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SunShot 2030 for Photovoltaics (PV): Envisioning a Low-cost PV Future

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Webinar: September 26, 2017

NREL/PR-6A20-70193

- SunShot Initiative began in 2011
- SunShot Vision Study provided modeling for showing impacts of achieving goal
- Many changes since then
  - Shale gas
  - Lower wholesale power prices
  - Declining wind costs
  - Limited load growth
  - ITC extension
  - RPS changes

Recent News Headlines – SunShot 2020 Targets Achieved

SunShot Beats Its Solar Cost Goal 3 Years Early

Clean Technica

SHINE, BABY, SHINE

Solar is now so cheap in the US it beat government goals by three years

QUARTZ

DOE expands SunShot program after hitting original cost goal 3 years early

Utility DIVE

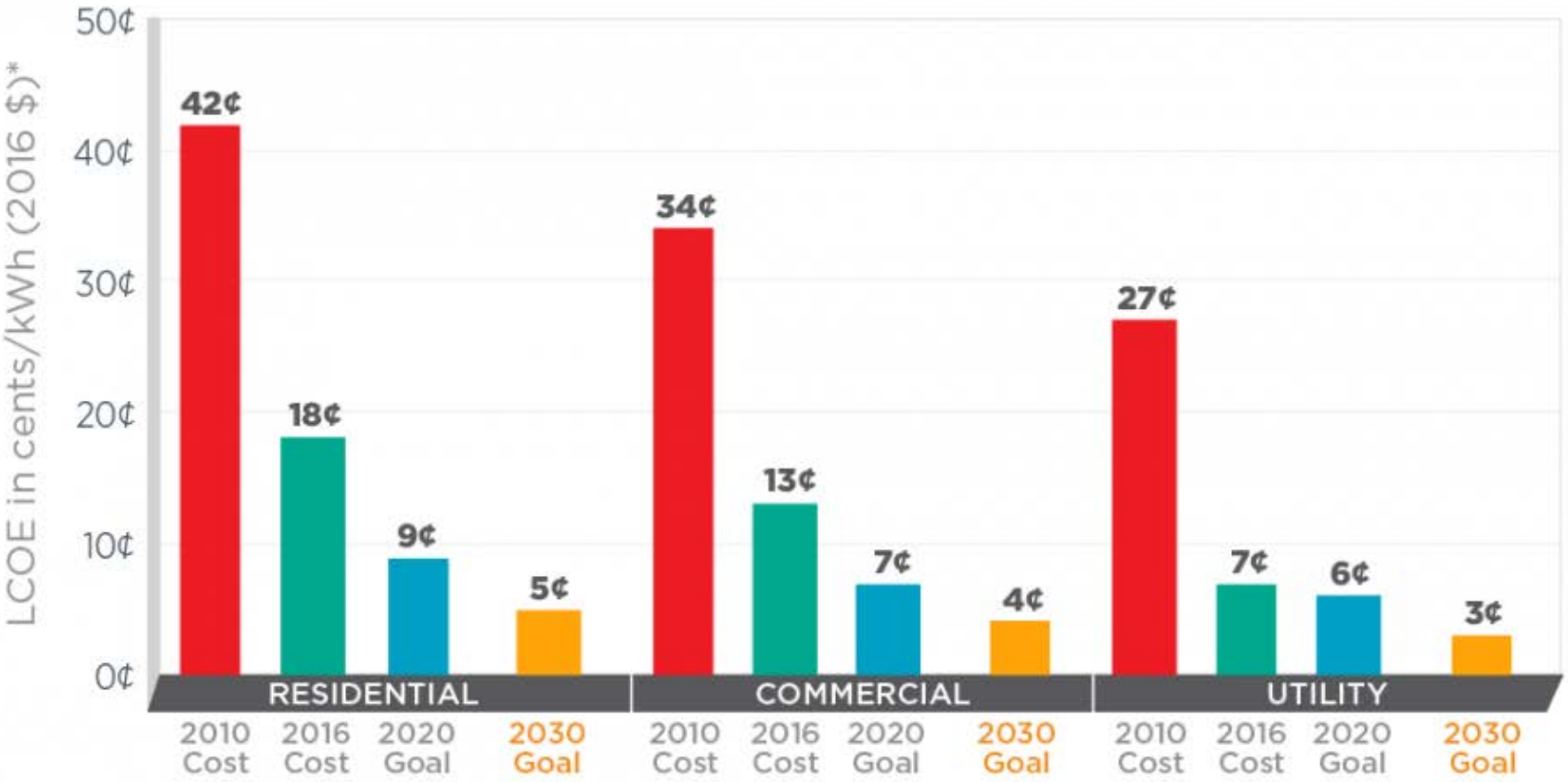
DOE Officially Marks SunShot's $1 per Watt Goal for Utility-Scale Solar

SunShot $1 per Watt Solar Cost Goal: Mission Accomplished, Years Ahead of Schedule

gtm:

SunShot 2030 Goals

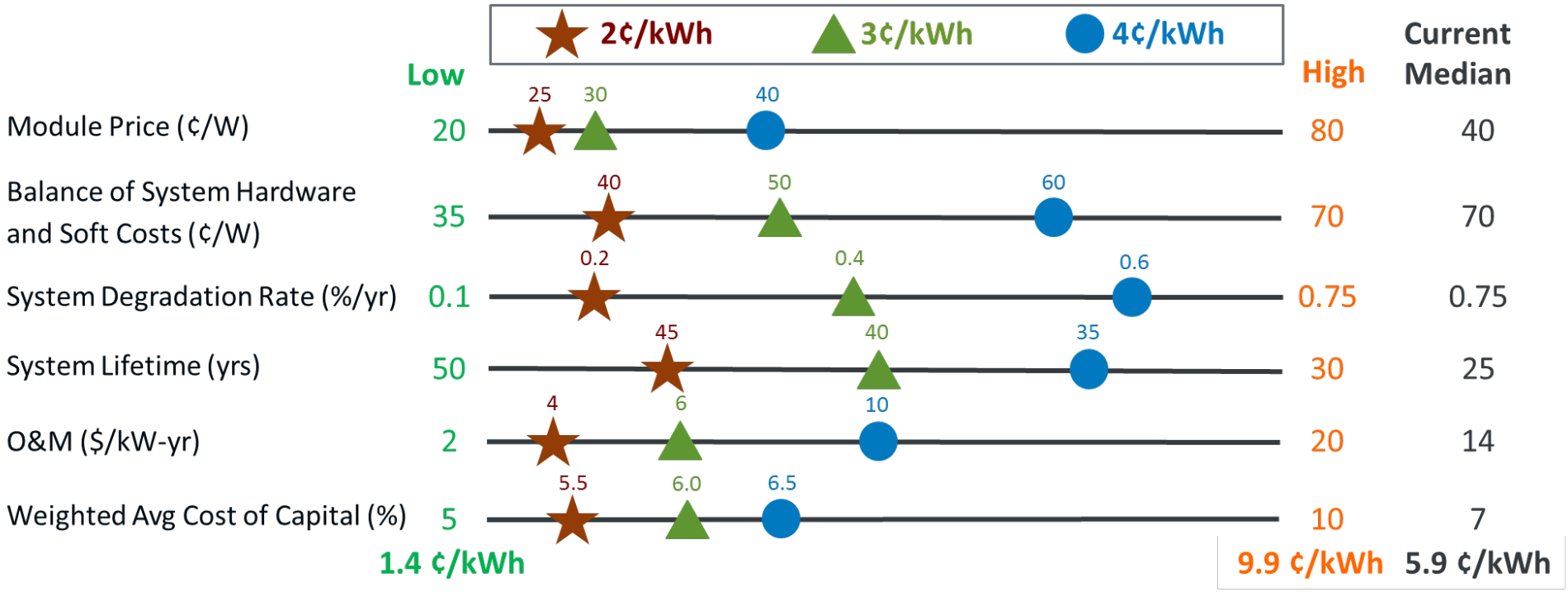
- Goals announced in fall of 2016
- 3¢, 4¢, 5¢/kWh for utility, commercial, and residential PV



*LCOE progress and targets are calculated based on average U.S. climate and without the ITC or state/local incentives. Utility-scale PV uses one-axis tracking.

Potential Cost Reduction Pathways

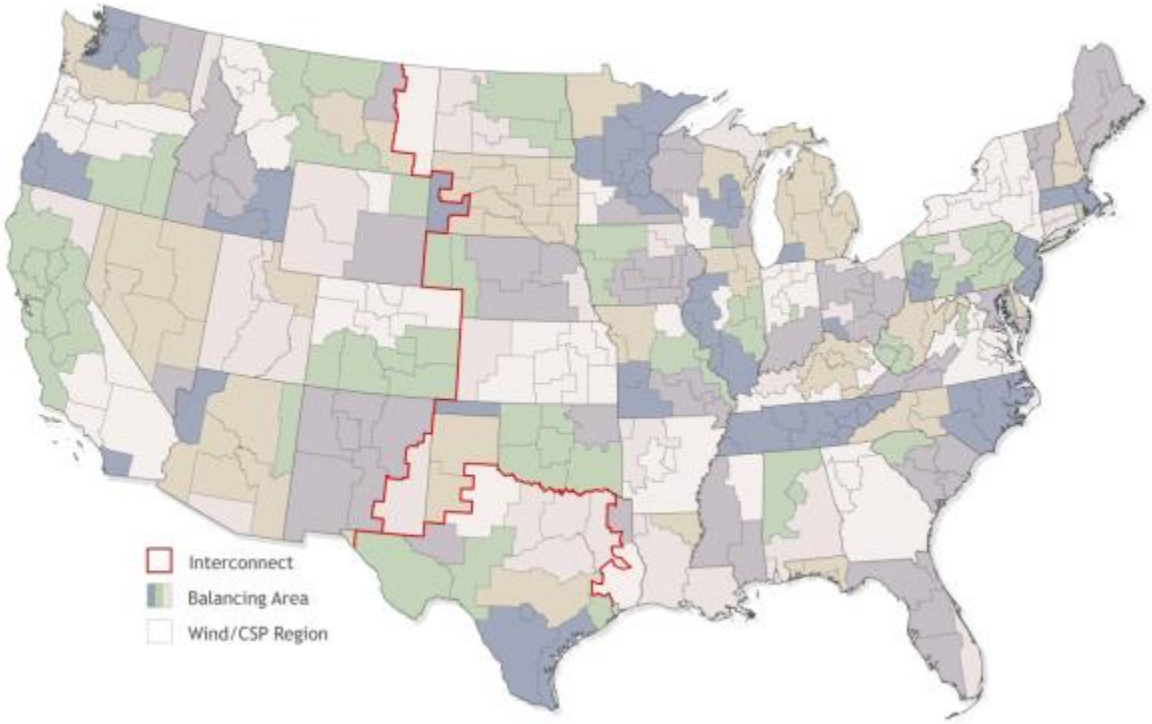
- The SunShot goals define LCOE targets, but not the pathway to get there
- Many pathways exist for achieving the cost reductions



Purpose of This Work

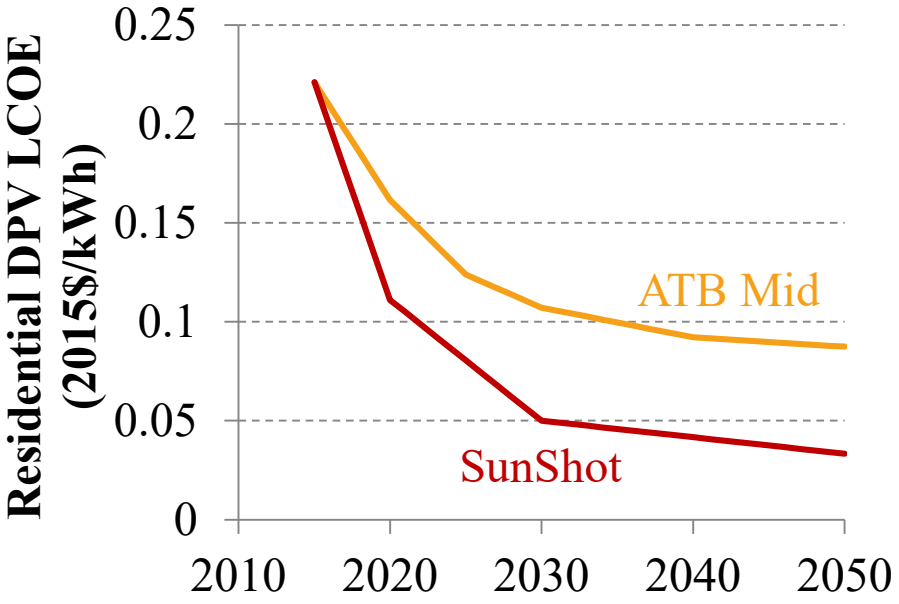
- Quantitatively assess the impacts of achieving the SunShot 2030 goals for PV
  - PV deployment
  - System generation mix and operations
  - System costs and electricity prices
  - CO_2 emissions and water usage
- This work does not
  - Assess the probability of achieving the SunShot goals
  - Consider the forthcoming SunShot goals for concentrating solar power (CSP)
  - Define the pathway for achieving the SunShot goals

