FG1: Climate neutrality: energy modelling, weather and climate

Session description

It is clear that by mid-century Europe has to be climate neutral with respect to its use of energy. That will likely demand the transition to an energy system based on 100% renewable electricity and fuels. Given the environmental limitations to expanding hydropower production, and the likely high costs of geothermal energy over most of the continent, the primary source of energy is likely to be intermittent solar and wind power production. It is well known that this creates challenges for the stability and reliability of the electric supply system. The means of coping with this problem are temporal balancing through storage and load management, geographic balancing making use of long-distance transmission lines, and utilizing overcapacity in the power generation system to synthesize hydrogen and hydrocarbon fuels. Each of these has its drawbacks, whether associated with high costs or lack of public acceptance. Finding the right combination of these mechanisms will be crucial for ensuring that energy remains affordable and the European economy strong.

Spatially and temporally highly resolved energy and power system models being developed through H2020 funding are increasingly being used to investigate credible designs for this future European energy system. Because weather-dependent renewable electricity is likely to play such a key role, a particularly important aspect of this research area is the linking of energy, meteorology, and climate models. Representing weather parameters at highly resolved temporal and spatial scales is crucial for projecting wind and solar power production and variability. The changing climate will be a major driver of hydropower production on the one hand, and heating and cooling demand on the other. State-of-the-art models can operate over a wide range of geographic coverage, from local and potentially energy self-sufficient communities to an entire fully integrated European energy system. Ultimately the results from these models form the basis for developing scenarios to identify the pathways to achieve such a system in the time available.

In this session, we will examine the state of the art of spatially and temporally resolved energy system models, the kinds of questions they have recently answered and still need to answer, what the weather and climate community is ready to provide for energy applications, and what critical issues remain open at this intersection.

Summary of results from the four topics discussed in the session

A: Key insights from the most recent generation of spatially and temporally resolved energy system models (Input speaker: Tim Tröndle, IASS Potsdam)

Discussion focus was on creating an “energy-modeller’s wishlist” for climate scientists.

Two focus points:

1. What do we need to answer the research questions that we are not currently able to tackle?

2. What can we do already today but could be made easier through better climate products?

Resulting wishlist:

- Interoperability of existing projects - climate scientists more strongly interacting with projects providing singled catalogued data (e.g. Power Genomics)
- Ensure that climate data are open licensed (e.g. Open Energy Data Initiative).
- Produce a single point of access through an API.
- Slice atmospheric data so as to be easily usable by energy modelers (so to reduce shear mass and irrelevant overload of data on upper atmosphere). Focus on useful data fields: 2mT, wind fields at different heights, soil temperature, direct and diffuse radiation.
- Deliver standardised data and methodologies relevant for demand and supply side of energy.
- Data formats in CSV and NetCDF.
- Increase time resolutions (e.g. to address problem of low inertia in energy systems) and spatial resolutions (e.g. to address problems of urban heat island effects or complex topographies).
- More strongly characterise the responses of different climate models so to assess the robustness of energy models to them.

B: Energy-relevant weather and climate data through the Copernicus Climate Change Service (C3S) and related initiatives (Input speaker: Alberto Troccoli, WEMC)

Discussion issues:

- What is actually out there? Operational products, CLIM2power, CCRS, → Matteo's table
- Often no good help available with decisions when using data: e.g. which historic year to use?
- Comparison of different input data would be valuable.
- Where to find specific data such as future heating degree days?
- Co-production: lots of overhead, understanding terminology, but really important to manage expectations, helps to build more robust services that are more useful for end users
- Embedding climate satisfactorily will take years

C: Critical questions at the intersection of weather, climate, and energy models (Input speaker: David Brayshaw, University of Reading)

Decarbonisation (i.e. pushing for high renewable penetration) increases energy system dependence on weather. Yet, are solutions currently being generated by energy models robust to climate-change-related future modifications of weather? How much are energy modelling 'solutions' (i.e. power system configurations) robust to multiple possible realisations of uncertain future climate/weather?

1. As regards the sampling of (historical) weather data, often we use one or few weather years, not representative enough of what might happen in the future! The 'optimum' of an energy system model with respect to, e.g., wind capacity to install, changes **a lot** if changing weather year - e.g. from 1 GW to 35 GW; optimising across all weather years, instead, gives you some 17 GW.
2. And are results robust to future climate modifications? No, because the impact of climate-induced changes in weather is only just beginning to be unveiled.

There's some good news, however. Renewable generation estimates are becoming common in meteorological data. And Global Circulation Models (GCMs) are starting to appear more frequently within detailed energy system planning analyses. But there are many challenges:

- Sometimes GCMs give completely different responses; how to handle that for use in energy models?
- Changes in the energy system change the type of weather variable we care the most about - e.g. maybe we cared a lot about temperature before, now we still do but we care a lot more about wind speed.
- And then, of course, there's plenty of intrinsic uncertainties in reanalyses and weather models more generally
- There's also an issue concerning the fact of having at some point just too much data - even just in terms of TBytes of memory needed for performing, e.g., uncertainty analyses across different realisations/sources of those. So computational tractability is a thing.

To conclude: energy-system and climate modellers need to interact more, and build bridges, because there's poor mutual understanding at the moment. We need to build a clearer *common language* based on which the two disciplines can better interact.

D: Pitfalls when using weather and climate data for energy applications. (No speaker, discussion group host: Stefan Pfenninger)

This resource is new and very useful (started by Matteo De Felice):

https://github.com/energy-modelling-toolkit/climate-driven-energy-datasets

- Contributions to add detail to this list are welcome!
- We need better way to formalize and share informal knowledge, i.e. what is "known" in specific research groups about where specific datasets really shine or where they have issues.