Optimization of the Integrated Geological Sequestration of Carbon Dioxide in Illinois Basin

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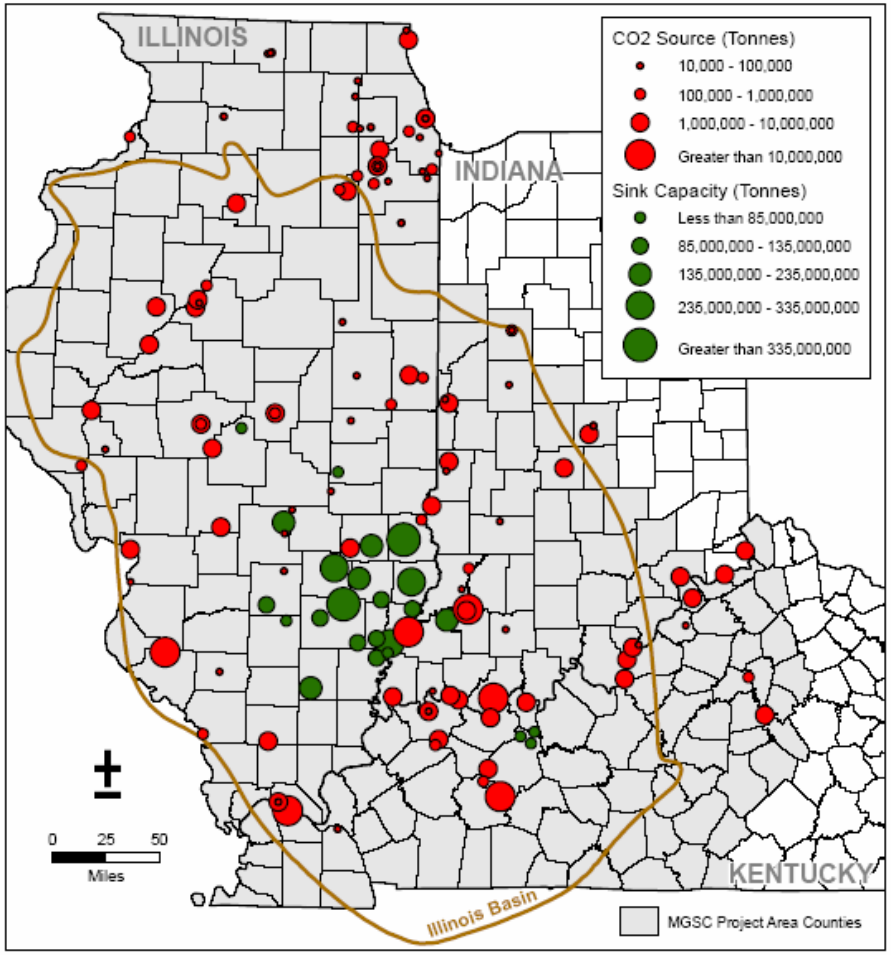
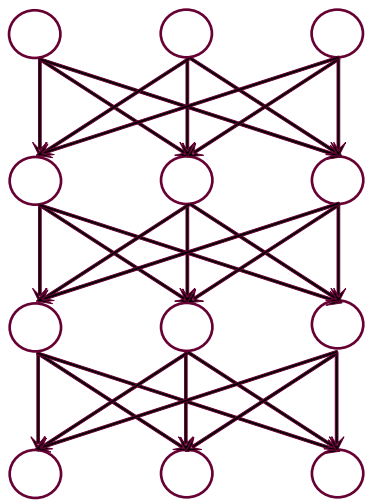
Objective of the Optimization

- *Optimize integrated CO_2 sequestration scenarios by determining the most cost-effective distribution of captured CO_2 from coal-fired power plant among all the identified geological fields in the Illinois Basin*



Optimization Modeling in Illinois Basin

- *Model scheme*
  - *Emission source selection*
  - *CO_2 Separation technology selection*
  - *EOR, ECBM and saline reservoirs*
  - *Pipeline routes*



… level i = 1,2,3… CO_2 emission sources

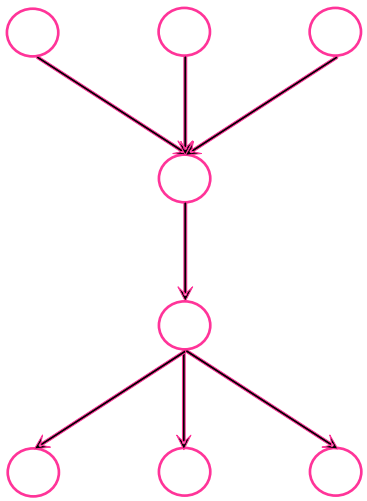
… level j = 1,2,3… Separation technologies

… level k = 1,2,3… Transportation methods

… level l = 1,2,3… Storage fields

Modeling Assumptions

- CO_2 capture only from coal-fired power plants
- Process 100% of flue gas
- MEA process and 90% capture
- Straight pipeline between a source and a sink
- Emissions from each source allowed to be stored in multiple sinks
- Electricity loss not compensated
- CO_2 capture/sequestration for 30 years



