



Role of CO₂ reuse and its policy implications - introduction

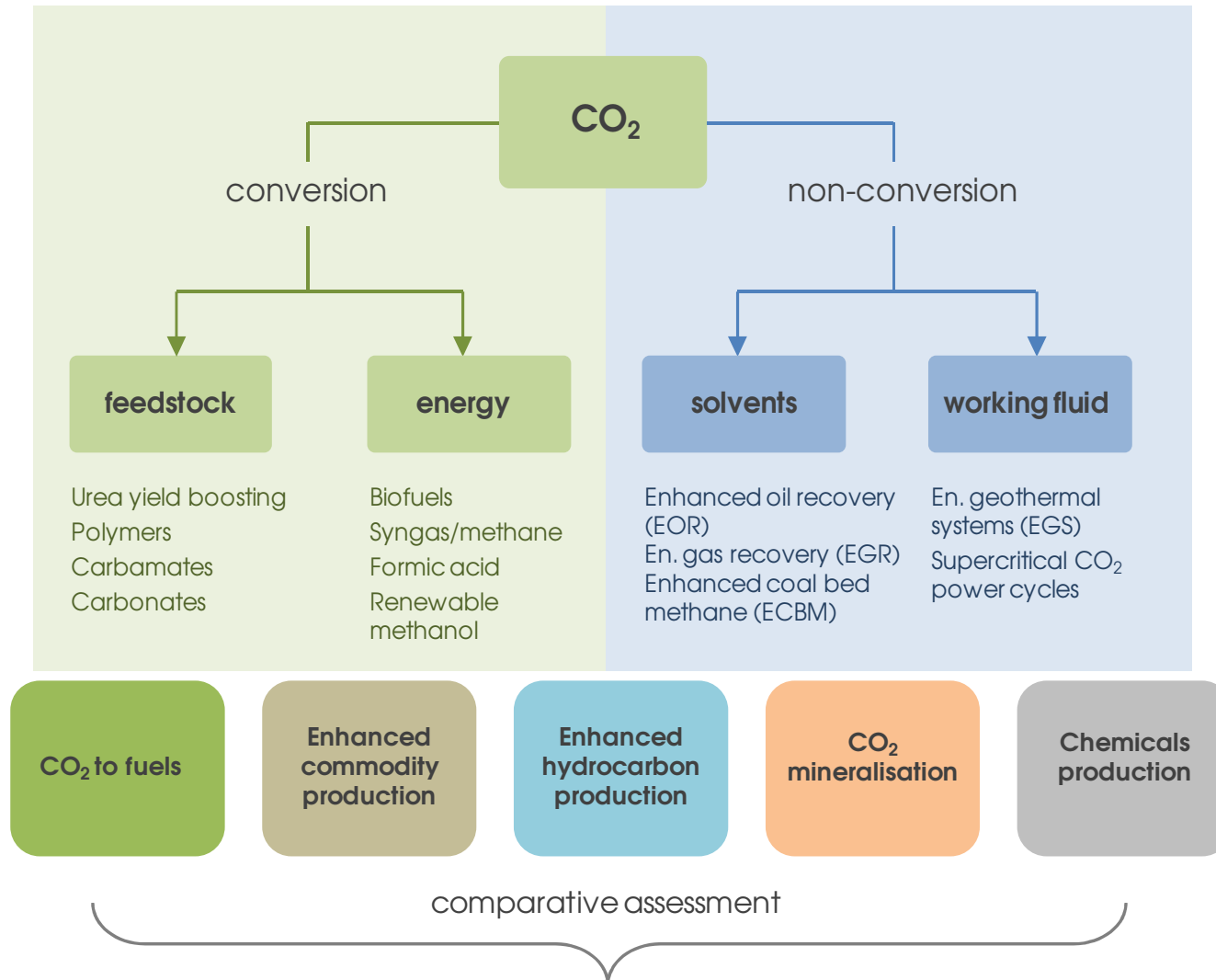
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CO₂ reuse: interest increases

- Progress on CCS is slowing down
- Stepping stone for implementing CCS and public acceptance of CCS
- The CO₂ value chain needs to be improved
- CCU addresses more (policy) targets than climate change only

CO₂ reuse technologies





Study focuses

- on emerging applications
- the reuse potential; market creation; GHG abatement;
- the applicability to the EU?

