



Better Planning for Future Adoption of Distributed Energy Resources (DERs)

Ben Sigrin, National Renewable Energy Laboratory
June 2021

With assistance by Madeline Schroeder (NREL)

How do DERs fit into future power grids?

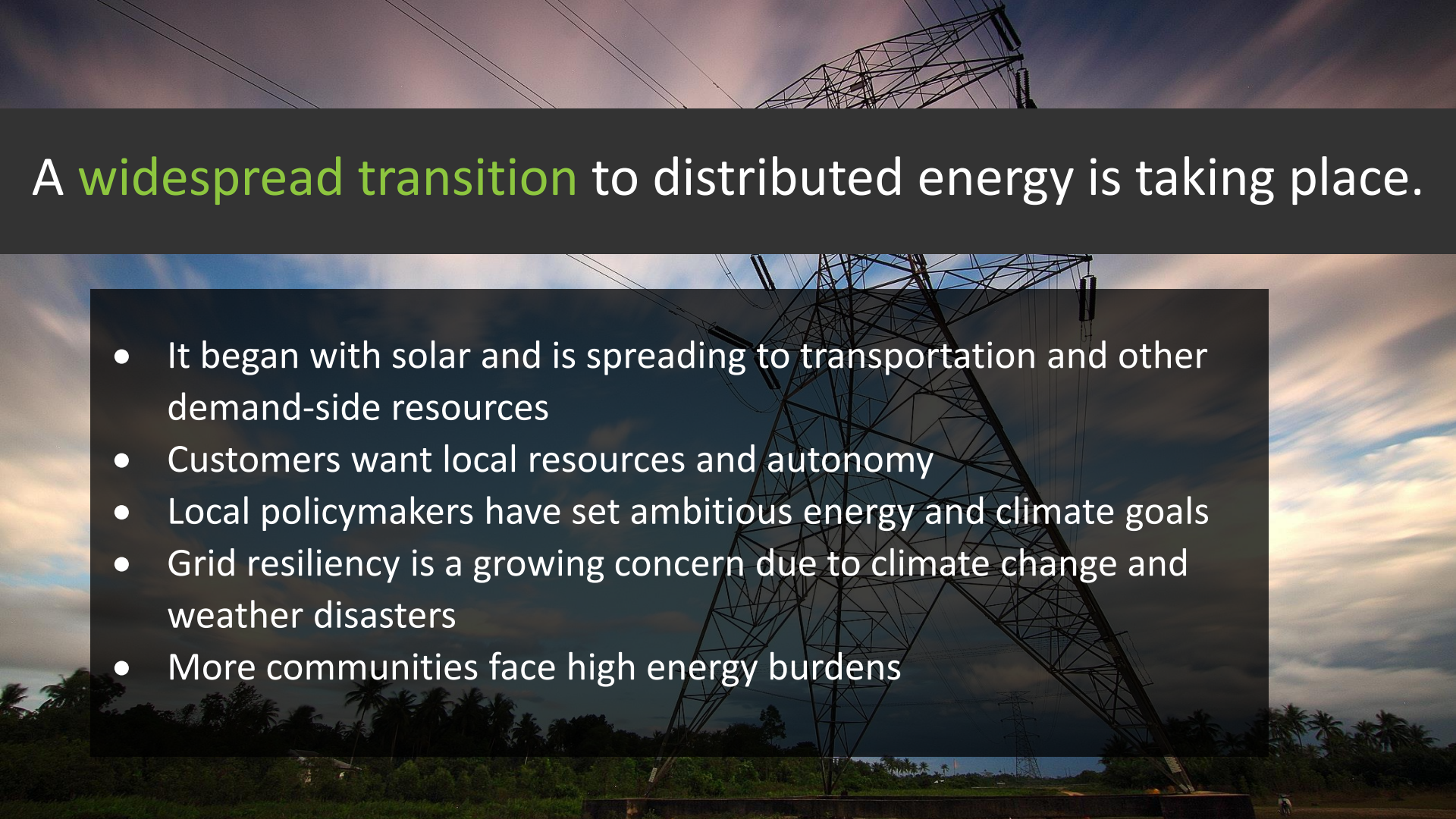
- Future power systems will have substantially more DERs
- Traditional utility planning does not consider DERs
- Better models needed for integrated distribution planning
- Distribution systems and transmission systems are linked

The background image shows a high-voltage electrical substation. Large, dark brown, cylindrical insulators with many horizontal ridges are prominent. They are connected to metal structures and power lines. In the background, there are tall metal lattice towers and more insulators. The sky is clear and blue. The text is overlaid on a semi-transparent dark rectangle in the upper left portion of the image.

Historically, **resource planning** does not consider distributed energy resources.

Planning entities (e.g. utilities and commissions) conduct long-term planning to determine least-cost options for meeting changing demand and maintaining reliability.

Traditional frameworks forecast demand independently from supply and do not consider local resources or services.

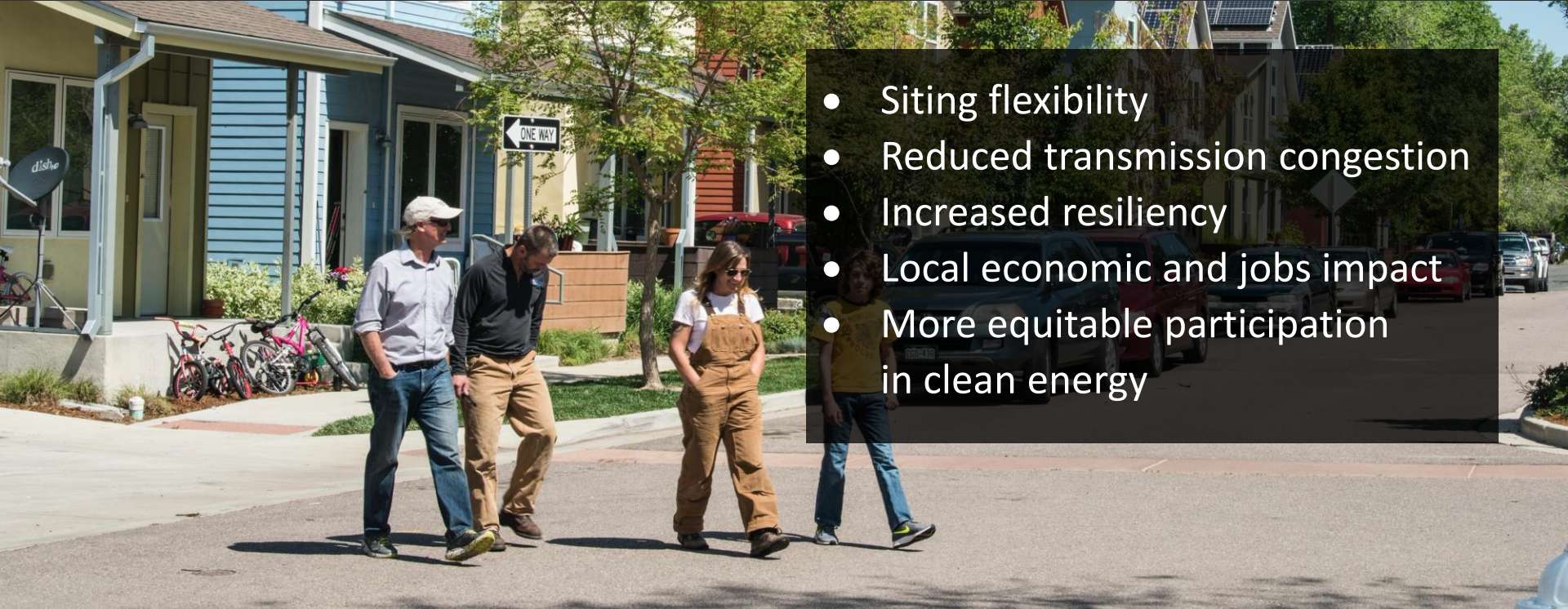


A **widespread transition** to distributed energy is taking place.

