NREL Transforming ENERGY

Renewables, Resource Adequacy, and Reliability

Gord Stephen
National Renewable Energy Laboratory

Legislative Energy Horizon Institute, Richland 2022
August 7, 2022

Photo by Dennis Schroeder, NREL 55200

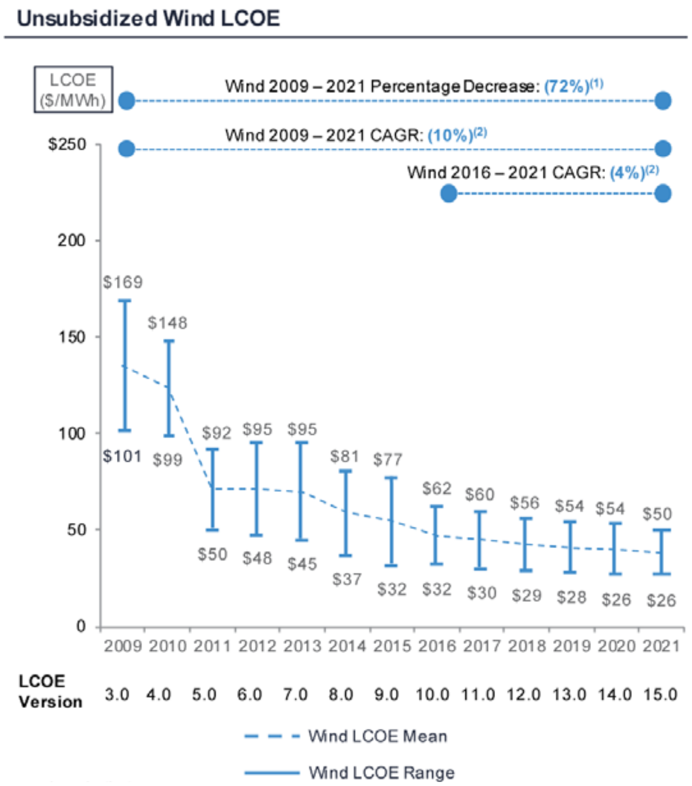

1
Renewables & Growth Trends
2
Reliability & Resource Adequacy
3
Distributed Energy Resources

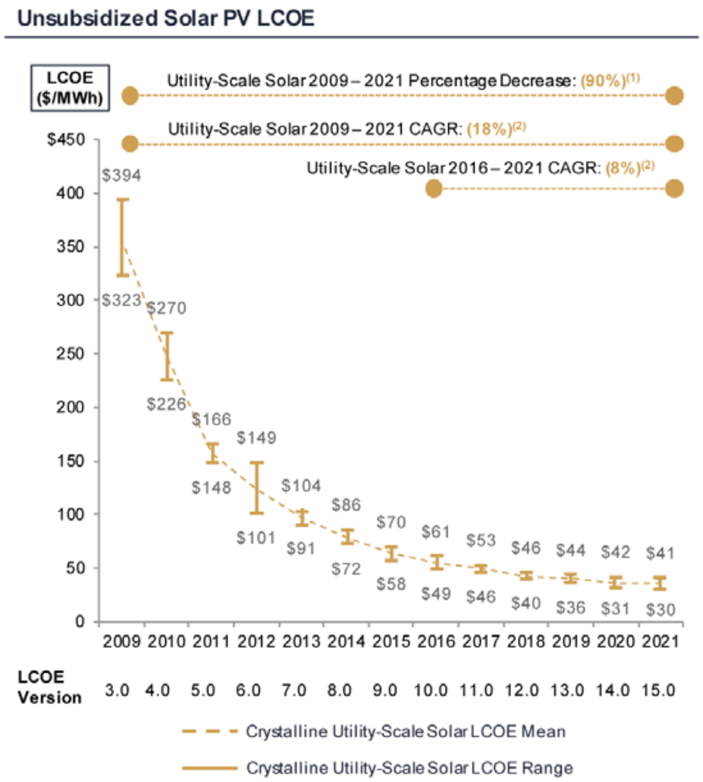
Renewables & Growth Trends

Photo by Dennis Schroeder, NREL 53294


“Renewable” generation covers many energy sources…
…focus today is on grid impacts of wind and solar