Current status of CO₂ reuse technologies

CCU category	CCU technology	Research	Demonstration	Economically feasible under certain	Mature market
CO ₂ to fuels	Hydrogen (renewable methanol)				
	Hydrogen (formic acid)				
	Algae (to biofuels)				
	Photocatalytic processes				
	Nanomaterial catalysts				
Enhanced commodity production	Power cycles (using scCO ₂)				
	Enhanced production (urea; methanol)				
Enhanced hydrocarbon recovery	Miscible/immiscible floods (CO ₂ -EOR)				
	Miscible/immiscible floods (CO ₂ -EGR)				
	Sorption-based displacement (ECBM)				
CO ₂ mineralisation	Carbonate mineralisation				
	CO ₂ concrete curing				
	Bauxite residue carbonation				
Chemicals production	Sodium carbonate				
	Polymers				
	Other chemicals (e.g. acetic acid)				
	Algae (for chemicals)				

 Main activities
 Some activities

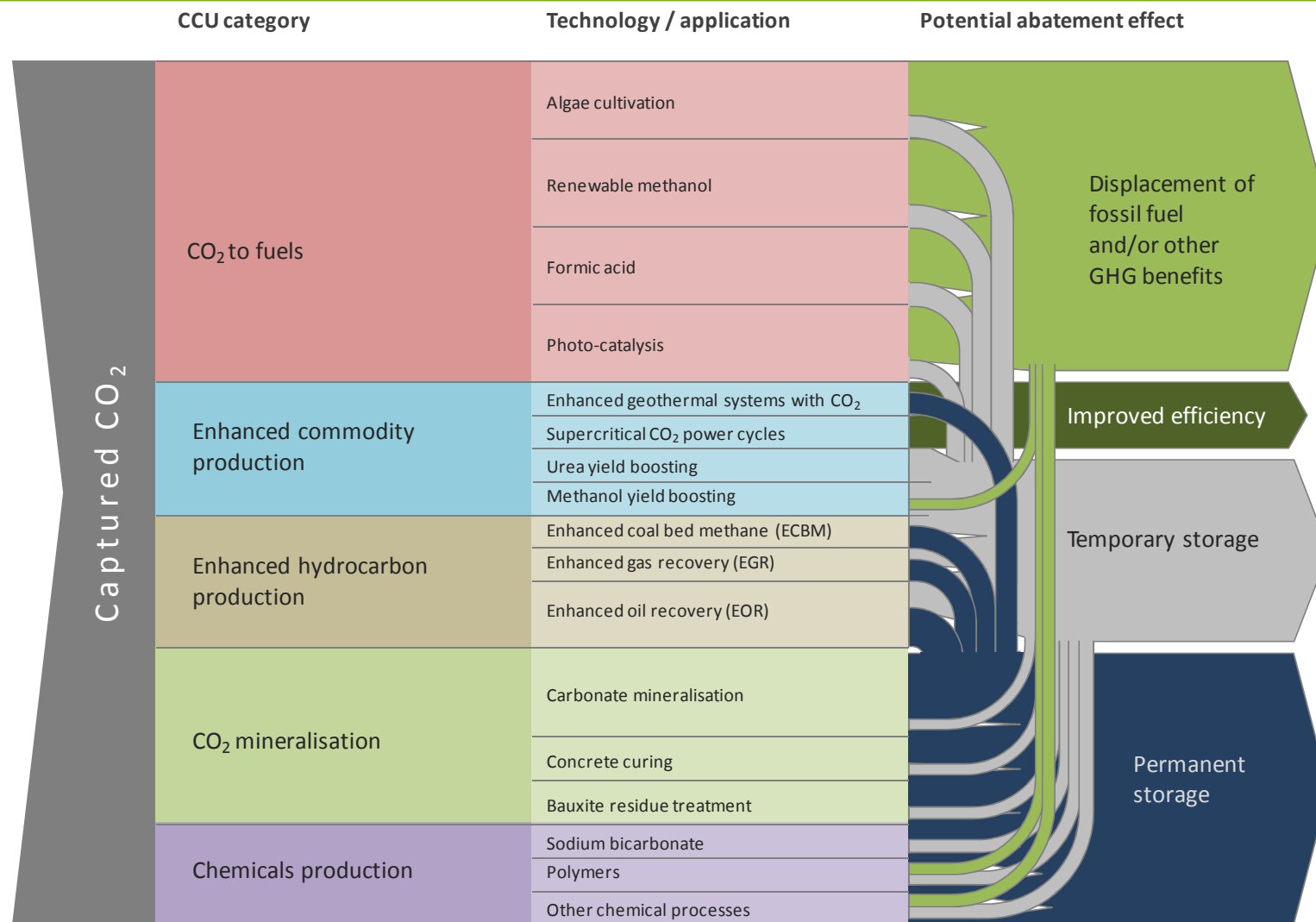
Economics of CO₂ reuse technologies

CCU category	CCU technology	Sources of Revenues	Market develop't issues	Costs	Barriers to commercial
CO ₂ to fuels	Hydrogen (renewable methanol)	Fuel	Fuel specifications	Variable	Competition from other fuels
	Hydrogen (formic acid)	Fuel	Competition	High	High costs
	Algae (to biofuels)	Broad	Variable across mkts	High	Scale
	Photocatalytic processes	Fuel	Competition	High	Scale
Enhanced commodity production	Power cycles (using scCO ₂)	Power	Unclear	Unclear	Limited interest
	Enhanced production (urea; methanol)	Fertiliser	Market demand	Low	Few
Enhanced hydrocarbon recovery	Miscible/immiscible floods (CO ₂ -EOR)	Oil	Competition	Variable	Variable
	Miscible/immiscible floods (CO ₂ -EGR)	Gas	Competition	Variable	Viability
	Sorption-based displacement (ECBM)	Gas	Competition	Variable	Viability
CO ₂ mineralisation	Carbonate mineralisation	Construction	Scale	High	High costs
	CO ₂ concrete curing	Construction	Competition	High	High costs
	Bauxite residue carbonation (red mud)	Avoided cost	Niche	Unclear	Replicability
Chemicals production	Sodium carbonate	Bulk chemicals	Market demand	Unclear	Unclear
	Polymers	Chemicals	Competition	Improving	High costs
	Other chemicals (e.g. acetic acid)	Chemicals	Variable across mkts	Variable	High costs

1. Reducing CO₂ emissions

- CO₂-based products replaces fossil fuels
 - The CO₂ utilisation process provides the opportunity to use energy when supply is high and demand is low
- The CO₂ utilisation process reduces the CO₂ *process* emissions
- The CO₂ utilisation process is more energy efficient than the alternative production process
- The CO₂ utilisation process fixes or stores carbon for (considerable) period of time

CO₂ reuse and climate policy



2. Reducing other environmental impacts

- Bauxite carbonation (“red mud”)
 - stabilise mine tailings, with attendant environmental benefits
- Polycarbonate production involves the reaction of bisphenol A with phosgene gas
 - Bisphenol A: public health concerns over the exposure of humans to trace levels in polycarbonates