Data Input

- *Source*

  location (longitude/latitude), emissions

- *Sink*

  location, capacities of EOR, ECBM and aquifer

- *Distance*

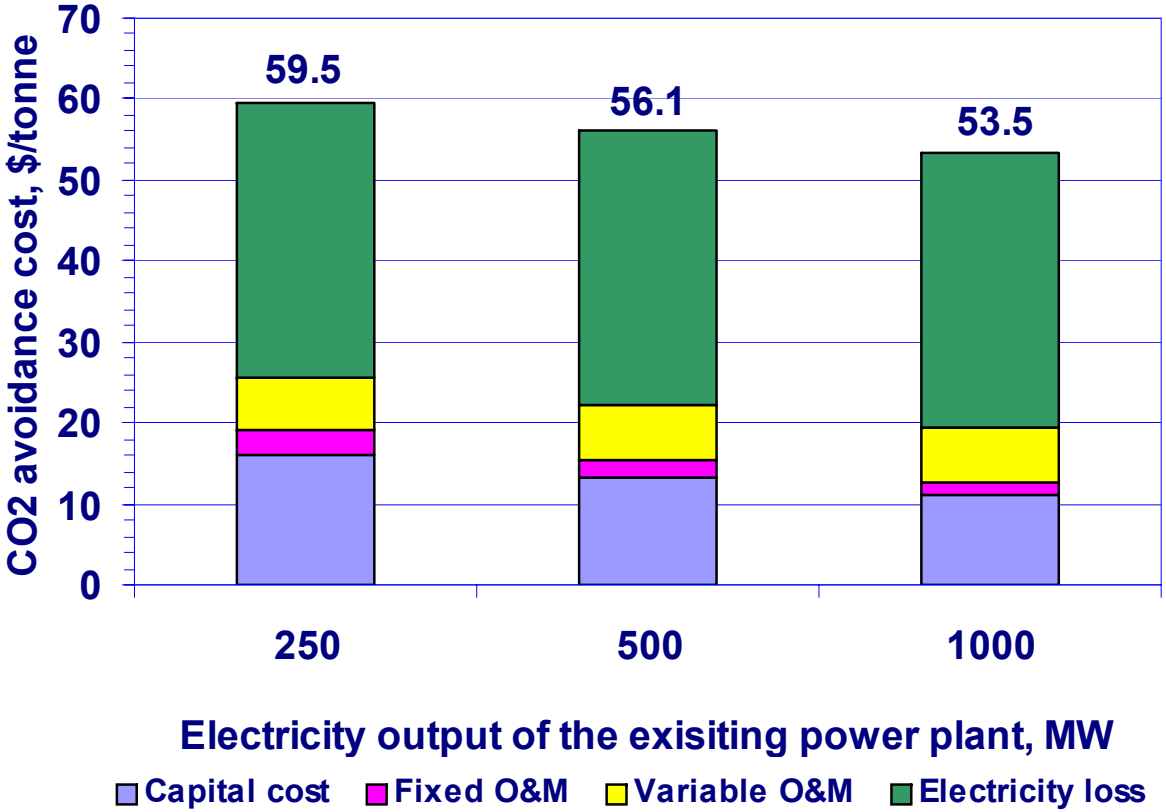
  source to sink

- *CO_2 control target*

- *Cost functions*

  CO_2 capture, pipeline and storage

CO_2 Separation Cost

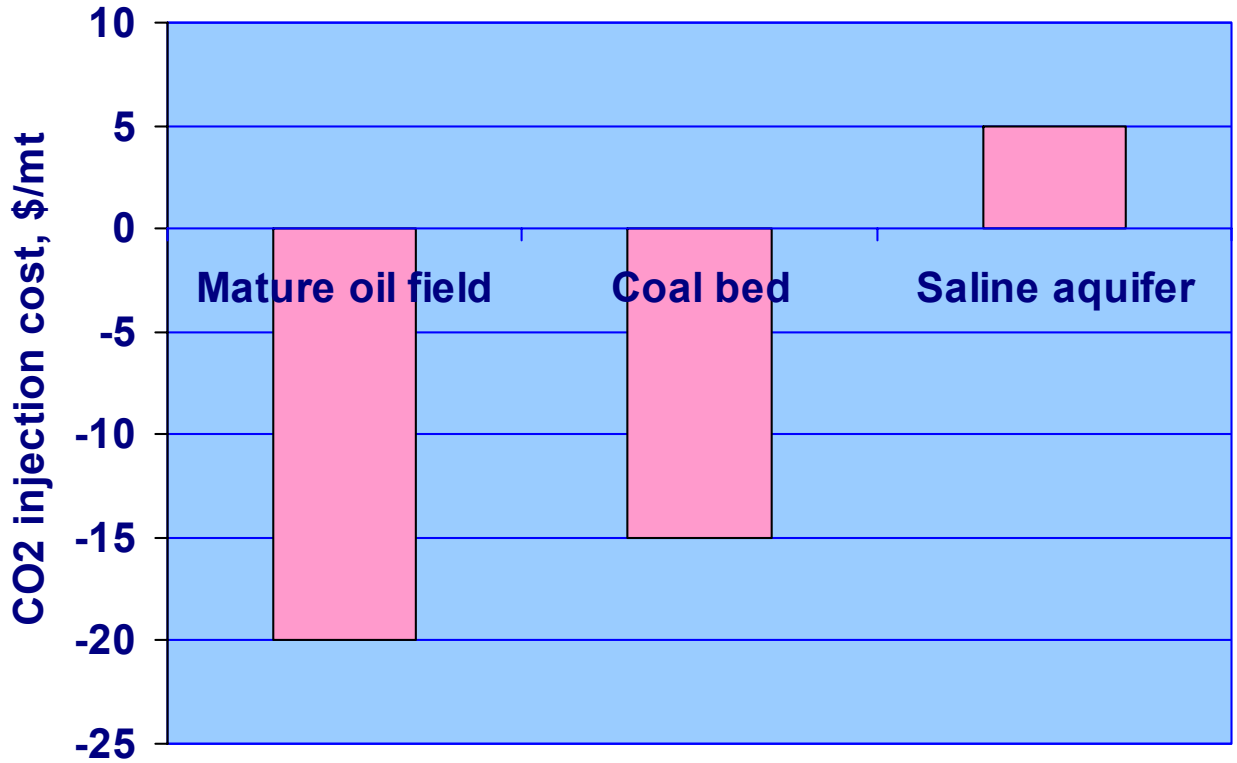


$$Capture\ Cost\ (\$/metric\ ton) = 60.0574 \times Q^{-0.0774}$$