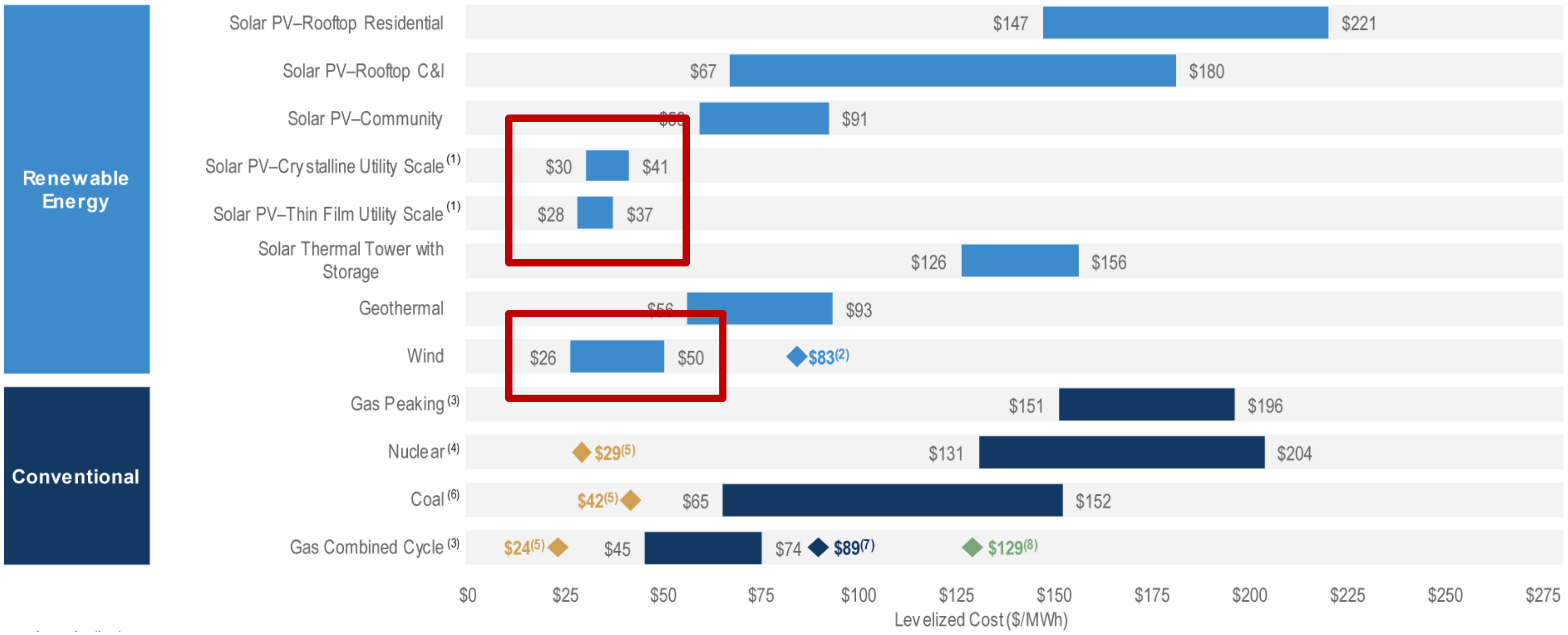
Wind and solar costs are dropping…





https://www.lazard.com/perspective/levelized-cost-of-energy-levelized-cost-of-storage-and-levelized-cost-of-hydrogen/

…and now cost less than traditional generation

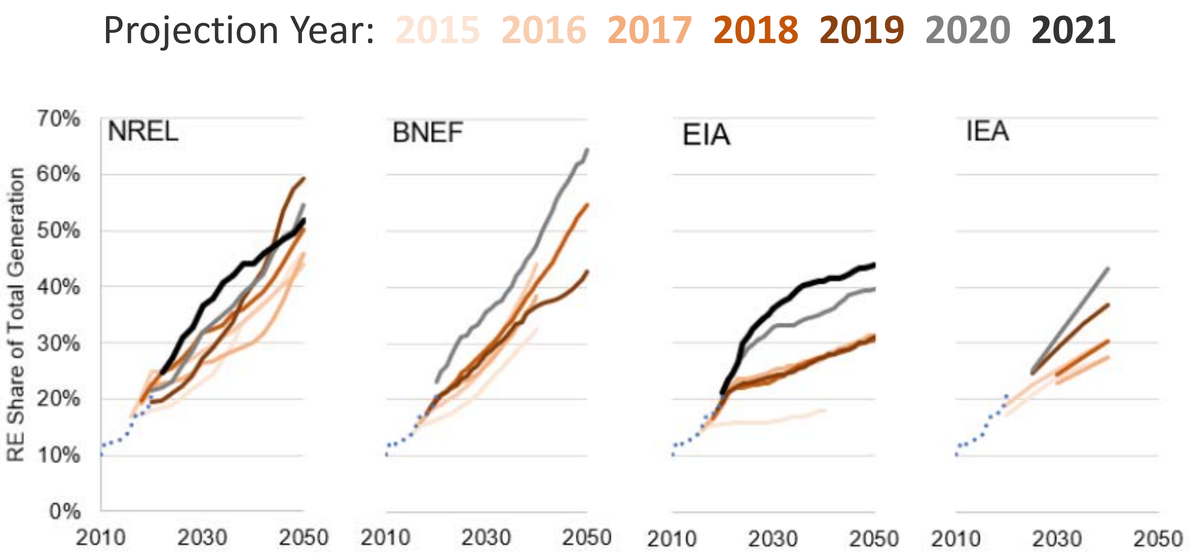


https://www.lazard.com/perspective/levelized-cost-of-energy-levelized-cost-of-storage-and-levelized-cost-of-hydrogen/

At these costs, there's a lot more wind and solar on the way

Renewable energy made up **20%** of US electricity generation in 2021, and is expected to reach **30%** by 2026

EIA AEO 2022, Reference Scenario



2021 Standard Scenarios Report, Cole et al, NREL

SPP Southwest Power Pool

March 29, 2022

SPP sets regional records for renewable er

LITTLE ROCK, ARK. —Southwest Power Pool (SPP) set several renew

set May 8, 2021. This means SPP served 90.2

renewable energy sources, and marks the first

May 8, 2021.

California ISO

News Release

April 14, 2022 **Media Email | ISOMedia@caiso.com**

California ISO hits all-time peak of more than 97% renewables

Electric grid breaks another record, giving glimpse of zero-carbon future

FOLSOM, Calif. – In another sign of progress toward a carbon-free power grid, the California Independent System Operator (ISO) set a new record on April 3, when 97.6 percent of electricity on the grid came from clean, renewable energy.

The peak, which occurred briefly at 3:39 p.m., broke the previous record of 96.4 percent set on March 27, 2022. Before that, the grid's record for clean power was 94.5 percent, set on April 21, 2021. The new milestone comes as the ISO integrates growing amounts of renewable energy onto the grid in support of the state's clean energy goals.

Side note: Understanding generation numbers

Term	Definition
Peak **instantaneous generation** fraction	% of total generation from some source, at a single moment in time
Average **annual generation** fraction	% of generation from some source, over the entire year
Installed capacity fraction (new or existing)	% of system's maximum / "nameplate" generating potential from some source – may or may not follow same trends as actual generation

Reliability & Resource Adequacy

Photo by Dennis Schroeder, NREL 18980

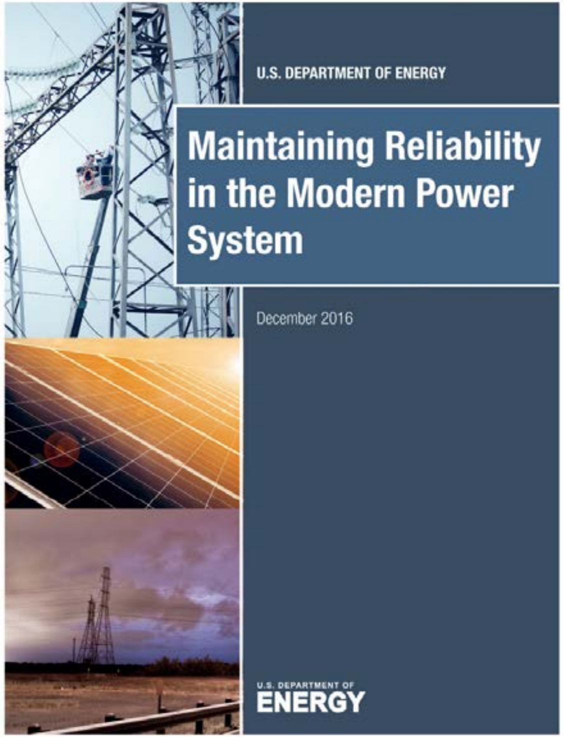
What is “reliability”?

