HiPerCap - High Performance Capture

FP7 Grant agreement n° 608555

Assessment of Various Post-combustion Technologies in the HiPerCap Project

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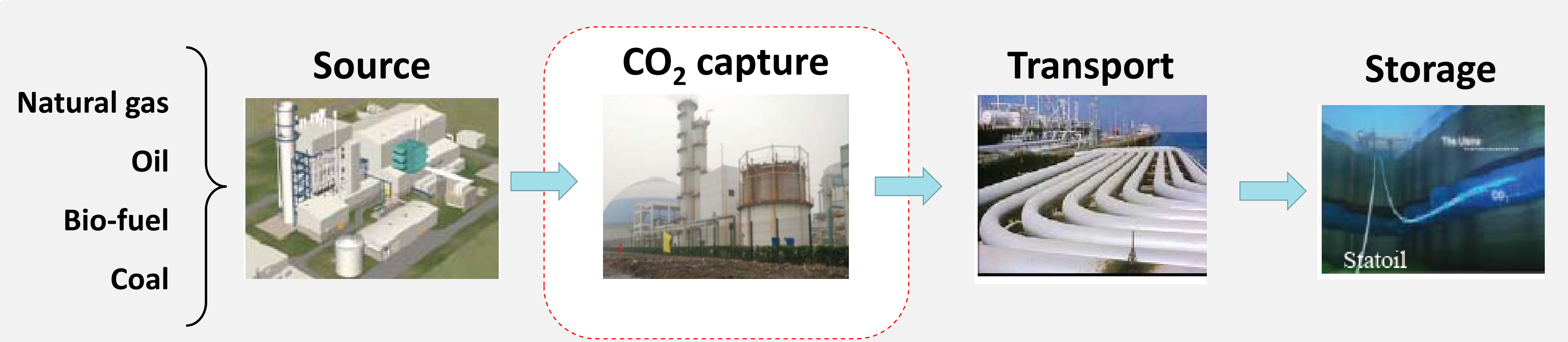

Content

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- Capture technologies addressed in the project
- Important aspects for technology assessments
- Technology assessment and benchmarking in HiPerCap

Main facts

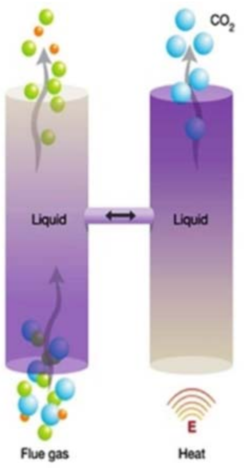
- HiPerCap is funded by EU
  - ✓ Call specifically important twinning with Australian partners and projects
  - ✓ Integrated with 5 other projects within the same call
- Budget:
  - ✓ Total: 7.7 M€
  - ✓ From EU: 4.9 M€
- Duration:
  - ✓ 4 years started January 2014
- 13 EU partners + 1 from Australia, 1 from Canada, and 1 from Russia

Main objectives

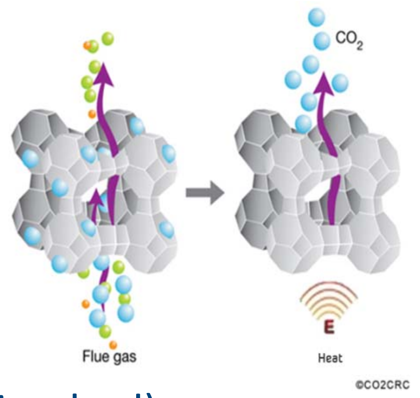
1. Develop environmentally benign energy- and cost-efficient technologies for post-combustion capture
    - ✓ Absorption
    - ✓ Adsorption
    - ✓ Membranes
2. Develop a methodology for fair comparison and benchmarking of the technologies
3. Develop technology roadmaps for the two most promising technologies

HiPerCap Post-combustion capture technologies

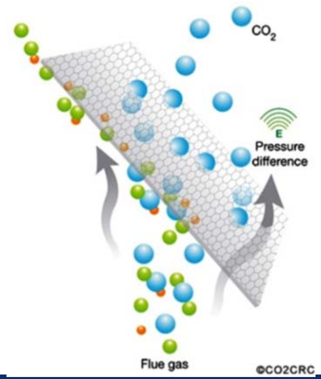
- Absorption
  - ✓ Enzyme based solvent system
  - ✓ Precipitating solvent system
  - ✓ Strong bicarbonate solvent system
  - ✓ Combination with algae production
  - ✓ Bio-mimicking systems



- Adsorption
  - ✓ Testing of various sorbents including "green" sorbents
  - ✓ Studying two different reactor systems (fixed-bed and moving-bed)



- Membrane
  - ✓ Hybrid (polymer+nanoparticles) membranes
  - ✓ Supported ionic liquid membranes



Key focus on *potential* of the capture technologies

- What are major benefits?
- What are the major differences to other post-combustion technologies?
- What are major challenges related to upscaling ?
- What are the major challenges related to the assessment and comparison?