$$Q: amount\ of\ captured\ CO_2, MM\ mt/year$$

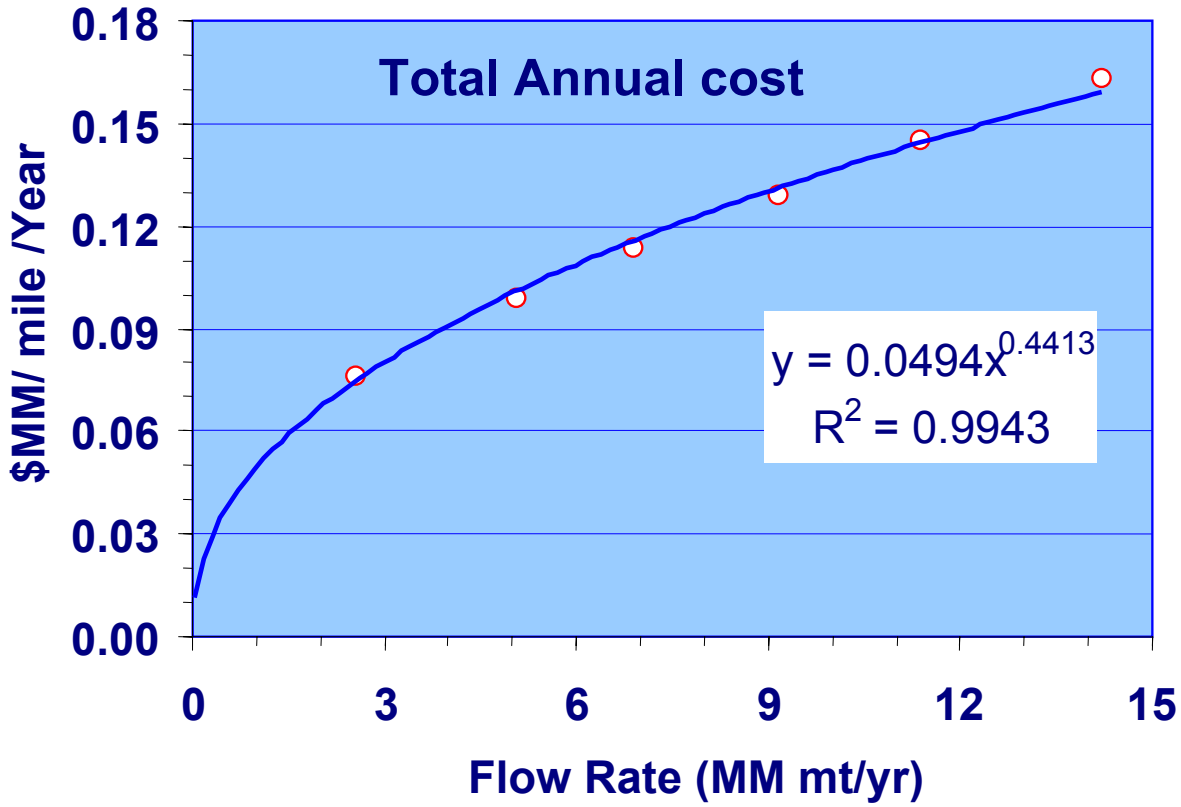
For scales>1000MW, cost assumed constant as 1000MW

Geological Storage Cost



- *Saline reservoir: \$5/mt CO_2*
- *Coal bed: \$15/mt CO_2 credit for CBM*
- *Mature oil field: \$20/mt CO_2 credit for oil recovery (corresponding to an oil price of \$25/barrel)*

