Emerging CO_2 Capture Technologies

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Research Opportunities for Application of Carbon Capture Technologies to California Natural Gas Power Plants

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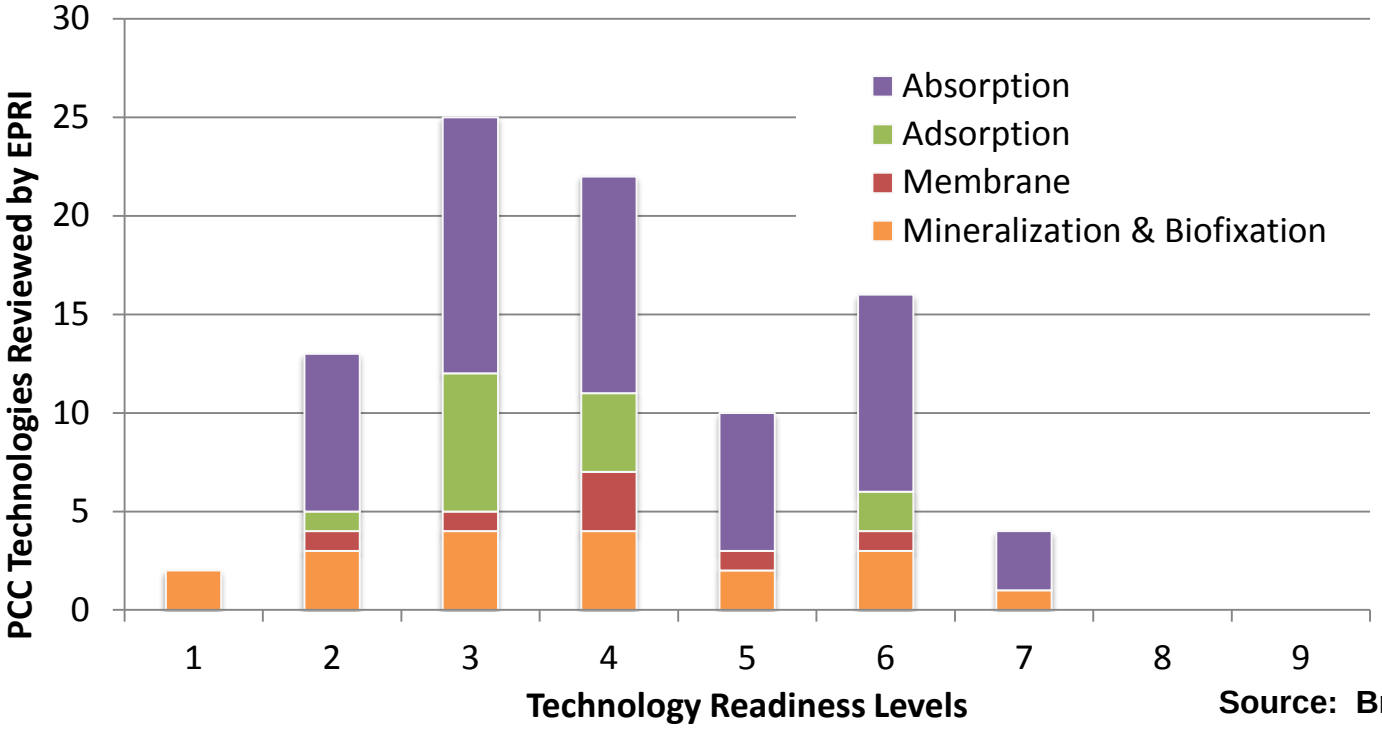
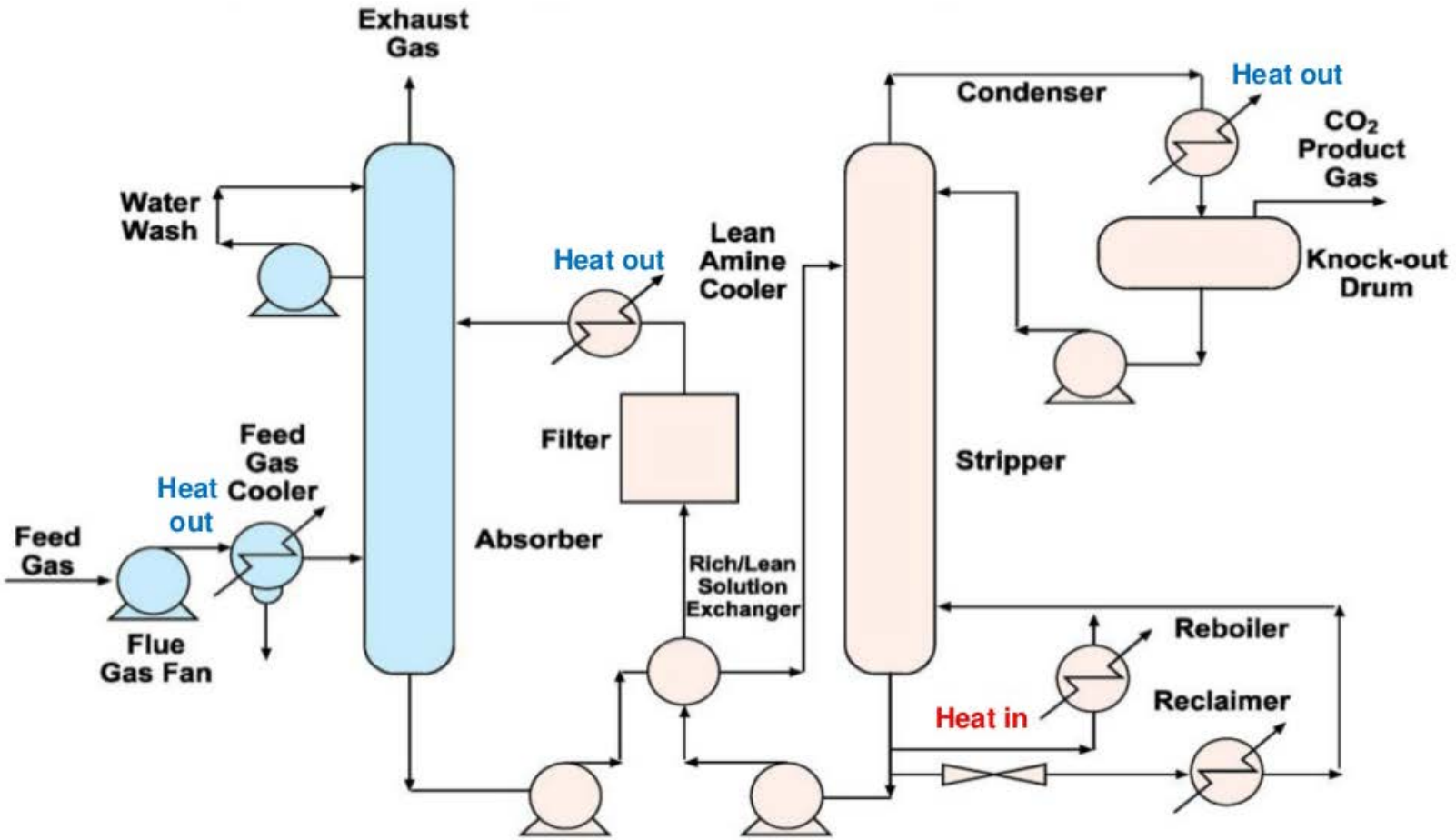
Post-Combustion CO_2 Capture Technologies