Important aspect: Major benefits

Separation method	Process concept	Major benefits
Absorption	1a. Enzyme catalysis	Environmentally friendly promoter
	1b. Precipitating systems	Higher absorption capacity, Environmentally friendly systems (amino acid salts)
	1c. Strong bicarbomate formting systems	High cyclic capacity, Lower energy concumption
	1d. CO_2 capture with biological systems	Combination of CO_2 capture and utilization
Adsorption	2a. Fixed-bed adsorption system	Mature technology for similar applications. Enhanced mass transfer and hydrodynamics with structured materials (monolith)
	2b. Moving-bed adsorption systems	Reduced pressure drop. Enhanced heat transfer. Compact unit design
Membrane	3a. High flux mixed matrix membrane	Low cost and low energy (heat) requirements. Both high permeance and high selectivity
	3b. Supported ionic liquid membranes	

Important aspect: Major differences to other concepts

Separation method	Process concept	Major differences to other concepts
Absorption	1a. Enzyme catalysis	Natural (biological) rate promoter
	1b. Precipitating systems	pH swing rather than a temperature swing regeneration
	1c. Strong bicarbomate formting systems	Mature technology compared to other concepts
	1d. CO_2 capture with biological systems	Algae bioreactor for regeneration
Adsorption	2a. Fixed-bed adsorption system	Solid-gas interaction, no liquid associated. Lower heat (steam) requirements
	2b. Moving-bed adsorption systems	
Membrane	3a. High flux mixed matrix membrane	No emissions. No liquid or solids involved. No regeneration. Modular technologies.
	3b. Supported ionic liquid membranes	

Important aspect: Up-scaling challenges

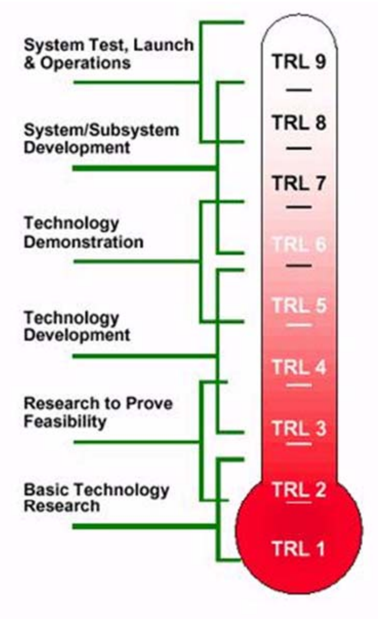
Separation method	Process concept	Major up-scaling challenges
Absorption	1a. Enzyme catalysis	Enzyme stability and thermal stability
	1b. Precipitating systems	Controlled absorption and precipitation. Slurry process development
	1c. Strong bicarbomate formting systems	Potentailly low absorption rate. A promoter is required
	1d. CO_2 capture with biological systems	Effect of CO_2 on the stability of algae strains. "Algae-friendly" solvent selection and enhanced CO_2 dosing system
Adsorption	2a. Fixed-bed adsorption system	Identification of the optimal process design. Scarce data on equipment scale up
	2b. Moving-bed adsorption systems	
Membrane	3a. High flux mixed matrix membrane	Manufacturing of new membrane material. Durability of the membrane material
	3b. Supported ionic liquid membranes	

Important aspect: Assessment challenges

Separation method	Process concept	Assessment challenges
Absorption	1a. Enzyme catalysis	Life time of the enzymes
	1b. Precipitating systems	Performance and influence of slurry handling system. Identification and implementation of "waste heat" source for solids dissolution.
	1c. Strong bicarbomate formting systems	Influence of the promoter (kinetics) on the process perfomance
	1d. CO_2 capture with biological systems	CO_2 utilization
Adsorption	2a. Fixed-bed adsorption system	Lack of data from larger (pilot) scale capture units imply high uncertainty in model parameters obtained based on the data from the lab. No public information on solid sorbent system cost
	2b. Moving-bed adsorption systems	
Membrane	3a. High flux mixed matrix membrane	Lack of data from larger (pilot) scale capture units imply high uncertainty in model parameters obtained based on the data from the lab
	3b. Supported ionic liquid membranes	

