Source-sink matching

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- – Minh Ho,
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- – Dianne Wiley and
- – Guy Allinson

of the CO2CRC Economics Group @ UNSW

Outline

- What is source-sink matching?
- Factors affecting matching
  - Choosing sources
  - Choosing sinks
  - Making links
- Conclusions
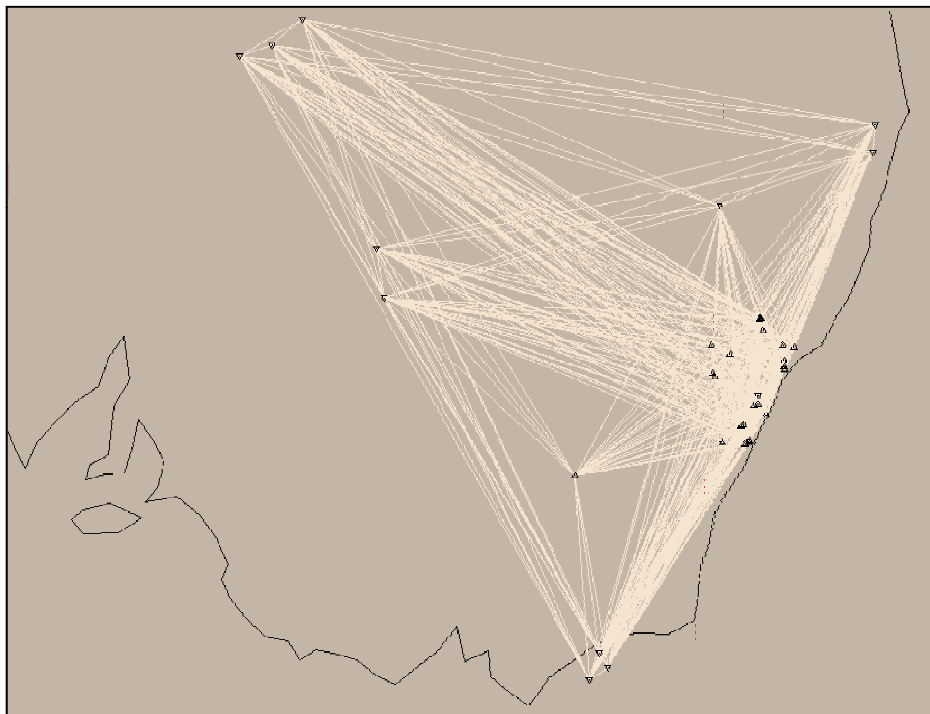
What is source-sink matching?

Which source(s)?

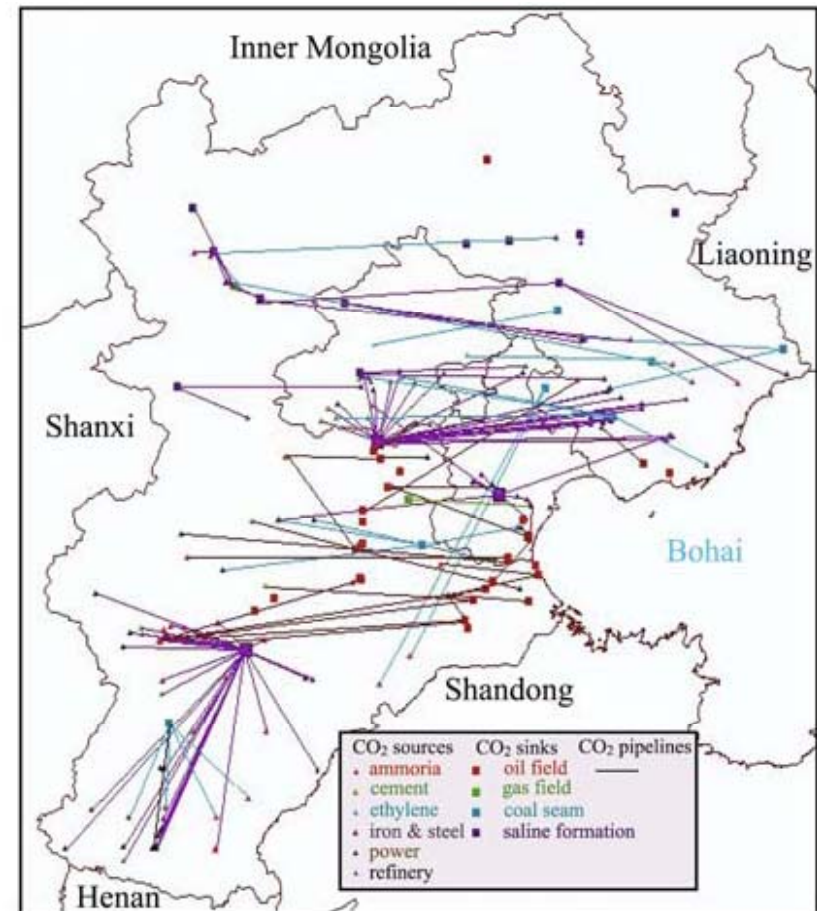Which sink(s)?

How to we link them?

What does it look like?

South-East Australia

Fimbres Weihs & Wiley. CO2CRC
Annual Research Symposium, 2009.

Jing-Jin-Ji, China

Zheng et al., Front. Energy
Power Eng. China 2009, 3(3): 359–368

Decision variables

$$CO_2 \text{ avoided} = \begin{array}{c} CO_2 \text{ emitted without CCS} \\ \text{less} \\ CO_2 \text{ emitted with CCS} \end{array}$$

$$\text{Cost of } CO_2 \text{ avoided} = \frac{PV(\text{all costs})}{PV(CO_2 \text{ avoided})}$$

$$\text{Cost of Electricity} = \frac{PV(\text{all costs})}{PV(\text{Electricity sent out})}$$

Factors affecting source-sink matching

Sources	Sinks	Links
CO_2 content	CO_2 content	CO_2 content
Flow-rate	Flow-rate	Flow-rate
Source type	Areal extent	Distances
Capture method	Formation depth	Onshore or offshore
Source temperature	Formation permeability	Water depth
Source pressure	Formation porosity	Land use
…	Formation thickness	…
	Formation temperature	
	Formation pressure	
	Fracture pressure	
	Injection well type	
	Containment	
	Exploration	
	…	

Choosing sources

Factors affecting source-sink matching

CO$_2$ content affects costs

Source	Flue gas characteristics	
	% CO$_2$	Pressure (bar)
Oil refinery	3% – 13%	<1.5
Power plant (pulverised coal)	Up to 15%	<1.5
Cement	20% – 30%	<1.5
Blast furnace (iron and steel)	20% – 30%	< 5
Corex (advanced iron and steel)	30% – 45%	< 5