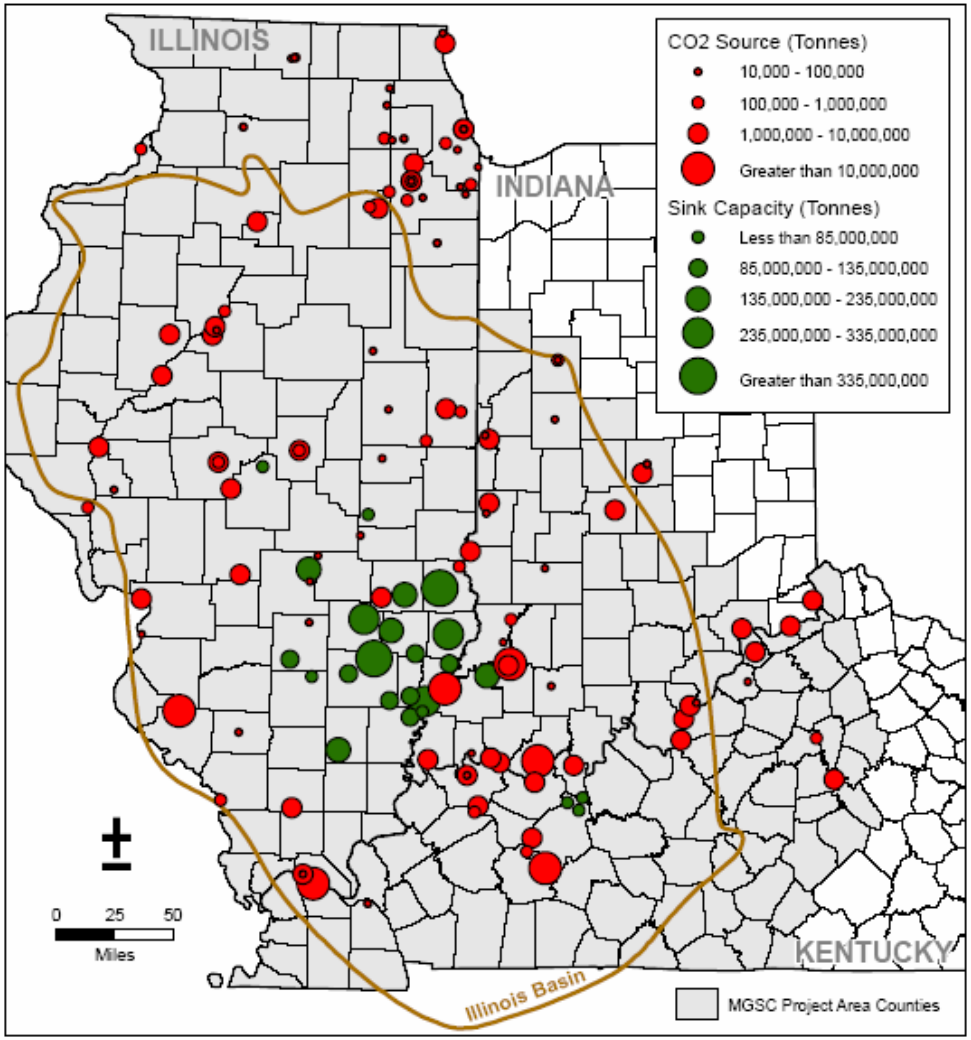
Pipeline Cost



Pressure drop: 5 psi /mile

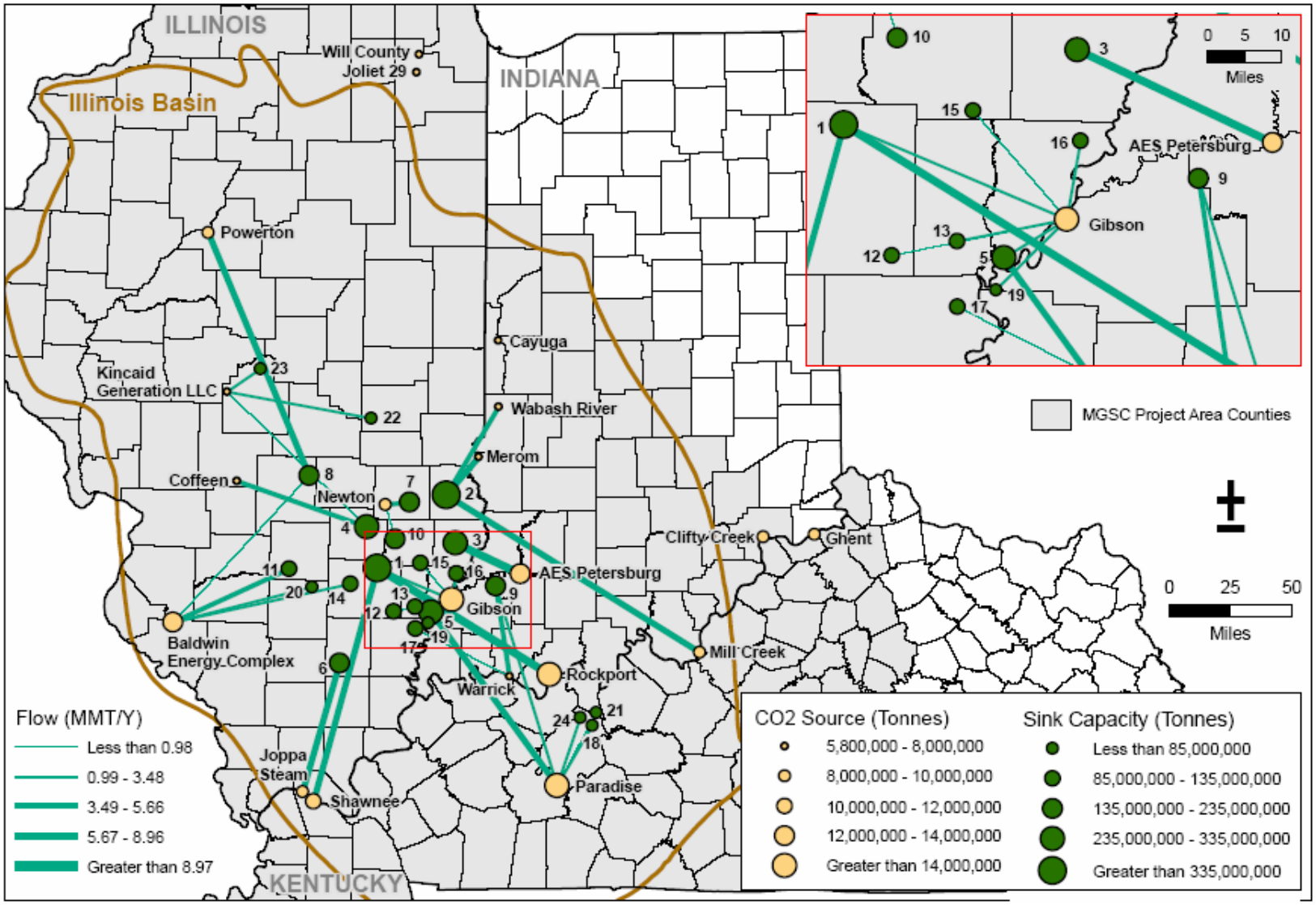
Without intermediate pressure boosting stations

