The Role of Projects of Common Interest in Reaching Europe's Energy Policy Targets★

Bobby Xiong[a,*], Iegor Riepin[a], Tom Brown[a]

[a]*Technische Universität Berlin, Department of Digital Transformation in Energy Systems, Berlin, Germany*

Abstract

The European Union (EU) aims to achieve climate-neutrality by 2050 — with ambitious 2030 targets — including a 55 % reduction in greenhouse gas emissions, 10 Mt p.a. of green H_2 production, and 50 Mt p.a. of CO_2 sequestration. The European Commission bi-annually selects so-called Projects of Common Interest (PCI) and Projects of Mutual Interest (PMI) which are of transnational importance as they link the energy systems of European countries. Using the open-source, sector-coupled energy system model PyPSA-Eur, we assess the impact of PCI-PMI projects on the EU energy system, focusing on power, heat, transport, industry, and agriculture. We look into how a delay of such projects may impact reaching the EU's policy targets, and explore how the different policy targets conflict with the overall greenhouse gas reduction target. While preliminary results for 2030 suggest that the policy targets can be achieved even without PCI-PMI projects, they bring additional benefits: i) H_2 pipelines improve affordability and distribution of green H_2 and kickstart the hydrogen economy, ii) CO_2 transport projects connect major industrial emissions to offshore sequestration sites in the North Sea. Next steps include incorporating all remaining PCI-PMI projects, i.e. hybrid interconnectors and CO_2 shipping routes, as well as the assessment of long-term pathway effects towards 2050. Our findings underscore the interplay between cross-border cooperation, infrastructure investments, and policy targets in the European energy transition throughout all sectors.

Keywords: energy system modelling, energy policy, infrastructure, resilience

43rd IEW relevant conference topics

Reaching net-zero emissions and climate neutrality (1) Role of renewable energy in the energy transition (2) Role of hydrogen, ammonia, e-fuels and e-methane in the energy transition (3) Managing power system transitions — integration of variable renewable energy and power-to-X (4) Sectoral pathways for the energy transition — transport, industry, and buildings (5) Energy transition infrastructure — assessment of infrastructure to enable the energy transition, including electrical transmission, storage, EV charging, and hydrogen distribution, CCS and CDR (6) Climate resilience of energy systems (12) Utilisation of scenarios by governments (13)

1. Introduction and motivation

On the pathway to a climate-neutral Europe by 2050, the European Union (EU) has set ambitious targets for 2030, three of the most prominent including a reduction of 55 % in greenhouse gas emissions [1], 10 Mt p.a. green H_2 production [2], and 50 Mt p.a. CO_2 sequestration [3].

To support reaching these targets, the EU has identified a list of Projects of Common Interest (PCI) which are key cross-border infrastructure projects that link the energy systems of EU countries, ranging from storages, over transmission lines to pipelines and carbon sinks [4], based on projects submitted by transmission system operators, consortia, or third parties. Projects of Mutual Interest (PMI) further include cooperations with countries outside the EU, such as Norway or the United Kingdom. With a PCI-PMI status, project awardees receive strong political support and are, amongst others, eligible for financial support (e.g. through funding of the Connecting Europe Facility) and see accelerated permitting processes. On the other hand, project promoters are obliged to undergo comprehensive reporting and monitoring processes. In order for projects to be eligible for PCI-PMI status, their potential benefits need to outweigh their costs [4]. Given the political and lighthouse character, these projects are highly likely to be implemented. However, any large infrastructure project, including PCI-PMI projects, commonly face delays due to permitting, financing, procurement bottlenecks, etc. [5].

Research questions. From the ambitious policy targets and the nature of PCI-PMI projects, we derive the following key research questions:

1. What is the cost of sticking to EU policy targets?
2. Do the hydrogen and sequestration targets conflict with meeting the greenhouse gas target cost-effectively?

