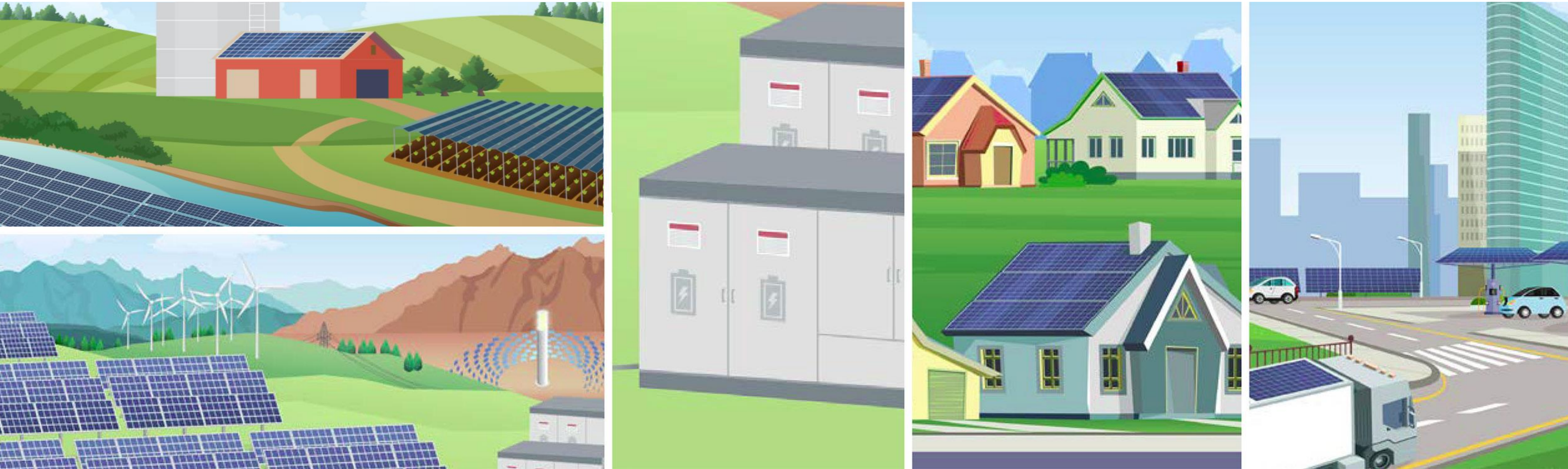
Solar Futures Study: Overview

September 2021



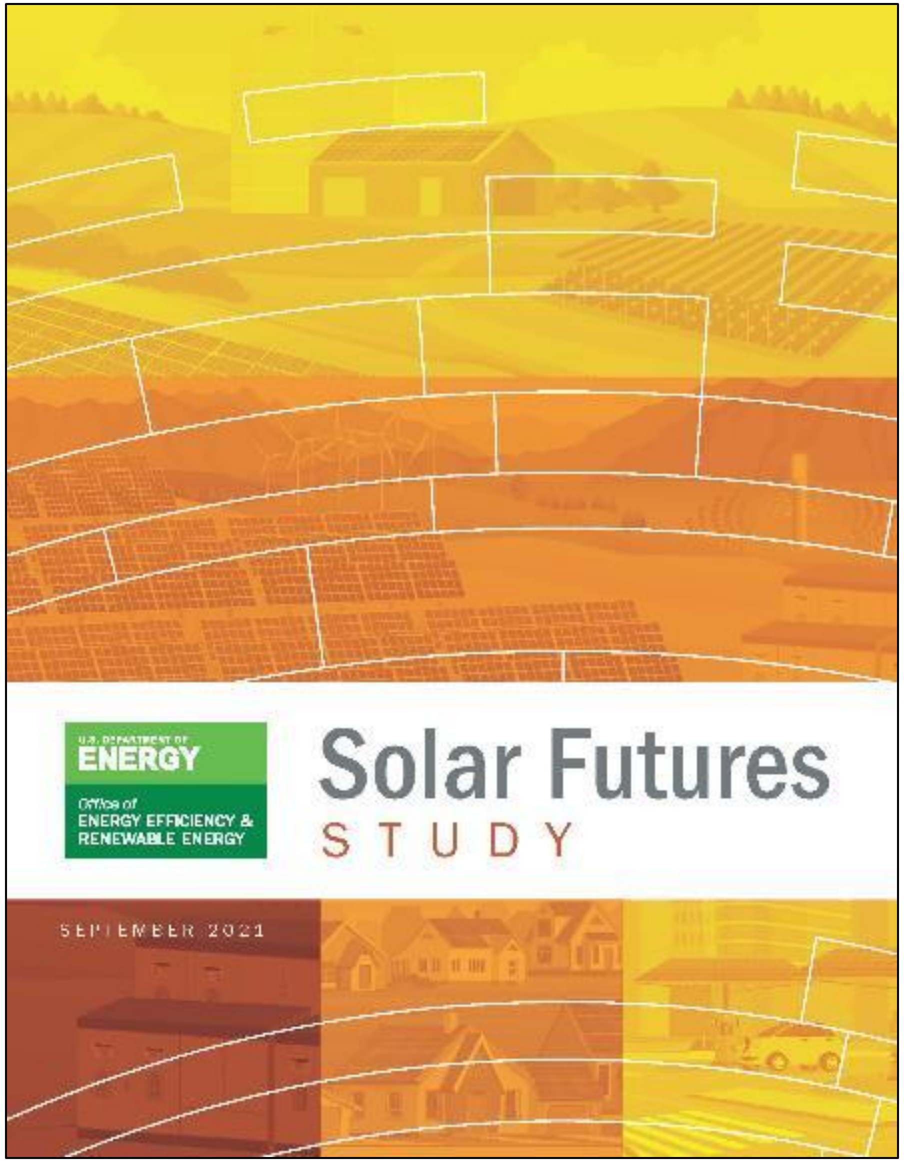
Study Overview

PURPOSE

- Comprehensive review of the potential role of *solar* in decarbonizing the electricity grid by 2035 and the energy system by 2050.
  - Addresses other large trends and activities across the U.S. economy that are necessary to achieve a zero-carbon energy system.
  - Builds analytical foundations to guide the next decade of solar research.

SCOPE

- Chapters cover future scenarios, technology advances, equity, grid integration, cross-sector interactions, supply chain, and environmental impacts.



Solar Futures Study: Key Results

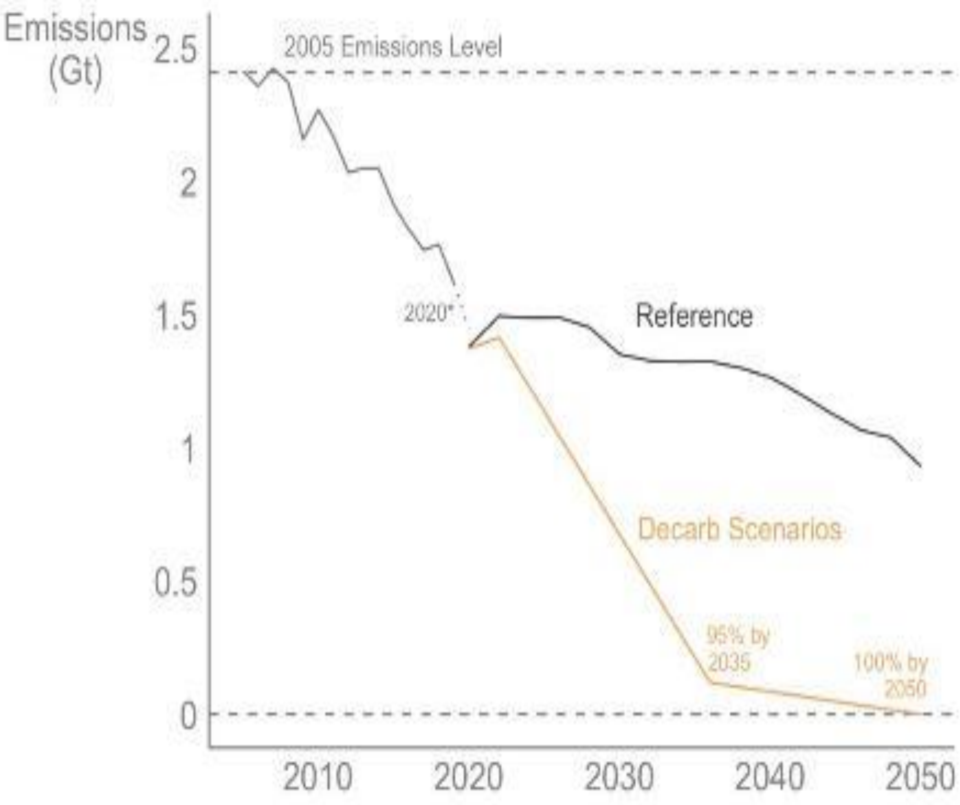
1. **Deploy, deploy, deploy.** We must install an average of 30 GW of solar capacity per year between now and 2025 and 60 GW per year from 2025-2030. (In 2020 the U.S. installed 15 GW.)
   - 1,000 GW of solar meets 40% of electric demand in 2035, 1,600 GW meets 45% in 2050.
   - We must reshape workforce development, supply chains, siting and permitting, and regulation.
   - Major growth in wind and storage are also required.
2. **With continued technological advances, electricity prices do not increase through 2035.** This includes solar, wind, energy storage, and other technologies.
3. **The grid will be reliable and resilient.** Storage, transmission, and flexibility in load and generation are key.
4. **Expanding clean electricity supply yields deeper decarbonization.** Electrifying buildings, transportation, and industry reduces carbon emissions.
5. **Policy changes are necessary**. Limits on carbon emissions and/or clean energy incentives.