Operating the elements of the bulk power system within equipment and electric system thermal, voltage, and stability limits so that **instability, uncontrolled separation, or cascading failures of such system will not occur** as a result of a sudden disturbance, including a cybersecurity incident, or unanticipated failure of system elements.

North American Electrical Reliability Corporation (NERC) Glossary – “reliable operation”

https://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf

Power system reliability has many elements



Resource Adequacy

System Flexibility

Our focus here

Frequency Stability and Control

Voltage Stability and Control

https://www.energy.gov/sites/prod/files/2017/01/f34/Maintaining%20Reliability%20in%20the%20Modern%20Power%20System.pdf

What is resource adequacy?

The ability of the electric system to **supply the aggregate electrical demand** and energy requirements of the end-use customers at all times, taking into account **scheduled** and **reasonably expected unscheduled outages** of system elements.

North American Electrical Reliability Corporation (NERC) Glossary – “adequacy”

https://www.nerc.com/pa/Stand/Glossary%20of%20Terms/Glossary_of_Terms.pdf

In short…

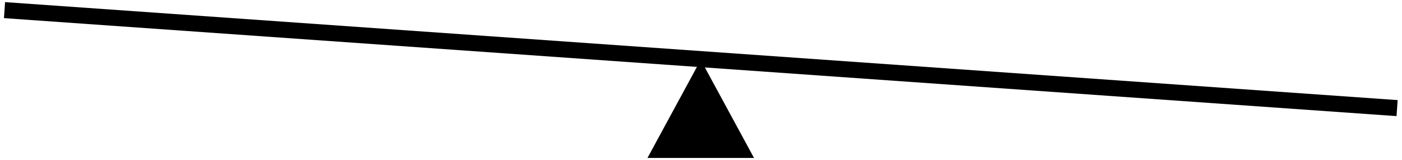
… is there enough energy available (in the right place, at the right time) for my system to serve load with **acceptably low shortfall risk**?

Risk can be reduced, but never be fully eliminated

What level of risk is "low enough" depends on costs and benefits…

Incremental benefits to society
from avoided outages

Incremental costs to society
of additional resource investments



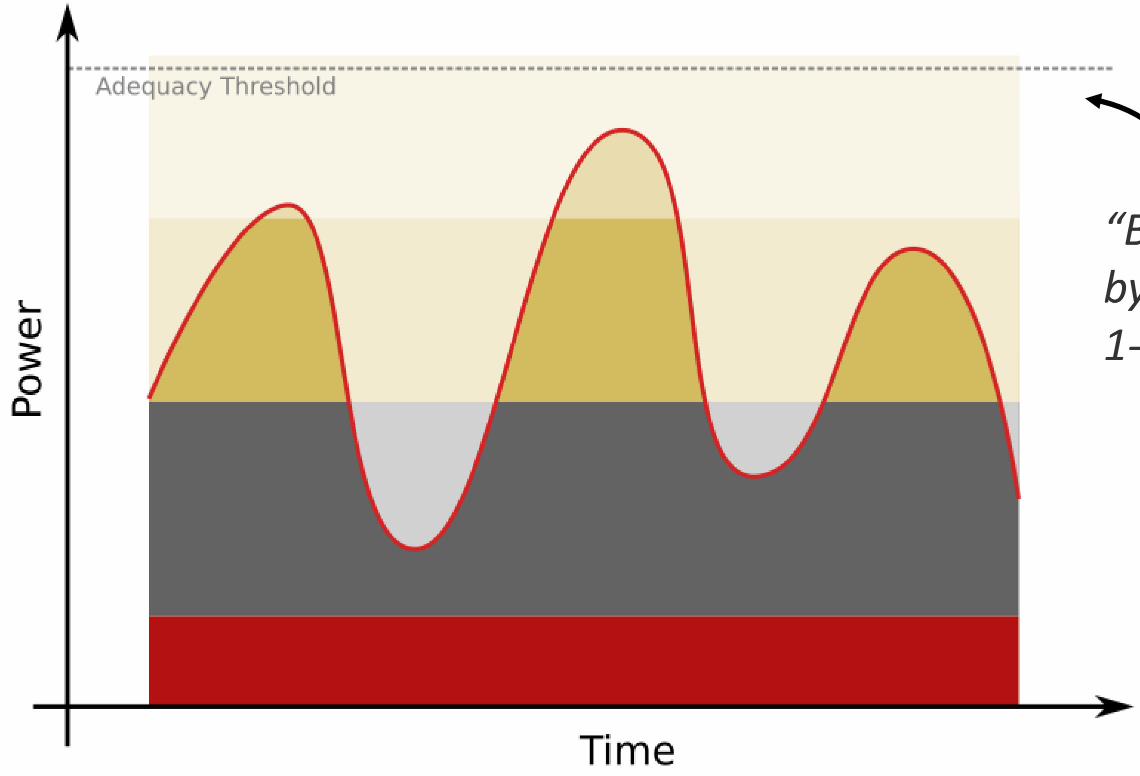
…plus distributional considerations: Who benefits/suffers? Who pays/saves?

Typical target: the 1-in-10 rule

A common rule of thumb in North America is to target an **average** adequacy level of at most **1 day with shortfall every 10 years**.

