

WHAT IS THE OPTIMAL ELECTRICITY SHARE FOR VERY INEXPENSIVE SOLAR PV?

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Research Question

- What factors affect the optimal amount of Solar PV in highly renewable Energy Systems?

Hypotheses:

- Average solar availability (capacity factor)
- Cost of solar
- Cost of synergizing/competing technologies (battery, wind)
- Latitude of region
- Including sectors besides electricity (eg: transport, industry, agriculture)
- Heating or cooling demand
- Correlation between electricity, heating, or cooling time series
- Transmission between nodes

Methods

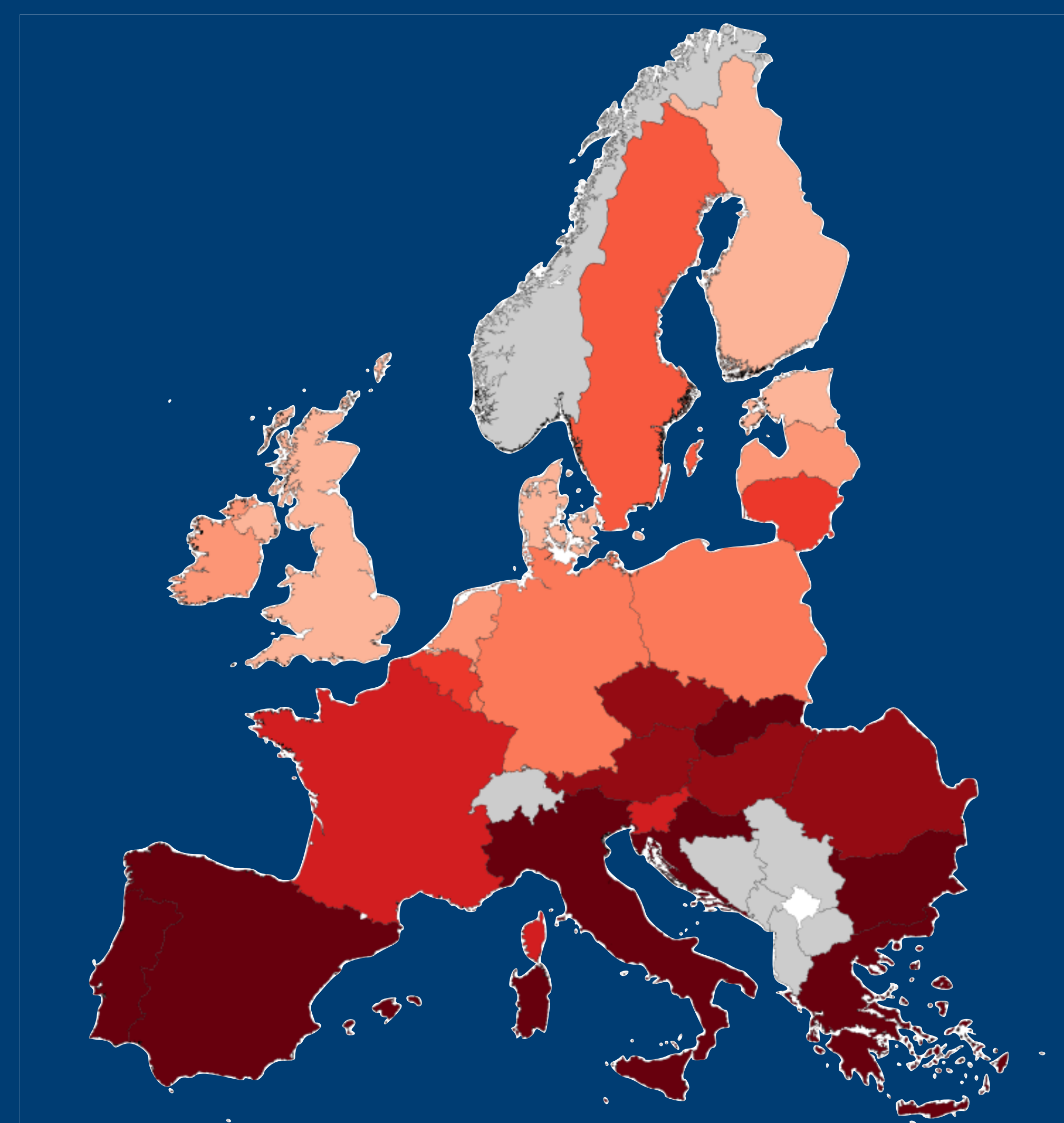
1. Project costs of solar, wind, and battery assuming learning rates and installation
2. Investigate the effect of cost and other factors with single node model for four regions with different solar resource (Denmark, Spain, California, Colorado), including solar, wind, and gas generators, with zero CO₂ emissions allowed
3. Then, use PyPSA-Eur-Sec, an open, networked, sector-coupled energy system model for European countries to investigate the effects from added complexity (e.g. transmission)