- It began with solar and is spreading to transportation and other demand-side resources
- Customers want local resources and autonomy
- Local policymakers have set ambitious energy and climate goals
- Grid resiliency is a growing concern due to climate change and weather disasters
- More communities face high energy burdens



DERs offer unique **technical**, **economic**, and **social** benefits.

- 
- Siting flexibility
 - Reduced transmission congestion
 - Increased resiliency
 - Local economic and jobs impact
 - More equitable participation in clean energy

But planning for DER technologies can be complex

Traditional planning methods consider distributed PV (DPV) and perhaps combined heat and power (CHP) growth.

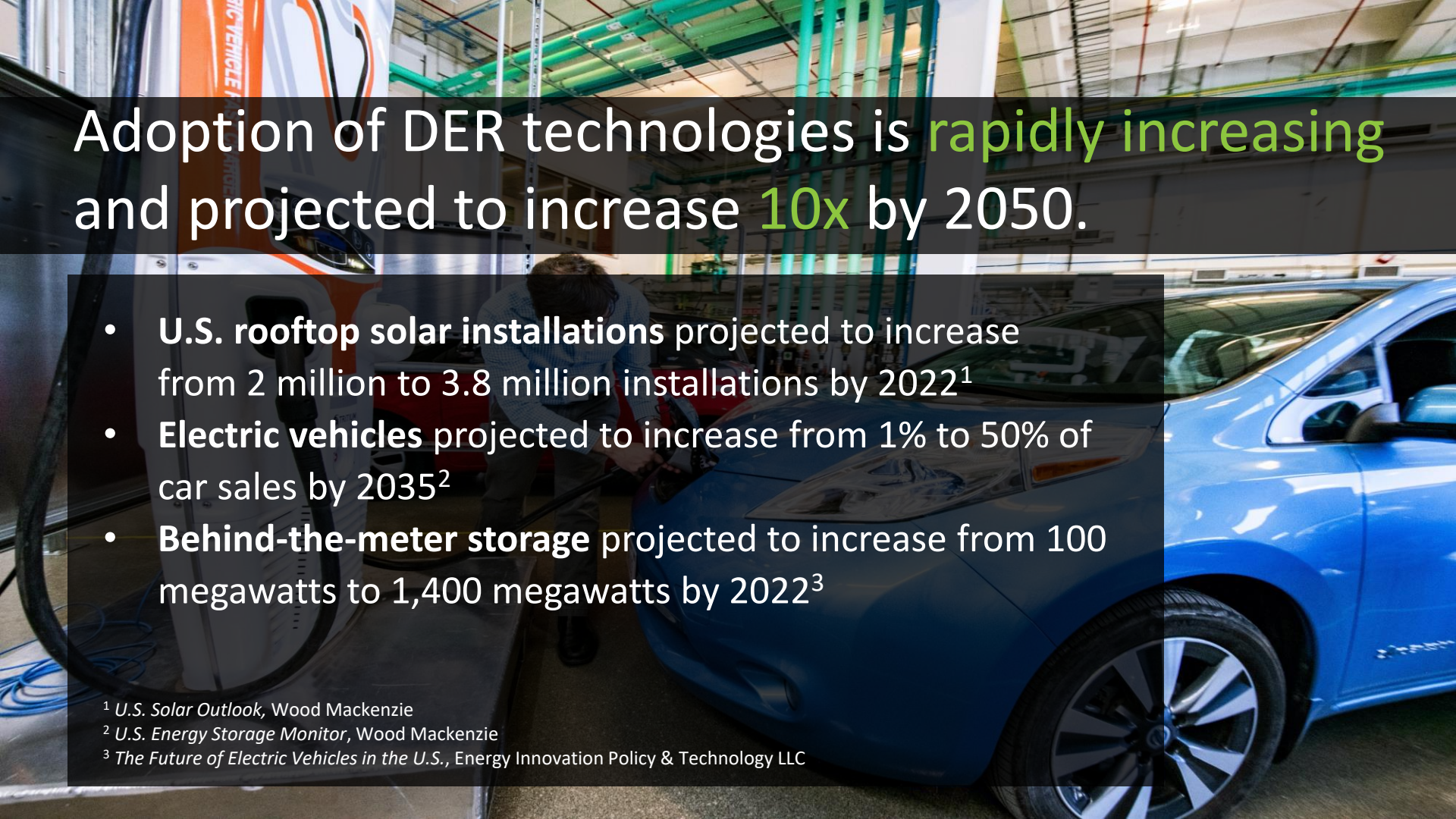
Emerging methods need to consider these and:

- Electric vehicles
- Energy storage
- Energy efficiency
- Demand response
- And others

Also:

Technology *co-adoption*

How technologies are *operated*

A blue electric car is parked at a charging station in a modern, industrial-looking facility. The car is connected to a charging cable. In the background, there are green pipes and structural elements of the building. The overall scene suggests a focus on sustainable transportation and energy infrastructure.

Adoption of DER technologies is rapidly increasing and projected to increase 10x by 2050.

- **U.S. rooftop solar installations** projected to increase from 2 million to 3.8 million installations by 2022¹
- **Electric vehicles** projected to increase from 1% to 50% of car sales by 2035²
- **Behind-the-meter storage** projected to increase from 100 megawatts to 1,400 megawatts by 2022³

