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Review and discussion of:

The Impact of Storage Costs on need and use of transmission for WECC and California

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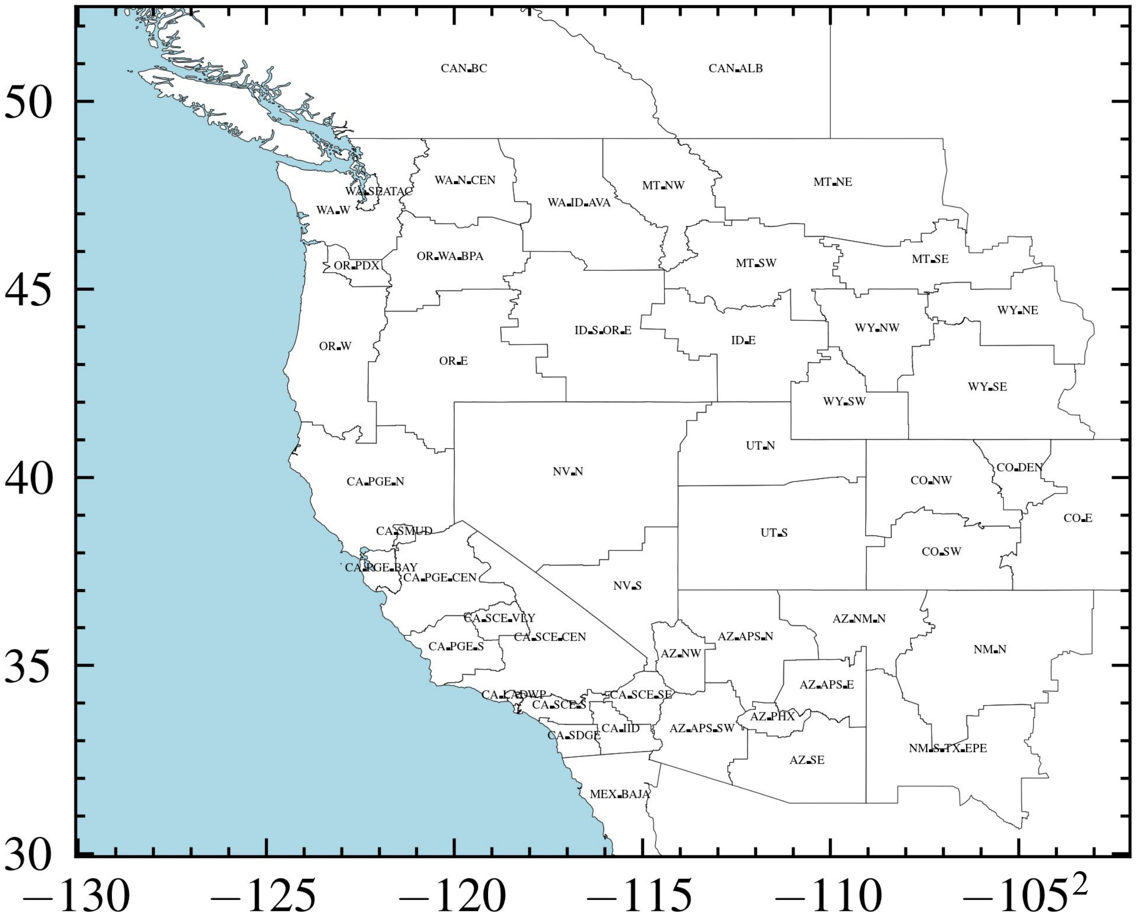
How is the Western Interconnection modeled in Switch?

1. 11 states (AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY) plus Canada (CAN) and Mexico (MEX).

2. 11 states disaggregated into 50 load zones shown in the map.

3. Each load zone has a demand and generation portfolio that can be expanded as the Switch model decides.

4. The load zones are connected through transmission lines that can be expanded as the Switch model decides.



Scenarios under analysis

Two scenarios are under analysis for 2050, assuming zero emissions target:

Scenario	Input parameters	
	Storage power capacity cost	Storage energy capacity cost
1	10 $/kW	10 $/kWh
2	140 $/kW	170 $/kWh

The SWITCH WECC model:

SWITCH takes storage power capacity cost and storage energy capacity cost as input parameters.

SWITCH computes the optimal value of energy capacity, power capacity, and duration for each storage project to build.

Highlights

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1. As storage cost declines, the WECC is more dependent on solar resources.

2. Expensive storage costs increase WECC building of new transmission capacity. On the other hand, cheap storage costs result in higher load factors for existing transmission lines.