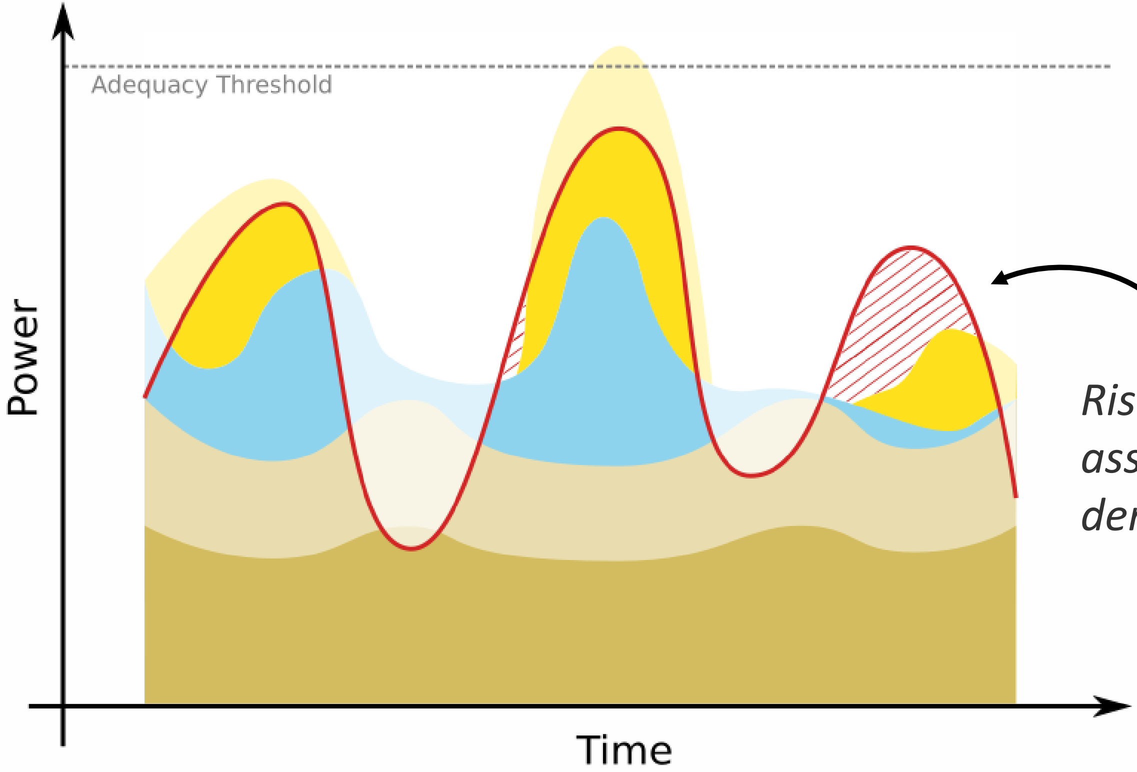
Only an average - systems might still get lucky and have fewer shortfalls, or unlucky and have more

Planning an adequate system (historically)



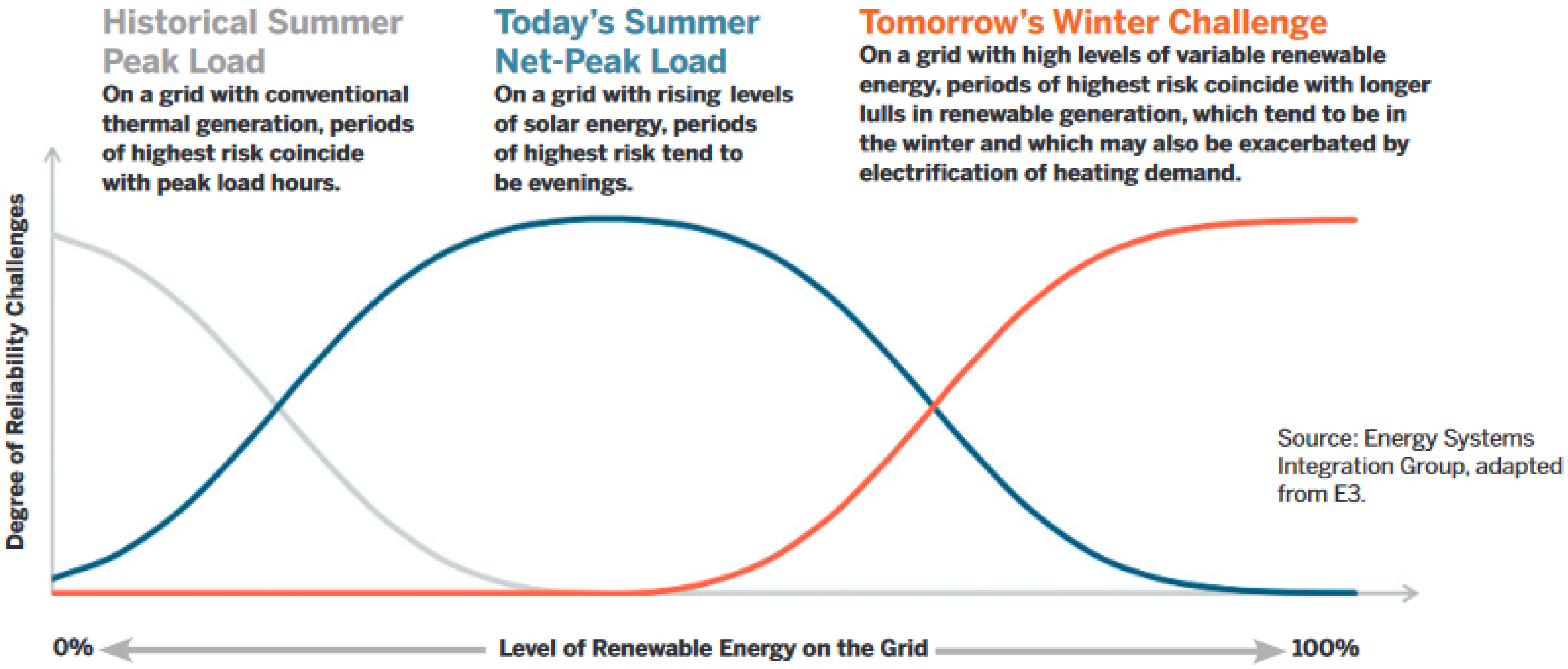
"Buffer" needed by system to meet 1-in-10 rule

