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# **The Cost of Carbon Capture**

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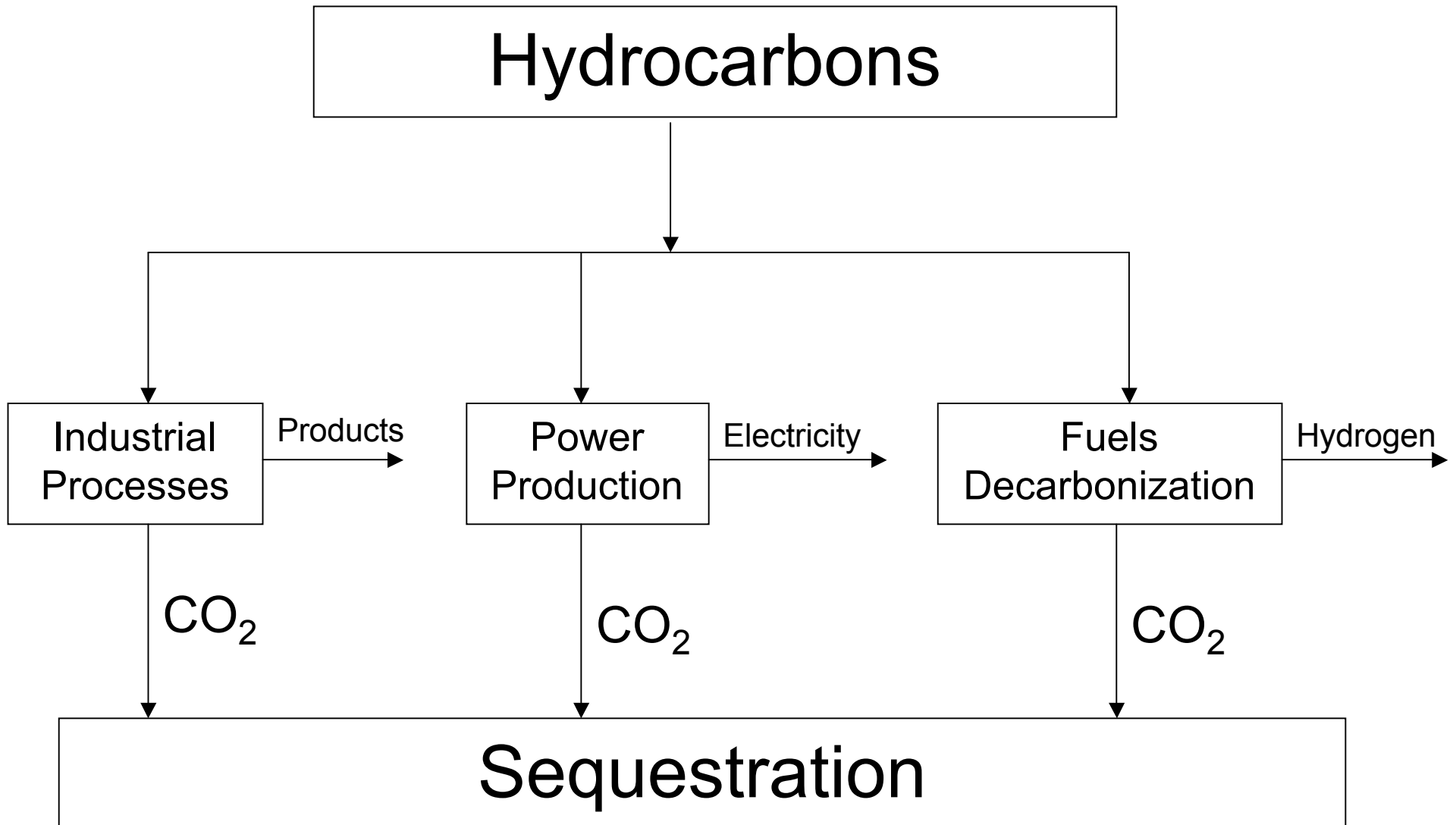
# Acknowledgements

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- Jeremy David (co-author)
- US Department of Energy (sponsor)
  - BER Program, Office of Science (John Houghton)
  - Office of Fossil Energy (Bob Kane)

# Carbon Sequestration

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# Cost Components

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- Capture
  - Separation
  - Compression
- Transportation
- Injection

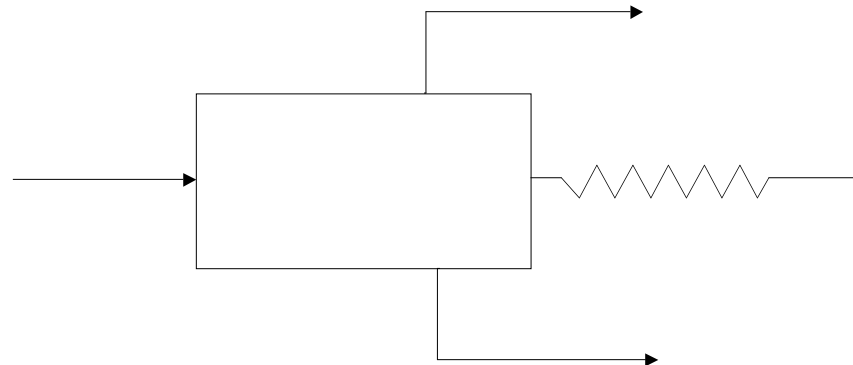
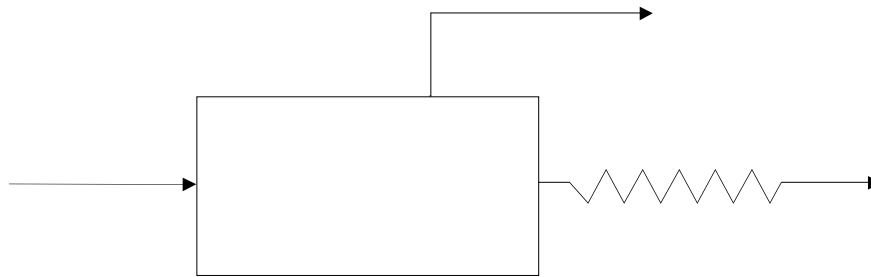
# Approach