3. California follows the same trend. Storage cost declines results in California building more in-zone transmission capacity. Contrary to the previous trend, storage cost declines increase California's build of intertie transmission

4. The cheapest storage encourages installation of more solar (e.g., in LA, SD) if there is available transmission capacity

5. During the California peak demand timestamp, the power flow goes from Oregon to southern California. This is the opposite direction than the average annual load factor.

How does storage cost affect the expansion and load factor of the transmission lines?

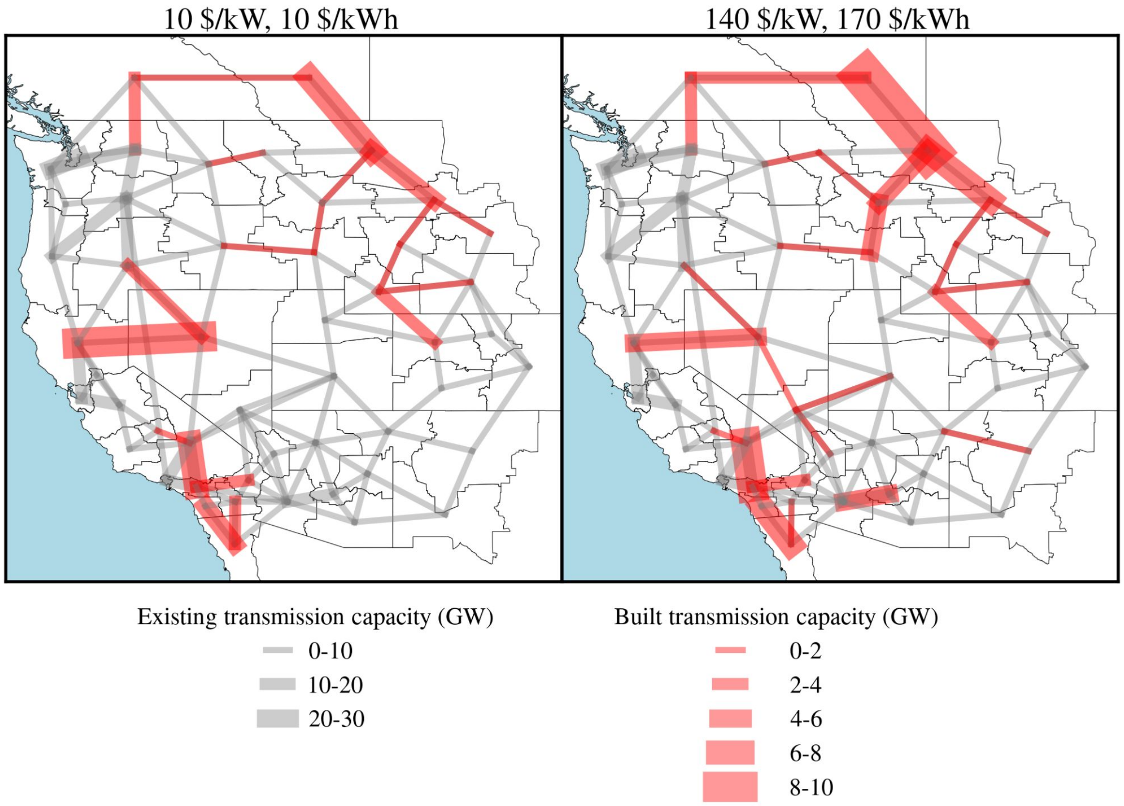
Intertie and in-zone transmission capacity

Legend

In-zone transmission line

Intertie transmission line

Transmission capacity (GW)



