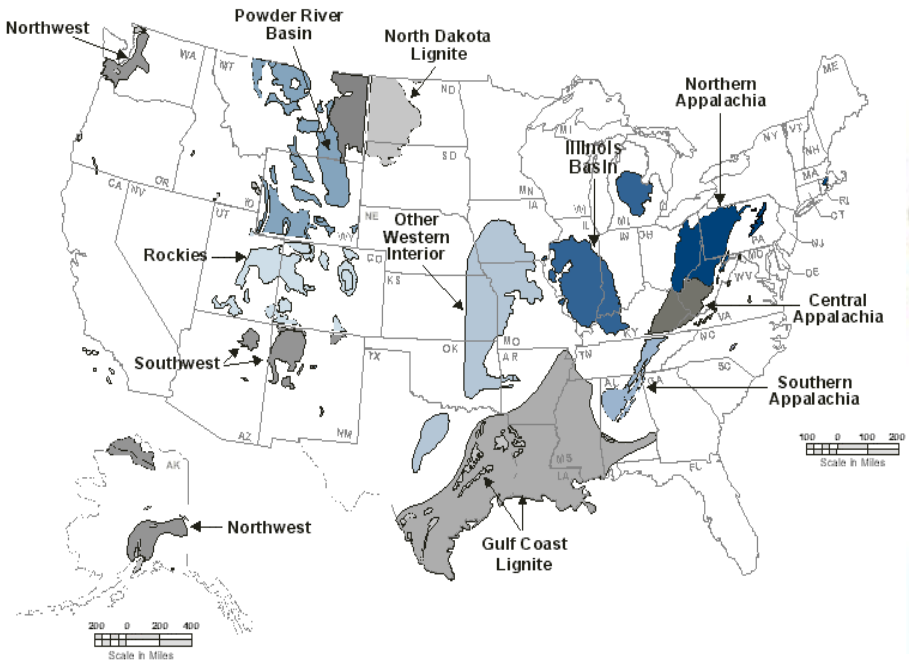
Transport Coal or Transmit Electricity?

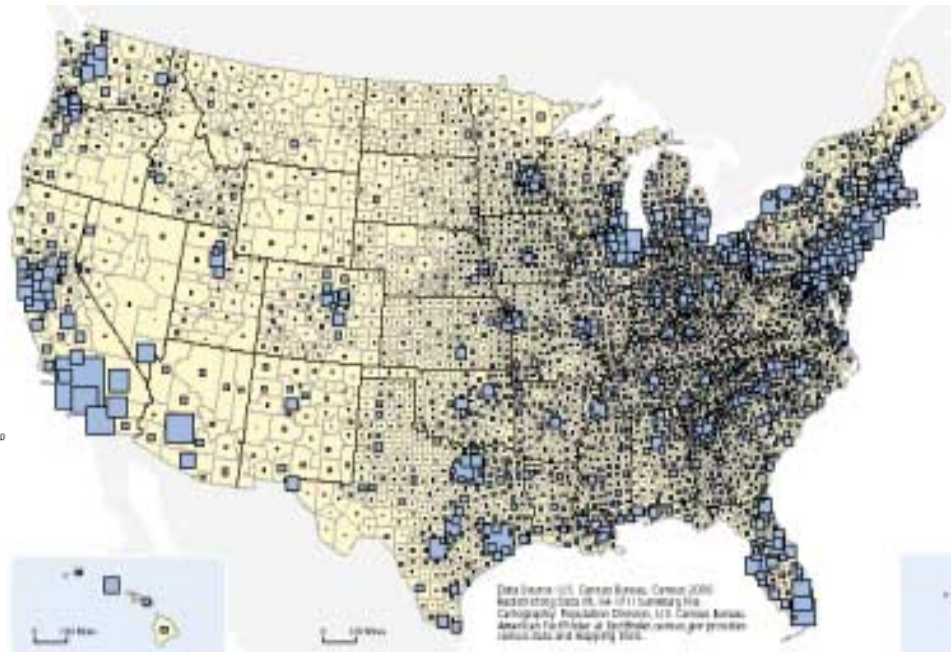
Comparative Hybrid LCA

Joule Bergerson, Lester Lave,
Chris Hendrickson, Scott Matthews, Alex Farrell
Carnegie Mellon University