Wiley, Ho & Allinson, CO2CRC Symposium 2009

CO$_2$ content affects costs

Wiley, Ho & Allinson, CO2CRC Symposium 2009
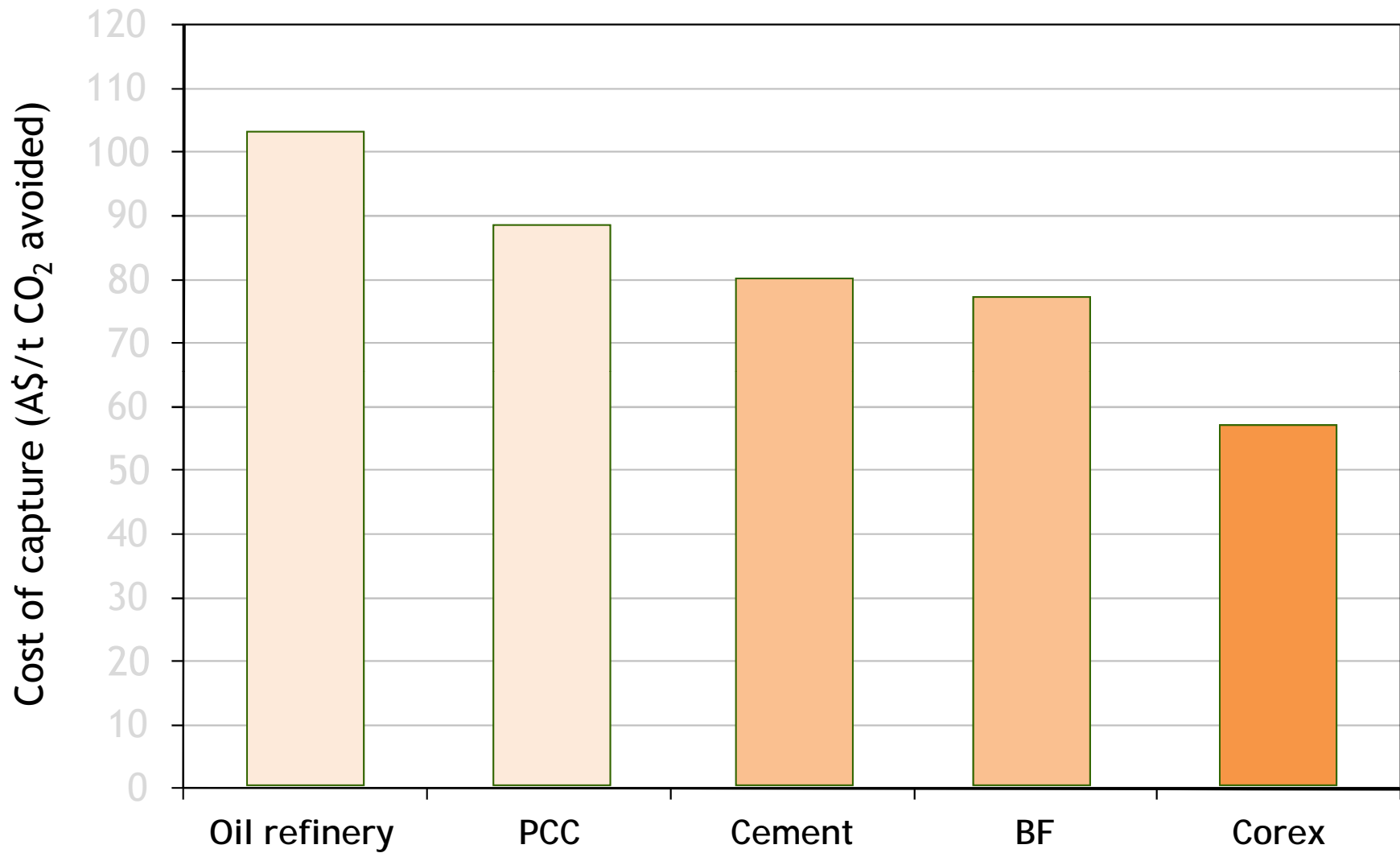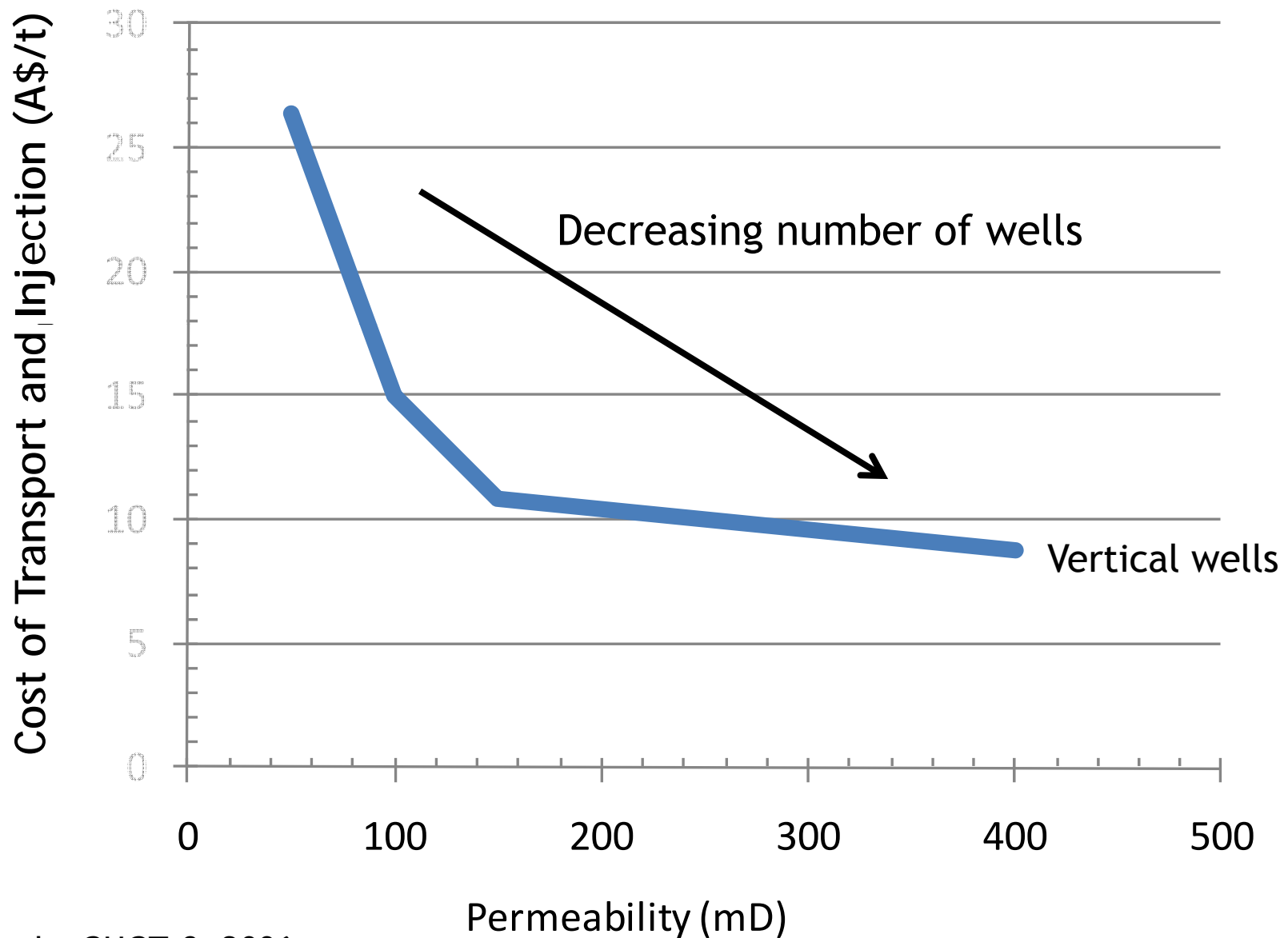
Optimal capture method depends on CO_2 content
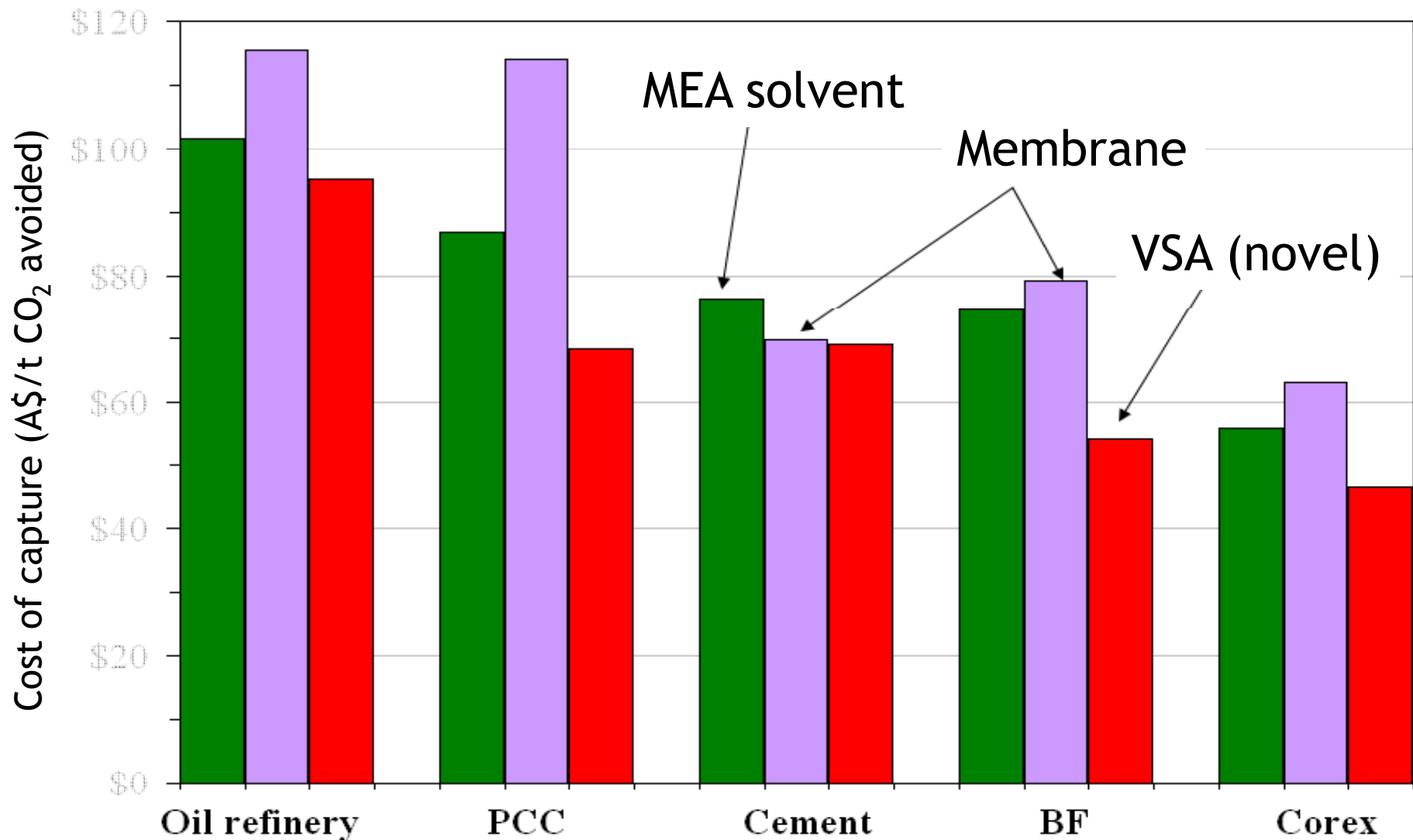
Choosing sinks