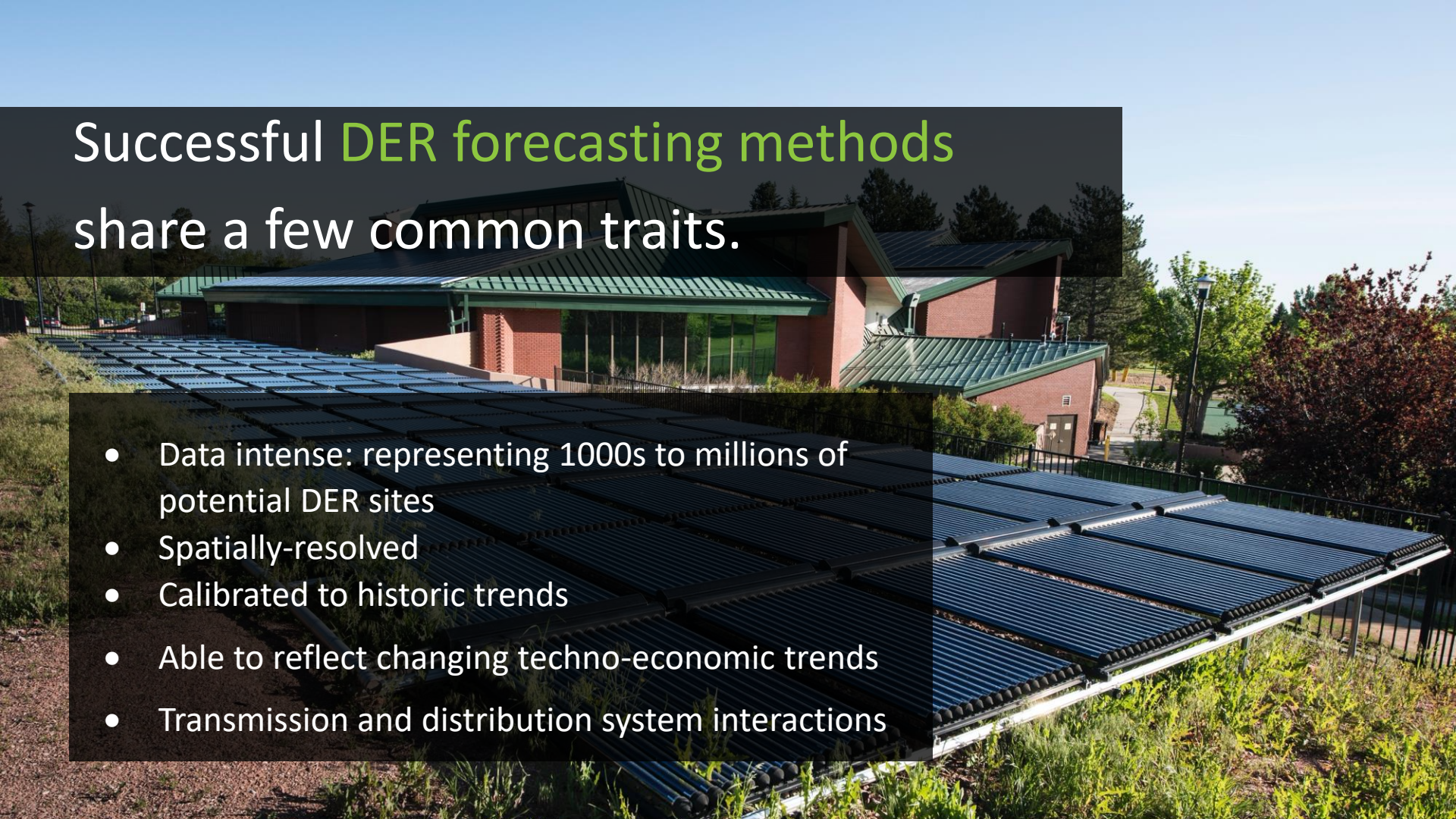
¹ *U.S. Solar Outlook*, Wood Mackenzie

² *U.S. Energy Storage Monitor*, Wood Mackenzie

³ *The Future of Electric Vehicles in the U.S.*, Energy Innovation Policy & Technology LLC

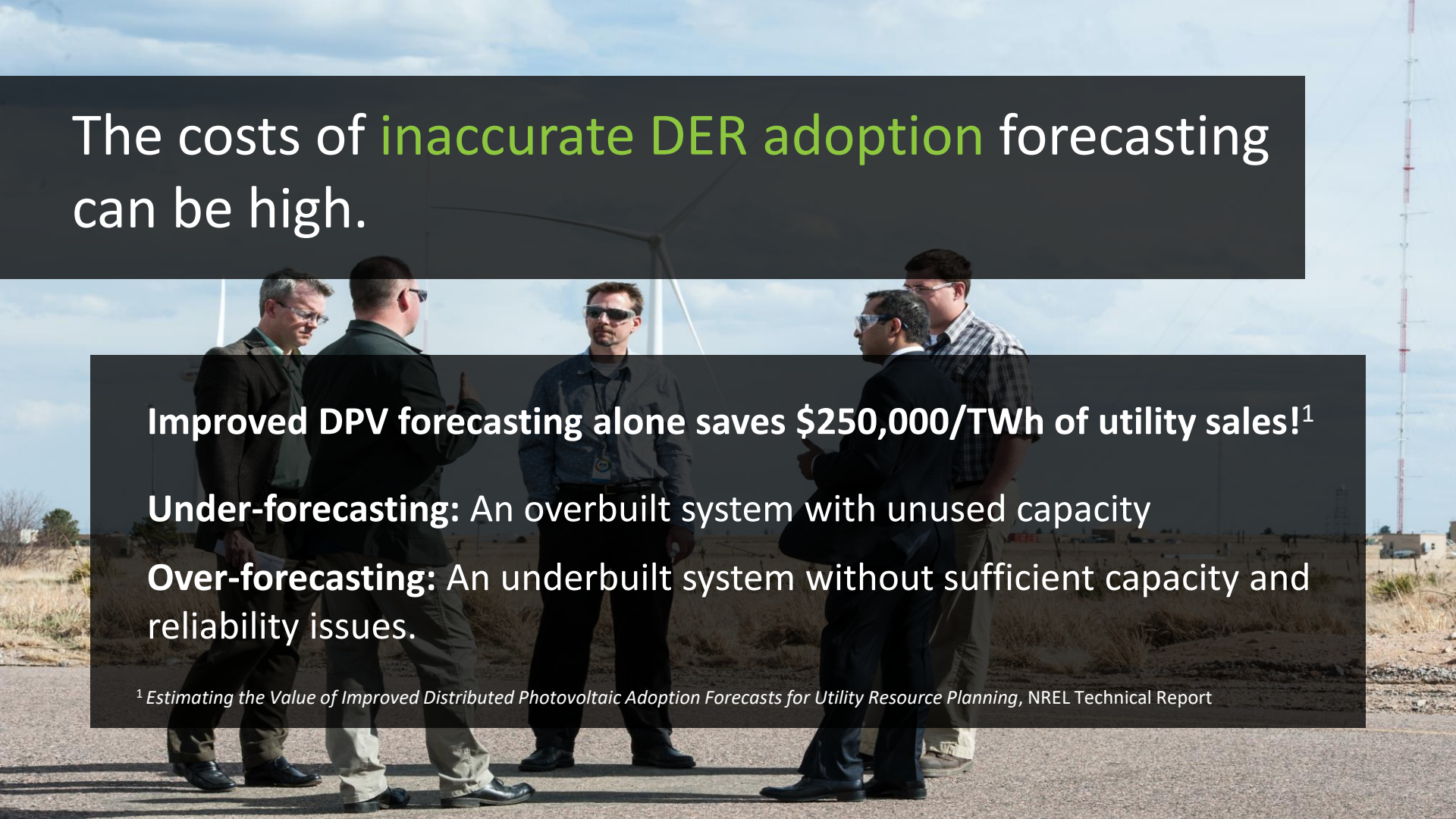


Power system planners need tools to understand the **opportunities** and **costs** of changing resource and demand options.



Successful DER forecasting methods share a few common traits.

- Data intense: representing 1000s to millions of potential DER sites
- Spatially-resolved
- Calibrated to historic trends
- Able to reflect changing techno-economic trends
- Transmission and distribution system interactions



The costs of **inaccurate DER adoption** forecasting can be high.

Improved DPV forecasting alone saves \$250,000/TWh of utility sales!¹

Under-forecasting: An overbuilt system with unused capacity

Over-forecasting: An underbuilt system without sufficient capacity and reliability issues.

¹ *Estimating the Value of Improved Distributed Photovoltaic Adoption Forecasts for Utility Resource Planning*, NREL Technical Report



More sophisticated models
are needed to support
integrated utility resource
planning for future grids.

