Comparative Overview of Costs for Capture Technologies

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The role of CCS economics

- **Economics is one of the four elements of quadruple bottom line business decision making**
- **Decisions also need to ensure sustainable management of risk and reliability**
- **Technology assessments used to support decisions on technology selection, capital investments, marketing strategies, R&D priorities, and related activities.**
  - Understand where and what the cost drivers are to enable development of novel and creative ways to reduce cost.

Measures of CCS economics

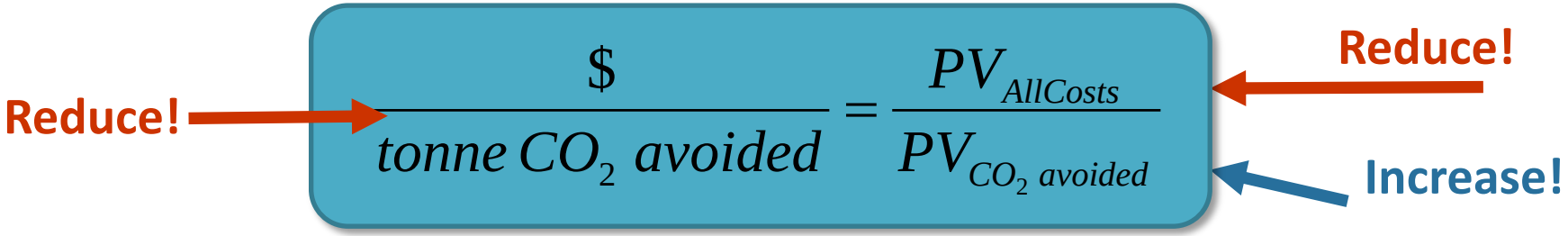
- **Indirect**
  - Energy penalty
  - CO_2 avoided/emission intensity

- **Direct**
  - Cost/Present Value (PV, $)
  - Cost of CO_2 avoided/captured/injected (($/t $CO_{2\ \text{avoided/captured}}$)
  - Production cost (eg. LCOE $/MWh, $/ton steel etc.)

Techno-economic assessments

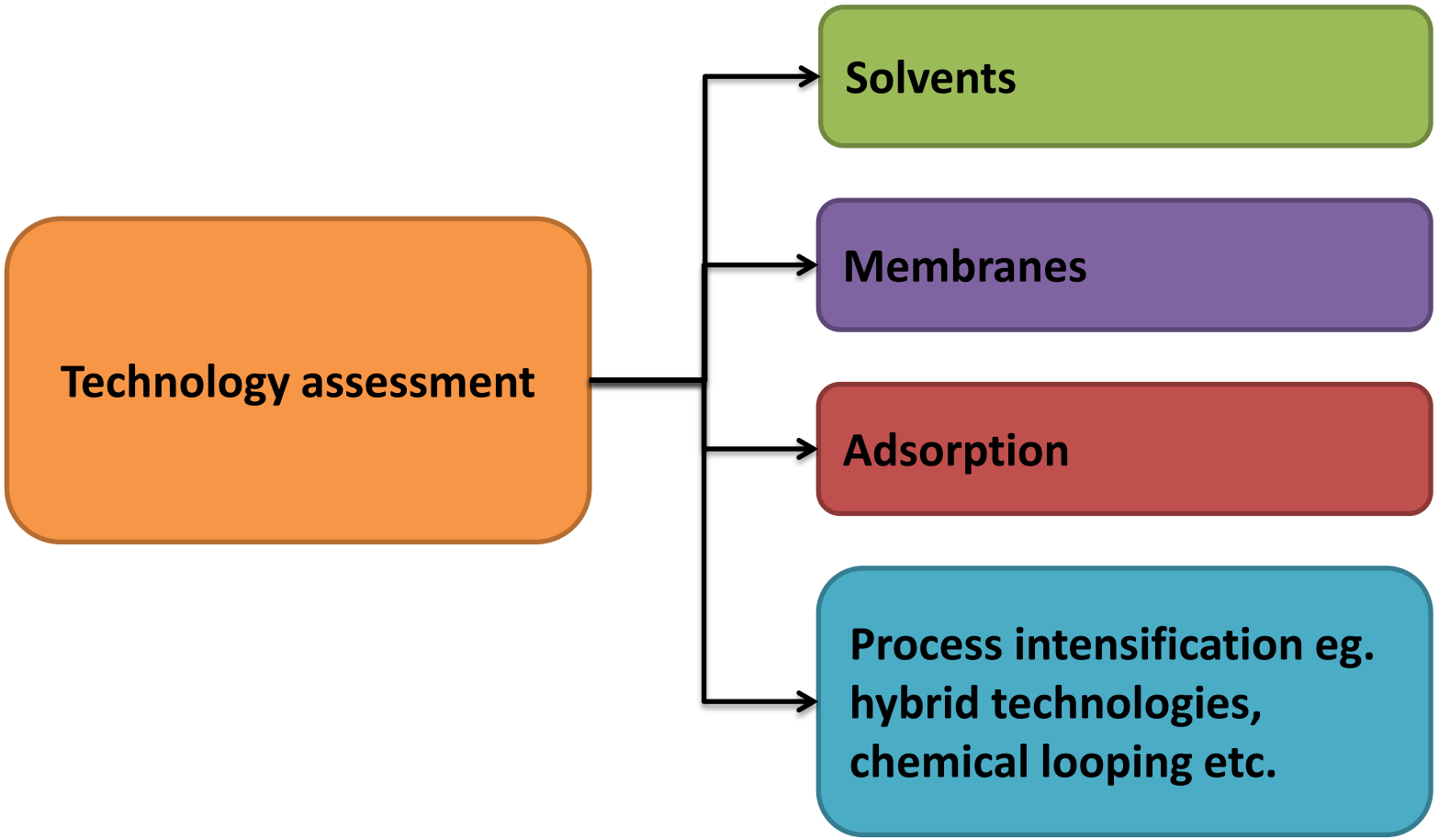
- **Compare costs of alternative options.**
- **Differences reflect different configurations and operating alternatives.**
  - Relativities just as important as absolute values.
- **Rely on "technology-levelling" assumptions.**
  - Process assumptions e.g. plant size, fuel type, capacity factor, reference plant.
  - Economic assumptions e.g. cost of capital, cost year, discount rate, energy/fuel costs, nominal vs. real costs, project life.
- **Require appropriate technology benchmark.**