Factors affecting source-sink matching

Permeability affects injectivity and cost

Neal et al., GHGT-8, 2006.

Effect of well type — high flow-rates (15 Mt/yr)

Neal et al., GHGT-8, 2006.
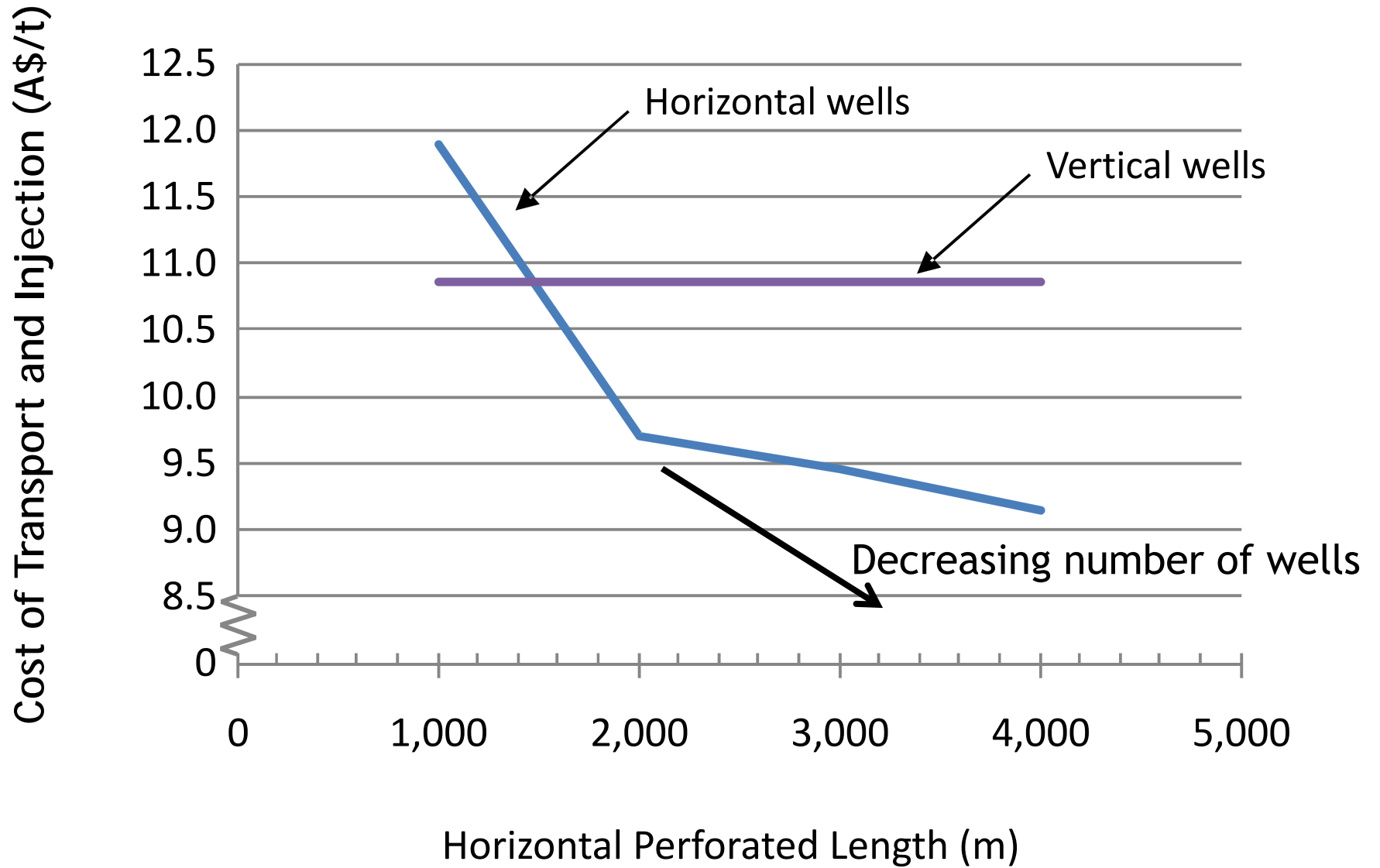
Effect of well type – low flow-rates (1 Mt/yr)