- Absorption
- Adsorption
- Membranes
- Mineralization
- Biofixation



Source: Brice Freeman, EPRI (2010)

CO_2 Capture from Flue Gas using Solvent Absorber and Stripper/Reboiler



Based on: Paul H.M. Feron, Exploring the potential for improvement of the energy performance of coal fired power plants with post-combustion capture of carbon dioxide, International Journal of Greenhouse Gas Control 4(2), 2010, 152-160

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Commercial Absorption Plants

240 MW MHI CO2 Capture Plant at WA Parish

Source: NRG

100 MW Shell/Cansolv CO_2 Capture Plant at Boundary Dam

Source: SaskPower

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Adsorption

- CO_2 preferentially adsorbs onto a sorbent
- Non-aqueous chemistry avoids latent heat of vaporization (in absorption systems), offering lower regeneration energy
- Can be pressure swing (PSA), vacuum swing (VSA) or thermal (TSA) swing cycles.
- Wide range of sorbent materials are available

Source: DOE

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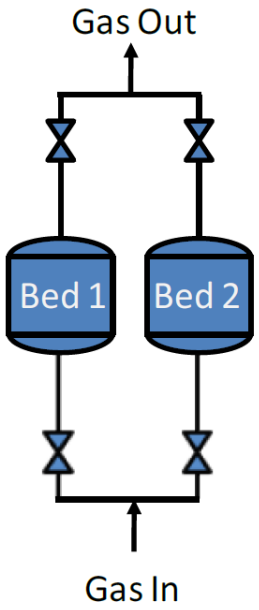
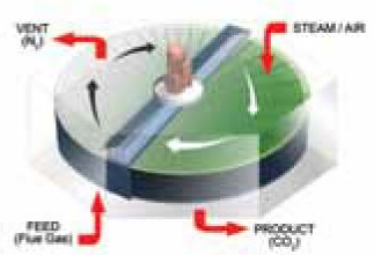
Adsorption Process Designs

- Fixed Bed, moving bed, fluidized bed and novel systems





Structured Adsorbent Blocks are Assembled to form a Wheel

Howden Structured Adsorbent Wheel with Ducting Attached

Source: Inventys

Source: ADA-ES

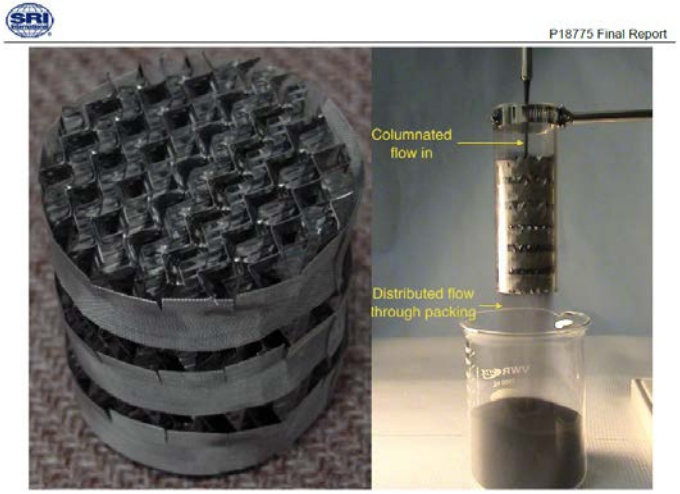


Figure V-2. Photograph of the structured packing used in the bench-scale reactor and a demonstration of the packing effectiveness at distributing the flow of sorbent granules.

Source: SRI, ATMI

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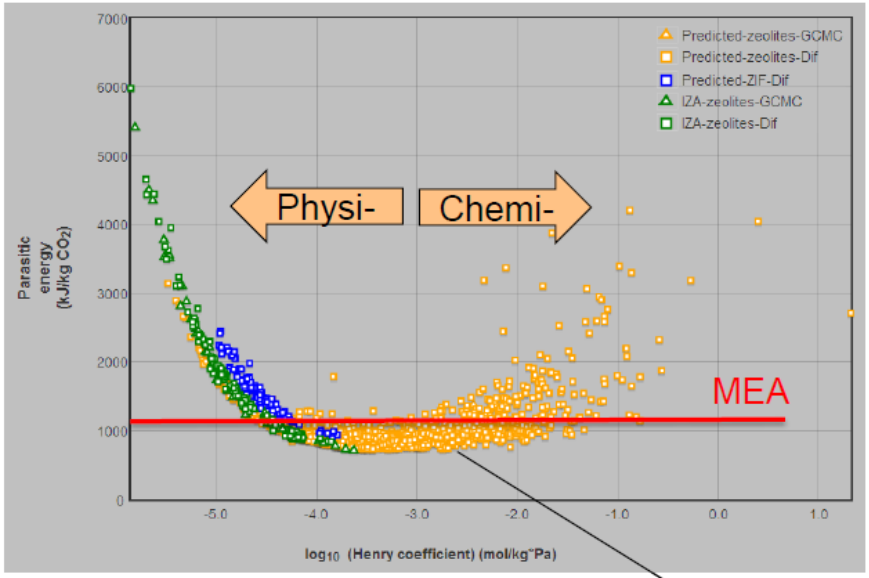
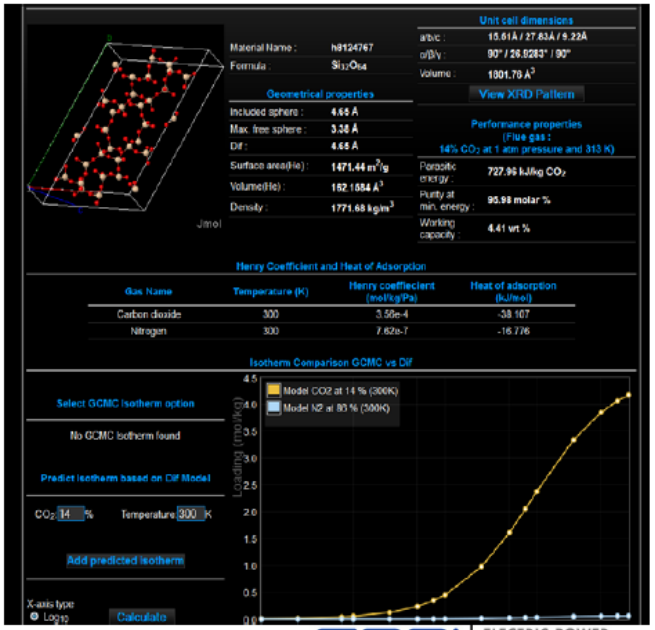
Materials Studies