Reducing capture costs

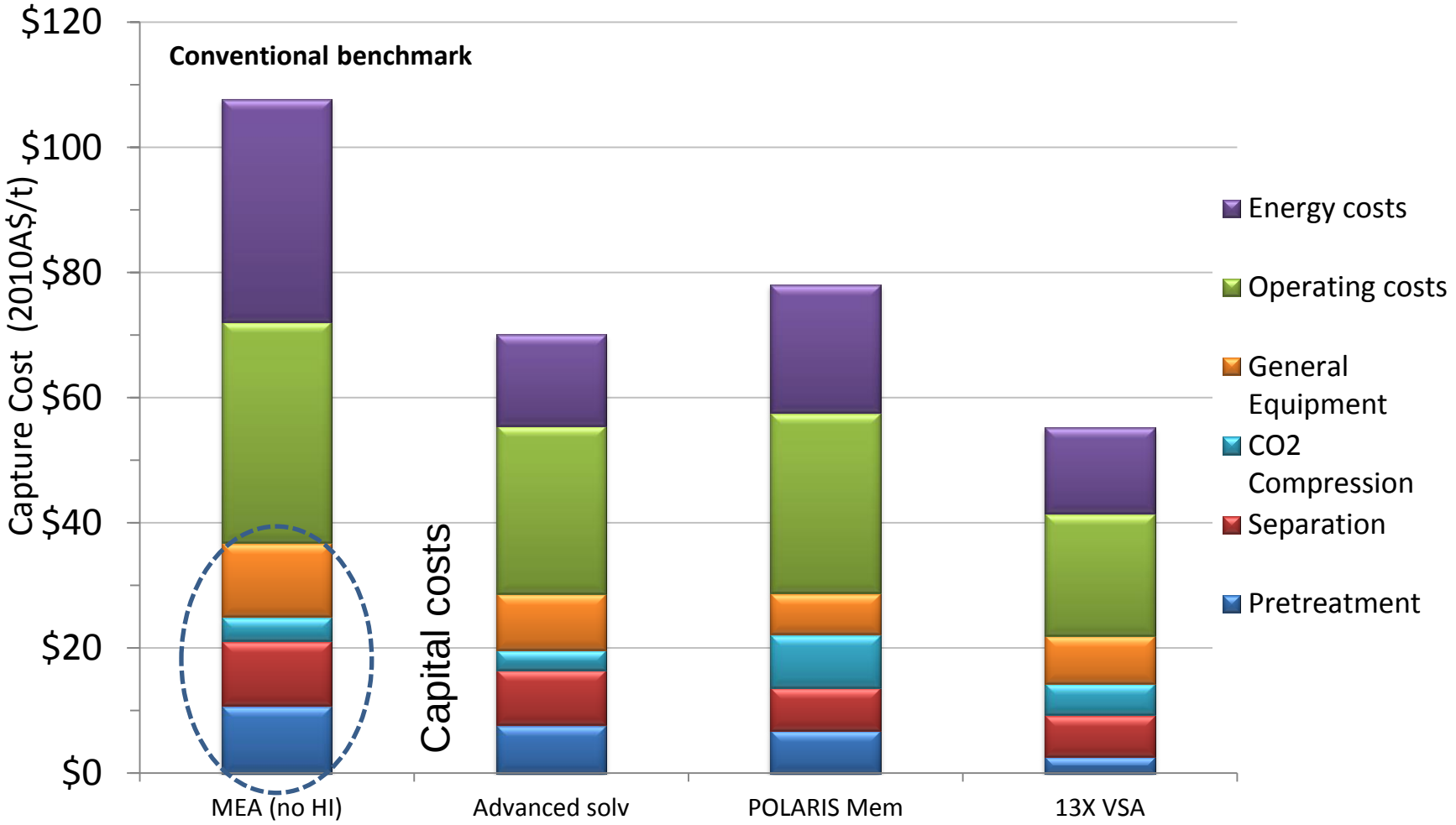


- **Reduce Capital costs**
  - cheaper equipment
  - more efficient (smaller) equipment
- **Reduce Operating costs**
  - more efficient equipment
  - less energy demand
- **Reduce energy penalty**
  - use improved technologies
  - heat and process integration
- **Increase CO_2 captured**
  - improve capture efficiency
  - improve capture rate
- **Reduce CO_2 emitted**
  - improve process efficiency
  - change fuel
- **Increase energy efficiency**
  - heat and process integration