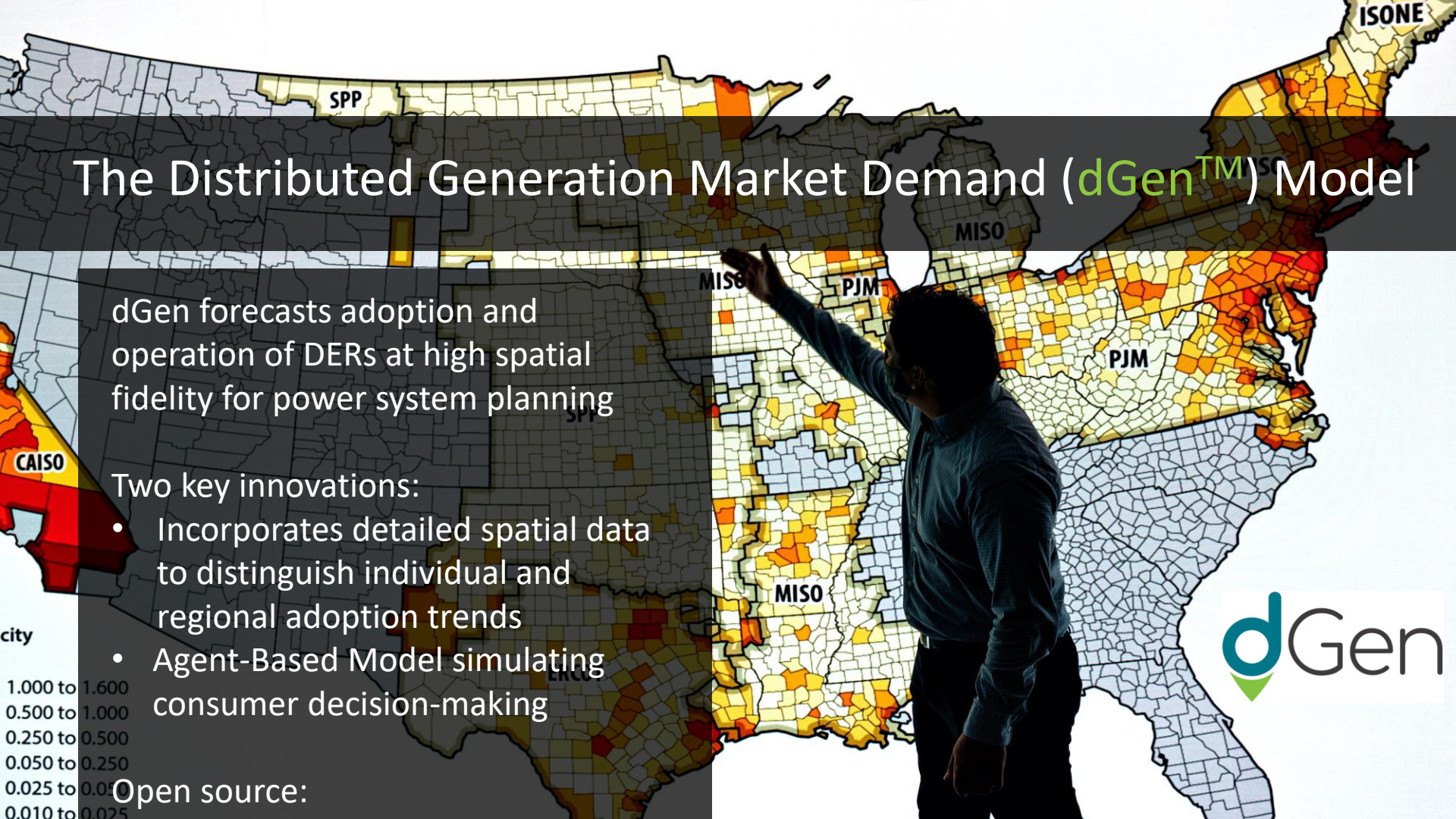
The Distributed Generation Market Demand (dGenTM) Model

dGen forecasts adoption and operation of DERs at high spatial fidelity for power system planning

Two key innovations:

- Incorporates detailed spatial data to distinguish individual and regional adoption trends
- Agent-Based Model simulating consumer decision-making

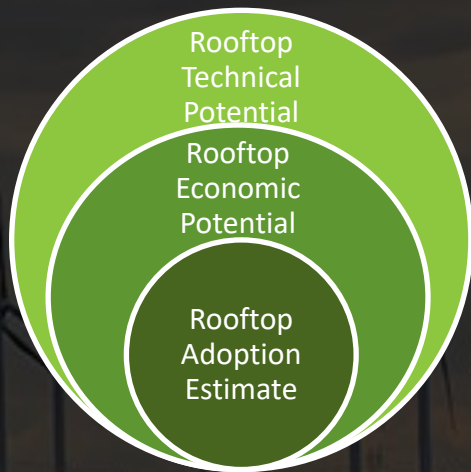
Open source:



city

1,000 to 1,600
0.500 to 1,000
0.250 to 0.500
0.050 to 0.250
0.025 to 0.050
0.010 to 0.025

dGen™ uses a **bottom-up, agent-based** modeling approach.



- Starts at the bottom and forecasts up
- Agent decisions based on census data and peer effects
- Spatially resolved data factors in spatial and socioeconomic considerations
- Lidar scans assess roof suitability
- Customizable framework

Two types of methods are emerging



Transmission-level

- Focus is on predicting aggregate amount, e.g. state, county, or ISO-level
- Forecasts primarily affect generation and transmission resource plans



Distribution-level

- Focus is on predicting spatial pattern of adoption, e.g. feeder-level or household-level
- Forecasts primarily affect distribution resource plans

An aerial photograph of Los Angeles, California, showing a dense urban landscape with numerous buildings, streets, and green spaces. In the background, a range of mountains is visible under a clear sky. The image is used as a background for a presentation slide.

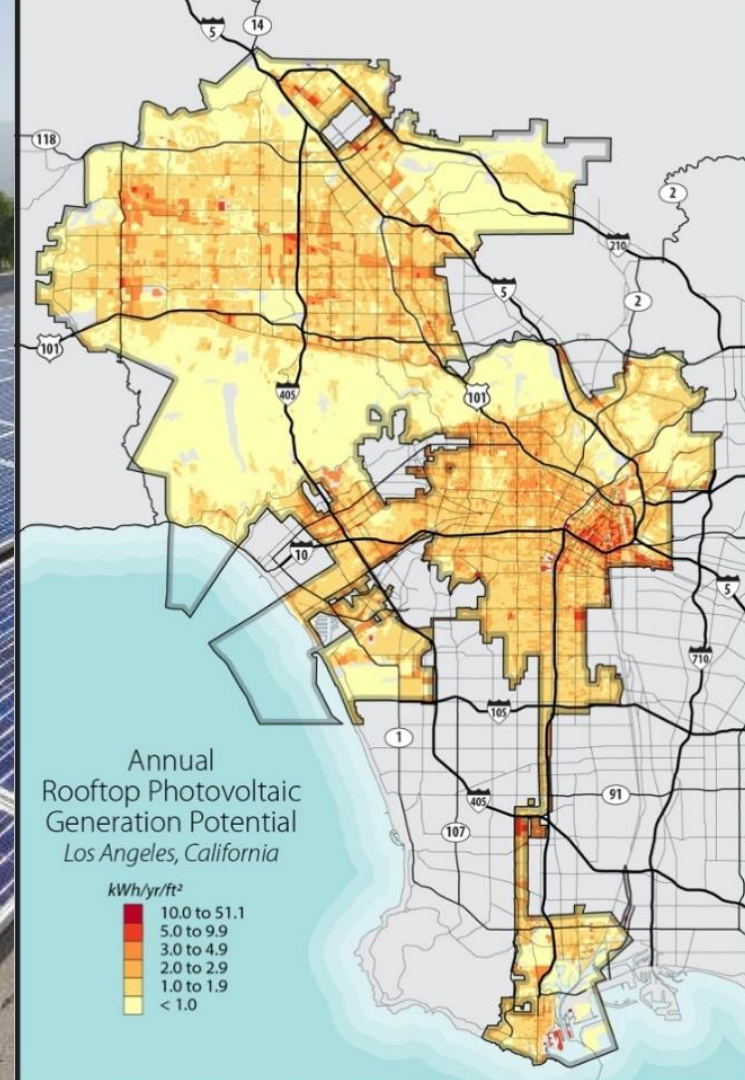
DER customer adoption forecasts help inform Los Angeles energy planning.