As storage cost decreases,

1. California requires more intertie transmission capacity.

2. California requires less in-zone transmission capacity.

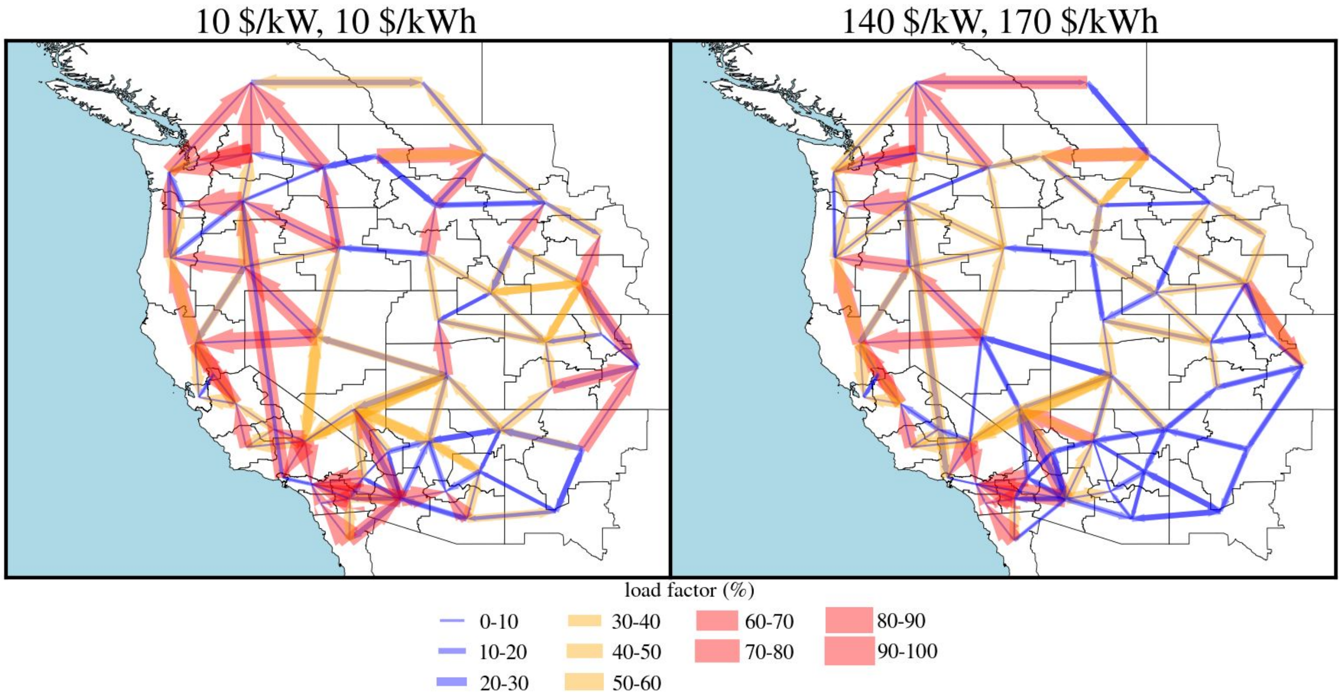
3. WECC requires less transmission capacity.

	Low storage cost scenario	High storage cost scenario
Intertie capacity for California	50.7 GW ↘	45.7 GW
In-zone capacity for California	114.7 ↗	116.5
WECC-wide	455 GW ↗	475.5 GW

1. Average annual load factor of the transmission lines
2. The load factor of the transmission lines at the peak California demand timestamp
3. Load factor at the lowest energy exchange California ratio timestamp

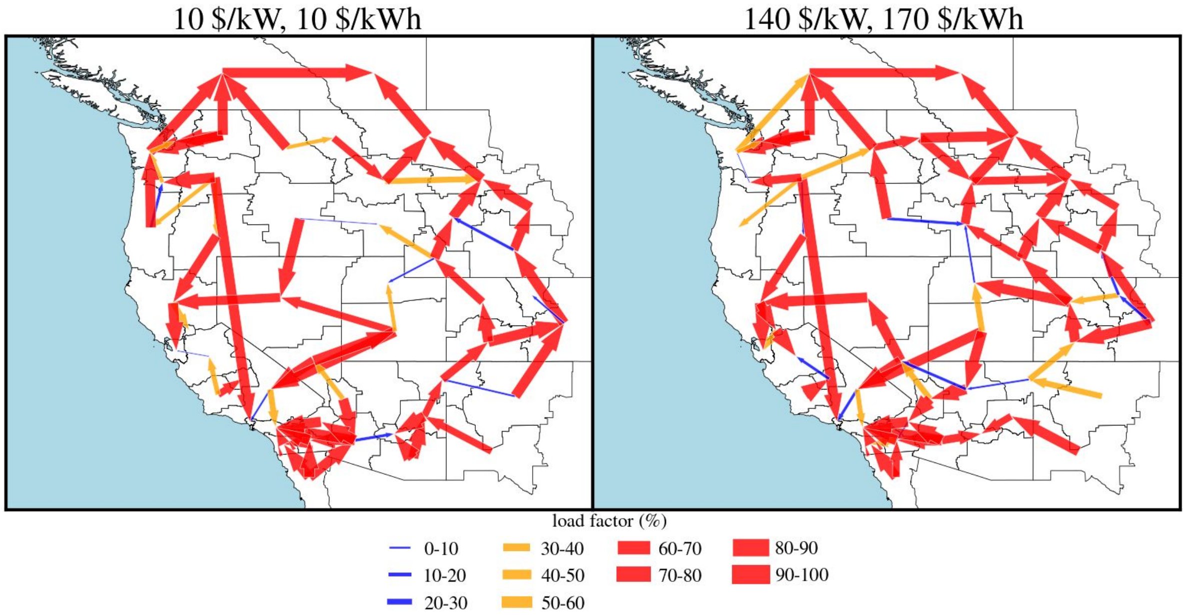
} The worst case scenarios (extreme cases) — applies to items 2 and 3

Average annual load factor of transmission lines



1. The lines within OR, WA and CA of the 10-10 scenario show higher average annual load factors than the same lines of the 140-170 scenario.

