NEGEM

Quantifying and Deploying Responsible Negative Emissions in Climate Resilient Pathways

Presentation for Work Packages 4 & 7

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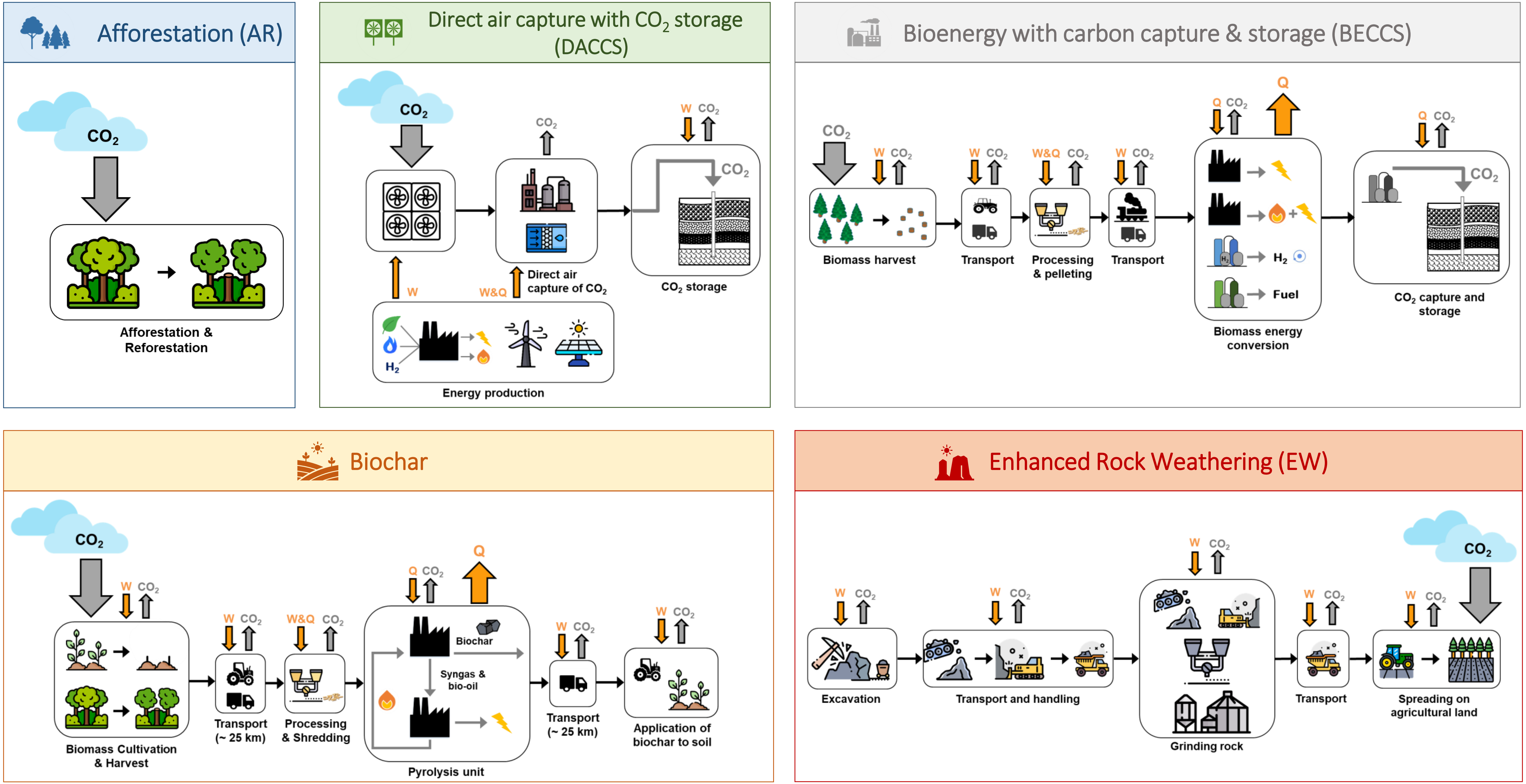
NETPs in the MONET-EU framework