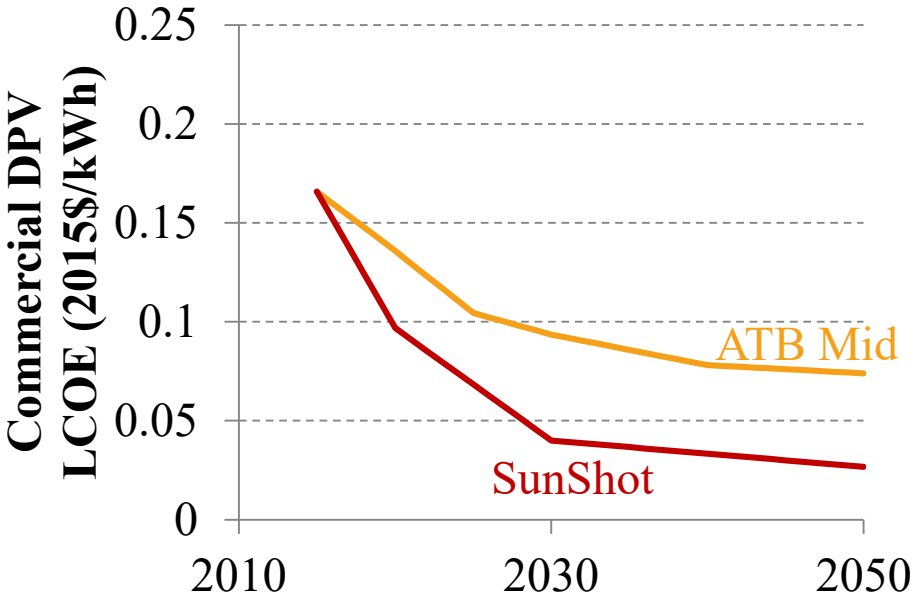
Modeling Tools

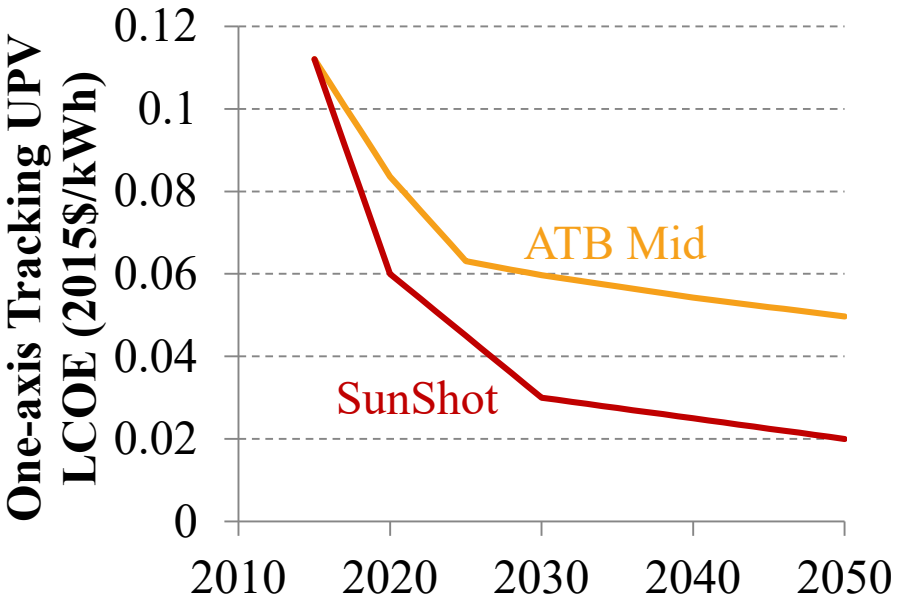


- **ReEDS**: Central-planning optimization model of U.S. Electricity Sector
  - 134 Balancing Areas
  - Explicit consideration of RE integration issues
  - Represents transmission
- **dGen**: Consumer adoption model of distributed PV
  - Solar PV
  - County-level resolution
  - Incorporates state and local incentives and rate structures
  - Residential and C&I included

PV Cost Inputs

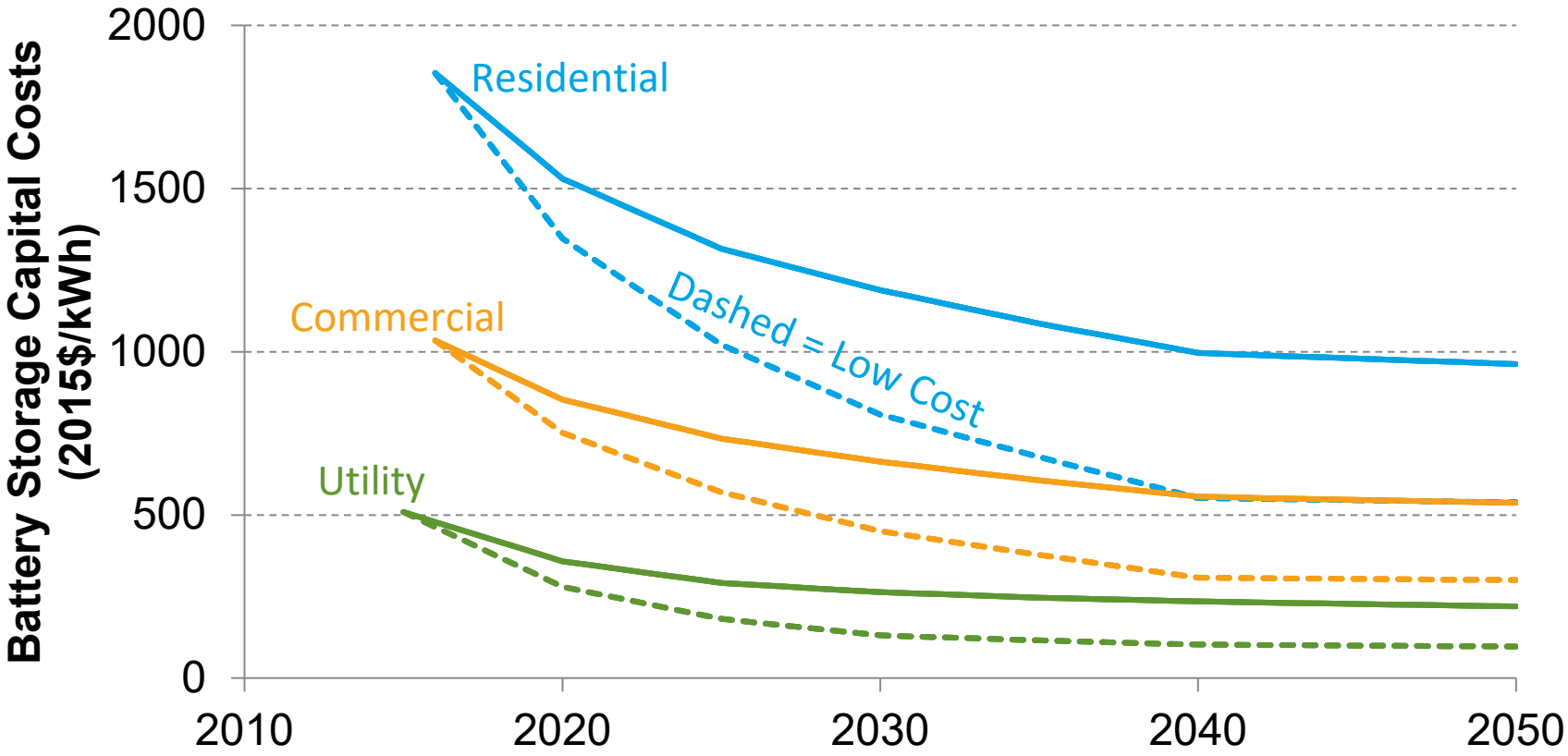






- ATB Mid is baseline cost projection
- 33% cost decline from 2030 to 2050 (after SunShot target is reached)

Storage Cost Assumptions



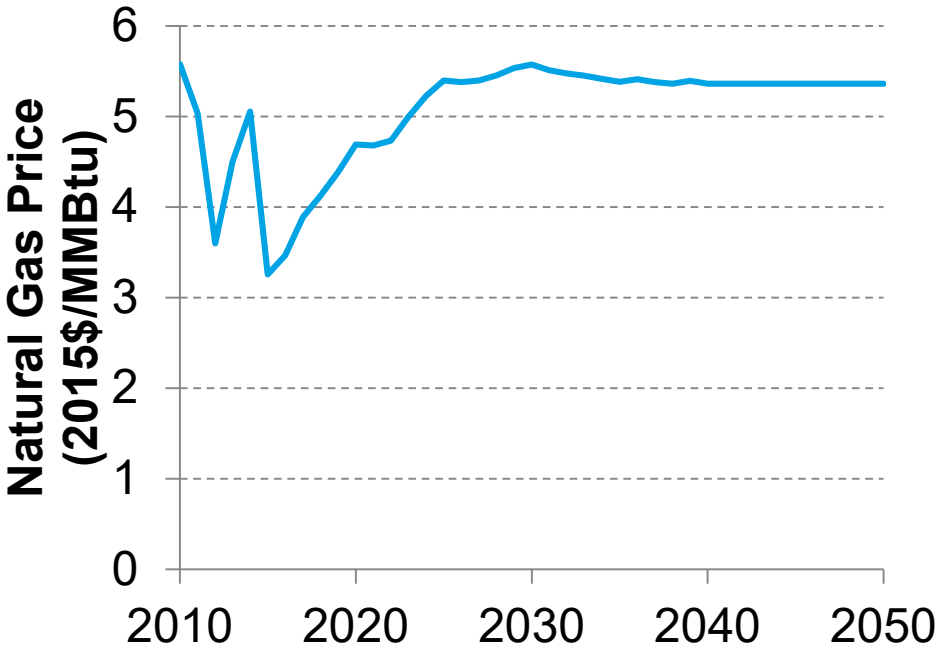
Commercial and residential: 3-hour storage