Load factor of transmission lines at the peak California demand

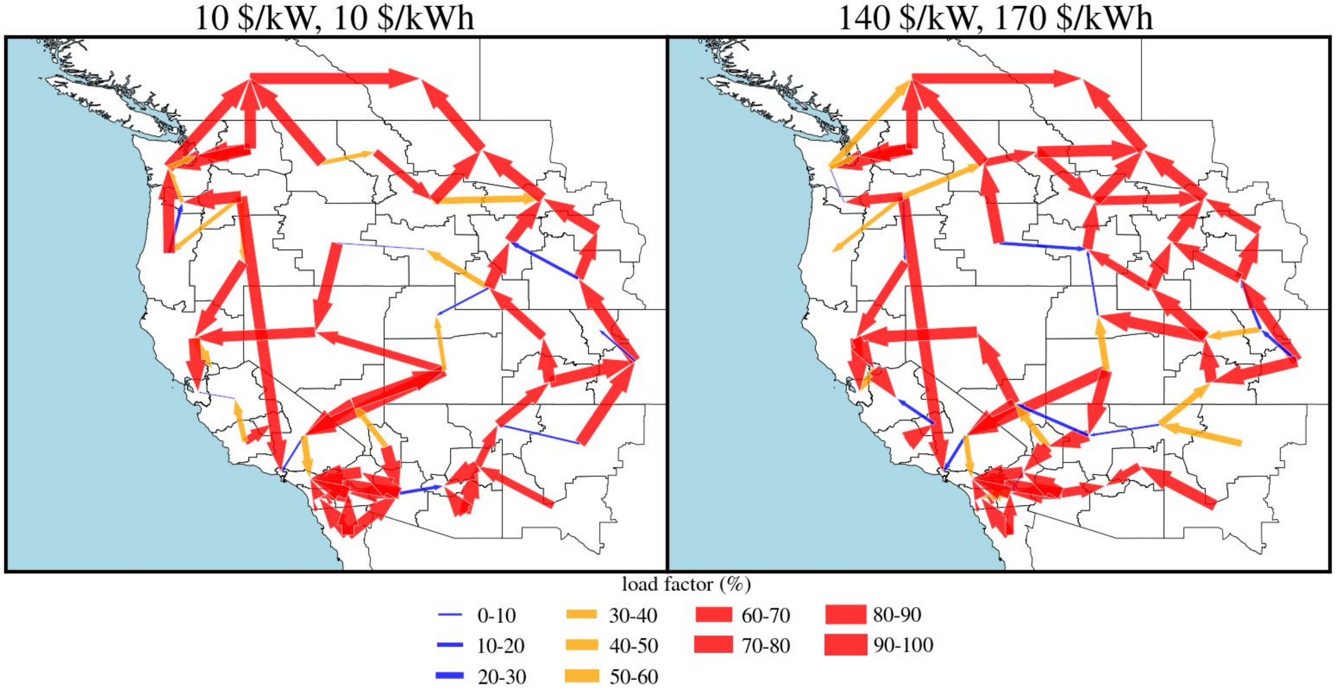


1. When California reaches its highest demand of the year, regardless of the storage cost:

1.1. Nevada always exports energy to the neighboring zones. Oregon zones and northern California zones are the most benefited ones.

1.2. The zones in southern California are significantly dependent on the imports from Arizona and Mexico Baja, which both are greatly solar generation-based zones.

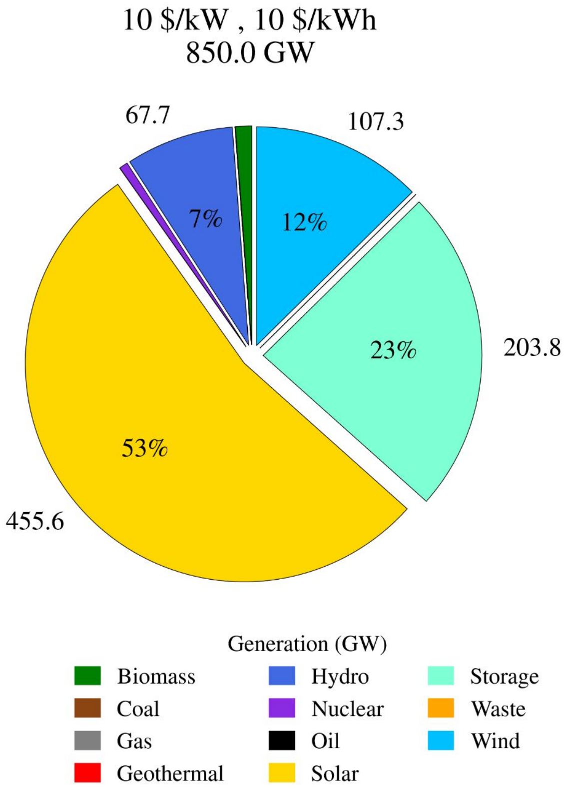
Load factor of transmission lines at the lowest energy exchange



Results show a similar load factor of transmission lines during California's peak hour and when California's imports are the highest in 2050.