122 Power Plants and 24 largest Sinks



The optimal solution is the most cost effective CO_2 flow allocations between sources and sinks

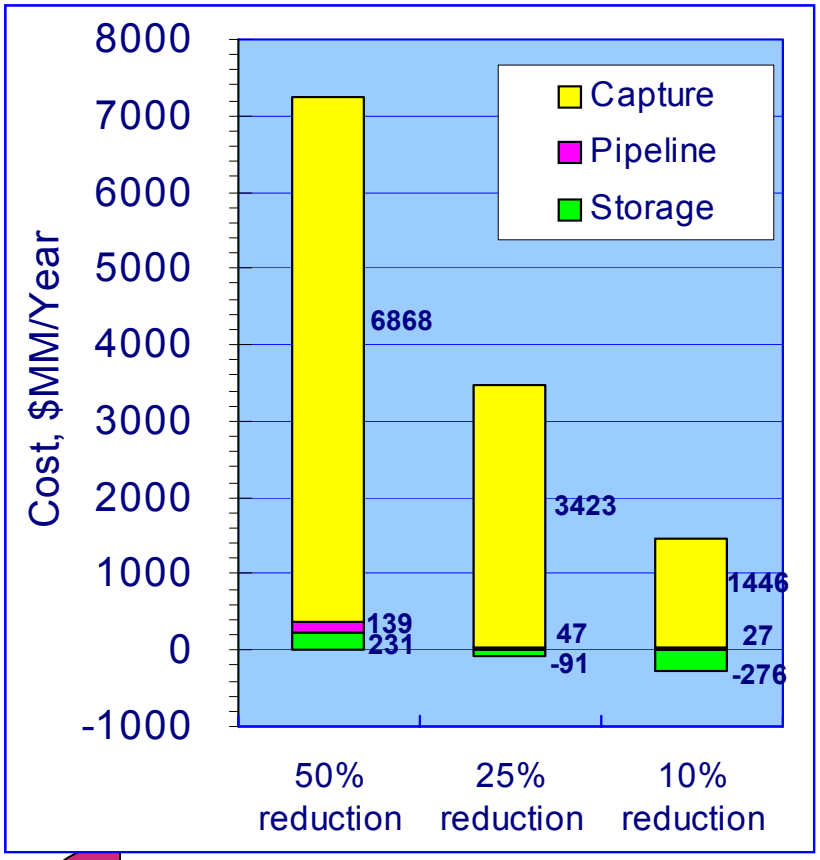
50% Reduction: with EOR and ECBM Benefits