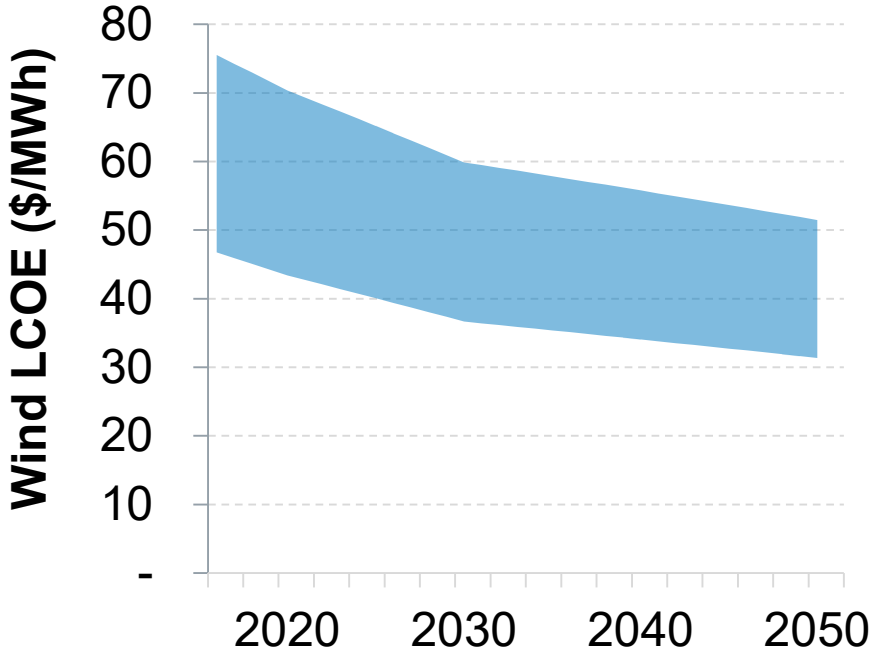
Utility: 8-hour storage

Other Assumptions: 90% round-trip efficiency, 15-year life

Other Assumptions

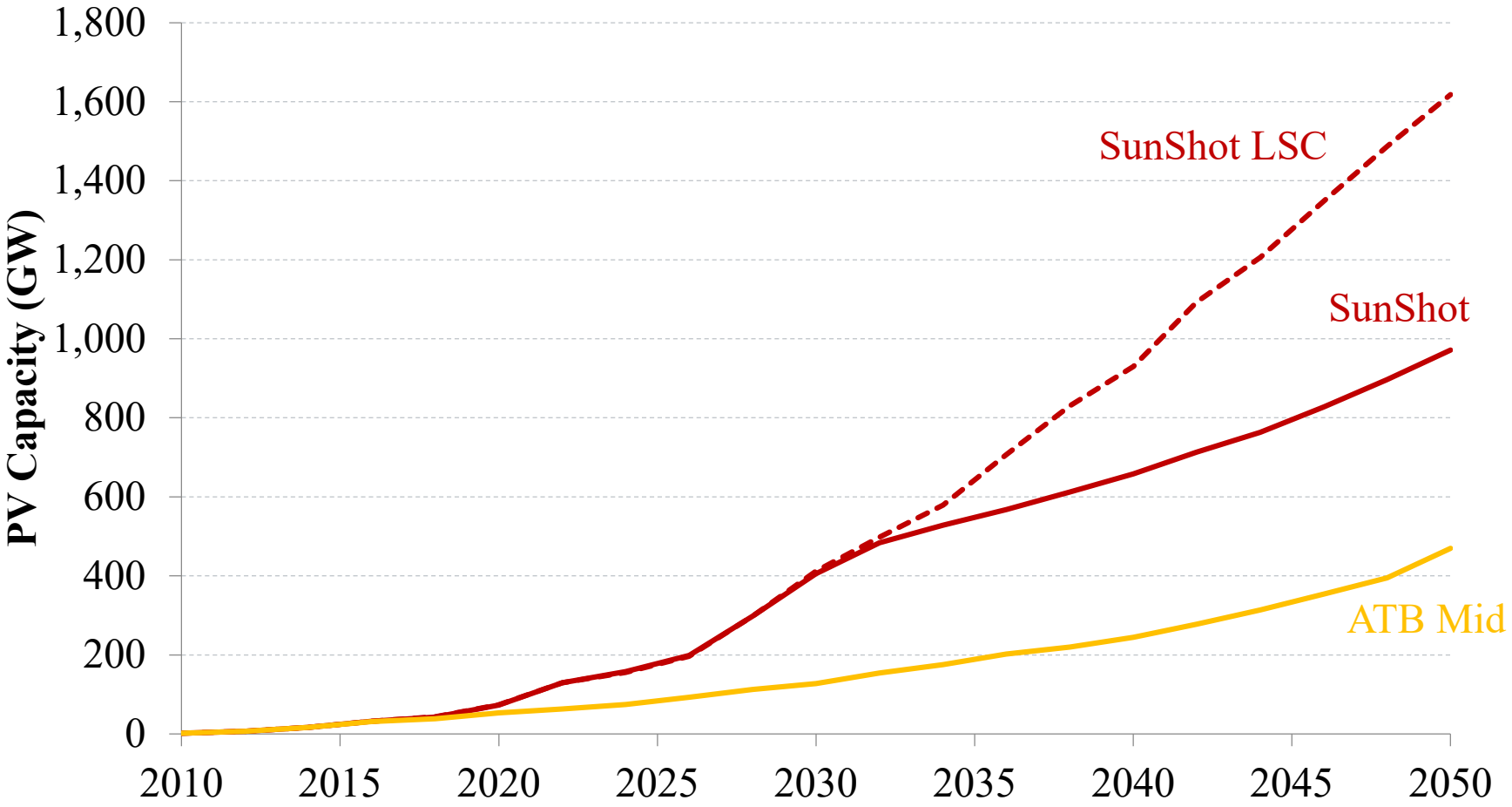
- Demand and fuel prices from AEO 2016 Reference Case
- Technology costs and performance from 2016 ATB Mid Case