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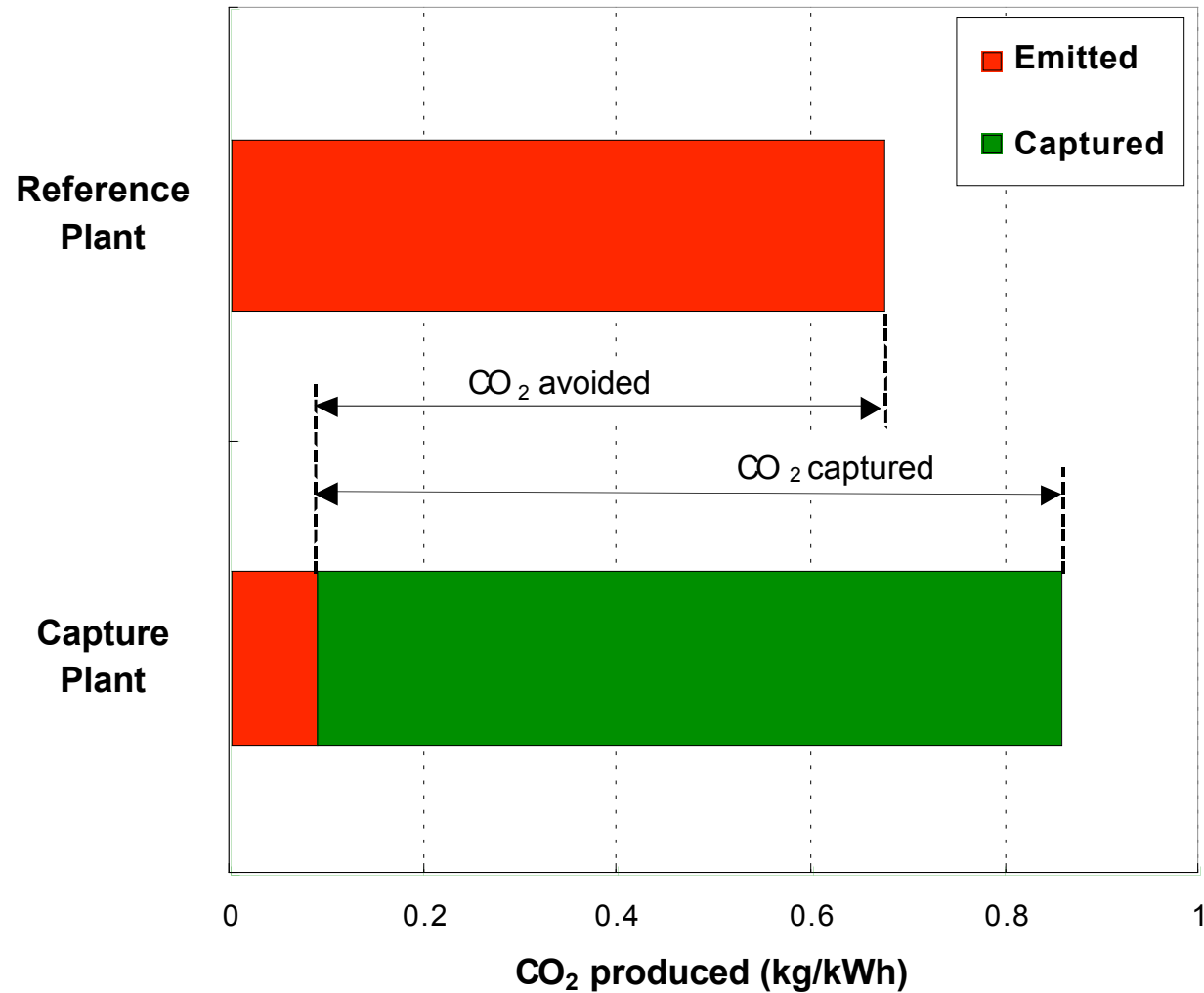
- Extract cost data from literature studies
- Adjust cost data to common economic basis
- Construct composite cost model
- Conduct sensitivity analyses and other studies with the composite cost model

# Methodology for Analysis of Economic Studies

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# CO<sub>2</sub> Captured vs. CO<sub>2</sub> Avoided