Wind and solar complicate capacity accounting



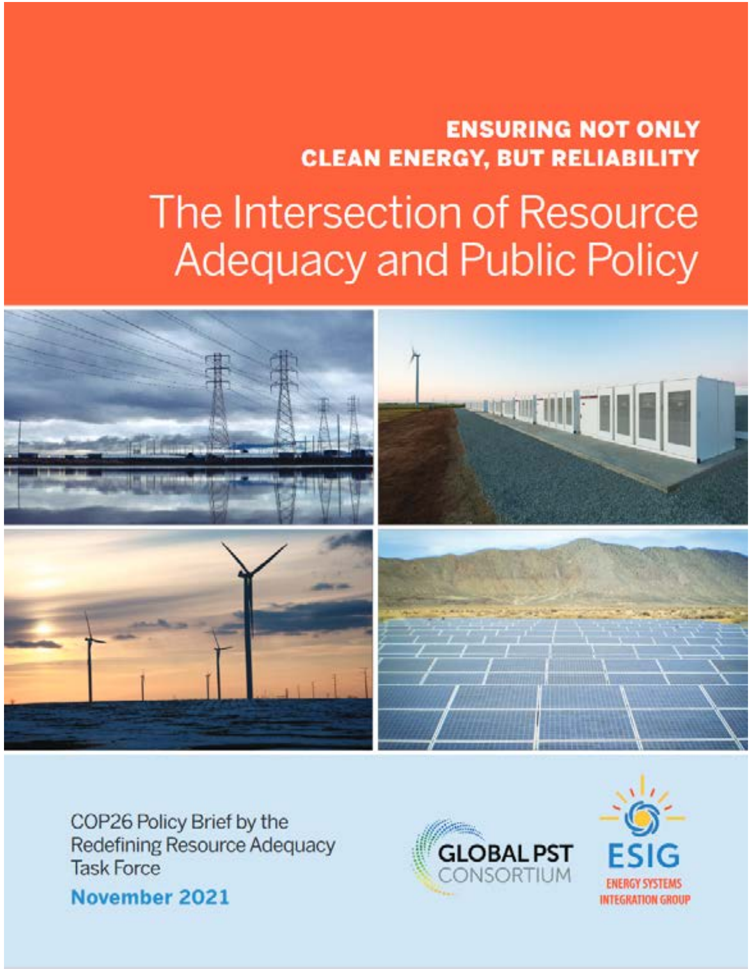
Risk no longer associated with peak demand

Wind and solar shift the nature of shortfall risks



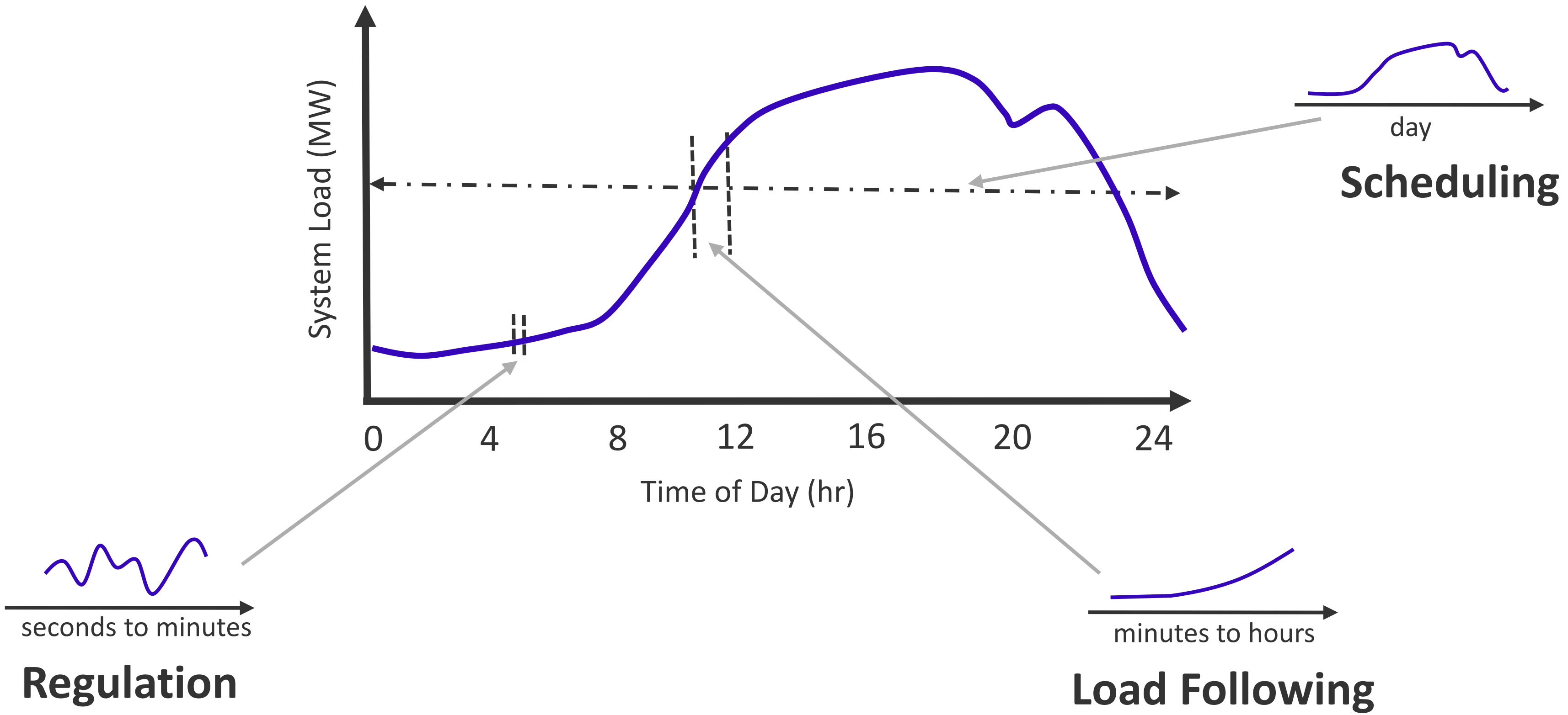
Interested in learning more?