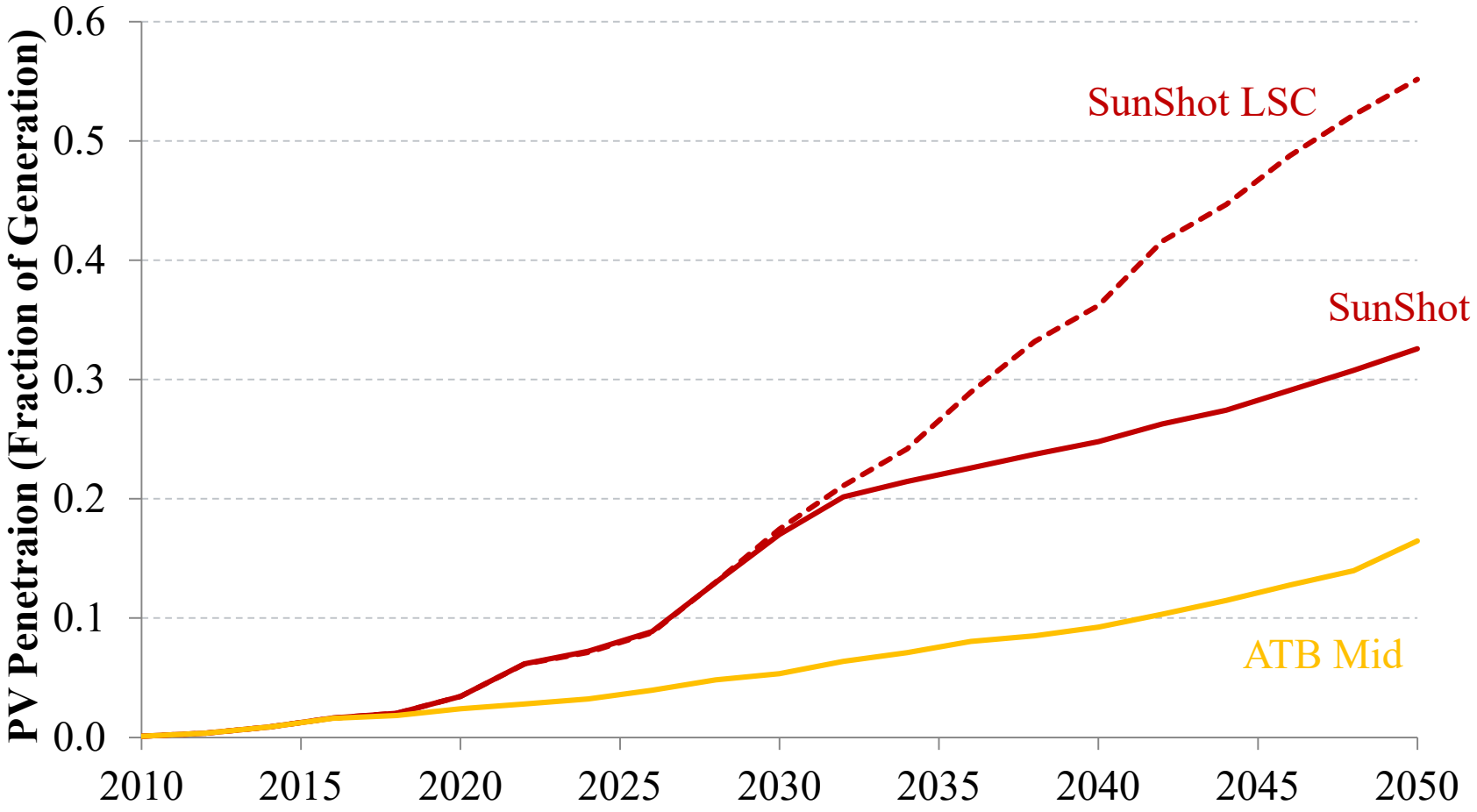
PV Deployment

- LSC = Low Storage Cost



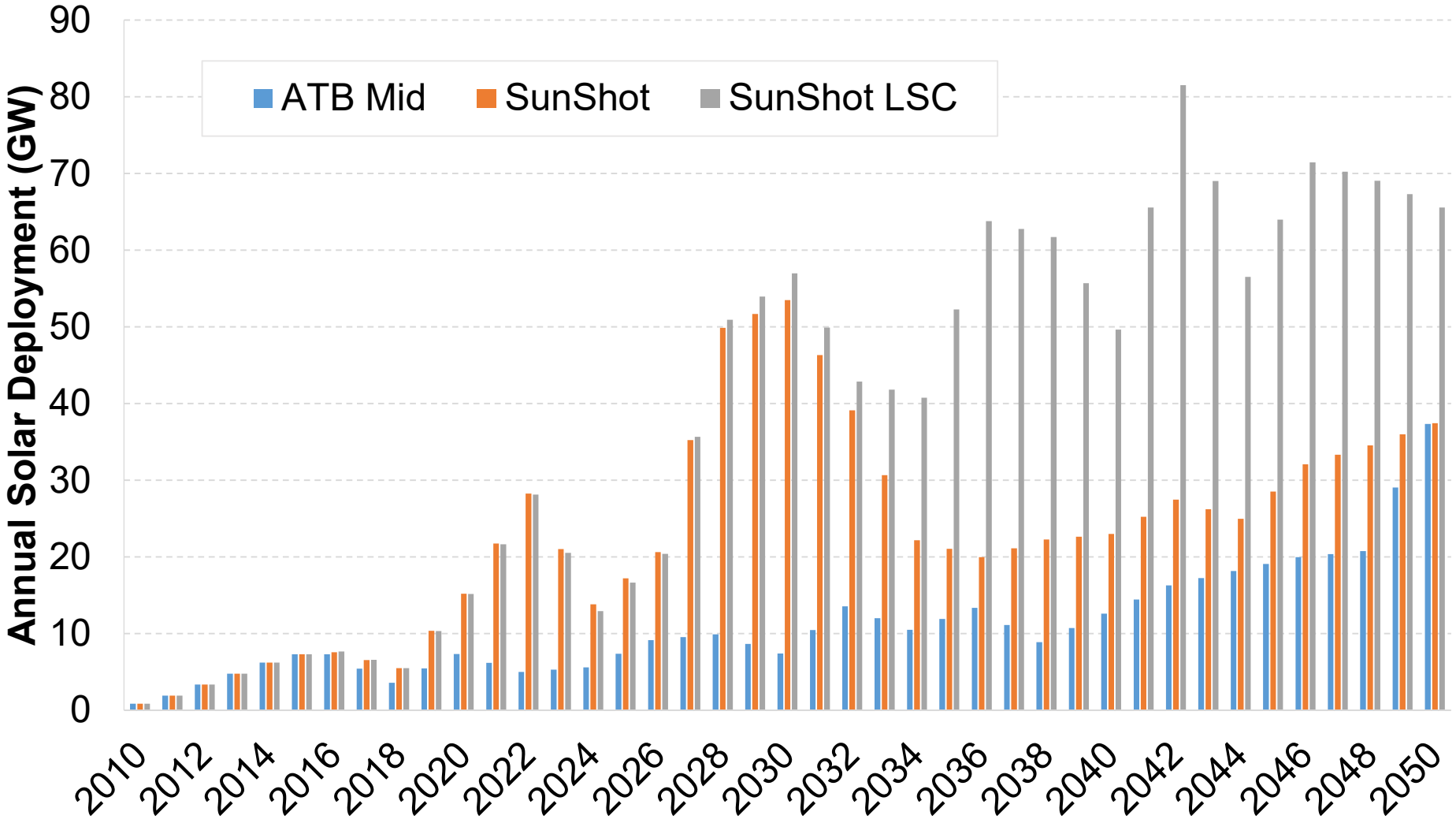
PV Penetration

- LSC = Low Storage Cost

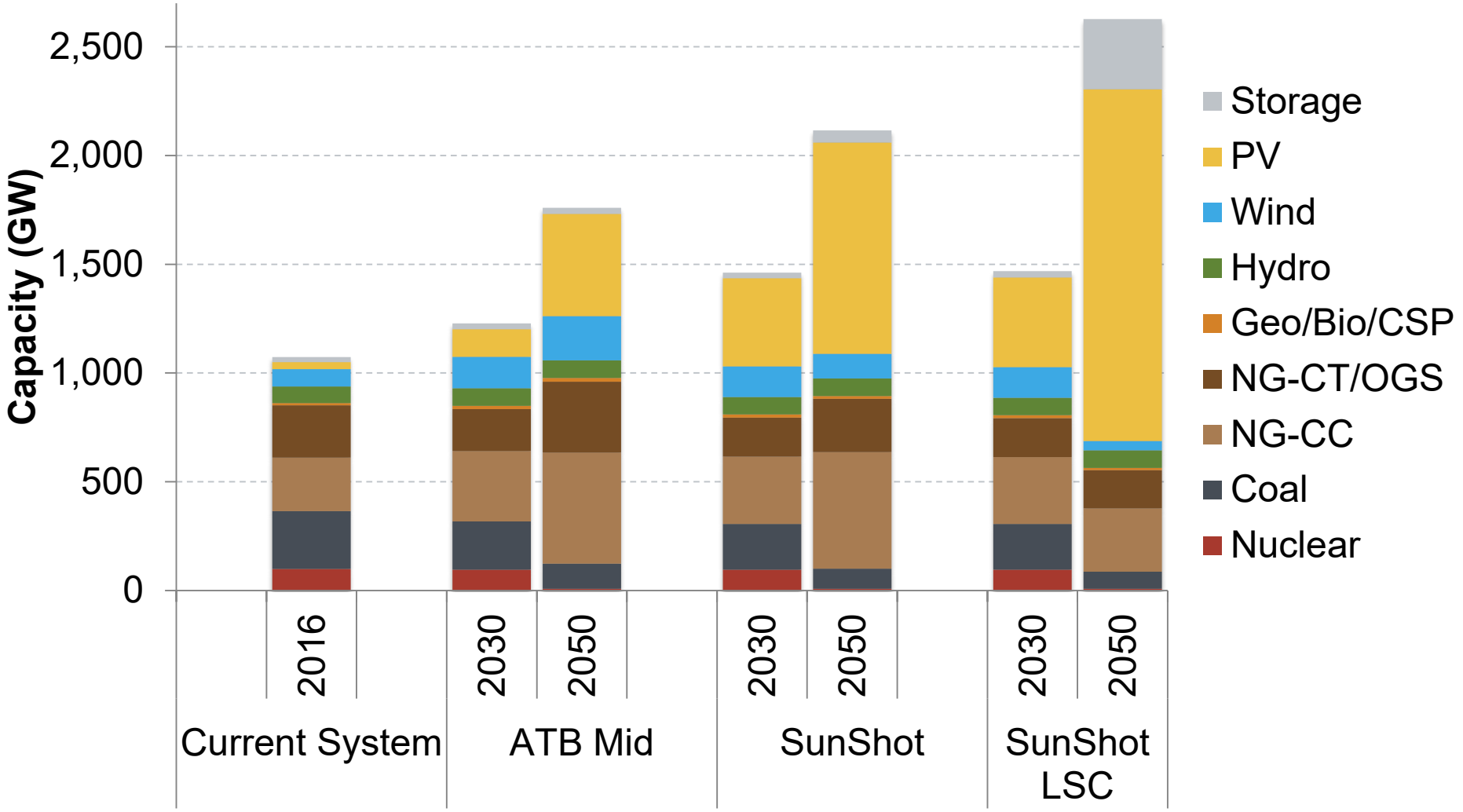


Annual Solar Deployment

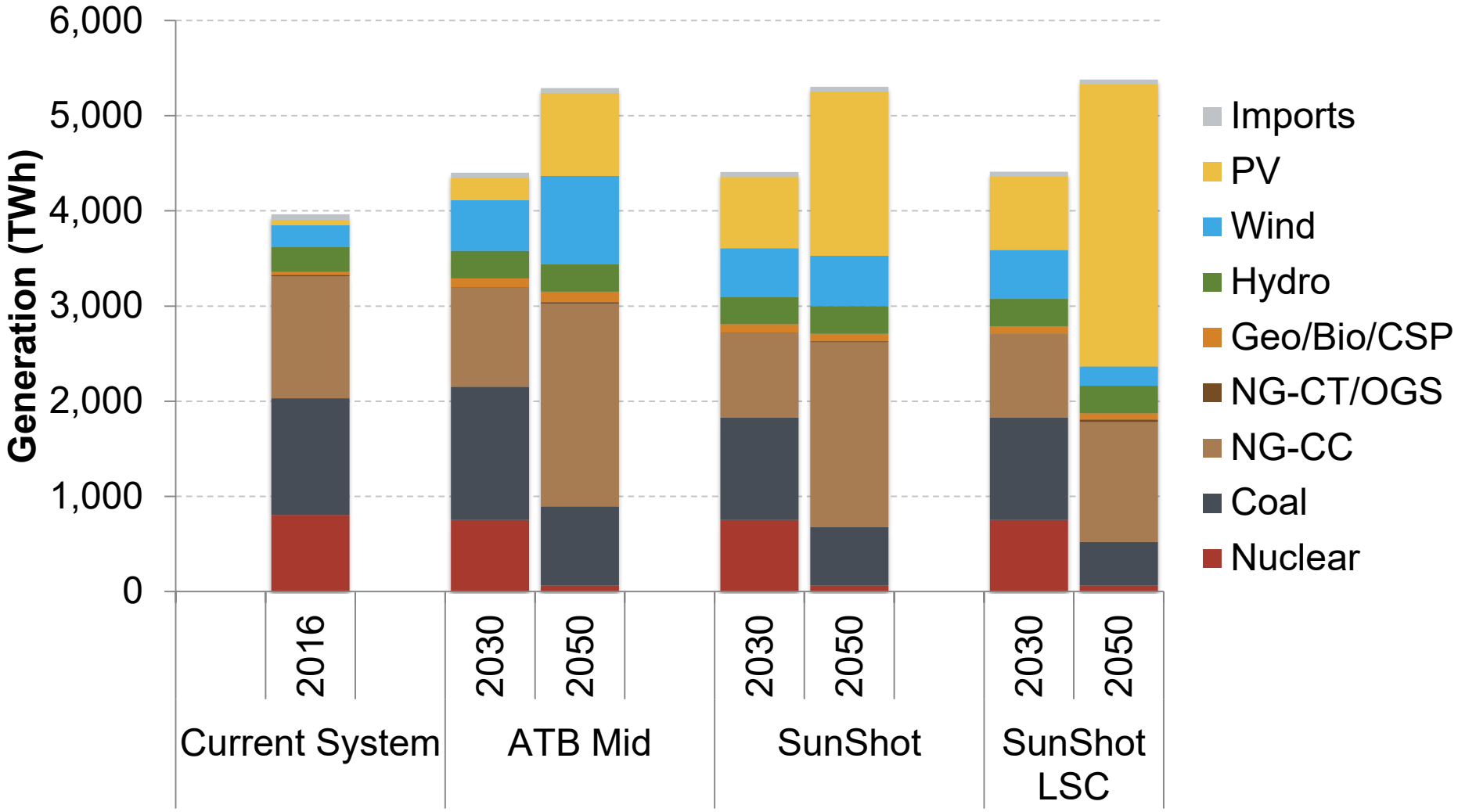
- LSC = Low Storage Cost



Capacity Mix

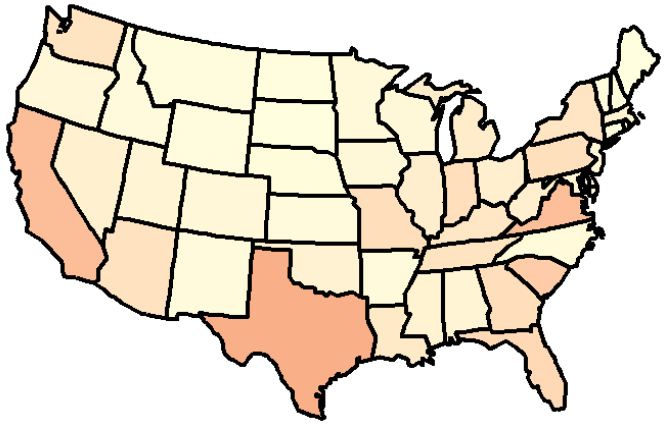


Generation Mix

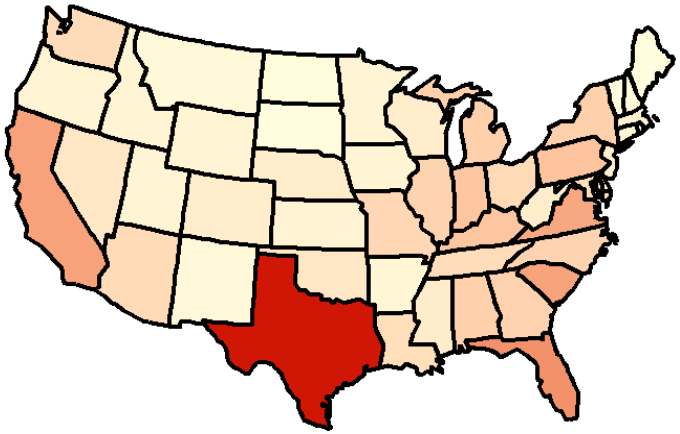


Regional Distribution

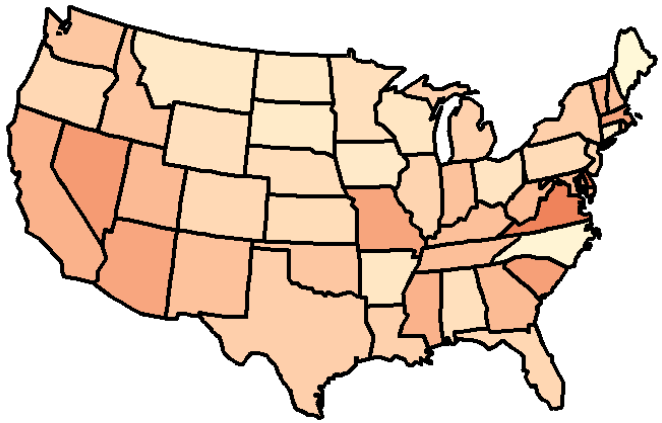