Conclusions

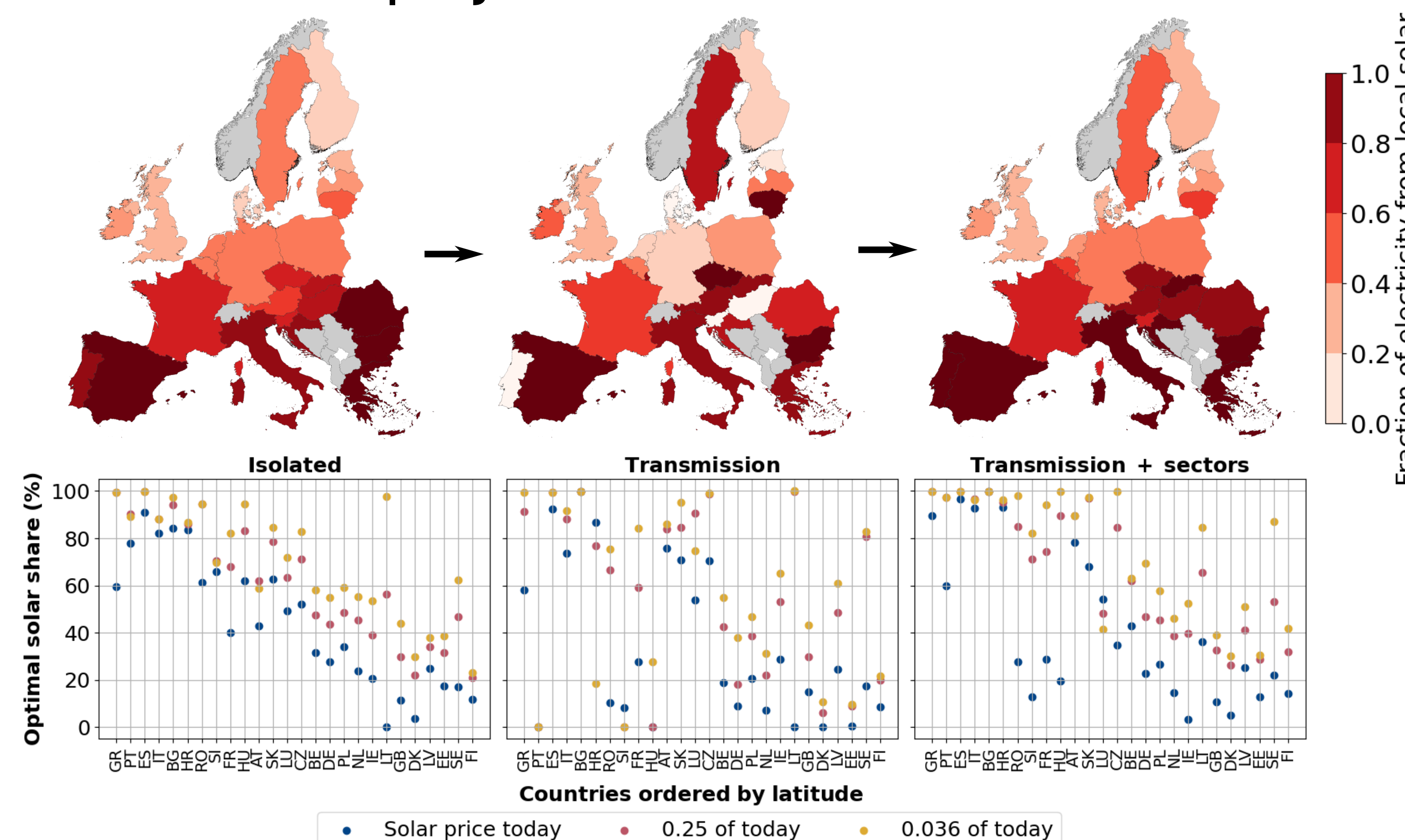
- For a single node model, we find:
 - Solar is already dominant in places like California
 - Even least-optimistic assumptions of future solar prices increase solar share dramatically
- For a sector-coupled model, we find:
 - Without transmission, solar is correlated with latitude
 - Adding transmission weakens correlation
 - Sectors restores correlation
- There is no single optimal value for solar penetration