Three Core Scenarios

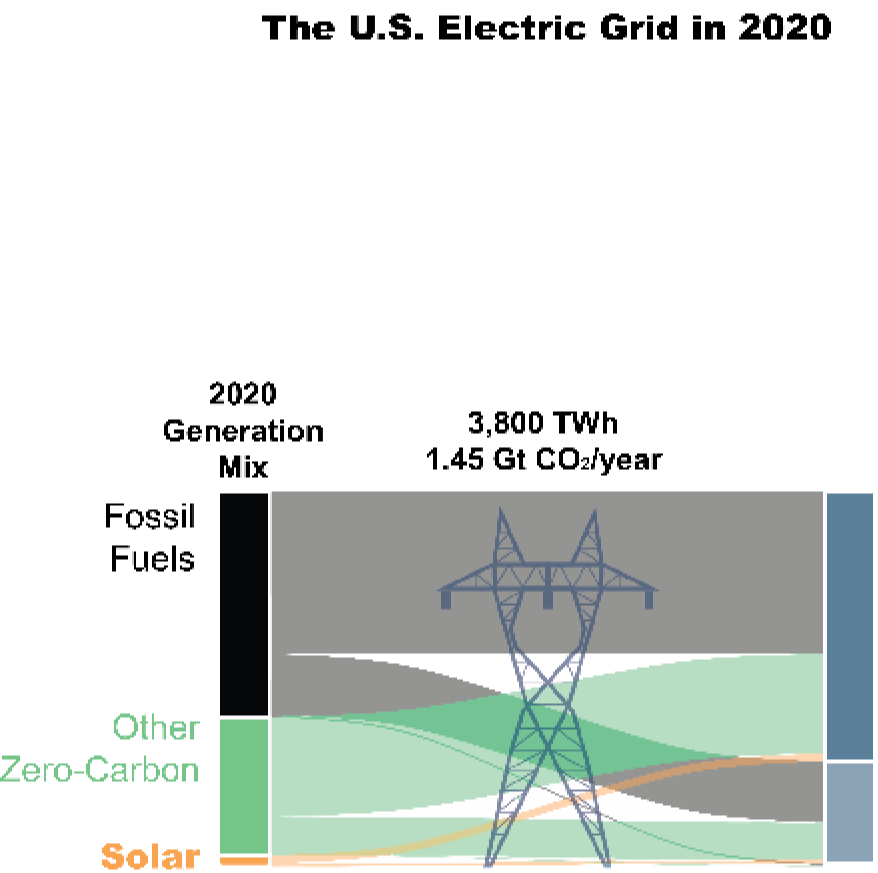
Solar Futures Study models three core scenarios for the evolution of the U.S. grid:

- **Reference:** business-as-usual costs, policies, electricity demand
- **Decarb:** carbon constraint, BAU electricity demand, advanced technology improvements
- **Decarb + E:** same as Decarb but with enhanced electrification and demand flexibility

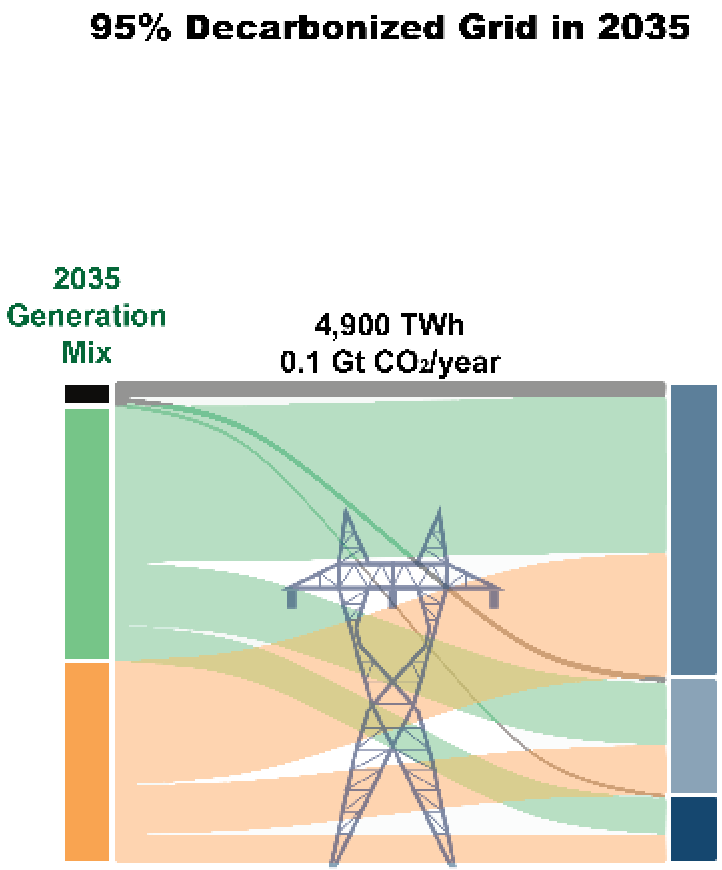
Scenario Name	Renewable Energy & Storage Technologies	Electricity Demand	Policies
Reference	Moderate cost reductions	U.S. Energy Information Administration Reference	Existing policies as of June 2020
Decarbonization (Decarb)	Advanced cost reductions		95% reduction in CO_2 emissions from 2005 levels by 2035, 100% by 2050
Decarbonization with Electrification (Decarb+E)		Electrification Futures Study: High Electrification with Enhanced Flexibility	



