

Optimizing the Californian Power System according to the Renewable Portfolio Standards for 2030 and beyond

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Renewable portfolio standards (RPS)?

Electricity retail sellers and publicly-owned utilities have to procure:

33% of their electricity from eligible renewable energy resources by **2020**, and **50%** of it by **2030**.

Eligible RES: PV, wind, most biomass, geothermal, small hydro (<30MW)

Not: large hydro, nuclear (obviously).

Beyond 2030: we add a **100%** by **2050** (hypothetical, not based on any plans).

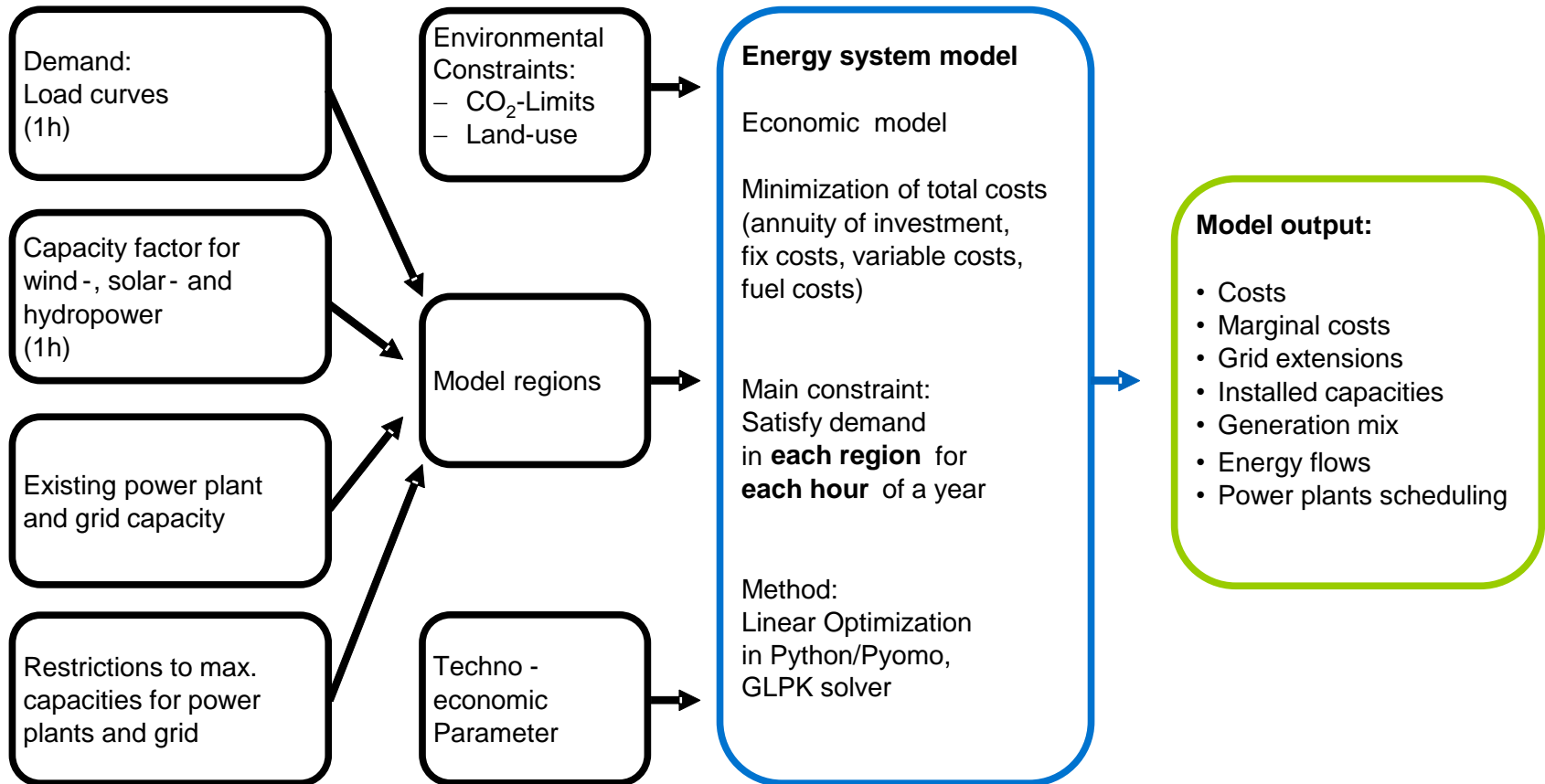
Research question

Which options for a cost-optimal solution are there? (social planner perspective, using a partial-equilibrium electricity model)

