The economics of CCS technology

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CAGS Workshop II:
CO_2 Aquifer Storage

cags China Australia Geological Storage of CO_2
中澳二氧化碳地质封存

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Aims of presentation

- To show:
  - how CCS costs are calculated
  - some of the factors that affect CCS costs
  - how to read the CCS research literature and economic reports
  - how economics can be used to make business and investment decisions for CCS

Outline

Part I – Economic methodology

- Fundamentals of cash flow analysis
- Net and incremental cash flow for a project
- Economic indicators – present value

Part II – Calculating the effectiveness of CO_2 mitigation

- CO_2 avoided
- $ per tonne CO_2 avoided
- Other indicators

Part III – Evaluating CCS projects

- Factors affecting capture costs
- Factors affecting transport and injection costs

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Aims of doing economics

1. Assess whether the project is economically viable
2. Compare CCS with alternatives
3. Comparison within CCS projects (trade-offs)

Why use cash flow?

- Most of the literature has analyses that show economics without projecting cash flow.
- This is simplistic.
- Projecting cash flow allows revenues and costs to change over time.
- The effect of tax, inflation and other costs can be changed over time.

Cash Flow

- Cash flow is the cash received less the cash spent over a defined period of time

Net cash flow = cash received

less

cash spent

Cash in = Revenue

- Examples of CCS revenue
  - – Enhanced oil recovery
  - – Enhanced coal bed methane recovery
  - – Enhanced gas recovery
  - – Revenue from a carbon price

Cash spent = Project costs

- Capital (2-3 years+)
  - explore, design, purchase, install equipment, compressors, pipelines, wells
- Operating (20-40 years+)
  - energy, materials, cooling water, maintenance, monitoring, administration, labour
- Abandonment (1-2 years+)
  - decommissioning, salvage, plugging wells, monitoring

Incremental net cash flow (NCF)

Net cash flow for original project + CCS project

less

Net cash flow for original project

equals

Incremental Net cash flow for CCS project

Present value

- One way to present project costs as a single number is the present value (PV)

- PV is the equivalent value of the costs today

- It is the money we would invest today in a bank to enable us to meet the costs of the project as they fall due

Discount rate

- **The bank rate in the previous example is the discount rate**

- **In general, the discount rate is the return we would get on an alternative investment**

Calculating Present Value

$$DiscountRate = d\%$$

$$DiscountFactor_n = \frac{1}{(1+d\%)^n}$$

$$PV = \sum_n \frac{dollars_n}{(1+d\%)^n}$$

Net Present Value (NPV)

- It is the present value of the NET cash flow
- It is the money you have to put in the bank today to match the NET cash flow from the project

$$NPV = \sum PV$$

$$= PV_{Revenue} - PV_{Capital} - PV_{Operating}$$

$$- PV_{Abandonment}$$

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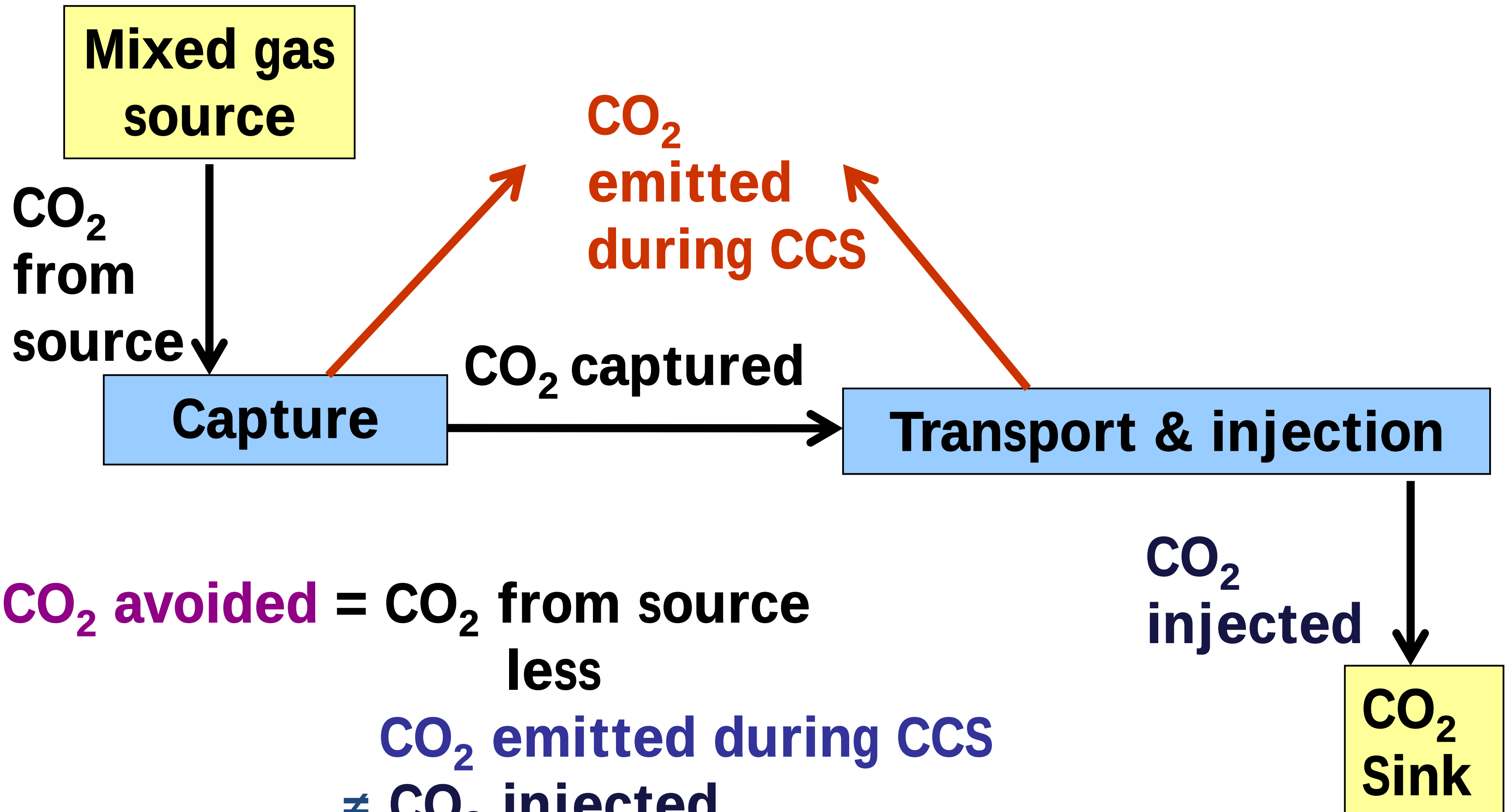
CO_2 flows during CCS



