TU Delft

Energy system optimization modelling, near cost-optimal system configurations and the integration of smart charging mechanisms with Calliope framework

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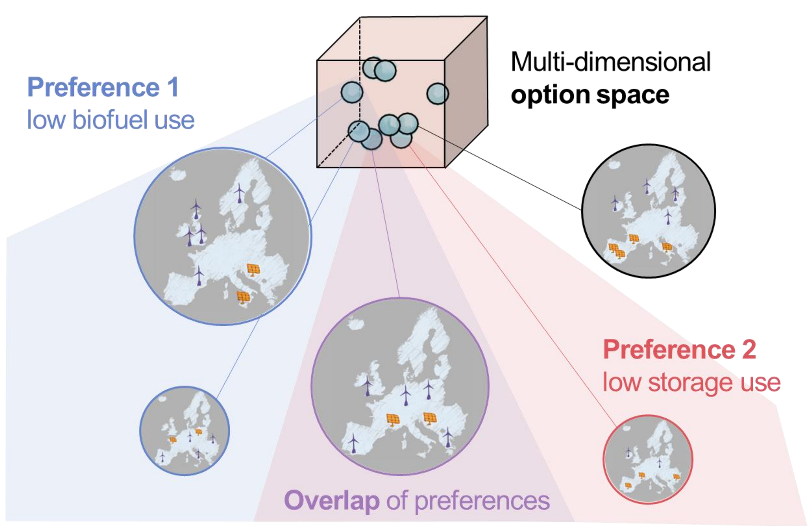
Recent advancements in Energy System Modelling has demanded increasing computational power to deal with sector-coupled energy system models and to perform time-consuming system optimization runs.

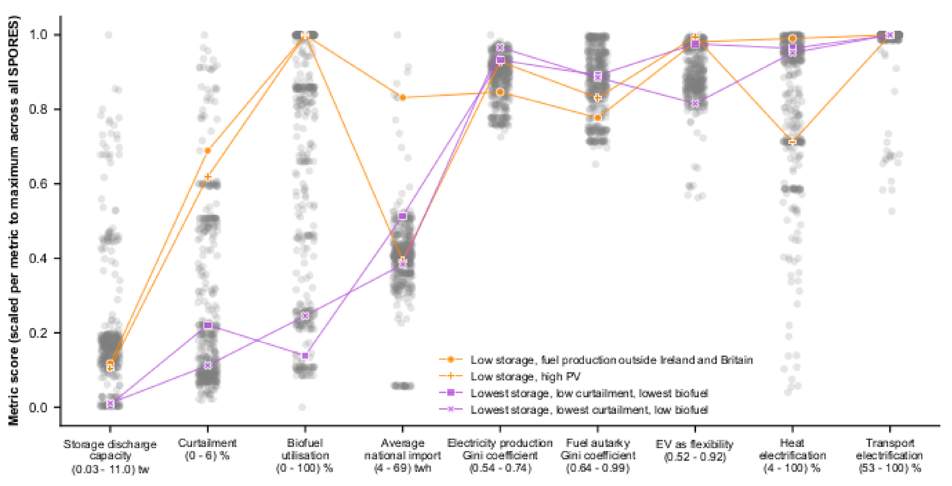
Now consider to generate N parallel near cost-optimal solutions for each model run. The computational burden could have been borne only thanks to the support of **an HPC**.