2. Methodology

We use the open-source, sector-coupled energy system model PyPSA-Eur [6, 7, 8, 9] to optimise investment into generation, storage, and transmission infrastructure (including electricity,

★working title

*Presenting author (xiong@tu-berlin.de)

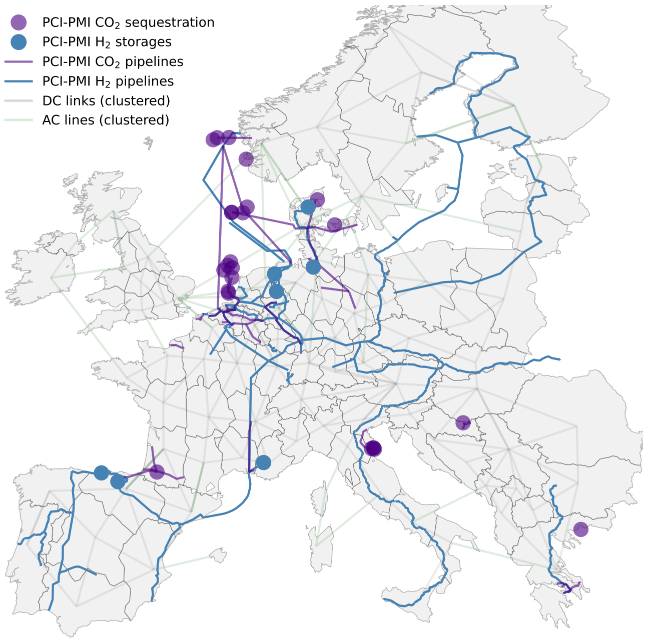


Figure 1: PCI-PMI projects implemented in the PyPSA-Eur model as of the date of submission. Own illustration based on data from the European Commission [13].

natural gas, hydrogen, CO_2, and Power-to-X conversion) as well as operation/dispatch. The model is spatially and temporally highly resolved and covers the entire European continent, including stocks of existing power plants [10], renewable potentials, and availability time series [11]. It covers today's high-voltage transmission grid (AC 220 kV to 750 kV and DC 150 kV upwards) [12].

2.1. *Feature implementation*

By accessing the REST API[1] of the PCI-PMI Transparency Platform [13] and associated public project sheets provided by the European Commission, we implement the PCI-PMI projects into the PyPSA-Eur model to assess their impact in the power, heat, transport, industry, feedstock, and agriculture sector. Note that we use standardised costs for all PCI-PMI projects [14] for two reasons: i) Cost data provided by project promoters can be incomplete and may not include the same cost components, and ii) to ensure comparability as well as level-playing field between all potential projects, including both PCI-PMI and model-endogenous investments. Our implementation can adapt to the needs and configuration of the model, including selected technologies, geographical and temporal resolution, as well as the level of sector-coupling. An overview of the implemented PCI-PMI projects is shown in Figure 1.

2.2. *Scenario setup*

As of the date of submission, we model three key scenarios for the target year 2030 which will set the base year for

Table 1: Initial scenario setup. Own illustration.

Scenario	Base	A. All targets	B. Emission target
PCI-PMI projects	on time	delayed	delayed
CO_2 emission	−55 %/2 Gt p.a.	−55 %/2 Gt p.a.	−55 %/2 Gt p.a.
CO_2 sequestration	50 Mt p.a.	50 Mt p.a.	—
Green H_2	10 Mt p.a.	10 Mt p.a.	—
CO_2 seq. sites	PCI-PMI	endogeneous	endogeneous
H_2 storage	PCI-PMI	endogeneous	endogeneous
CO_2 pipelines	PCI-PMI and endog. expansion	—	—
H_2 pipelines	PCI-PMI and endog. expansion	—	—
AC/DC lines	PCI-PMI	—	—

pathways towards 2050: a *Base* scenario in which policy targets are achieved and all projects are commissioned on time as well as two PCI-PMI delay scenarios *A* and *B*. Table 1 gives an overview of the scenarios' key assumptions and their differences. Depending on the scenario, we formulate and activate additional constraints to ensure the fulfilment of the EU policy targets. We solve all scenarios by minimising total system costs, resolving 34 countries to 90 buses at 3-hourly temporal resolution.