Optimal solar penetration depends on the system's global connectivity and complexity

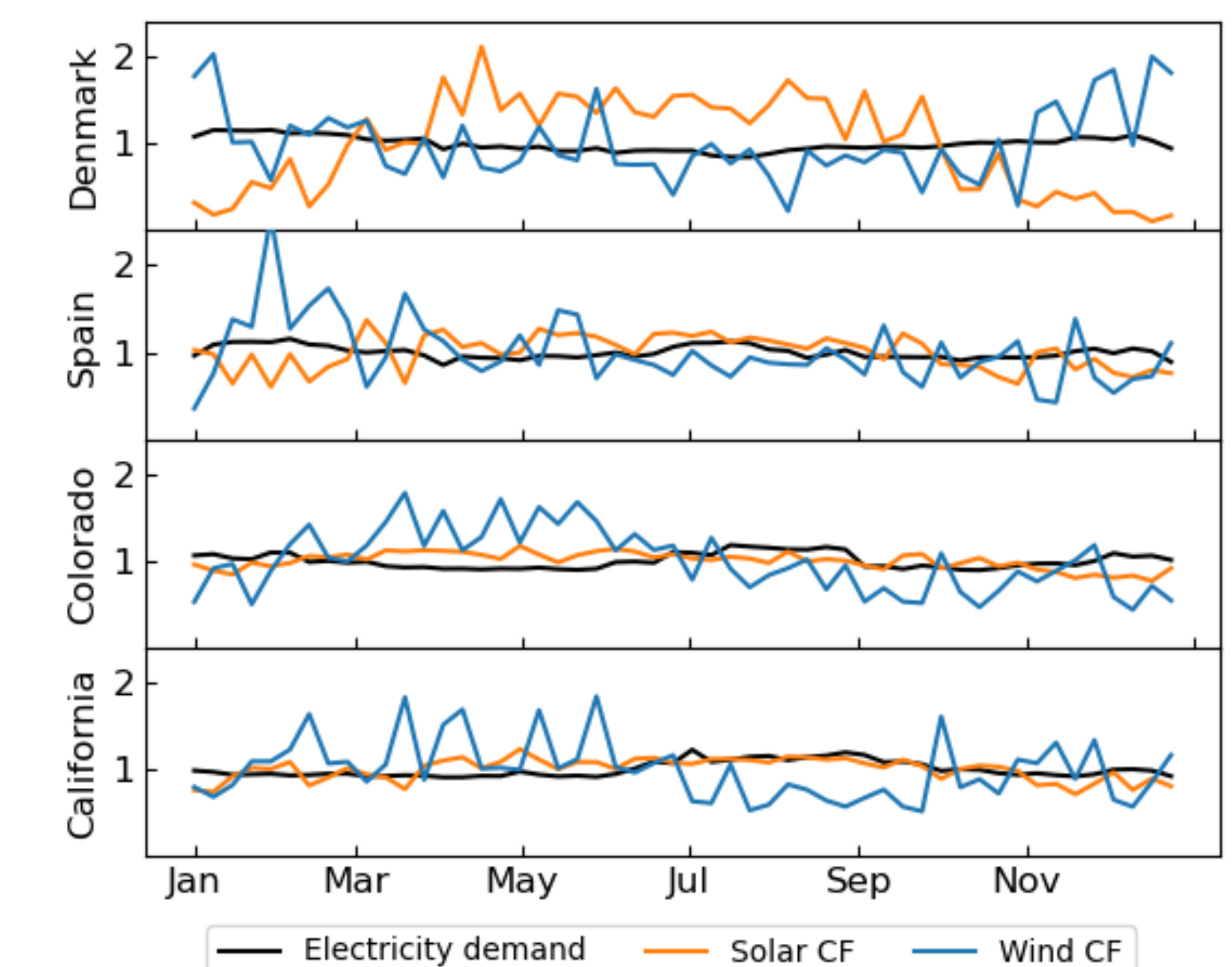


Transmission decreases solar correlation with latitude; sector coupling restores it