Capture economics

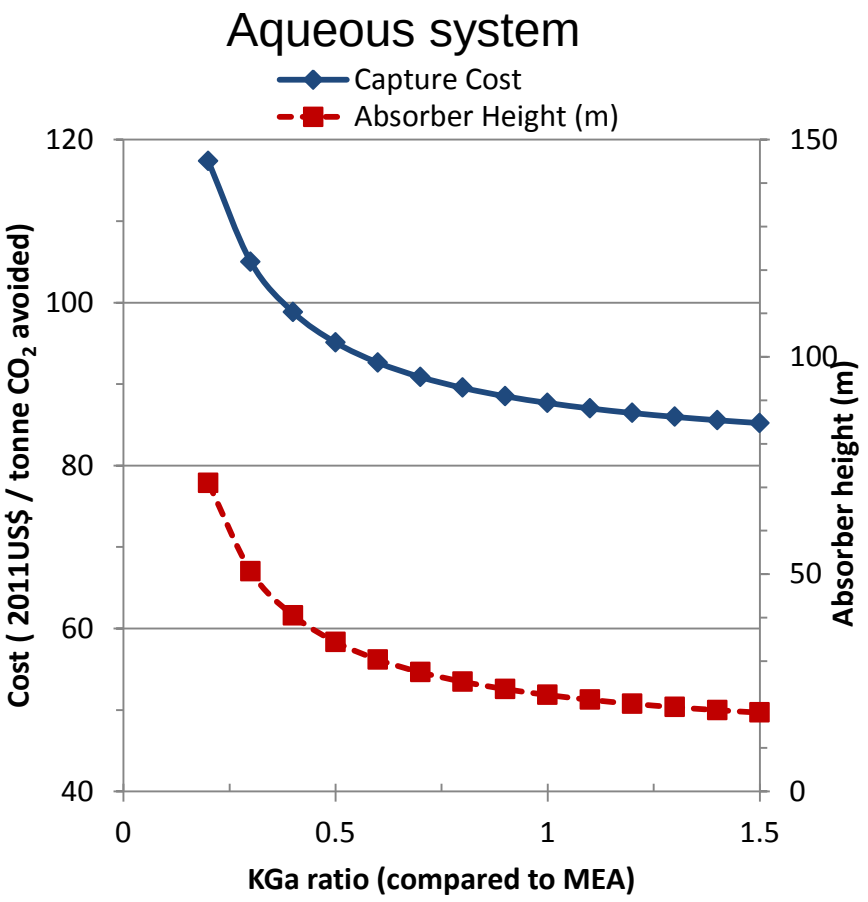


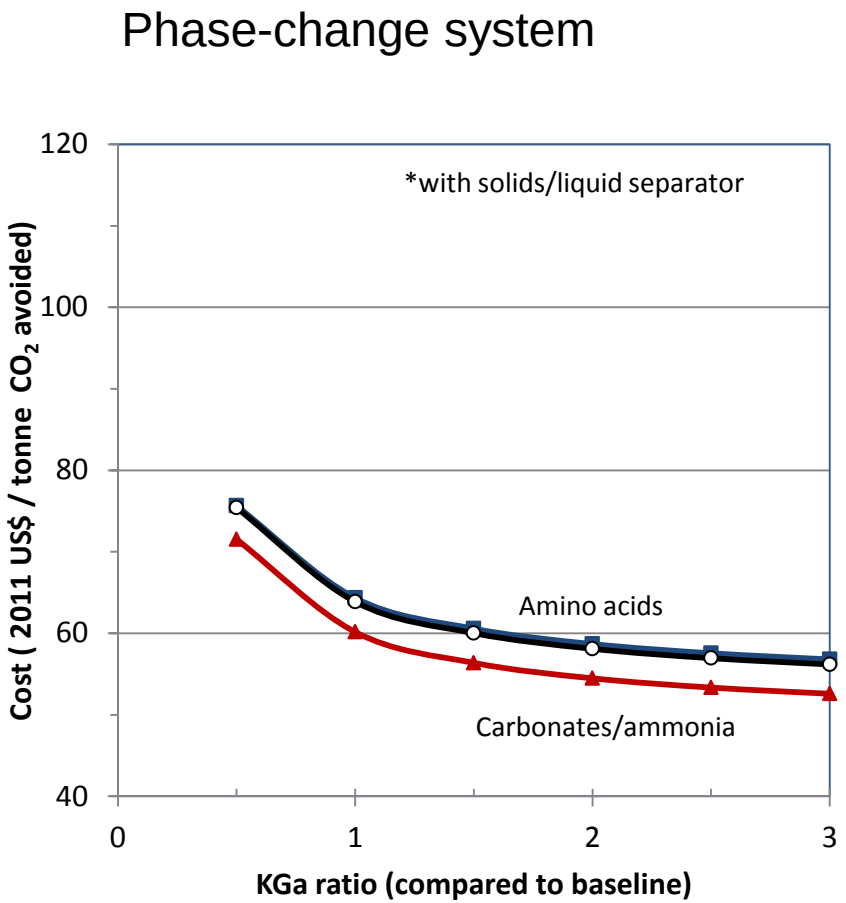
Technology comparison (500 MW black Australian coal power plant)



Adapted from: Stevens et al. Post-combustion Carbon Dioxide Capture Technologies for Brown Coal Power Generation - Final report for Brown Coal Innovation Australia (Condensed Version).CO2CRC Publication Number RPT11-2962

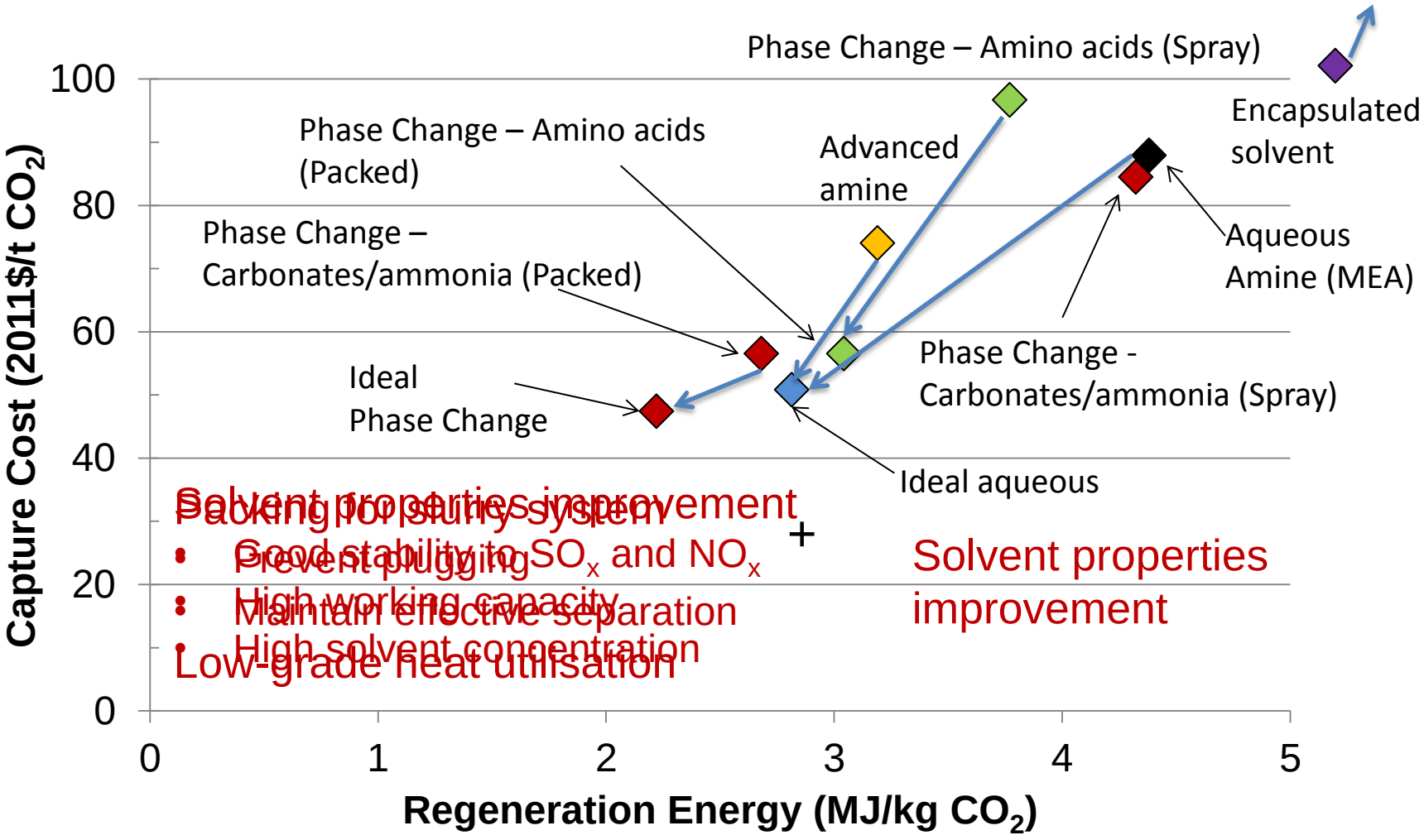
Solvent improvement: size and capital costs