Diversity of options to achieve carbon-neutrality and energy self-sufficiency in Europe[1]

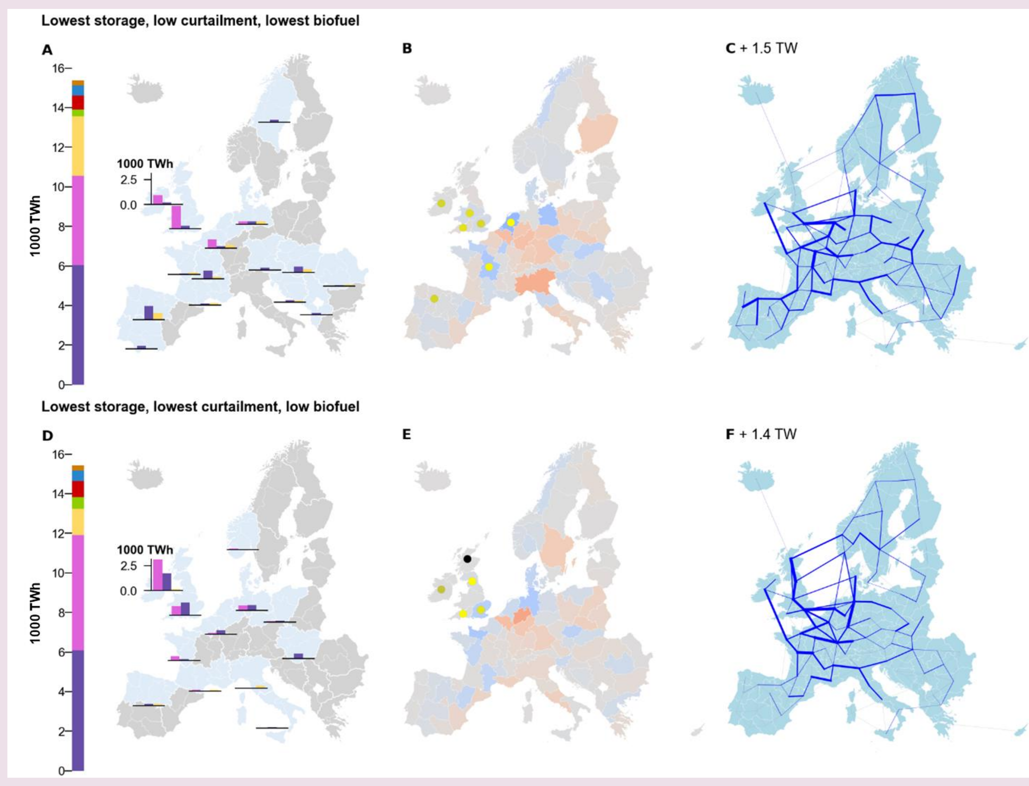
With the **SPORES** method and the **Euro-Calliope** mode**l**, **we generate 441 technically feasible and cost-effective options** ( ) for an energy self-sufficient, carbon-neutral Europe



With **4 example SPORES** we illustrate here the synergies and trade-offs that may open up between plausible real-world competing stakeholder goals across a number of pre-defined metrics



Explore further trade-offs yourselves, with our interactive data explorer! explore.callio.pe