Adsorbents (BES/EFRC, ARPA-E, EPRI)
UC Berkeley, LBNL, Rice U, EPRI



- Rapidly calculate properties and least imposed load for each material
- Predicted ~30% lower imposed load than MEA possible



- Very broad minimum; thousands of promising new compounds identified
- 2×10^{-4} < Henry's Coefficient < 2×10^{-3}
- No single defining characteristic
- www.carboncapturematerials.org

Lin et al., Nature Materials, 11, 633 (2012)

EPRI ELECTRIC POWER RESEARCH INSTITUTE

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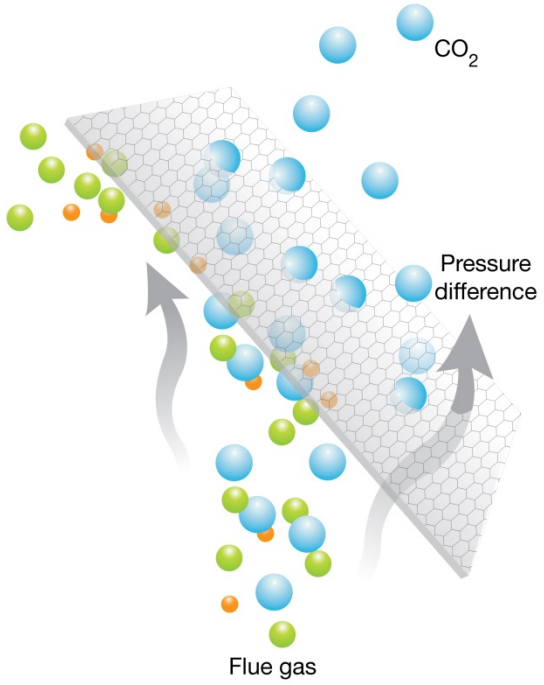
Membranes

- Materials which selectively permeate CO_2 from flue gas (N_2)
- Operate using a difference in CO_2 partial pressure
- No steam cycle integration
- Most efficient at less than 90% capture.



