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International Institute for  
Applied Systems Analysis  
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science for global insight

# Draft: Modelling Carbon Neutrality –

## Approach to Technology Deep Dives

02 June 2021



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# Technology Deep Dives

## **Three deep dives** under investigation:

- Carbon capture and storage (CCS) and direct air capture (DAC)
- Nuclear energy (Small Modular Reactors (SMR))
- Hydrogen pathways

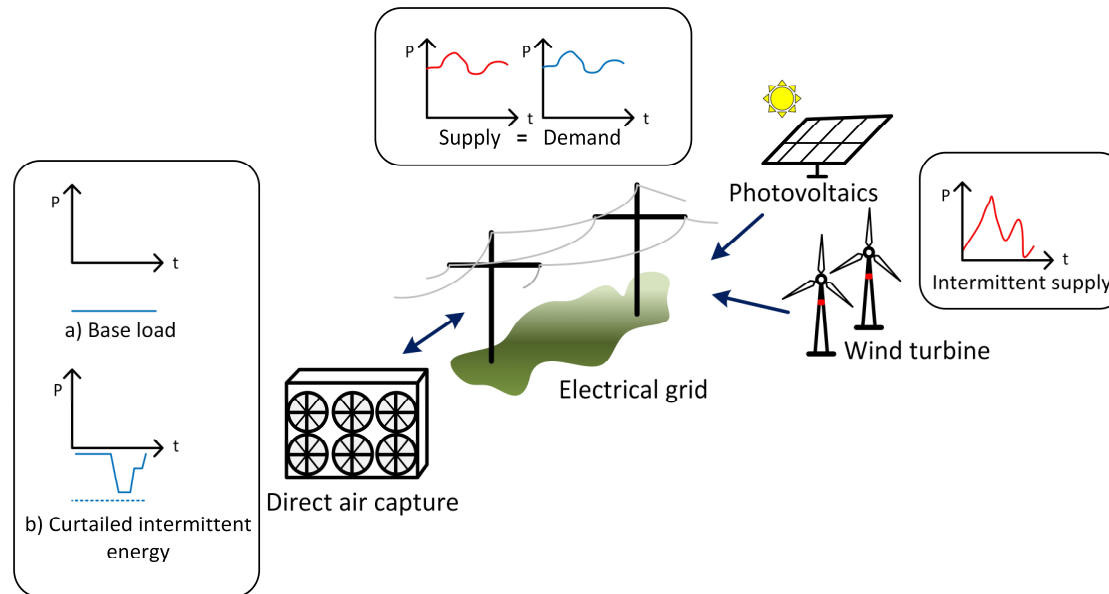
## **Objectives of deep dives:**

- Improving the model for better representation of technologies/processes
- Exploring the role of innovation (cost reduction) and new use cases in diffusion of these technologies
- Sensitivity analyses and looking into technology interplays

# Direct Air Capture (DAC) and CO<sub>2</sub> storage

## Questions?

- CO<sub>2</sub> potential in different regions in the world
- Role of DAC in different cost development assumptions
- Role of different DAC technology configurations, based on the services they can provide
- Impact of upscaling of DAC on other technologies (e.g., integration of wind and solar)



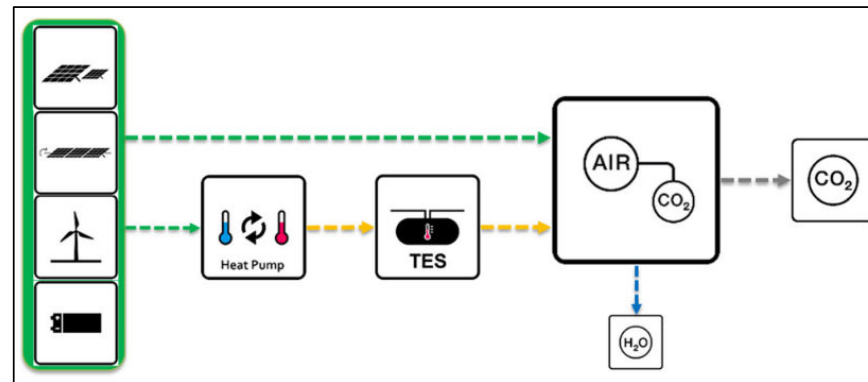
# Four DAC designs added to MESSAGE

## Techno-economic assessment

Source: Benjamin Mitterutzner

Technology	Thermal energy input	Operability	Energy input		Economics		Water input usage (t/tCO <sub>2</sub> )	Effective FLh
			kWh <sub>el</sub> /t	kWh <sub>th</sub> /t	capex (€/tco <sub>2</sub> *a)	opex (€/tco <sub>2</sub> *a)		
HT aqueous solution	electrical (+battery)	Intermittency	1535.0	0.0	1160.4	39.6	4.3	8000
HT aqueous solution	electrical	Base load	1535.0	0.0	815.0	30.2	4.3	8000
HT aqueous solution	natural gas	Base load	0.0	2450.0	1032.0	38.2	4.3	8000
LT solid sorbent	heat pump (+ heat storage) + battery	Intermittency	888.8	0.0	1272.3	39.2	0.0	8000