Cinar et al., SPE-108924, 2009.
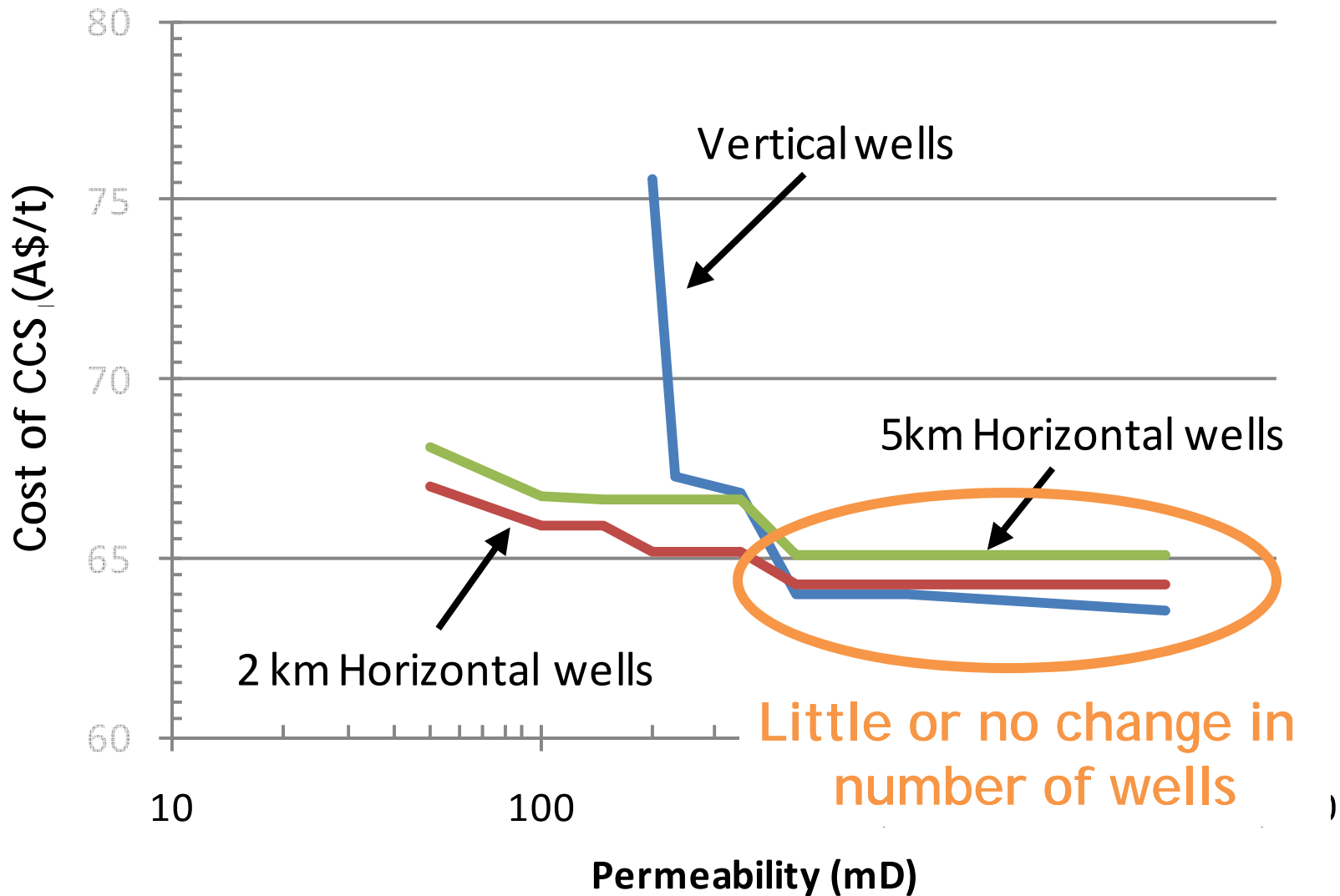
Effect of exploration uncertainty

Neal et al., CO2CRC Annual Research Symposium, 2009.
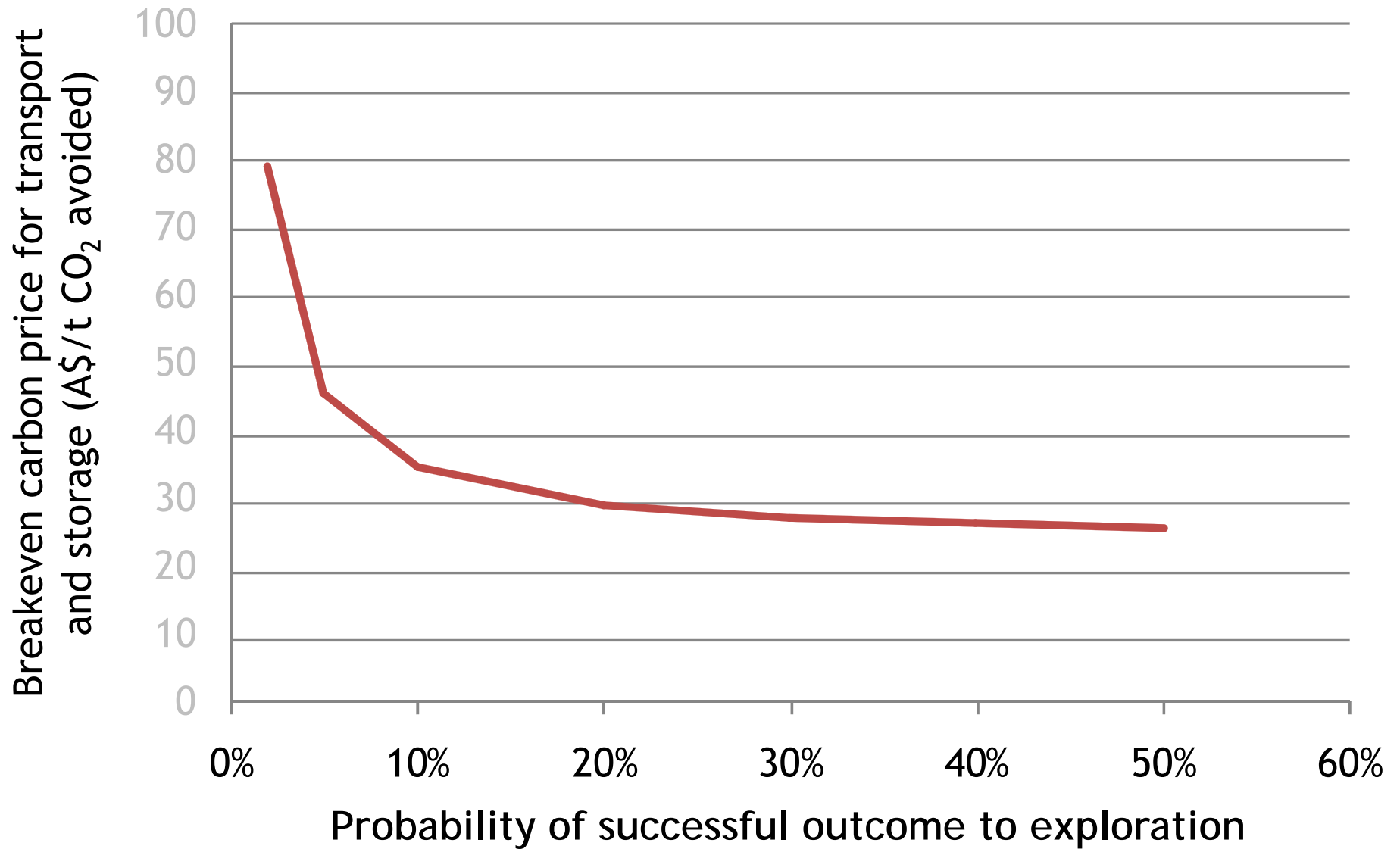
Making links

