What Do We Need for Cost-effective CCS

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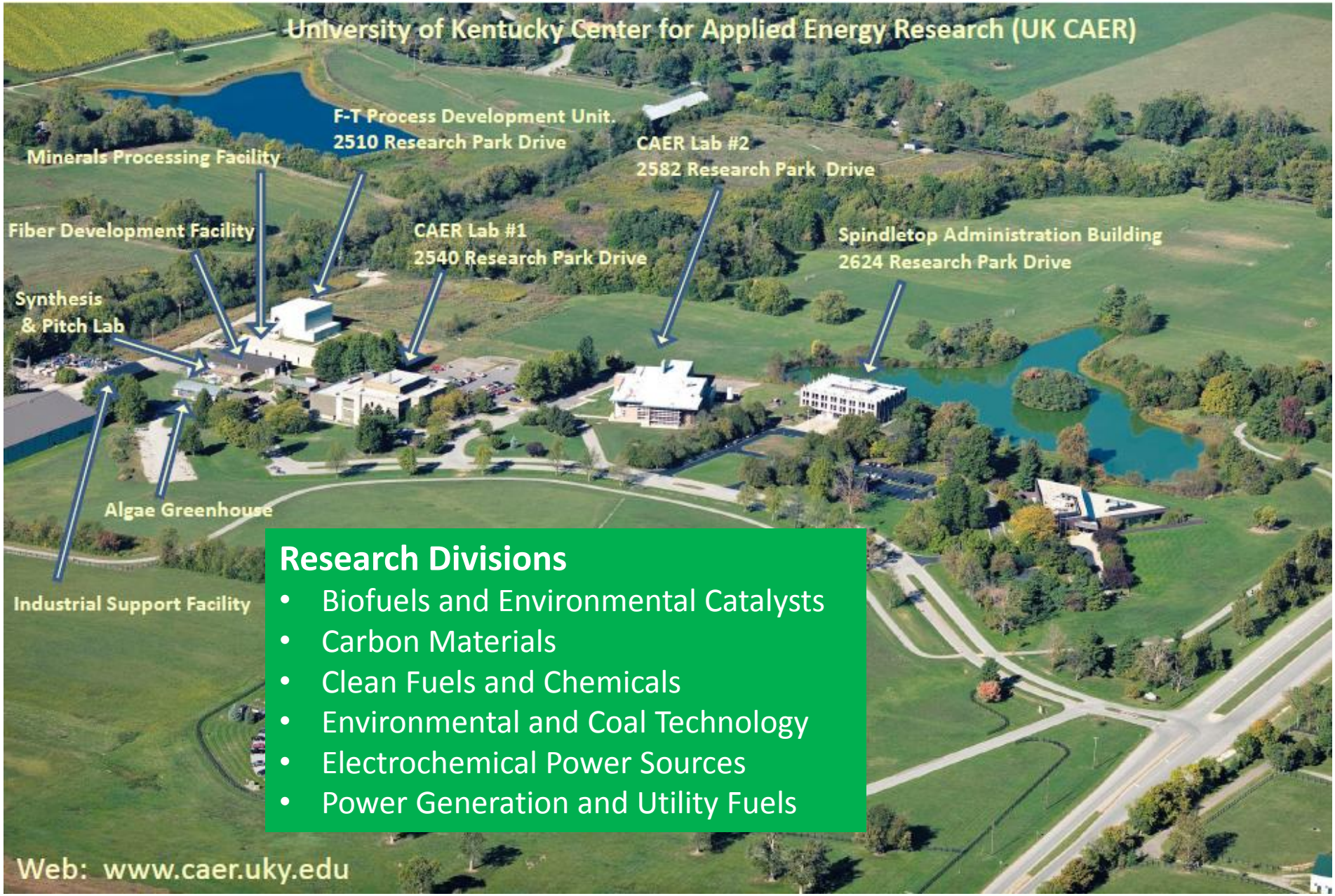