SunShot in 2050



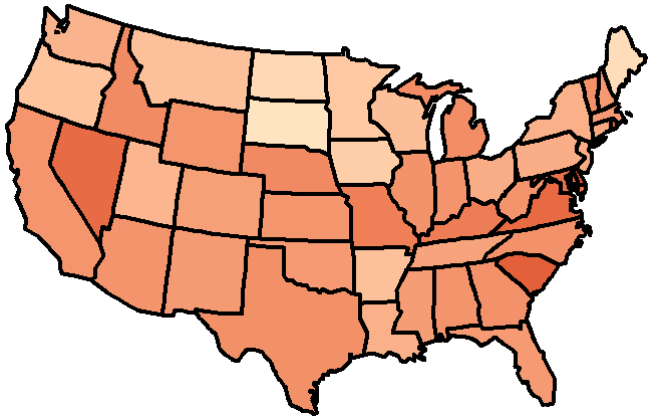
SunShot LSC in 2050

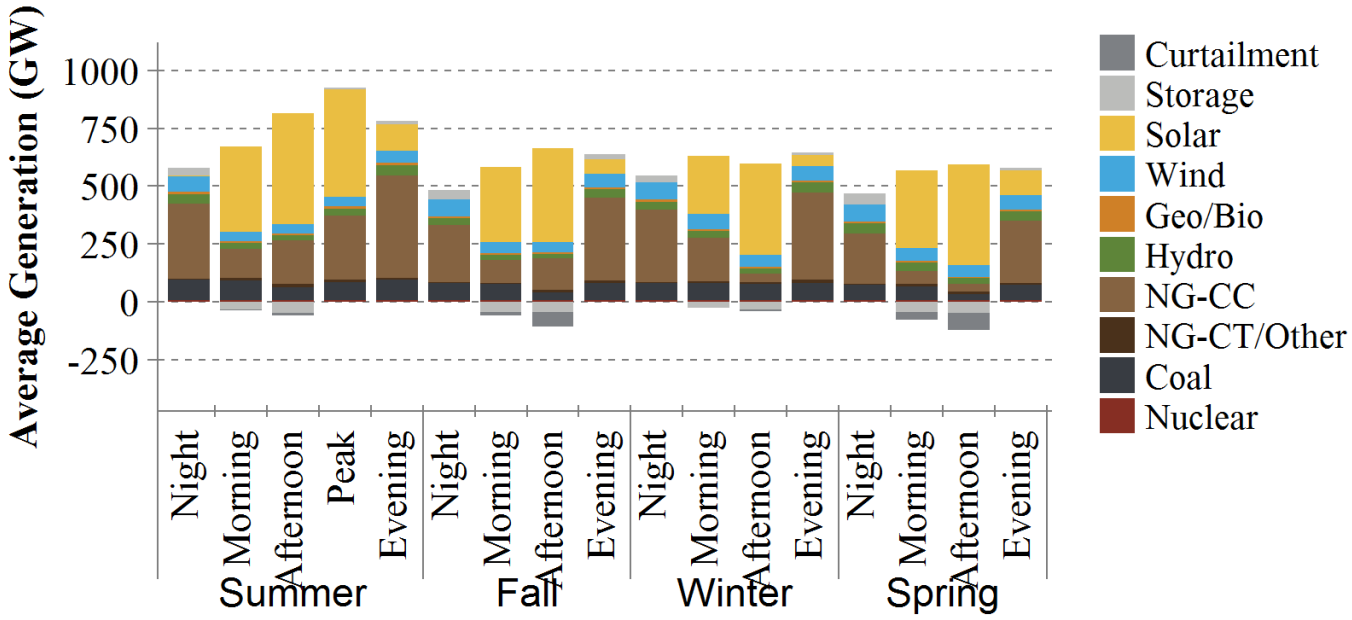


SunShot in 2050

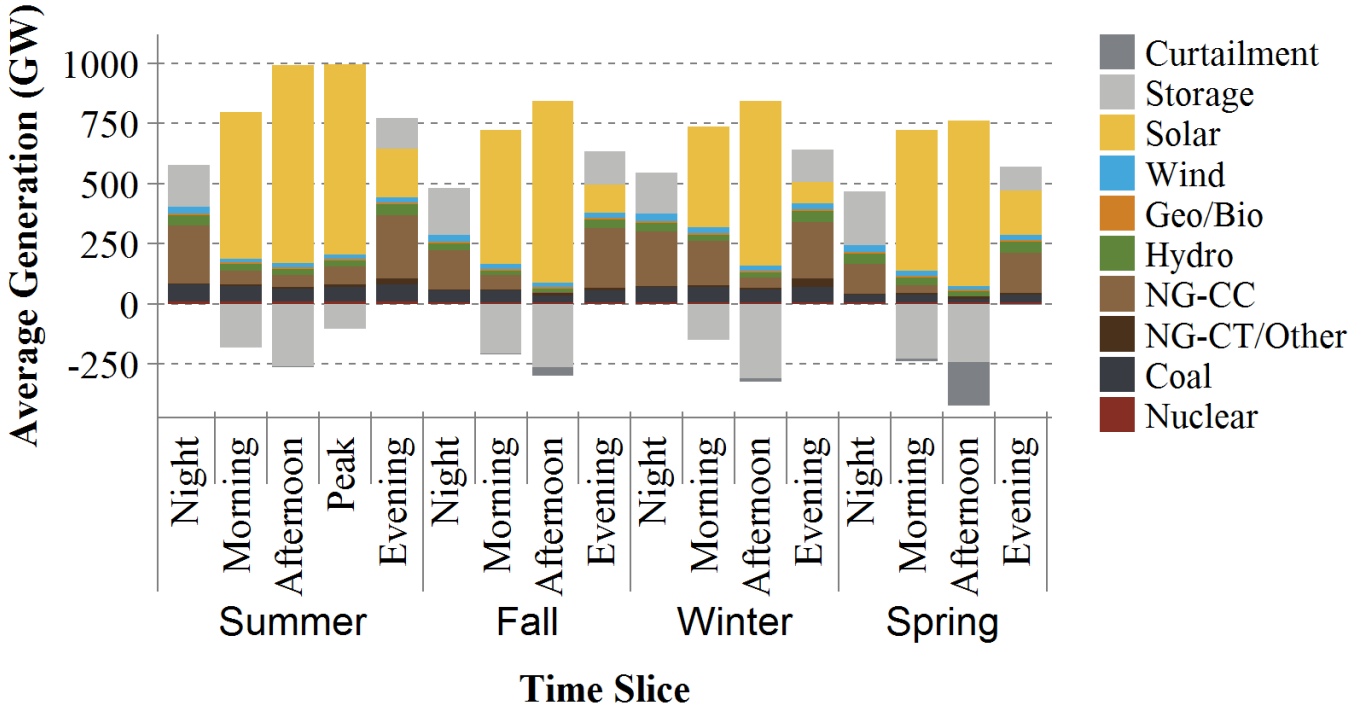


SunShot LSC in 2050





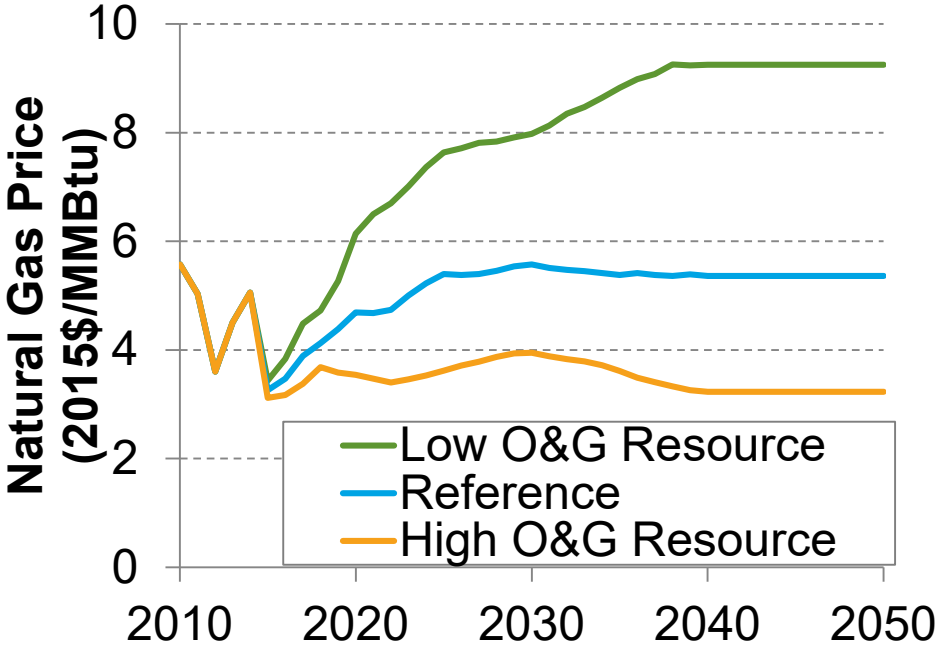
SunShot Scenario in 2050

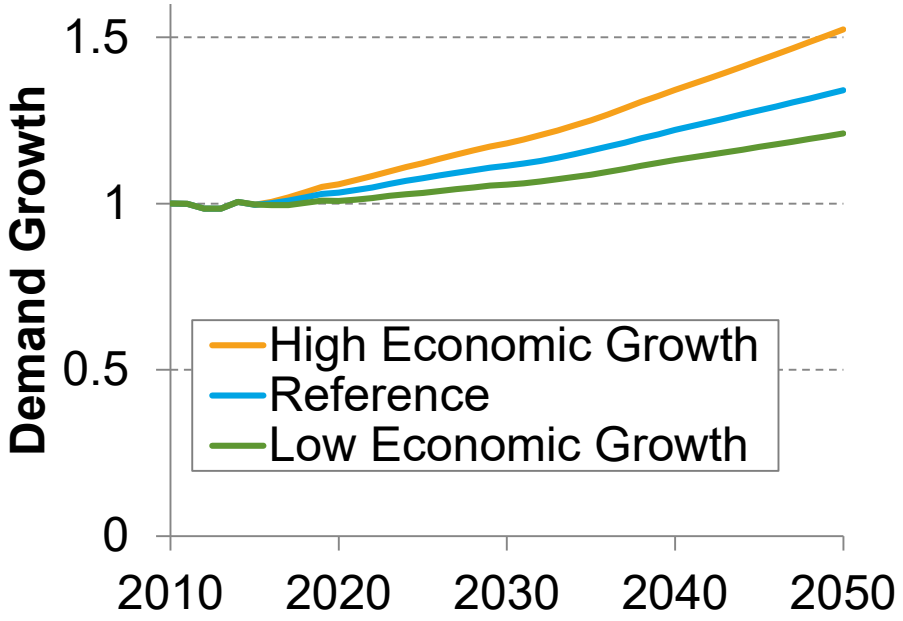


SunShot LSC Scenario in 2050

Sensitivity Scenarios

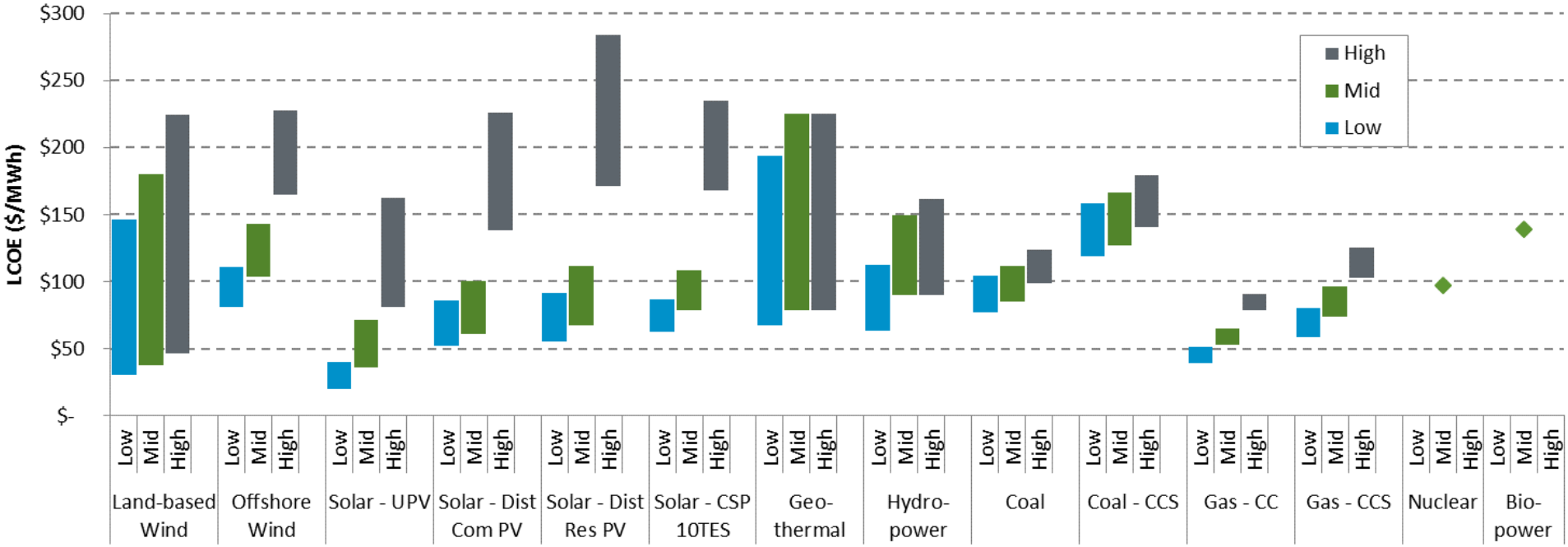
- Low & high natural gas prices
- Low & high demand growth