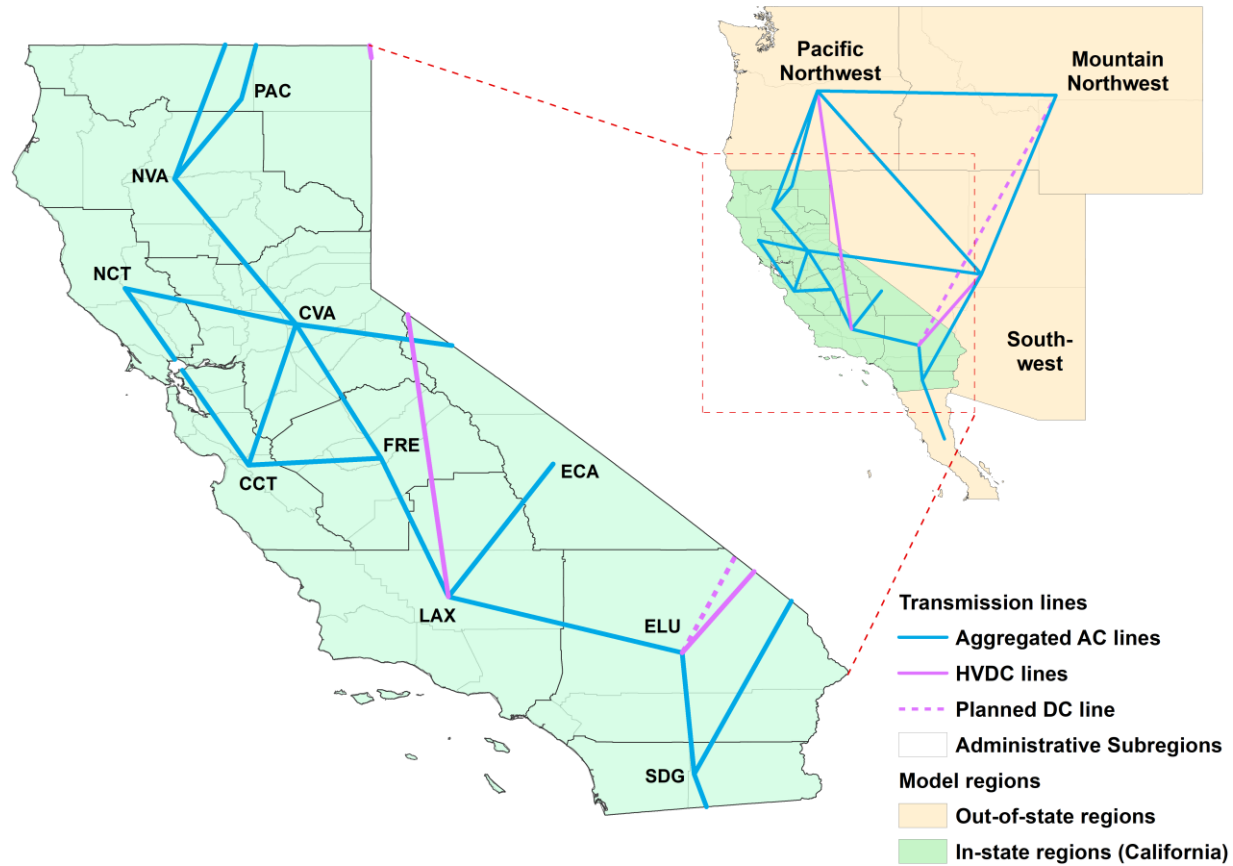
- Install more PV and onshore wind in California?
- Out-of-state generation?
- More storage to integrate more RES?
- Offshore wind?

- RPS Vs. carbon tax?
- Costs?
- CO₂ emissions?