Factors affecting source-sink matching
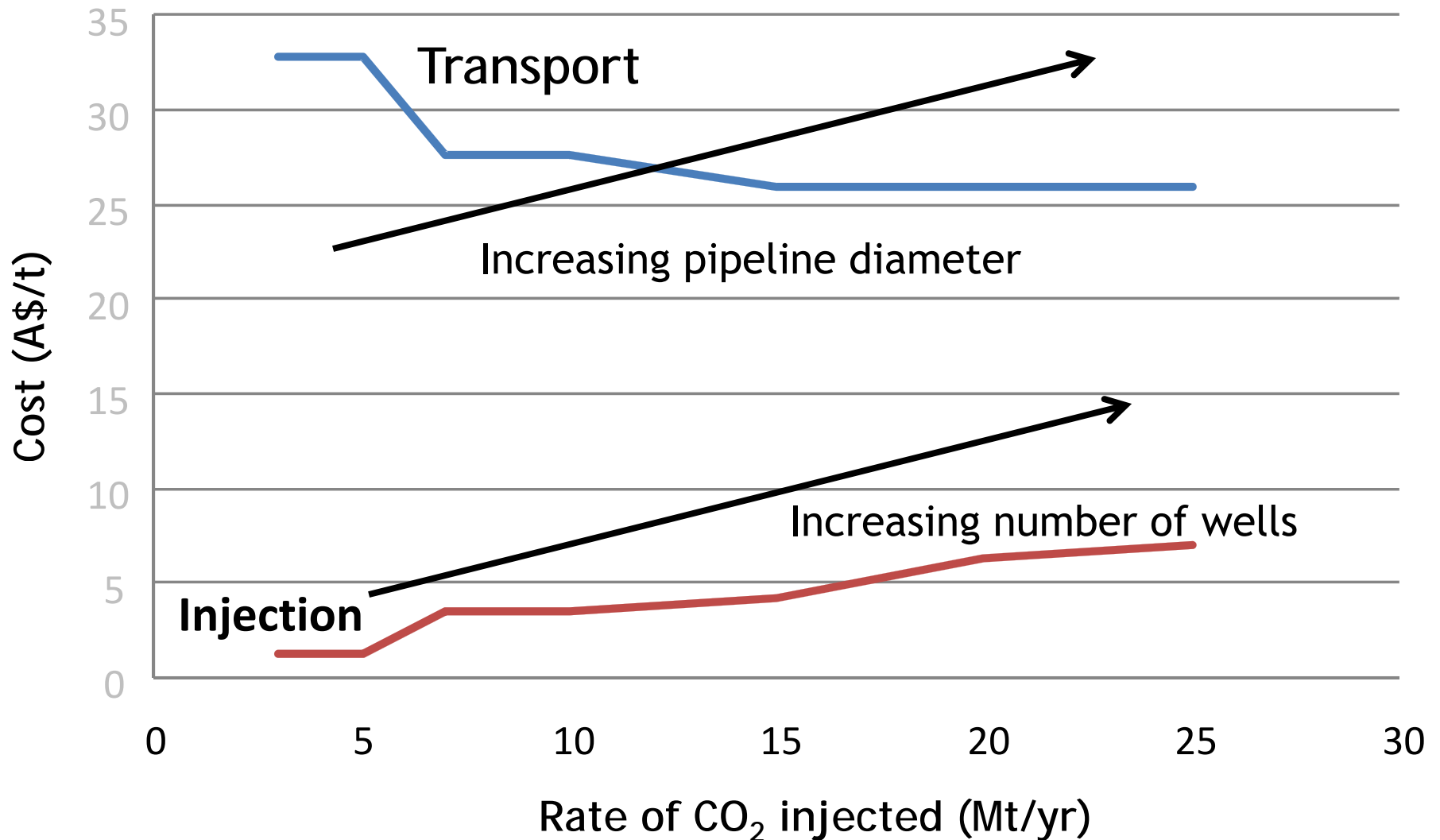
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Schematic CCS network in Central Queensland
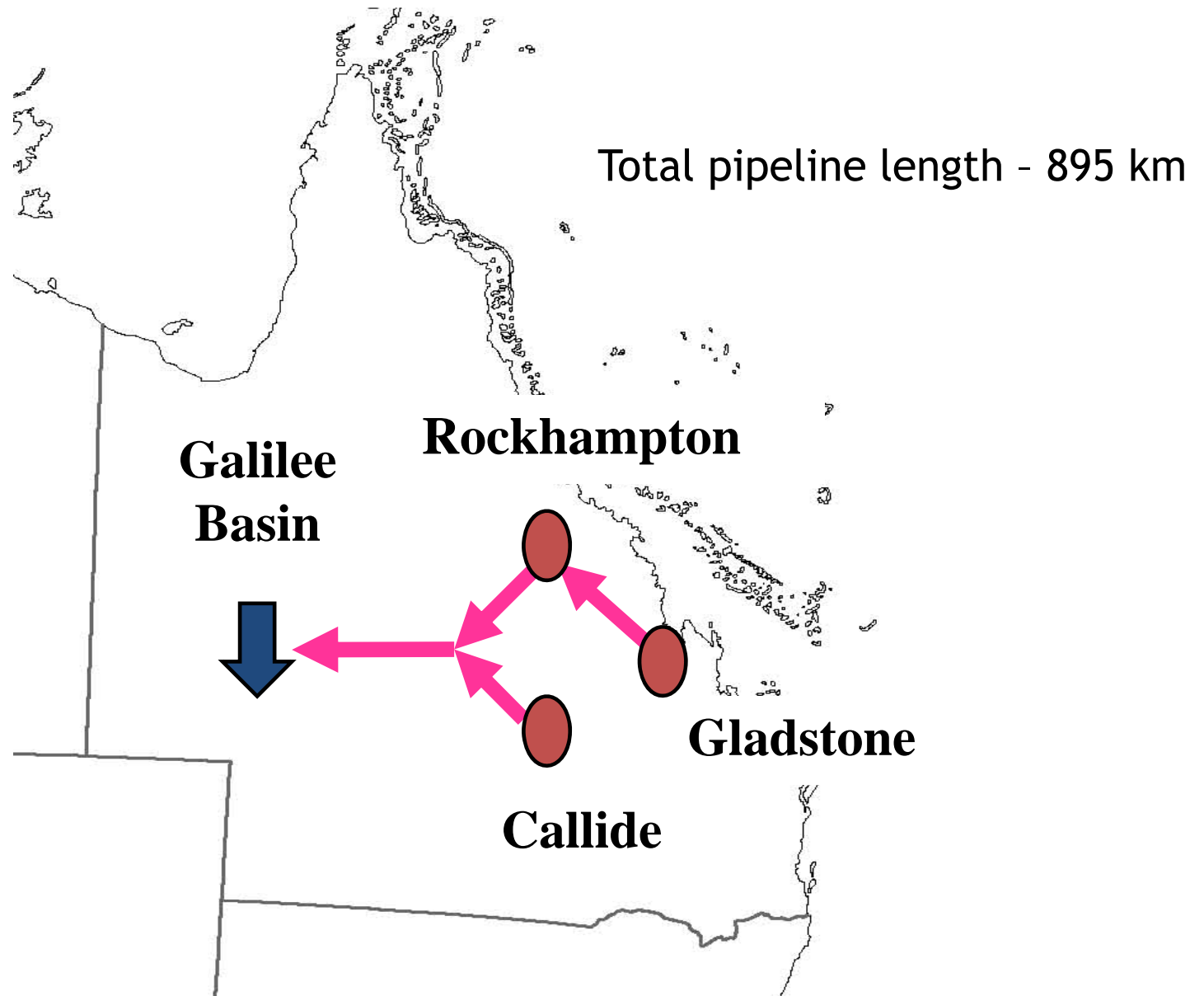
Total pipeline length – 895 km