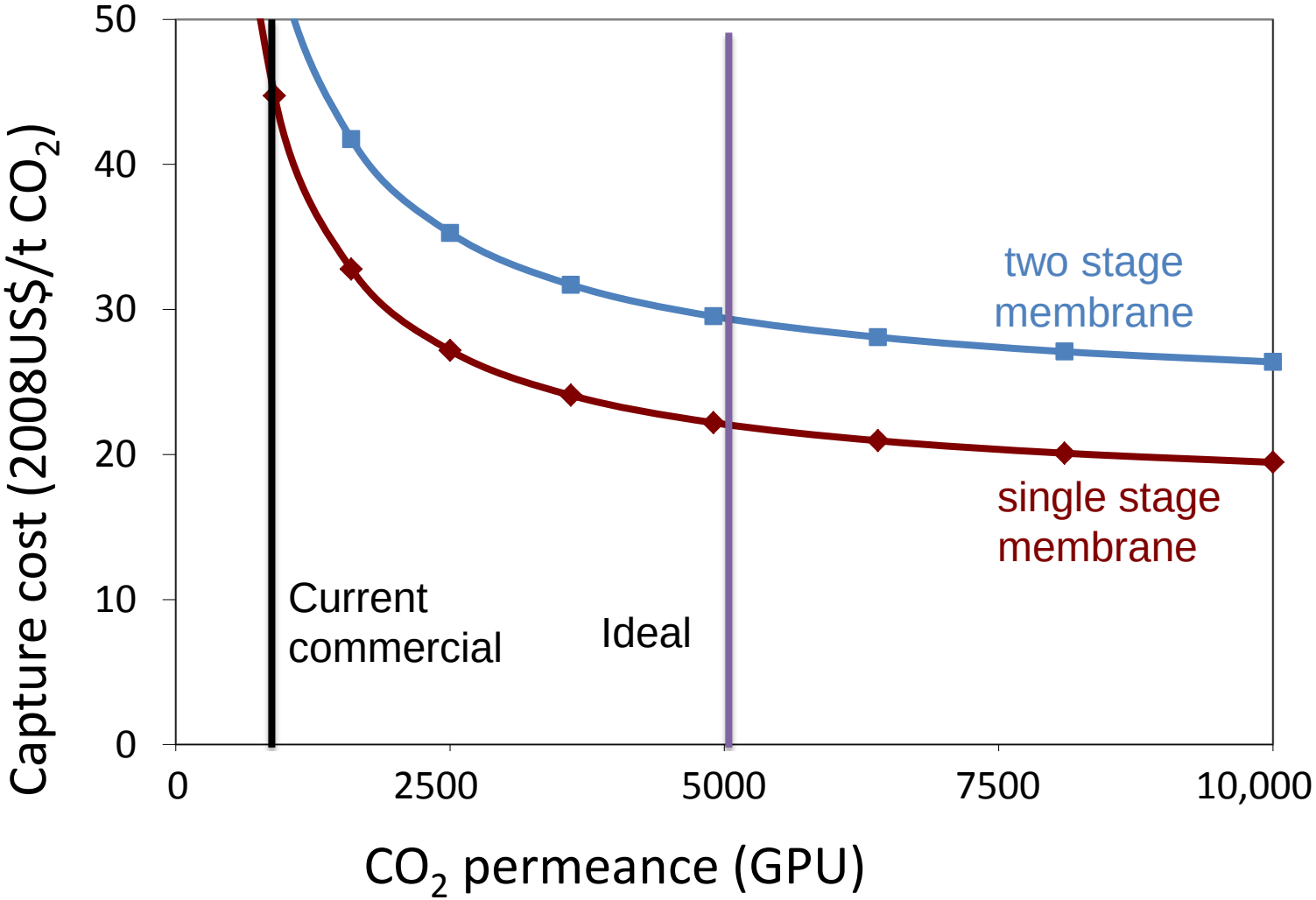


Adapted from: Raksajati et al (2013) 'Reducing the cost of capture from flue gas using aqueous chemical absorption' IECR 52 16887