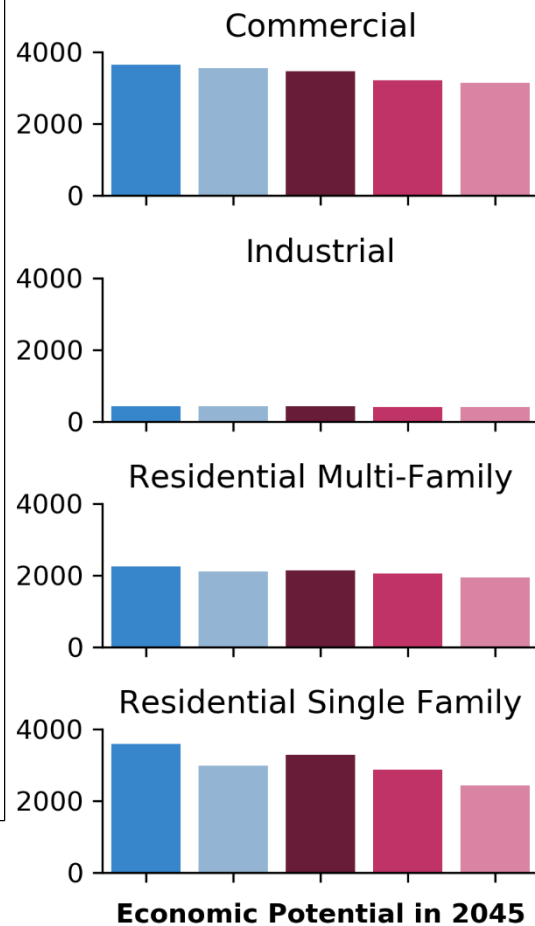
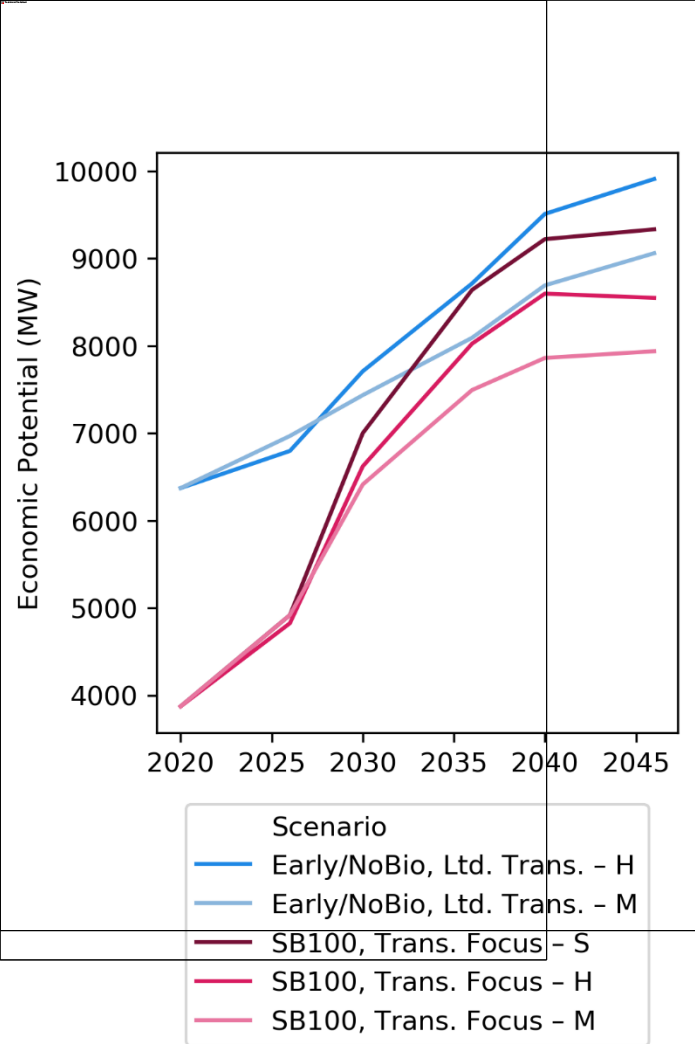
- LA100 Study: Los Angeles 100% Renewable Study
- NREL partnership with Los Angeles Department of Water and Power
- Rigorous, integrated engineering-economic analysis of LA's future grid with 100% renewable energy supply by 2045
- Modeled technical and economic potential for both customer-adopted and utility-procured DERs.

How much potential exists for customer-adopted DERs in LA?

Customer-adopted DER modeled for each building in LADWP service territory identifying *how much* is technically feasible, economically viable, and ultimately adopted.

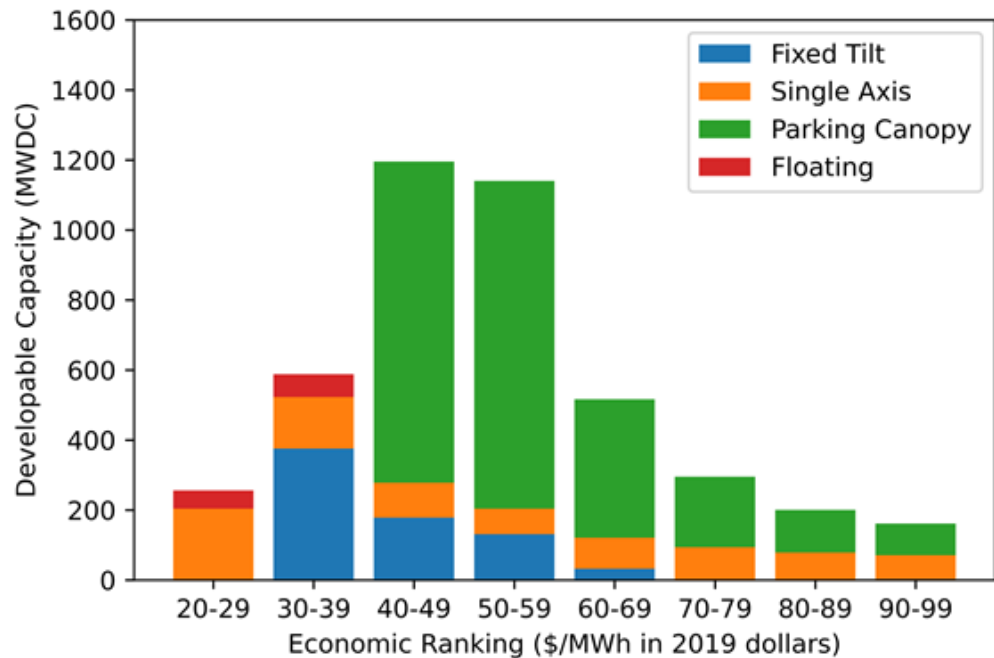
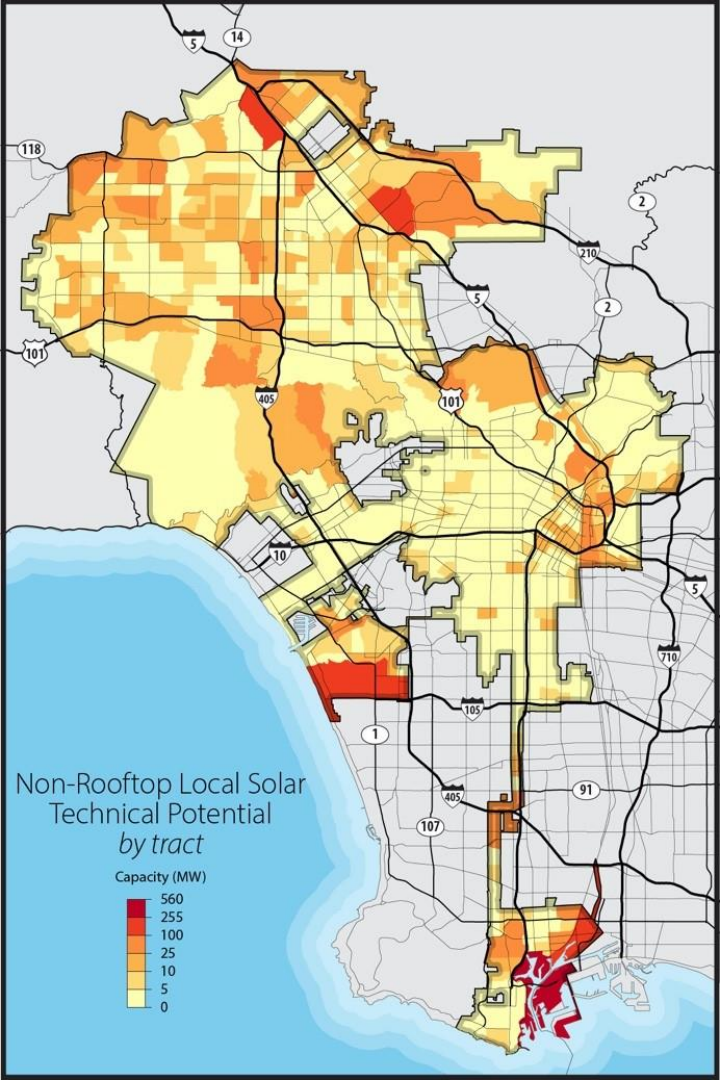
Each scenario is done in concert with bulk power capacity expansion and production cost models