Thursday September 25, 2003

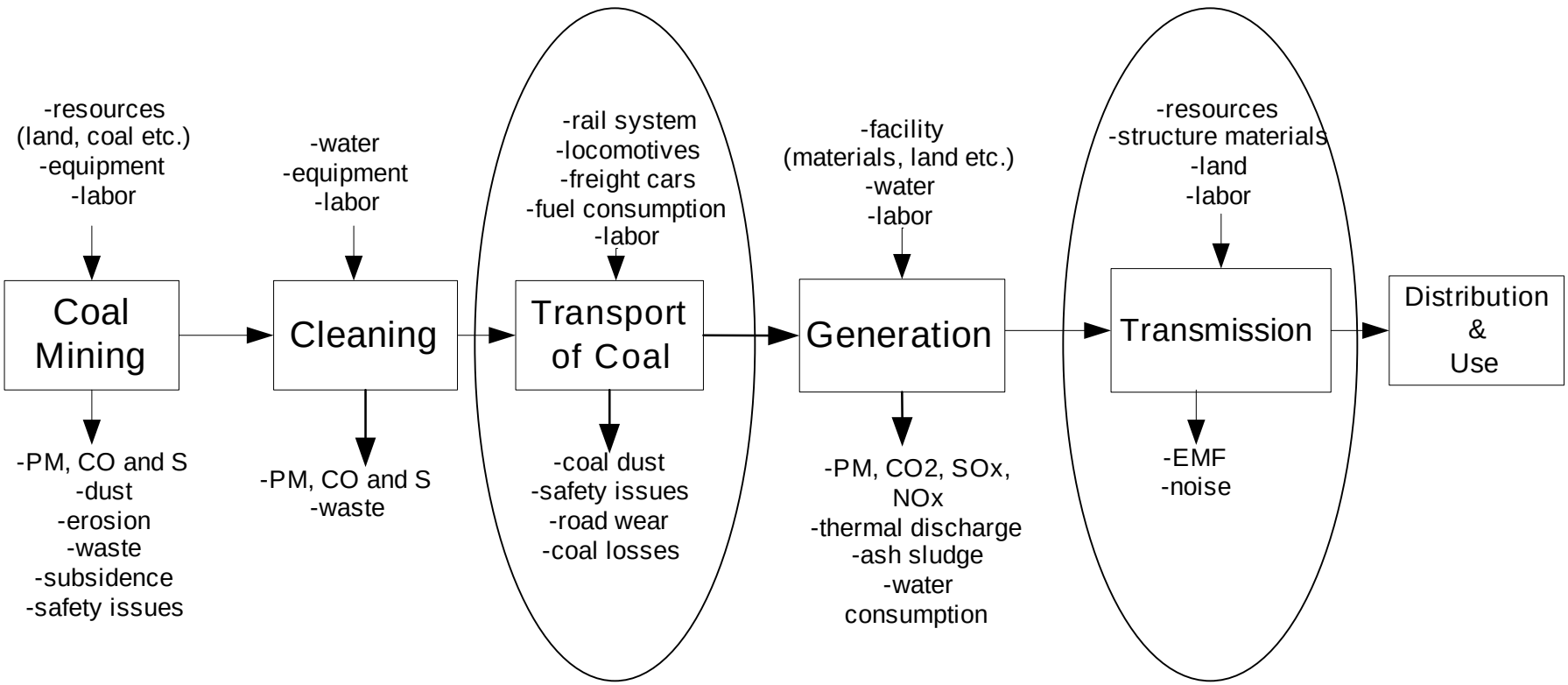
US Coal Supply and Population





A ton of coal is shipped by rail an average distance of 800 miles

Life Cycle of Coal-Fired Electricity



Tools

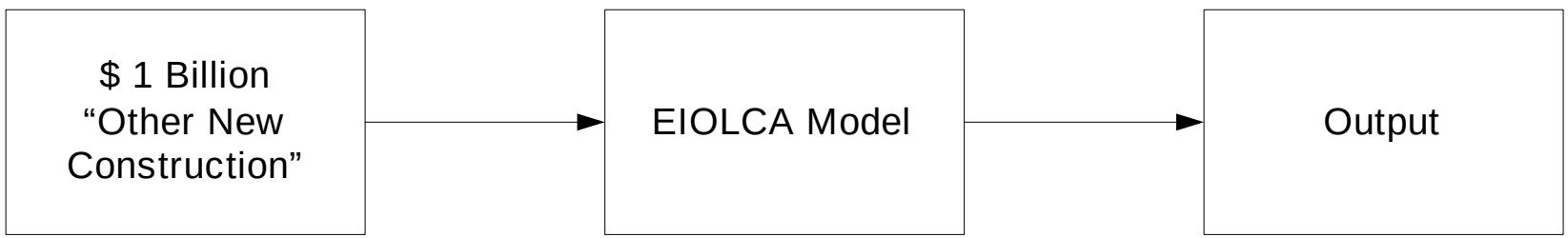
- Life Cycle Analysis
  - SETAC – Society of Environmental Toxicology and Chemistry
    - Basic Framework for LCA
    - Disadvantage: Time consuming and costly
  - EIOLCA – Economic Input-Output – Life Cycle Analysis
    - US I-O tables with Environmental Impacts
    - Disadvantage: Aggregation
- IECM – Integrated Environmental Control Model
  - Customized power plant design
  - Disadvantage: does not include all phases of life-cycle

Solution: Hybrid Approach

EIOLCA example: Transmission Construction

1. **Determine total economic input from sector**
   - Prices Vary but $1 billion is a rough estimate

2. **Find IO category**
   - **"Other new construction"** (110900)
     - Major Group 16: Heavy Construction Other Than Building Construction Contractors
       - SIC 1623 Water, Sewer, Pipeline, And Communications And Power Line
         - **Transmission line construction-general contractors**



EIOLCA Output

Summary of eiolca.net Output	
Effects	**Total for all sectors**
Electricity Used [Mkw-hr]	320
Energy Used [TJ]	7100
Conventional Pollutants Released [metric tons]	**16000**
OSHA Safety [fatalities]	**2.5**
Greenhouse Gases Released [metric tons CO2 equivalents]	**530000**
Fertilizers Used [$ million]	0.4
Fuels Used [Terajoules]	6700
Ores Used - at least [metric tons]	**210000**
Hazardous Waste Generated [RCRA, metric tons]	20000
External Costs Incurred [median, $ million]	32
Toxic Releases and Transfers [metric tons]	750
Weighted Toxic Releases and Transfers [metric tons]	6300
Water Used [billion gallons]	2.9