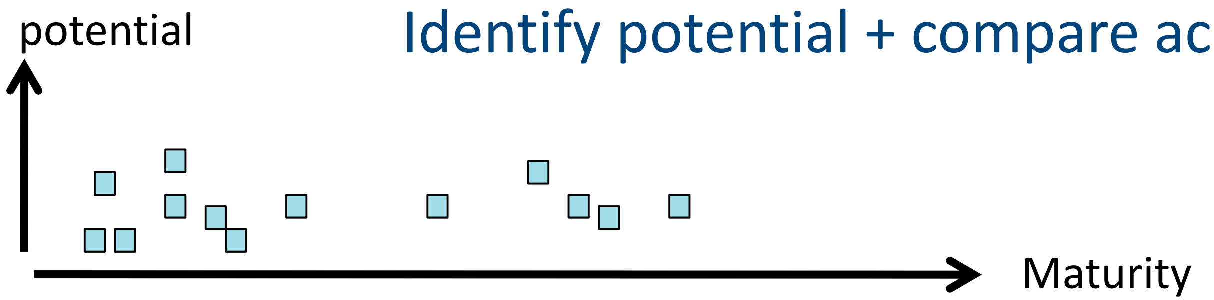
Challenges for assessment and benchmarking of capture technologies

- No reference performance data available -> no peer group
  - ✓ Other reference needed
- What to use as reference?
  - ✓ Several CO_2 sources
  - ✓ Various transport and storage options
- In HiPerCap
  - ✓ Novel technologies with incomplete data set for assessment
  - ✓ Not the same level of maturity (model ≠ pilot ≠ demo ≠ full scale)
    - ➢ How to scale for comparison across maturity?
- Scaling means uncertainty



How to deal with these issues?

Benchmarking of technologies in early stage of development



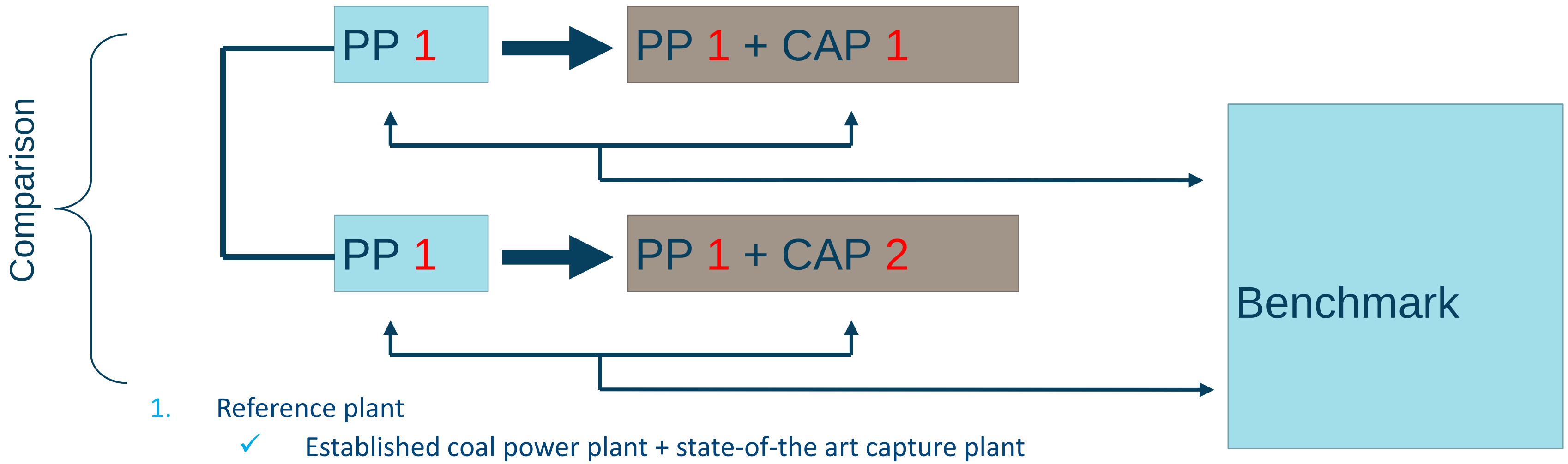
Identify potential + compare across maturity