Solvent improvement: reducing energy

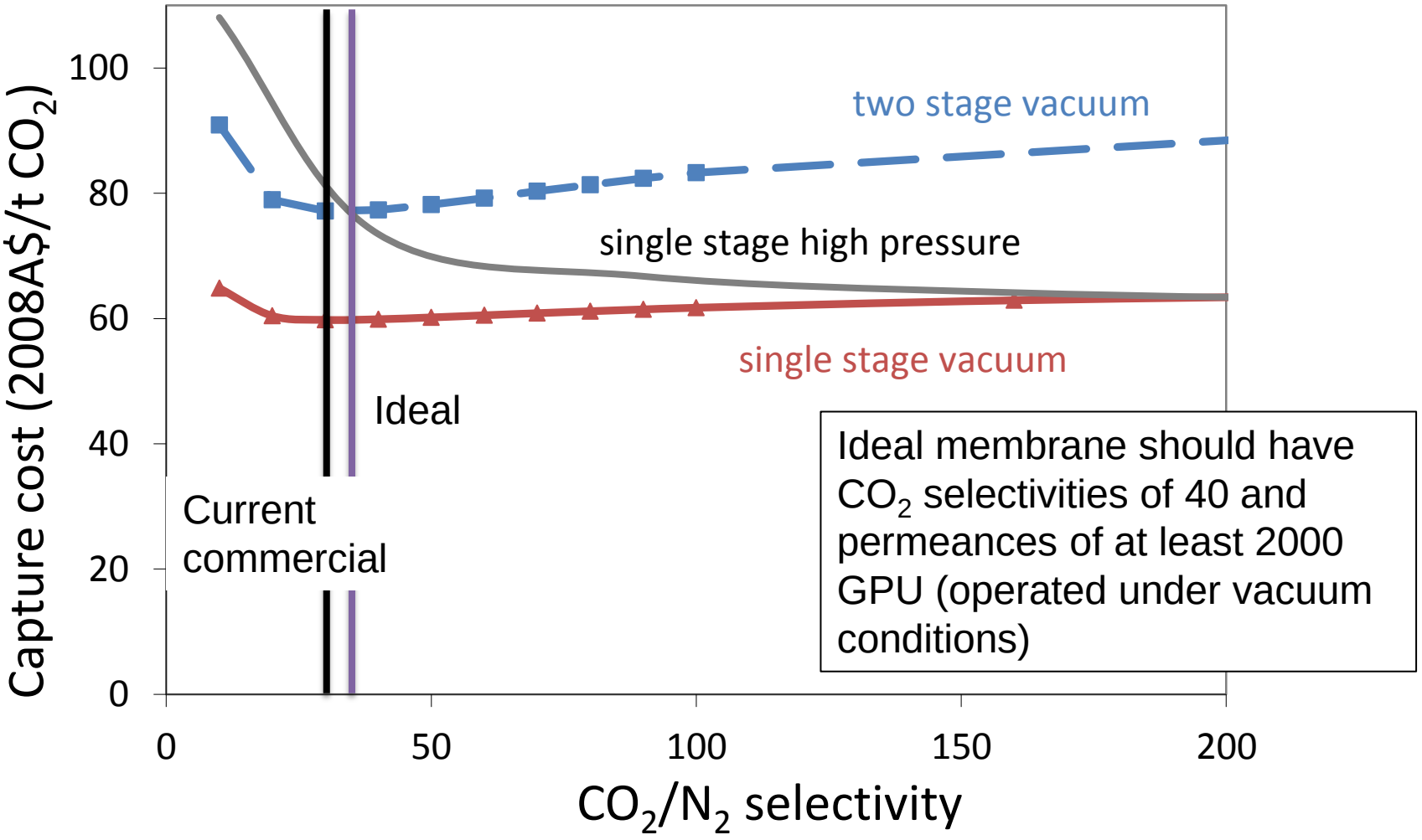


Membrane improvement: size and cost



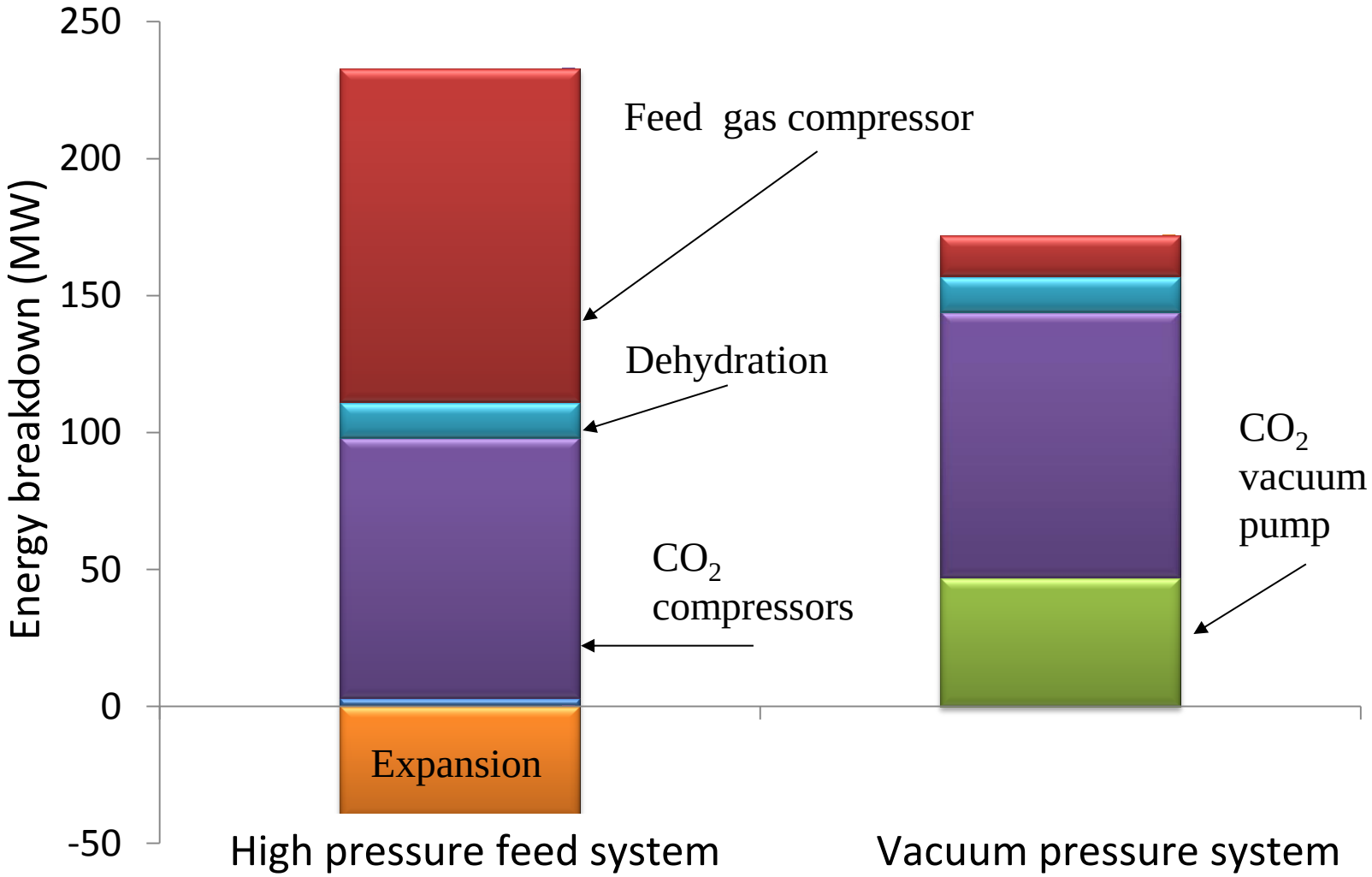
Adapted from: Ho et al (2008) 'Reducing the cost of capture from flue gas using membrane technology' IECR 47 1562-1568