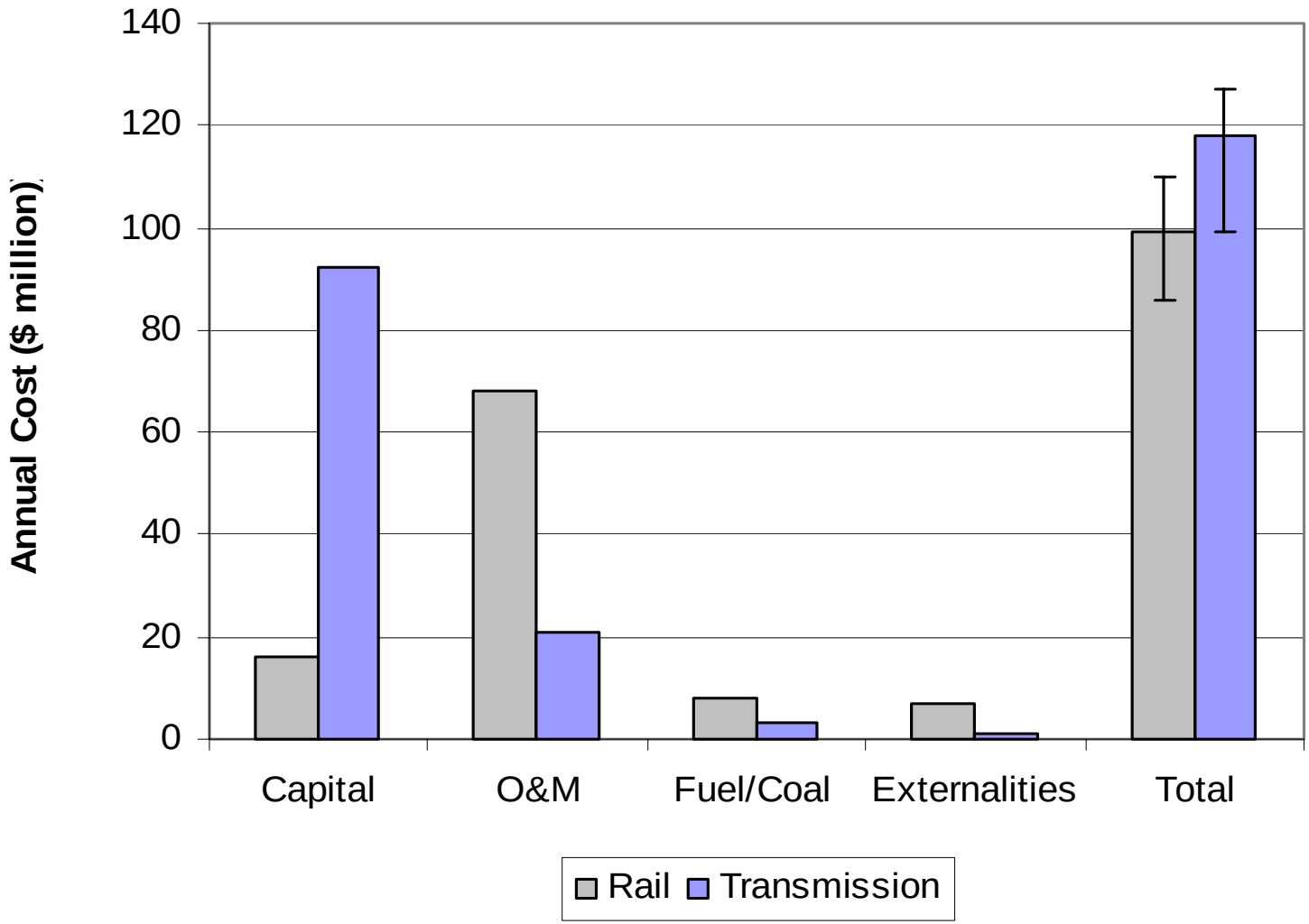
Top 6 Sectors Contributing to GWP				
	GWP	**CO_2**	**CH_4**	**N_2O**
Sector	**MT CO_2E**	**MT CO_2E**	**MT CO_2E**	**MT CO_2E**
Total for all sectors	**530000**	480000	48000	460
Electric services (utilities)	190000	170000	20000	38
Blast furnaces and steel mills	52000	48000	3800	23
Trucking and courier services, except air	47000	42000	4600	80
Other new construction	42000	40000	2700	58
Cement, hydraulic	17000	15000	1500	8
Industrial inorganic and organic chemicals	13000	11000	700	7