3. Results — preliminary

First results for the modelling year 2030 show that reaching the EU's 2030 H_2 production and CO_2 sequestration targets translates into around 20 bn. € p.a. in total system costs for

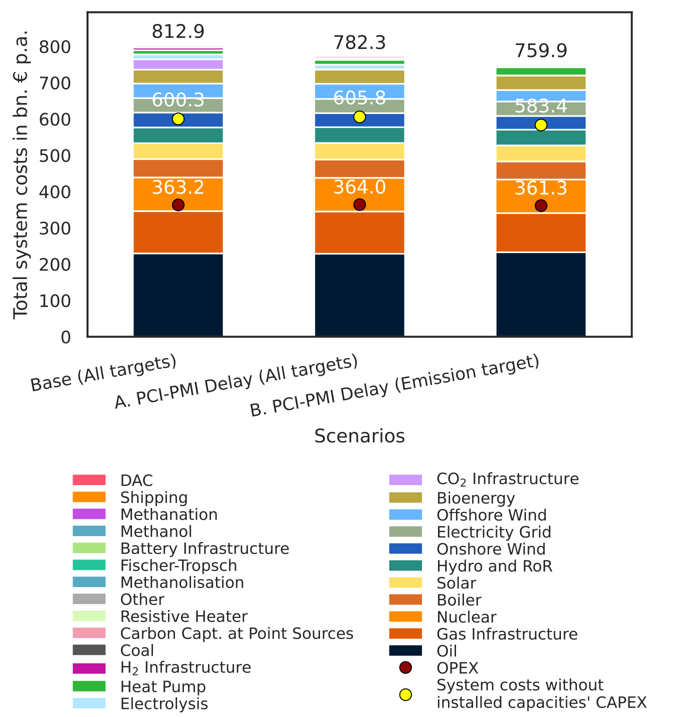


Figure 2: Results — Total system costs by technology and infrastructure. Own illustration.

[1]Representational State Transfer Application Programming Interface

all included sectors (Figure 2). This is true for both comparing scenario *A* and *Base* scenario with scenario *B*, respectively, deducting the cost of the PCI-PMI projects. Assuming standardised cost assumptions for all PCI-PMI projects.

Base scenario. Figure 3 shows the regional distribution of the H_2 and CO_2 value chain in the Base scenario. Note that for the specific year of 2030, a disconnect in H_2 infrastructure between central and southeastern Europe can be observed, due to the delay in commissioning of the project connecting the two networks. Within the two interconnected regions, almost homogenous average marginal prices for H_2 can be observed. Note that Figure 3a shows the cost of all H_2 produced, weighted by the respective regional demand at a certain point in time. CO_2 prices are higher in demand regions for industry processes and methanolisation located in northwestern Europe — primarily Norway and the United Kingdom (Figure 3b). Negative CO_2 prices in souhtheastern Europe indicate a lack of demand and missing economic value. Utilisation of H_2 pipelines vary strongly across the PCI-PMI projects. In most of the times, pipelines serve the purpose of transporting H_2 in a single direction only, i.e. from high renewable potential regions to H_2 consumption sites, where it serves as a precursor for methanolisation or direct use in industry and shipping (see Figure 3a). Prominent PCI-PMI projects with particularly high full-load hours include P9.9.2 *Hydrogen Interconnector Denmark-Germany* (6937 h) and P11.2 *Nordic-Baltic Hydrogen Corridor* (2295 h), followed by projects connecting major steel-industrial and chemical sites of Germany (southwest) with Belgium (P9.4 *H2ercules West*, 1634 h), the Netherlands (P9.6 *Netherlands National Hydrogen Backbone*, 1967 h and P9.7.3 *Delta Rhine Corridor H2*, 1510 h), and France (P9.2.2 *MosaHYyc*, 4662 h). PCI project P13.8 *EU2NSEA* connects CO_2 from process emissions in Germany, Belgium and the Netherlands to major geological sequestration sinks close to the Norwegian shore *Smeaheia* and *Luna* with an annual injection potential of 20 Mt p.a. and 5Mt p.a., respectively.

Scenario A compared to Base. PCI-PMI infrastructure account for a total of around 30 bn. € p.a. in additional total system costs, indicating that for the target year 2030, the projects are not cost-optimal. With a delay of PCI-PMI projects in scenario *A*, Europe's policy targets can still be achieved at significantly lower cost. However, this comes at the expense of a less interconnected energy system, which may lead to higher costs in the long run. Further, H_2 prices vary more strongly across regions, seeing higher costs in southeastern Europe due to industrial demand and lower renewable potentials (Figure B.7a). We make similar observations for CO_2 — a lack of pipeline infrastructure increases spread of CO_2 prices, seeing higher values for CO_2 in regions with high demand (e.g. for industrial processes or methanolisation).