# Approaches to CO<sub>2</sub> Separation

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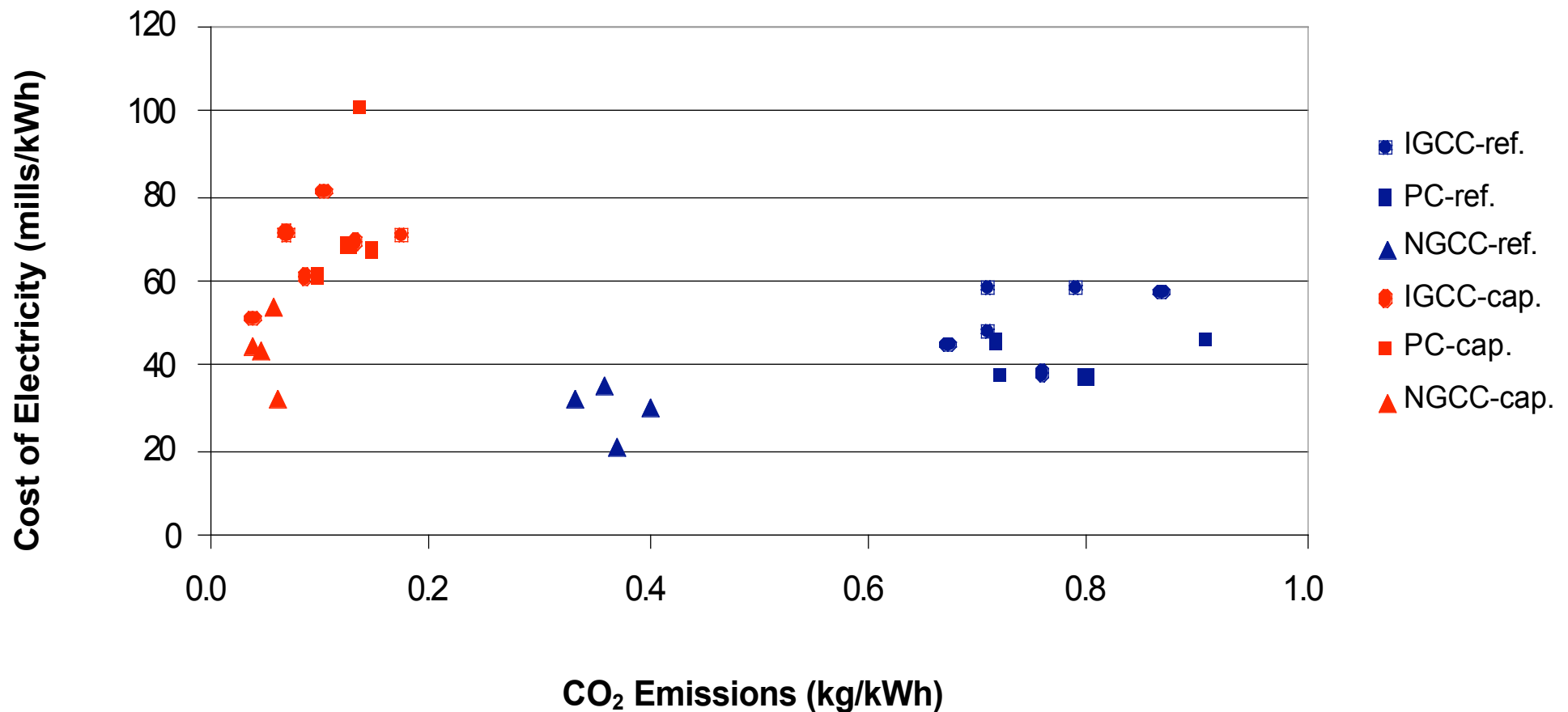
Approach	Coal	Gas
Flue Gas	Flue gas clean-up followed by CO <sub>2</sub> separation process (e.g., amines)	CO <sub>2</sub> separation from flue gas (e.g., amines)
Oxygen	Oxygen plus recycled flue gas in place of air Steam turbine	Oxygen plus recycled flue gas in place of air Modified turbine/CC
Hydrogen (or Syn-Gas)	Gasification Shift Capture H <sub>2</sub> to turbine/CC	Steam Reforming Shift Capture H <sub>2</sub> to turbine/CC