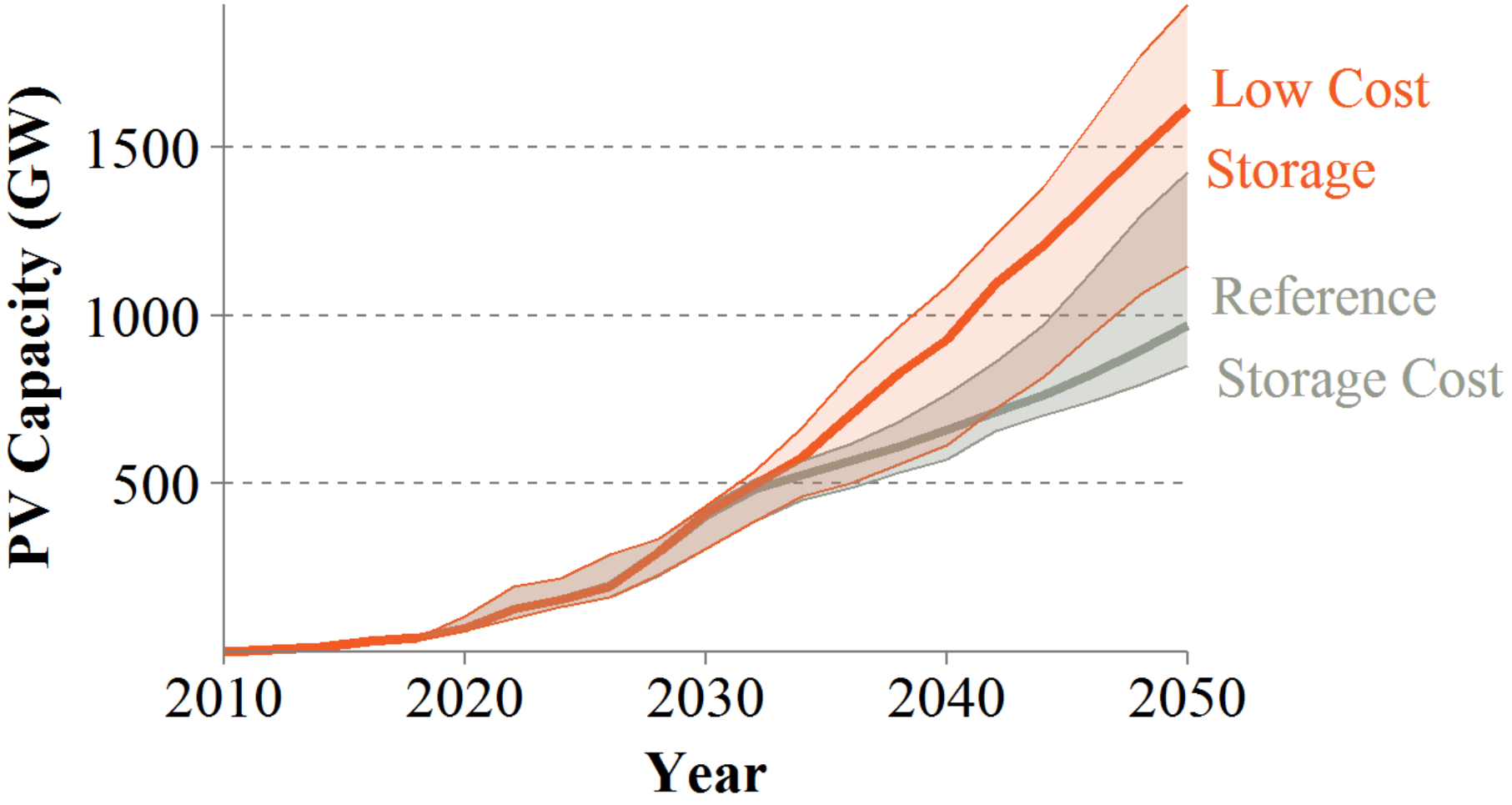


Sensitivity Scenarios

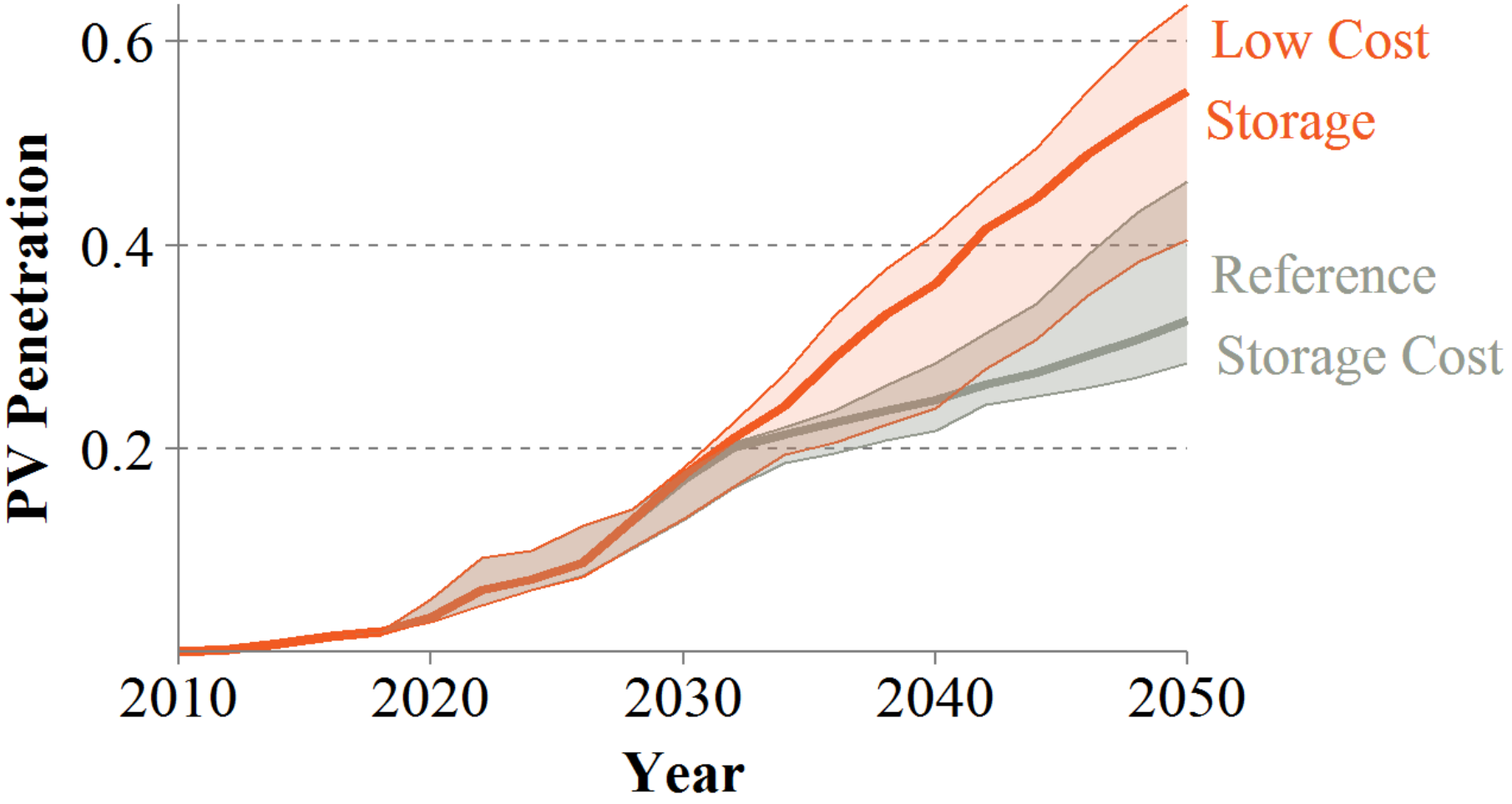
- Low & high natural gas prices
- Low & high demand growth
- Low & high renewable energy costs
- Low & high retirements
- Growth penalty for PV



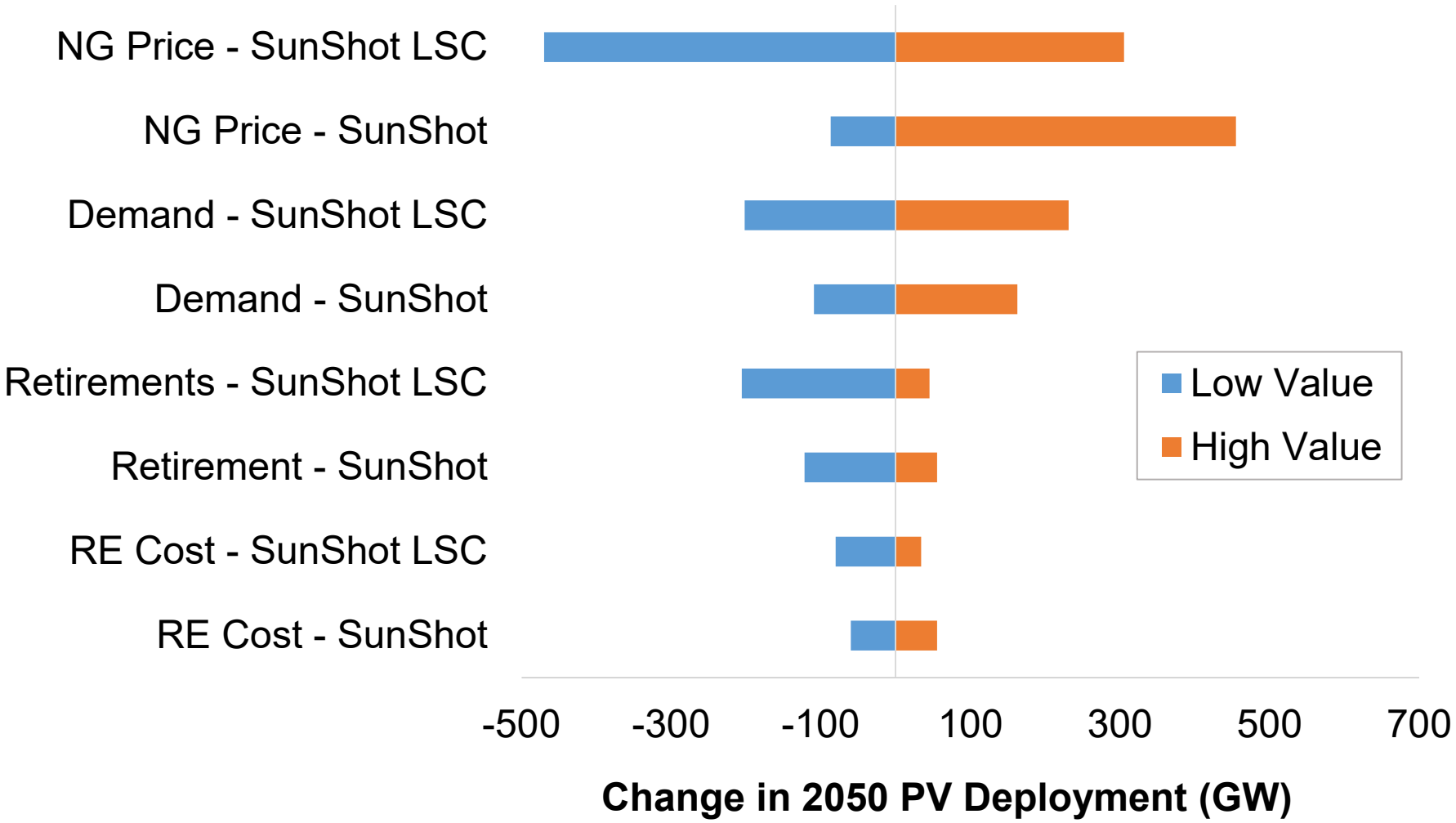
PV Deployment



PV Penetration (fraction of generation)



Impact of Various Sensitivities

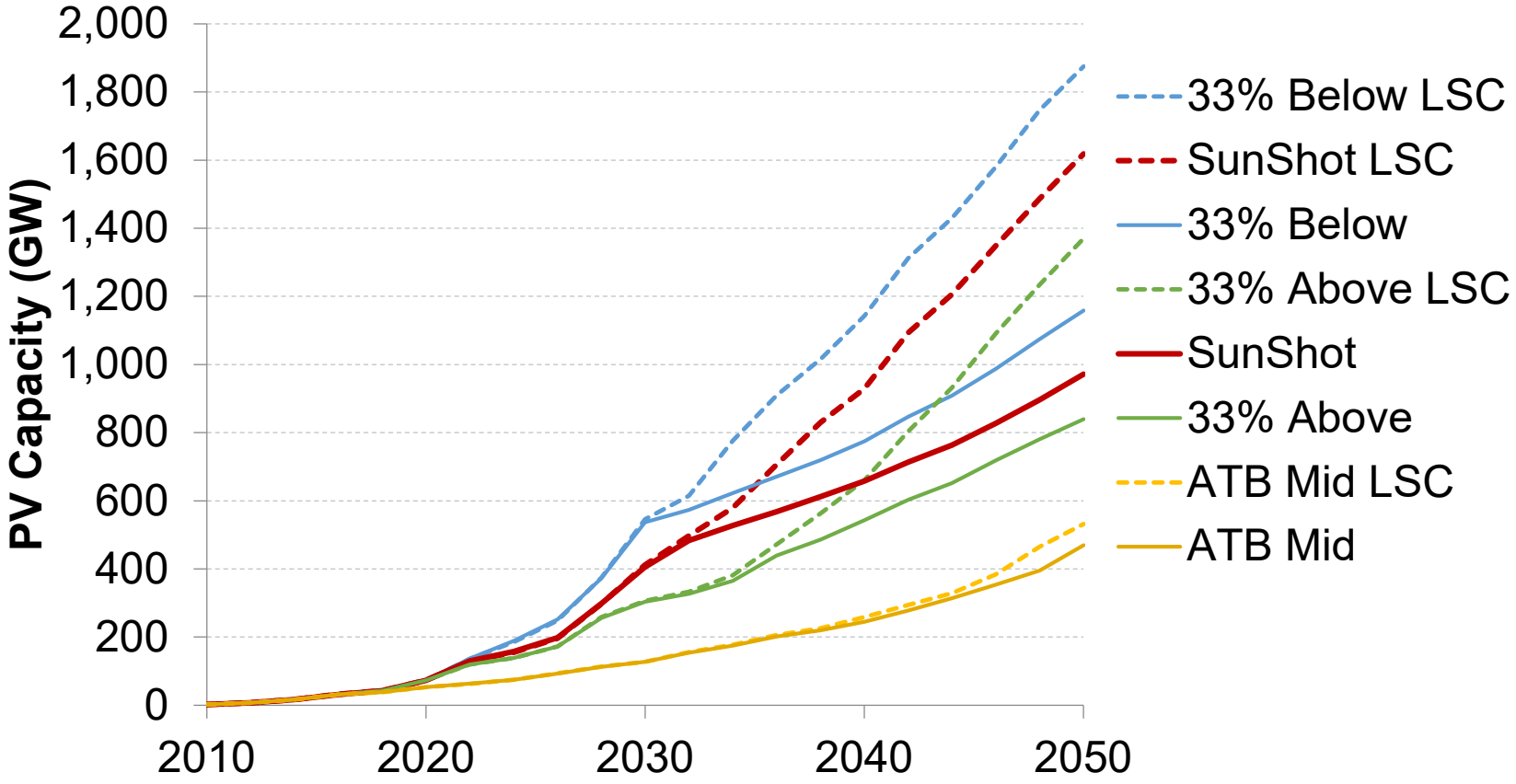


Method for Evaluating Impacts

- Consider SunShot scenario versus baseline
- Include two other PV costs scenarios
  - 33% above SunShot (UPV: 4 cents/kWh in 2030)
  - 33% below SunShot (UPV: 2 cents/kWh in 2030)
- These cost sensitivities represent under and over deployment of PV relative to the SunShot scenario