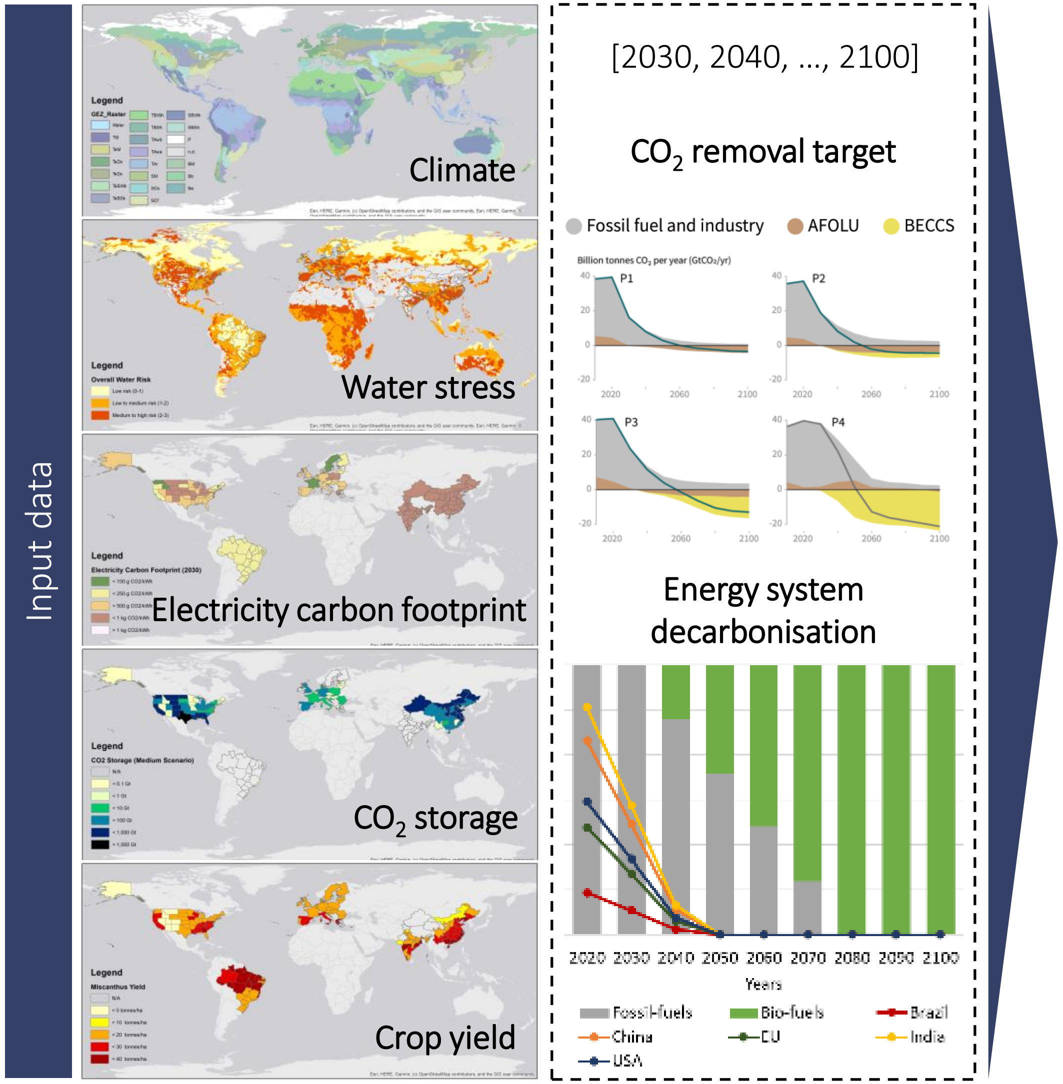
Factors that influence the domestic CO_2 removal potential

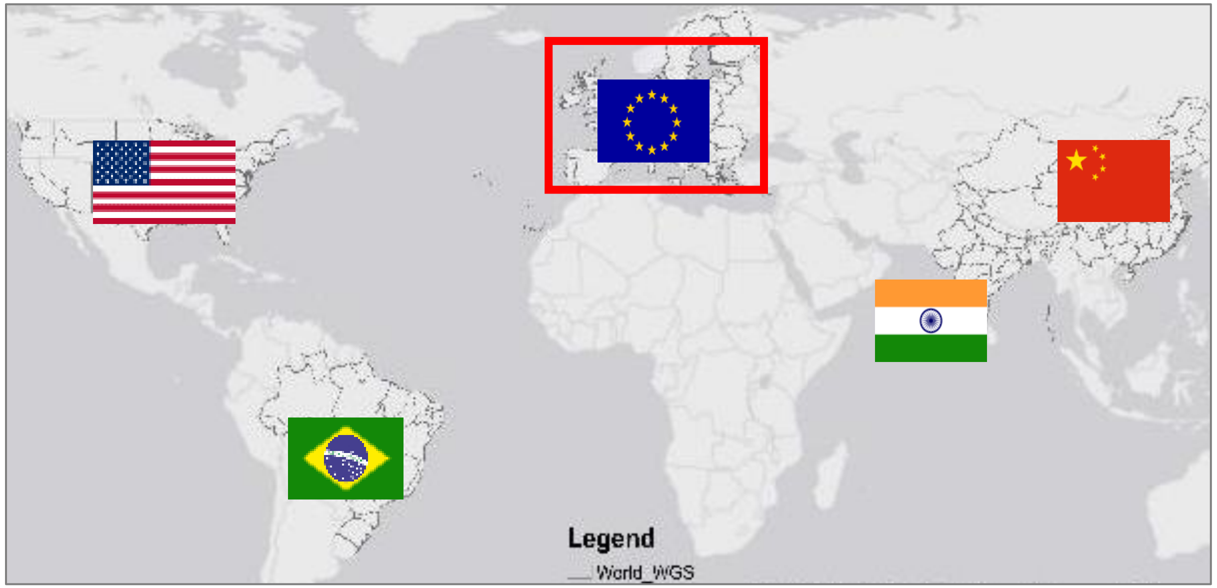
BECCS	Potential is function of types of biomass feedstocks and their availabilities. Technology archetypes and the CO_2 capture rates. Emissions from processing in the supply chain. CO_2 sequestration potential.
Biochar	Very similar to the list for BECCS. Scale- and output-dependent constraints and highly variable based on method of production. Soil and environment conditions.
Afforestation	Depends on forest management and the type of land used – new land or land with reforestation potential? Indirect emissions from energy and supply chain.
Enhanced Weathering	Availability of basic rock formations. Indirect emissions from energy and equipment. Particle size and weathering rates. Soil characteristics.
DACCS	Technology archetypes – requires different energy sources, e.g., electricity and/or low temperature heat, high temperature heat. Depends on availability of low carbon energy sources and CO_2 sequestration potential.