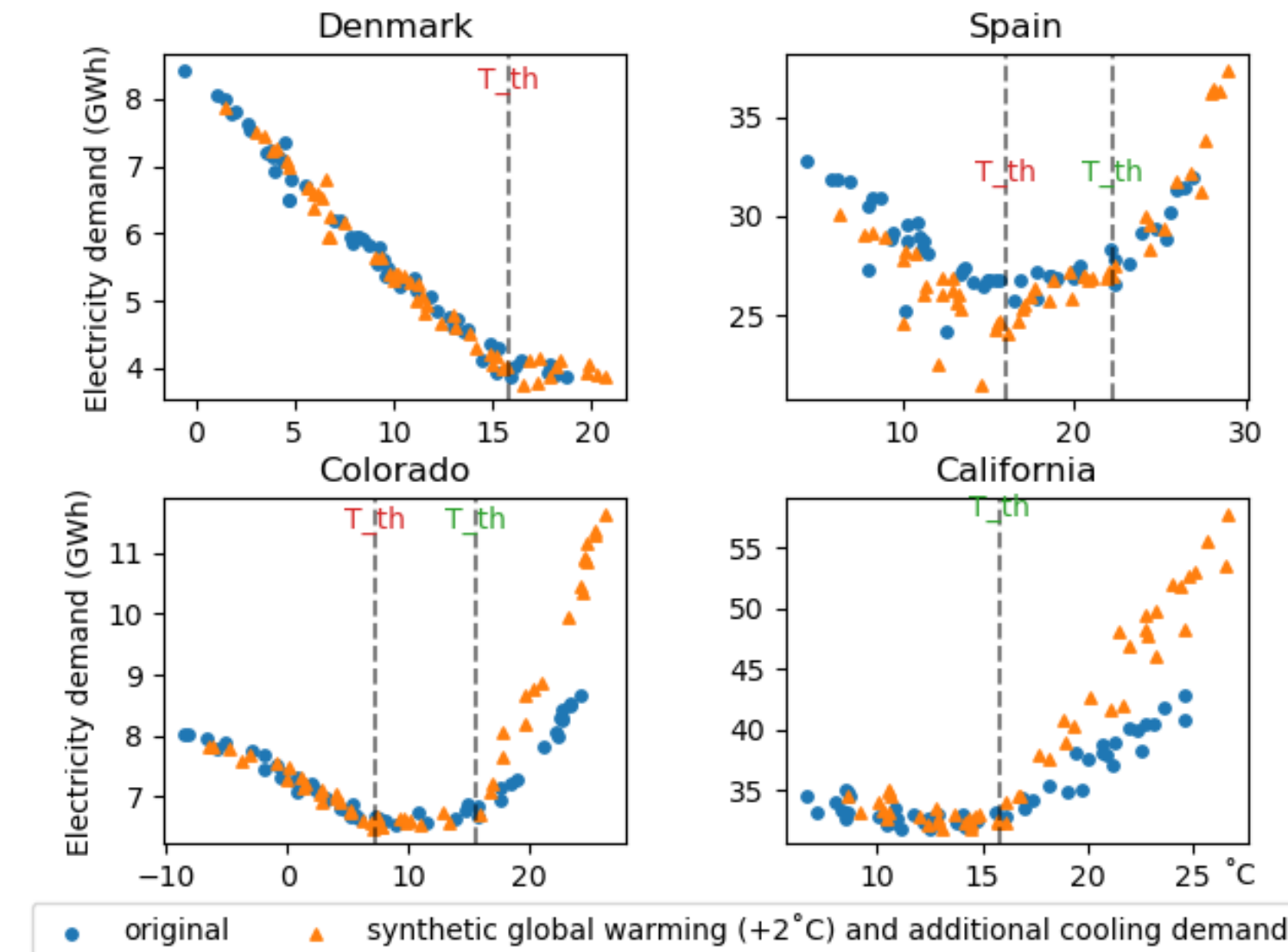


SINGLE NODE MODEL RESULTS