# Cost of Electricity vs. CO<sub>2</sub> Emissions

## Reported Data

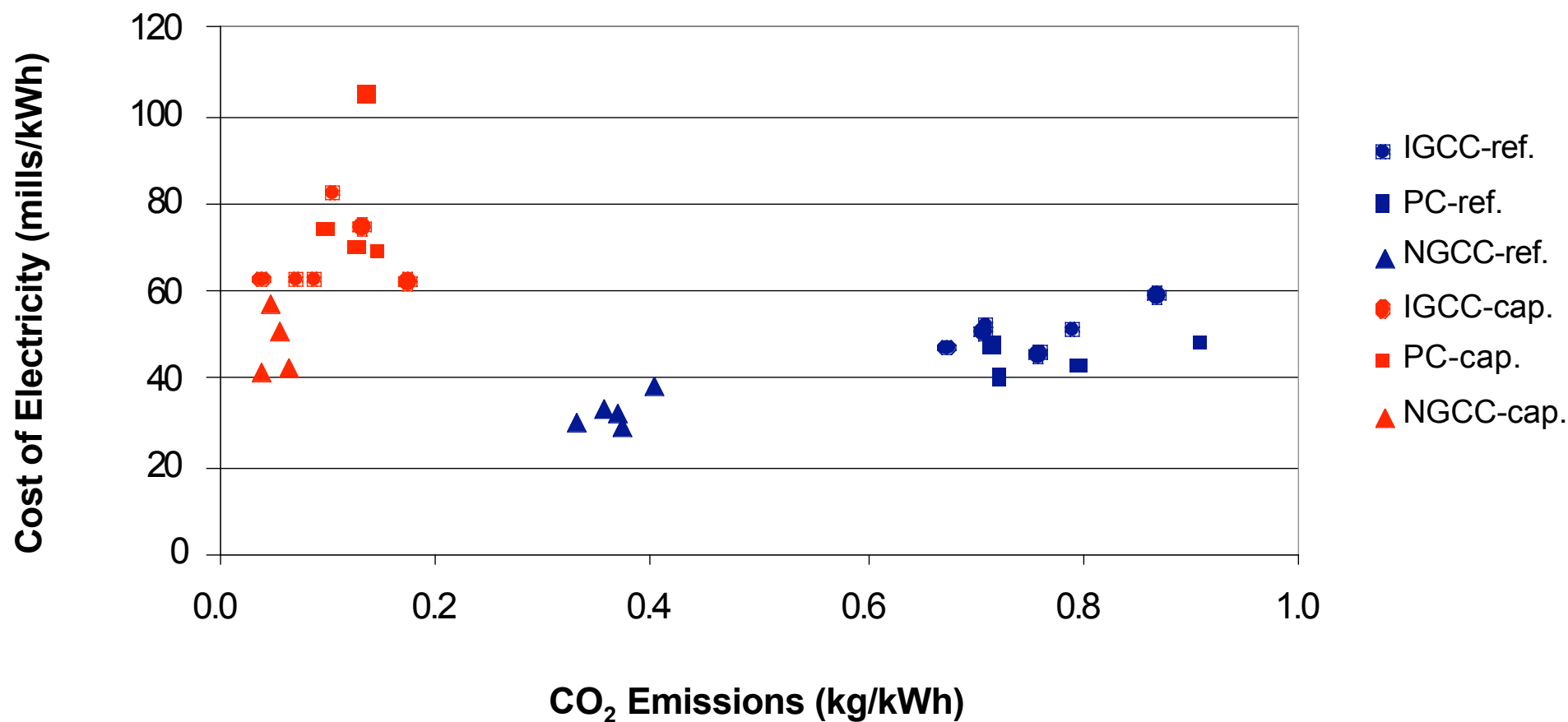
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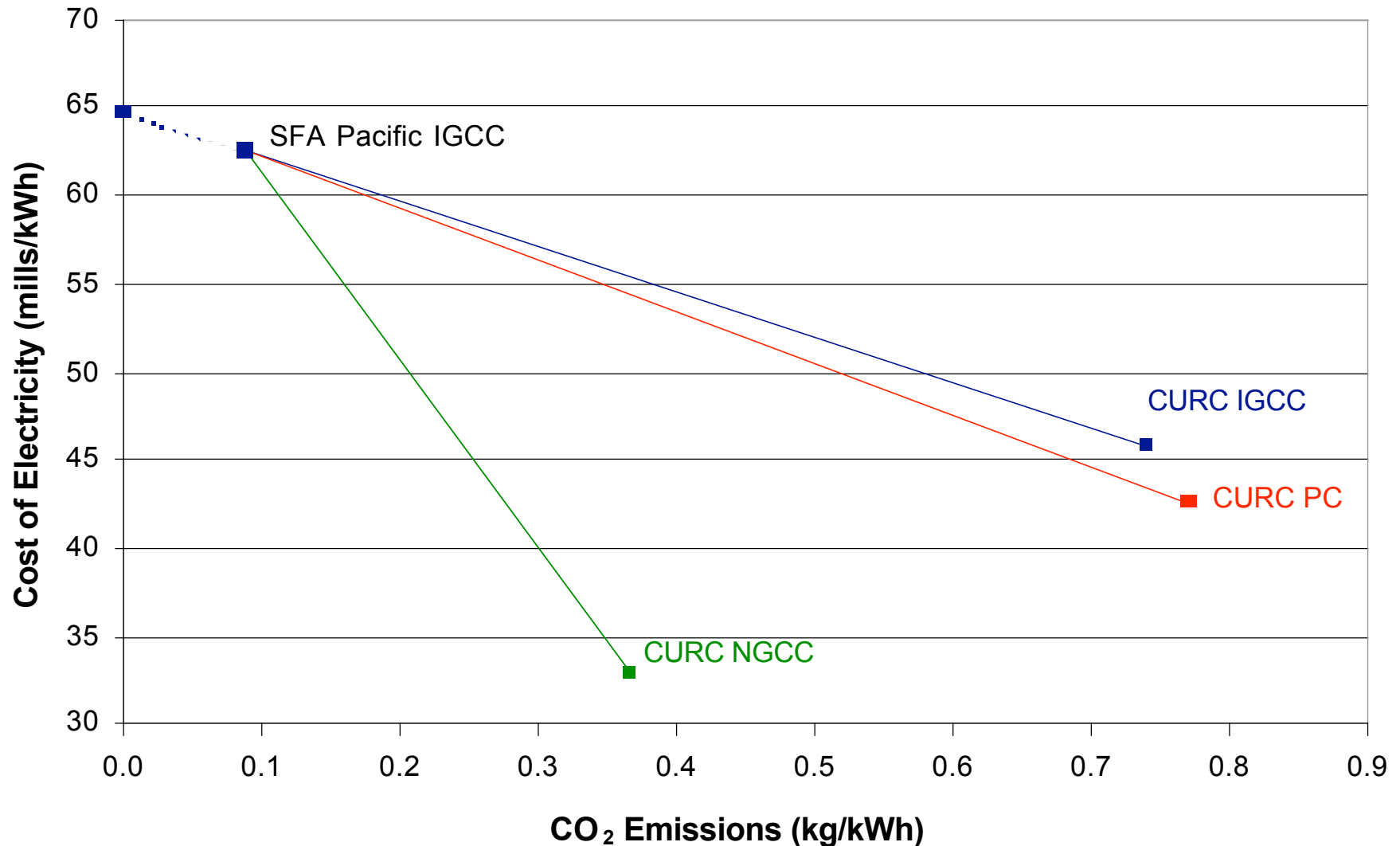
# Cost of Electricity vs. CO<sub>2</sub> Emissions