Modelling & Optimisation of Negative Emissions Technologies (MONET)

Spatial

Temporal





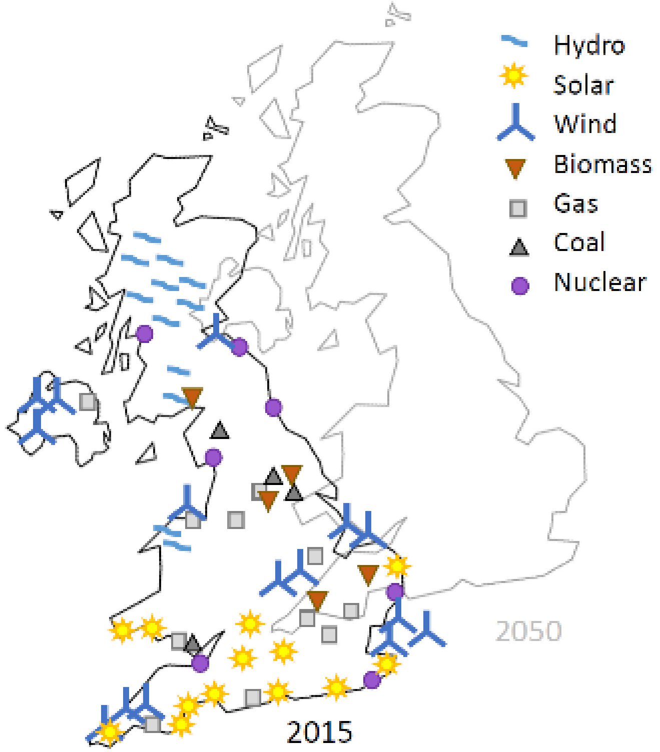
minimise:

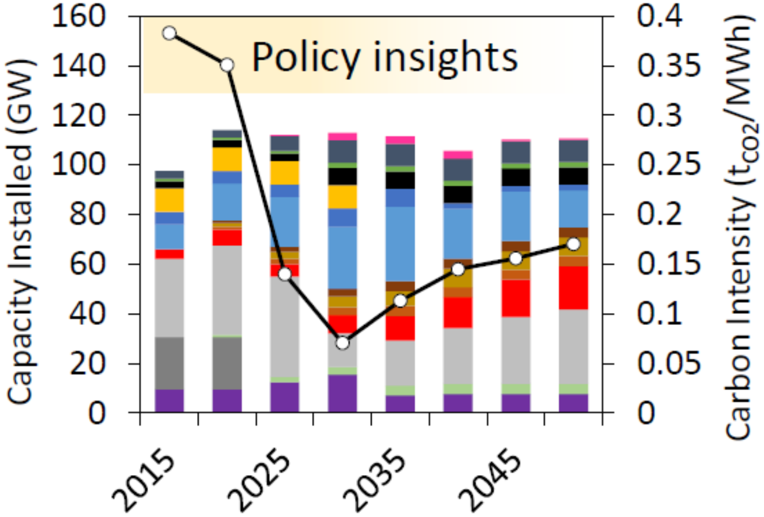
subject to:

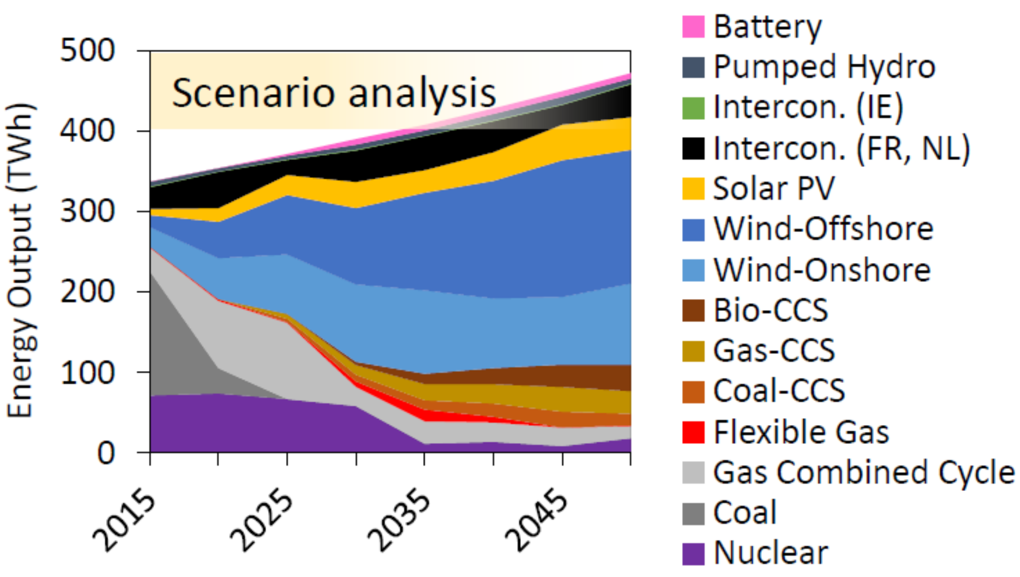
BECCS	CO_2 Removal Target	CO_2 Storage
DACCS		
Afforestation	Land Availability	Water Stress
EW		
Biochar		