 - Phosgene: posing occupational health issues during the production
- Algae and photocatalytic routes to biofuels
 - using brackish water; eliminating land competition for agricultural production and potable water resources

3. CO₂ utilisation process cost-competitive

- The availability of low-cost carbon dioxide
- Use of CO₂ to enhance hydrocarbon recovery like oil (EOR) or natural gas (EGR)
- CO₂-based products have superior properties compared to its alternative
- Use energy when it is abundantly available
 - access wind or solar energy
 - low-grade energy (e.g. waste heat)

4. Alternative to oil as source of carbon

- Oil is the main sources of carbon for the petrochemical industry
- Utilisation of carbon dioxide will reduce the dependency on oil as a carbon feedstock
- With some forms of utilisation of carbon dioxide, the carbon is retained within a cycle, reducing the need for addition supply of carbon

5. Improve security of energy supply

- Algae as source of energy, e.g. for transport fuels
- Production of fuels using renewable energy
 - Energy storage avoiding the issues with intermittence of the wind or solar energy supply

Summarised: impacts of CO₂ reuse application

1. reduces the net emissions of carbon dioxide to the atmosphere, and/or
2. reduces other environmental impacts, and/or
3. it offers a cost-competitive alternative, and/or
4. it provides an alternative to oil as a source of carbon, and/or
5. it provides other benefits, e.g. reducing energy dependency by producing energy locally

What can CO₂ reuse offer for policy targets?

- Climate Action
 - Reducing CO₂ emissions
 - Supporting introducing CCS
- Energy policy – enhancing security of supply
 - Enhanced hydrocarbon production
 - Improved use renewables
 - Enhanced biomass production
- Industry policy and innovation
 - Creation of new products, value chains and more efficient use of resources

Barriers to uptake of CCU

- Economic
 - CCU is generally not economically attractive compared to alternative means of supplying the same goods or service
- R&D
 - CCU is generally not an identified topic in research programmes, like FP7
- Policy & Regulatory
 - recognition of CCU applications as CO₂ abatement techniques
 - not included in carbon pricing schemes
 - acceptance of products derived from CO₂ utilising processes in the relevant end markets

Conclusions / wrap up

- CCU is very divers portfolio of technologies
- CCU offer various potential benefits
- CCU may contribute to various policy targets (climate, energy security, industry & innovation)
 - Extent to achieve this policies unclear
 - Current potential to avoid emissions seems limited and innovation required to boost the potential
- Implications of CCU for current and future policies are unclear

Thank you!

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