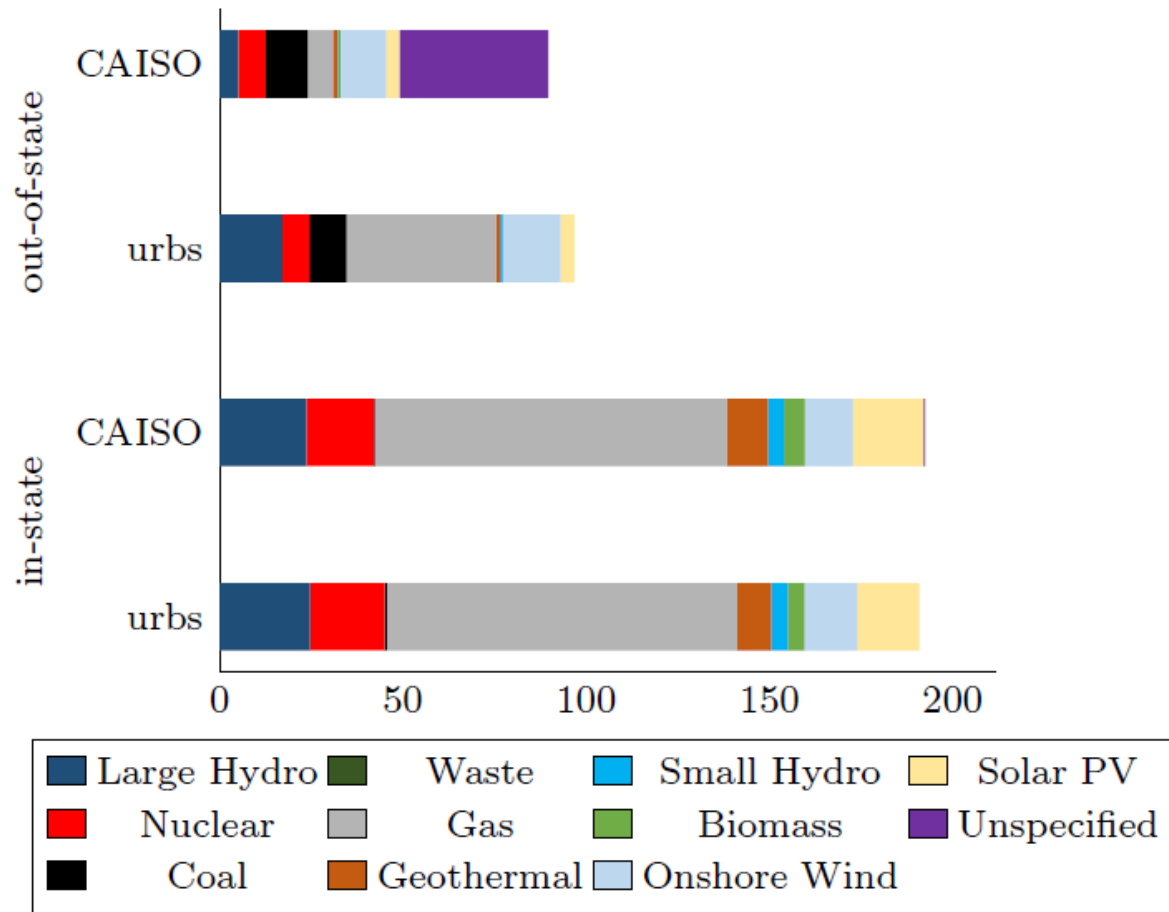
Model *urbs*



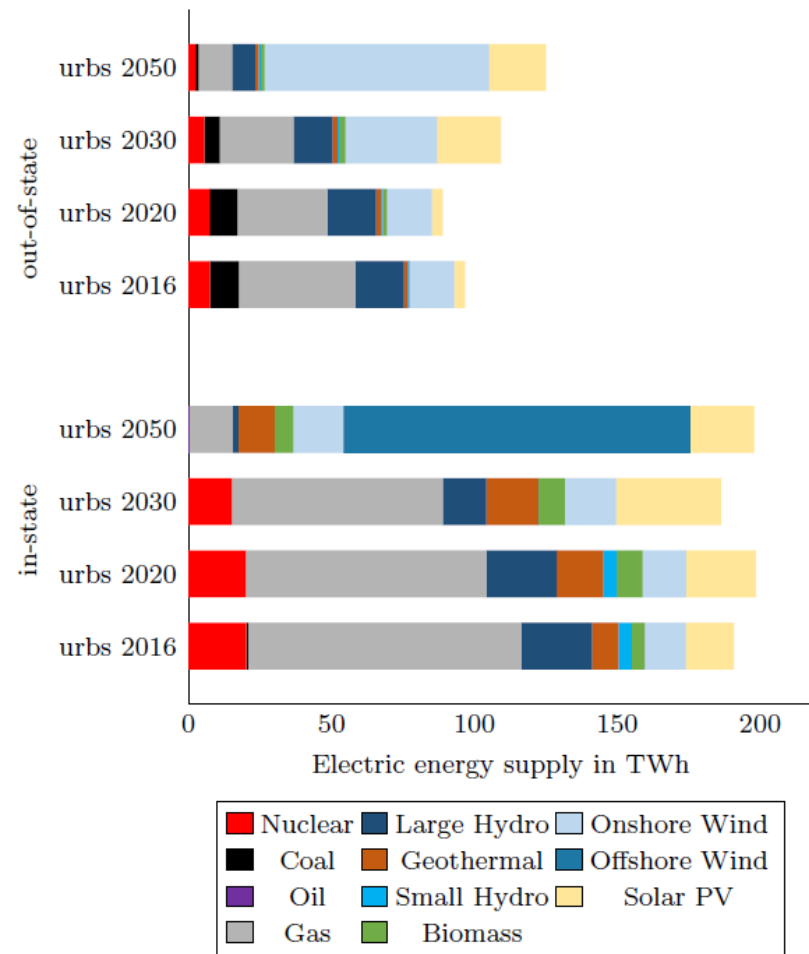
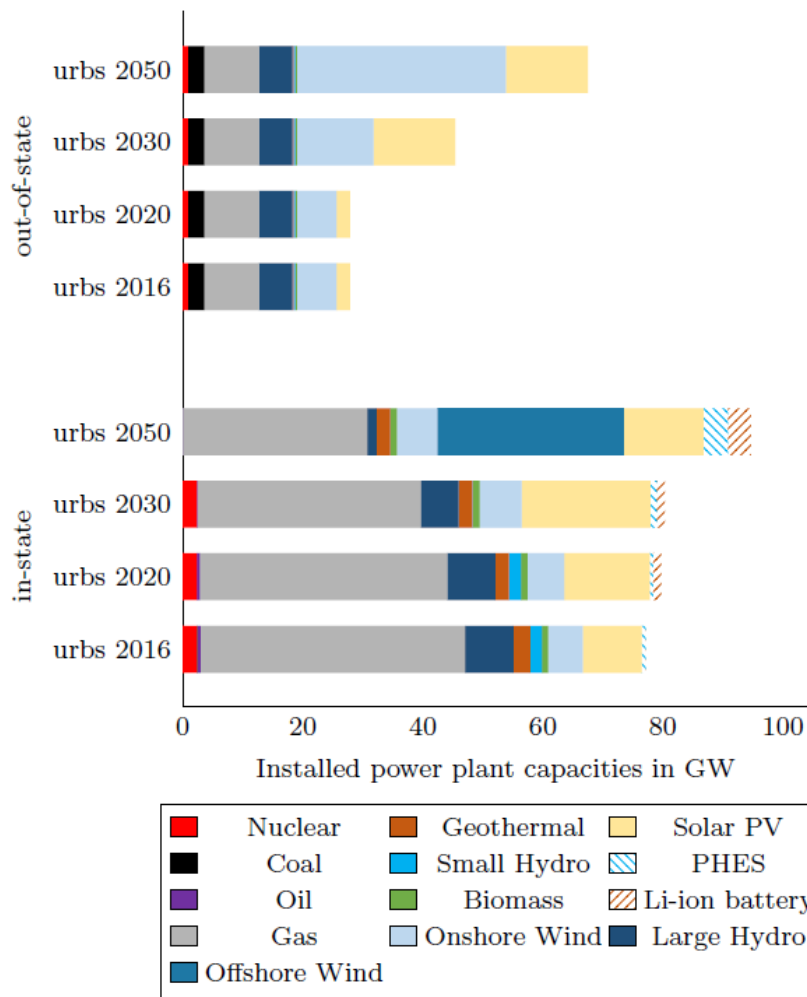