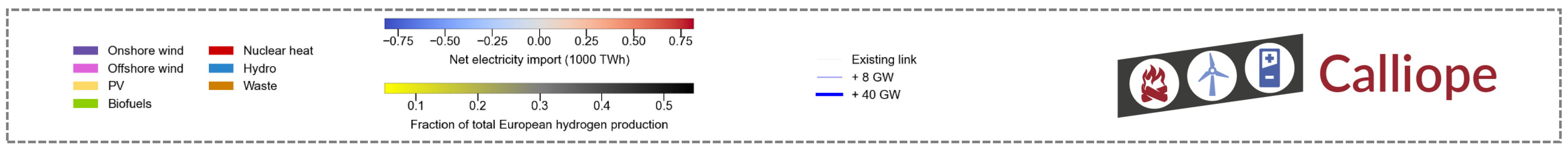


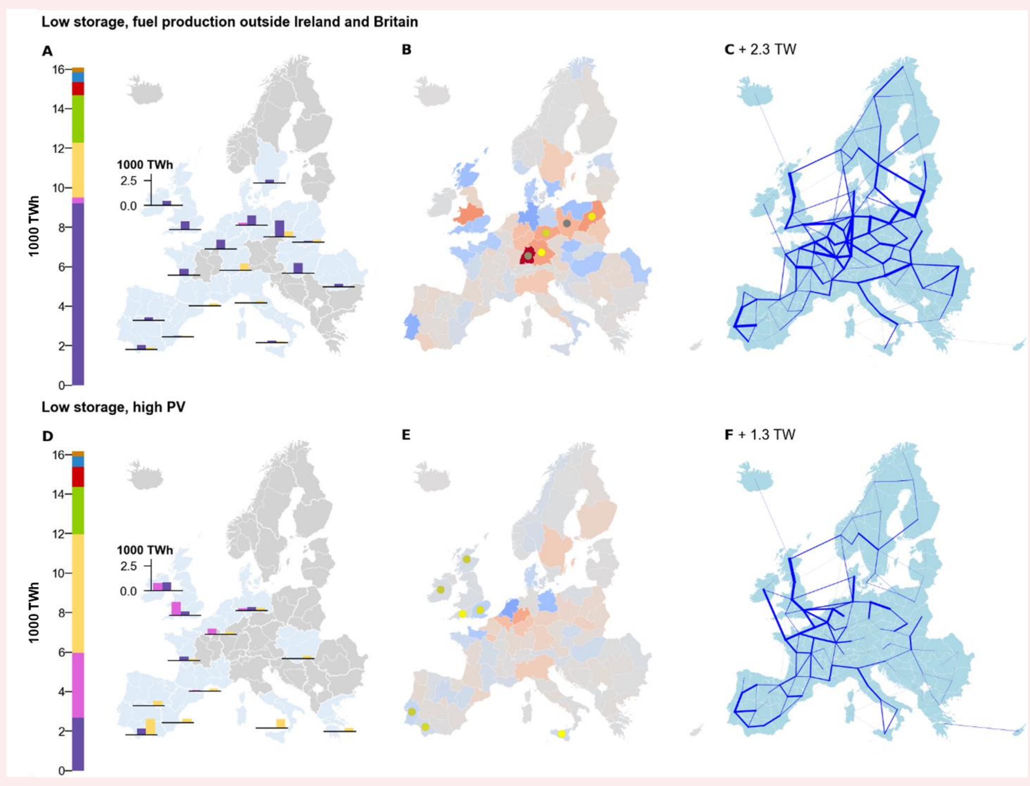
Overlap of preferences

Almost anything is technically possible, but **preferences** restrict the spatial and technical **maneouvering space**

When many preferences overlap, such as **'low storage use'** and **'low biofuel use'** some features become must-haves

For instance, a strong deployment of wind generation in Britain and Ireland





Preference 2 only

More relaxed preferences, say not limiting the use of (residual) biofuels, lead to **radically different spatial configurations**

Hubs for the production of **hydrogen** and synthetic fuels could be moved to **Eastern Europe**; or to the **Mediterranean** alongside a larger deployment of solar generation

Computational burden inevitably increases when new technologies – such as Vehicle-to-Grid – are modelled …

Integrating Smart Charging Mechanisms into Calliope energy system modelling framework[2]

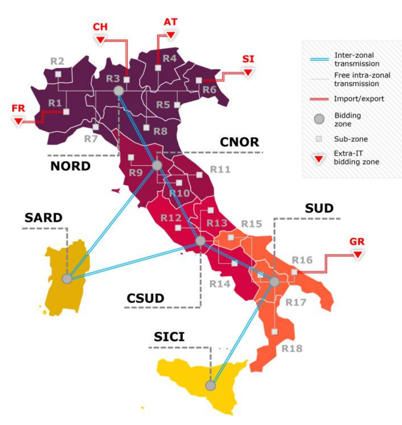
The integration of **Smart Charging Mechanisms** into **Calliope** which has been first tested on a national case study will be extended to the **European context**.