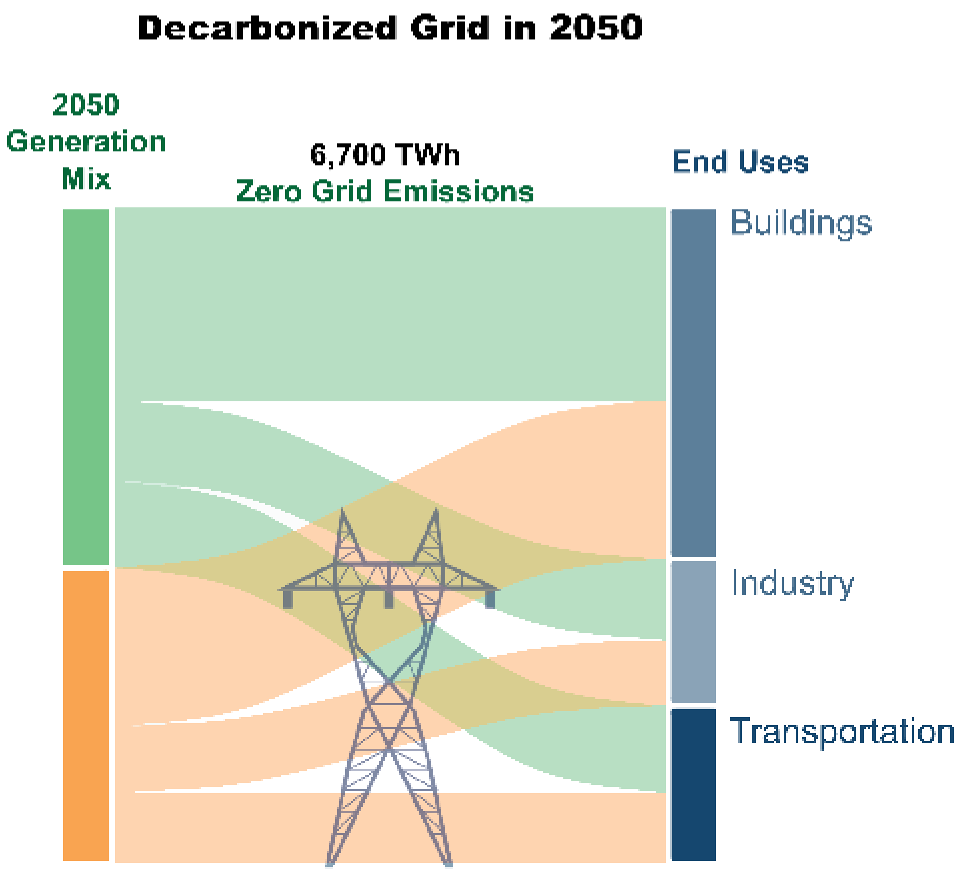
U.S. Energy Mix 2020-2050



Solar: 3% of electricity demand, 80 gigawatts AC installed



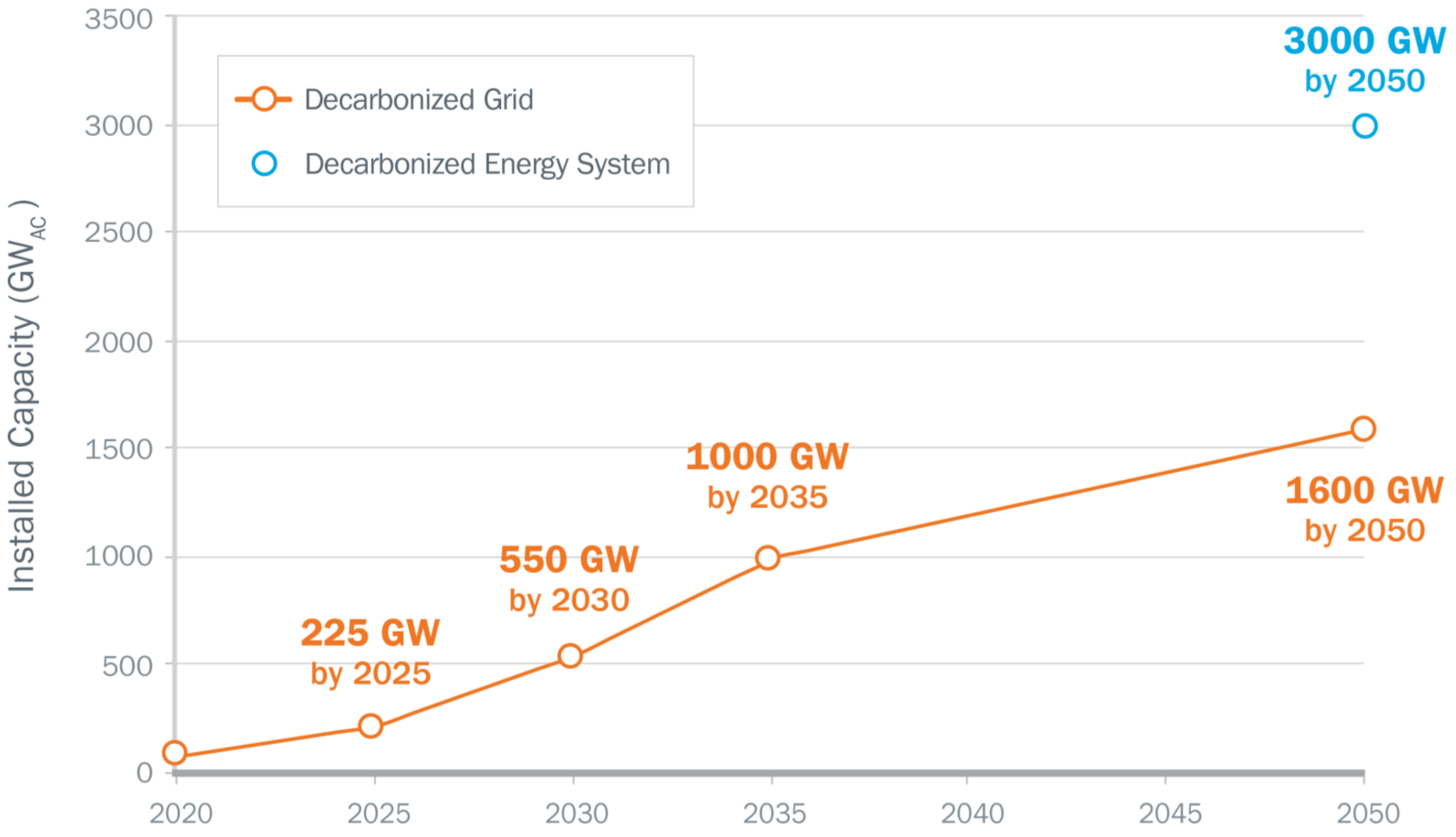
Solar: 40% of electricity demand, 1,000 gigawatts installed