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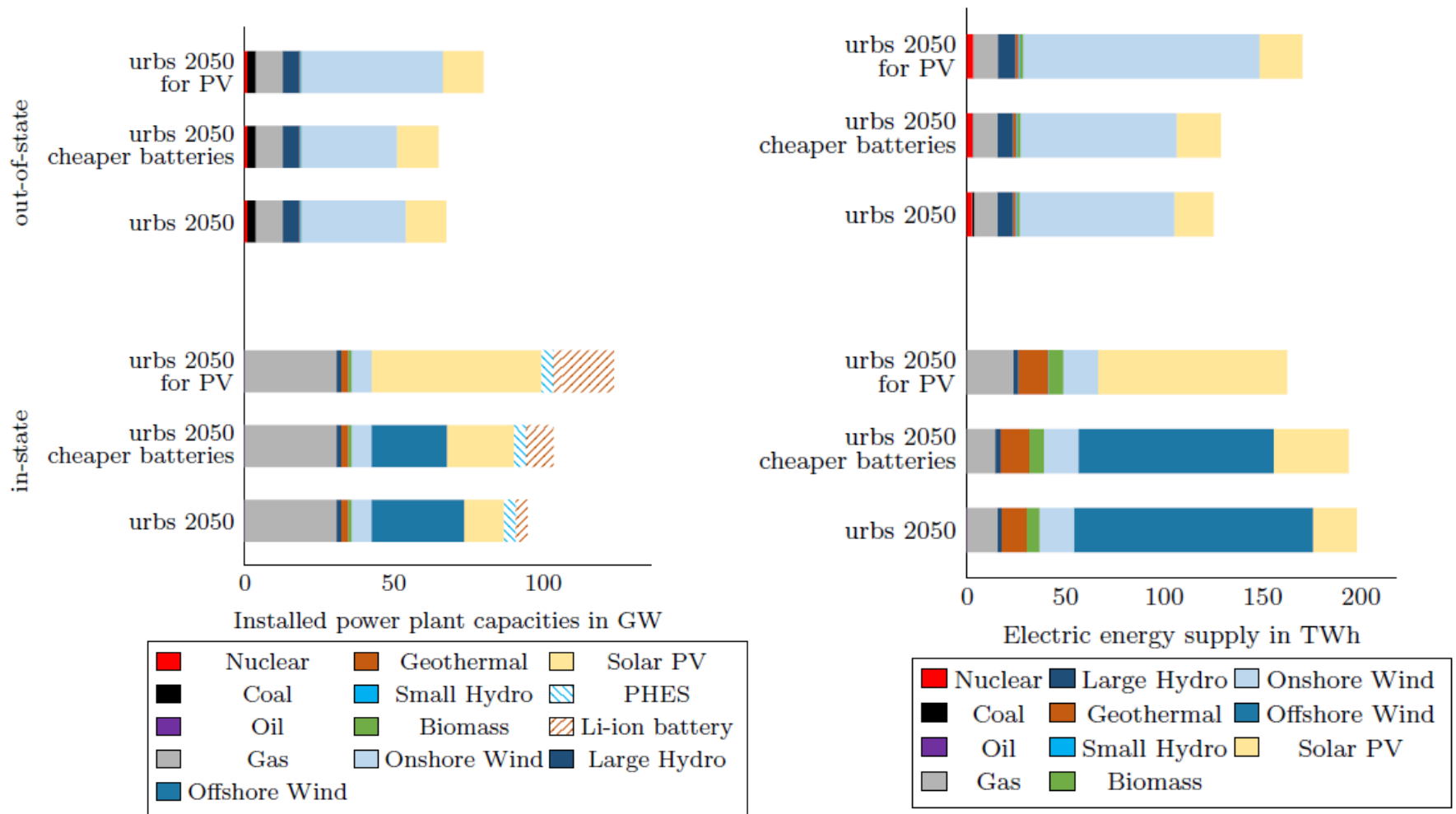
Calibration with CAISO statistics