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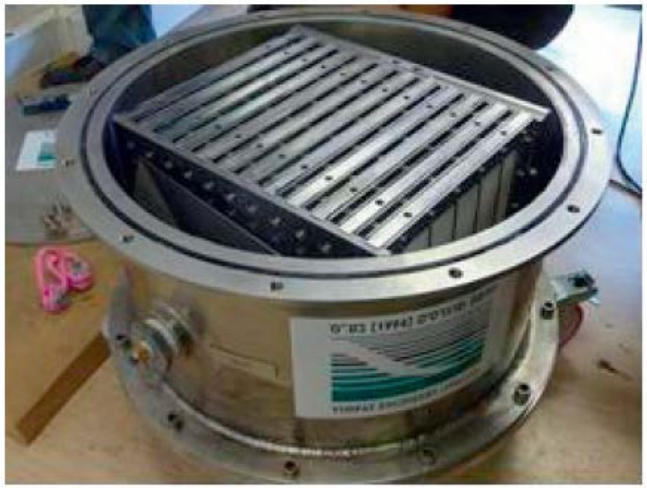
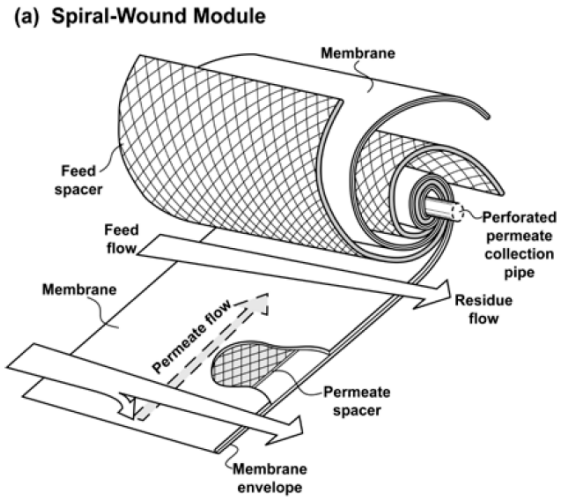
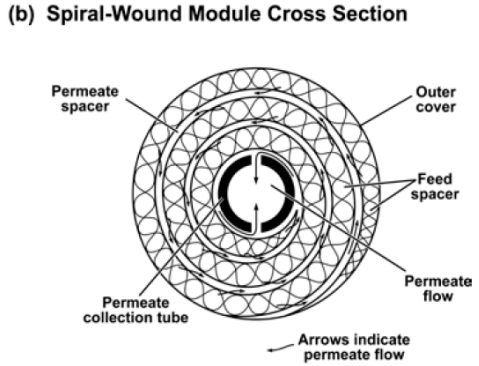
Membrane and Membrane Modules Form Factors

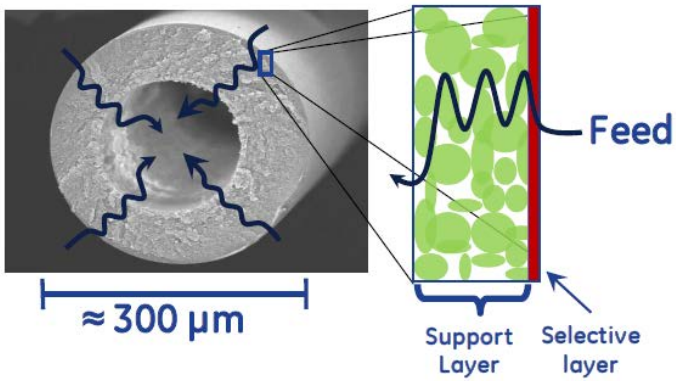


1.5 m^2 NTNU-Sintef facilitated transport membrane Source: NTNU





Typical spiral wound membrane module. Source: MTR



Schematic representation of post-combustion CO_2 capture using hollow fiber membranes

GE imagination at work

GE's Hollow fiber membrane. Source: Dhaval Bhandari, GE

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Adapting Existing Capture Technology to a California NGCC Power Plant

- Adapt for the physical differences in flue gas streams.
  - Larger flue gas volumes
  - CO_2 content
  - O_2 content
- CA specific design issues/constraints
  - Flexible Operation
  - “Permitability”

