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Synthesis of Session 3B: Linking Climate and Energy Models

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This session comprised 2 talks and group discussions aiming at identifiying kacks in current research and propose new research activities, around the topic "How to include Climate – and Climate Change- in Energy models. In order to better prepare the discussions, a questionnaire was sent to all registered participants before the conference.

- Introduction and Context by Sandrine Charousset
- *Talk 1* - Dr. Laurent Dubus (EDF – Électricité de France/ WEMC – World Energy & Meteorology Council): *"The Copernicus Climate Change Service Sectoral Information System for the Energy Sector"*
- *Talk 2* – Dr. Pedro Crespo del Granado (NTNU – Norwegian University of Science and Technology): *"Research needs and linking energy system models: experiences, challenges and opportunities"*

State of the art 'How Climate is included in Energy Models' – From Questionnaire answers

Very often, climate variability and climate change are not included in models, due to the fact that most models are deterministic. Main initiatives to assess the impact of climate/climate change thus only rely on sensitivities in different parameters (mainly in energy demand). Some studies include sensitivities on the capacity factors. There exist a few studies done with energy models that try to account for the impact of climate variability and climate change, using a various range of (past) time series representing the diversity of climatic situations (including hydro capacity/inflows, Wind and PV generation, energy demand, availability of power plants). The former scenarios may include correlations between different variables. The same approach can be used for assessing the impact of different scenarios of climate change when using prospective time series. Moreover, some models also include the impact of climate on economic growth and technology performances.

Main foreseen impacts of climate change on the energy system

- Impact on Energy Generation :
    - Power plant performances, especially Hydro, WindPower directly linked to precipitation / wind
    - Reduction in reliability
    - Forecasts may become more difficult
    - Increased variability
    - Impact of extreme events (draughts, water shortages, extreme cold long periods….)
    - Availability of power plants (linked to river temperature/cooling)
- Impact on energy demand
    - Change in the heat/cooling demand (linked to temperature)
    - energy demand (linked to temperature but also indirect impact on GDP/population)
    - Increased energy demand for water supply

- Impact on infrastructure (eg. Extreme weather events might increase transmission network failures)
- Impact on performances of Power-to-Heat technologies (eg. air-source Heat Pumps)

Energy models should include the following aspects for accounting for climate

- Dynamic coupling between climate and energy system models
- Link with climatic/energy data
    - (PV, Wind, ….) timeseries with high spatial and temporal resolution), enabling to simulate eg renewable capacity timeseries consistant with climate patterns
    - Specific focus needed on hydro, in different climate scenarios.
    - Including correlations between variables, eg very cold/no wind/no PV during extreme cold periods
    - Including impacts of changing weather patterns on previous correlations (if any)
- Long-term tendancies AND short-term dynamics (including Changing dynamics)
- extreme weather events in climate scenarios
- high-level climate change impacts on GDP, population, total energy demand.
- Methods :
    - Account for robustness in regard to Climate change

Proposals: research topics (to launch or to increase) – from Questionnaire answers

- Accurate spatial and temporal climate data to feed new-generation detailed energy system models, including high resolution, correlations, impacts of climate on performances, patterns, dynamics of climatic variables (cold waves, peaks….)
- Model and quantify impact of extreme weather events in energy models
- New market design :
    - Incentives, such as positive pricing of emission reductions
    - Value of flexibility linked to its capacity to balance climate impacts?
- More stochasticity
    - Representative set of ‘scenarios’
    - Robust investment decision models towards uncertain impact of Climate change
- Define model outputs related to the currents energy and mitigation policies

Proposals: research topics (to launch or to increase) – from Focus Group discussions

- **Uncertainty**: As the impact of climate on the energy system increases drastically with the integration of more and more renewables, it is needed to account for this variability and to account for the uncertainty (most models today are deterministic). This may require:
    - Methods to select from the numerous climate forecasts which one are more relevant to be included in energy models ; how can we obtain a representative set of scenarios that is both including all climatic situations that may have impacts on the system and allow computations…. (running 1000000 scenarios seems unreachable)
    - Methods to represent uncertainty in energy models and account for it (robust/stochastic/multi scenario/probabilities……)
    - Methods to interpret results from stochastic/probabilistic models
    - Impact of extreme events : translating the climate data / projections / forecasts into energy models inputs especially for extreme events => include representative extreme events in numerical data

- **Impact of climate change on the related energy variables; Include in particular the temporal aspect**
    - Include the potential changes in correlations between temperature and demand for heating and cooling (historic correlation may no longer apply ; daily peaks may change…; more cooling, more heat dumps)
    - Include potential changes in correlations between wind and windpower, solar radiation and PV generation…..
    - How to include temporal variations between energy model classes (e.g. Integrated Assessment Models and power system models)

- **Impacts of climate on operation/performance/security of assets and infrastructure** : in some cases today no impact is accounted for but this may change along with climate change (e.g. if extreme temperatures are more frequent then it will be important to include the link between temperature and performances of some assets, when today the impact is neglected)
    - For all kinds of generating assets
    - For the grid
    - Where and when will it be a problem to cool themal power plants?

- **Societal aspects** : Climate related societal effects should be included in energy models
    - Future change in lifestyle patterns due to climate (eg. Work from home due to heat….)
    - Degrowth
    - Decreasing demand
    - Migration (climate refugees)
    - Social acceptance of RES => include more uncertainty

- **Use of resources**
    - Concurrent water uses considering adaptation strategies (e.g. less precipitations and higher temperature may induce less water in reservoirs and higher needs for irrigation, then less water available for power generation
    - Batteries
    - Spatial competition for land use between energy (PV/biomass), food production, afforestation

- Can heating grids be also used for cooling?
- Will massive wind/pv future deployments change the regional wind/pv patterns?
- Impact of climate on fuel supply and distribution

Research around ‘climate and energy models’ may be of interest in this currently open H2020 topic on bringing climate-energy models.