Scenario B compared to Base. By omitting a green H_2 target, almost no electrolysers are installed. Around 8 Mt are still produced to cover industrial H_2 and methanol (primarily shipping) demand (Figures B.5 and B.6). However, this demand is met by decentral steam methane reforming instead of electrolysers (Figure B.5). Without specifying a CO_2 sequestration target, the system still collects around 21 Mt of CO_2 p.a. primarily from process emissions in the industry sector and sequesters it in carbon sinks near industrial sites where a sequestration potential is identified (see Figure A.4) [15]. This carbon sequestration is incentivised by the emission constraint for 2030. As no pipeline infrastructure is built in these scenarios, the chosen locations differ in the delay scenarios — this can be observed for regions near the coast, such as the United Kingdom and Norway (see Figure A.4). Given the lack of infrastructure, both the average cost for H_2 and CO_2 are higher in scenario *B* compared to the Base scenario (Figures B.7c and B.7d.

4. Conclusion — preliminary

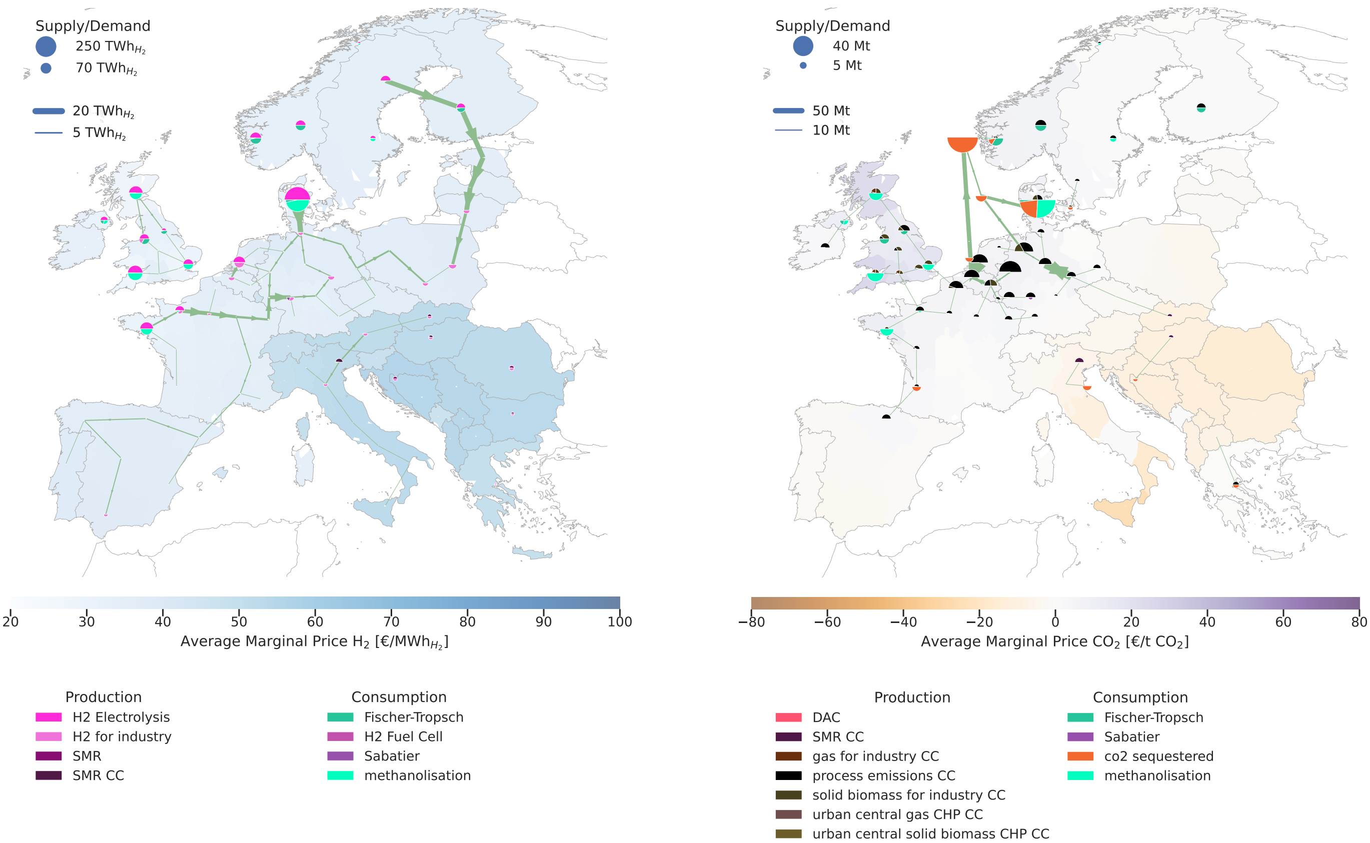
We conclude that while all three EU policy targets for 2030 can be achieved without PCI-PMI infrastructure, they bring additional benefits: i) H_2 pipelines projects help distribute more affordable green H_2 from northern and south-western Europe to high-demand regions in central Europe; ii) CO_2 transport and storage projects help decarbonising the industry by connecting major industrial sites and their process emissions to offshore sequestration sites in the North Sea (Denmark, Norway, and the Netherlands). Preliminary results have further shown that most PCI-PMI projects seem to be over-dimensioned and are not cost-optimal, as very few projects show full-load hours of above 1000 p.a. However, to adequately assess the value of PCI-PMI projects, we need to assess their benefits in future target years. Further, policy targets for 2030 are not cost-effective, although needed in the long run to reach net-zero emissions by 2050.