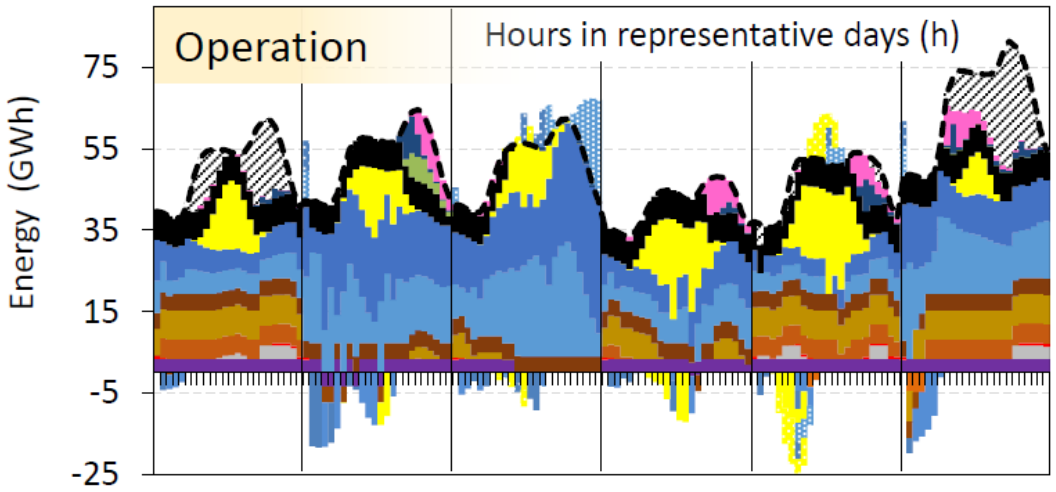
Fajardy, M. & Mac Dowell, N. (2017). Energy and Environmental Science, 10 (6), 1389-1426.
Fajardy, M. & Mac Dowell, N. (2018). Energy & Environmental Science, 11 (6), 1581-1594.
Fajardy, M., Chiquier, S. & Mac Dowell, N. (2018). Energy & Environmental Science. 11, 3408-3430.

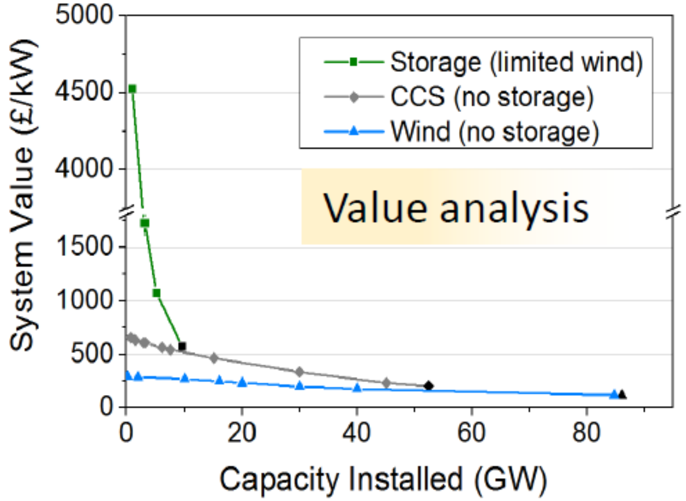
Electricity Systems Optimisation (ESO) Framework











ESO is available for different countries (e.g., Spain, Poland)

Heuberger, C. F., et al. (2016). Energy & Environmental Science, 9 (8), 2497-2510.
Heuberger, C. F. & Mac Dowell, N. (2018). Joule, 2 (3), 367-370.

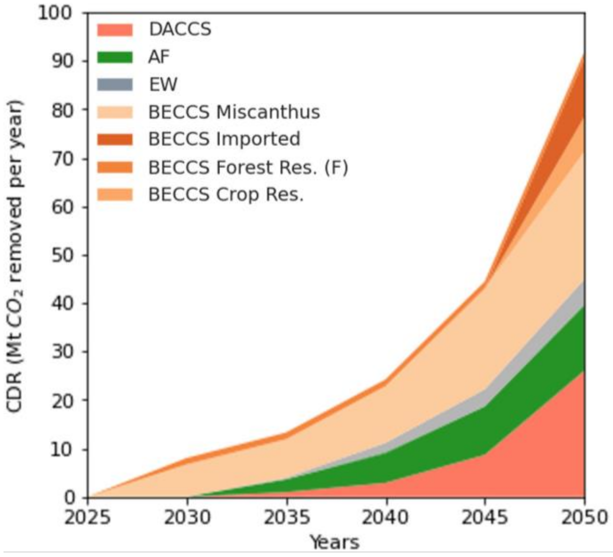
Heuberger, C. F., et al. (2018). Nature Energy, 3 (8), 634-640.
Pratama & Mac Dowell, (2019). https://iea.blob.core.windows.net/assets/c3ddfd83-9b65-425d-aa09-7707e97ed0b3/RoleValueofCCSReport.pdf

