# The Potential Role of Concentrating Solar Power within the Context of DOE’s 2030 Solar Cost Targets

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**DOE Solar Energy Technology Office Summit**

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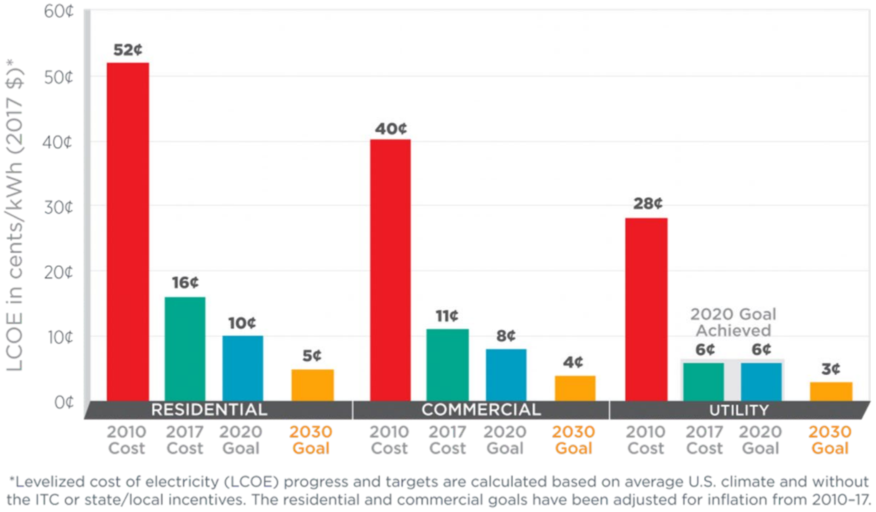
**Presentation based on https://www.nrel.gov/docs/fy19osti/71912.pdf**

# What are the potential impacts of simultaneously achieving DOE's 2030 cost targets for PV and CSP-TES?

SunShot PV Progress and Goals




SunShot CSP Progress and Goals

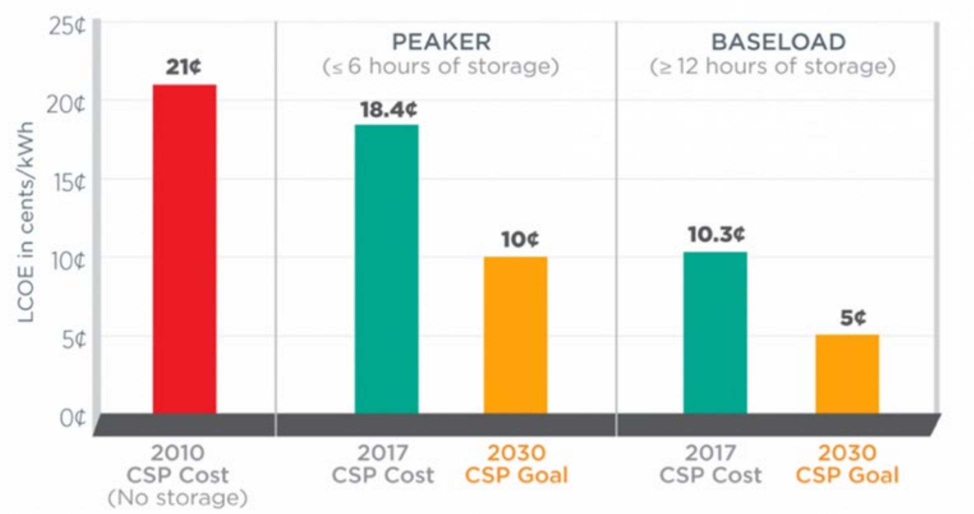
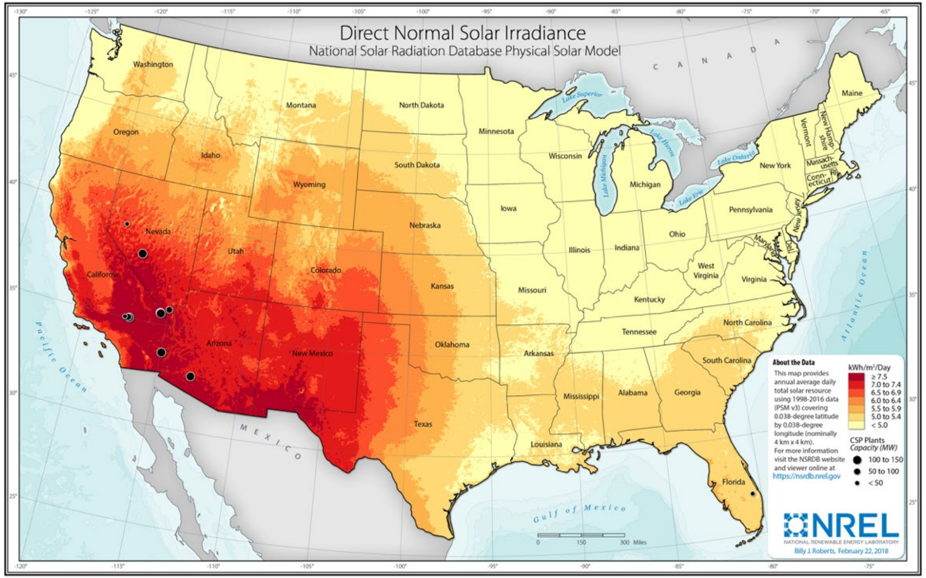



Figure source: https://www.energy.gov/eere/solar/goals-solar-energy-technologies-office

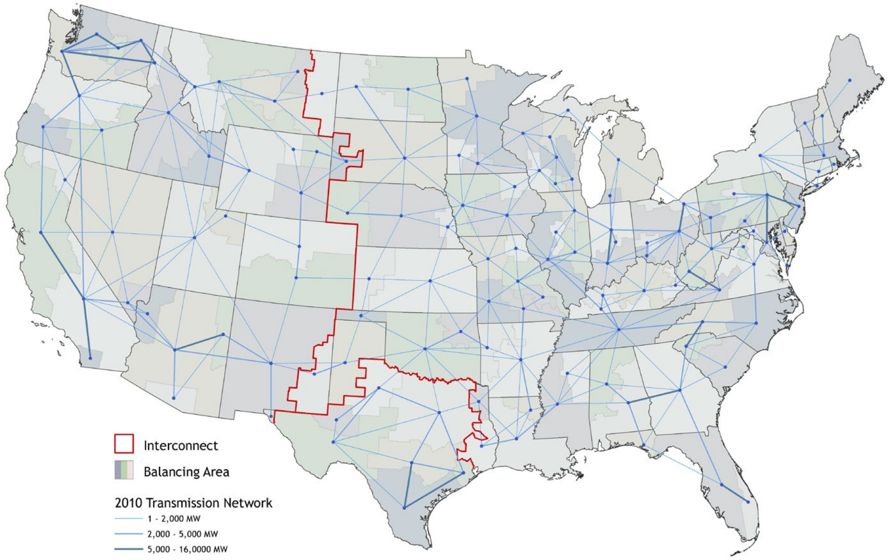
# Approach: Capacity Expansion Modeling

**Scenario analysis** to evaluate the potential impacts of simultaneously achieving the 2030 cost targets for PV and CSP-TES through long-term capacity expansion modeling, which simulates the expansion and operation of the U.S. generation and transmission systems through 2050

## National Solar Radiation Database (NSRDB)



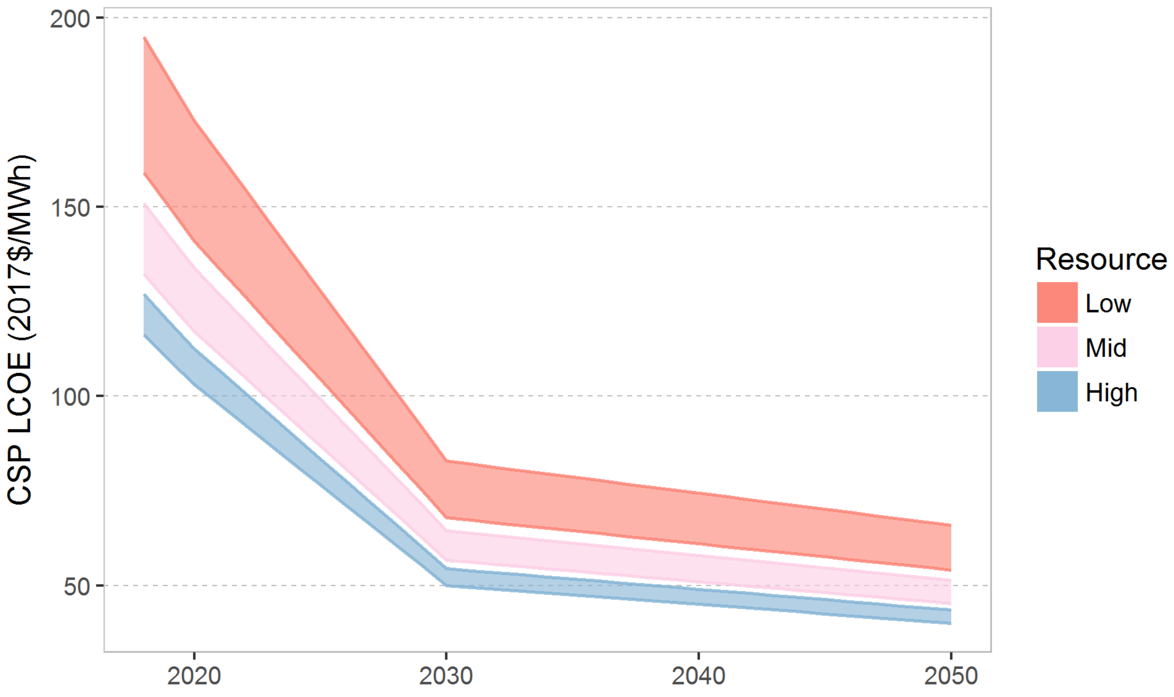

## Regional Energy Deployment System (ReEDS) model



# Representing DOE's Cost Targets for CSP-TES

- DOE's 2030 cost target for CSP-TES assumes 50%-80% reductions in the solar field and TES material costs