How does storage cost affect the generation portfolio and investments?

Installed power capacity in the WECC

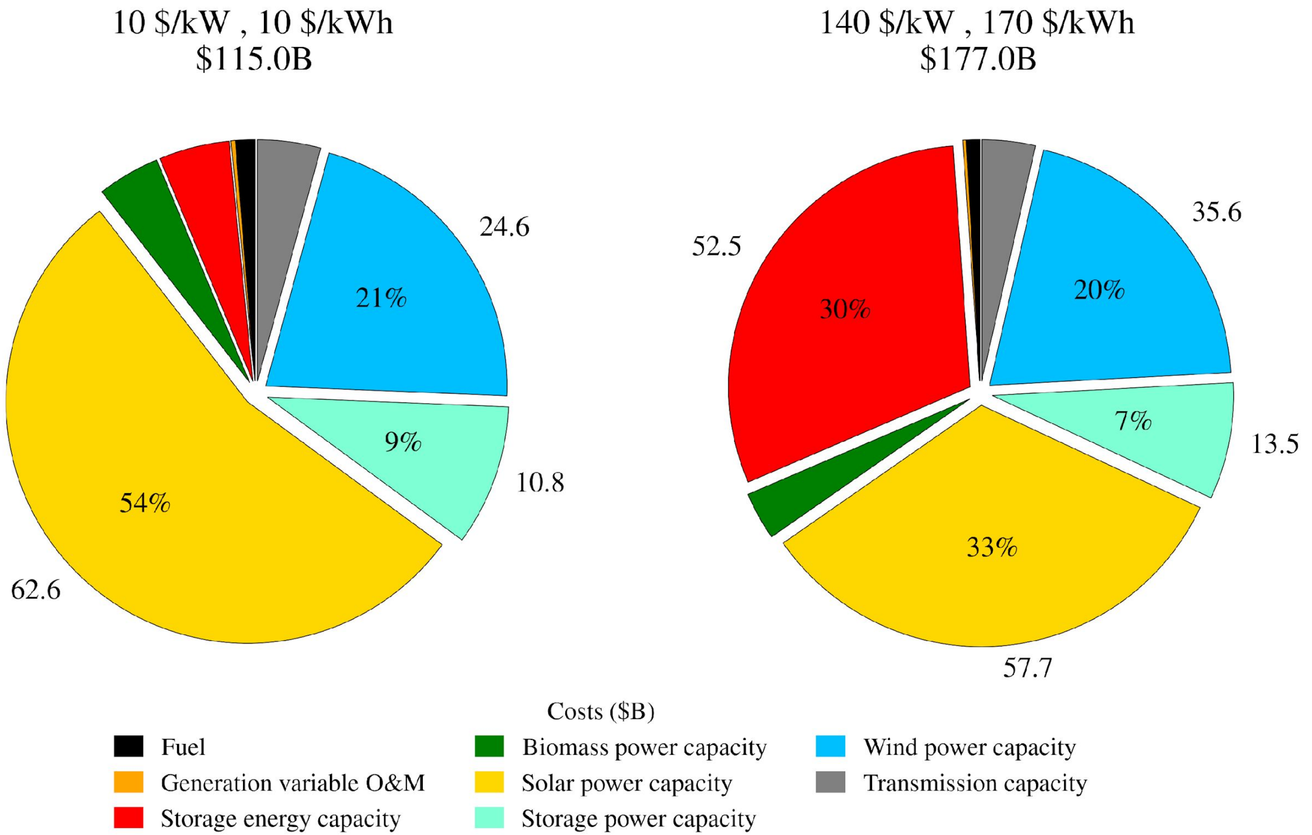


1. Both scenarios show a similar share of solar power.

2. In the low cost scenario, total installed capacity increases by 34 GW (WECC).

3. The low cost scenario deployed 47 GW more of storage power capacity.

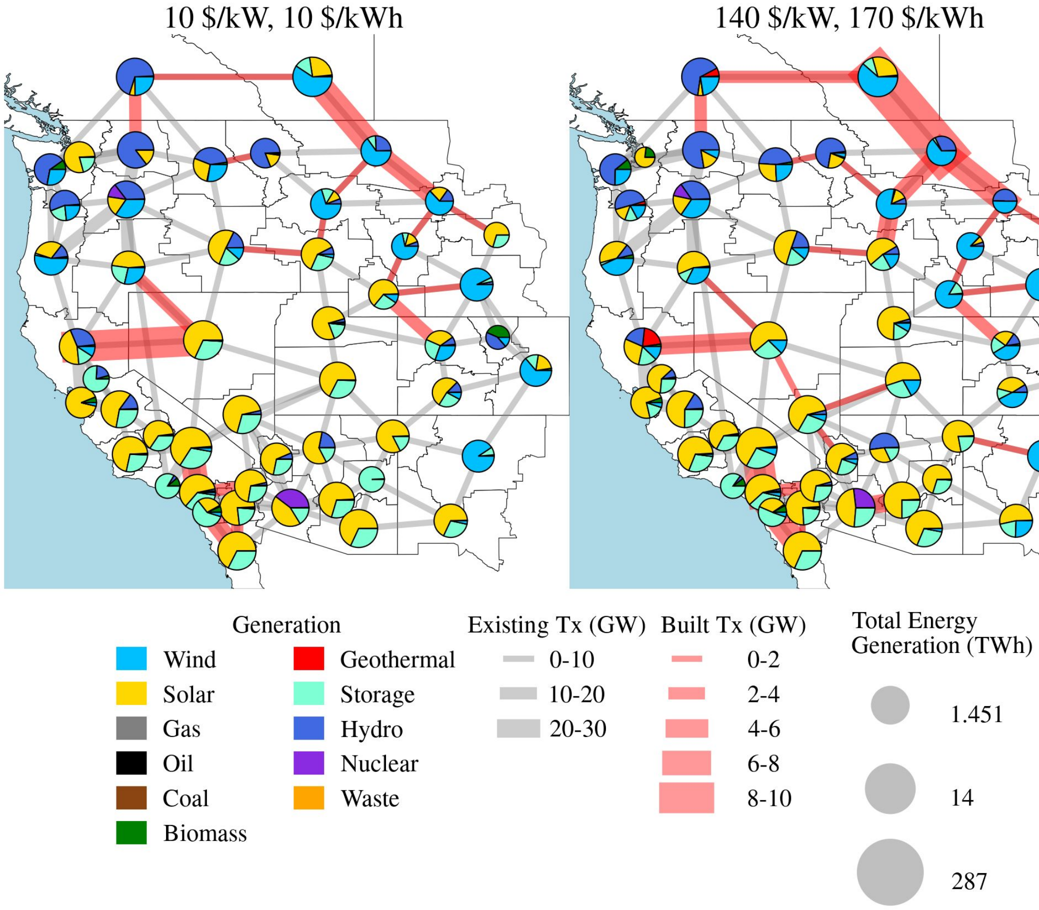
WECC cost breakdown (Breakdown of the objective function



1. The low cost scenario has a significant cost share (more than 50%) of solar power capacity.