Solar: 45% of electricity demand, 1,600 gigawatts installed 3,000 GW in decarbonized energy system

Solar Deployment by 2050

- Need rapid, sustained growth over next decade+.
- Simplified analysis of 100% energy decarbonization shows solar capacity reaching 3,000 GW by 2050.

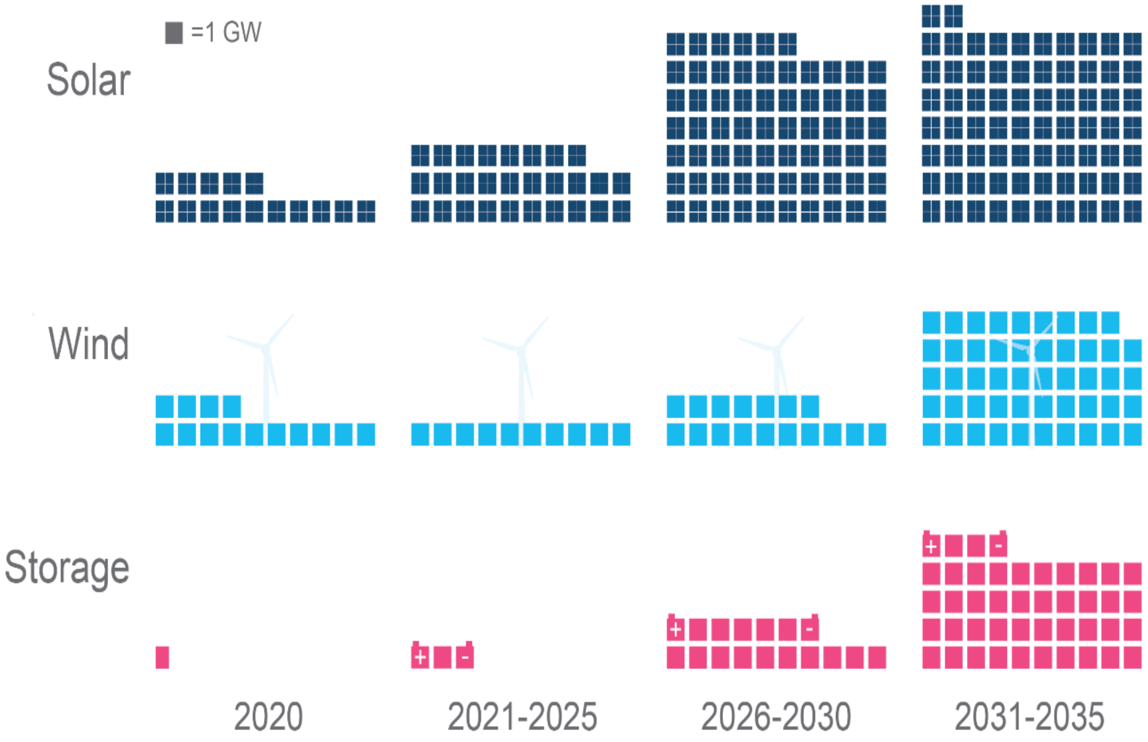


Note: The Solar Futures Study modeled the deployment of solar necessary for a decarbonized grid. Preliminary modeling shows that decarbonizing the entire energy system could result in as much as 3,000 GW of solar due to increased electrification across the energy system.

Is it possible to ramp up as the Solar Futures scenarios envision?