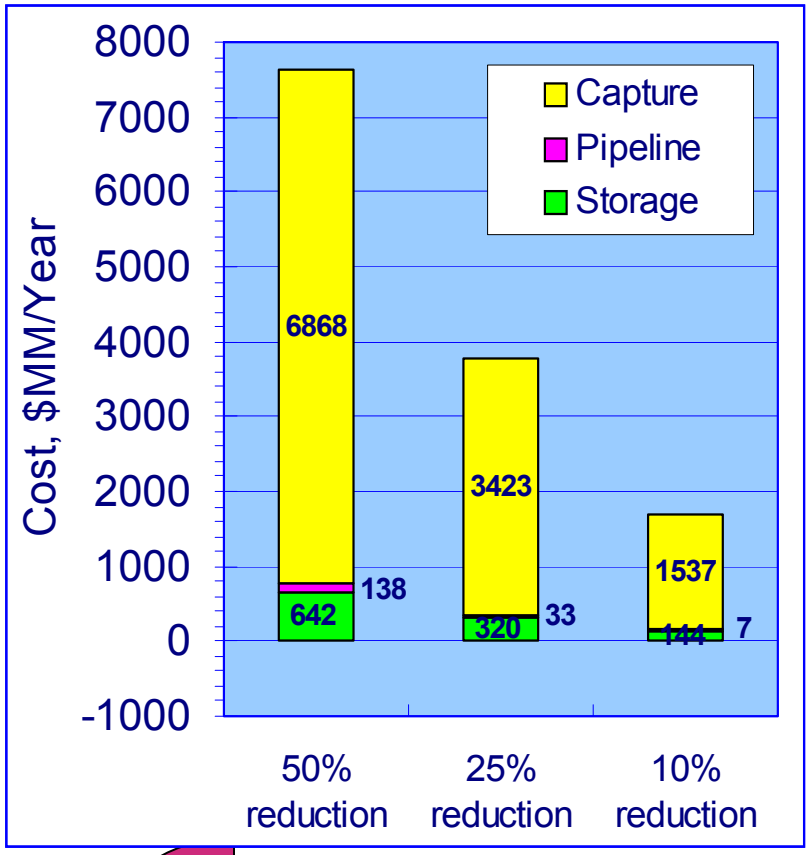
- *15 power plants, 128 MM mt/y CO_2 reduction , ~7746 MW electricity loss*
- *82% of storage capacity including all EOR and ECBM*
- *Average pipeline distance 57.4 miles*

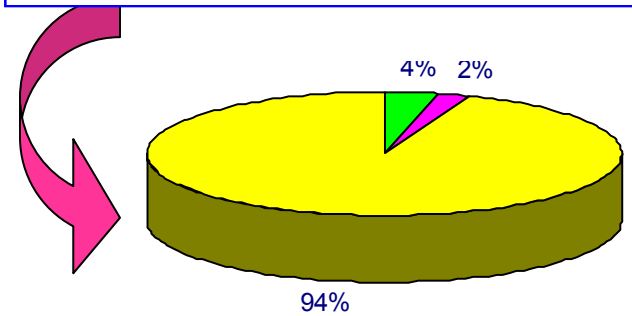
Cost Comparison: Annual Total Cost ($MM/year)