CO_2 avoided = CO_2 from source
less
CO_2 emitted during CCS
≠ CO_2 injected

\$ per tonne CO_2 avoided

- Represents the revenue per tonne you need to make CCS viable

- Using PV method –

$$\frac{\$}{tonne \quad CO_2 \quad avoided} = \frac{PV_{AllCosts}}{PV_{CO_2 \quad avoided}}$$

Other Indicators

- **Incremental cost of electricity**
  - Difference between the cost of electricity with and without CCS ($/MWh)

- **Energy Penalty**
  - Energy required for CCS (MW)

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Major factors affecting CCS costs

- Economic factors
  - Discount rate
  - Project life
  - Capex, Opex and Abandex

- Project specific factors
  - CO_2 avoided
  - Energy used
  - Load factor

Reducing capture costs

$$\frac{\$}{tonne\ \ CO_2\ \ avoided} = \frac{PV_{AllCosts}}{PV_{CO_2\ \ avoided}}$$

Reduce!

Reduce!

Increase!

- **Reduce Capex** – cheaper, more efficient equipment
- **Reduce Opex** – more efficient equipment, less energy demand
- **Reduce energy penalty** – use improved solvent, heat and process integration
- **Increase CO_2 captured** – improve capture efficiency
- **Reduce CO_2 emitted** – improve process efficiency, change fuel
- **Increase energy efficiency** – heat and process integration

Example: Effect of solvent regeneration energy

- Compare the capture costs and energy demand using MEA or KS1 solvent absorption

Solvent	Solvent loss (kg solvent / tonne CO_2 captured)	Steam used (kg steam / kg CO_2 captured)	CO_2 avoided (tonne / MWh)	Capture Cost ($ / tonne CO_2 avoided)*
MEA	1.6	1.8	0.500	65
KS1	0.35	1.5	0.542	53