## Adjusted Data

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# Calculation of Mitigation Costs



# Composite Cost Model Inputs

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	Reference Plant	Capture Plant
Capital Costs	\$/kW	\$(kg/h)
O&M Costs	mills/kWh	mills/kg
Energy Requirements	Btu/kWh	kWh/kg

# Composite Cost Model Results

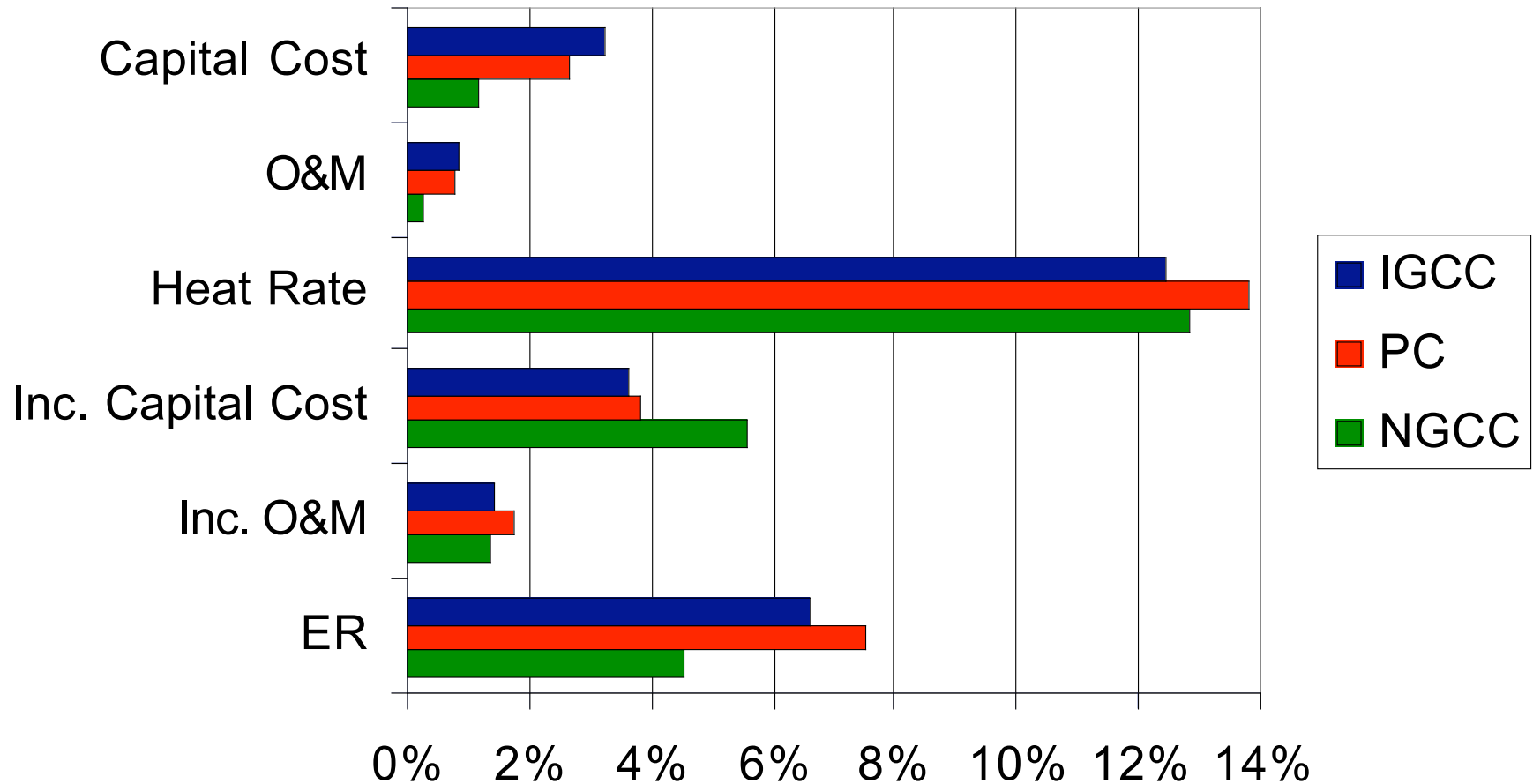
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	IGCC Today	IGCC 2012	PC Today	PC 2012	NGCC Today	NGCC 2012
Cost of Electricity without capture (cents/kWh)	5.0	4.1	4.4	4.1	3.3	3.1
Cost of Electricity with capture (cents/kWh)	6.7	5.1	7.7	6.3	4.9	4.3
Incremental Cost of Electricity (cents/kWh)	1.7	1.0	3.3	2.2	1.6	1.2
Energy Penalty	15%	9%	25%	15%	13%	10%