Methodology

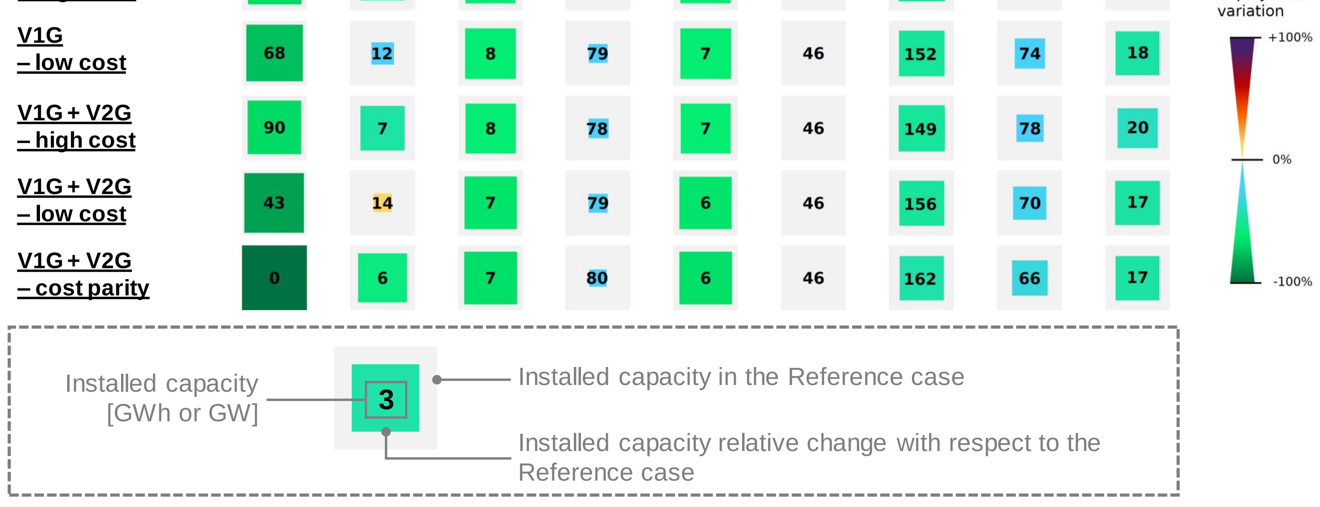
We add novel constraints into Calliope to model the deployment of both unidirectional (**V1G**) and bidirectional (**V2G**) charging infrastructures as **competing technologies**.