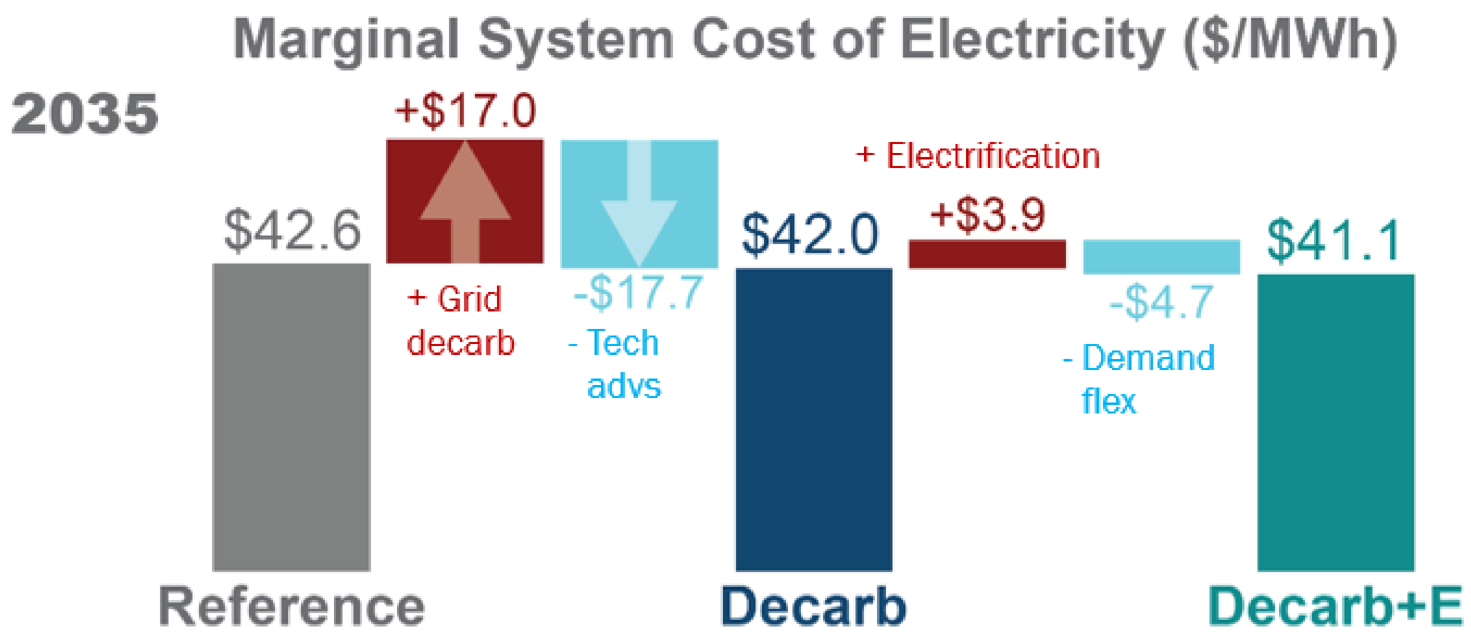
Decarbonization requires significant, but achievable acceleration of clean energy deployment.

- For 95% grid decarbonization by 2035, U.S. must install ~30 GWac of solar each year between now and 2025 and ramp up to ~60 GWac per year from 2025-2030.
- Deployment rates accelerate for wind and energy storage as well.



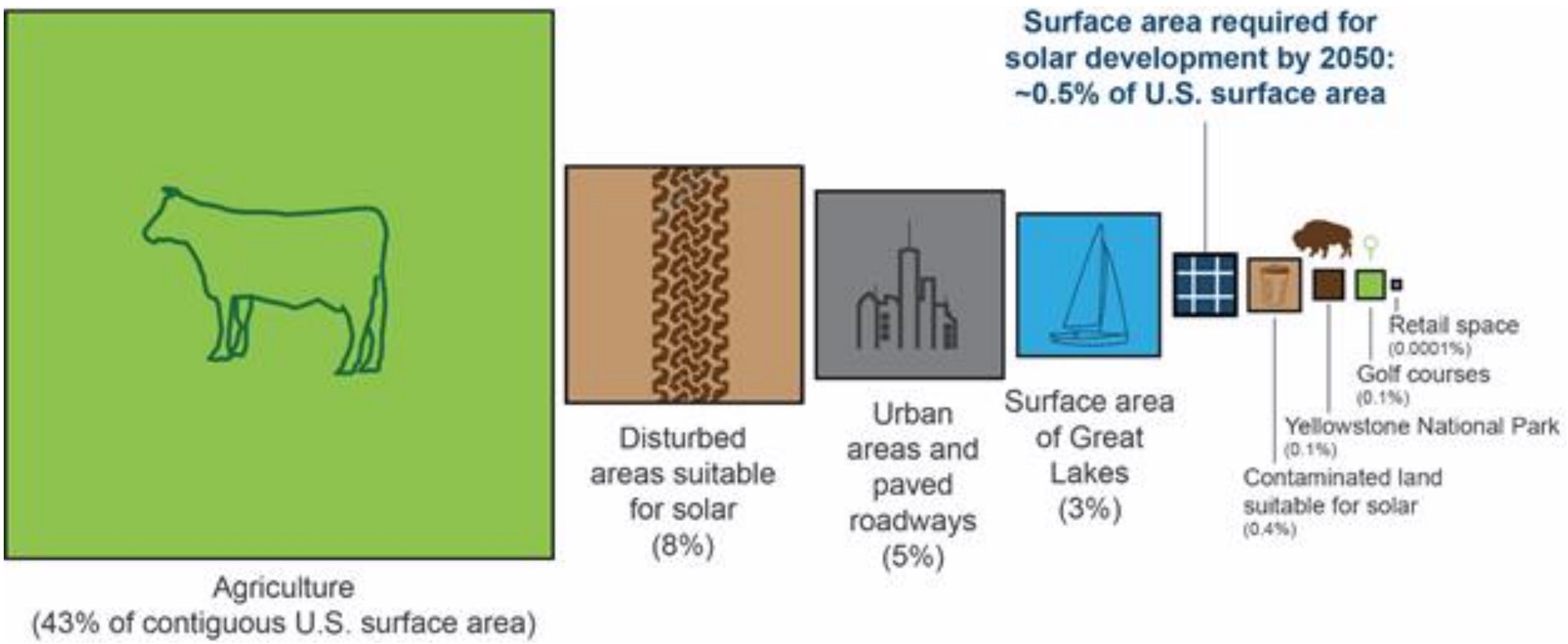
Historical annual technology deployment rates vs. projected average annual deployment rates during 5-year periods under the Decarb+E scenario

Will achieving the Solar Futures Scenarios be costly?