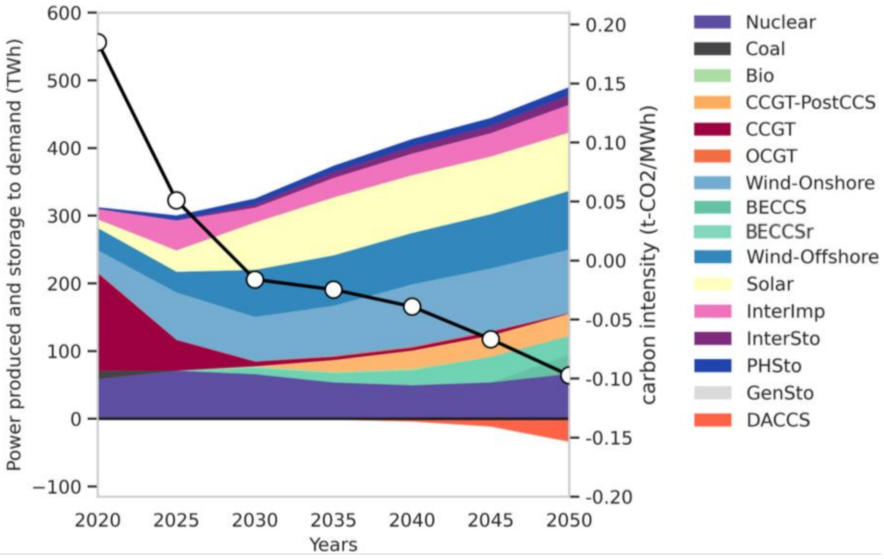
UK Case study: Impact of CDR deployment on the electricity grid

CDR target: 90 $MtCO_2$ removal by 2050

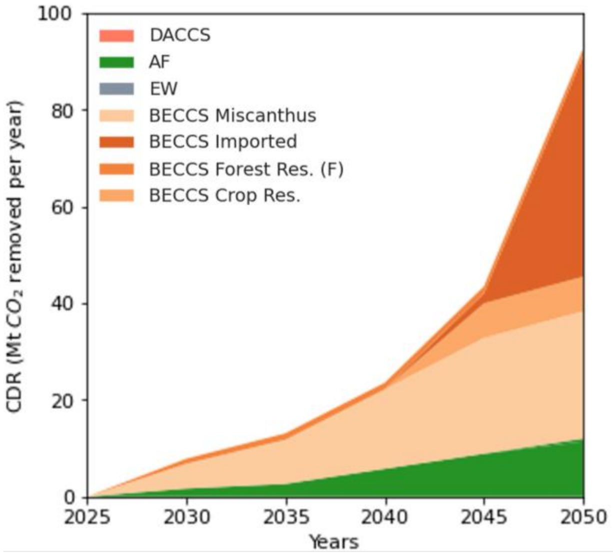
CDR system | Electricity system

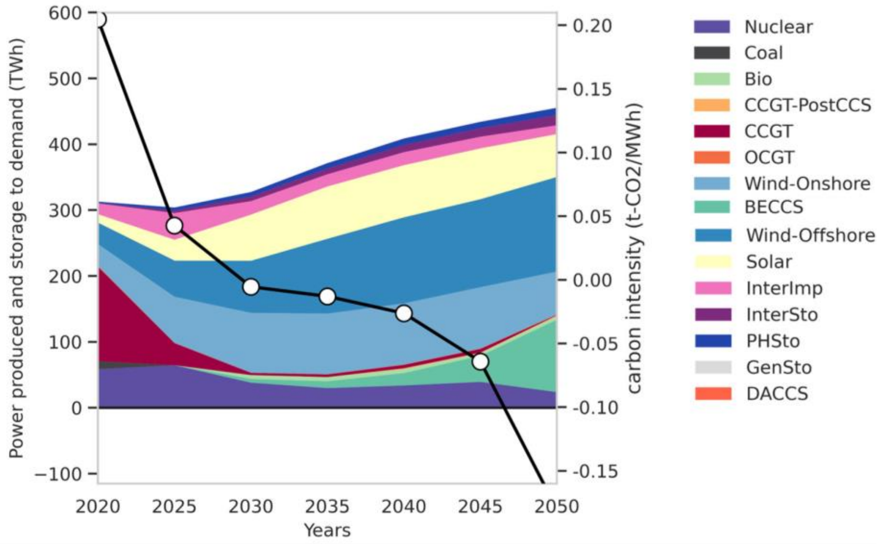
All CDR technologies & Low biomass availability





All CDR technologies & High biomass availability





In the limited biomass scenario, BECCS delivers up to 46 Mt CO_2 per year of removal by 2050.

With increased biomass availability, more BECCS is deployed, reducing the share of DACS.

AF is limited by anticipated plantation rates. EW is limited by rock availability, type and particle size.

DACS is deployed after other CDR options have reach their maximum potential (i.e., DACS is used last).