Source: www.eiolca.net

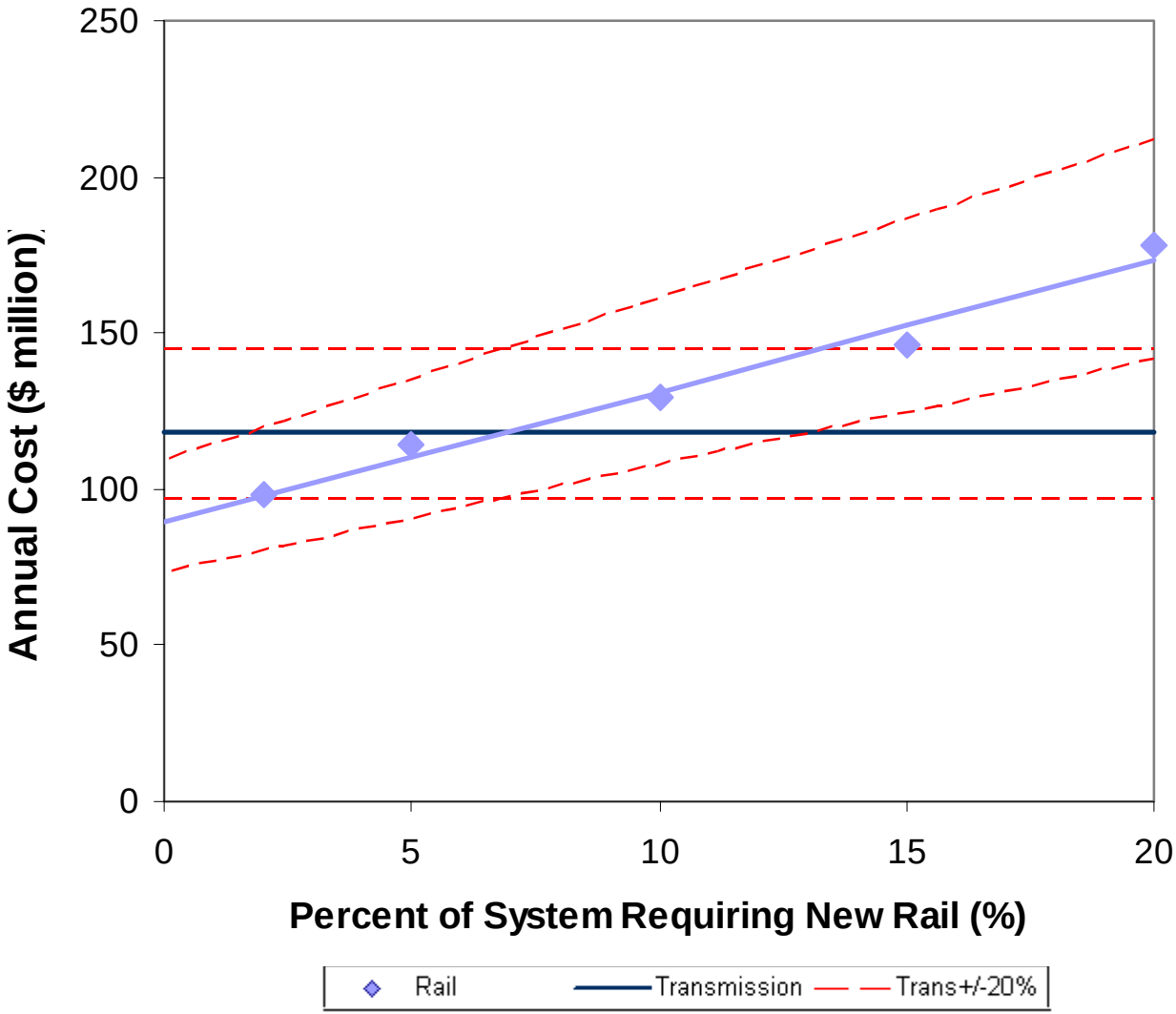
Base Case Assumptions

- Power Plants identical (SUPC – 40% efficiency, 75% capacity factor)
  - Therefore base production ignored for comparison
- 1000 MW (plus compensation for 7% transmission line losses)
- Approximately 1000 miles
- No siting difficulties or grade crossing upgrades
- Capital
  - Rail – minimal new track capacity, new trains
  - Transmission – new HVDC lines, substations
  - Amortized over life of investment (cost of capital 8%)