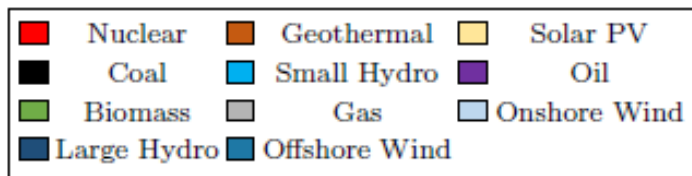
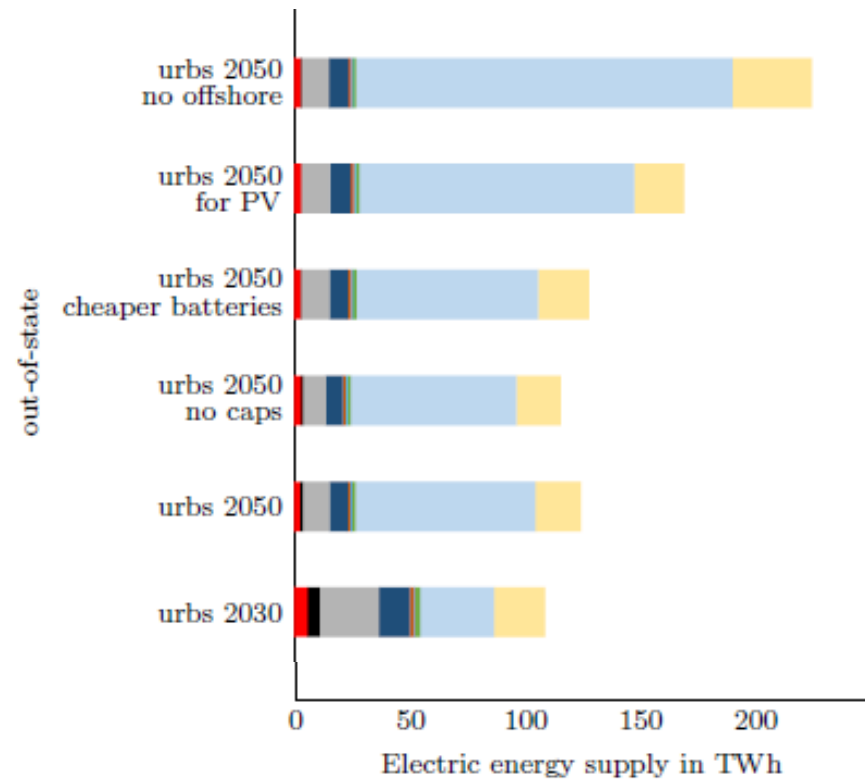
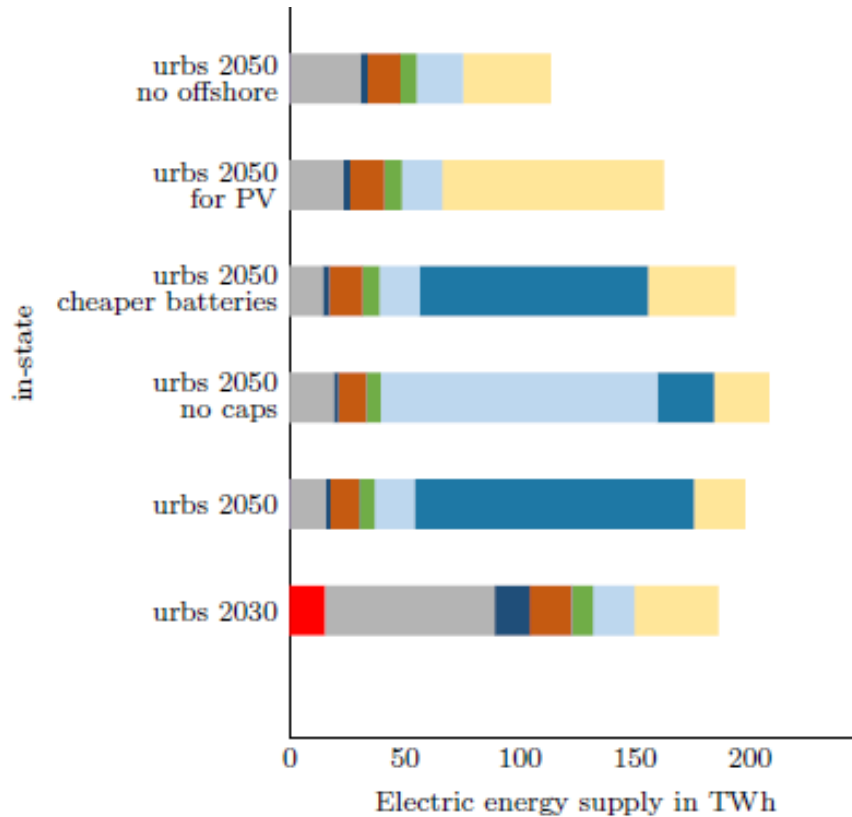
Optimal technology mix 2016-2050