- Cost reductions after 2030 represent technology learning and/or improvements that could result from innovation

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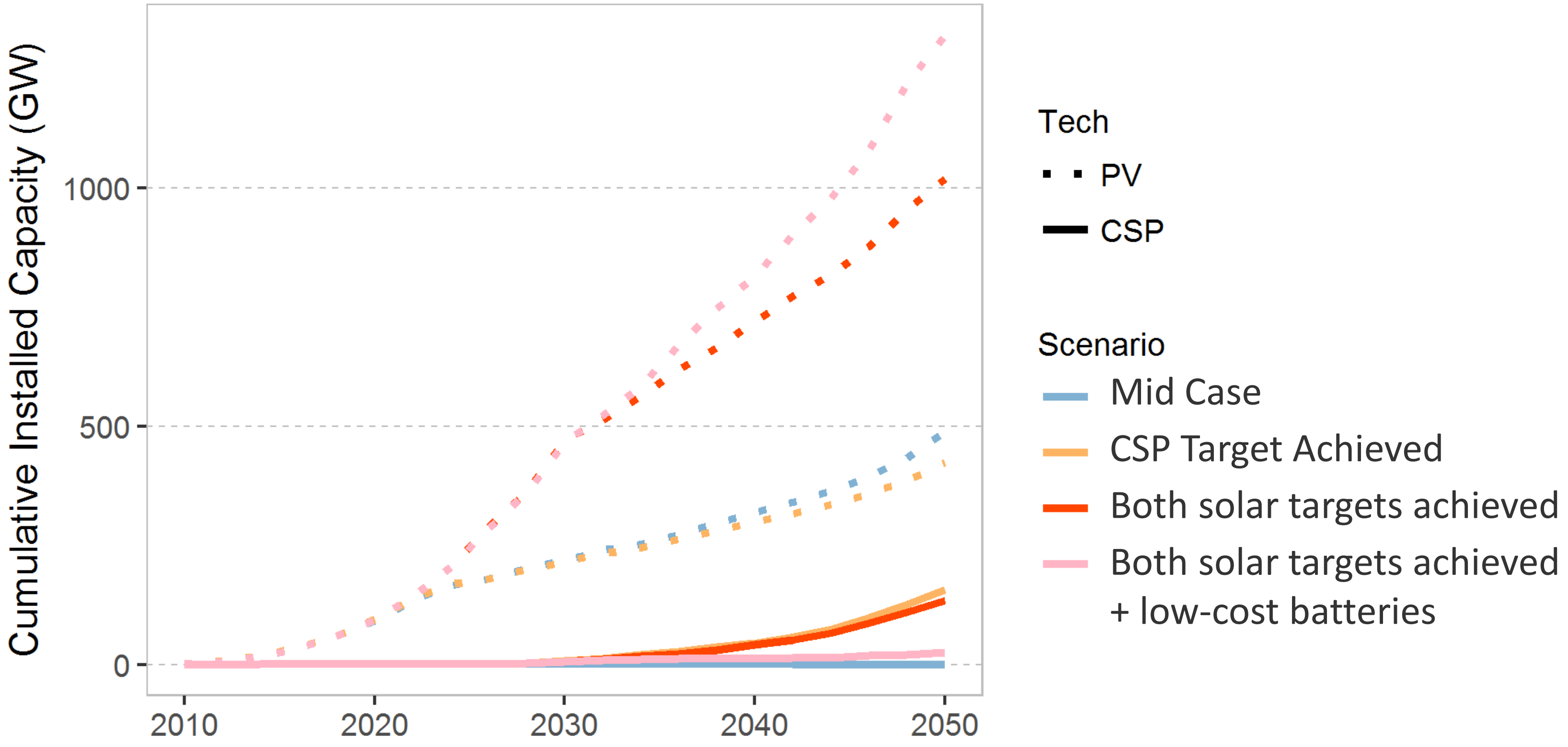
# Achieving DOE's 2030 solar cost targets could drive an expansion of installed solar capacity by 2050

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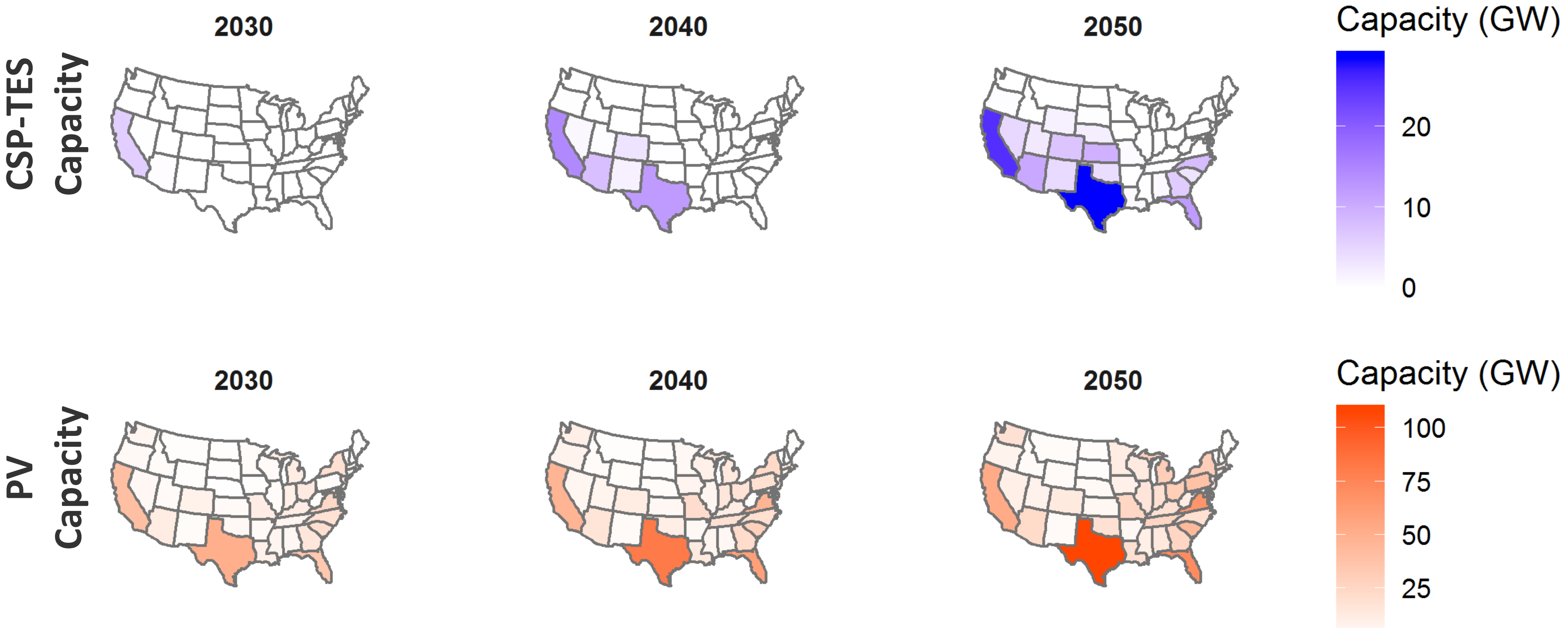
# Achieving DOE's 2030 solar cost targets could expand the geographic distribution of economic solar deployment