78% reduction

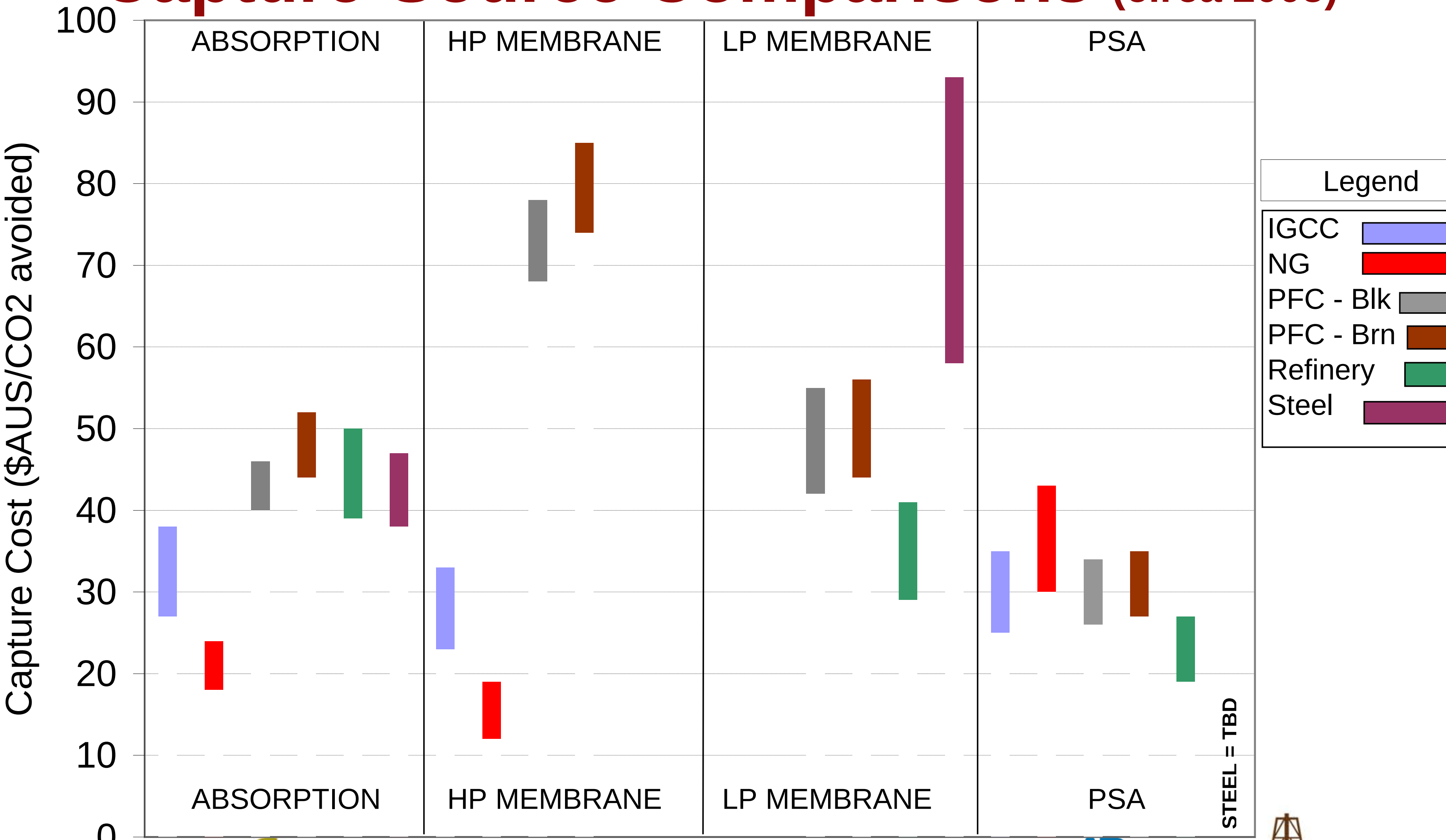
15% reduction

8% increase

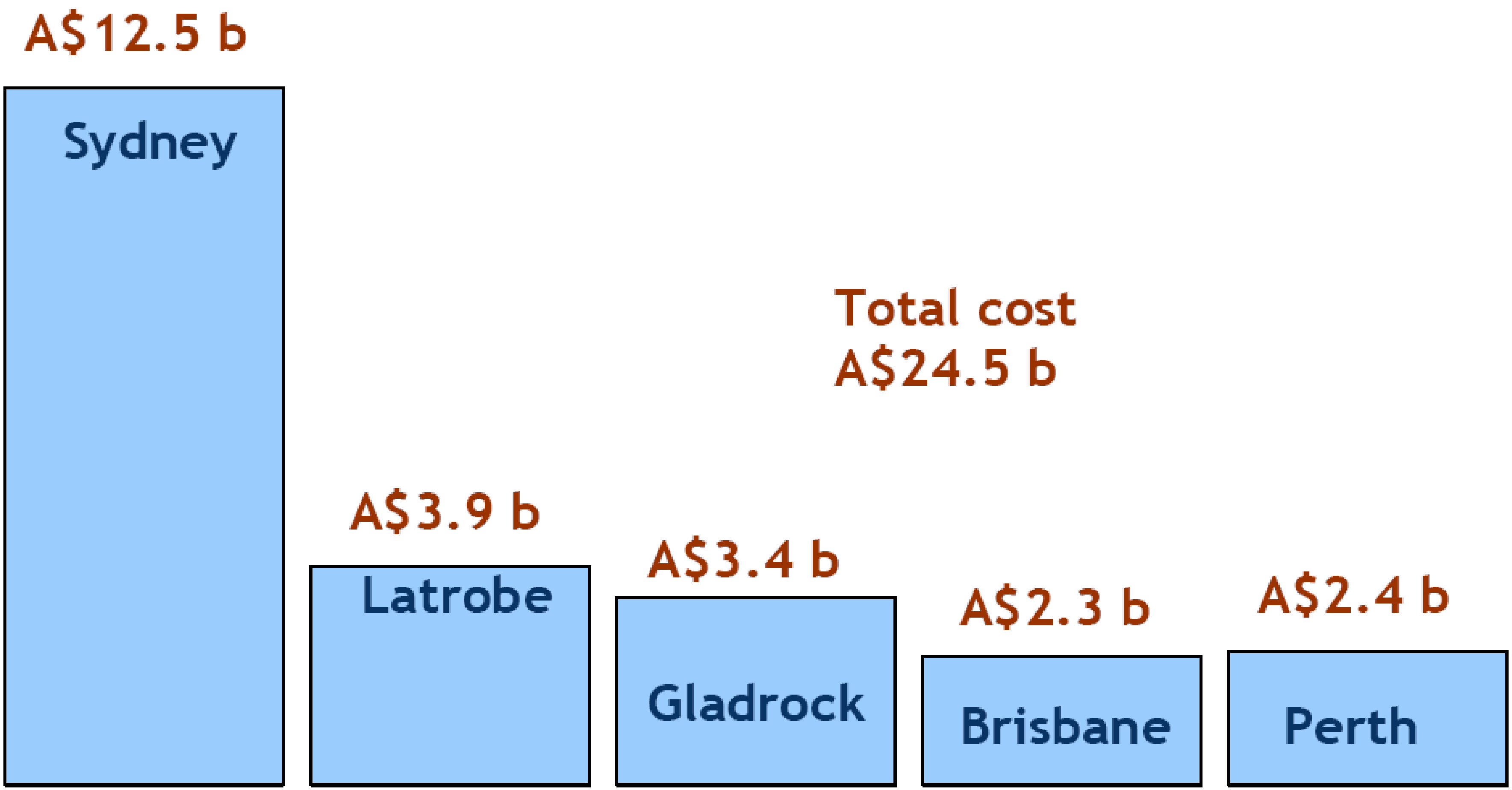
18% reduction

*Costs in 2008 Australian dollars

Capture-Source Comparisons (circa 2005)