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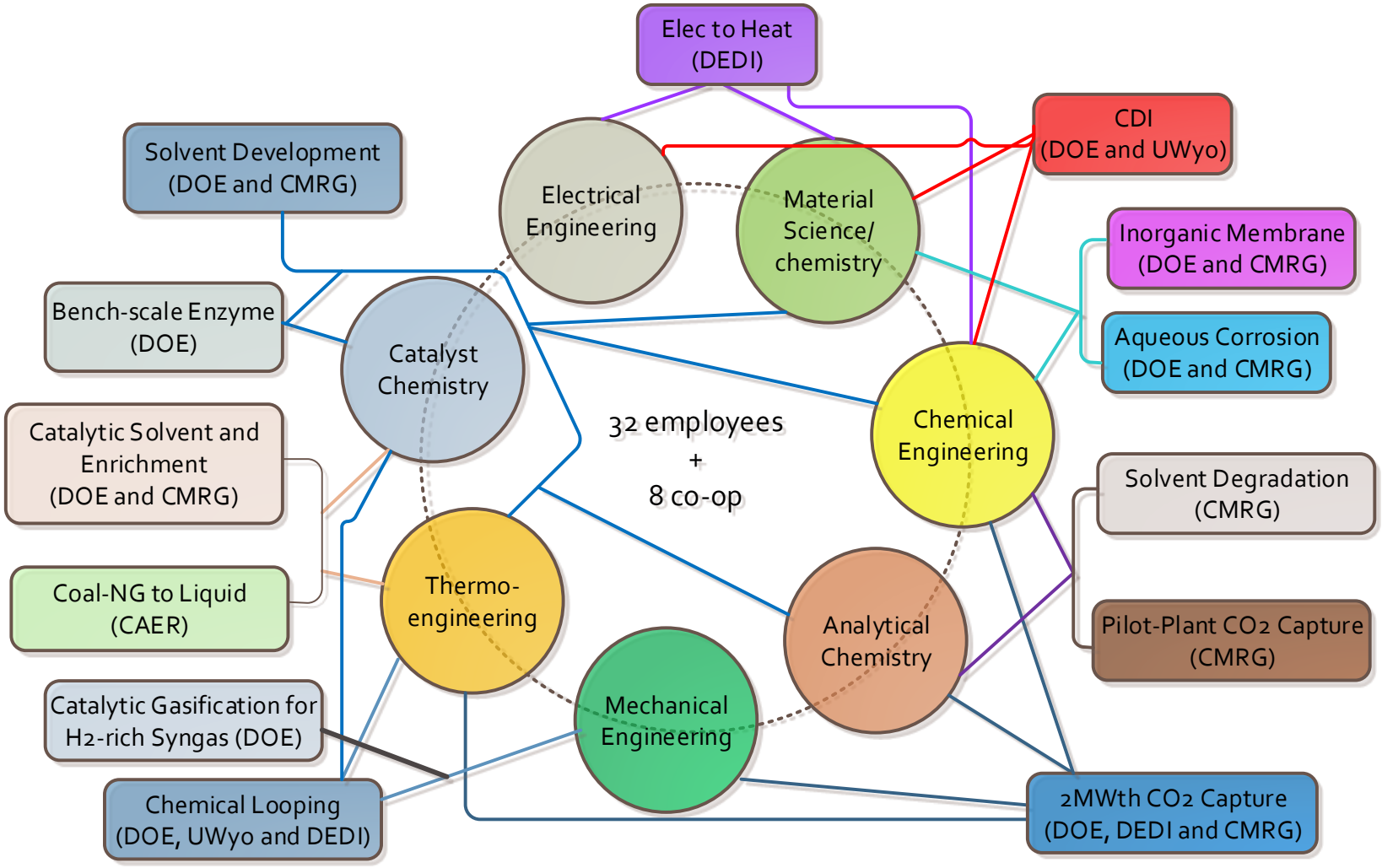
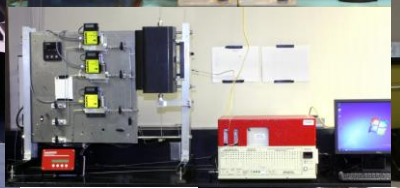
Our Expertise and Projects on CCS