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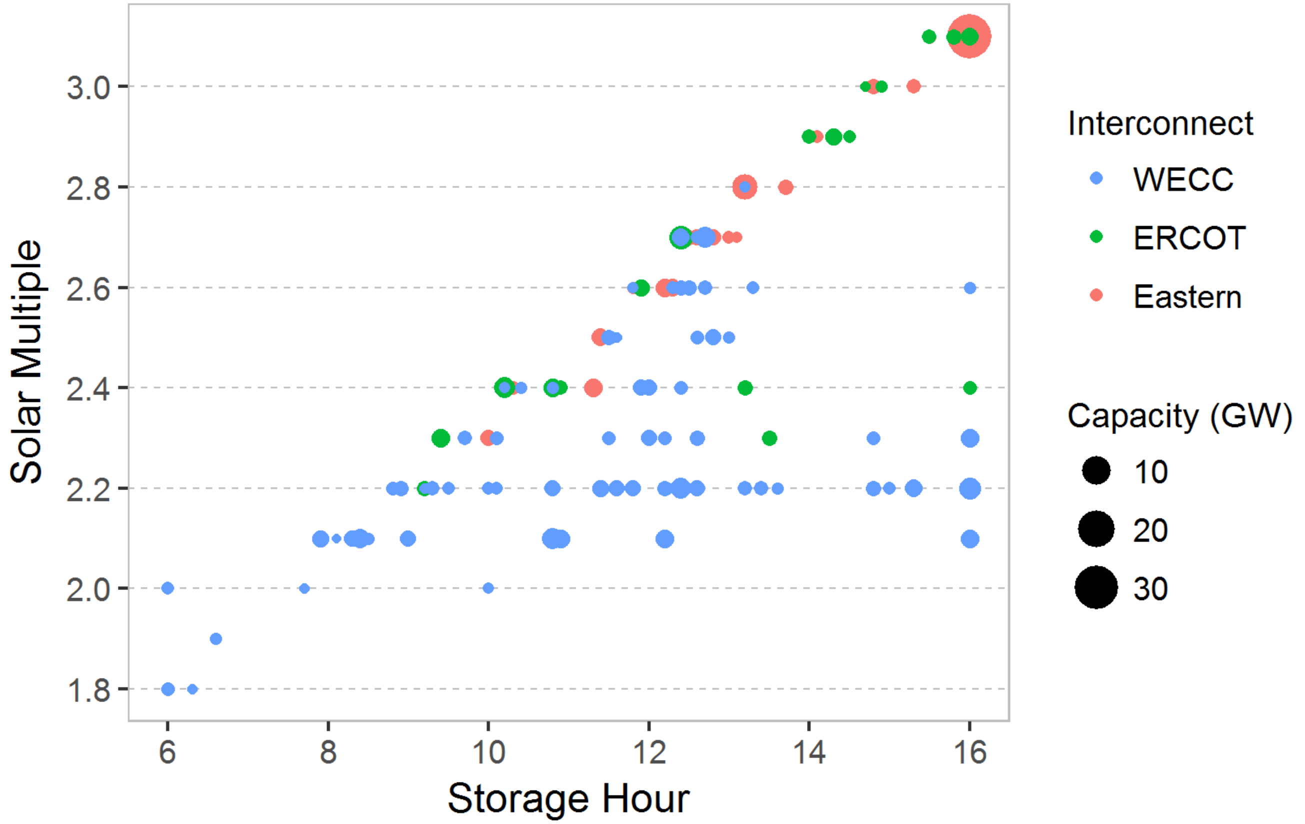
# The ReEDS model finds the highest-value in low-cost CSP-TES plants that have high-capacity factor configurations

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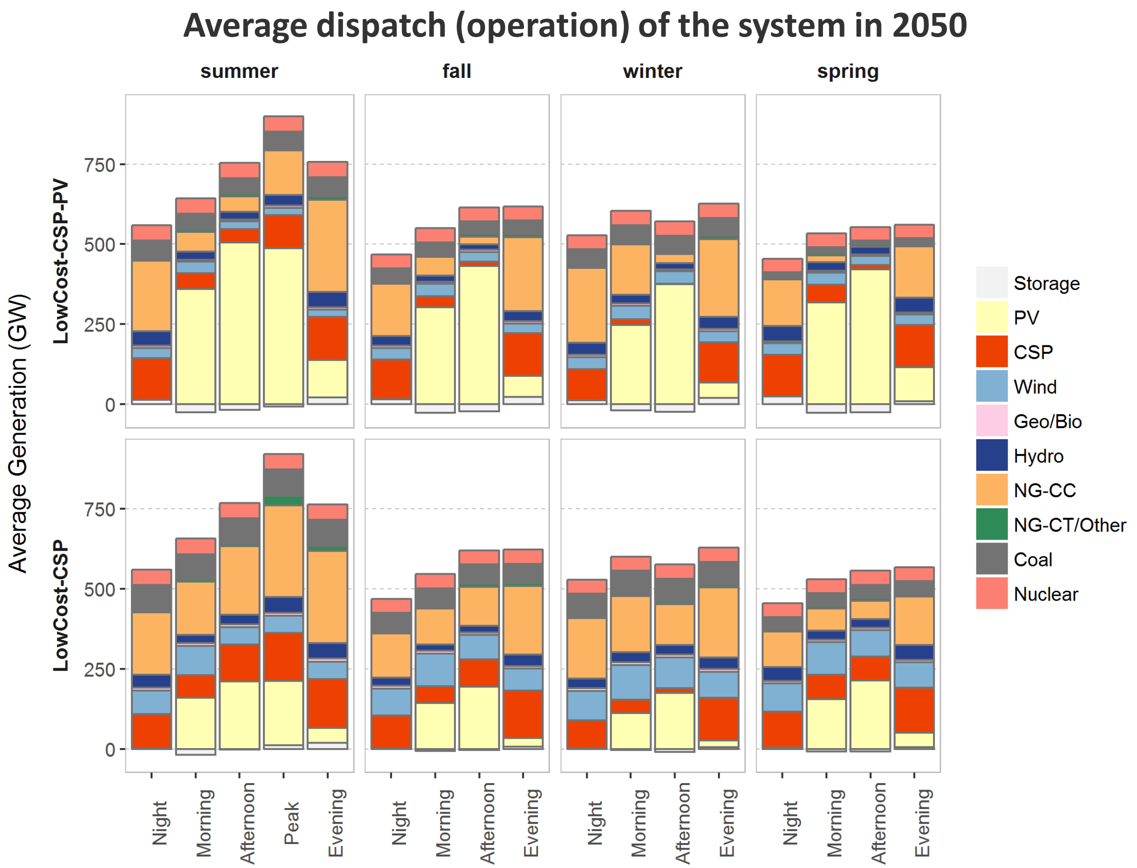
# Low-cost CSP-TES provides firm energy value

- CSP-TES generation is highest during the evening and overnight hours in low-cost solar scenarios
- This result highlights the importance of thermal energy storage, which offers *flexibility* and allows CSP-TES to provide dispatchable generation when the sun is down

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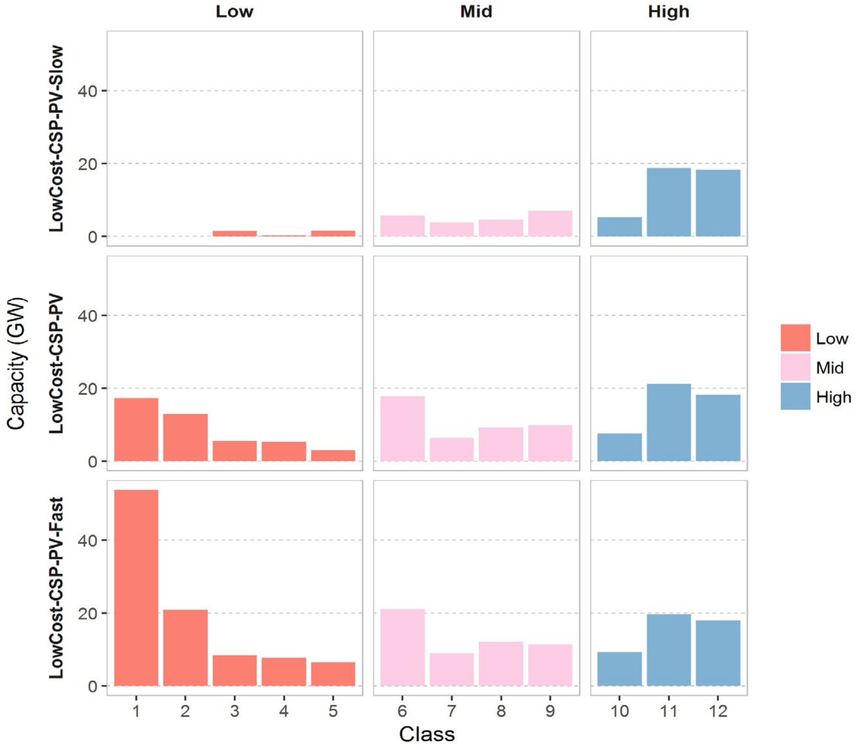
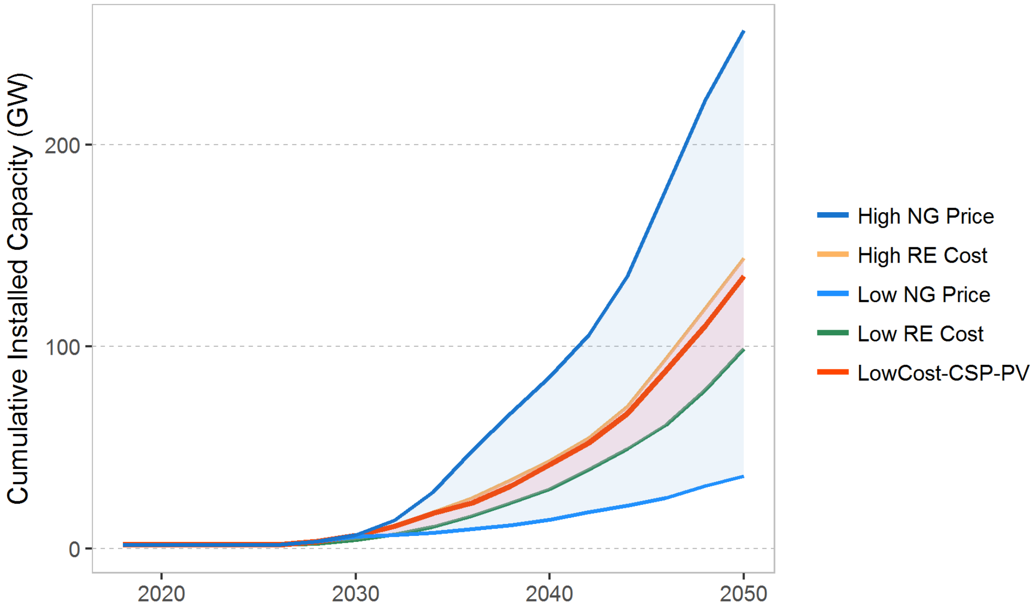
# CSP-TES deployment results are sensitive to many technology cost and fuel price assumptions