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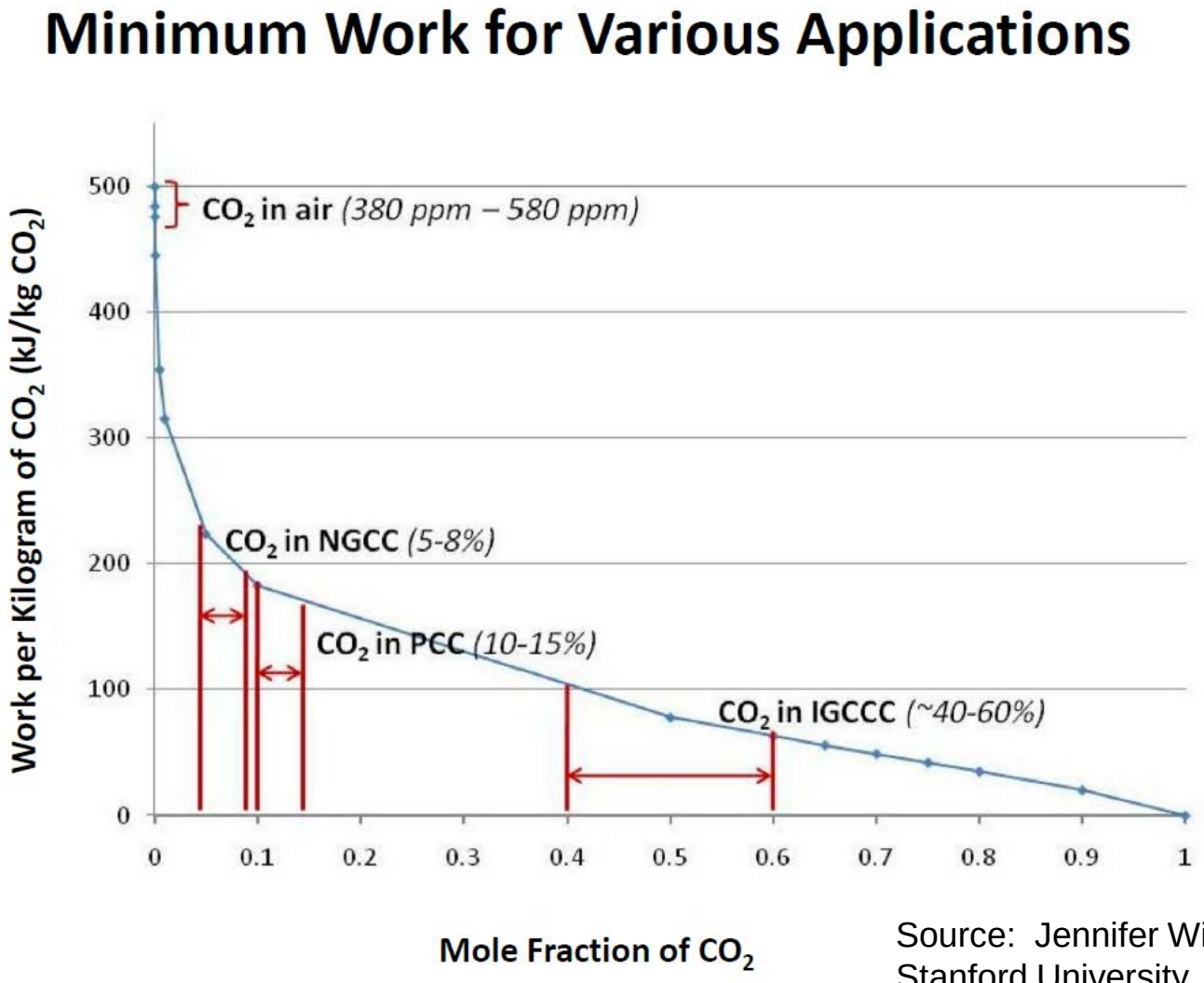
Energy of Separation vs. CO_2 Concentration