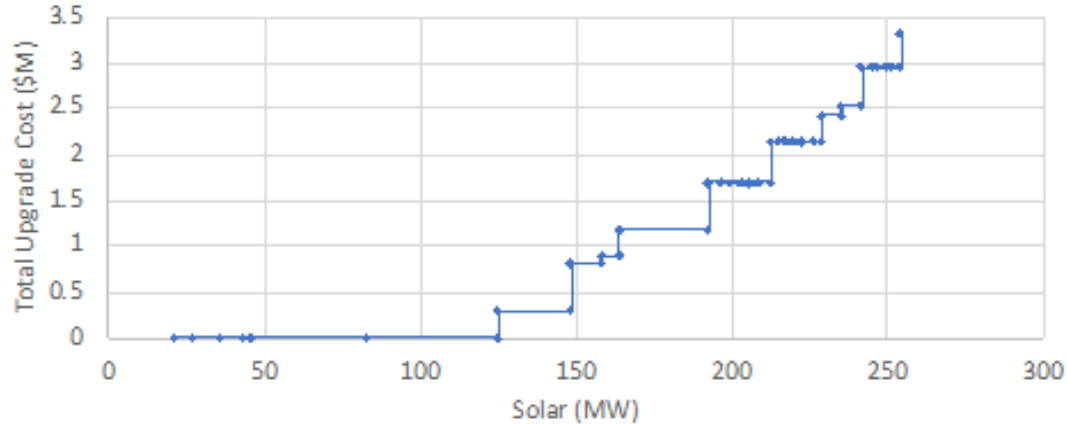
Result in detailed insights:
when, where,
and how much?

How much potential exists for **non-customer solar in LA**?