With EOR/ECBM credits

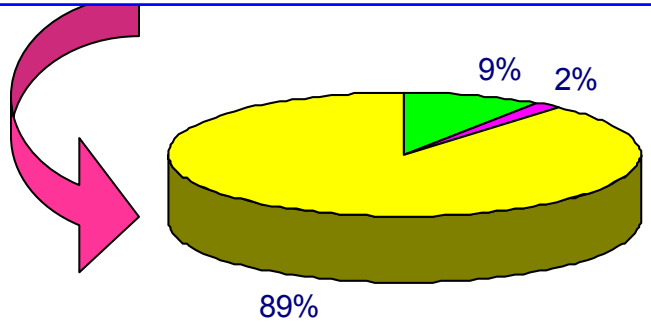


Without EOR/ECBM credits

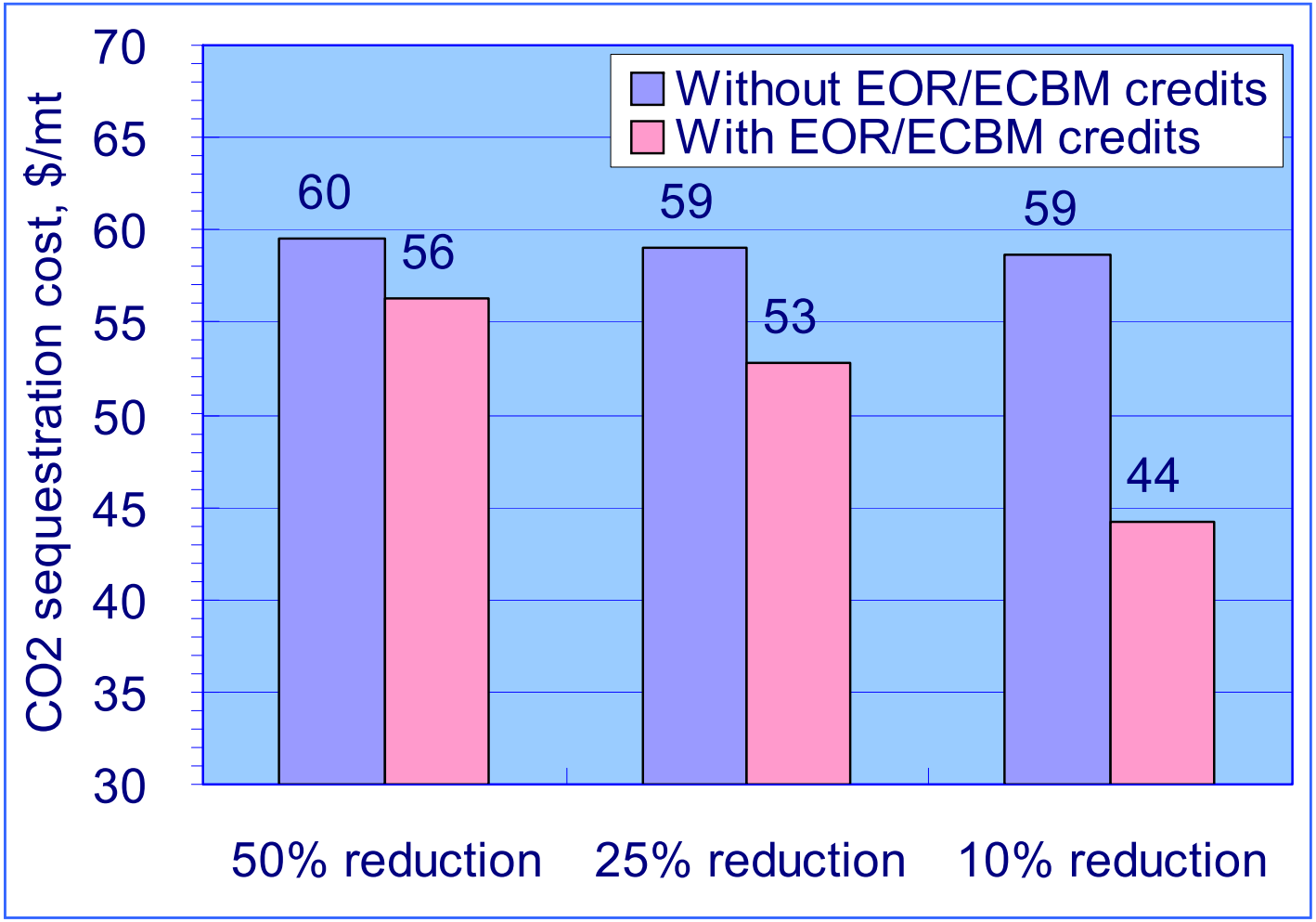




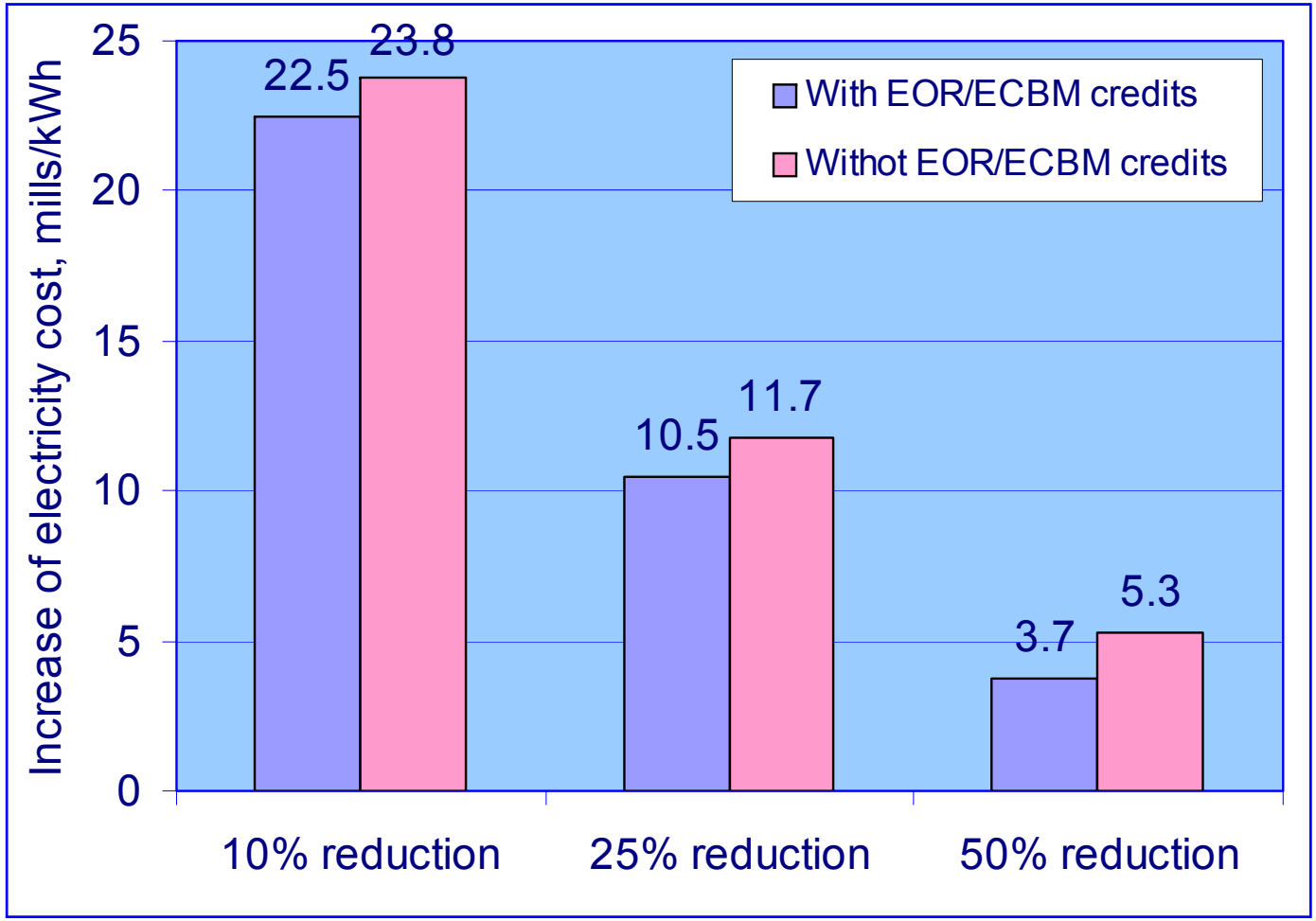
Cost distribution



CO_2 Sequestration Cost ($/mt)

