IM3 INTEGRATED MULTISECTOR MULTISCALE MODELING



When Do Different Scenarios of Future Electricity Demand Start to Meaningfully Diverge?

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I) Introduction

Climate and socioeconomic change are known to influence electricity demand, but what is the impact of uncertainty in climate and socioeconomic projections on electricity demand projections? This question is important for demand-driven investment decisions in the energy sector, which are typically made using a 15- to 30-year time horizon. If future climate and socioeconomic projections do not lead to distinctly different demands within the first 30 years, then it may not matter which pathway we are likely on. This research explores two basic questions: When do future electricity demand projections start to meaningfully diverge and what are the key drivers of that divergence?

The IM3 project has generated a wide yet plausible range of 21st century high-resolution climate and socioeconomic scenarios for the U.S.

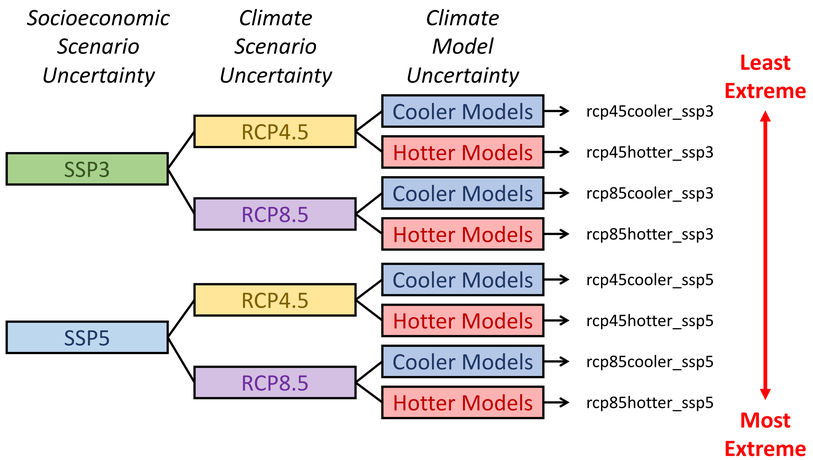


Fig. 1. The eight IM3 future scenarios reflect a range of Shared Socioeconomic Pathways (SSPs), Representative Concentration Pathways (RCPs), and climate model uncertainties. See https://tgw-data.msdlive.org/ for more information.

Given three sources of uncertainty, we can explore the relative influence of each by holding two sources constant and comparing the remaining two scenarios that differ only by the third variable. We can gauge when the remaining source of uncertainty starts to impact electricity demand by analyzing the evolution of the difference in those paired scenarios.

II) Methods

A series of 9 models and 16 model couplings converts the IM3 scenarios of climate and socioeconomic change into hourly time series of electricity demand at the county-, state-, and balancing authority-scale.

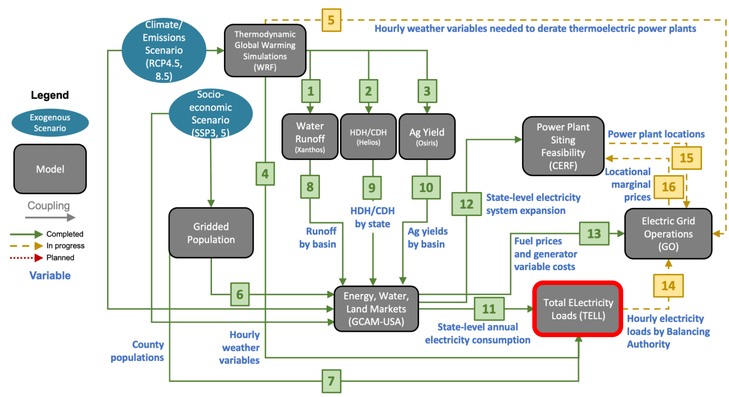


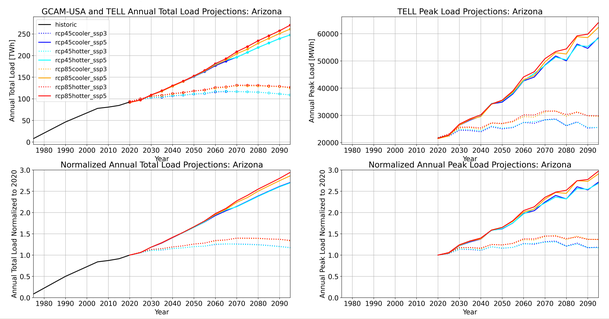
Fig. 2. Wiring diagram showing the flow of inputs and outputs from the IM3 climate and socioeconomic scenarios through to hourly electricity demands. See https://github.com/IMMM-SFA/exp_group_b_test and https://github.com/IMMM-SFA/tell for more information.

III) Annual Load Projections

The evolution of annual loads at the state-scale is a useful guidepost for understanding sensitivity. Using Arizona as a representative example:

- The dominant signal is the split between the SSP3 and SSP5 scenarios
- Climate scenario and climate model uncertainty become more apparent later in the century

Fig. 3. Projections of annual total (left column) and hourly peak (right column) electricity demand in Arizona for each of the IM3 scenarios.



IV) Divergence of Electricity Demand Scenarios

Using a threshold of 5% as a ”meaningful” difference between scenarios:

- The two socioeconomic scenarios diverge within the first 10 years
- The climate scenarios start to diverge as early as 2045, with slightly earlier and larger differences in peak loads compared to mean loads
- The hotter and colder climate scenarios remain similar through 2095

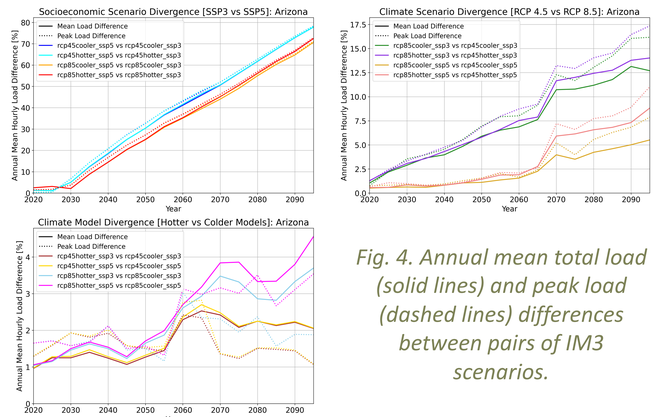


Fig. 4. Annual mean total load (solid lines) and peak load (dashed lines) differences between pairs of IM3 scenarios.

- SSP scenario divergence happens simultaneously across states
- RCP scenario divergence happens slightly earlier in the south

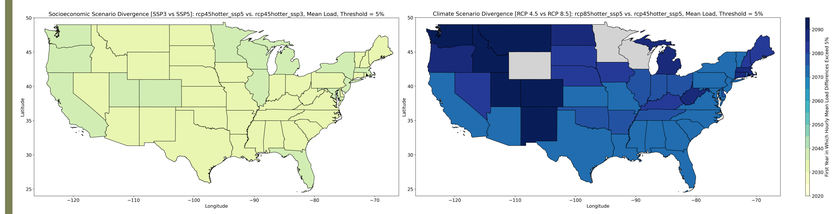


Fig. 5. Maps of the first year when the mean difference between pairs of IM3 scenarios exceeds 5%. Gray indicates that the scenarios never diverge.

V) Conclusions

In order of relative importance for projections of electricity demand:

1. Socioeconomic scenario uncertainty: Matters almost immediately
2. Climate scenario uncertainty: Matters within 20-30 years
3. Climate model uncertainty: Matters only after 50+ years

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