Source: A. Prado, S. Chiquier, M. Fajardy and N. Mac Dowell, (2023), Assessing the impact of carbon dioxide removal on the power system. iScience, 26, 106303. https://doi.org/10.1016/j.isci.2023.106303

MONET-JEDI: Evaluating the socio-economic impacts of CDR deployment

Socio-economic analysis → Investment analysis → Sector disaggregation → Impact analysis

OECD/ILOSTAT Database

Socio-economic indicators

- GVA
- Employment rate
- Household income
- Labour share of GVA
- Wages
- I/O tables

OECD | ILO

MONET-EU model

Sector disaggregation

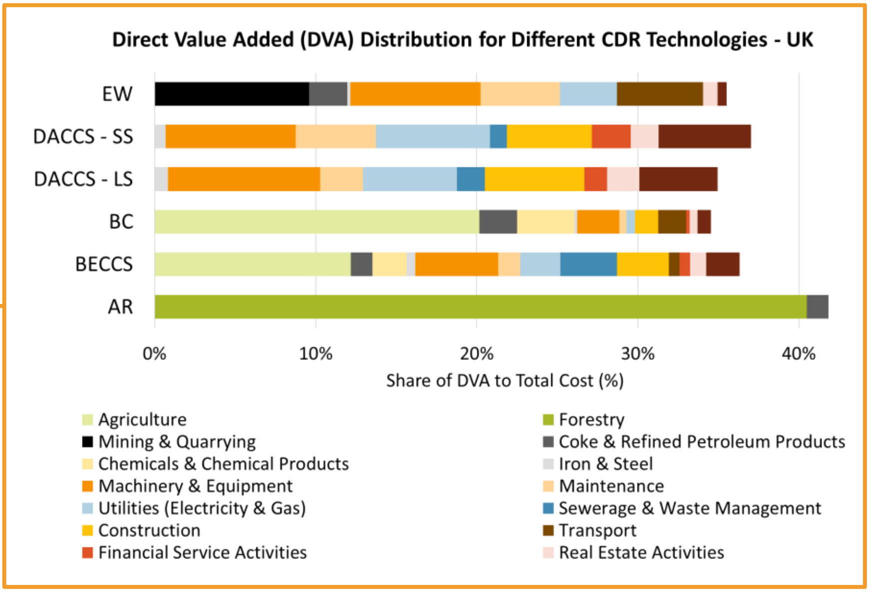
JEDI model

Direct Impacts

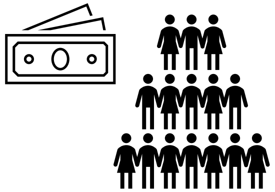
$$VA_{c,i,t} = Output_{i,t} \times \%VA_{c,i}$$