2. The high cost scenario has much more cost share of storage energy capacity than the one of the low cost scenario. We assume that this happens because of the cost of storage energy capacity.

Generation portfolio (GW) and transmission capacity (GW)



The pie charts show the shares of power generation capacity of the generation fleet in each load zone.

We recall from slide 7:

	Low storage cost scenario	High storage cost scenario
Intertie capacity for California	50.7 GW ↘	45.7 GW
In-zone capacity for California	114.7 ↗	116.5
WECC-wide	455 GW ↗	475.5 GW

Deployment of storage technologies

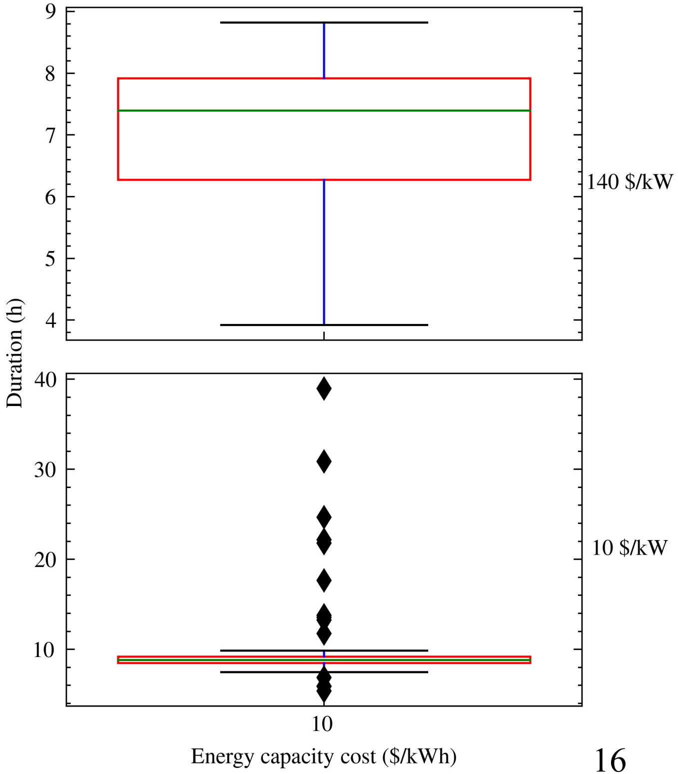
Summary of the deployment of storage in the WECC