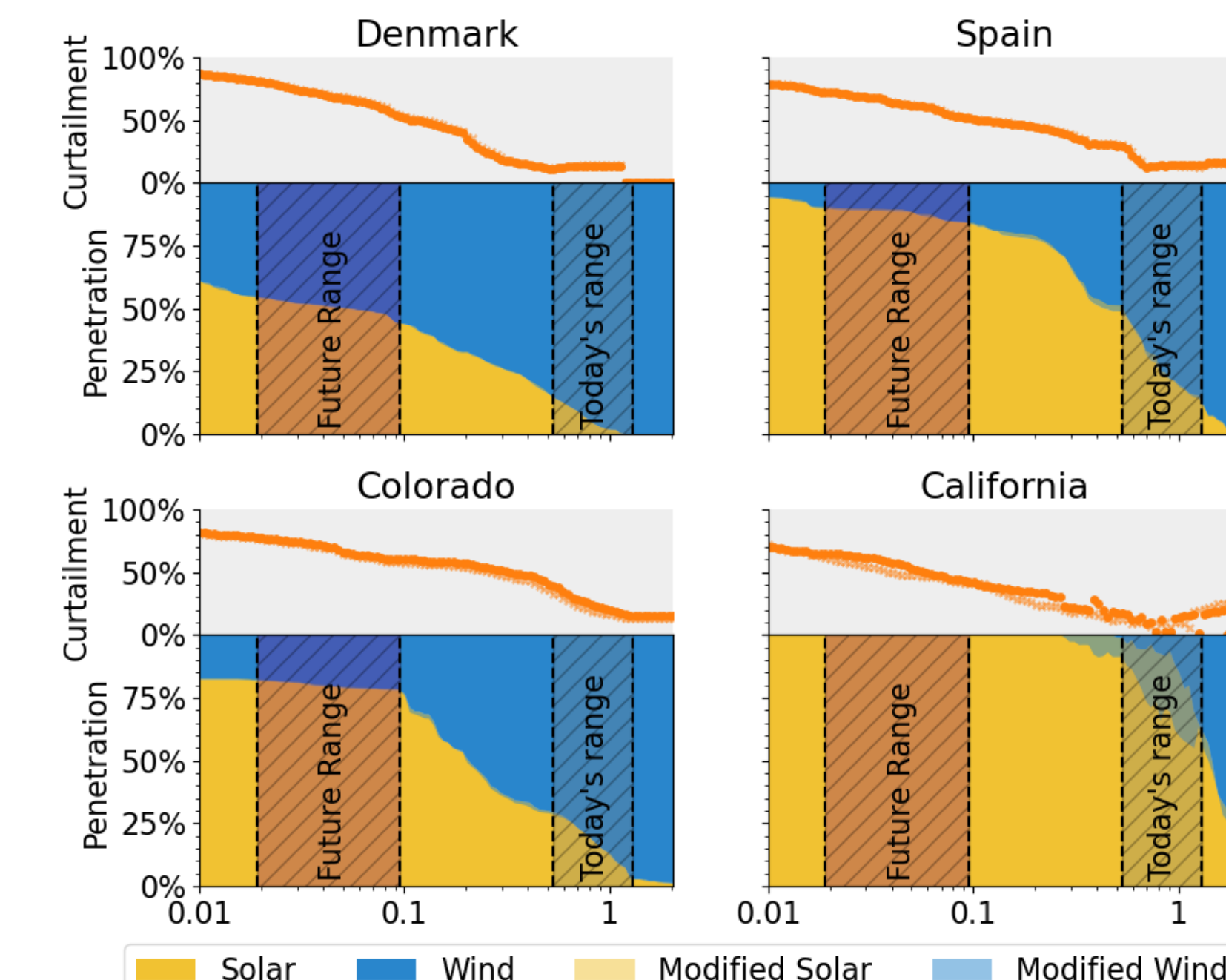
Seasonal Variation of Wind, Solar, and Electricity Demand