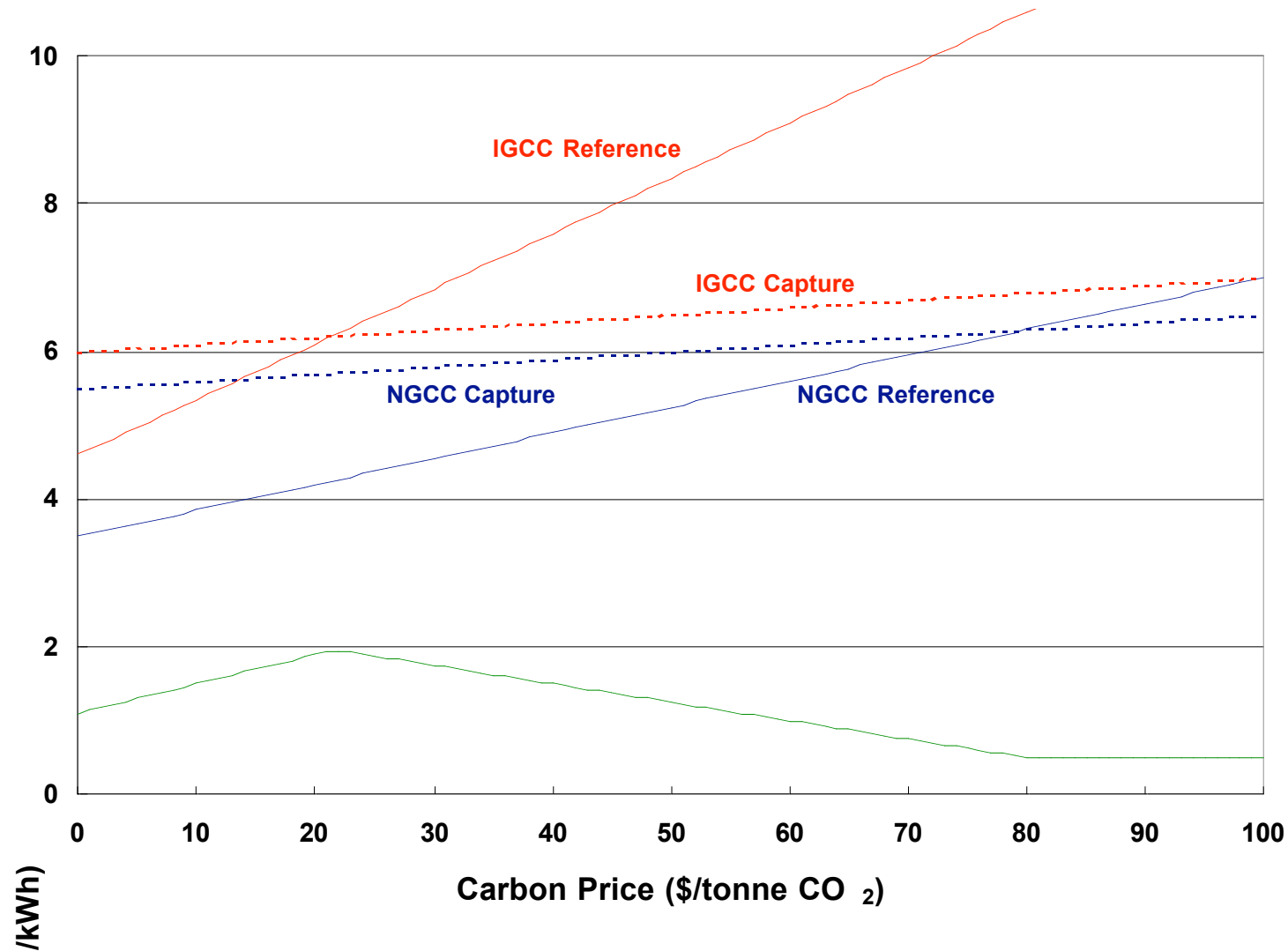
# Sensitivity Study

## Incremental Cost of Electricity

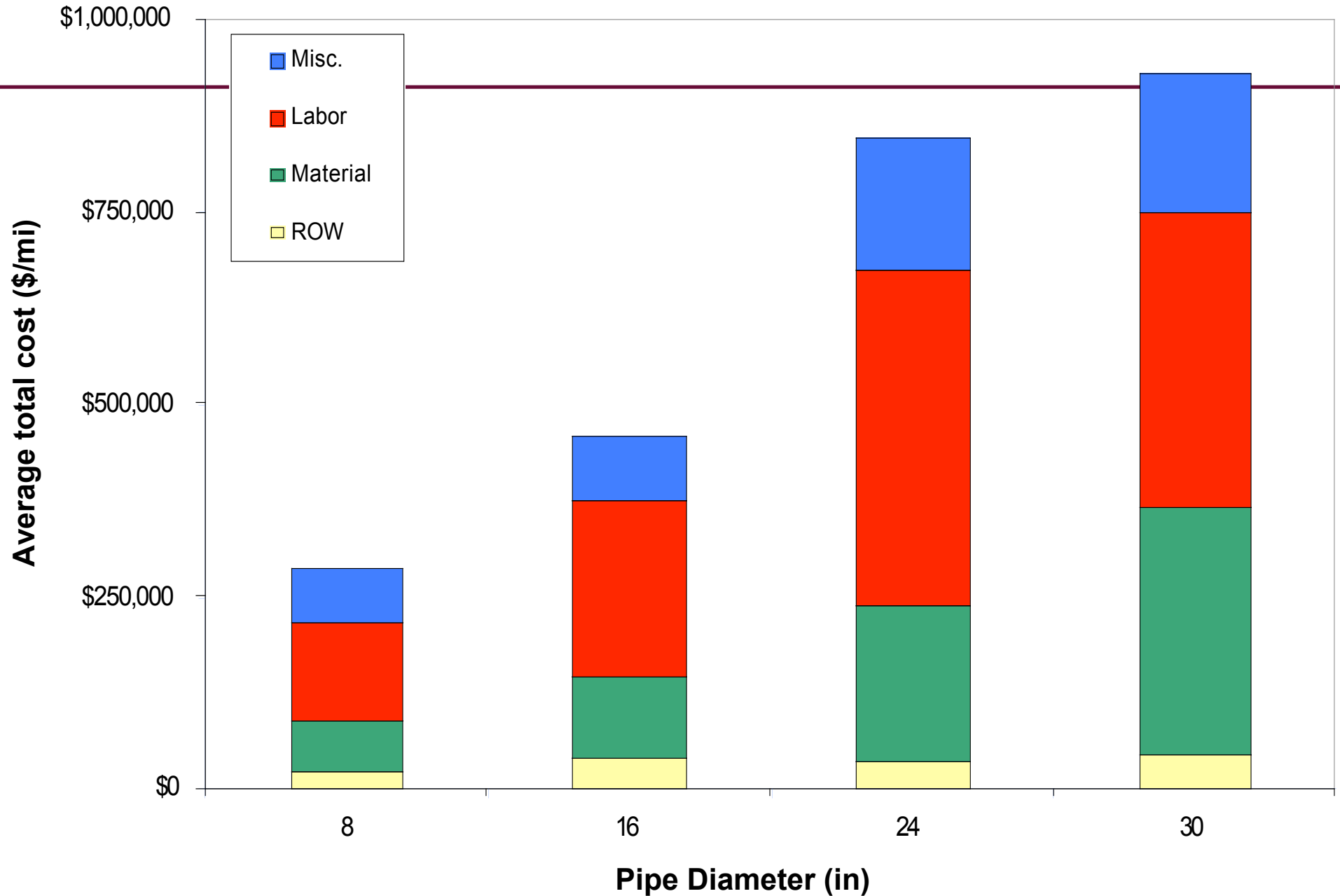
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# Comparing IGCC & NGCC Costs