Galilee Basin

Rockhampton

Gladstone

Callide

Bukhteeva et al., GHGT-9, 2008.

Effect of flow rate — economics of scale

Bukhteeva et al., GHGT-9, 2008.

Effect of flow rate — economics of scale

Allinson et al., CO2CRC Report #09-1536, 2009.
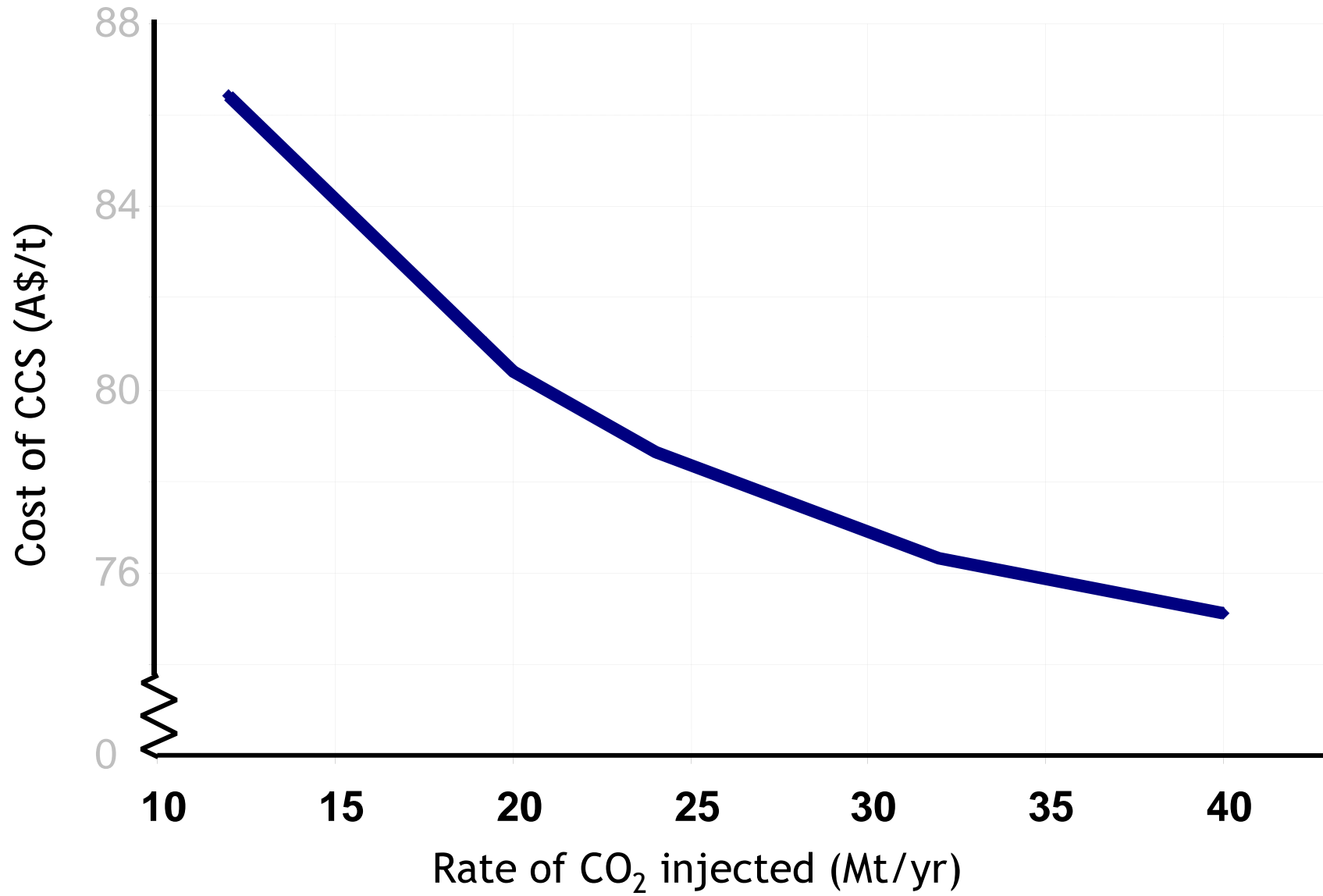
Pipeline length and pipeline sections

Existing roads		Total length (km)	Cost of CCS (A$/t)
Base Case	9 unequal pipeline sections	895	75.1
Case 1	8 equal pipeline sections	895	76.2
Direct route			
Case 2	6 unequal pipeline sections	720	71.8
Case 3	6 equal pipeline sections	720	71.5

Bukhteeva et al., GHGT-9, 2008.

