Transformation pathways towards a climate neutral European energy system using integrated power and gas networks

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REMix
Renewable Energy Mix

https://gitlab.com/dlr-ve/esy/remix/framework

Motivation

Key challenges

- Achieving a net-zero energy system by 2050
- Developing a hydrogen import strategy
- Planning the future of the European gas network
- Ensuring a reliable and resilient power system based on VRE

Political targets

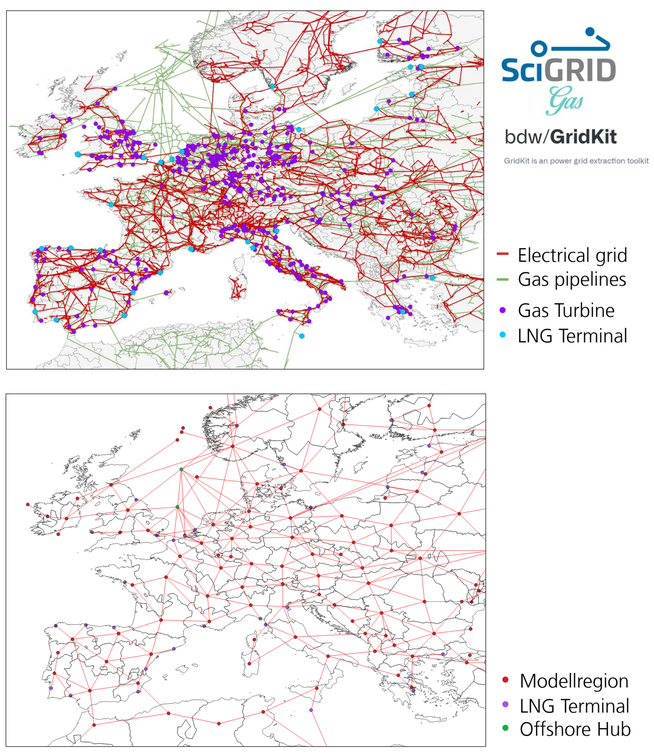
- 10 Mt of hydrogen imports and 10 Mt of domestic production by 2030
- Creation of hydrogen valleys to facilitate supply in key demand regions
- Accelerate the emergence of a European hydrogen market through H2global

Research question

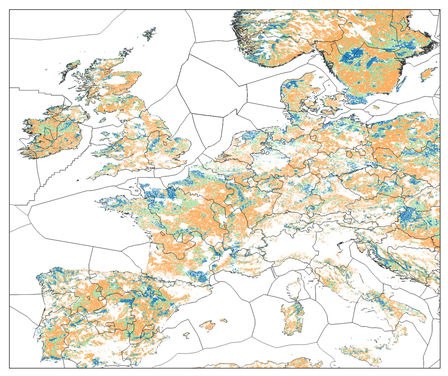
- How can current infrastructure be utilized and expanded to ensure efficient and reliable supply during the transition to a net zero energy system?

Methodological framework

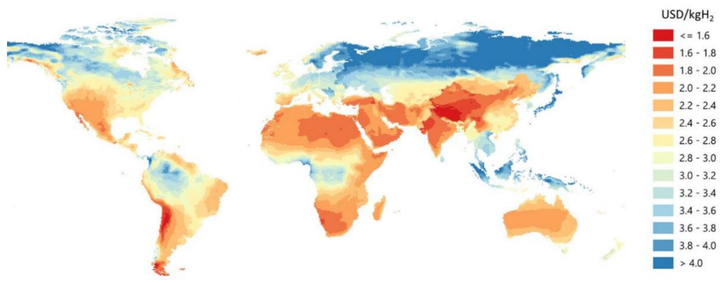
Topology reduction using modified Girvan-Newman graph partitioning to identify key infrastructure corridors [1,2,3]



Identification of best sites for renewable energy based on global solar and wind atlas data [4,5]

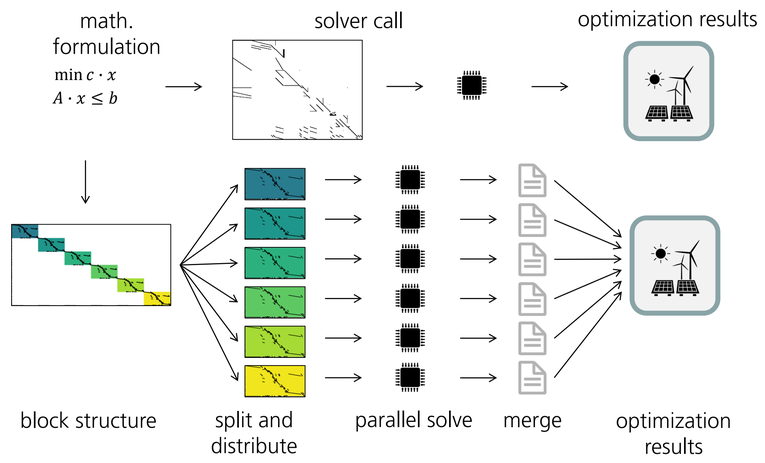


Selection of future hydrogen import costs and ramp up of available import volumes