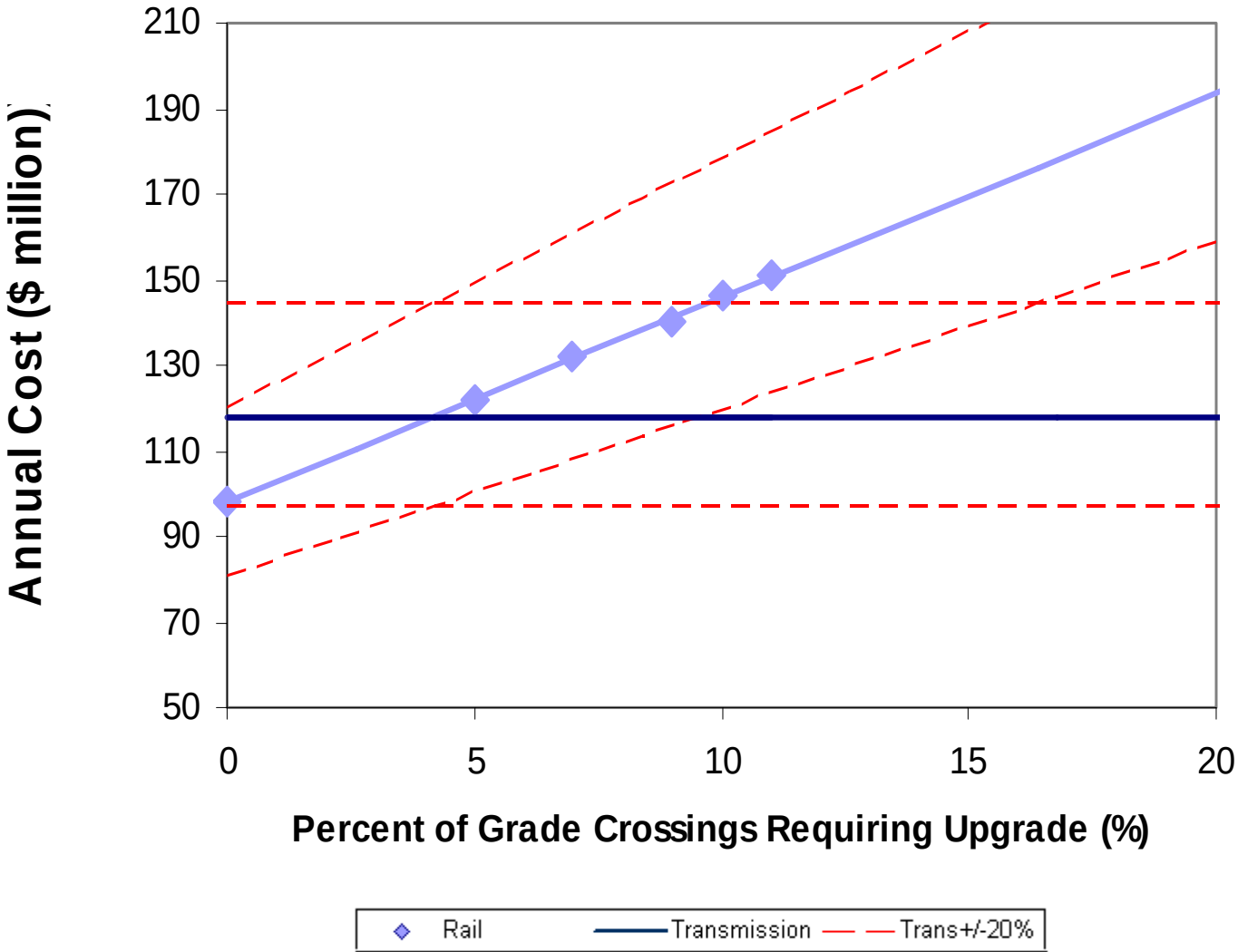
Base Case Economic Results



Scenario: New Rail Construction



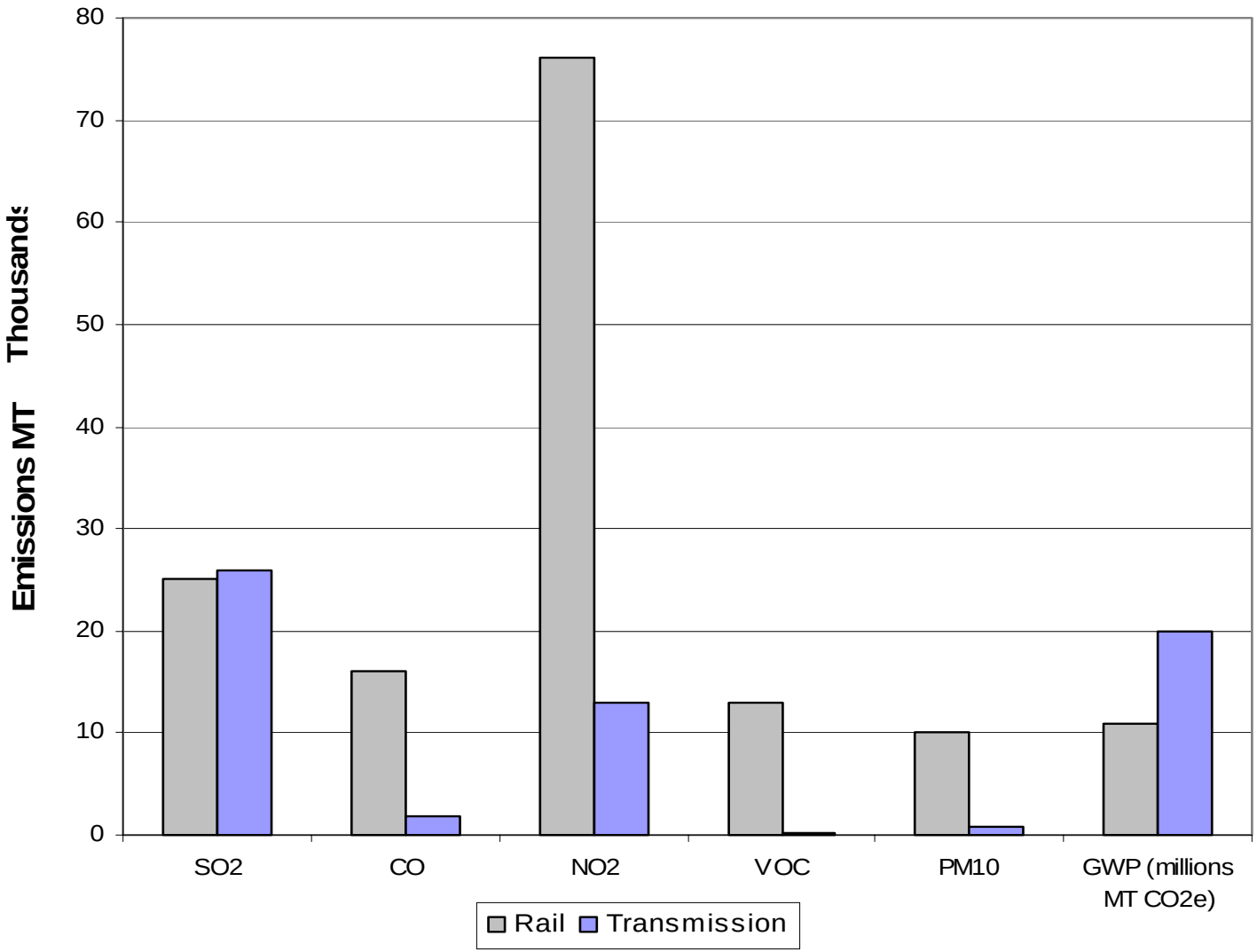
Scenario: Grade Crossings



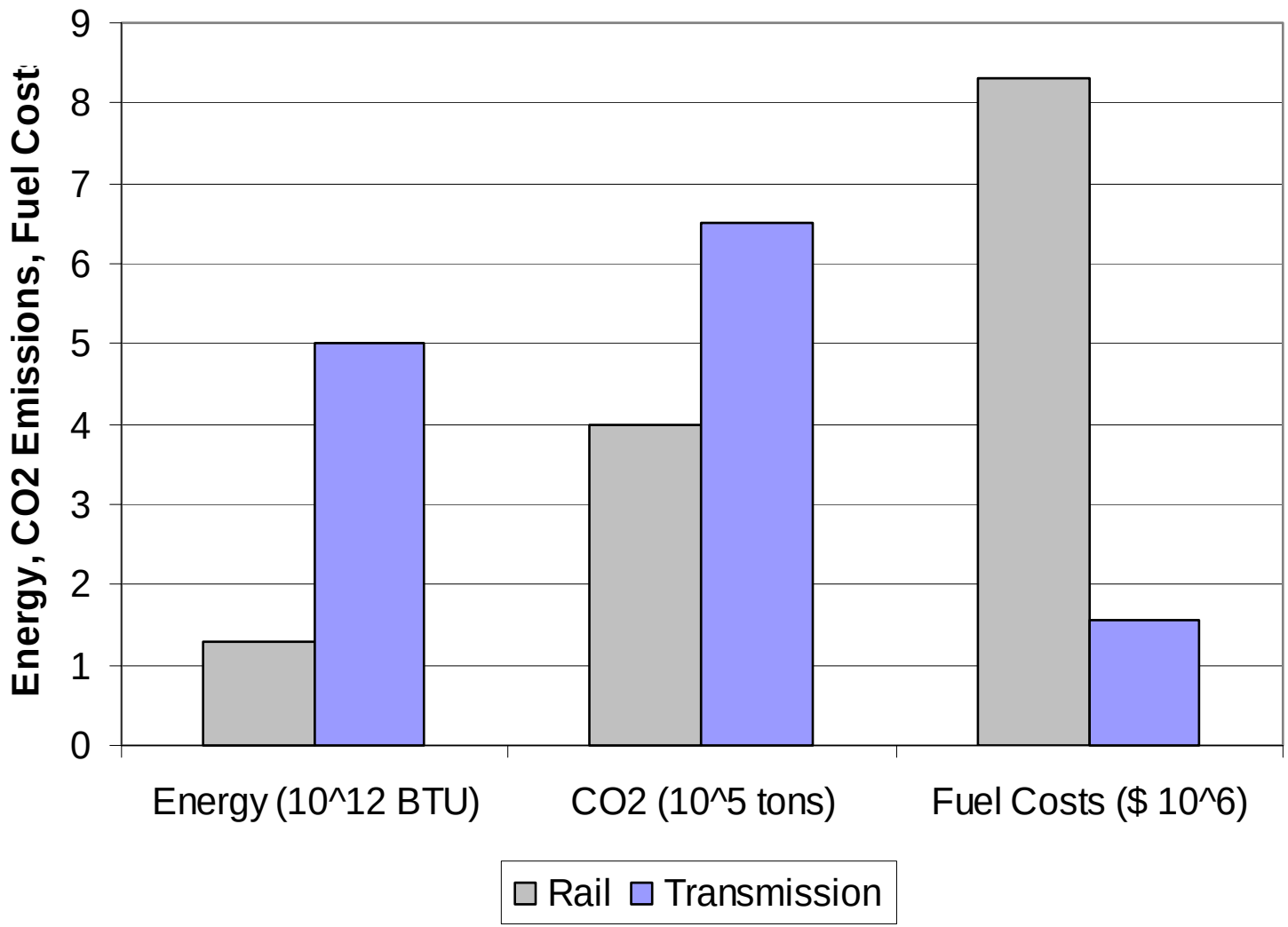
Scenario Analysis - Other

Scenario	Base Case	Break Even Value
Fuel Price	$0.9/gallon	$6-7/gallon
Cost of Capital	8%	3-4%
Distance	1000 miles	600 - 700 miles
Carbon Tax	$0	as little as $5/ton

Air Emissions (30 years)



Comparative Annual Energy Consumption



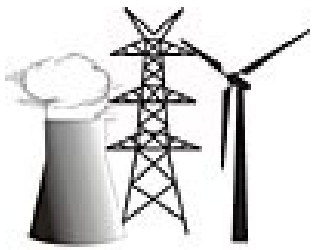
Some Alternatives

- Coal to Methane or Hydrogen
- Coal Slurry Pipeline
- AC Transmission
- High Temperature Superconductors
- Barge and Rail

Conclusions

- From the current case there is no economic/environmental gain in switching to minemouth generation
  - Some scenarios change this result
- Cost and environmental emissions from existing system are significant
  - Other methods of transporting energy should be investigated
- Contribution has been made from developing a method to compare alternative transport/transmission scenarios in terms of economic and environmental impact

Thanks to Support from….



Carnegie Mellon Electricity Industry Center

Green Design