Primer on resource adequacy and renewables from the Energy Systems Integration Group (ESIG) and Global Power System Transformation Consortium (G-PST)

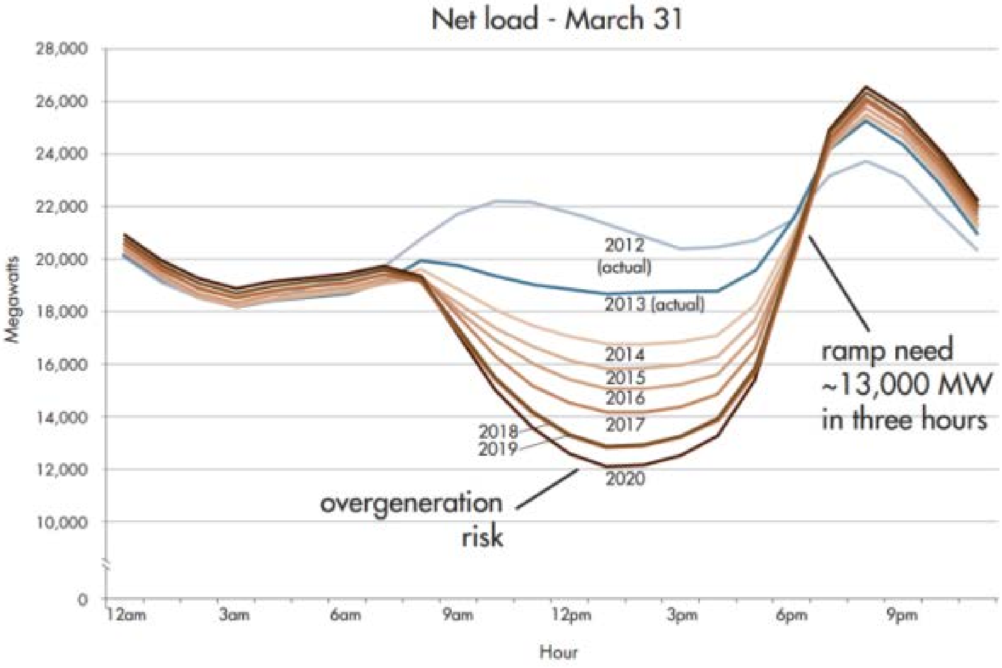


https://www.esig.energy/resource-adequacy-for-modern-power-systems/

Ensuring system flexibility



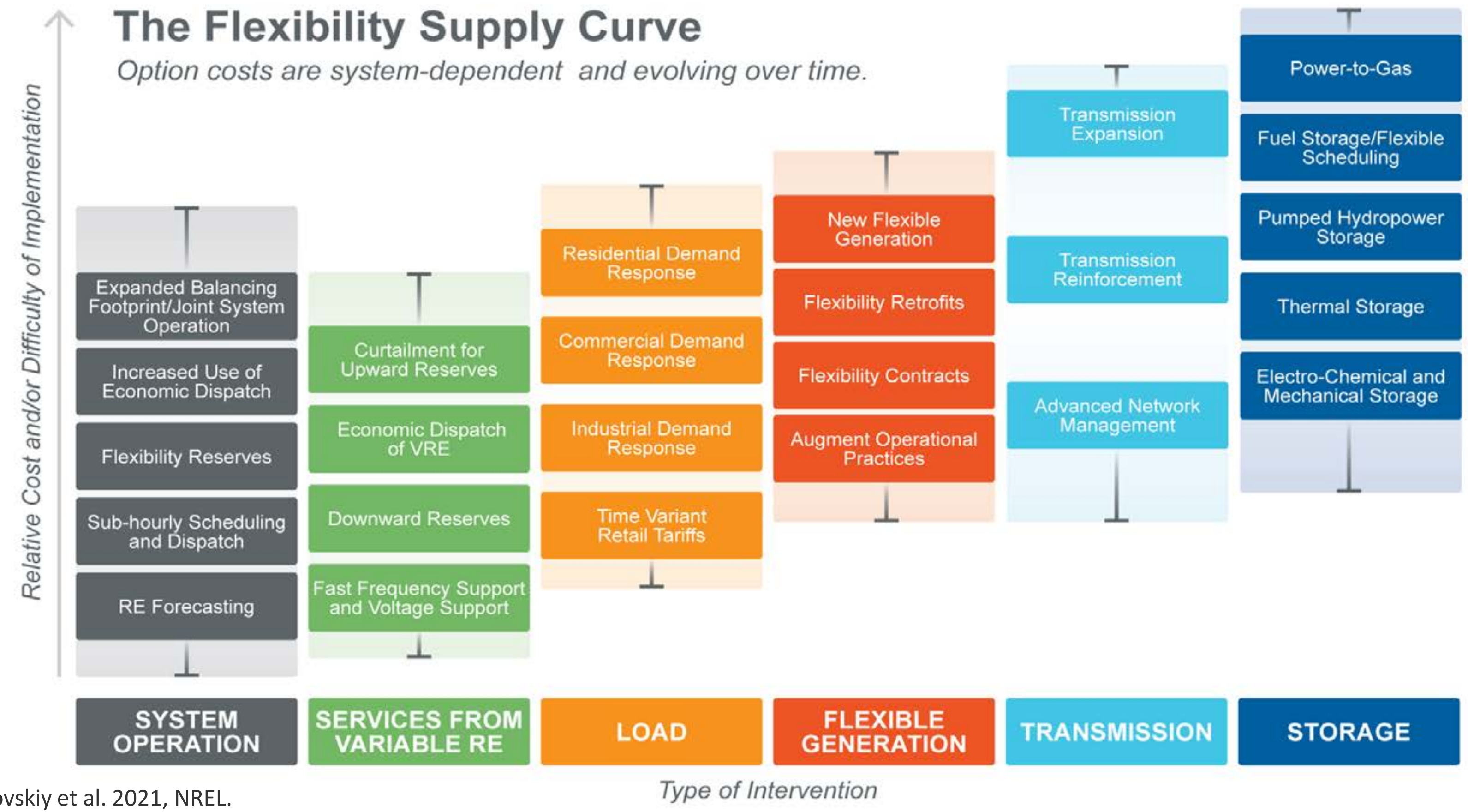
Wind and solar increase flexibility requirements



- Increased uncertainty in net load
  - More operating reserves to compensate for another ‘unknown’
- Greater variation in net load
- Increased ramp (speed and range)
- More requirements for **grid flexibility**