Source: Jennifer Wilcox, Stanford University

Operational Flexibility is Important

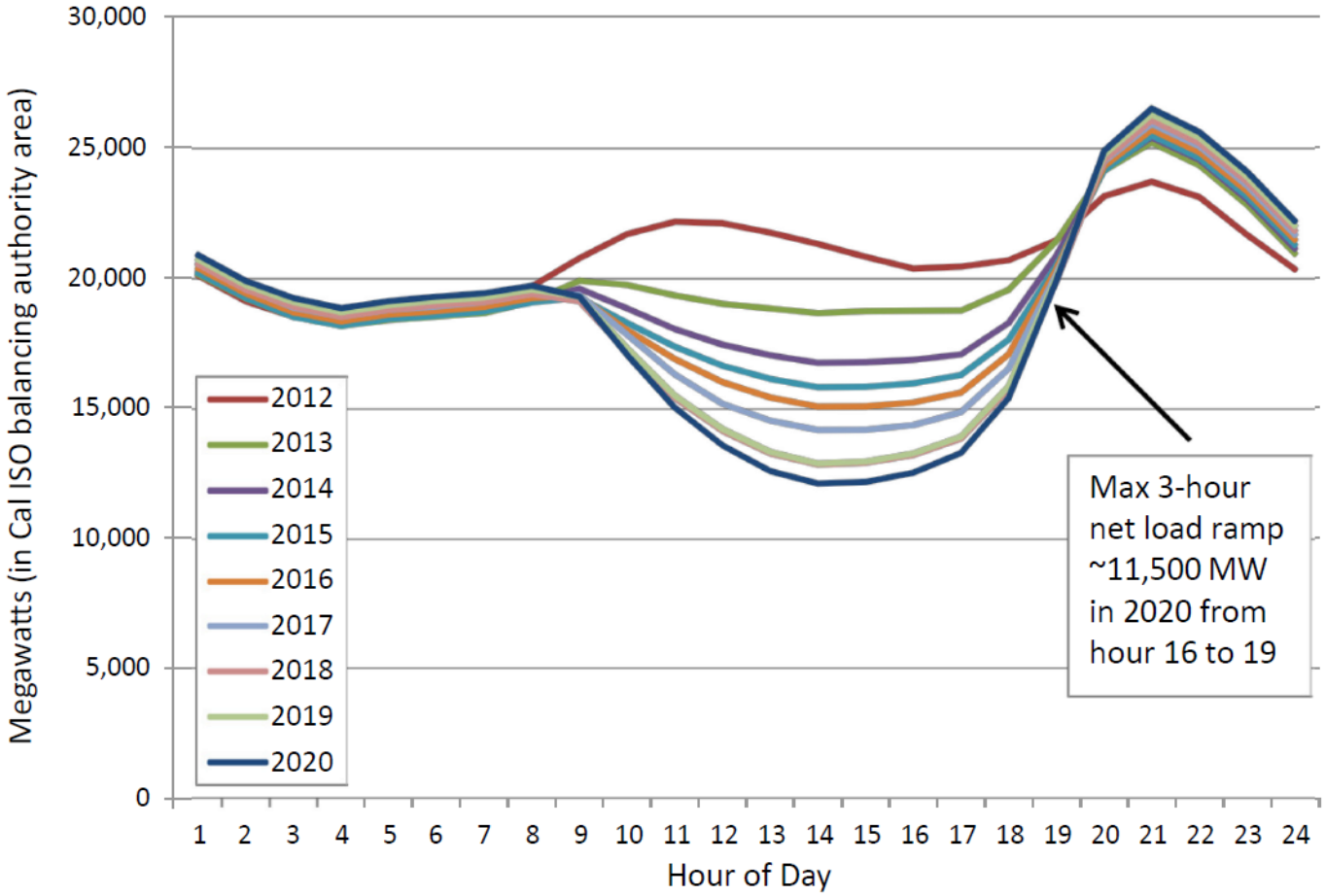
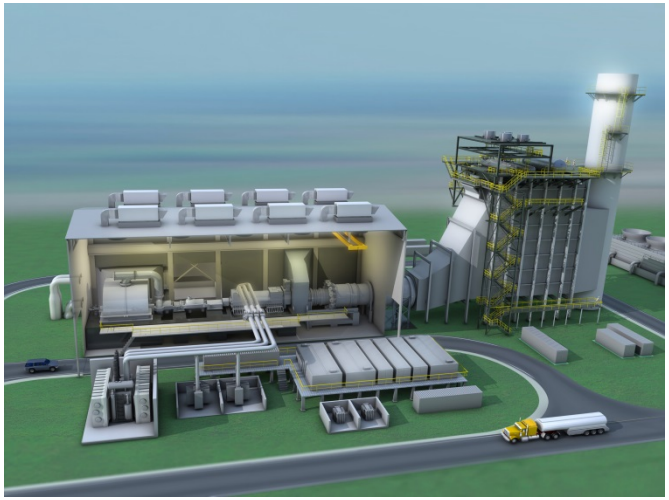


Figure 1. "The Duck Chart" – California expected net peak spring loads 2012-2020. In particular, net load for critical spring day (March 31) of various years. *Source*: CPUC/CEC 2013.

Visual Impacts

- The average stack height for larger and newer CA power plants is 152 feet.
- Typical amine absorption towers are taller and, for NGCC plants, will be taller still.
- TCM amine tower is 62 m (203 ft.)
- Faster solvents and EGR should lead to shorter columns.

Source: Test Center Mongstad



Source: GE Power

Questions?

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