From continental to local: Downscaling energy system models to detect local barriers and benefits

Launer, Jann; Lombardi, Francesco; Tindemans, Simon; Pfenninger-Lee, Stefan

DOI
10.5194/egusphere-egu25-15951

Publication date
2025

Document Version
Final published version

Citation (APA)
Launer, J., Lombardi, F., Tindemans, S., & Pfenninger-Lee, S. (2025). *From continental to local: Downscaling energy system models to detect local barriers and benefits*. Abstract from EGU General Assembly 2025, Vienna, Austria. https://doi.org/10.5194/egusphere-egu25-15951

EGU25-15951, updated on 29 Apr 2025
https://doi.org/10.5194/egusphere-egu25-15951
EGU General Assembly 2025

From continental to local: Downscaling energy system models to detect local barriers and benefits

Jann Launer[1], Francesco Lombardi[1], Simon Tindemans[2], and Stefan Pfenninger-Lee[1]
[1]TU Delft, Technology, Policy and Management, Engineering Systems and Services, Delft, Netherlands (j.a.c.launer@tudelft.nl)
[2]TU Delft, Electrical Engineering, Mathematics and Computer Science, Delft, Netherlands

How can large-scale energy system optimisation models attain high spatial resolution while remaining computationally tractable, with the aim of better representing spatial variability and assessing the environmental and societal impacts of scenarios?

Energy system optimisation models are a widely-used approach to generate and study scenarios for techno-economically feasible system designs that meet emission reduction targets. These models have a particular strength in representing the spatial-temporal variability of renewable generation and demand and the energy system's capability to balance them.

Spatial detail is crucial for these models: first, to represent variability and flexibility needs accurately, and second, when the goal is to assess environmental and societal impacts of scenarios. However, models with extensive scope (continental or national) are limited by computational resources, which requires spatial aggregation. Regional models that resolve greater spatial detail, on the other hand, are usually limited in spatial scope and are not necessarily consistent with the broader context.

Here, we present, test and compare different downscaling methods that increase the spatial resolution of energy models for system design and operation using a 2-step approach. The first step involves running an aggregated model at low resolution, which provides boundary conditions for the second downscaling step, which yields a feasible solution at the desired high spatial resolution.

We compare the methods, some of them described in the literature, some of them entirely novel, with respect to design goals like consistency, approximation, variety and computational complexity reduction in a simple test setting, thereby providing original insights on their trade-offs. Our findings support an informed use of downscaling methods for energy system optimisation models, with a wide range of applications in refining large-scale models and incorporating local societal and environmental information into energy system scenarios.