Facilities/Apparatus









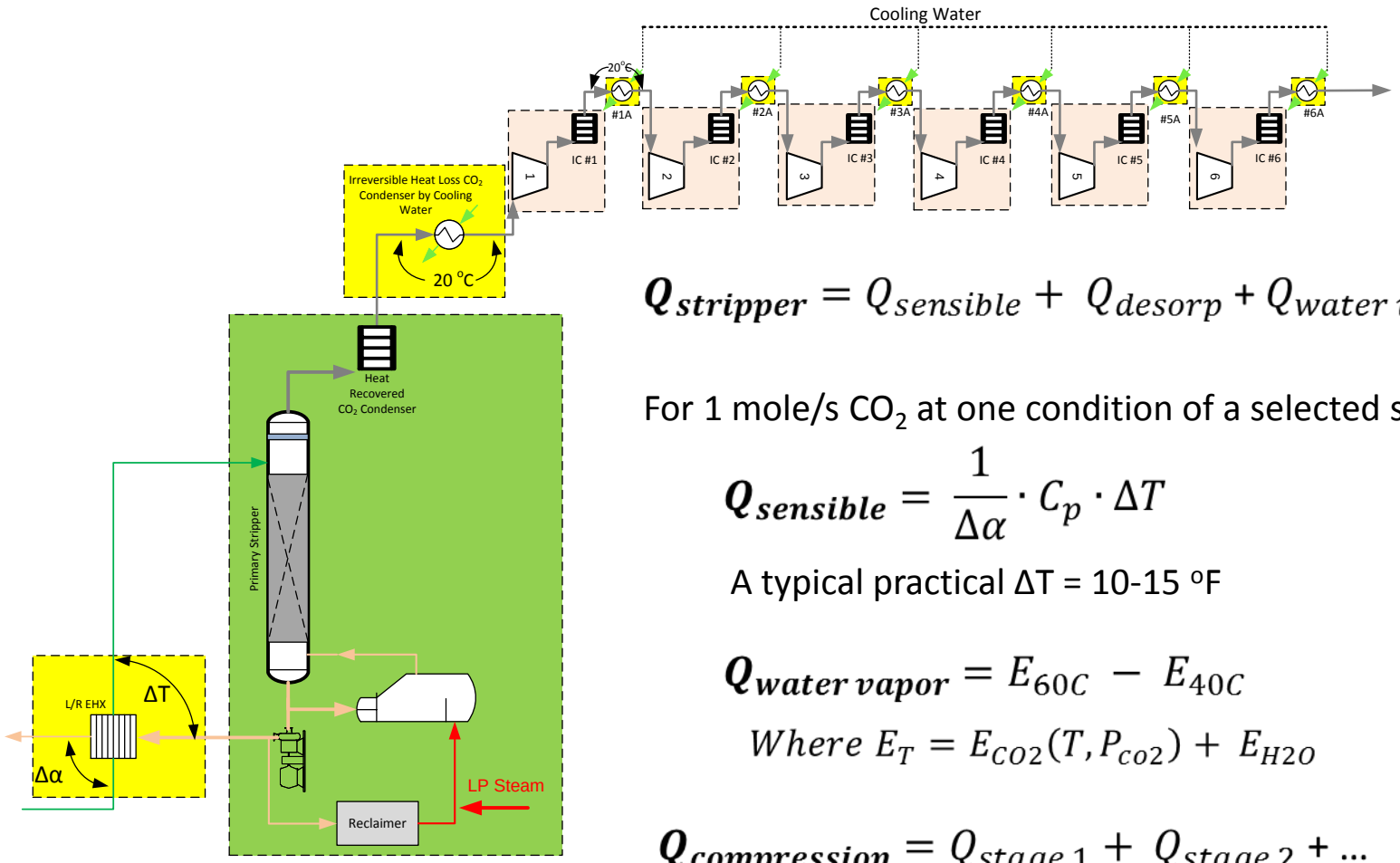





Post Combustion Scrubbing in Fossil Power Plants

- **Challenges**:
  - Low CO_2 partial pressure (~0.14 atm)
  - Large volume
  - Poisoning
- **Consequences**:
  - Capital Costs $700-1000/kW
  - Absorbers three or four times diameter as FGD with packing
  - Strippers and BOP
  - 25-35% of plant output reduction