The island of Ireland

Portpatrick

Belfast

Cork

North Celtic Sea
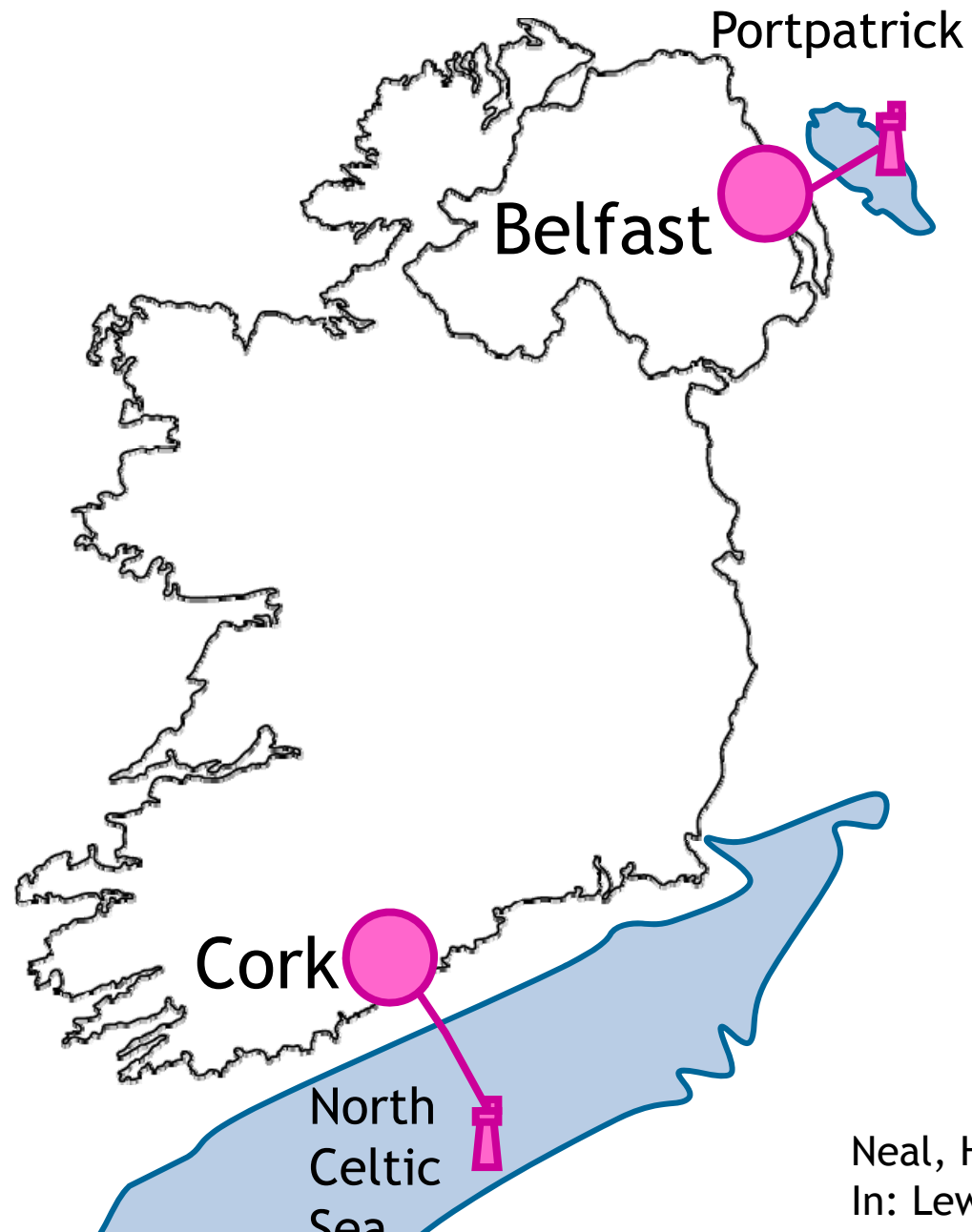
Neal, Ho & Allinson,
In: Lewis et al. GHGT-9, 2008.

Effect of water depth

Neal, Ho & Allinson, In: Lewis et al. GHGT-9, 2008.
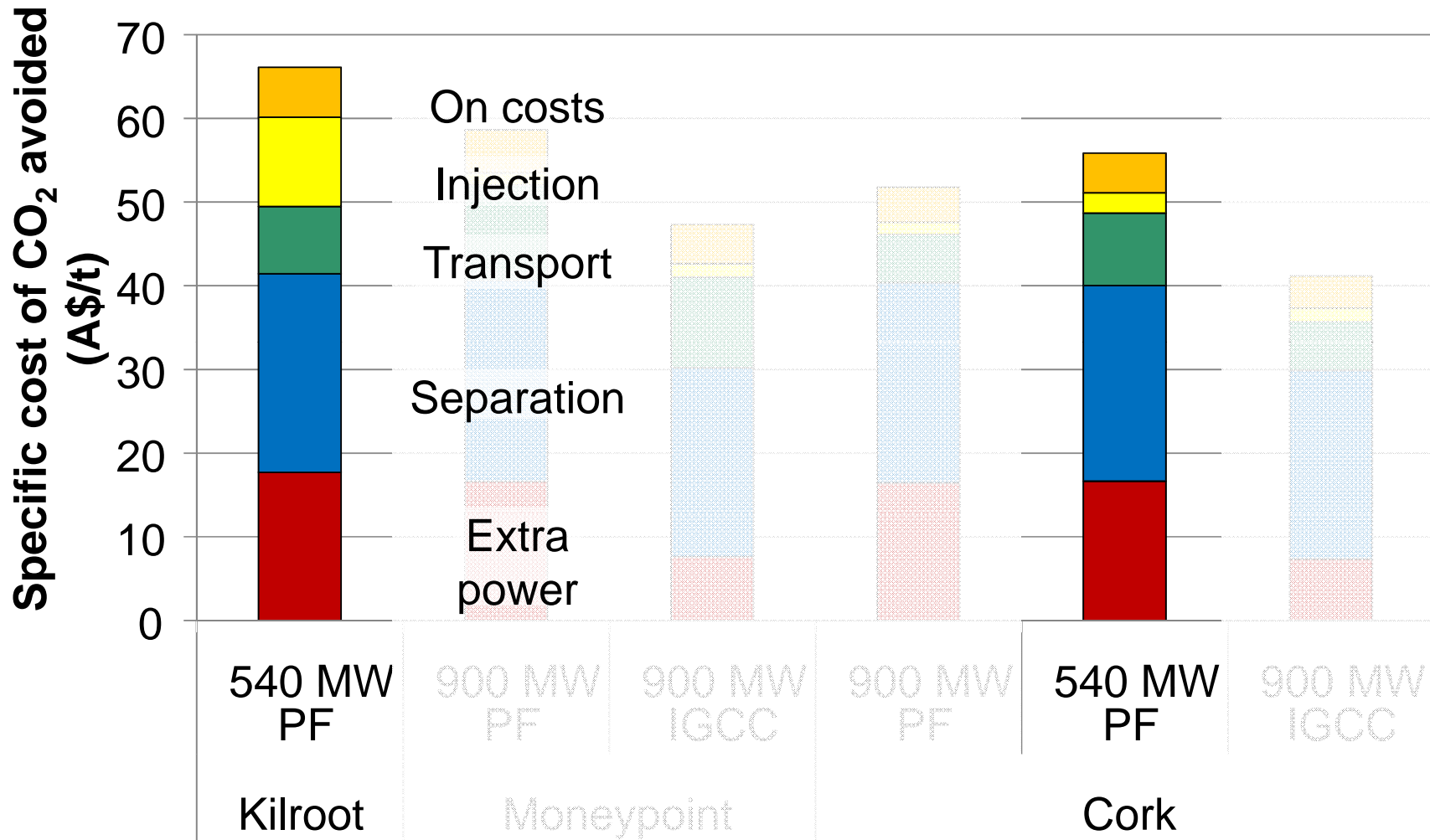
Simple example