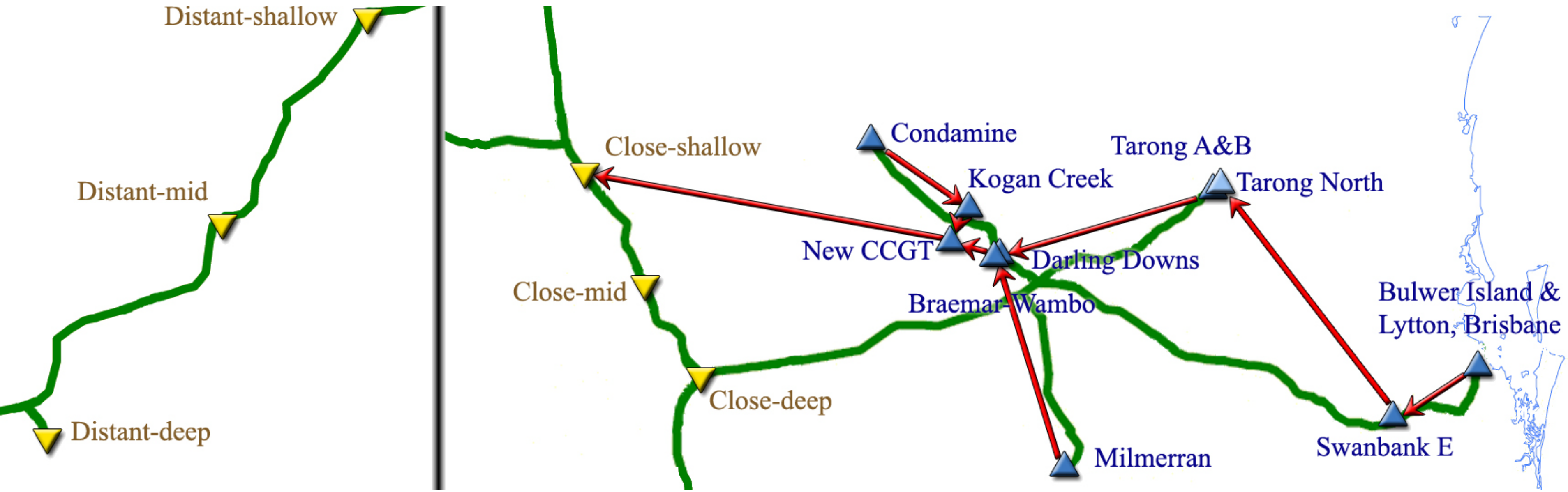


Capital costs for CO_2 transport & injection*

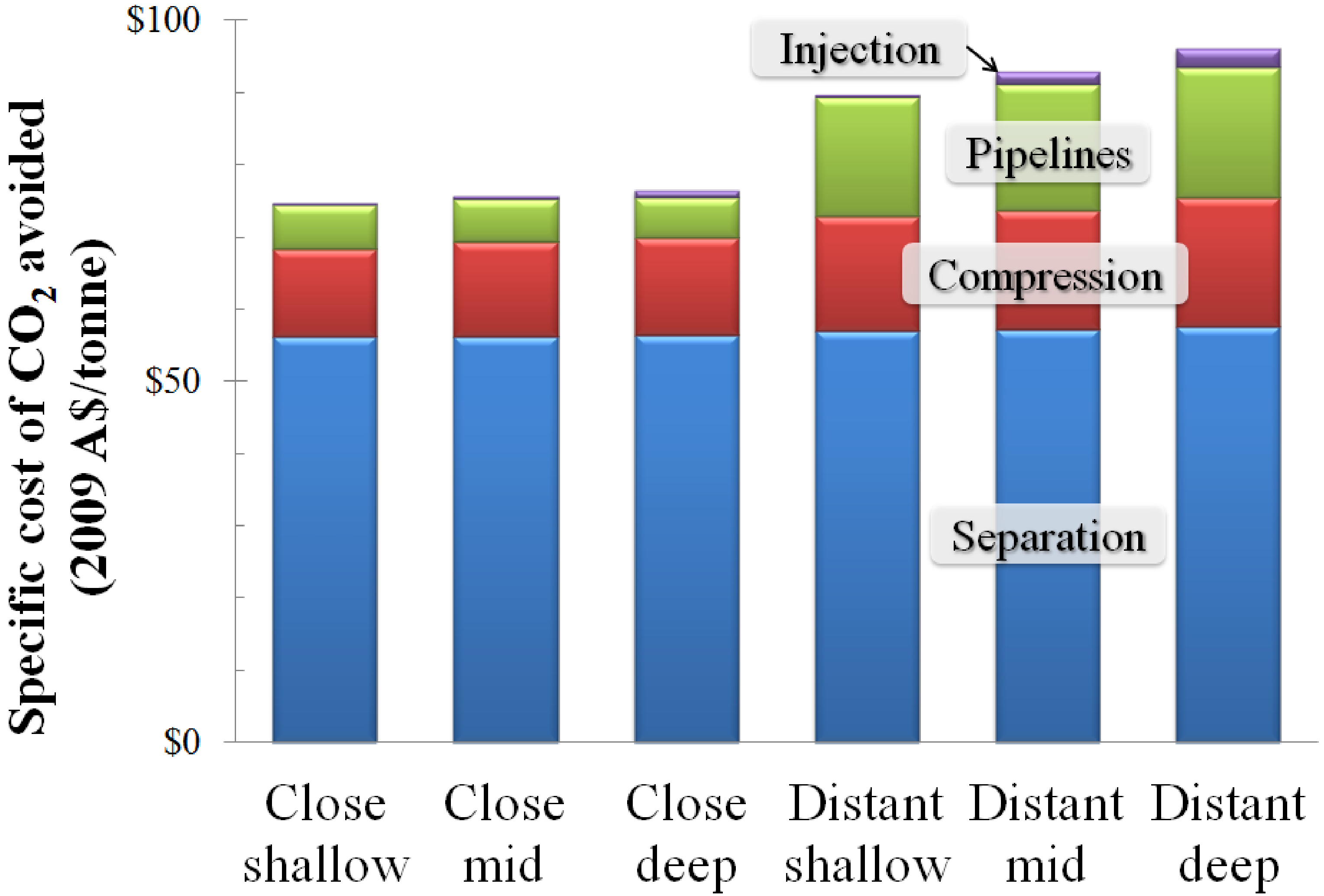


*Costs in billions – 10^9 – of Australian dollars in 2006

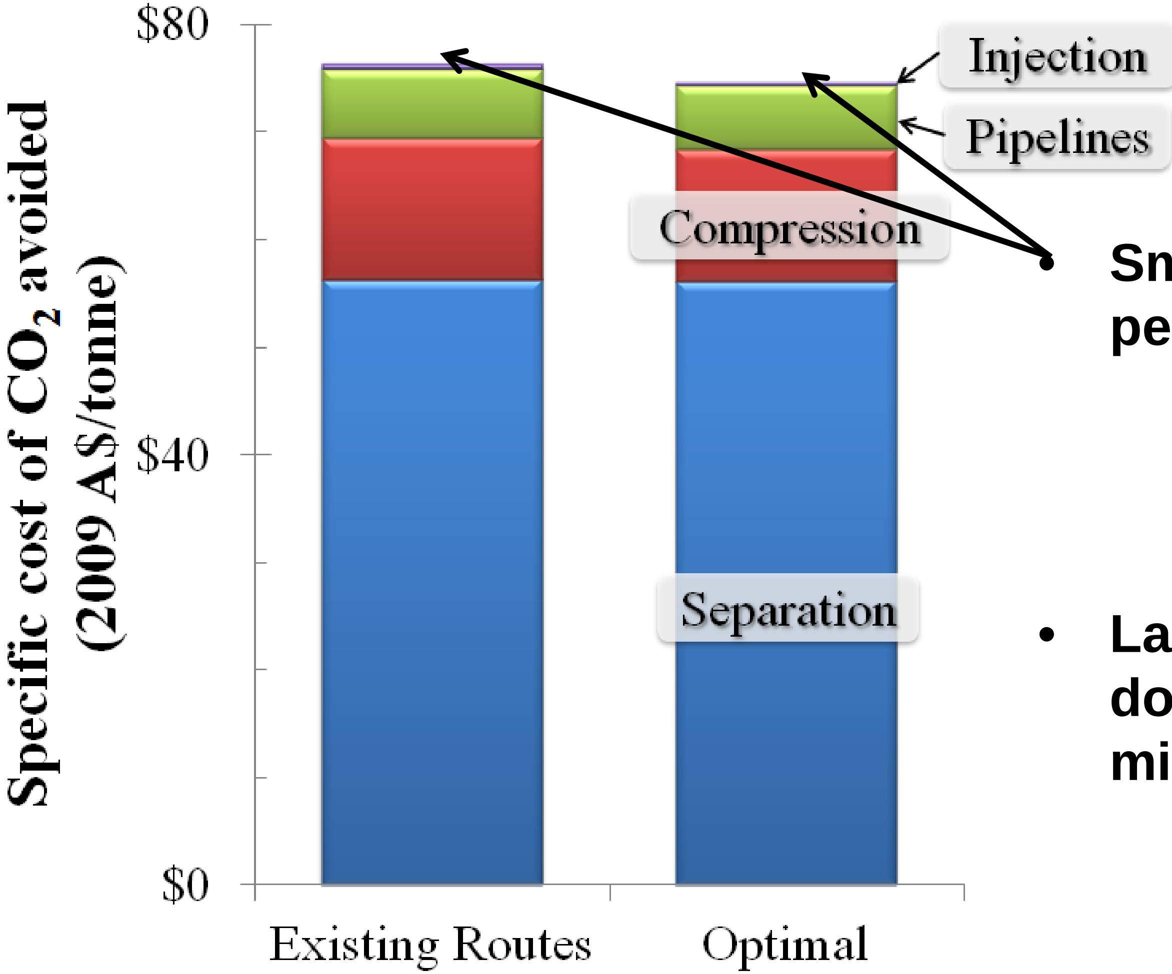
Example: CCS in South-East Queensland



Choosing injection location



Choosing pipeline routes

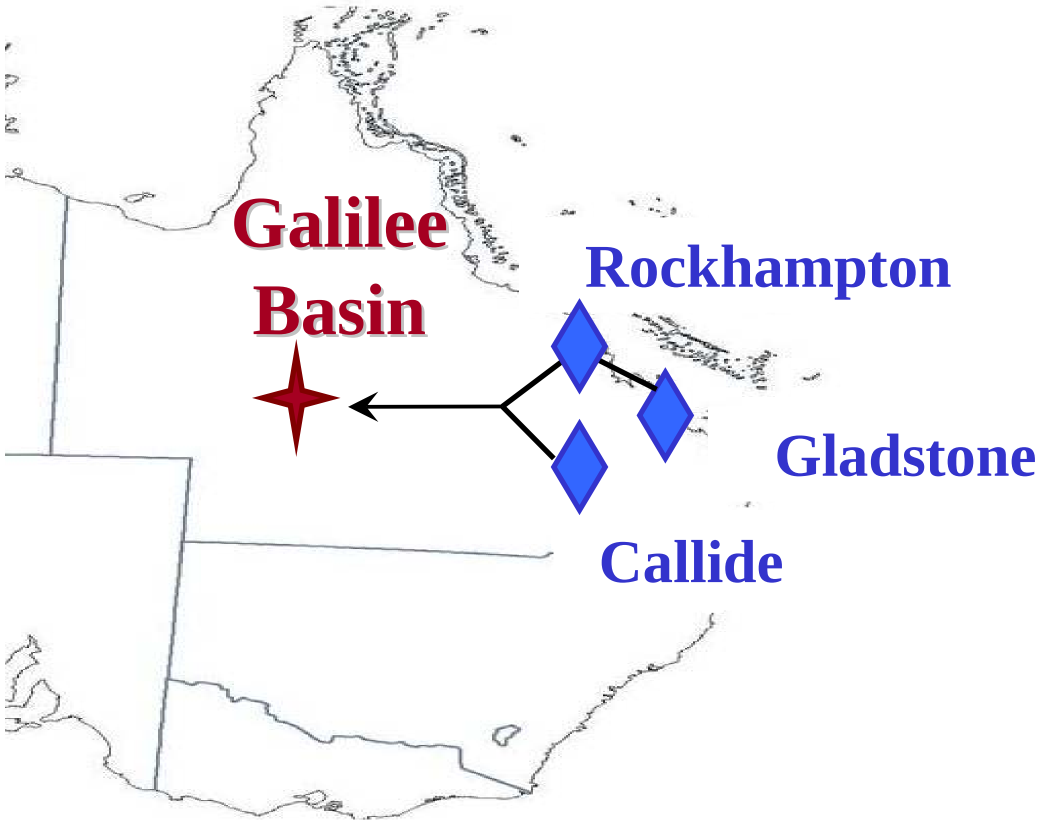


- **Small differences in cost per tonne avoided**