https://www.caiso.com/Documents/FlexibleResourcesHelpRenewables_FastFacts.pdf

Many options exist for increasing flexibility supply

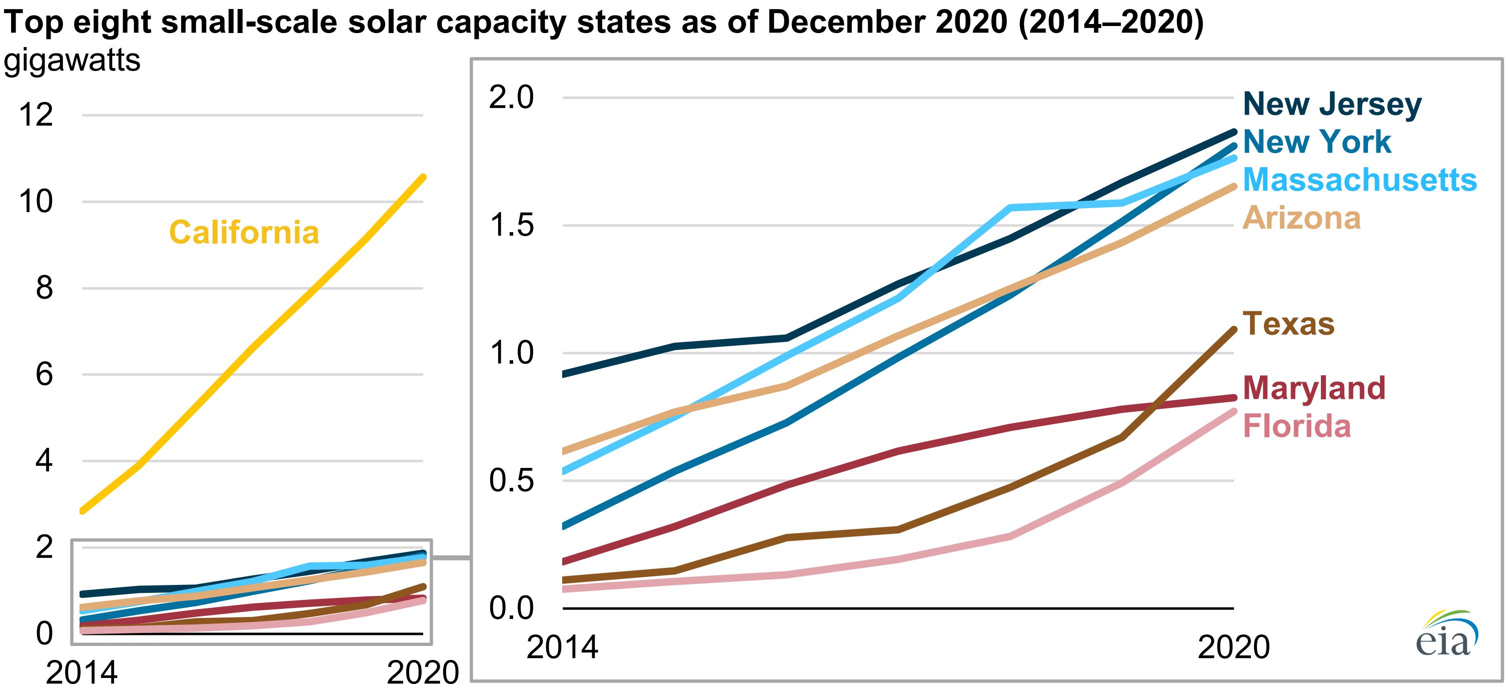


Chernyakhovskiy et al. 2021, NREL.


That's the bulk power system…
Photo by Dennis Schroeder, NREL 50673

Photo by Werner Slocum, NREL 66339

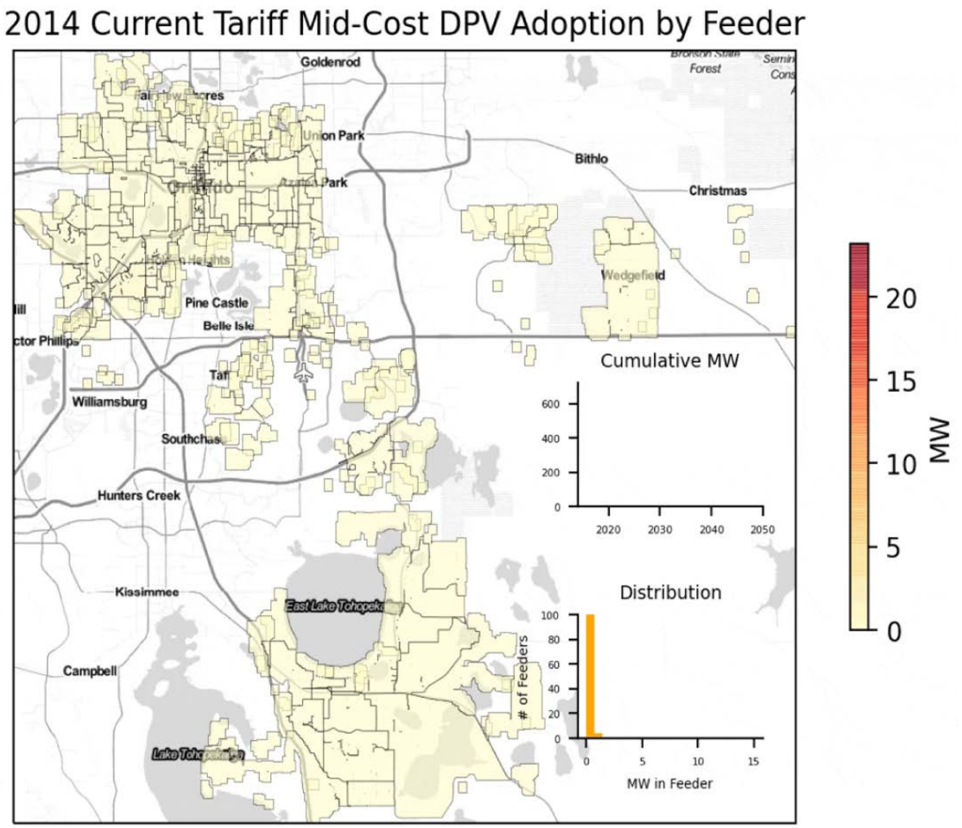
Behind-the-meter resources are also growing



https://www.eia.gov/todayinenergy/detail.php?id=46996

Utilities have less control over behind-the-meter resources, which complicates planning

NREL's dGen model helps forecast when and where resources such as rooftop solar may be adopted



https://www.nrel.gov/docs/fy21osti/77308.pdf

But distributed resources can also provide significant benefits to reliability and resilience

Most power outages are from interruptions to the local distribution system, not adequacy shortfalls

After cutting power to thousands, winter storm to exit Northeast on Friday night

The storm, which unloaded heavy snow and ice from New Mexico to Maine, snarled traffic and canceled thousands of flights

By Matthew Cappucci and Jason Samenow
Updated February 4, 2022 at 5:42 p.m. EST | Published February 4, 2022 at 10:02 a.m. EST