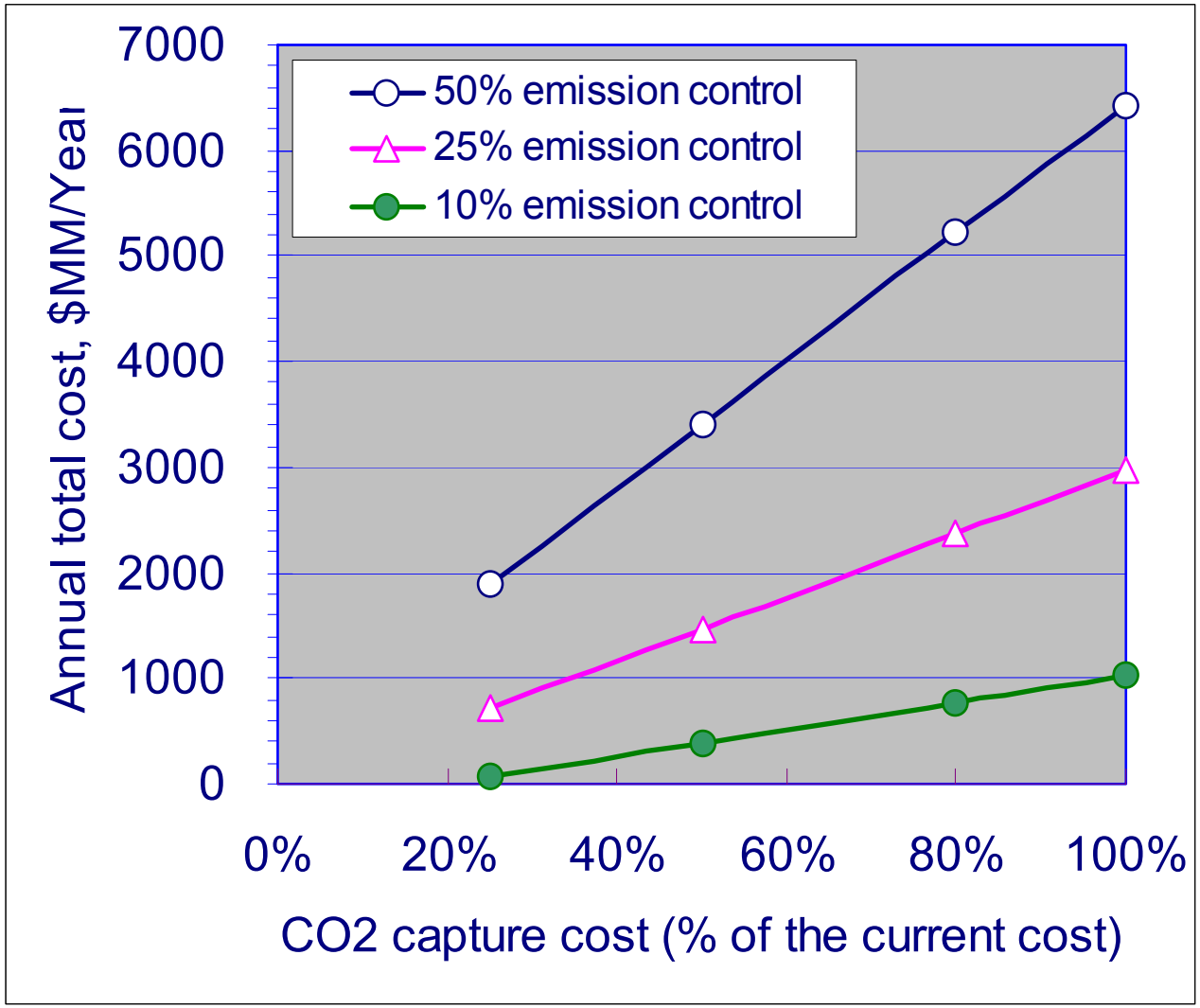


Increase in Electricity Cost (mills/kwh)



Assume that sequestration costs are shared by all utilities in the Basin

Impact of CO_2 Capture Cost



Summary

- *CO_2 capture from large power plants is generally more economically attractive*
- *CO_2 capture cost contributes to >~90% of the total sequestration cost*
- *CO_2 storage in EOR and ECBM fields are economically preferred regardless of their locations in the Basin*
- *82% of the identified capacity of the 24 largest geological storage sites in the Basin (defined by structural oil traps) would be used in 30 years at 50% CO_2 control level*
- *Sequestration cost ranges from \$38 to \$50/mt CO_2 for 10% to 50% control levels*
- *Sequestration cost significantly decreases at 10% control level if benefits from EOR and ECBM are included*