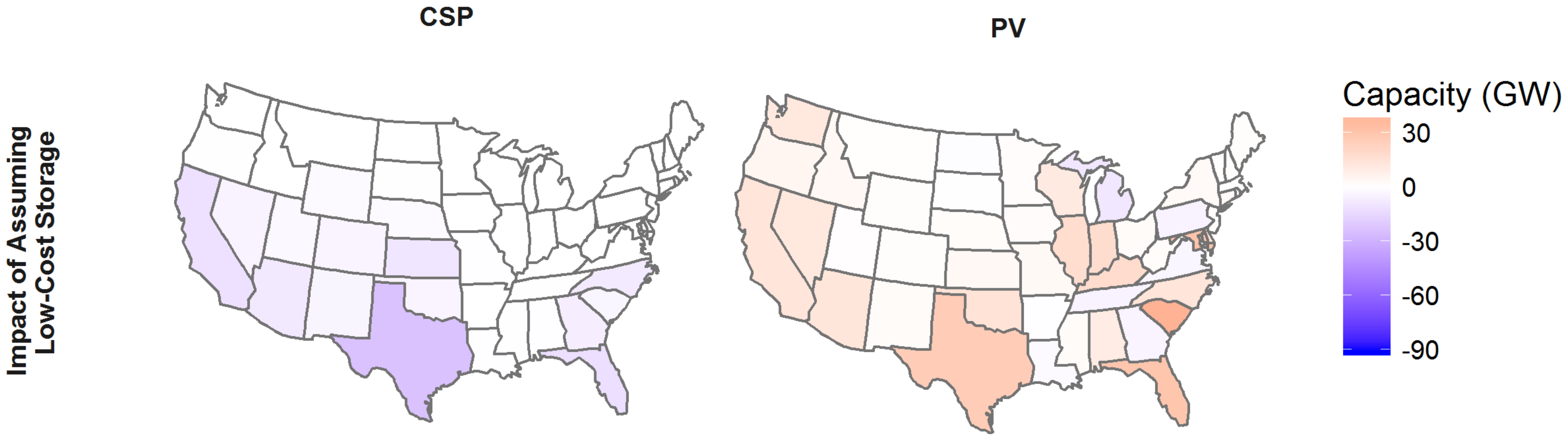



Lost-cost trajectories for non-solar renewable energy technologies are based on the *2017 Annual Technology Baseline* (https://atb.nrel.gov).

https://www.nrel.gov/docs/fy19osti/71912.pdf

# The magnitude and extent of solar installations depend on future costs for advanced energy storage




Assuming low-cost battery storage results in increased deployment of PV capacity across the contiguous United States, and a corresponding decrease in CSP-TES capacity

https://www.nrel.gov/docs/fy19osti/71912.pdf 

# Summary of Key Findings

- Solar electricity generating capacity could grow significantly by 2050 if DOE's 2030 solar cost targets are achieved
- The geographic extent of economic solar deployment could expand across the contiguous United States, particularly for low-cost CSP-TES
- CSP-TES is primarily deployed in a highly dispatchable, high-capacity factor configuration, which allows CSP-TES to provide valuable services to the grid
- The assumed price trajectories of natural gas and advanced energy storage have pronounced impacts on the magnitude and geographic extent of low-cost CSP-TES deployment

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# Thank You

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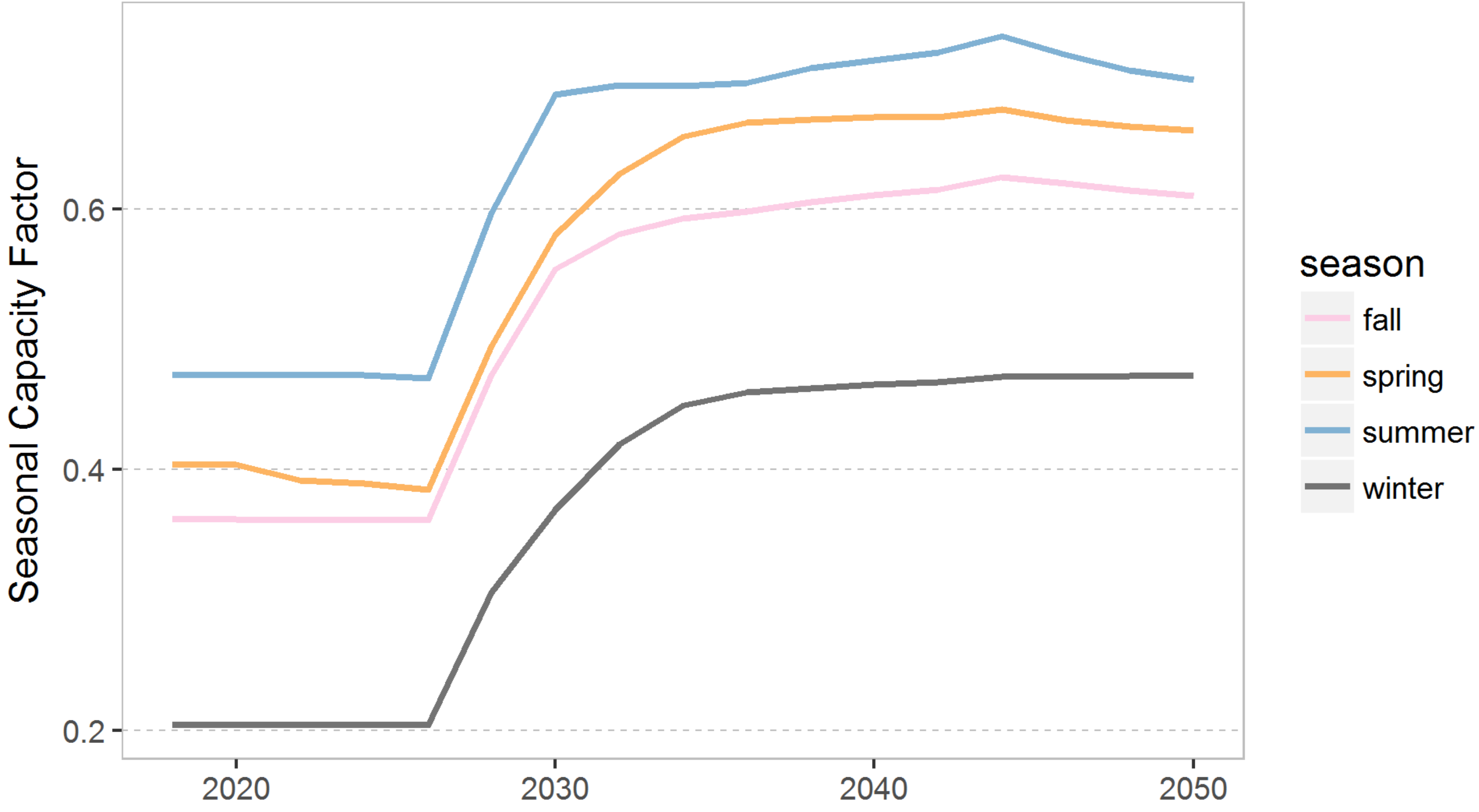
# The ReEDS model finds the highest-value in low-cost CSP-TES plants that have high-capacity factor configurations

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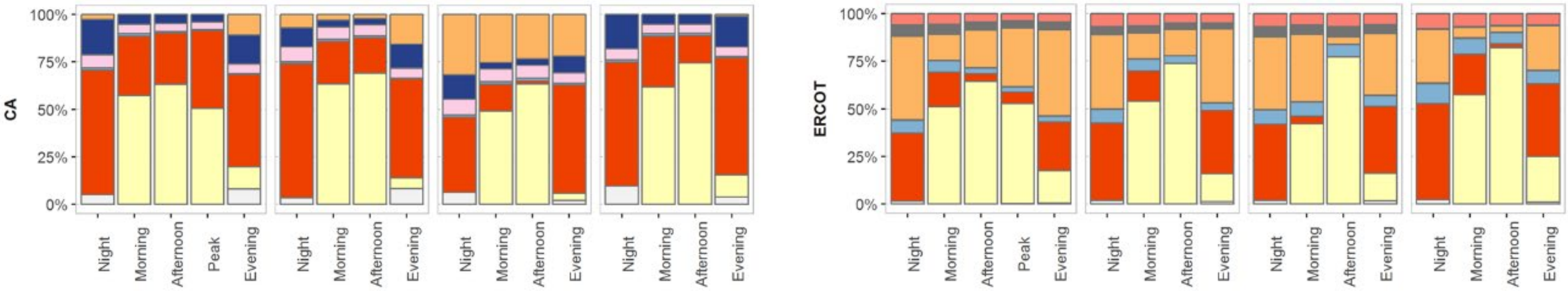
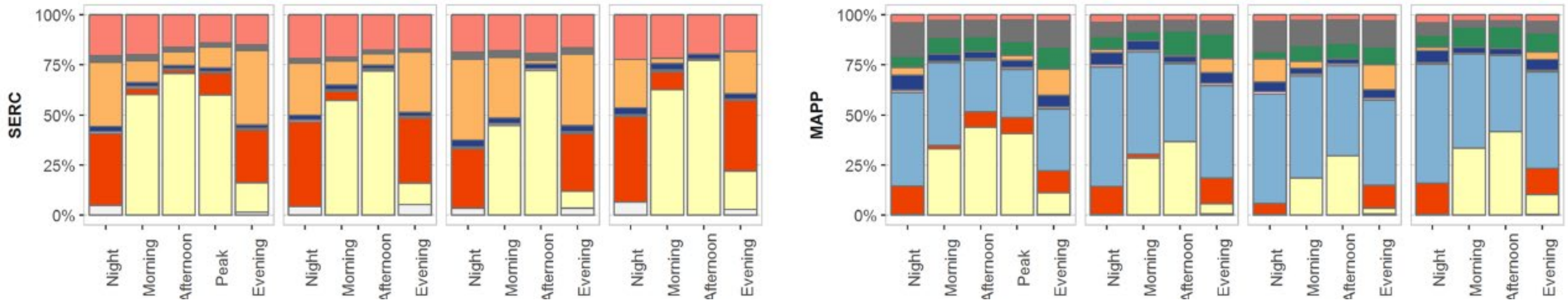
# The modeled dispatch of CSP-TES varies regionally, largely following the quality of solar resource