- Solar facilitates deep decarbonization of U.S. grid by 2035 without increasing projected 2035 electricity prices if targeted technological advances are achieved.
- Cumulative system costs 2020-2050 higher in the Decarb (10%) and Decarb+E (25%) scenarios but avoided climate damages and improved air quality more than offset those additional costs.
  - Resulting net savings of $1.1 trillion (Decarb) and $1.7 trillion (Decarb+E)

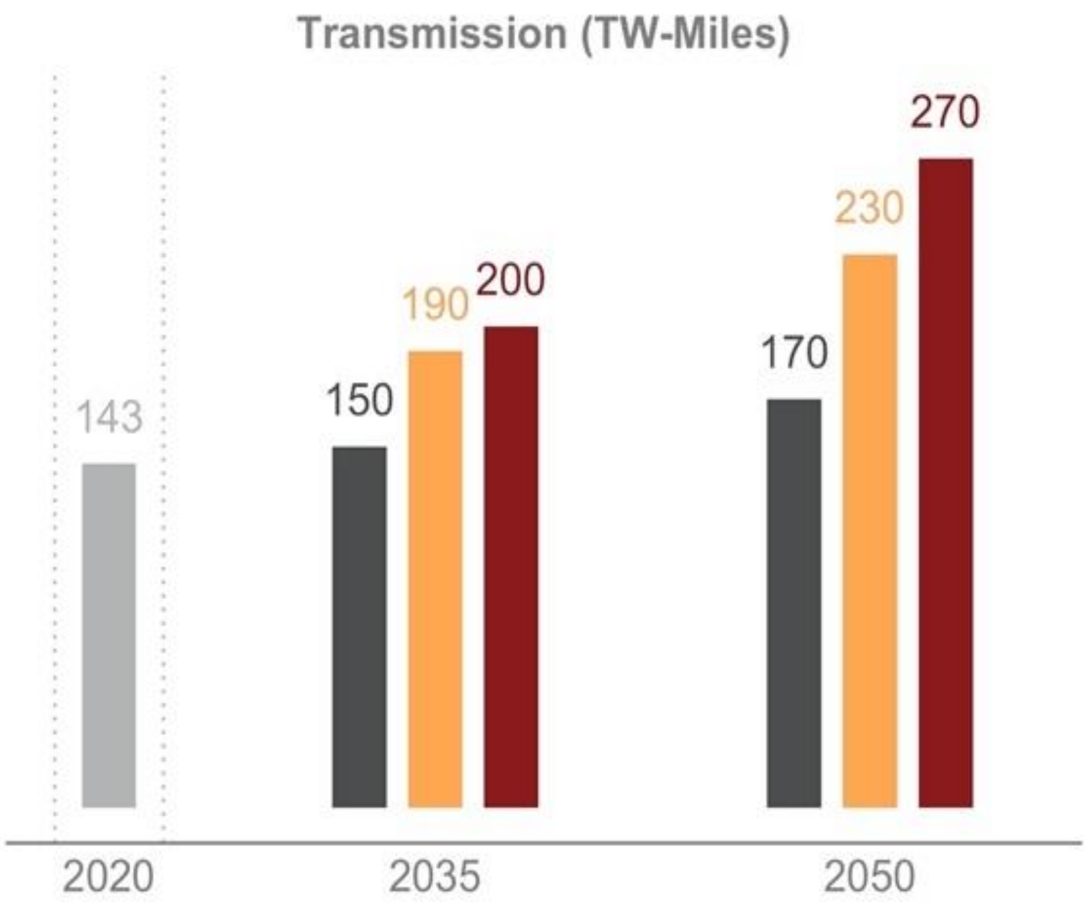
How much land will be required to achieve the scenarios?



Is new transmission needed to achieve the scenarios?

From 2020 to 2050, interregional transmission expansion increases by:

- 60% (86 TW-miles) Decarb
- 90% (129 TW-miles) Decarb+E



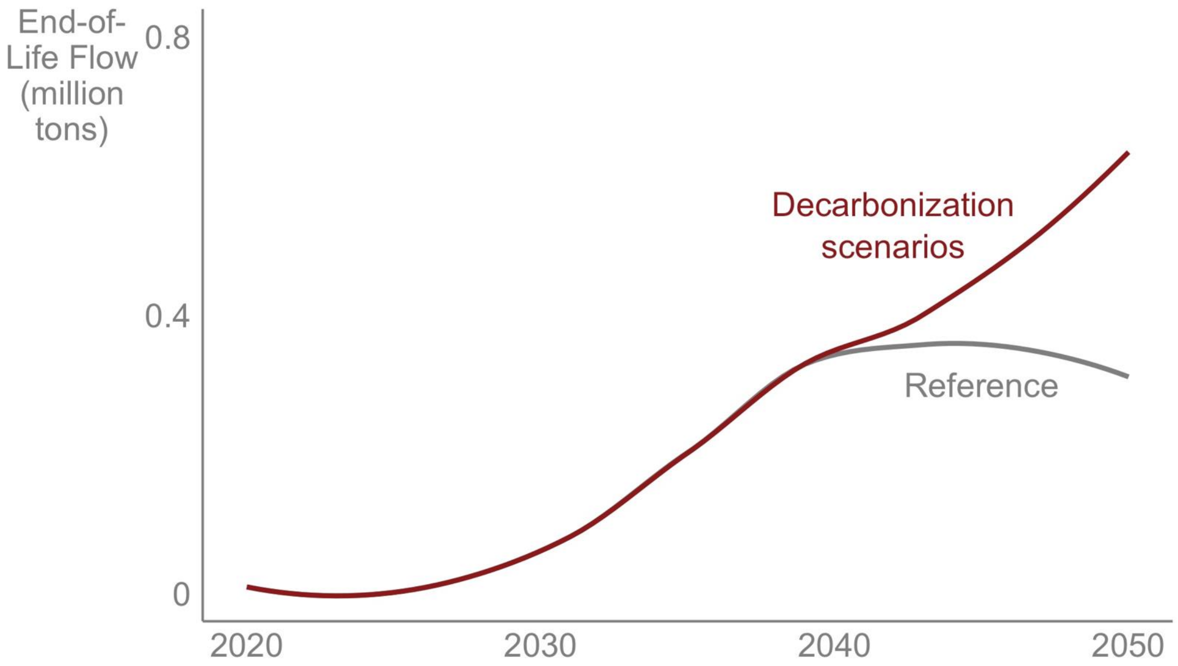
Will achieving the Solar Futures scenarios create a lot of waste?

Waste volumes increase as PV panels reach the end of their useful lives (typically 30 years), but can be reduced through sustainable end of life practices e.g.

- Recycling, re-use, re-manufacturing

Governments, industry, and associated stakeholders can begin preparing now for higher end-of-life solar volumes through various measures e.g.

- Development of low-cost recycling approaches
- Maximizing value from recovered materials
- Matching recovered materials with markets
- New policies and incentives for sustainable end-of-life practices



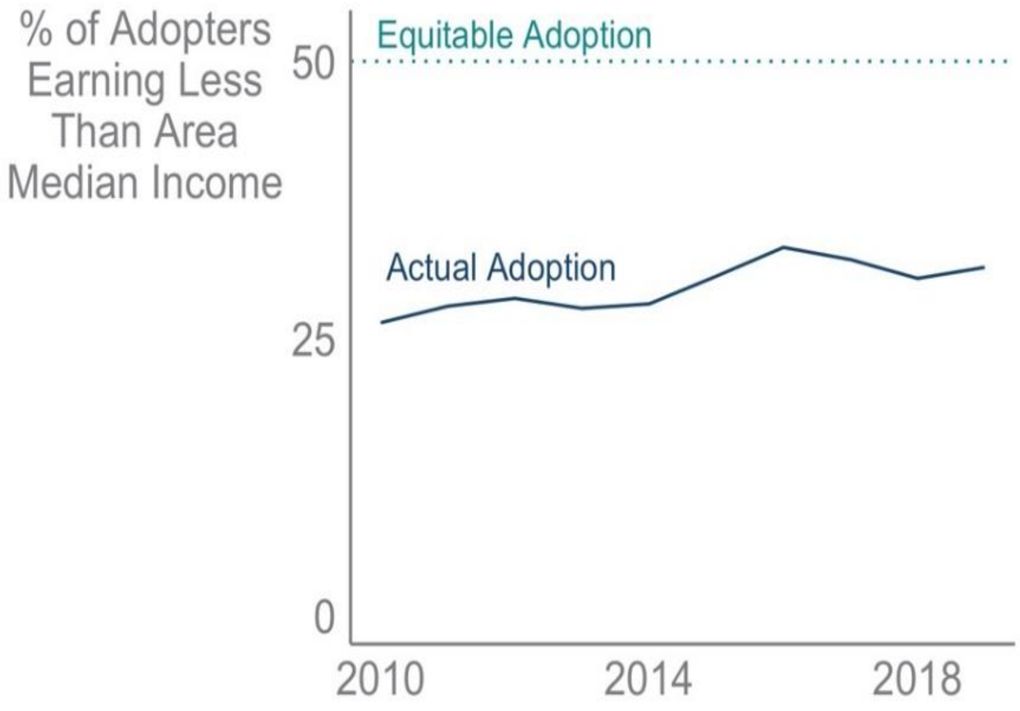
End of life material mass (million tons), Decarbonization scenarios vs. Reference Scenario

How can clean energy costs and benefits be distributed equitably?

Challenges must be addressed to ensure solar costs and benefits are distributed equitably.

Solar Futures Study explores:

- Cost and benefit distribution
- Procedural justice
- Workforce transition
- Negative externalities related to energy project siting and material disposal



Percentage of rooftop solar adopters earning less than area median income over time; Based on data from (Barbose et al. 2021)