Choosing between two sinks

Stationary source of CO_2

100 mD

1,000 km

High-Perm Reservoir

100 km

Low-Perm Reservoir   10 mD
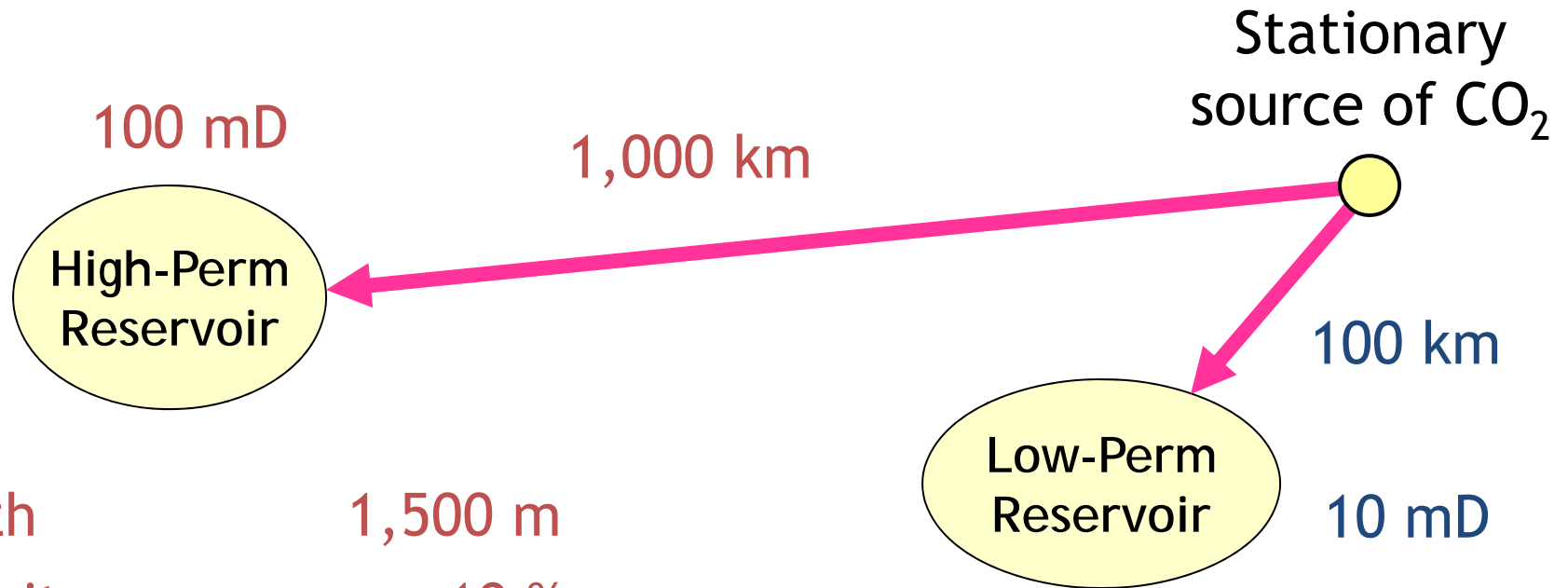
Depth	1,500 m
Porosity	10 %
Thickness	100 m
In. Pressure	18.2 MPa
Frac. Pressure	27 MPa

Depth	2,000 m
Porosity	5 %
Thickness	100 m
In. Pressure	22.7 MPa
Frac. Pressure	36 MPa

Cinar et al., SPE-114028, 2008.

Closer doesn't always mean cheaper

Cost of CCS (A$/t)

100 km
10 mD

1,000 km
100 mD

CO_2 captured and stored (Mt/y)

Cinar et al., SPE-114028, 2008.
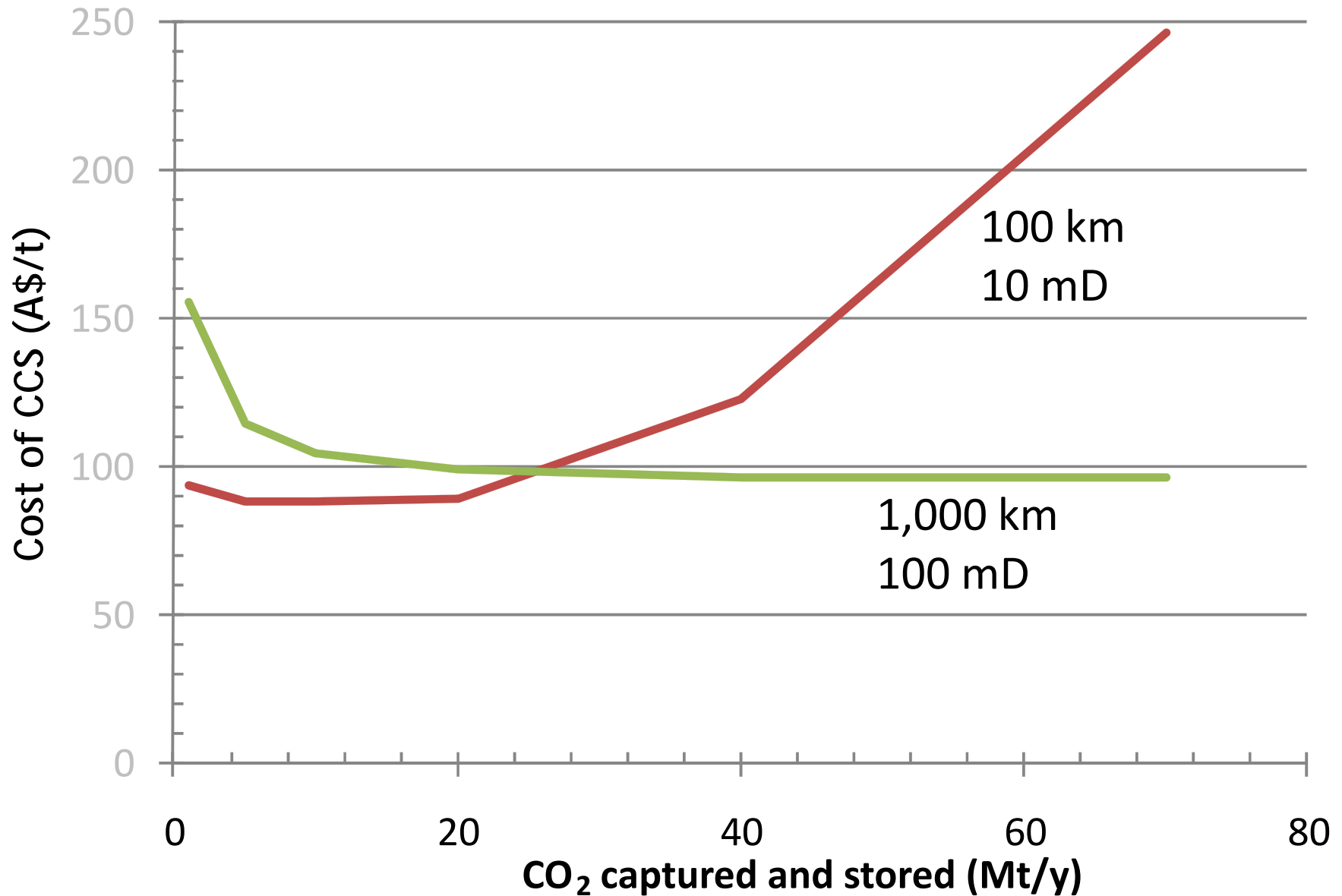
Summary

Summary

- Choice of source(s) and sink(s) affected by...
  - Source type, content & conditions
  - Capture method
  - Sink characteristics
  - Geography
- Economic models/optimisation allow
  - all these factors to be combined and
  - choices made using decision variable