Membrane improvement: compression energy

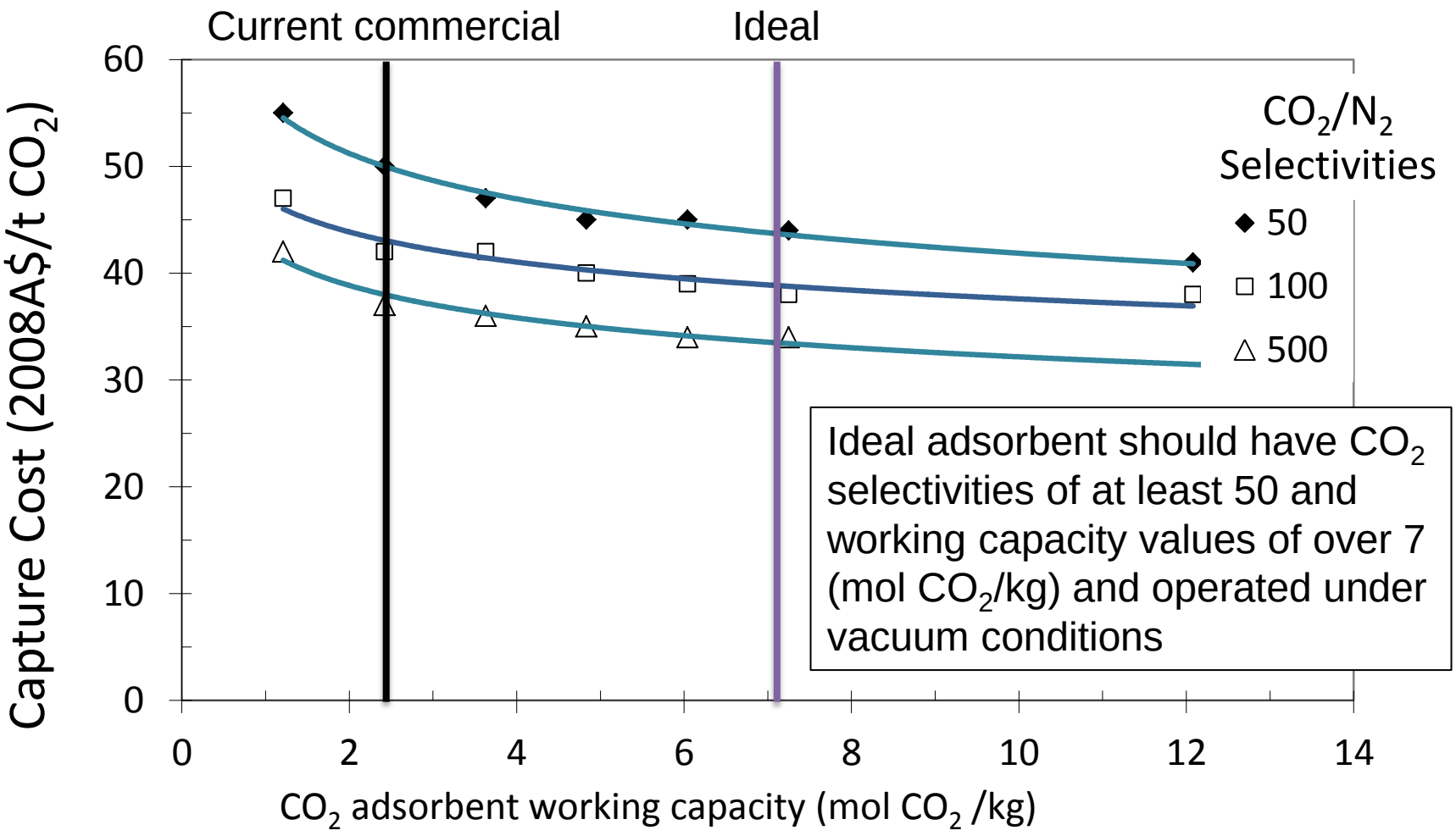


Adapted from: Ho et al (2008) 'Reducing the cost of capture from flue gas using membrane technology' IECR 47 1562-1568