Minimum Energy Needed for Stripping and Compression for a Selected Solvent



$$Q_{stripper} = Q_{sensible} + Q_{desorp} + Q_{water\ vapor}$$

For 1 mole/s CO_2 at one condition of a selected solvent

$$Q_{sensible} = \frac{1}{\Delta\alpha} \cdot C_p \cdot \Delta T$$

A typical practical ΔT = 10-15 °F

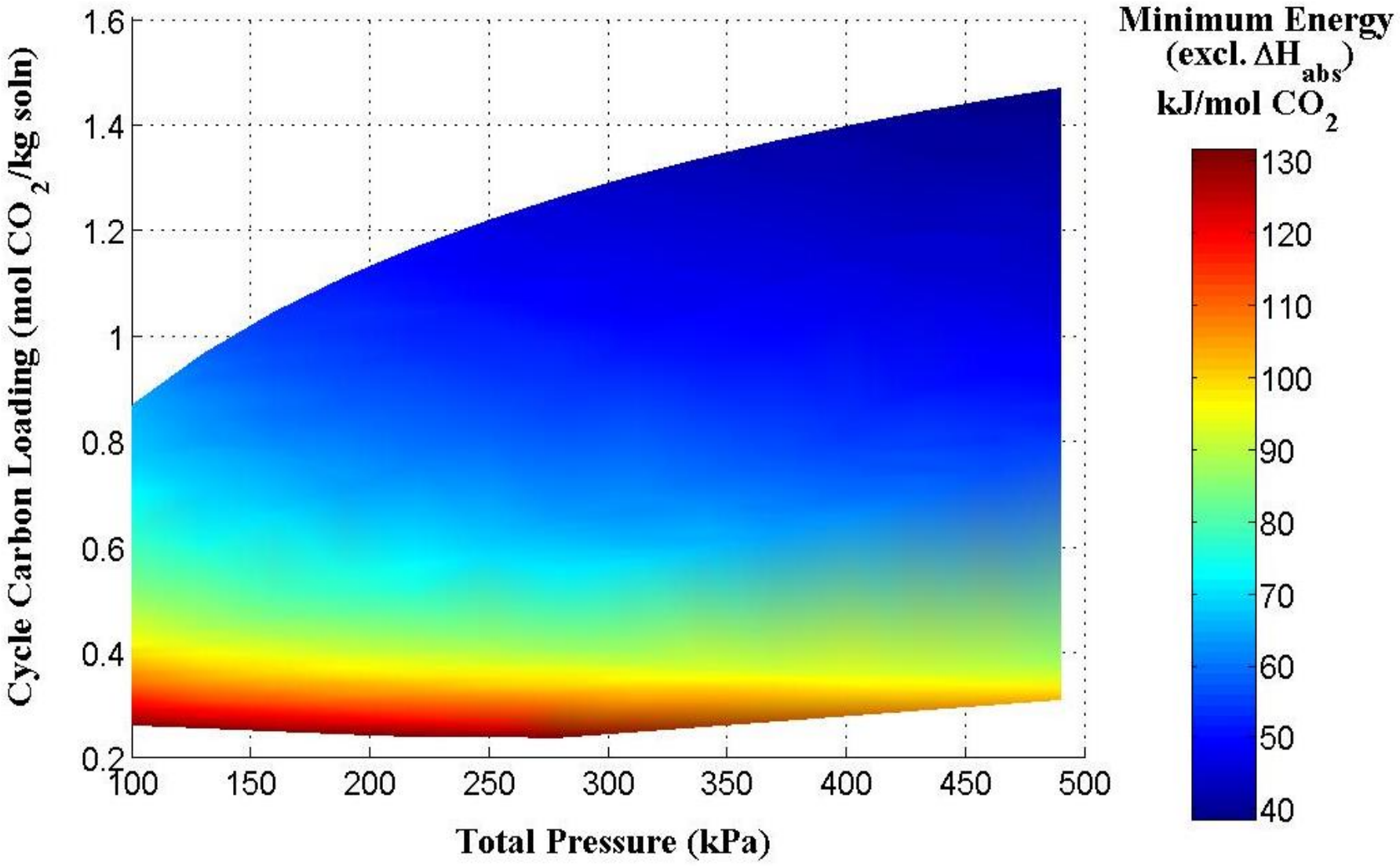
$$Q_{water\ vapor} = E_{60C} - E_{40C}$$