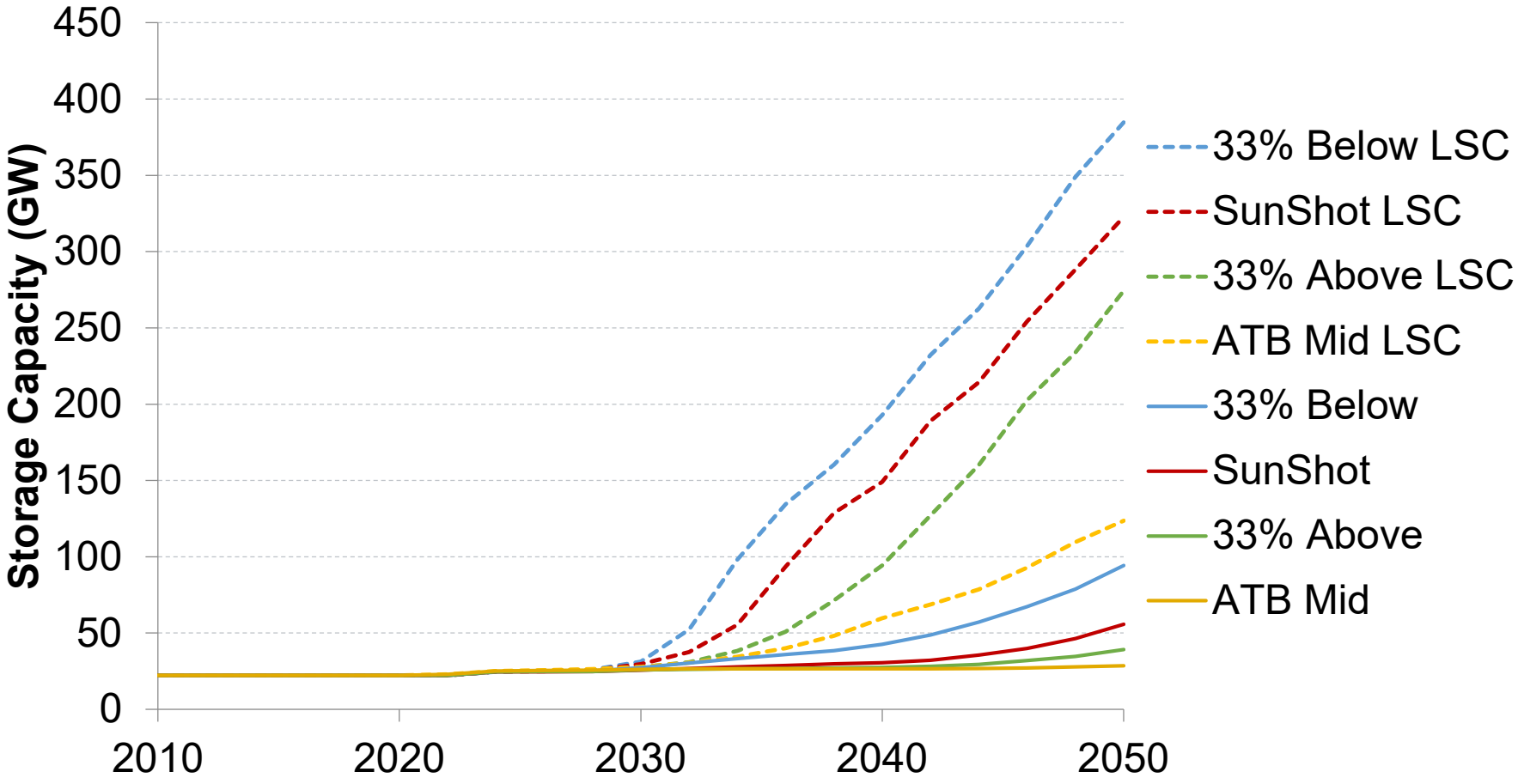
PV Deployment

- PV deployment slows around 2030 without storage

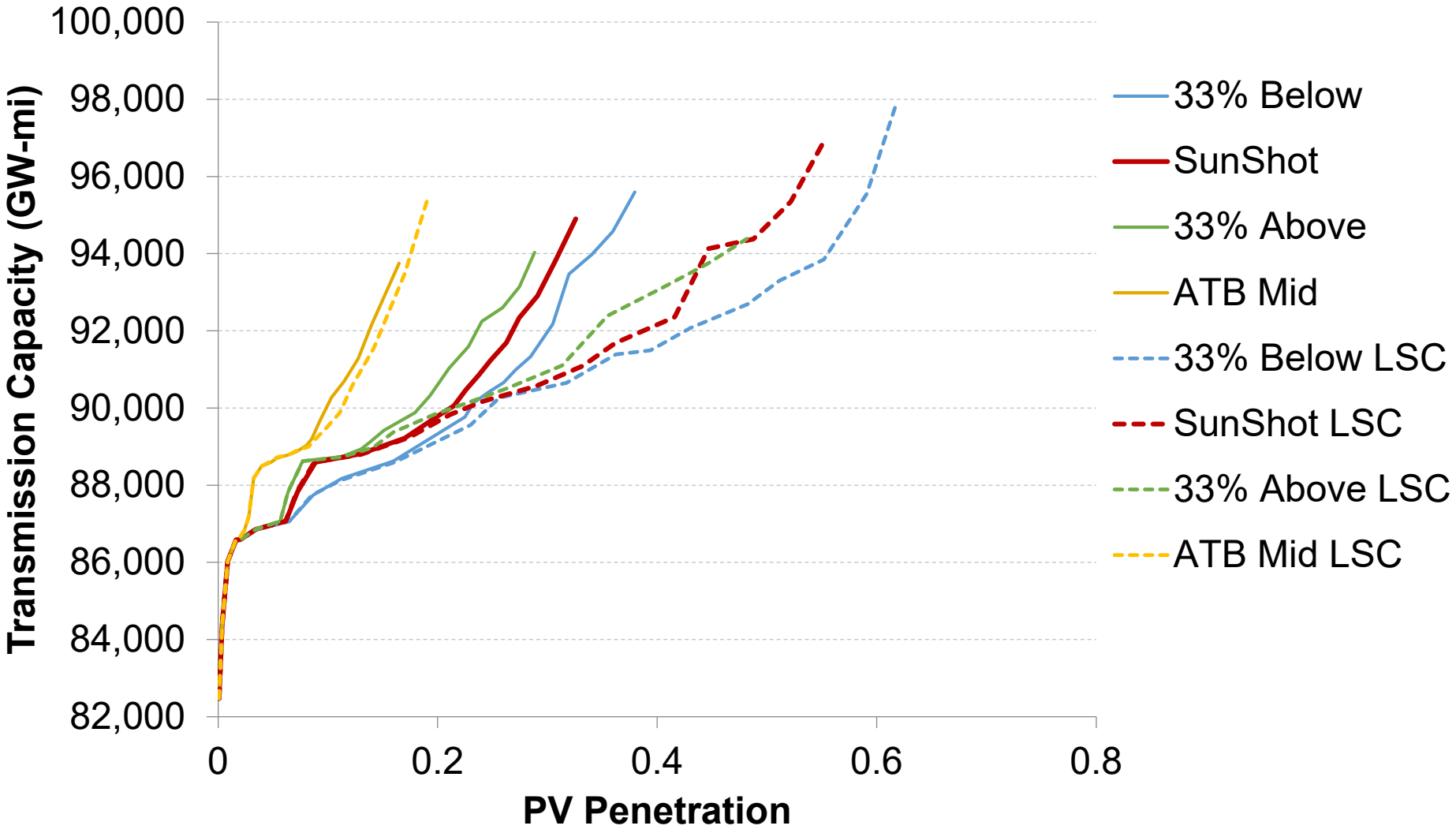


Storage Capacity

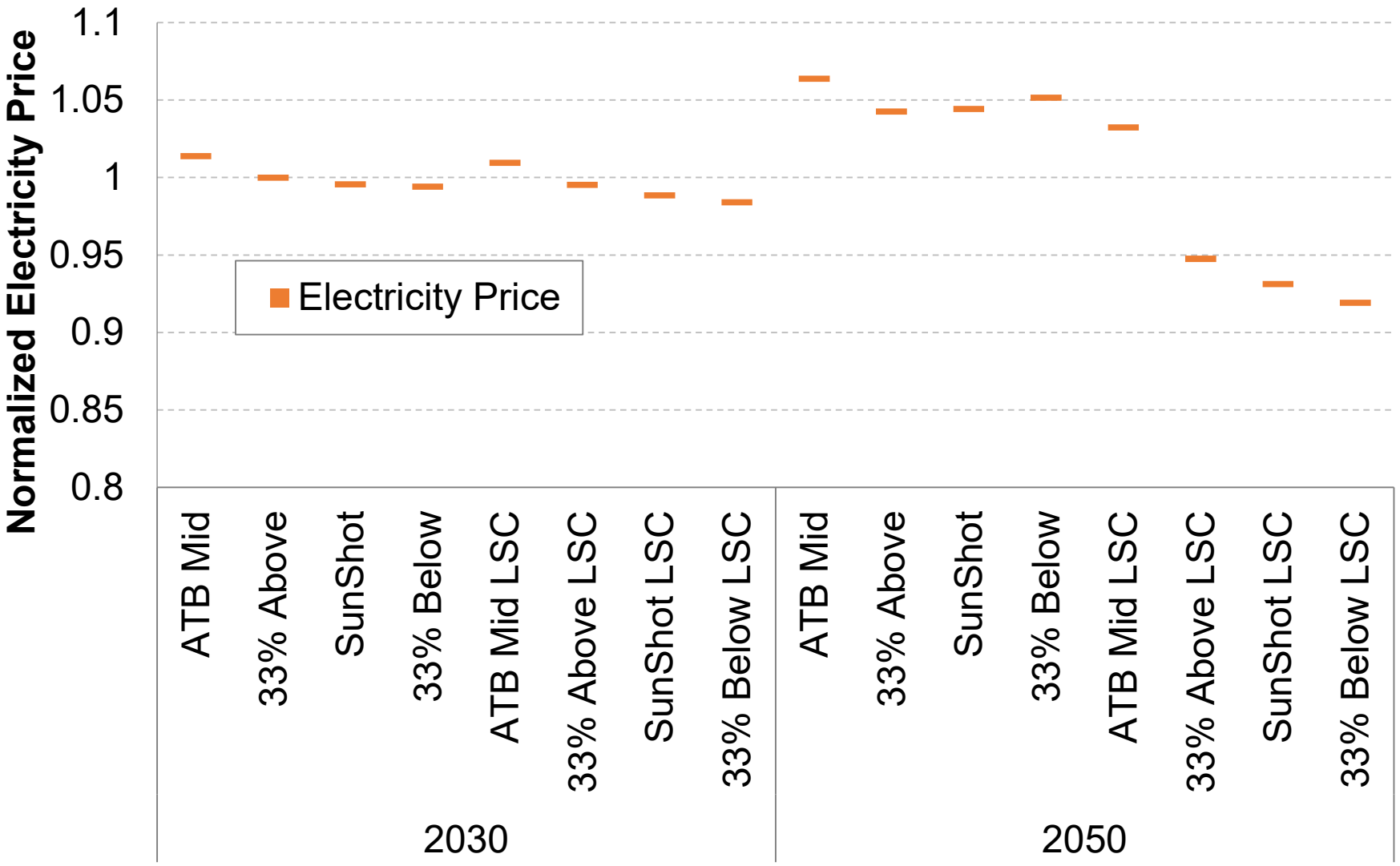
- Storage capacity grows in all scenarios, but strongly increases with increased PV deployment