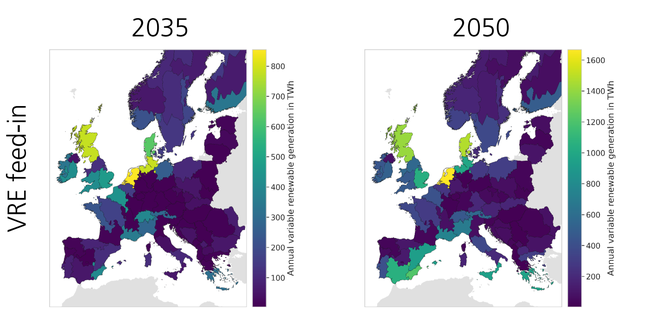
IEA 2020, The Future of Hydrogen

Enabling computation of transformation pathways via parallel block structure exploiting algorithms on high performance computers [6]

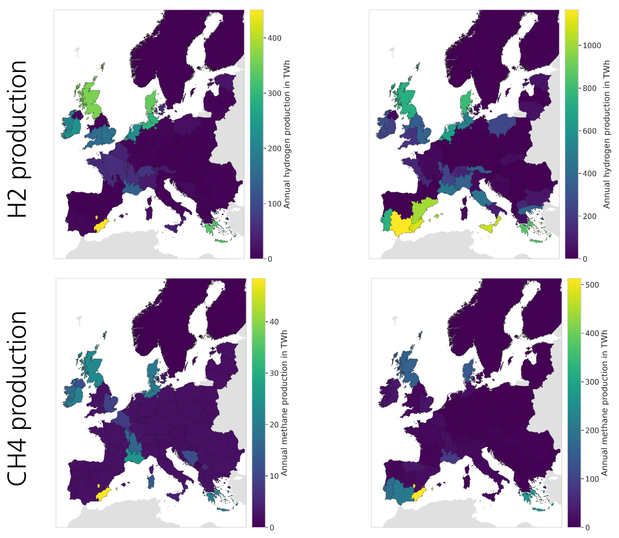


DLR, HPC cluster CARO

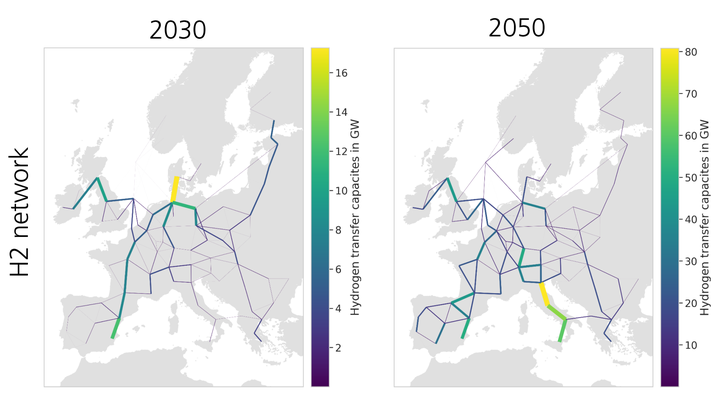
Results



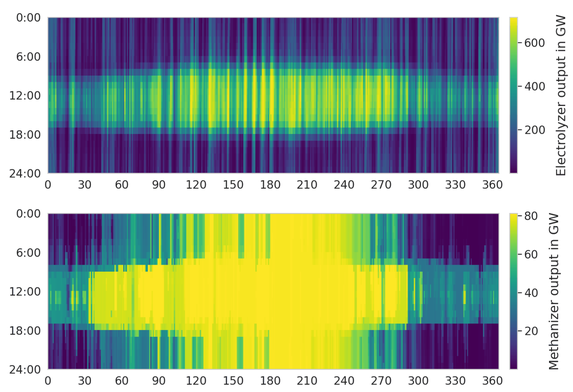
Renewable electricity generation distributed around the North Sea and Southern European countries



Production of green H2 correlated to VRE feed-in, production of green CH4 focused on a few regions



Initial H2 network connecting key production sites, evolution towards a more distributed system



Water electrolysis provides significant demand side flexibility while methanation shows a strong seasonal profile requiring long term storage options

Conclusions

- Proof of concept for the computation of transformation pathways with high spatial and temporal resolution for the integrated assessment of European network expansion
- Repurposing natural gas pipelines for hydrogen can lead to more efficient system transformation and avoid additional network expansion
- Domestic production can be cost-competitive with hydrogen imports and increase Europe's energy sovereignty

Future research

- Assessment of trade-offs between imports and domestic generation as well as strategic impacts of availability of energy technologies

[1] Girvan, M., and M. E. J. Newman. 2002. Community structure in social and biological networks. PNAS, 10.1073/pnas.122653799
[2] SciGrid_gas pipeline dataset https://www.gas.scigrid.de
[3] GridKit power grid extraction toolkit https://github.com/bdw/GridKit
[4] Global solar atlas https://globalsolaratlas.info/
[5] Global wind atlas https://globalwindatlas.info/
[6] Rehfeldt et al. 2022. A massively parallel interior-point solver for LPs with generalized arrowhead structure, and applications to energy system models. EJOR, 10.1016/j.ejor.2021.06.063

Knowledge for Tomorrow

Wissen für Morgen

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