Climeworks  
 Carbon Engineering



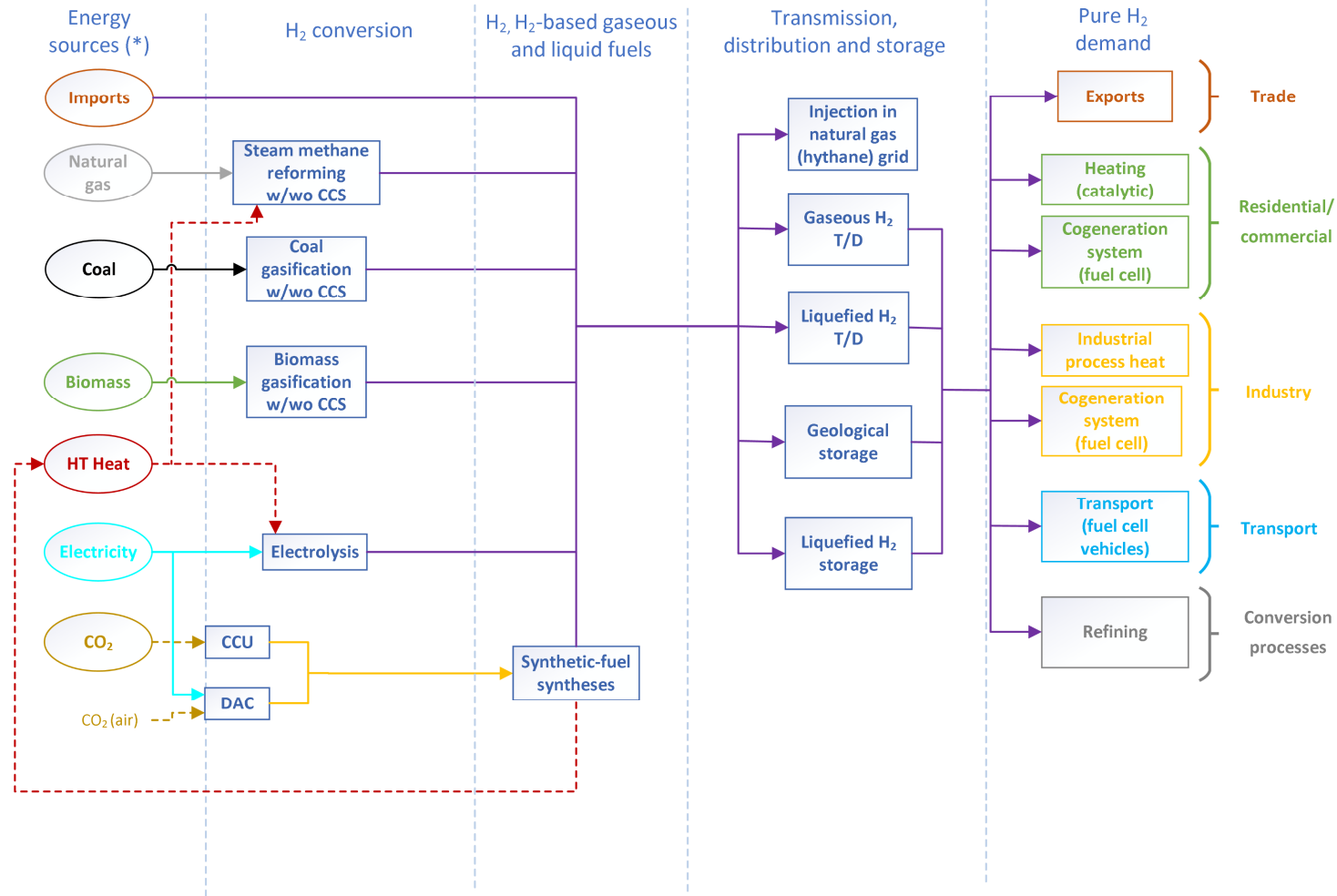
Source: Breyer, C., Fasihi, M., & Aghahosseini, A. (2020). Carbon dioxide direct air capture for effective climate change mitigation based on renewable electricity: a new type of energy system sector coupling. *Mitigation and Adaptation Strategies for Global Change*, 25(1), 43-65.

# Nuclear energy

## Questions?

- Role of nuclear energy in the carbon neutrality scenario
- Possible role of small modular reactors (SMR)
  - Offering higher flexibility in operation (power balancing services)
  - Providing low-temperature heat in district heating (DH)
  - Providing high temperature process heat in the industry
  - Combination with other processes, e.g., in hydrogen production
  - Deployment rate and technological diffusion
- Potential share of SMR in each of the use cases
- Which world regions can upscale the technology faster (role of technology readiness and existing policies)

# Hydrogen representation in *MESSAGE<sub>ix</sub>*



# Power-to-X in *MESSAGE<sub>ix</sub>*