## High- and Mid-Solar Resource Regions:





## Low and Mixed-Solar Resource Regions:

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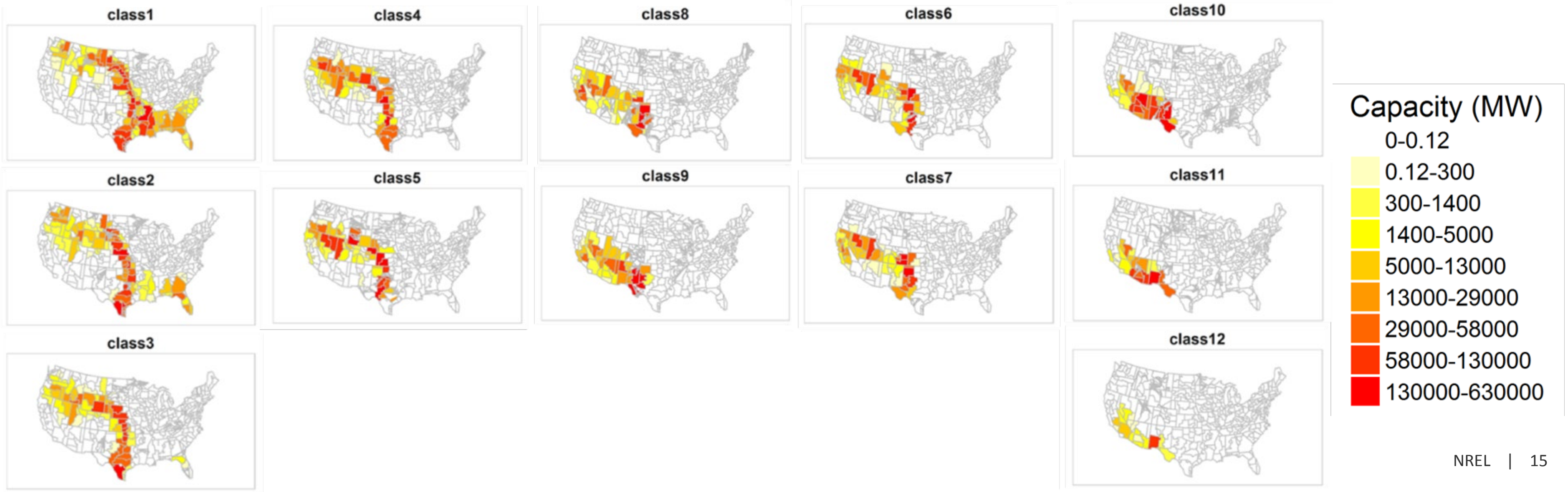
# Approach: Solar Resource for CSP-TES

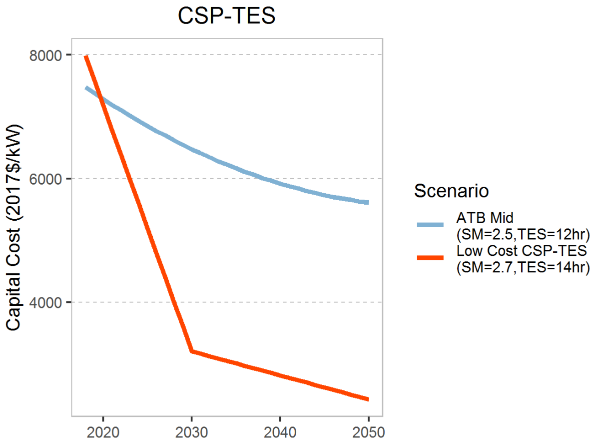
- This analysis assigns a lower threshold for the direct normal irradiance (DNI) of 5 kWh/m$^2$/day for CSP-TES, while new PV capacity is considered throughout the contiguous United States
- The resulting broad geographic extent of available resource for CSP-TES is shown here:

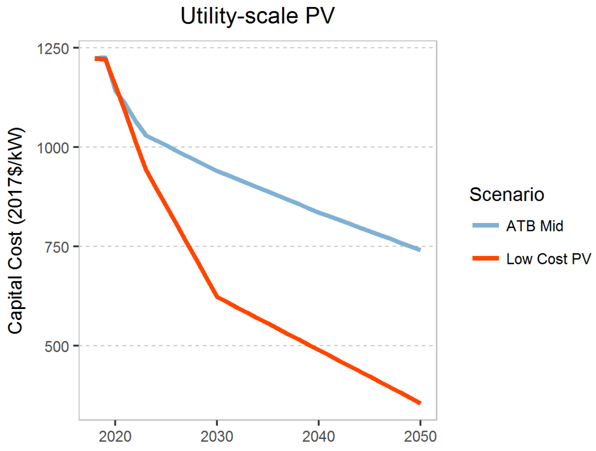
**Low Resource** **Mid Resource** **High Resource**

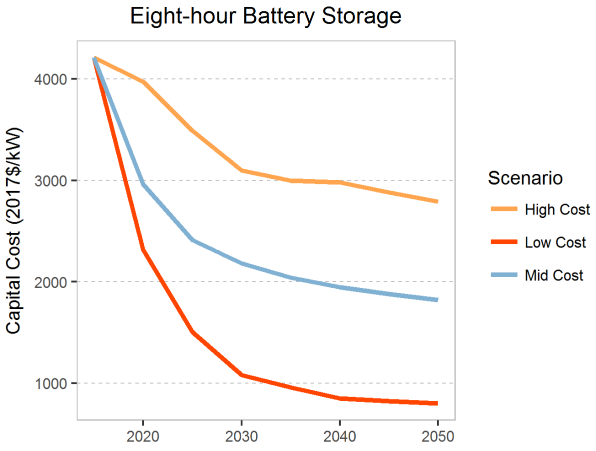


# Approach: Scenario Design & Cost Inputs

| Scenario | CSP Cost | PV Cost | Battery Cost |
|---|---|---|---|
| "ATB Mid" | ATB Mid | ATB Mid | Mid Cost |
| "LowCost-CSP" | Low Cost CSP | ATB Mid | Mid Cost |
| "LowCost-CSP-PV" | Low Cost CSP | Low Cost PV | Mid Cost |
| "LowCost-CSP-PV-Storage" | Low Cost CSP | Low Cost PV | Low Cost |