$$Where\ E_T = E_{CO2}(T, P_{co2}) + E_{H2O}$$

$$Q_{compression} = Q_{stage\ 1} + Q_{stage\ 2} + \ldots$$

$$Where\ Q_{stage\ i} = E_{i,60C} - E_{i,40C}$$

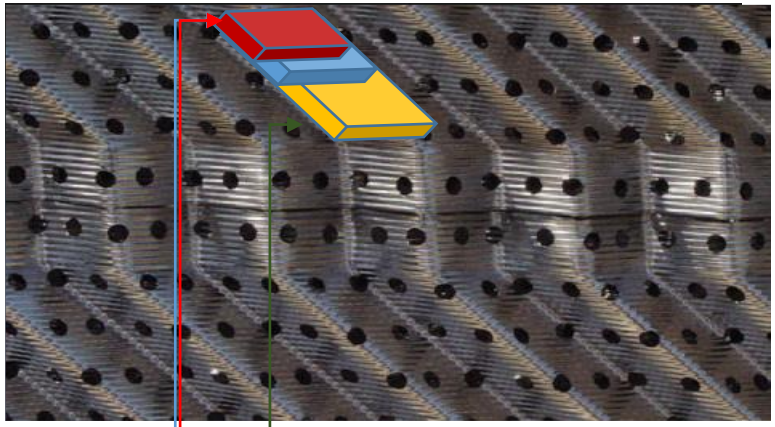
Minimum Energy Needed for Stripping and Compression for a Selected Solvent



What Does it Translate to CO_2 Flux?

- $flux = A \cdot k_G \cdot (P^{g}_{CO_2} - P^{*}_{CO_2})$

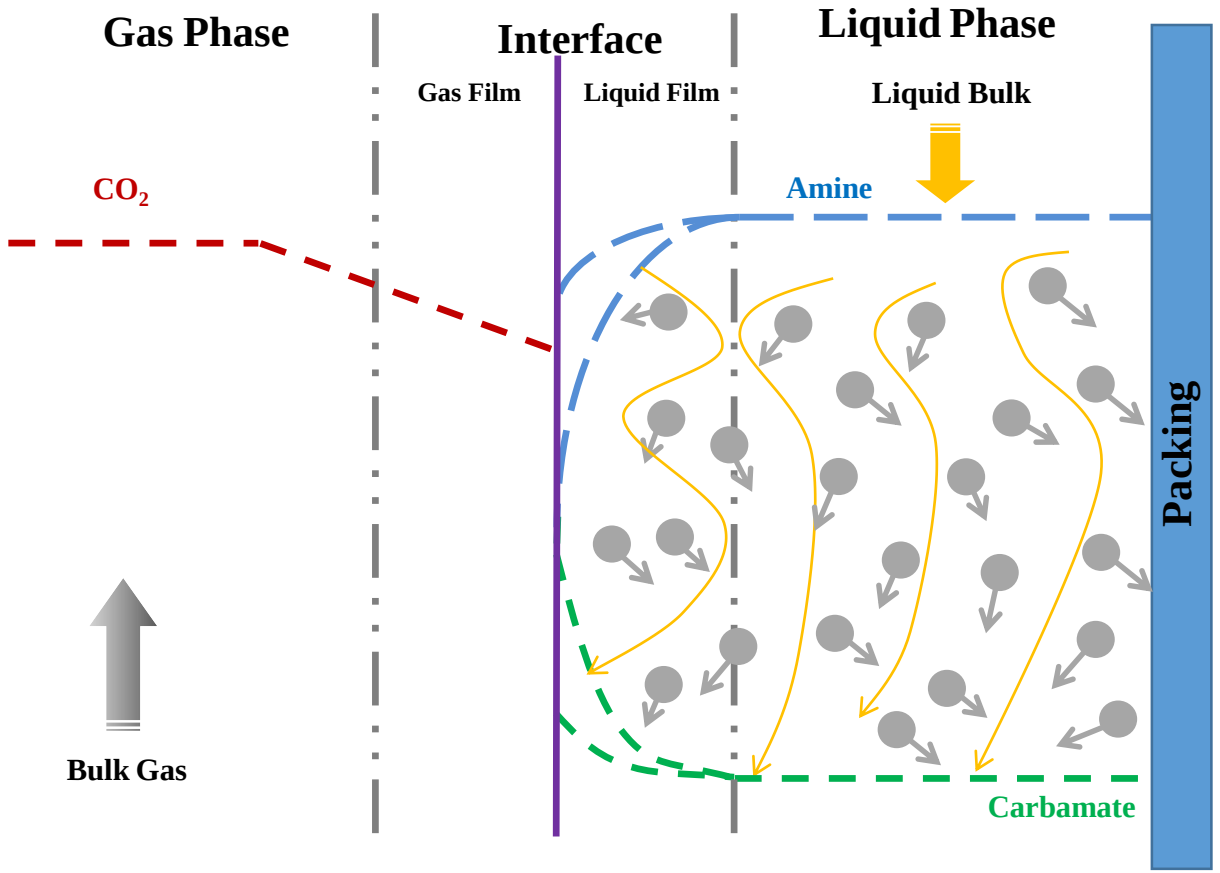
Where $k_G \propto \frac{\sqrt{D_{CO_2} \cdot k_2 \cdot [aime]}}{H_{CO_2}}$