Research outlook. Next steps include the implementation of remaining PCI-PMI projects, such as hybrid offshore interconnectors (energy islands), electricity storages, and CO_2 shipping routes. To evaluate the long-term value of PCI-PMI projects in a sector-coupled European energy system, we will model pathway dependencies towards 2050. We will also assess the sensitivity of the infrastructure to technology-specific build-out rates.

Acknowledgements

This work was supported by the German Federal Ministry for Economic Affairs and Climate Action (BMWK) under Grant No. 03EI4083A (RESILIENT). This project has been funded by partners of the CETPartnership (https://cetpartnership.eu) through the Joint Call 2022. As such, this project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement no. 101069750.

Appendix A. Additional input data



(a) H_2 regional balances and flows (all H_2 produced).

(b) CO_2 regional balances and flows.

Figure 3: Results *Base* scenario — Regional distribution of H_2 and CO_2 production, utilisation, storage, and transport in the Base scenario. Own illustration.

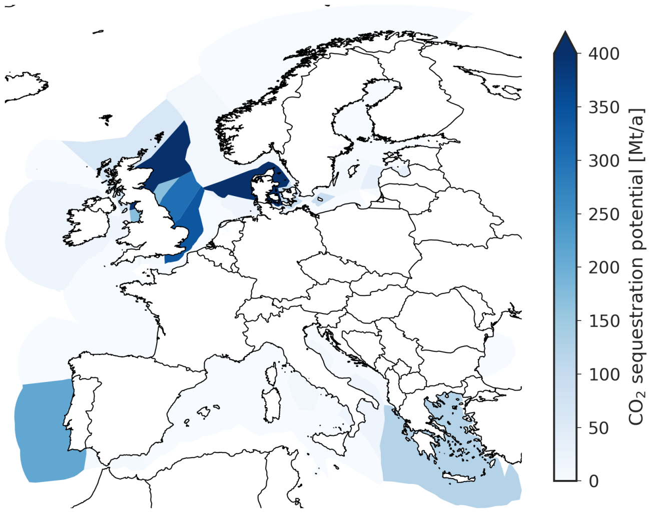


Figure A.4: Regional sequestration potentials in scenarios *A* and *B* according to [15].

Appendix B. Additional results

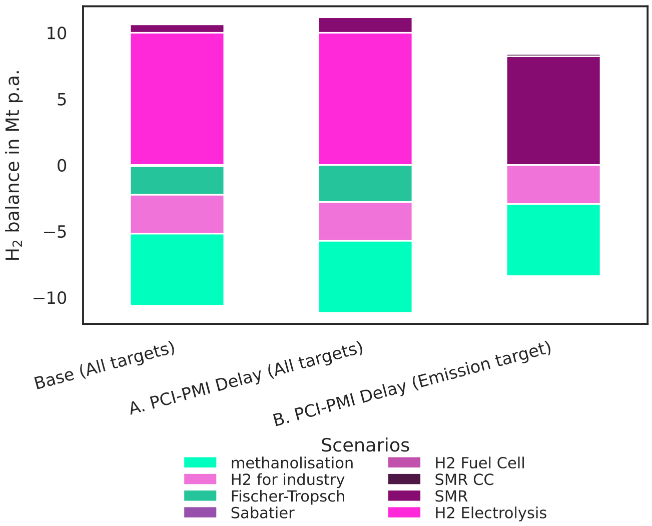


Figure B.5: Results — H_2 balance. Own illustration.