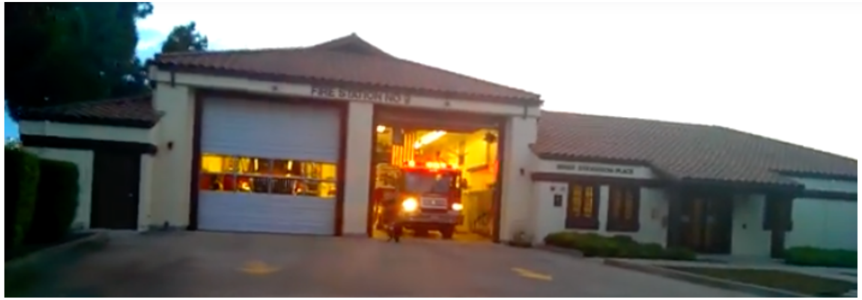
A large tree that fell because of ice accumulation blocks off North Cooper Street in Memphis on Feb. 3, 2022. (Brad Vest/Getty Images)

Comment Gift Article Share

More than 300,000 Americans are in the dark amid a serious winter storm that has dropped heavy snow and ice and brought down trees and power lines. The storm unloaded double-digit snow totals from New Mexico to northern New England, while freezing rain accumulated half an inch thick from parts of Texas through the Tennessee Valley to New York state.

“Microgrids” can operate independently during utility disruptions

Solar + storage systems can offer economic and resilience benefits over diesel generators



BATTERIES

Fremont, California, Fire Station Is First In US With Solar Microgrid

Planners in Fremont, CA, appear to be the first to complete a solar microgrid system with battery backup for a fire station in the United States, seeking to be more hardened against wildfire, utility blackouts, hurricanes, or other threatening events.

By Charles W. Thurston Published April 5, 2019

12 Comments

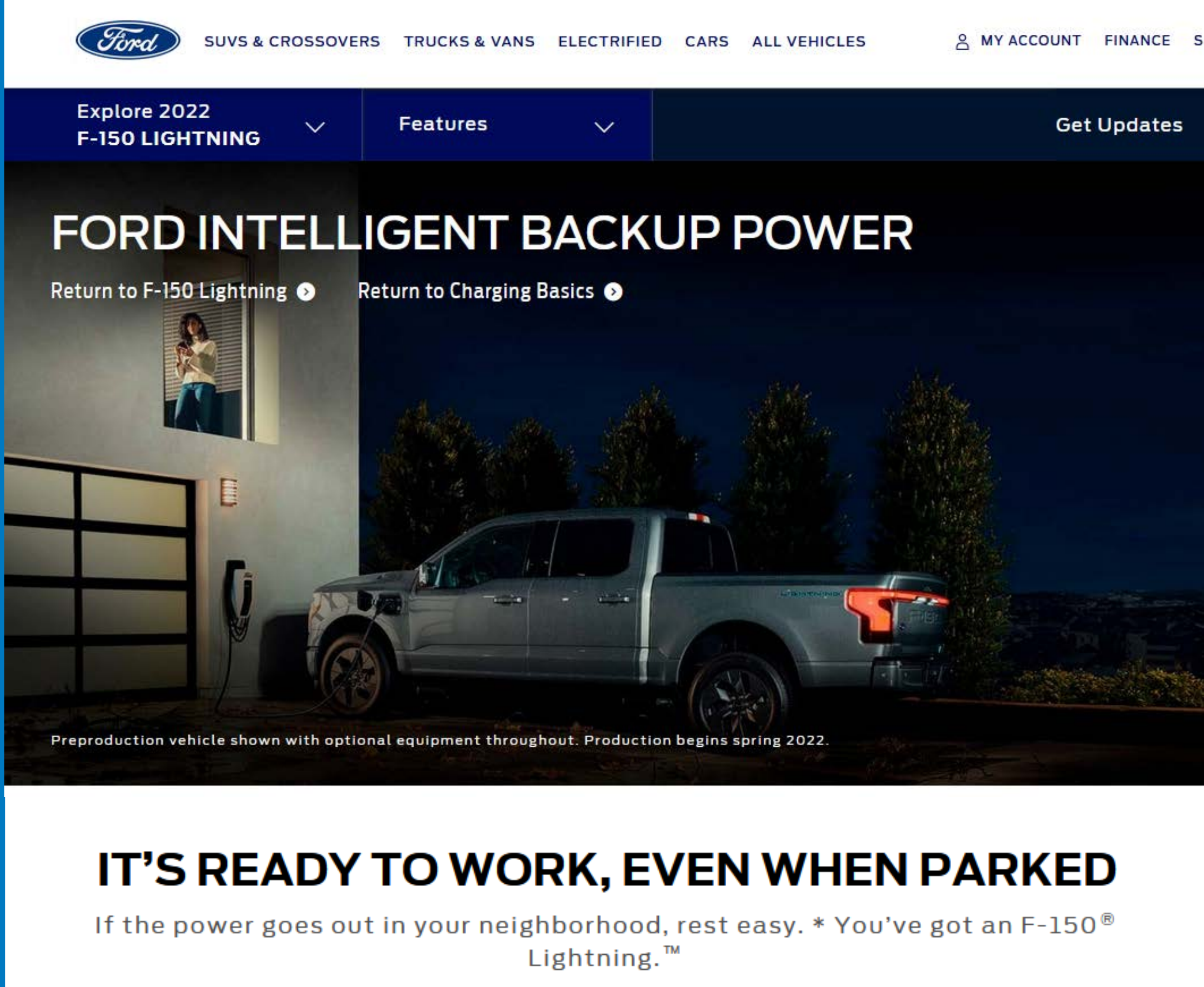
Demand can be a distributed resource…

Load flexibility and demand response can cut customer costs while supporting the grid

Photos by Werner Slocum, NREL 46052, and Erik Nelson, NREL 64287

...or even a source of supply

Electric vehicles have the potential for backup storage and vehicle-to-grid services



In summary…

- Wind and solar are here, with much more deployment on the way
- Renewables impact how we plan and operate the grid, at both the bulk and distribution system levels
- New resources change system needs but also provide new opportunities for grid reliability
- The tools and technologies needed for integration exist, and can be deployed as renewables expand

Photo by Eric Figgins, NREL 66300

Questions & Discussion

www.nrel.gov

NREL/PR-6A40-83654

Photo from iStock-627281636

NREL Transforming ENERGY