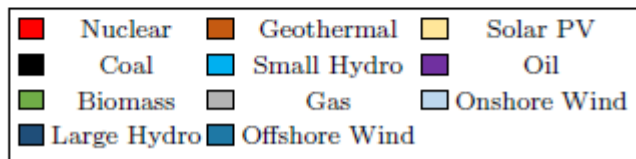
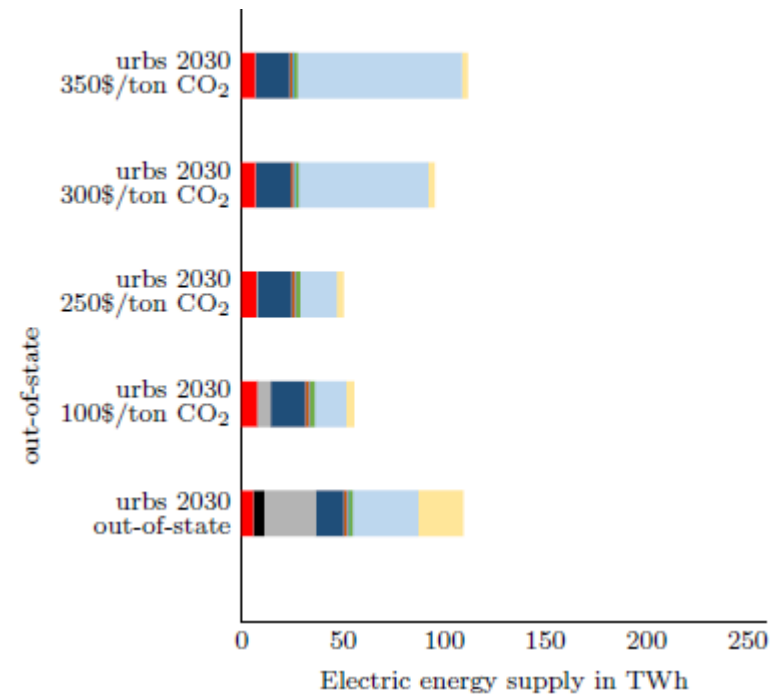
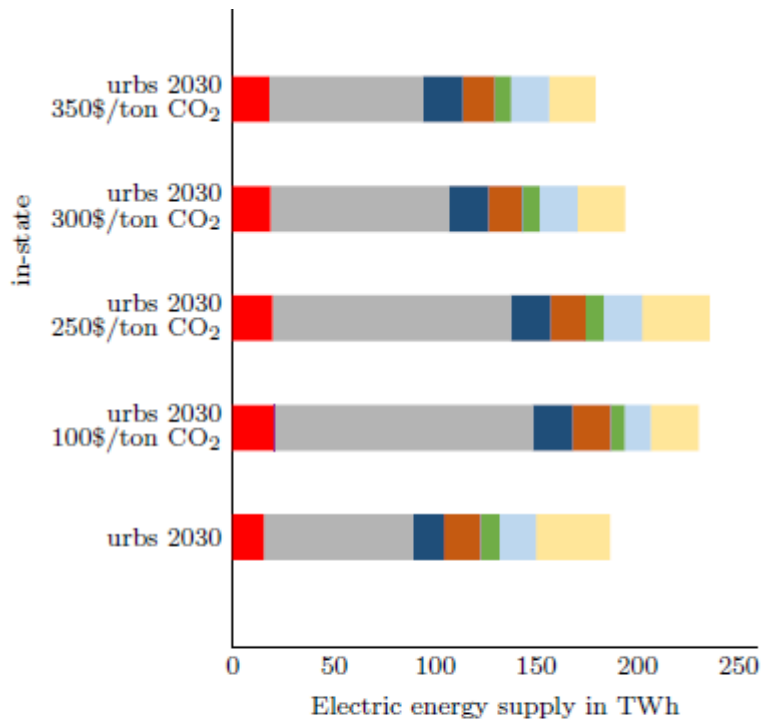
Sensitivity to battery costs