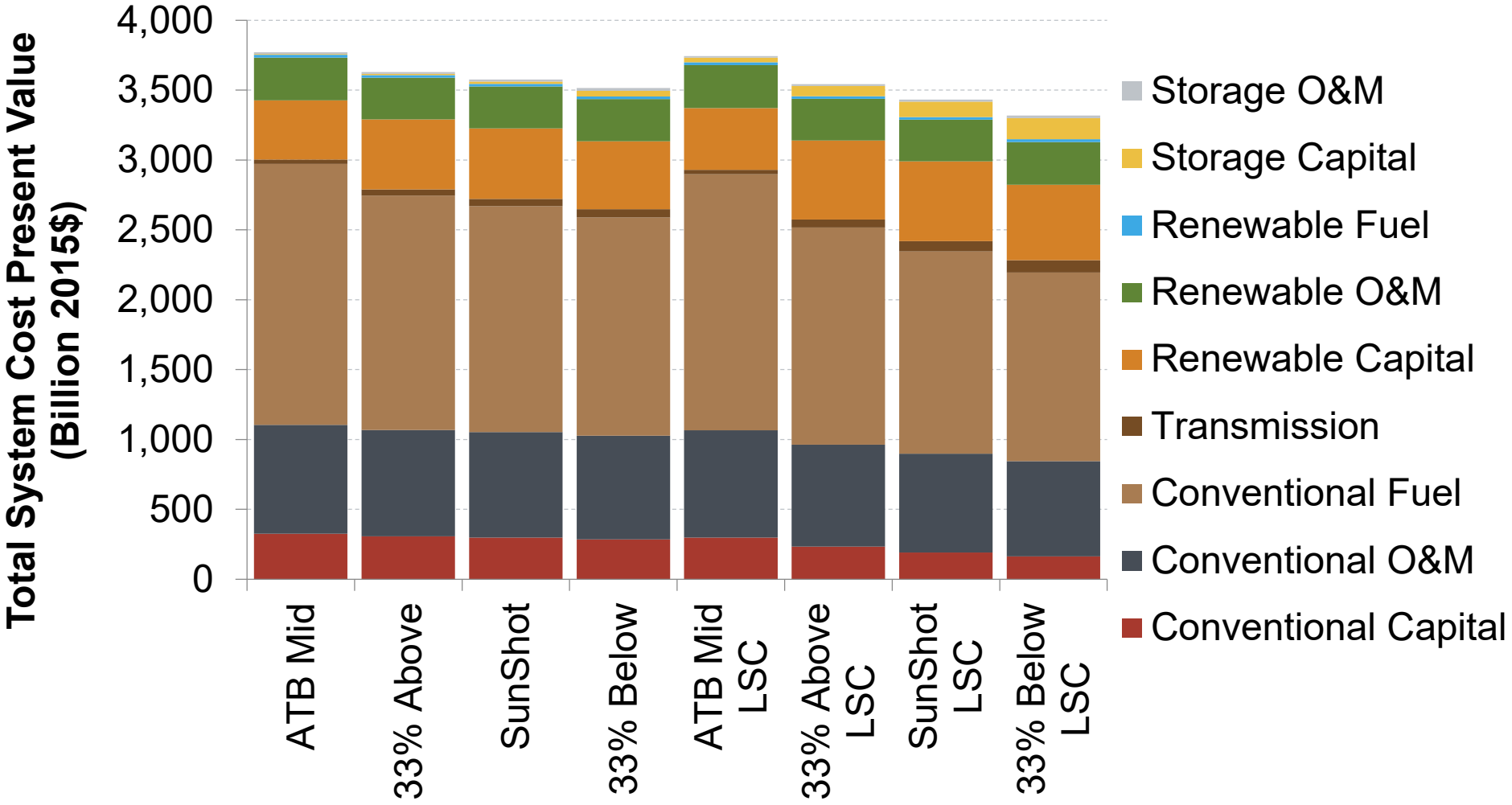
PV Does Not Drive Large Transmission Additions



Lower Cost PV Can Lower Electricity Prices

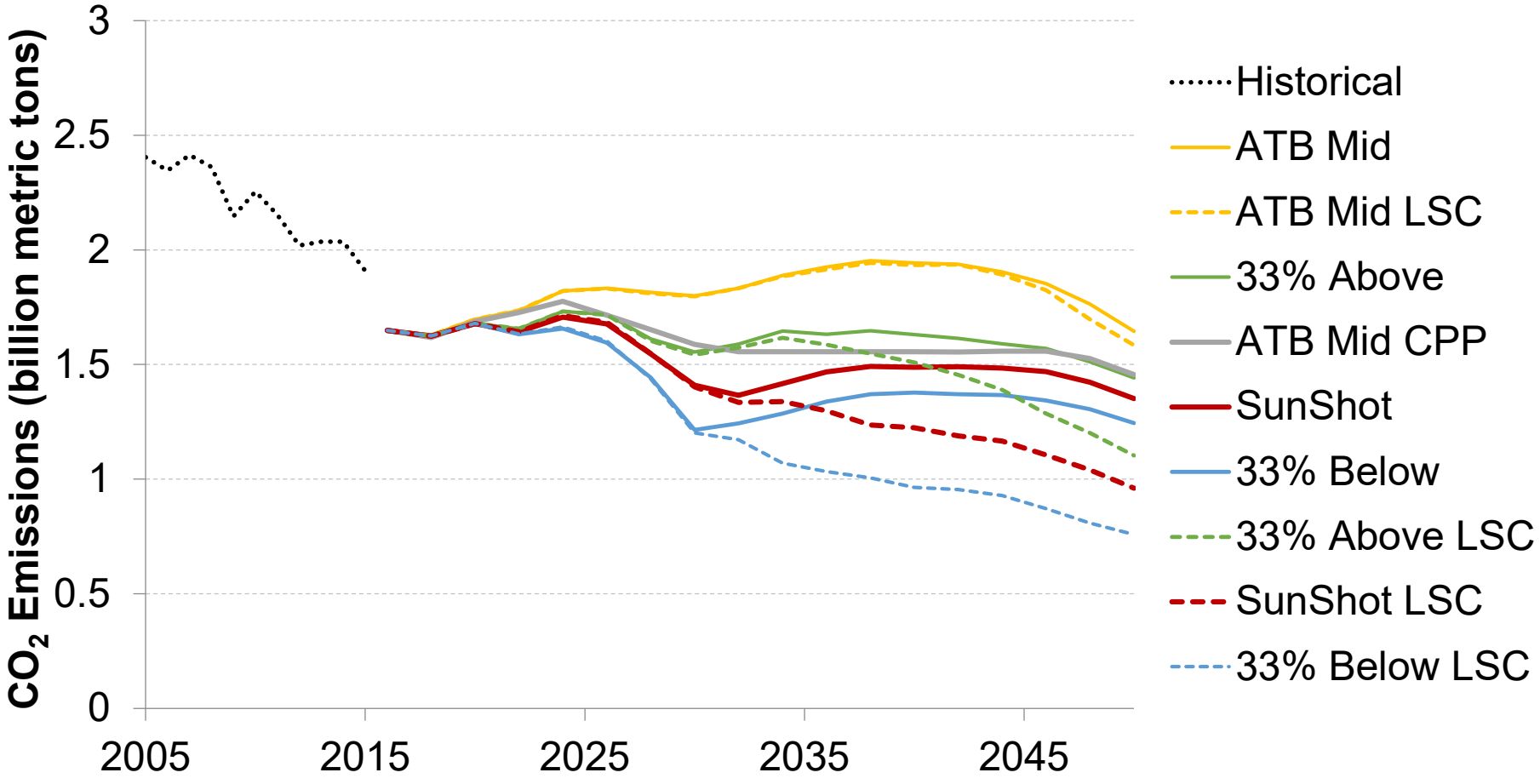


System Costs Significantly Reduced with Lower-cost PV



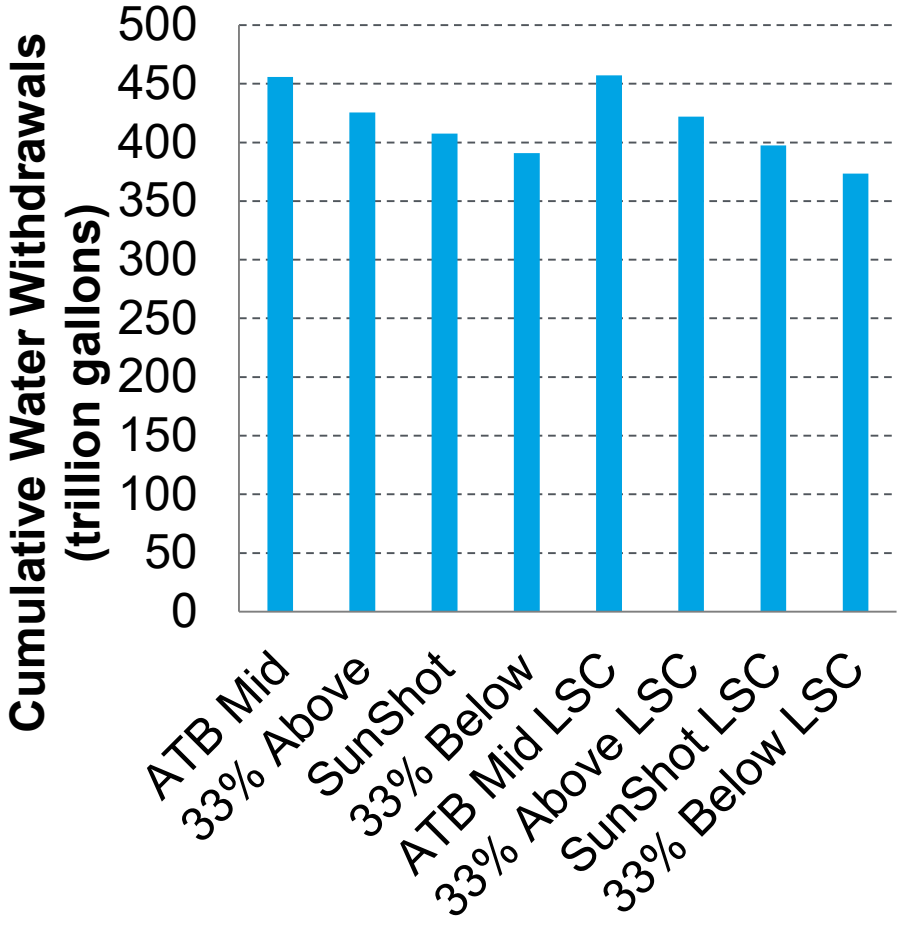
CO_2 Emissions Fall Under the Clean Power Plan Target

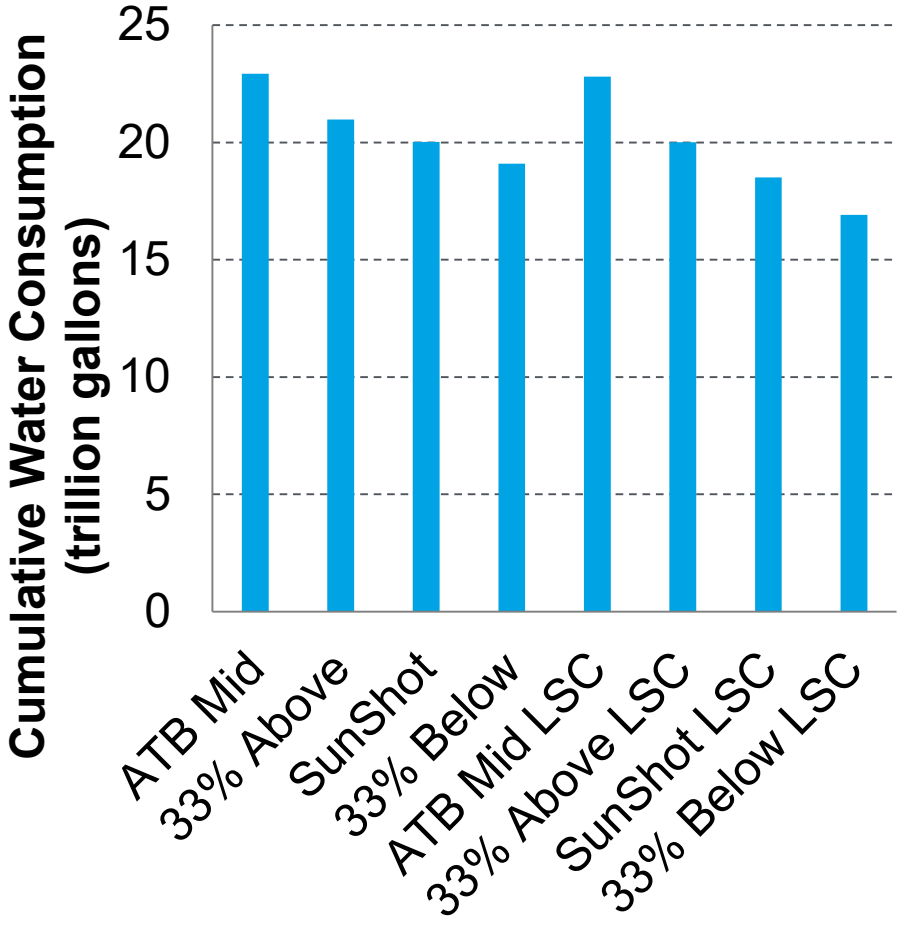
- Low Storage Cost (LSC) enables continued reduction in emissions post-2030



Water Usage Follows a Similar Trend

- Less thermal generation = less water usage





Area of Future Research

- Distribution grids
- Utility business models
- Grid integration challenges
- End-use demand changes (e.g., EVs, electrification)
- Land-use requirements and impacts
- Supply chain impacts
- Job impacts
- Role of concentrating solar power

Summary

- Reaching the SunShot 2030 targets would likely lead to significant PV deployment across all areas of the U.S.
- The availability of low-cost energy storage in combination with low-cost PV could have a transformative effect on the power sector
- There is still a lot of work to be done to understand the benefits and challenges of operating such high PV penetration systems

Questions or Comments?

The full report is available at

https://www.nrel.gov/docs/fy17osti/68105.pdf

(or Google “NREL SunShot 2030”)

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