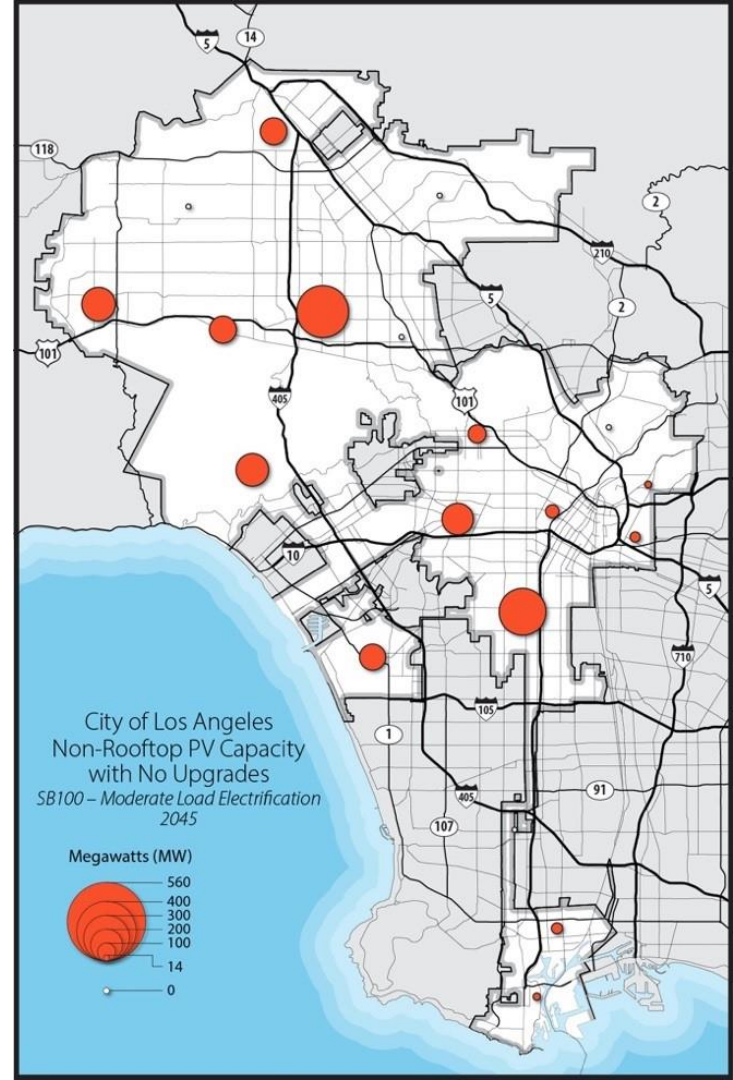


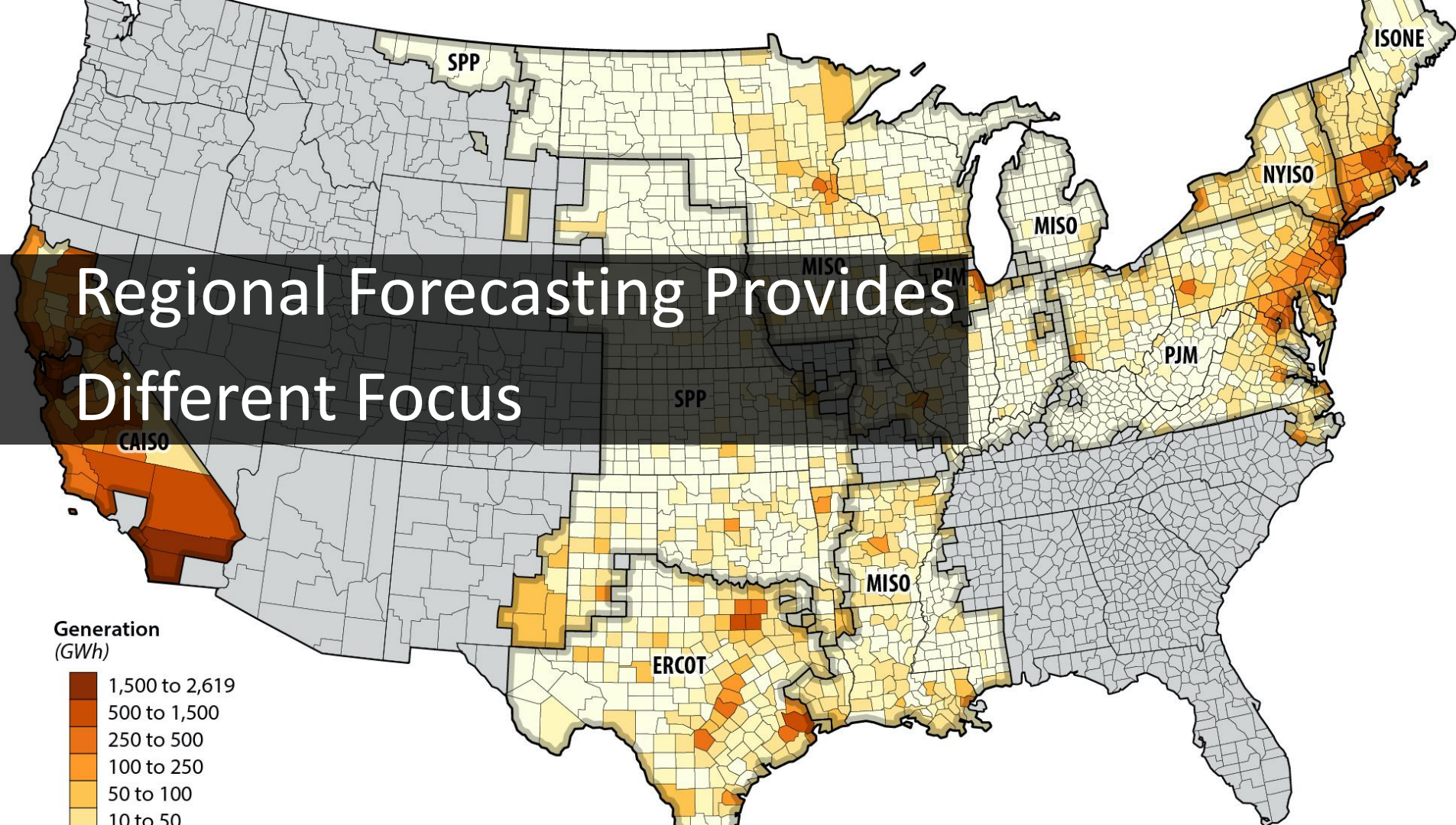
Pair with distribution models to
find **no-cost upgrade solutions**

Region C Upgrade cost for non-rooftop solar (SB100-M)



Mooney et al. 2021. "Chapter 5: Utility Options for Local Solar and Storage." In
The Los Angeles 100% Renewable Energy Study
<https://www.nrel.gov/docs/fy21osti/79444-5.pdf>.





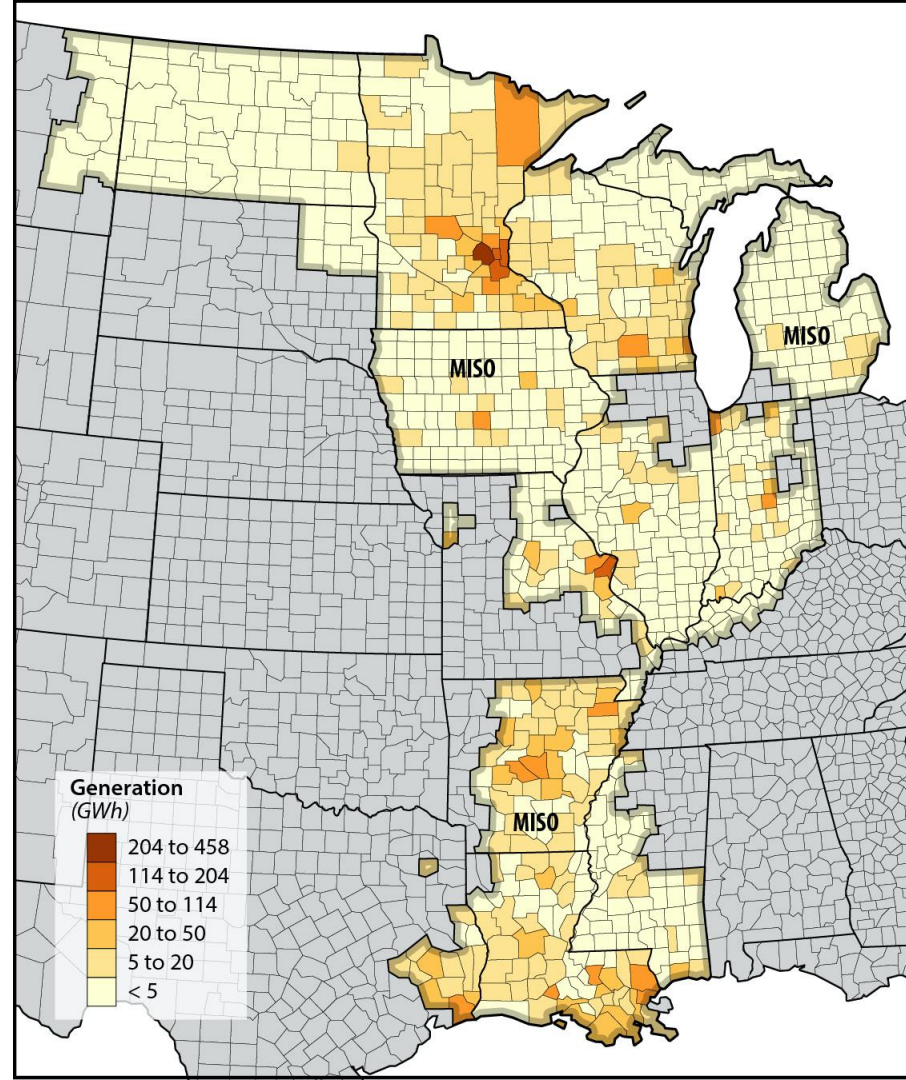


Transmission-level forecasts are traditionally used in IRPs, load forecasting, and other “big picture” studies

Less focus on predictive accuracy, instead understanding a range of outcomes or tipping points.