	MEA	PZ	MDEA
Rate Constant	5.94	69.21	0.004
Self-concentrated amine	1.0	3.5	~1
Calculated Kg' impact from [M]	1	1.87	~1
Calculated Kg' impact from k_2	1	3.41	0.03
Calculated Kg' Overal	**1**	**6.39**	**0.03**
Measured Mass Flux (WCC@0.1)	1	2.20	0.18

Turbulence Enhancement by Particles

➢Turbulence Enhancement by Particles

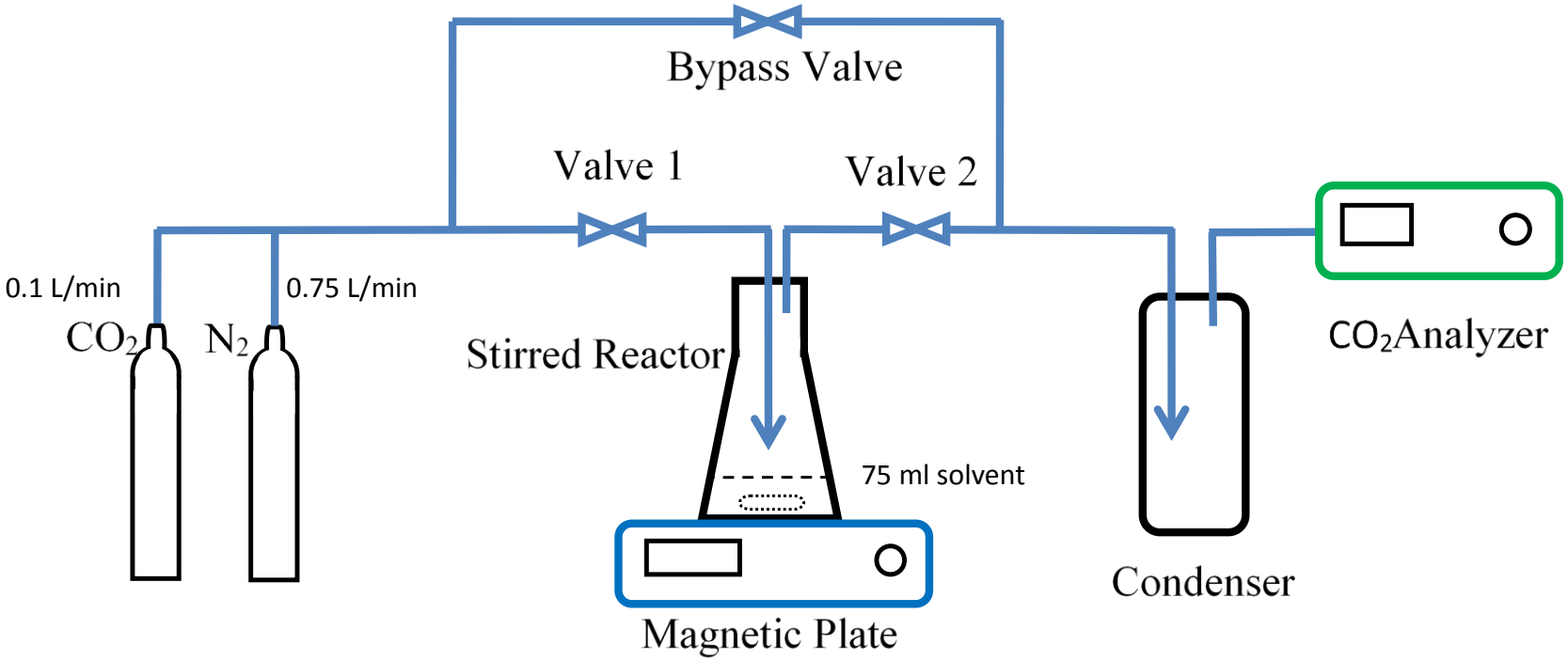


Entrained particles → Turbulence → Enhanced physical mass transfer

Mass Transfer Enhancement Experiment

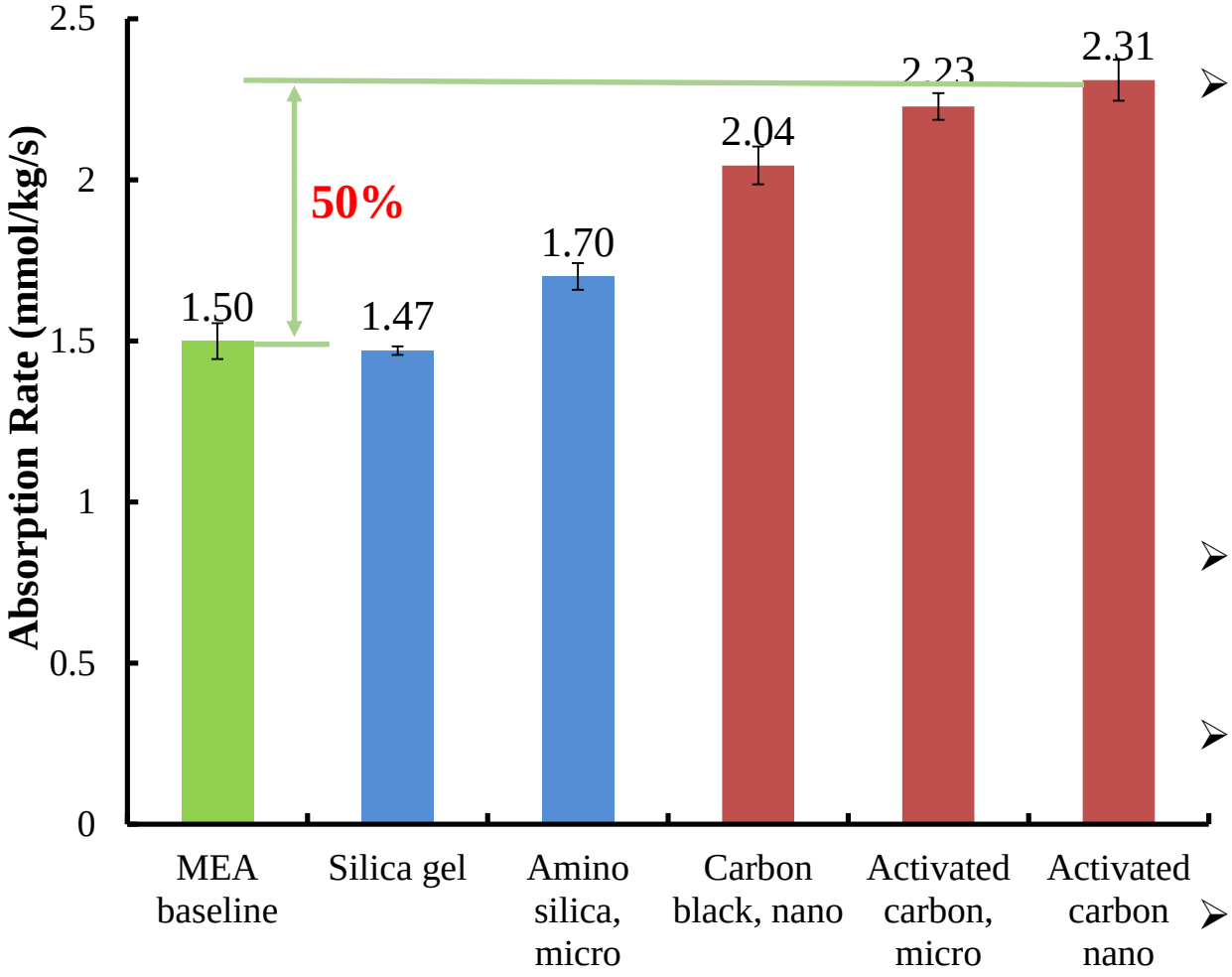
- Experiment Setup - Stirring Reactor with Stable Gas-Liquid Interface

Entrained particles → Turbulence → Enhanced physical mass transfer



Turbulence Enhancement by Particles

➢Preliminary Results of Effect of Different Particles on CO_2 Absorption Enhancement



Conditions: 5M MEA with and without 1 wt % particles

- Hydrophilic particles potentially interact with solutions:
  - Increase solution viscosity due to particle-H_2O interaction
  - Decrease amine activity due to particle-amine interaction
- Hydrophobic particles are better than hydrophilic ones.
- Activated carbon particles show best enhancement (>50%).
- Hydrophobic particles as turbulence promoters.

Thanks and Question?