Different technologies, different potential, different maturity

- Comparing different technologies in HiPerCap major steps:
  - ✓ Collecting data from technology developers and modellers
  - ✓ Establish/develop process concepts
  - ✓ Modelling processes in a consistent manner
  - ✓ Same scale for all processes
  - ✓ Define application
    - ✓ Source and reference plant

Reference

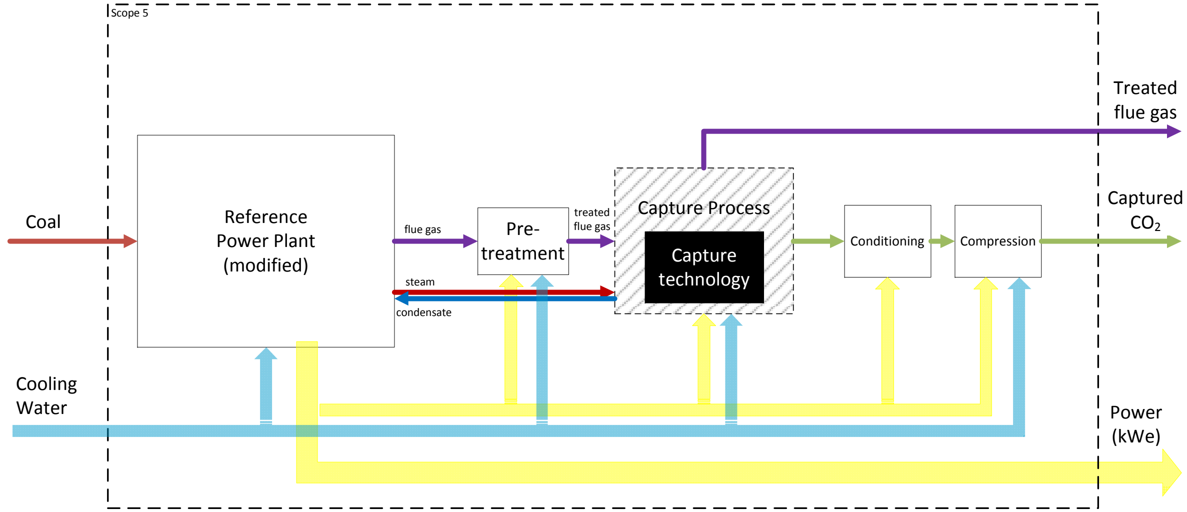
- When a peer group doesn't exist one could use a well defined reference plant.

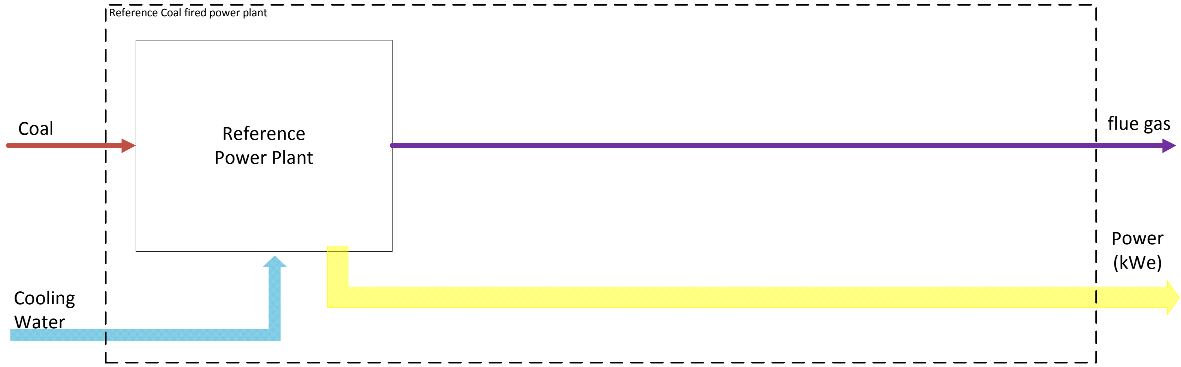


1. Reference plant
   - ✓ Established coal power plant + state-of-the art capture plant
2. Plant to be benchmarked

- In HiPerCap the power plant is defined based on the EBTF report; "European best practice guidelines for assessment of CO_2 capture technologies" and the state-of-the-art capture plant is based on the solvent system demonstrated in the EU project CESAR:
  - ✓ Advanced supercritical (ASC) pulverised coal fired plant with 819 Mwe Gross output
  - ✓ Conventional absorption cycle with CESAR1 (AMP+Piperazine) solvent system