$$Jobs_{c,i} = \frac{\sum_t (VA_{c,i,t} \times \%Labour_{c,i})}{Wages_{c,i}}$$

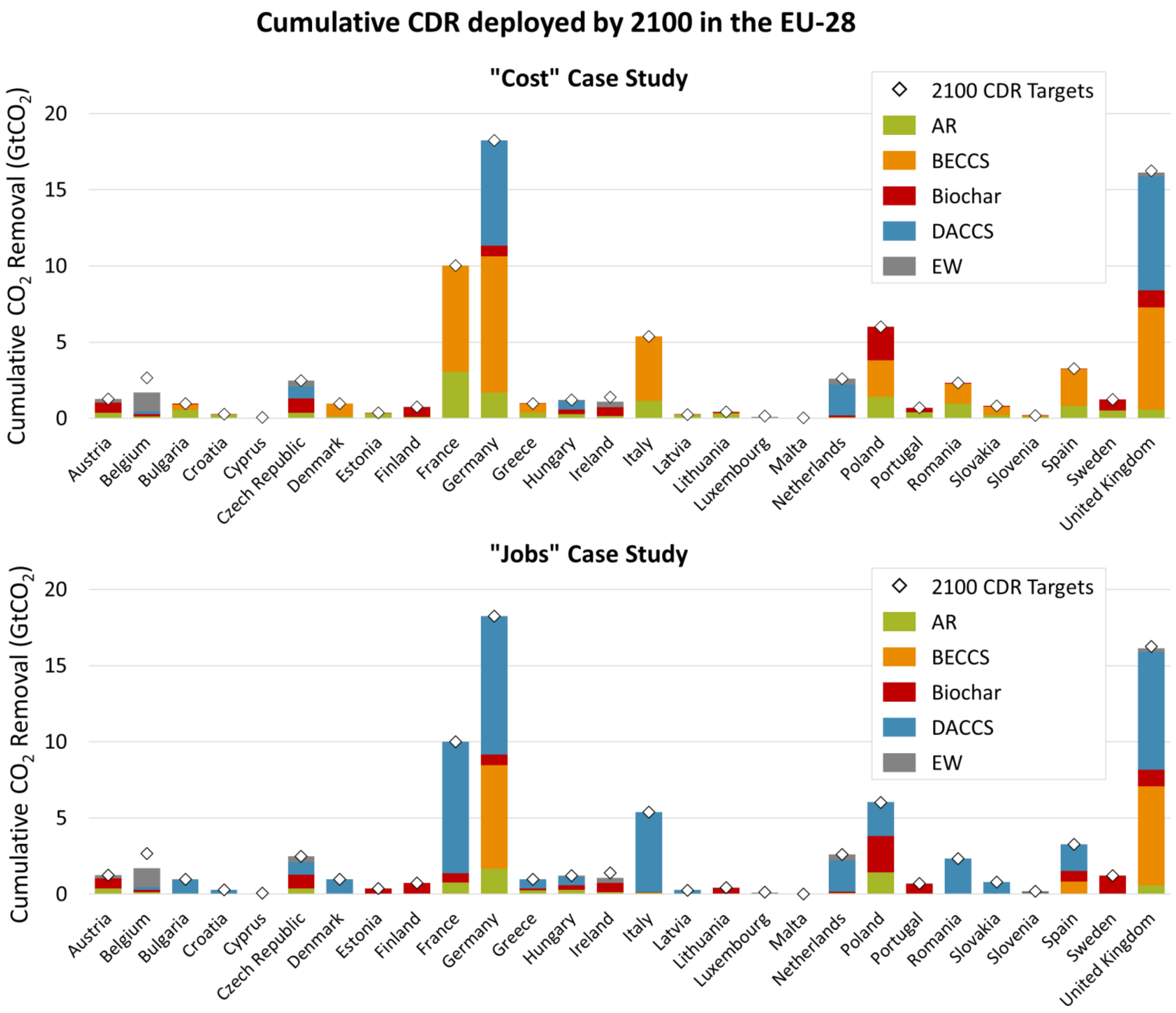
NREL NATIONAL RENEWABLE ENERGY LABORATORY



Determines the socio-economic impacts, e.g. GDP or job creation



Solene Chiquier, Piera Patrizio, Nixon Sunny, Niall Mac Dowell, (2022). Link MONET-EU and JEDI. https://www.negemproject.eu/wp-content/uploads/2022/06/NEGEM_D7.3_Link-MONET-EU-and-JEDI.pdf
Patrizio, et al. (2018). Reducing US coal emissions can boost employment. Joule, 2 (12), 2633-2648. https://doi.org/10.1016/j.joule.2018.10.004
Patrizio, P., et al. (2020). Socially equitable energy system transitions. Joule, 4 (8), 1700-1713. https://doi.org/10.1016/j.joule.2020.07.010



Cumulative CDR deployment by 2100 in Europe

EU Member States must meet a cumulative CDR target of up to 81 Gt CO_2 of removal by 2100. Two scenarios were investigated:
"Cost" – minimising the total system cost
"Jobs" – maximising the GVA of the system

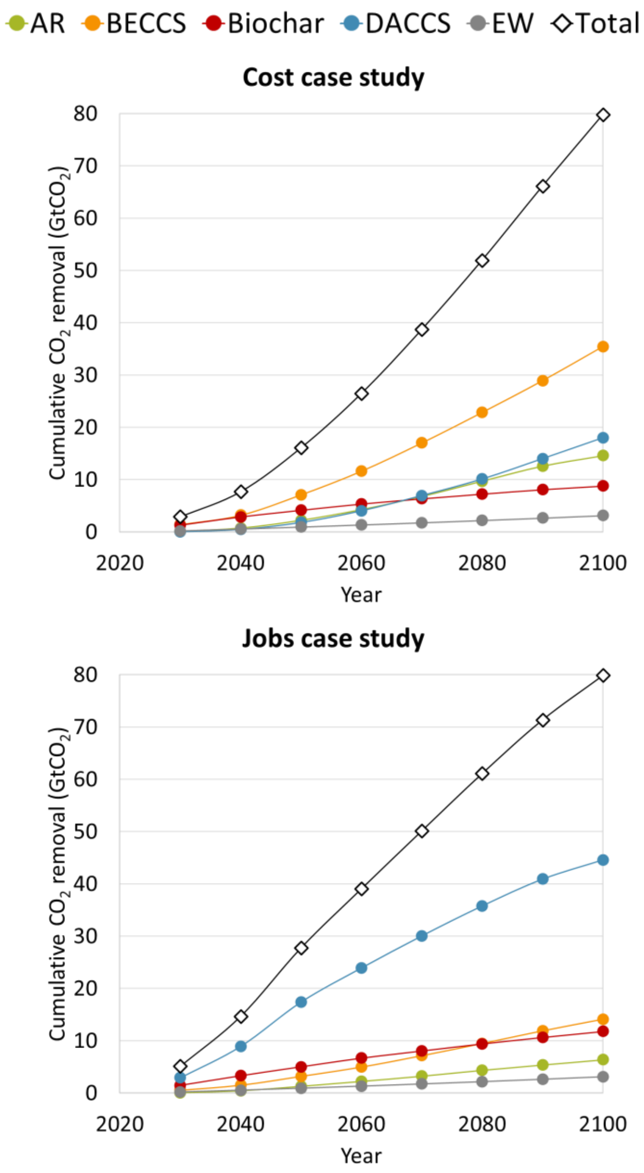
Distribution of CDR targets in line with the responsibility-based burden sharing principle and IPCC's P2 pathway.