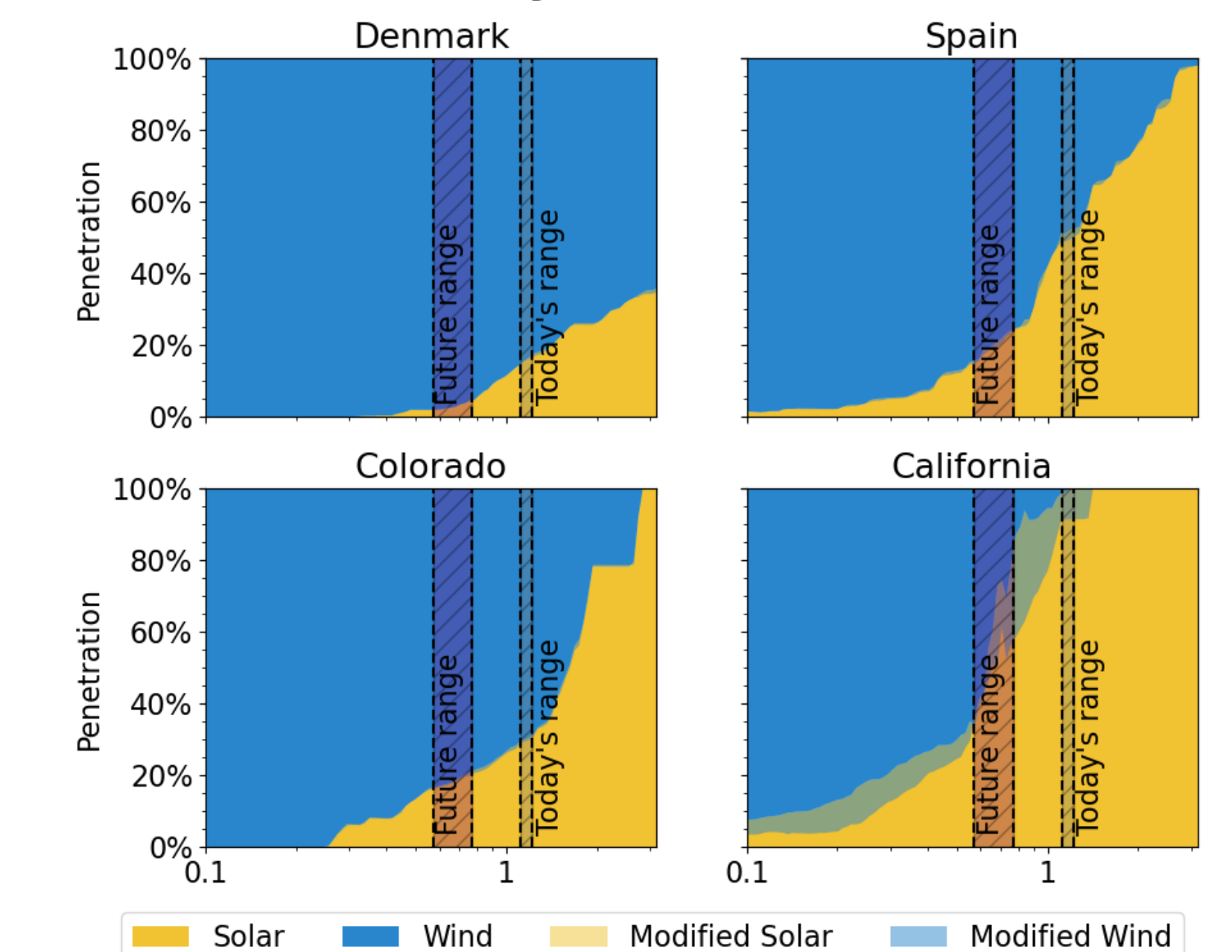
Electricity Demand Sensitivity to Temperature



Sensitivity to Cost of Solar (€/W)



Sensitivity to Cost of Wind (€/W)



Sensitivity to Cost of Battery (€/Wh)