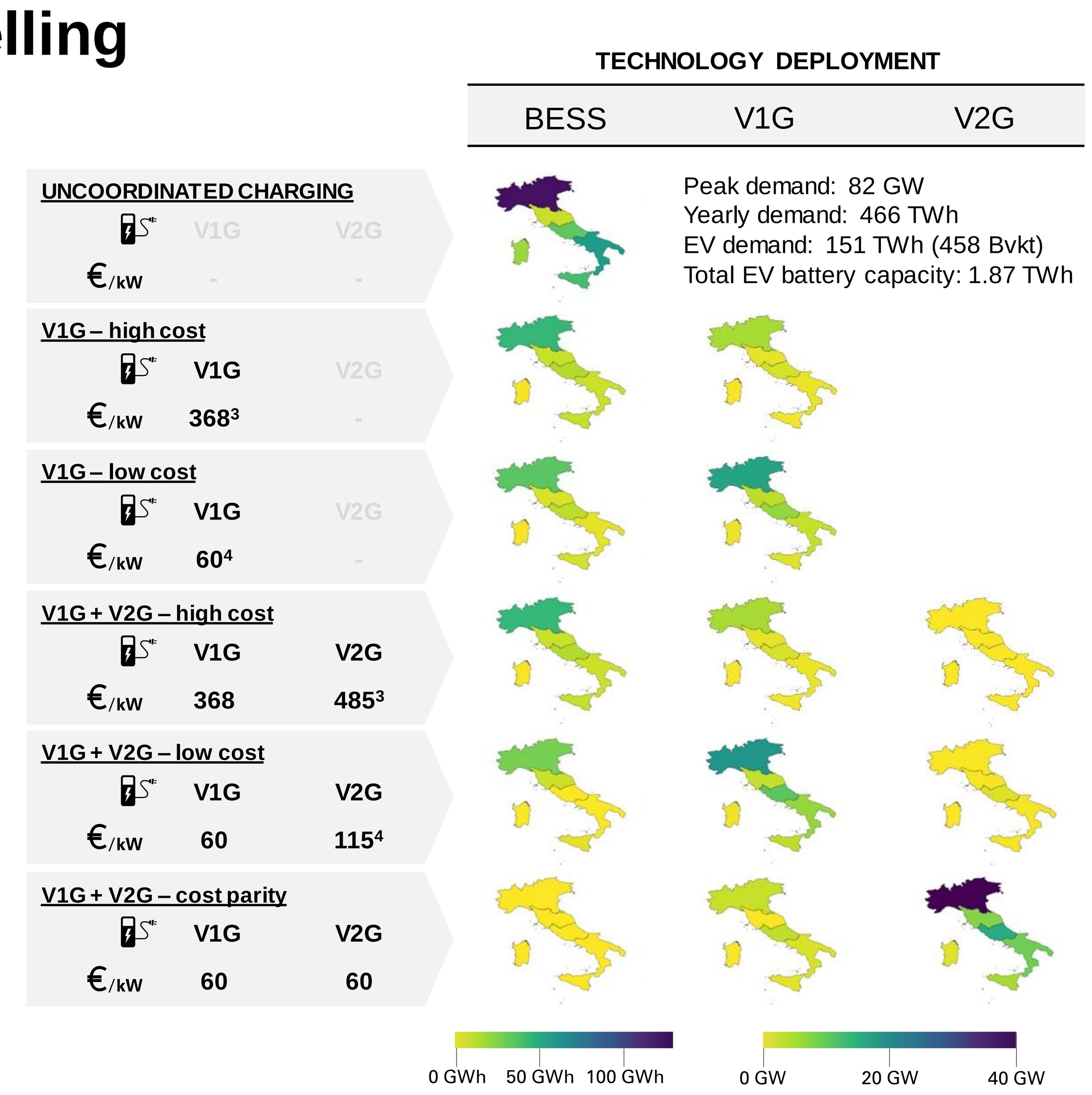
Case study

We consider the Italian **power sector-only** model projected to 2050 assuming **100% EV** car fleet.



	BESS (GWh)	CCGT syngas (GW)	Electrolyzers (GW)	Inter-zonal transmission (GW)	Methanation + DAC (GW)	PV farm (GW)	PV rooftop (GW)	Wind on-shore (GW)	Wind off-shore (GW)
UNCOORDINATED CHARGING	283	13	21	86	17	46	302	95	33
V1G – high cost	90	7	8	78	7	46	149	78	20
V1G – low cost	68	12	8	79	7	46	152	74	18
V1G + V2G – high cost	90	7	8	78	7	46	149	78	20
V1G + V2G – low cost	43	14	7	79	6	46	156	70	17
V1G + V2G – cost parity	0	6	7	80	6	46	162	66	17





Results

- V2G shows the potential of completely displacing BESS techs
- Reduction of installed capacity of VRES techs.
- Reduction of electricity curtailment (-40%/-50%)

REFERENCES

[1] Pickering, Lombardi, Pfenninger (2022). Diversity of options to eliminate fossil fuels and reach carbon neutrality across the entire European energy system. Joule. doi.org/10.1016/j.joule.2022.05.009.

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[4] Huber, De Clerck, De Cauwer, Sapountzoglou, Coosemans, Messagie (2021). Vehicle to Grid Impacts on the Total Cost of Ownership for Electric Vehicle Drivers. World Electric Vehicle Journal. doi.org/10.3390/wevj12040236.

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