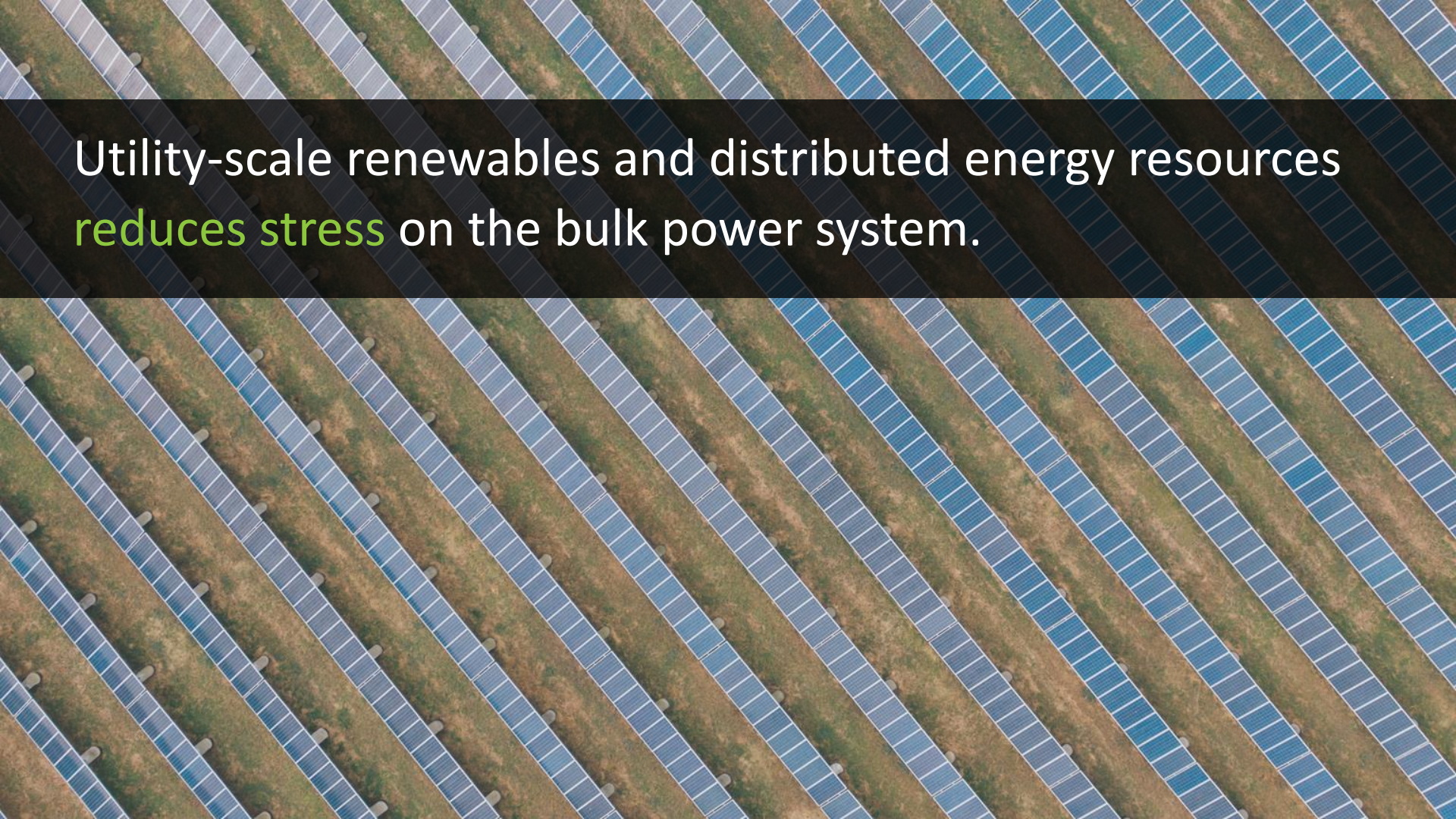
Often, the projections are highly dependent on policy assumptions

Helps to pinpoint
expected growth
and emphasizes
intra-regional
differences

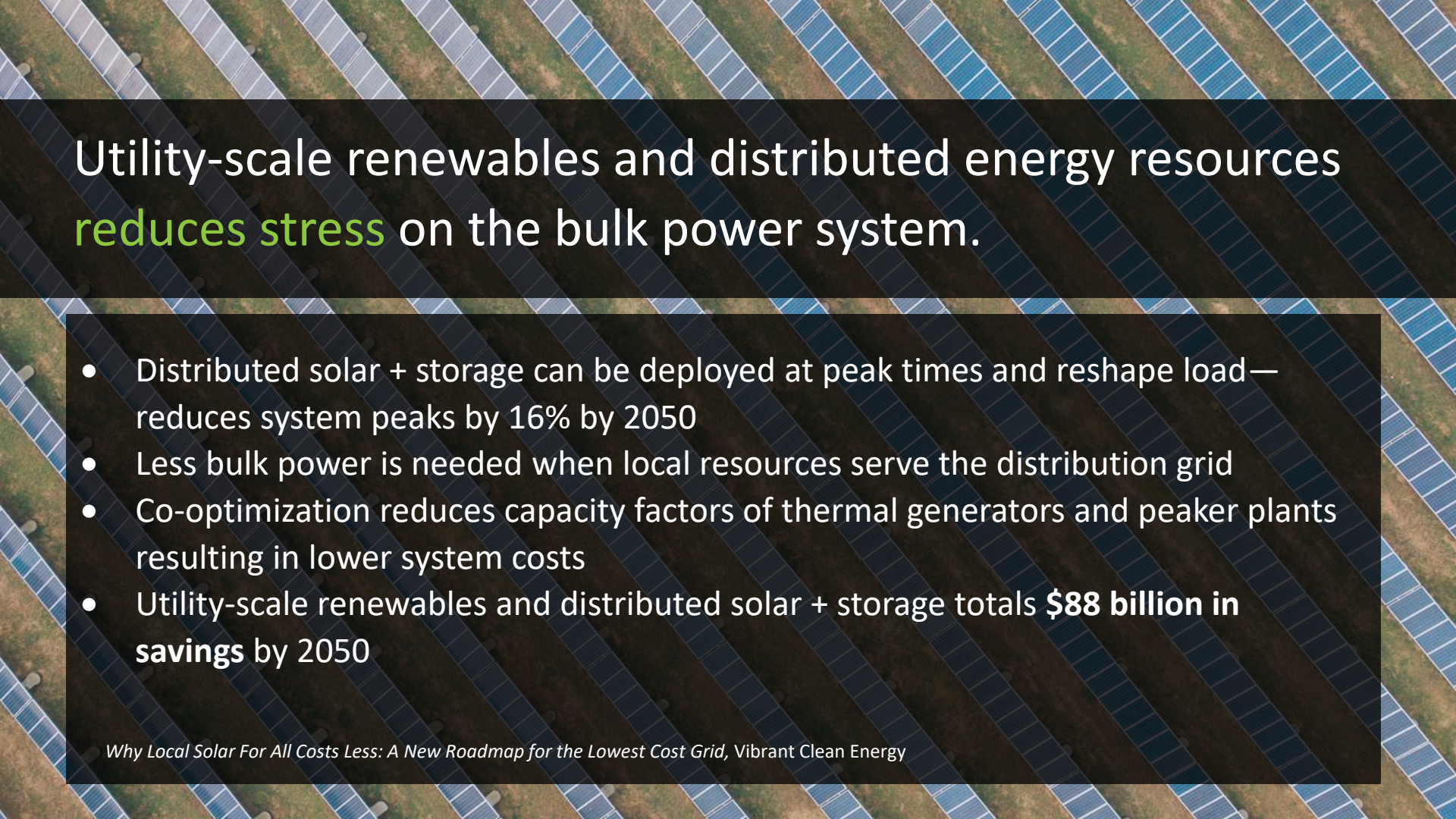


New and better models hint at a
symbiotic relationship between
utility-scale renewables and DERs.



An aerial photograph of a large-scale solar farm. The image shows numerous long, parallel rows of blue solar panels installed on a grassy field. The panels are tilted at an angle, and the rows are separated by narrow paths or access roads. The overall pattern creates a strong sense of perspective and repetition.

Utility-scale renewables and distributed energy resources
reduces stress on the bulk power system.

An aerial photograph showing rows of solar panels installed in a field, with the panels arranged in a grid pattern and separated by grassy areas.

Utility-scale renewables and distributed energy resources **reduces stress** on the bulk power system.

- Distributed solar + storage can be deployed at peak times and reshape load—reduces system peaks by 16% by 2050
- Less bulk power is needed when local resources serve the distribution grid
- Co-optimization reduces capacity factors of thermal generators and peaker plants resulting in lower system costs
- Utility-scale renewables and distributed solar + storage totals **\$88 billion in savings** by 2050

Four Grand Challenges for Reaching DER Potential

The background image shows two construction workers on a rooftop. One worker, wearing a yellow hard hat and a plaid shirt, is in the foreground, leaning over a solar panel. The other worker, wearing a white hard hat and a grey shirt, is in the background, also working on the panels. The rooftop is covered with solar panels, and a city skyline is visible in the distance under a clear blue sky.

Continued
Cost
Reduction

Harmonized
T. & D.
systems

Fully
Digitized
System

Pursue
System
Flexibility



Join the distribution planning **community**.

Ben.Sigrin@nrel.gov
[Nrel.gov/dgen](https://www.nrel.gov/dgen)