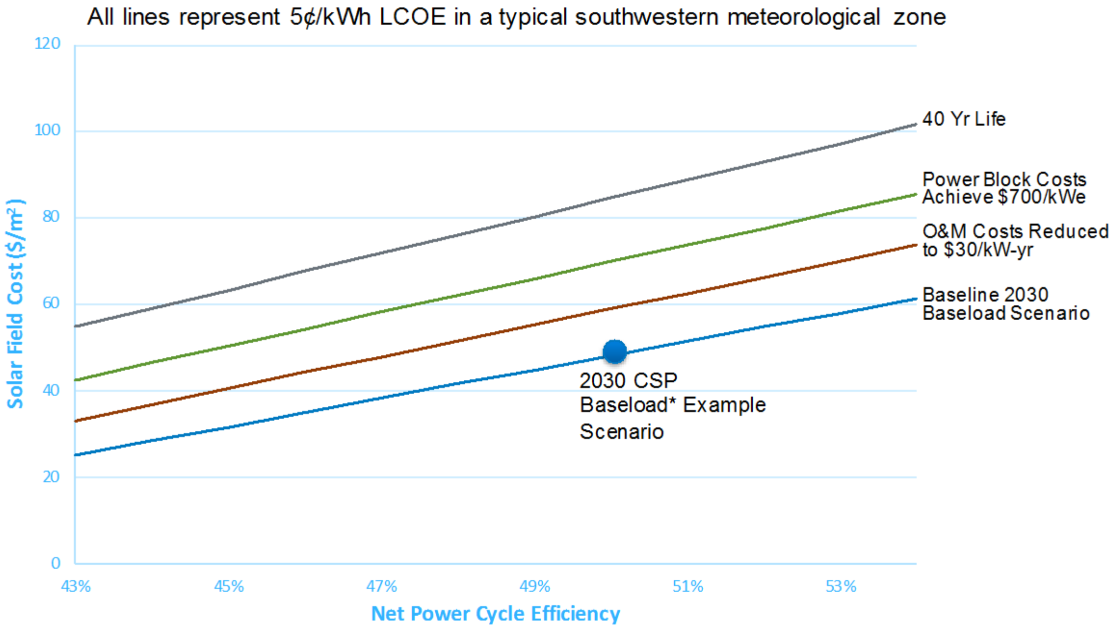



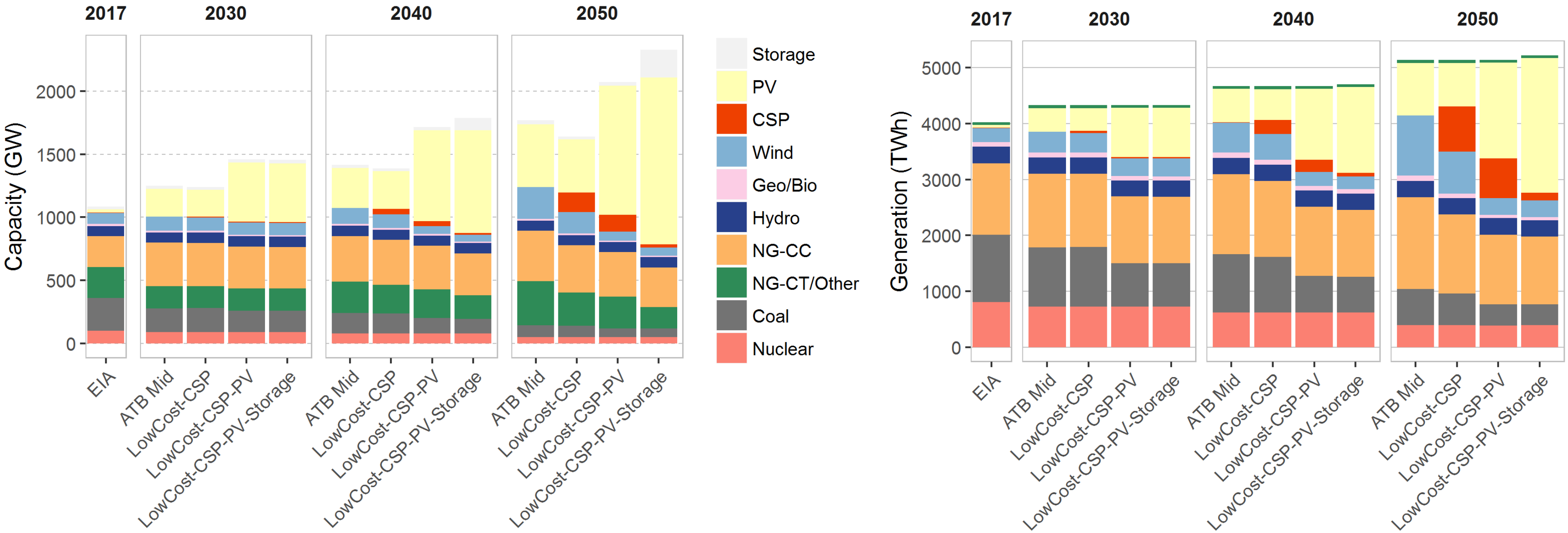

Data sources for figures: Cole et al. 2017; DOE, 2017; Cole, Marcy et al. 2016

# Approach: Representing DOE's Cost Targets for CSP-TES

- The assumed costs for individual components are *not* inherently required for achieving the 2030 cost targets for CSP-TES
- This figure demonstrates multiple pathways for achieving a similar LCOE through combinations technology advances, economies of scale associated with increased manufacturing, improved supply chain efficiencies, reduced O&M costs, and/or more favorable financing terms for CSP-TES plants



# Solar's share of the capacity and generation mixes

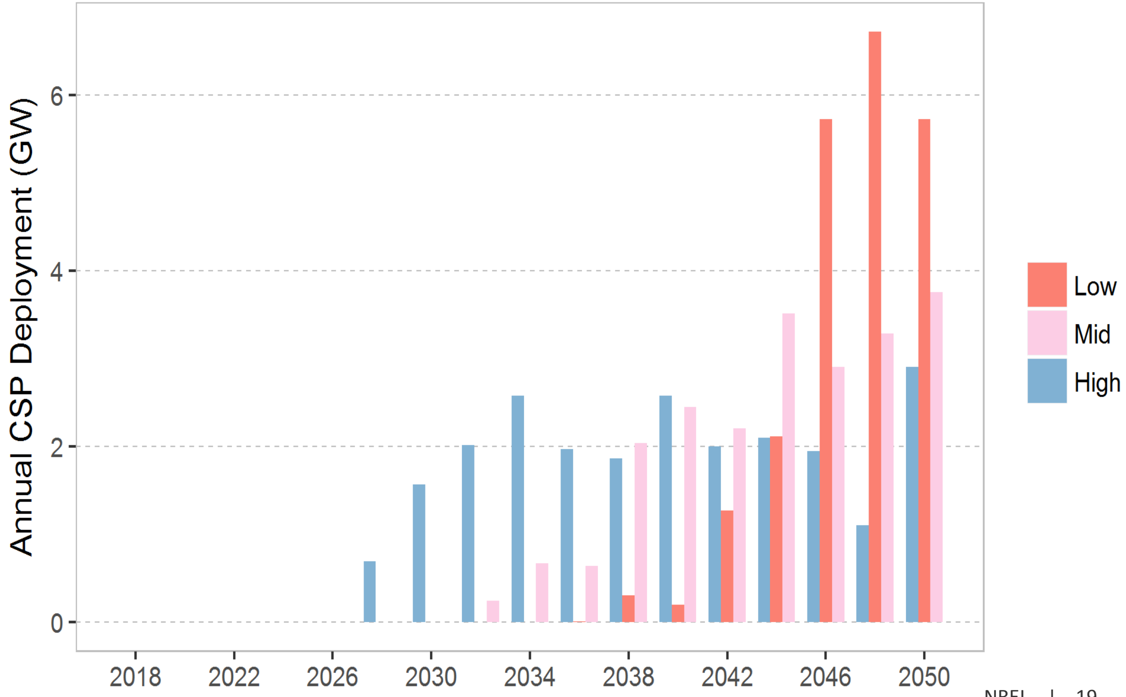



**Key Finding**: Achieving DOE's 2030 solar cost targets could result in solar playing a larger role in the capacity and generation mixes

# Deployment of low-cost CSP-TES begins in high-resource regions, but eventually expands to lower-resources

- The first new low-cost CSP-TES installations come online in the late 2020s, at a rate of 1–2 GW per year
- New low-cost CSP-TES capacity in mid-solar resource is delayed by a few years, but follows a similar growth trajectory through 2050
- Low-cost CSP-TES eventually becomes cost-competitive in even low-solar resource

*Results for the scenario that represents the achievement of DOE's 2030 solar cost targets*