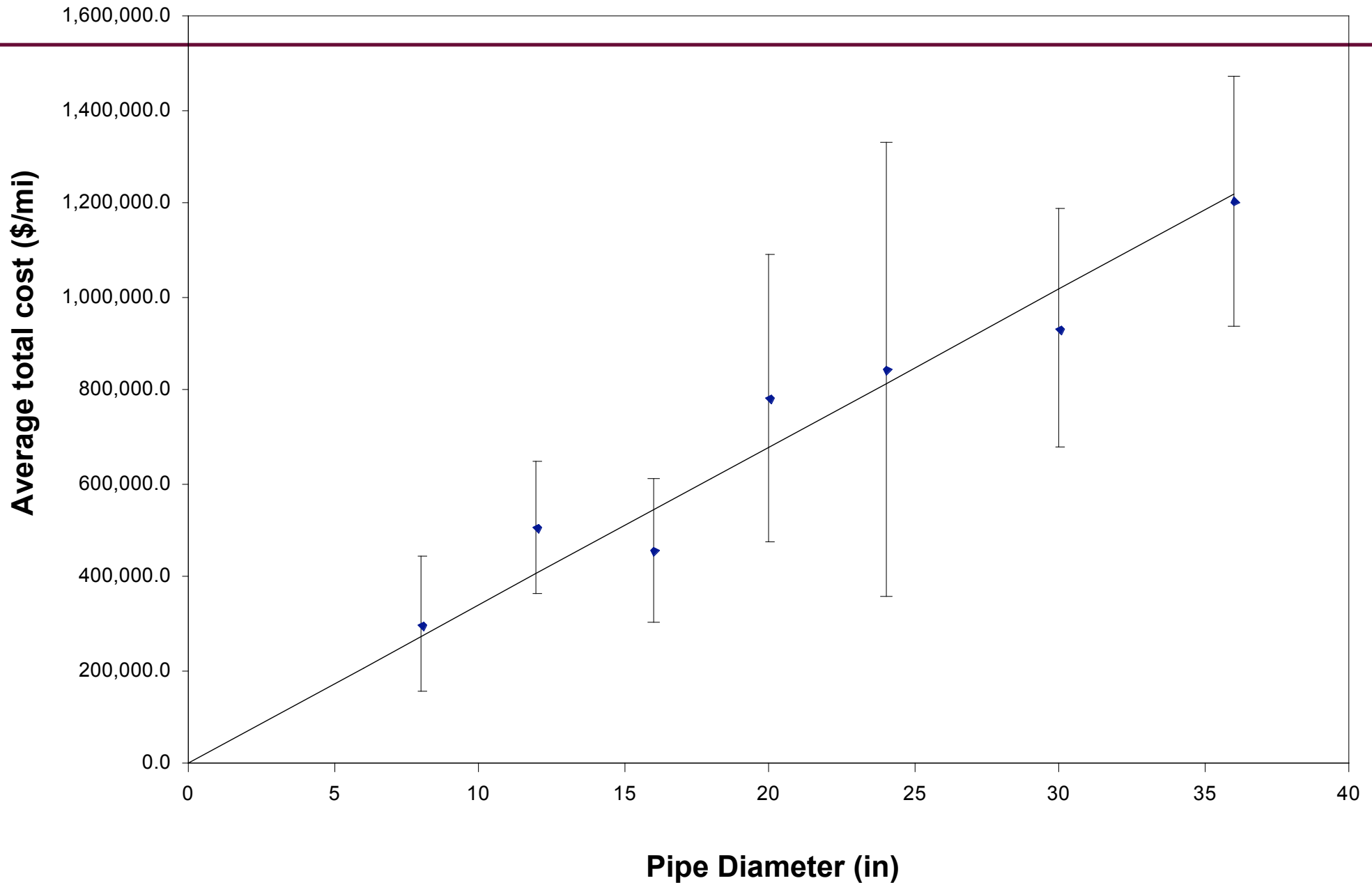


# Land Construction Costs of Natural Gas Pipelines (1989-1998) Breakdown by Cost Component

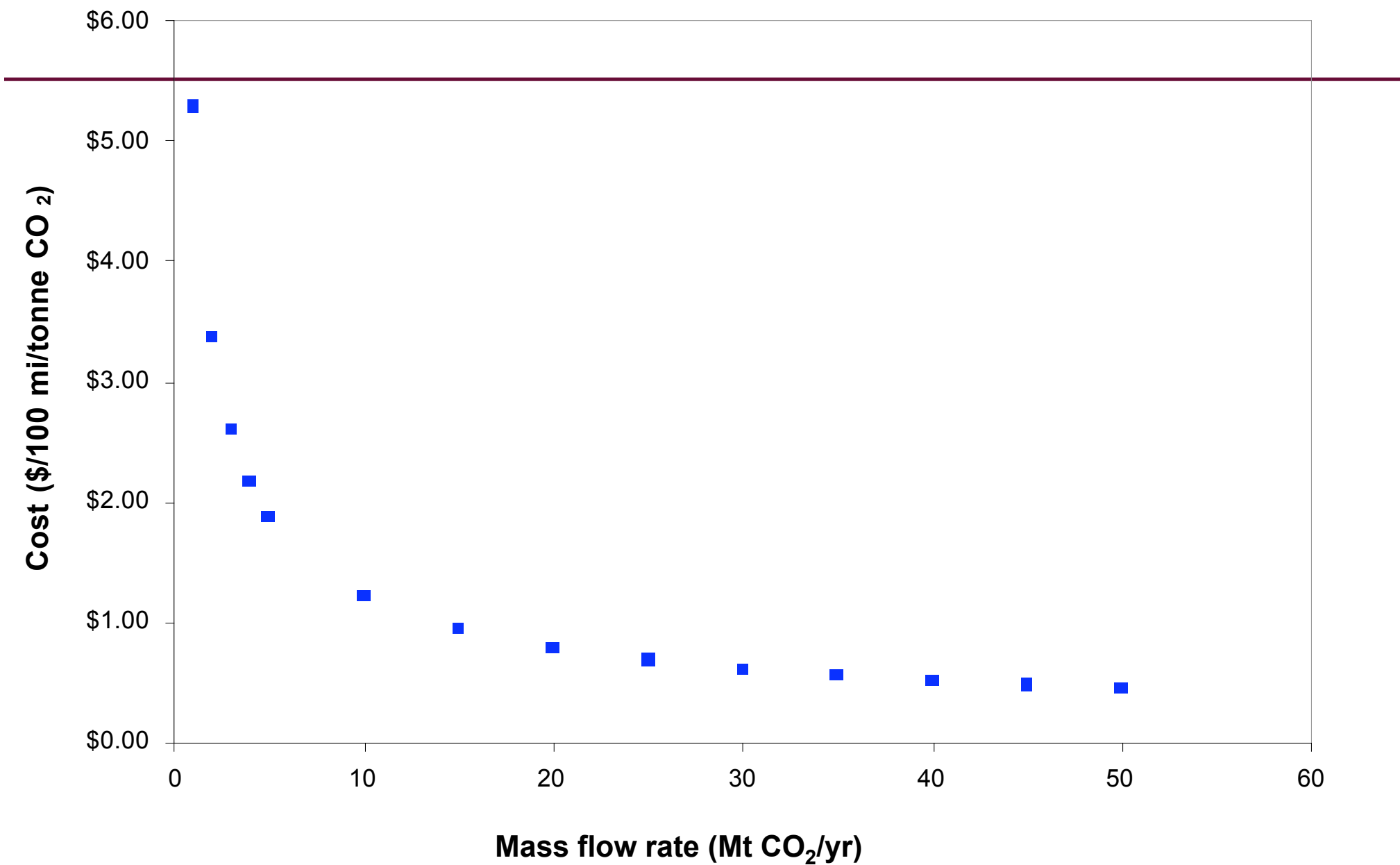




# Land Construction Costs of Natural Gas Pipeline (1989-1998) versus Pipe Diameter



## Cost of CO<sub>2</sub> Pipeline Transport



# Further Information

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- My home page:  
<http://web.mit.edu/energylab/www/hjherzog/>
- Jeremy David Thesis:  
<http://web.mit.edu/sequestration/JeremyDavid.pdf>