Scope of the assessment





Overall comparison

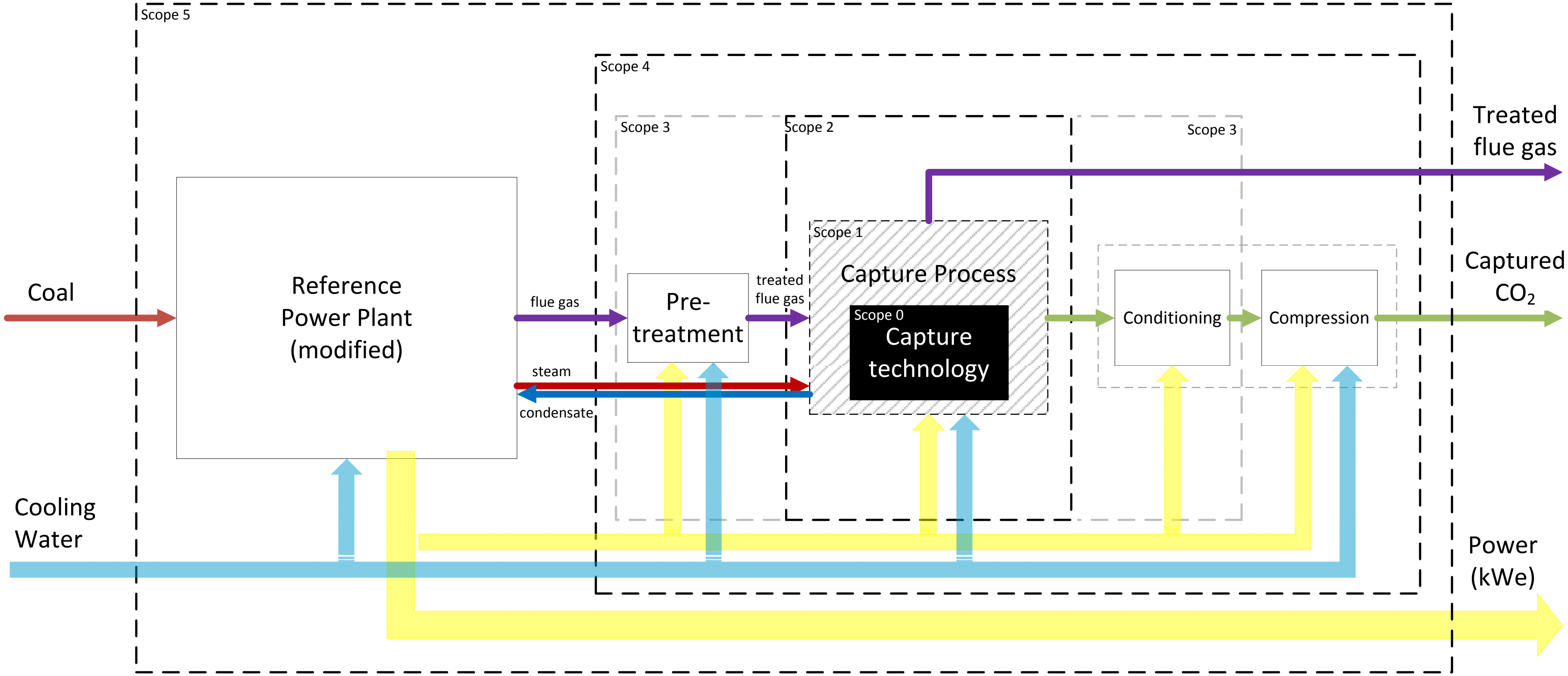
On level of key indicators the following performance can be determined:

Indicator Energy

Indicator Environmental

Indicator Cost

Approach and workflow for the assessment and comparison



Assessment in two stage approach:

1. Check for environmental issues and enough data
2. Complete assesment at same level

Further work

- The methodology (including detailed description of the reference plant) is described in a deliverable and
  - ✓ Plan to write a journal publication
- Start collecting data
- Make the assessment for the screening stage
- Determine the KPIs for remaining technologies and make the final assessment and benchmarking
- Determine the two most promising one for further studies
  - ✓ Establish roadmaps for further development and demonstration

Acknowledgements

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