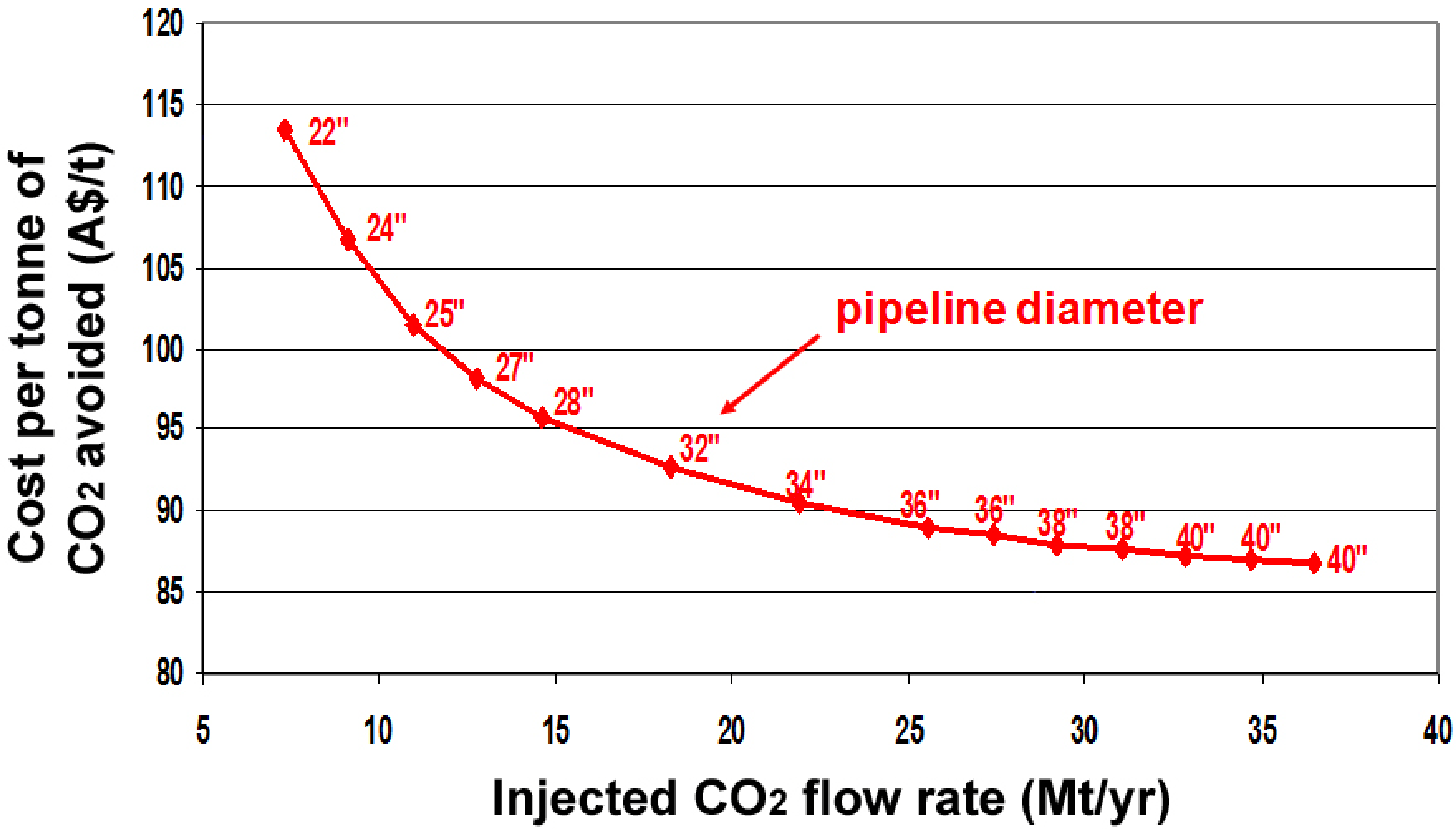
BUT

- **Large differences in total dollar values (A$360 million)**

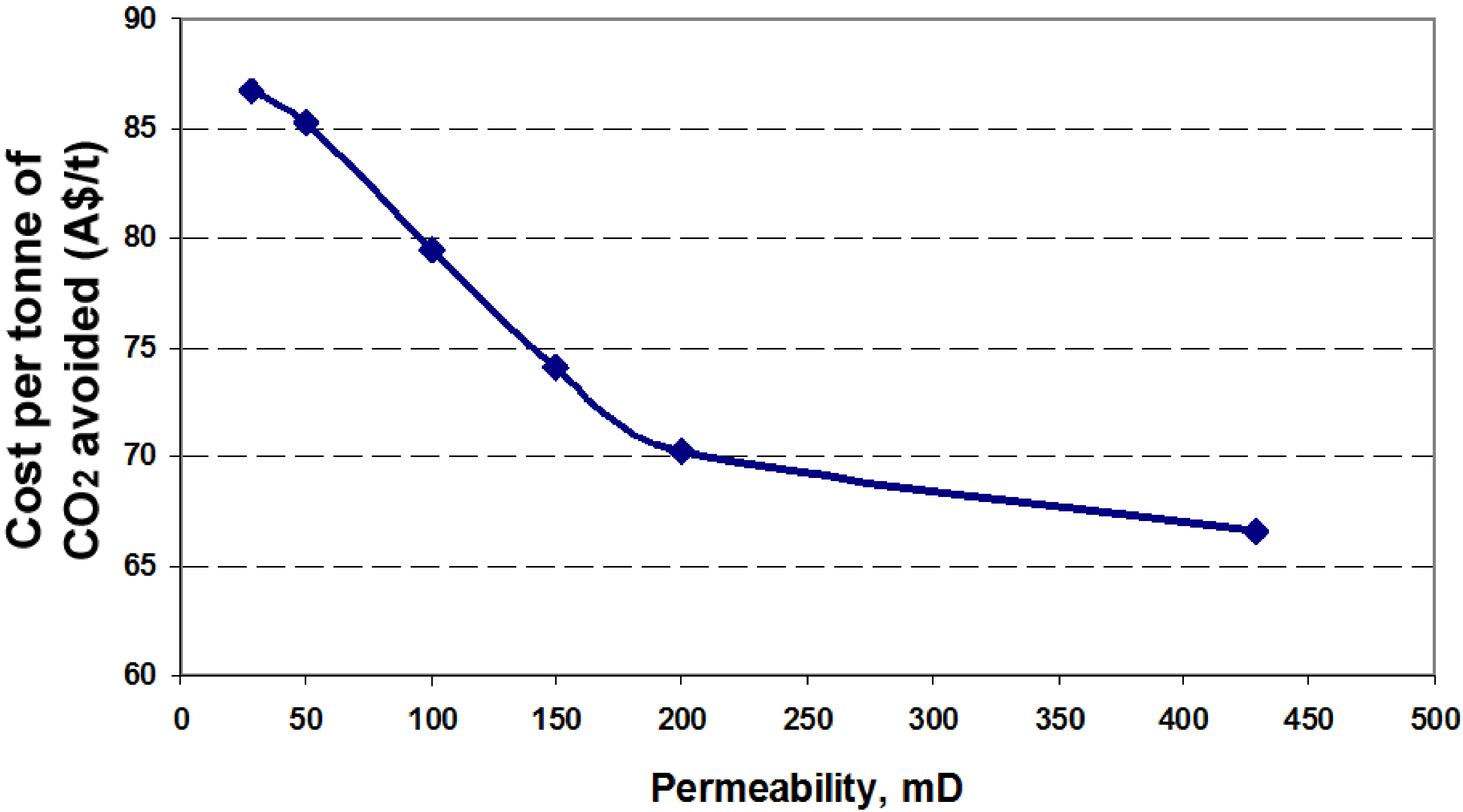
Example: CCS in central Queensland



Effect of flow rate



Effect of sink permeability



Effect of well type

- Horizontal wells compared to vertical wells
- Trade-offs –
  - Horizontal wells = high costs, better injectivity
  - Vertical wells = low costs, less injectivity

Summary

- CCS costs are project specific
- CCS projects require large expenditure
- There is variability and uncertainty in estimating costs

CO2CRC Participants

Australian Government
Geoscience Australia

CSIRO

Curtin University of Technology

MONASH University

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INPEX

GNS SCIENCE TE PŪ AO

NSW GOVERNMENT Industry & Investment

QER

Queensland Government

RioTinto

sasol reaching new frontiers

SOLID ENERGY Coals of New Zealand

STANWELL CORPORATION LIMITED

Schlumberger

TOTAL

State Government Victoria Department of Primary Industries

Government of Western Australia Department of Mines and Petroleum

xstrata coal

Supporting Partners: The Global CCS Institute, The University of Queensland, Process Group

CRC AUSTRALIA

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