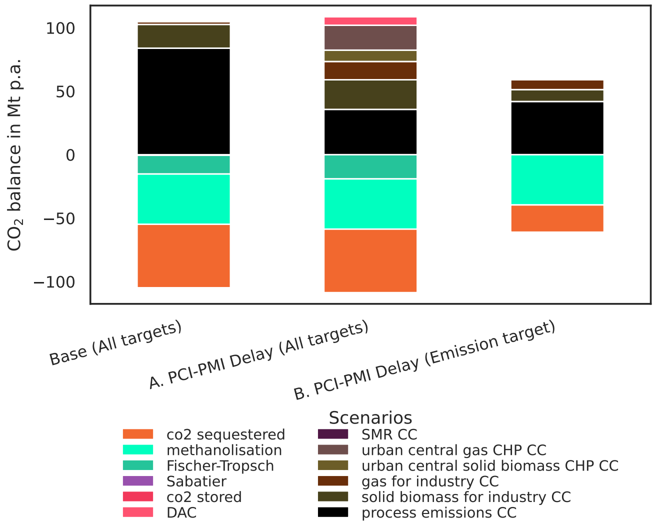


Figure B.6: Results — CO_2 balance. Own illustration.

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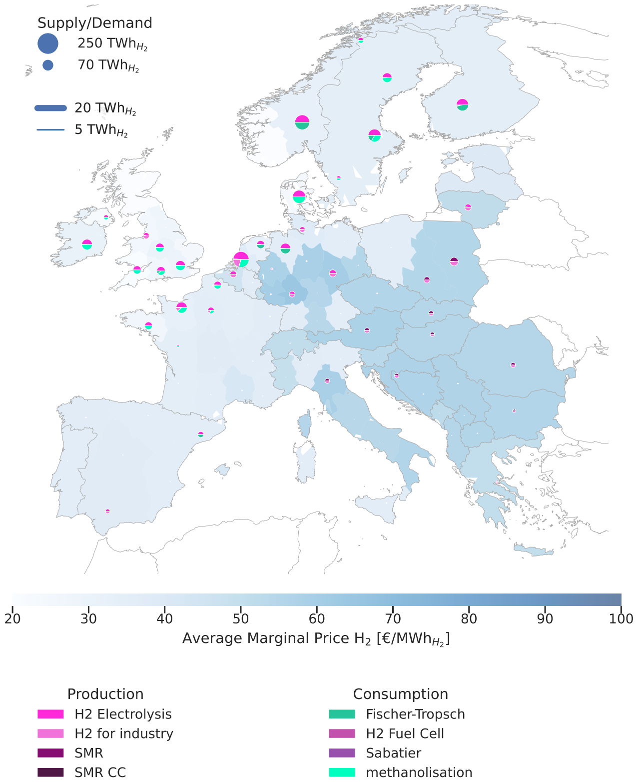
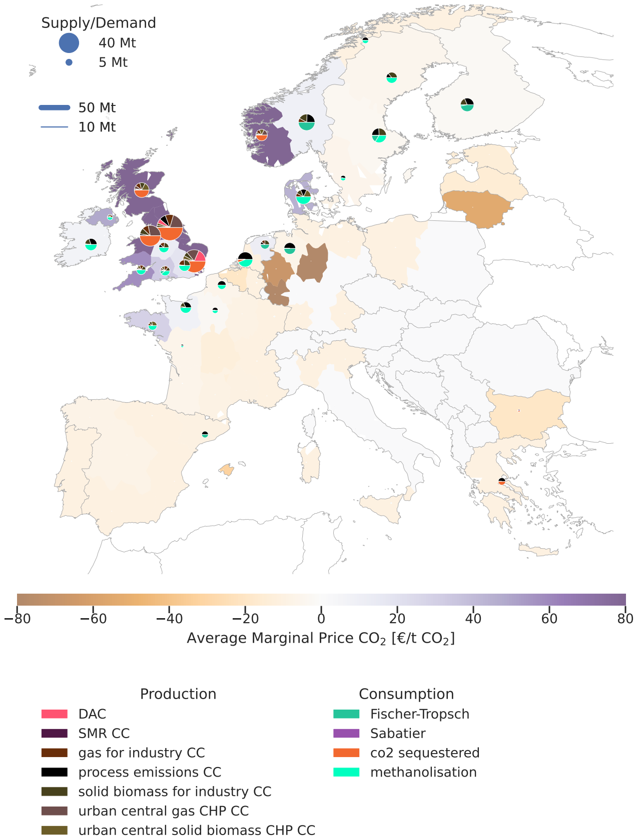
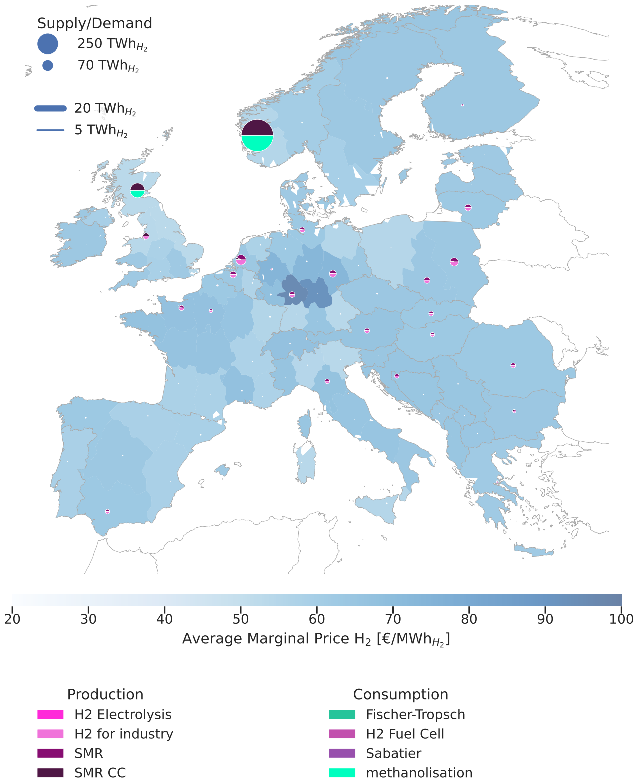