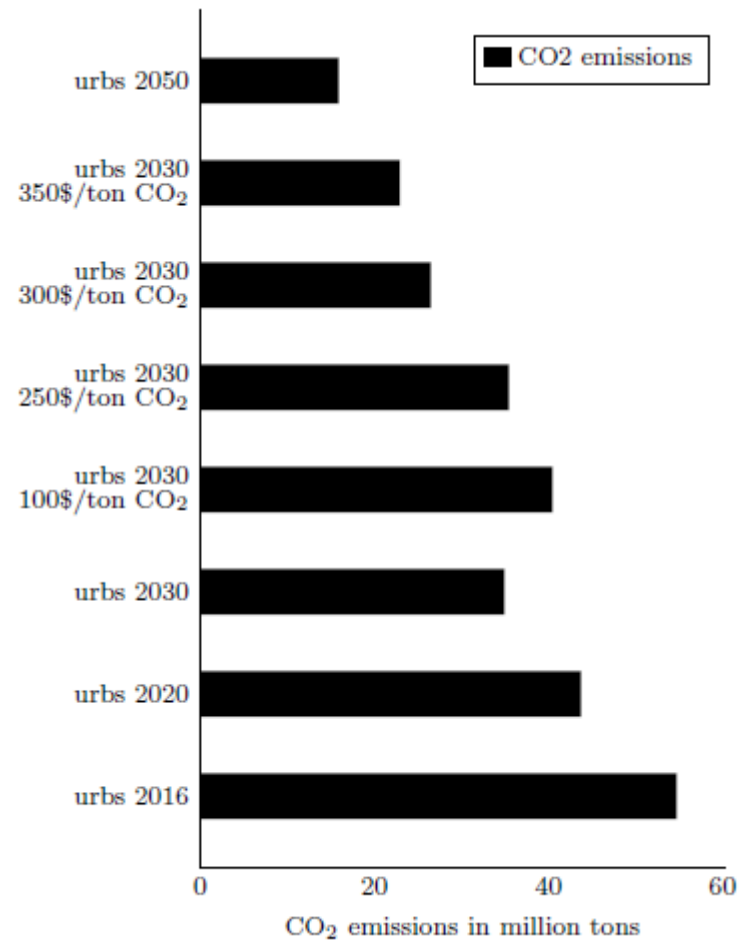
Impacts of capacity limits



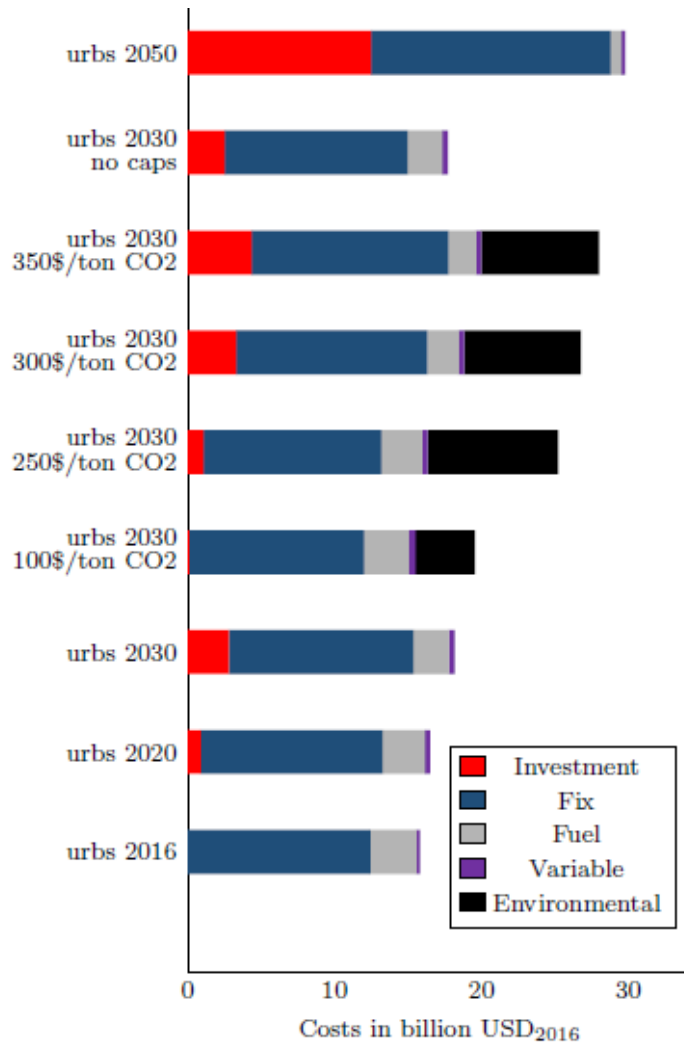
50% RPS Vs. carbon tax



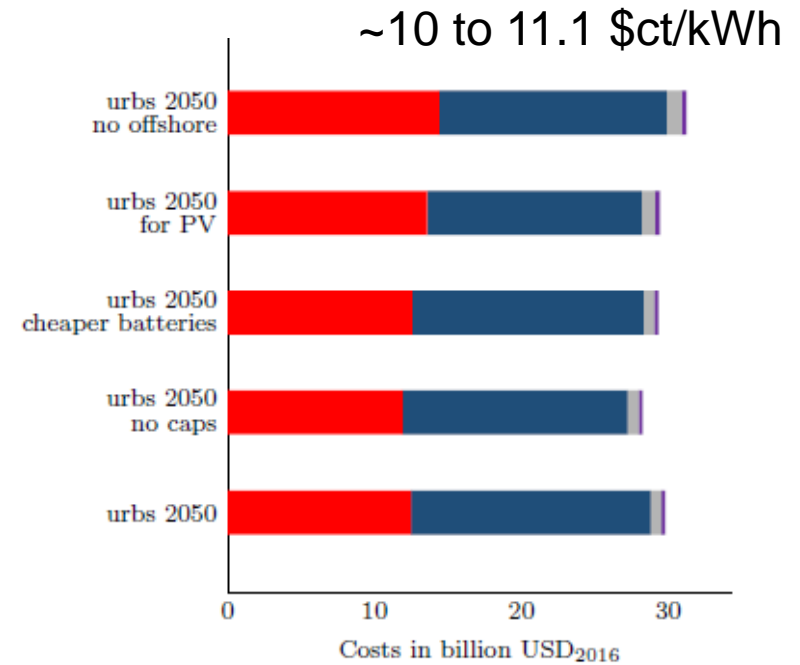
CO₂ emissions



System costs



~5.6 \$ct/kWh



Conclusions

California is on track to achieve its **2020 targets**.

Between 2016 and **2030**, California has to install around **11.5 GW of PV** and **1.3 GW** of onshore wind in-state, and will rely on additional **11.5 GW of out-of-state PV** and **6 GW of onshore wind** from Wyoming. The system costs will increase by **15%** compared to 2016.

Beyond 2030, floating **offshore wind** parks could play a major role. Otherwise: more in-state onshore wind parks, or even more **out-of-state** generation. System costs **double**.

Whereas the **carbon tax** needs to be very high to achieve the 50% RPS goal (~300\$/ton CO₂), it could lead to **less carbon emissions** and **higher in-state power generation**. The power mix features a higher share of **large hydro and nuclear** energy, and **less coal imports** from out-of-state regions.

The importance of **battery storage** correlates with the **installed PV capacity**.

Annex

Scenarios

urbs 2016 : This corresponds to the state of the electricity system by the end of 2016. No expansion is allowed.

urbs 2020 : Same as 2016, with an updated list of power plants and storage capacities. Planned power plants are included as minimum expansion targets, whereas the only coal power plant in California and the rarely used geothermal power plants (i.e. with a capacity factor lower than 40%) are decommissioned. Two constraints are enforced: the RPS at 33% and a battery mandate at 1.325 GW. The expansion of gas power plants and batteries is allowed in-state without a constraint. The implementation of solar PV and wind are constrained to reflect land use limitations and developing timeline of projects. Solar PV cannot expand more than 50% from the previous time step, and onshore wind cannot expand more than 25%. Only solar PV and onshore wind are allowed to expand out-of-state, with no limit. We assume average investment and fix costs for the period 2017-2020.

Scenarios

urbs 2030 : Building on the development of 2020, we further update the capacities of power plants and storage. Units that reached the end of their lifetime are retired, and capacities that were recommended in the expansion planning of the previous period are added. Two constraints are enforced: the RPS at 50% and a battery mandate at 1.325 GW. We assume average investment and fix costs for the period 2021-2030.

urbs 2050 : Same as 2030, with an updated list of power plants and storage capacities. Two constraints are enforced: the RPS at 100% and a battery mandate at 1.325 GW. We assume average investment and fix costs for the period 2031-2050.