Adsorption development: compression energy



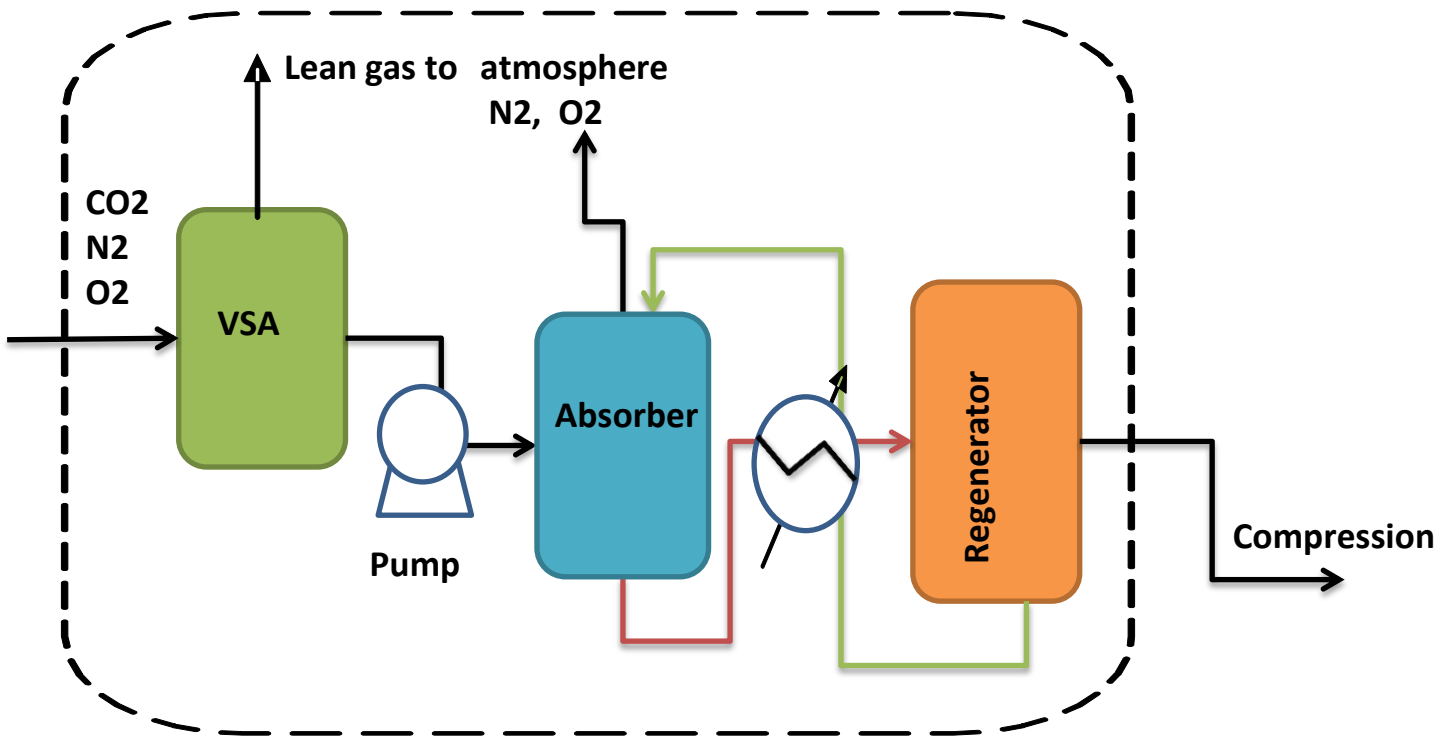
Adsorption improvement: size, energy, cost



Adapted from: Ho et al (2008) 'Reducing the cost of capture from flue gas using pressure swing adsorption' IECR 47 4883-4890

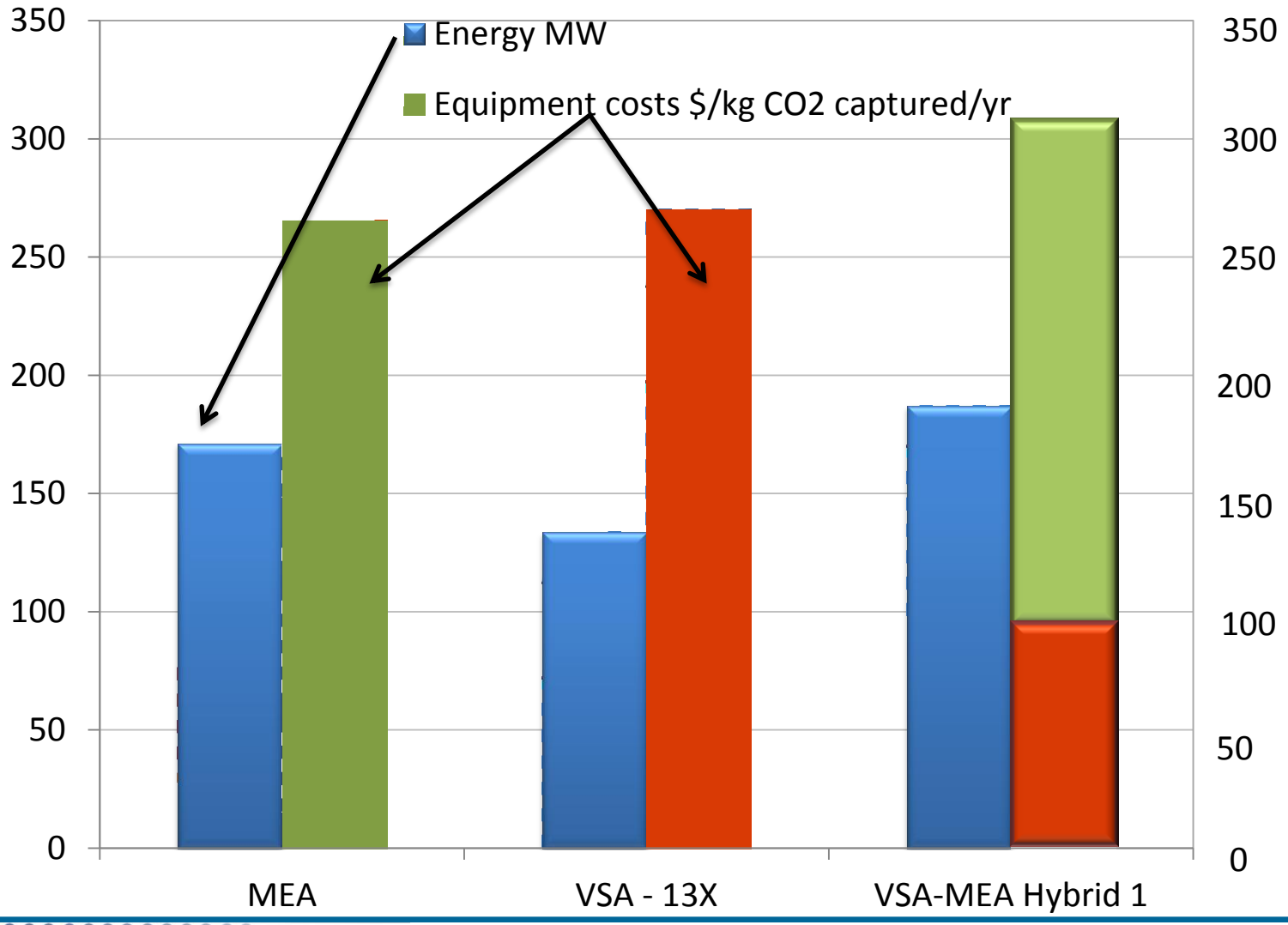
Process intensification: Hybrid capture

- **Combination of adsorption and solvent technologies, membrane and solvent, adsorption and cryogenic etc.**