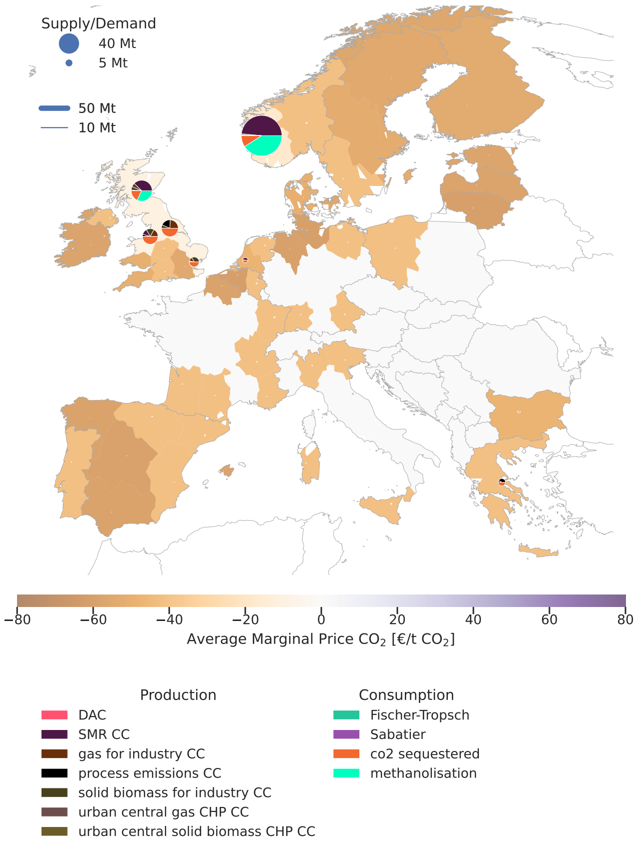
(a) H_2 regional balances and flows (Scenario A, all H_2 produced).



(b) CO_2 regional balances and flows (Scenario A).



(c) H_2 regional balances and flows (Scenario B, all H_2 produced).



(d) CO_2 regional balances and flows (Scenario B).

Figure B.7: Results scenarios *A* and *B* — Regional distribution of H_2 and CO_2 production, utilisation, storage, and transport. Own illustration.

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