Scenario	Duration (h)	Energy capacity (TWh)	Power capacity (GW)
Low storage cost	11.2	2.1	203.8
High storage cost	7.2	1.2	156.7

Summary of the deployment of storage in California

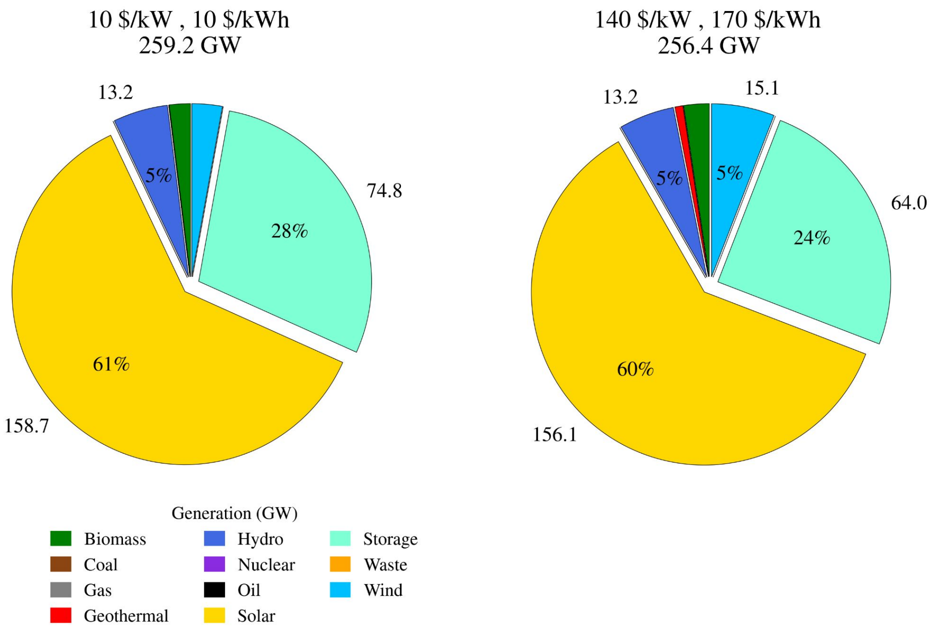
Scenario	Duration (h)	Energy capacity (GWh)	Power capacity (GW)
Low storage cost	7.9	611.8	74.8
High storage cost	7.3	487.2	64

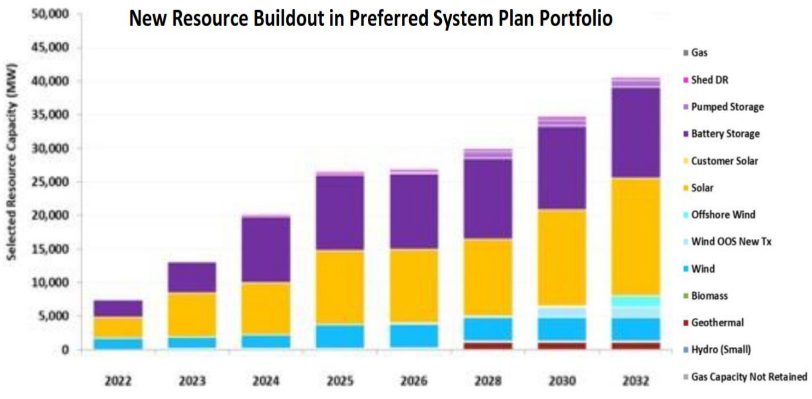
Distribution of the duration in the WECC