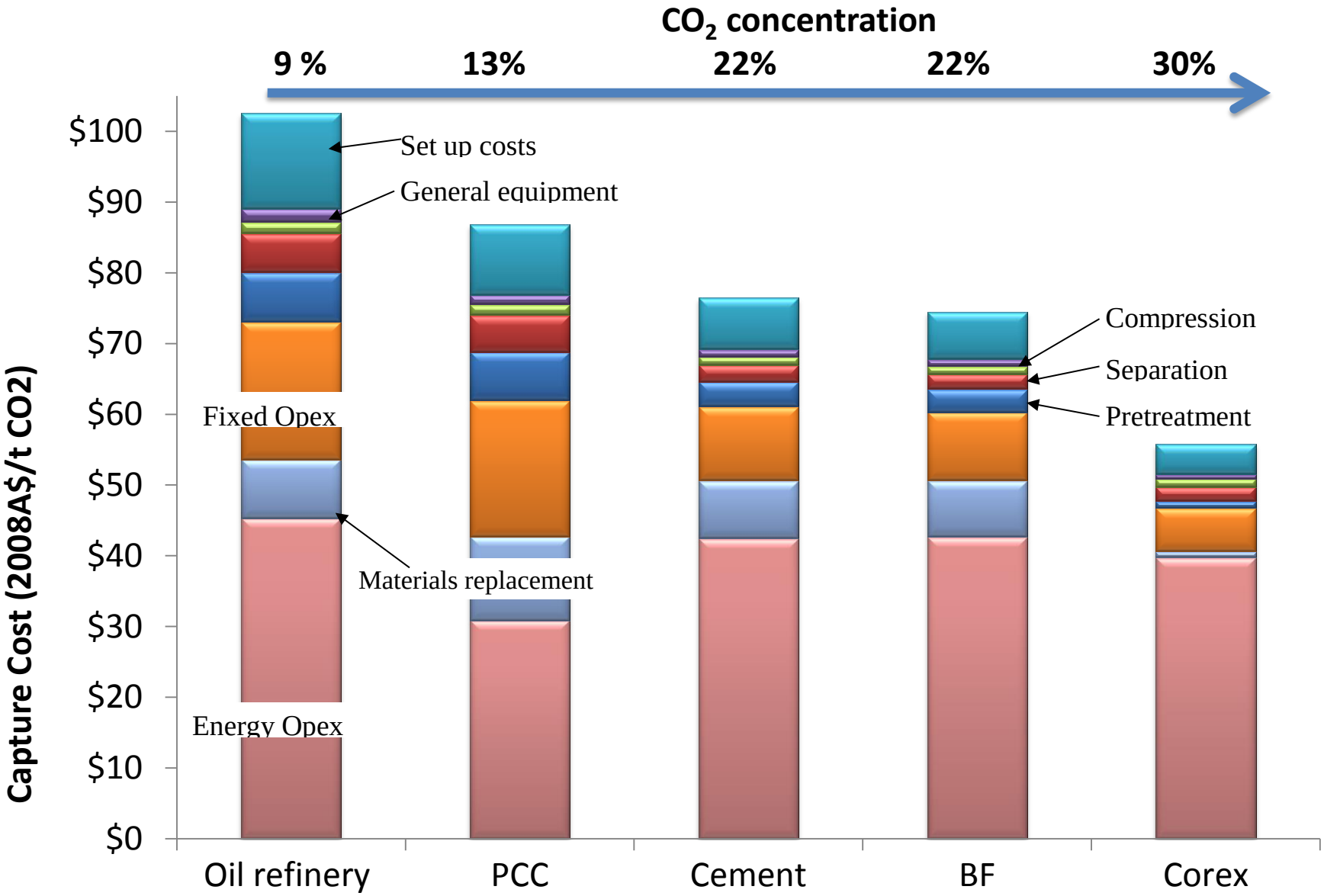


Adsorption + Solvent Hybrid Separation

Energy and costs of VSA-solvent hybrid



Effects of emission source on costs



Adapted from: Ho et al (2010) Comparison of MEA capture cost for low CO2 emissions sources in Australia, IJGGC 5(1):49-60. ·

Comparison of capture development options

Parameter	Solvents	Membranes	Adsorption
Capital cost			

Other factors to consider

- **Tolerance to impurities (SO_x, NO_x, water)**
- **Process configuration design and optimisation**
- **Optimising operating conditions**
- **Heat integration**
- **Load following and process flexibility**

Conclusions from comparative costing

- **Technology improvement driven by reductions in:**
  - Energy usage
  - Capital costs (size of equipment, level of pretreatment)
  - Operating costs (materials replacement)
- **Application dependent**
  - No silver bullet
  - Technology specific intensification and integration
- **Relies on consistent benchmarks and assumptions**

CO2CRC Participants

Australian Government
Geoscience Australia

CSIRO

Curtin University

MONASH University

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THE UNIVERSITY OF MELBOURNE

UNSW AUSTRALIA

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KIGAM Korea Institute of Geoscience and Mineral Resources

NSW GOVERNMENT Trade & Investment

RioTinto

sasol
reaching new frontiers

TOTAL

DEPARTMENT OF STATE DEVELOPMENT BUSINESS AND INNOVATION

State Government Victoria

Government of Western Australia
Department of Mines and Petroleum

GLENCORE

Supporting Partners: The Global CCS Institute | The University of Queensland | Process Group | Lawrence Berkeley National Laboratory
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