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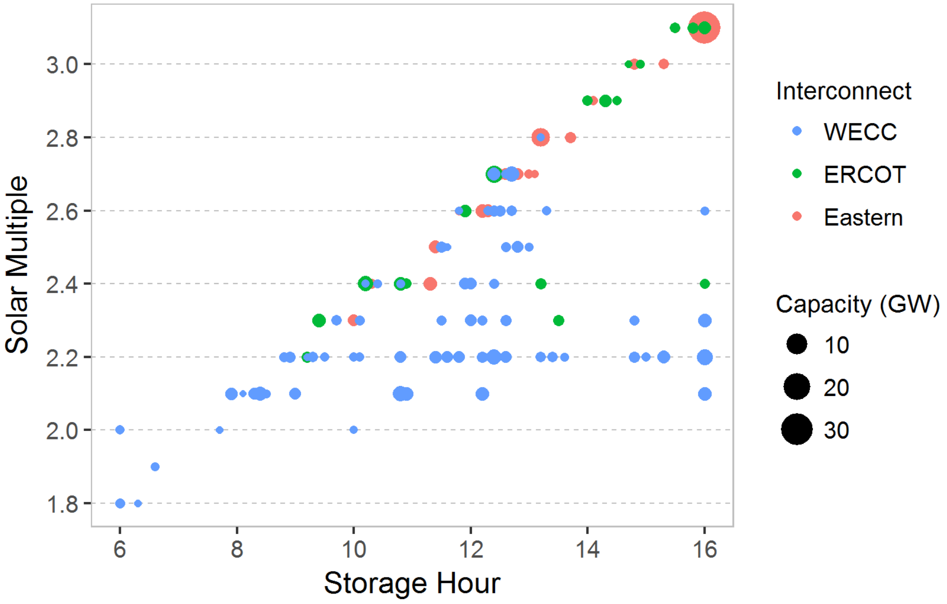
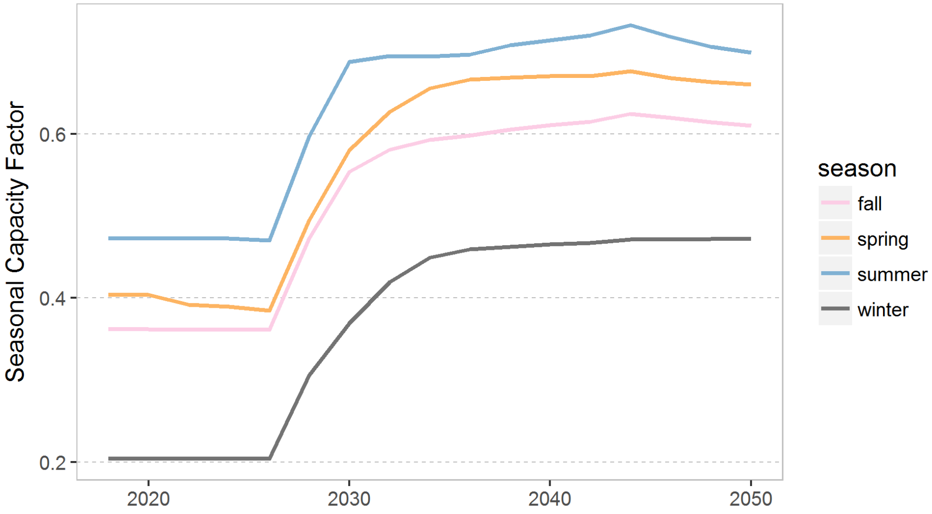
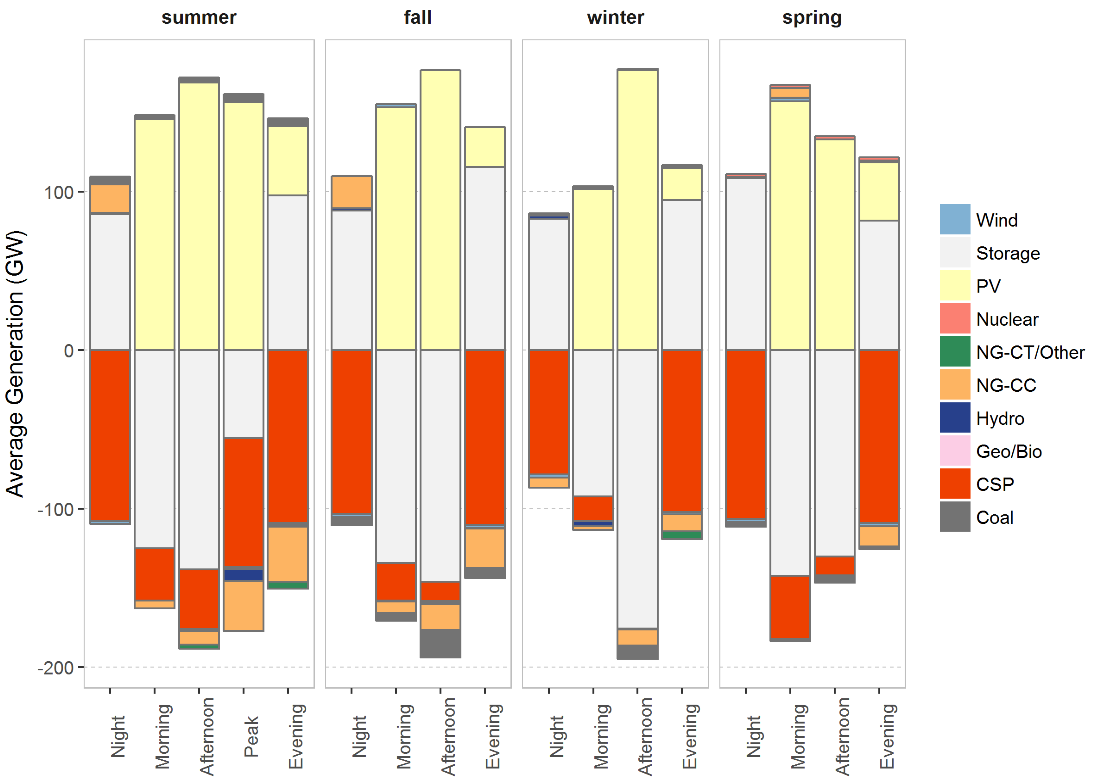


# Sensitivity to advanced energy storage cost assumptions

Direct competition between CSP-TES and the combination of low-cost PV and batteries is also apparent in the average dispatch patterns, and reflects the similar services provided by CSP-TES and the combination of low-cost PV and batteries.

**Difference in Average Electricity Dispatch (2050): LowCost-CSP-PV-Storage – LowCost-CSP-PV**




**Preliminary Results—Do Not Distribute or Cite**

# Summary Results: Main Low-Cost Solar Scenarios

| | | Capacity (GW)[b] | | | Penetration (% of Generation) | | |
|---|---|---|---|---|---|---|---|
| **Scenario** | Technology | 2030 | 2040 | 2050 | 2030 | 2040 | 2050 |
| **ATB Mid[a]** | CSP-TES | 1.9 | 1.9 | 0.5 | 0 | 0 | 0 |
| | PV[c] | 220 | 319 | 489 | 10 | 13 | 18 |
| | Total solar | 221 | 321 | 489 | 10 | 13 | 18 |
| | Battery storage[d] | 0 | 0.8 | 2.8 | 0.0 | 0.0 | 0.1 |
| **LowCost-CSP** | CSP-TES | 7 | 46 | 158 | 1 | 5 | 16 |
| | PV | 216 | 301 | 425 | 10 | 12 | 15 |
| | Total solar | 223 | 346 | 582 | 10 | 17 | 31 |
| | Battery storage | 0 | 0 | 0.5 | 0.0 | 0.0 | 0.0 |
| **LowCost-CSP-PV** | CSP-TES | 6 | 42 | 135 | 1 | 5 | 14 |
| | PV | 469 | 720 | 1,020 | 20 | 27 | 33 |
| | Total solar | 475 | 761 | 1,155 | 21 | 32 | 47 |
| | Battery storage | 0 | 0 | 2 | 0.0 | 0.0 | 0.1 |
| **LowCost-CSP-PV-Storage** | CSP-TES | 6 | 13 | 25 | 1 | 1 | 3 |
| | PV | 466 | 815 | 1,321 | 20 | 33 | 47 |
| | Total solar | 472 | 828 | 1,346 | 21 | 34 | 50 |
| | Battery storage | 5 | 73 | 199 | 0.3 | 3.4 | 9.2 |

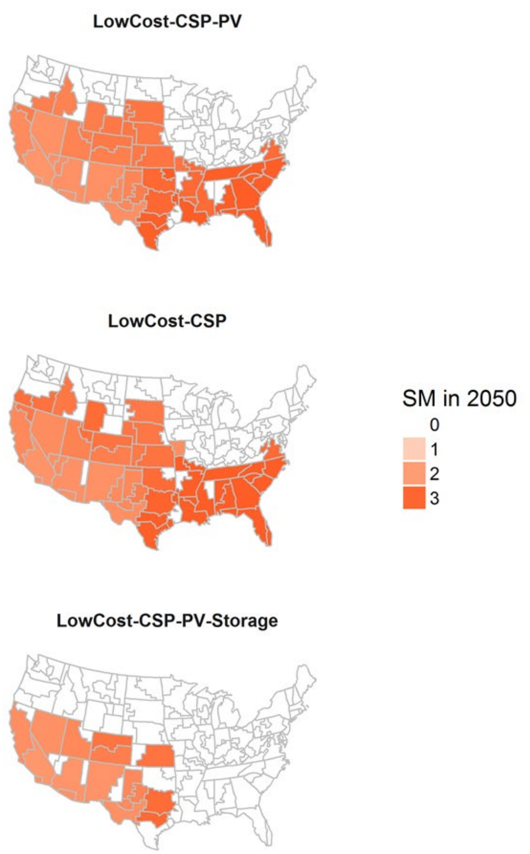
[a] Values for the ATB Mid scenario are based on the 2017 ATB.

# Summary Results: Sensitivity Scenarios

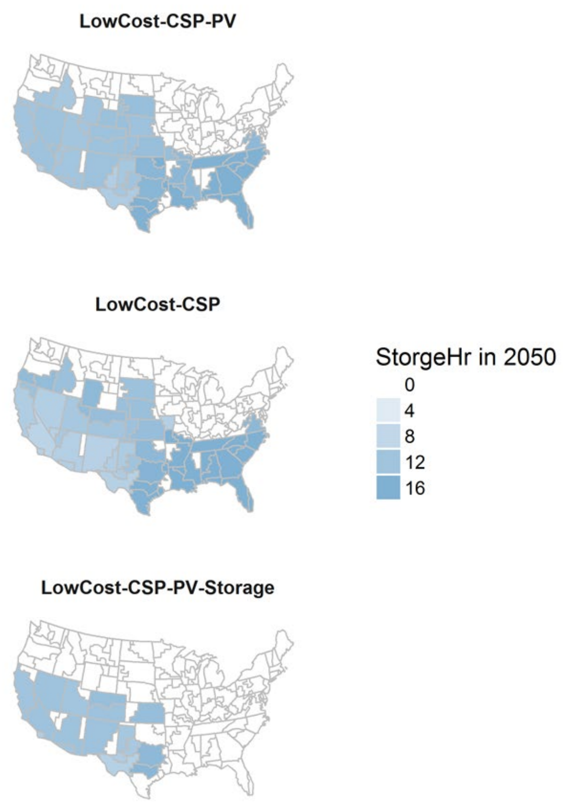
| | CSP-TES Capacity (GW) | | CSP-TES Penetration (% of Electricity Supplied) | |
|---|---|---|---|---|
| **Scenario Set** | 2030 | 2050 | 2030 | 2050 |
| **LowCost-CSP-PV** | 6.4 | 135.1 | 0.7 | 13.9 |
| **Low Natural Gas Price** | 5.9 | 35.9 | 0.7 | 3.8 |
| **High Natural Gas Price** | 6.6 | 256.8 | 0.7 | 25.2 |
| **Low-Cost Renewables** | 4.2 | 99.0 | 0.4 | 10.1 |
| **High-Cost Renewables** | 6.6 | 143.8 | 0.7 | 14.7 |
| **Low-Electricity Demand** | 5.4 | 101.5 | 0.6 | 11.5 |
| **High-Electricity Demand** | 6.6 | 162.5 | 0.7 | 15.2 |
| **Truncated Conventional Generator Lifetimes** | 5.7 | 147.0 | 0.6 | 14.9 |
| **Extended Conventional Generator Lifetimes** | 6.4 | 127.4 | 0.7 | 13.1 |