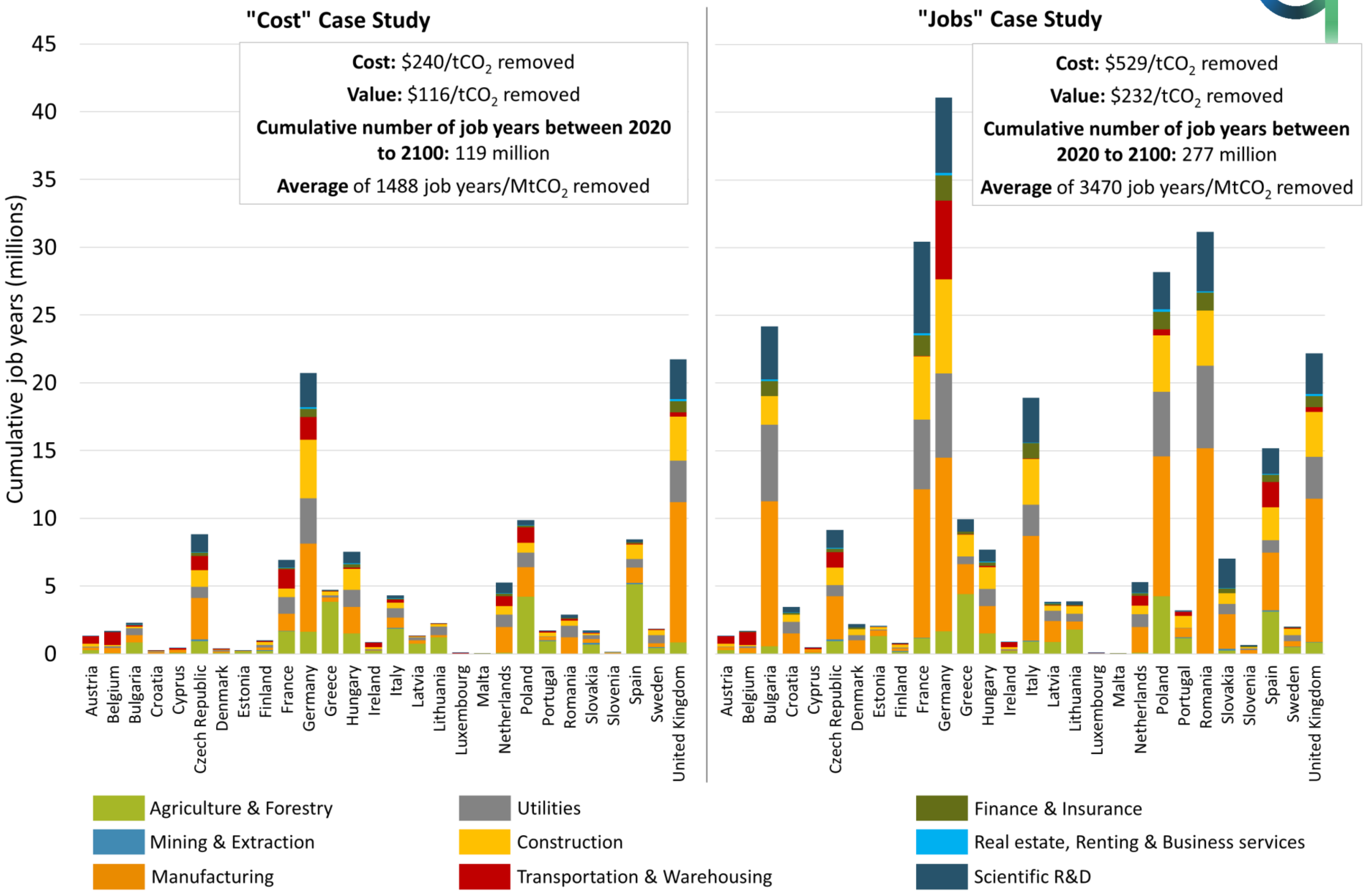
"Cost" case study mainly relies on cheaper biomass-based CDRs such as afforestation (AF), biochar and BECCS.

"Jobs" case study prioritizes technical CDR methods such as DACCS which increases average CDR cost.

Solene Chiquier, Piera Patrizio, Nixon Sunny, Niall Mac Dowell, (2022). Link MONET-EU and JEDI. https://www.negemproject.eu/wp-content/uploads/2022/06/NEGEM_D7.3_Link-MONET-EU-and-JEDI.pdf
Mai Bui, Nixon Sunny, Solene Chiquier, Piera Patrizio, Niall Mac Dowell, (2024). NEGEM Report for Task 7.4 Quantify the socio-economic value of intra-European collaboration.

MONET-JEDI: Evaluating the socio-economic impacts of CDR deployment





Solene Chiquier, Piera Patrizio, Nixon Sunny, Niall Mac Dowell, (2022). Link MONET-EU and JEDI. https://www.negemproject.eu/wp-content/uploads/2022/06/NEGEM_D7.3_Link-MONET-EU-and-JEDI.pdf
Mai Bui, Nixon Sunny, Solene Chiquier, Piera Patrizio, Niall Mac Dowell, (2024). NEGEM Report for Task 7.4 Quantify the socio-economic value of intra-European collaboration.

Conclusions: WP4 & WP7 key insights

Effect of CDR deployment on the power system

- Potential synergies between CDR options and the power sector (e.g., BECCS an energy producer, whereas DAC and EW are energy consumers) are explored with the MONET-ESO modelling system.
- BECCS is limited by biomass availability (national and imports). In the limited biomass scenario, BECCS delivers up to 46 Mt CO_2 per year of removal by 2050.
- DAC is deployed after all other CDR reach their maximum potential (i.e., DAC is used last).
- AF is limited by anticipated plantation rates.
- Dispatchable, low carbon power is needed to balance intermittent renewables (e.g., BECCS or CCGT). BECCS displaces natural gas with CCS by up to 4 times & intermittent renewables by up to 10%.

Socio-economic impacts of CDR deployment

- Cost case study – greater deployment of biomass-based CDR is expected to increase direct value added (DVA) in the agricultural and forestry sectors. Average cost of removal in 2100 is at \$240/tCO_2.
- Jobs case study – increased levels of DAC results in high average cost of removal at \$529/tCO_2 by 2100. Significant increase in GVA and jobs compared to the "Cost" case study (manufacturing and construction).

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Questions or comments?

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