Looking at California

Installed power capacity (GW) in California in 2050





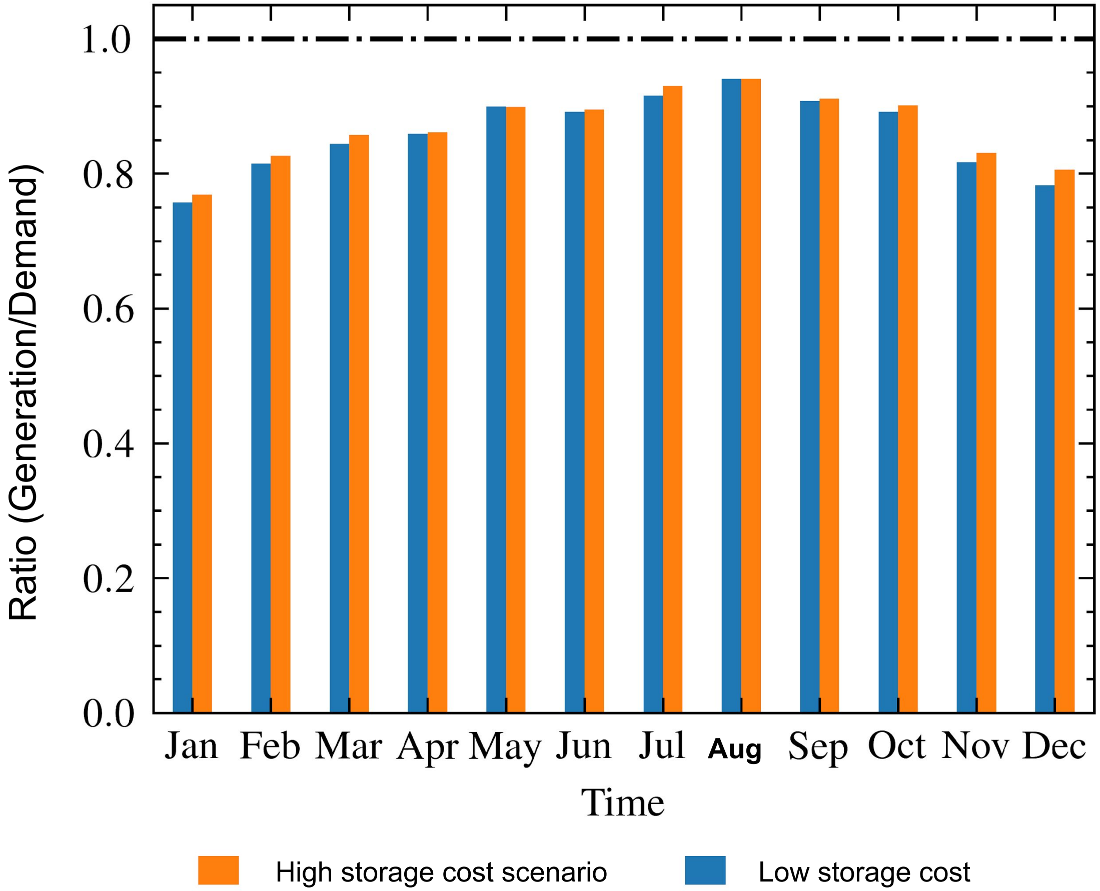
2021 CPUC IRP PSP[1]

CPUC’s IRP shows a ~39% of solar capacity in 2032, while SWITCH results show ~61% in 2050.

CPUC’s IRP shows a ~36% of storage power capacity in 2032, while SWITCH results show ~28% in 2050.

[1] California Public Utilities Commission, Fact Sheet: Decision Adopting 2021 Preferred System Plan

Monthly energy exchange ratio deployment of California



1. Storage cost declines do not affect the energy exchange ratio of California significantly.

2. California behaves as a net importer on a monthly basis regardless of the massive deployment of storage assets caused by storage costs declines.

3. Hence, extensive efforts are still required to make California self-sufficient.

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Appendix

Curtailment

scenario	period	Curtailment (GWh)	Dispatch (GWh)	Curtailment (%)
2050_wecc_10_10	2050	173.2	1343.0	11.4
2050_wecc_140_170	2050	241.8	1289.8	15.8

From previous slide, deployment of solar and wind resources:

10-10 scenario: 659.4 GW
140-170 scenario: 578.2 GW

1. As storage cost declines, the curtailment (GWh) decreased up to 28% despite the increase in 14 % of power capacity deployment of wind and solar resources.

2. Therefore, storage costs declines make the system able to efficiently exploit solar and wind resources by reducing curtailment as much as possible. This result goes hand in hand with the fact that storage costs declines cause more deployment of storage technologies with higher energy capacity which are able to shift energy over the time to reduce curtailment.

3. Storage costs declines encourage the upsize of power capacity of wind and solar resources. Though we may expect this upsize of power capacity may bring curtailment issues, the massive deployment of storage technologies due to storage costs declines addresses the curtailment issues.

4. Regional power systems towards 100 % clean target goals need lower storage costs, especially energy capacity costs, to spur the massive deployment of renewable energy with low levels of curtailment.

Questions to solve in this study

1. How does storage cost affect transmission capacity expansion of the WECC and California?

2. How does storage cost affect the load factor of the transmission lines of the WECC and California?

3. How does storage cost affect generation portfolios and curtailment of the load zones of the WECC?

4. How does storage cost affect the California importer/exporter behavior?

5. Next steps: varying cap on transmission capacity deployment in the WECC