# Summary Result: Optimal CSP-TES Configurations Across Select Low-Cost Solar Scenarios

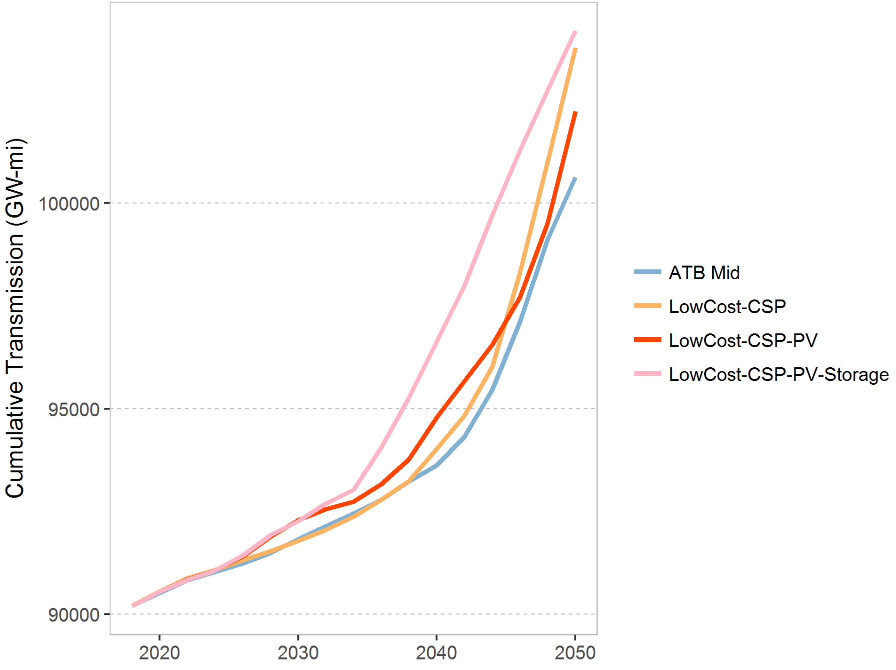
Solar Multiple

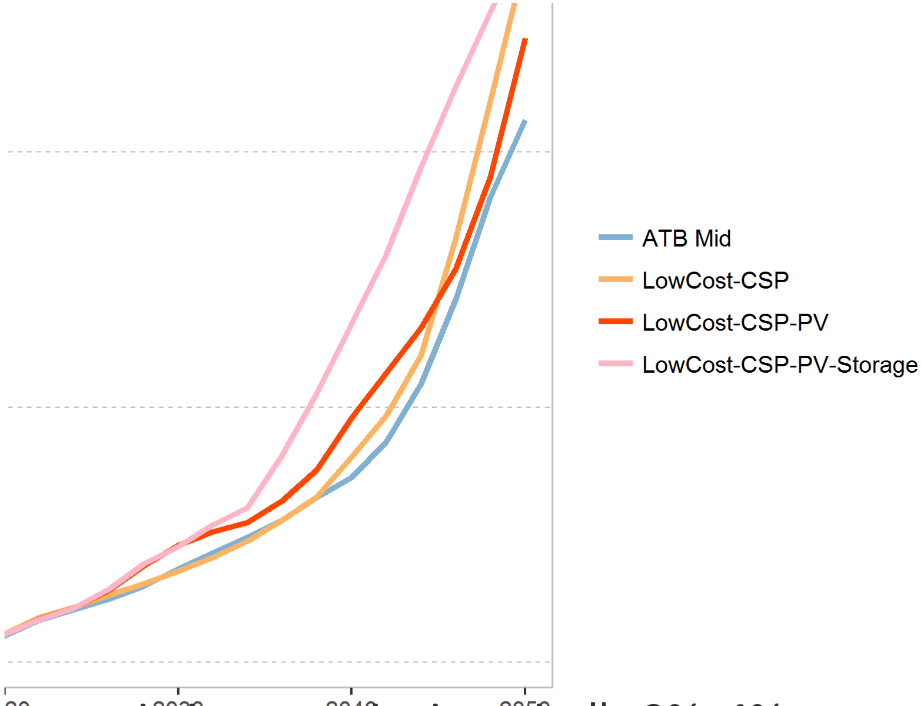



Storage Hour



# The need for additional transmission capacity is largely consistent with historical build-out rates

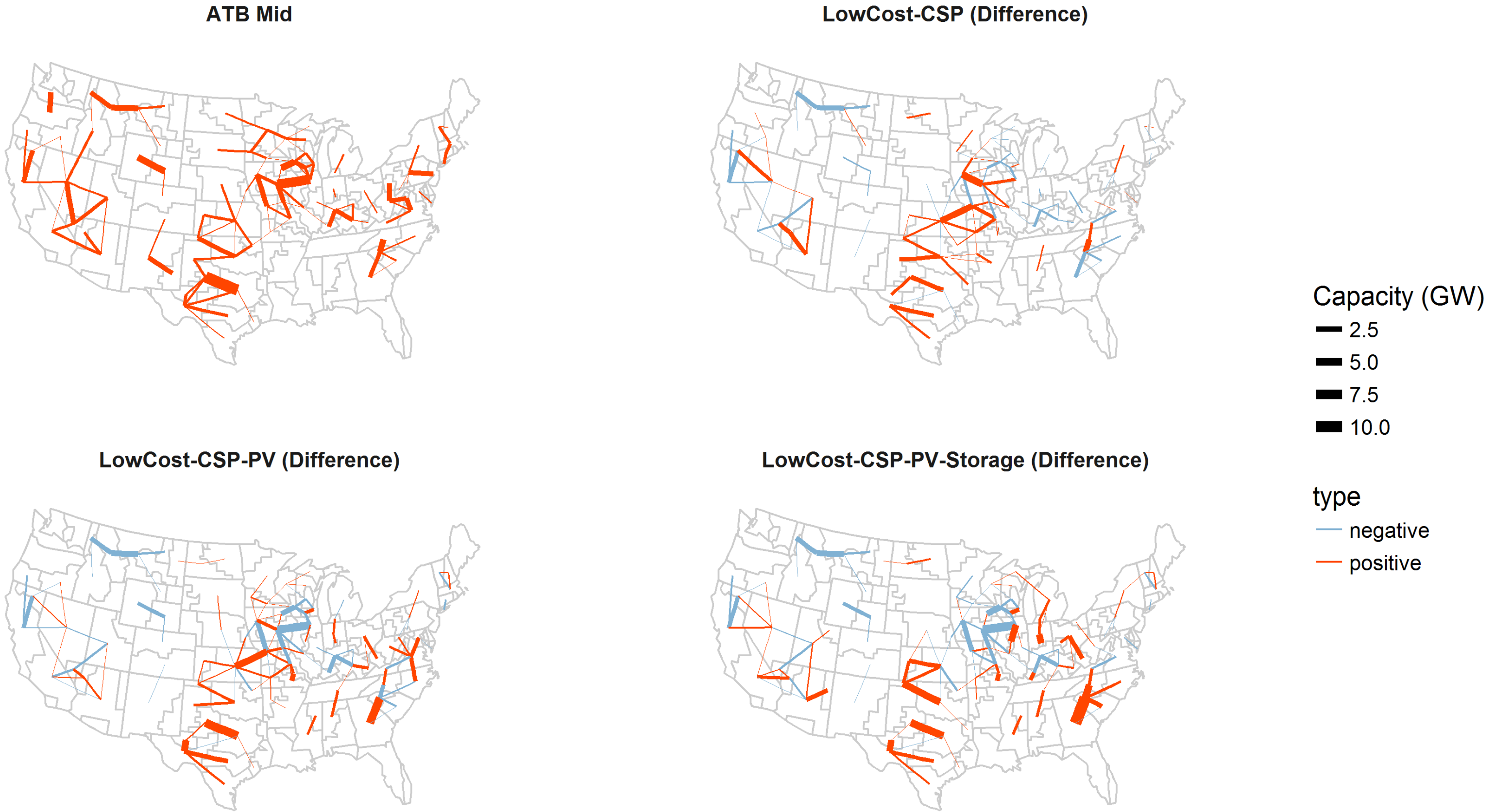



Across all scenarios, the incremental increase in transmission capacity is typically 2%–4% higher than the baseline scenario, which corresponds to a ~10% increase in transmission capacity relative to current levels.

**Preliminary Results—Do Not Distribute or Cite**

# Geographic distribution of new transmission capacity

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