TODAY'S WEBINAR WILL BEGIN SHORTLY

The Top Technologies Enabling the Net-Zero Grid of the Future

Christopher Robinson

Research Director

QUESTIONS?

Use the questions box on your screen

AUDIO ISSUES?

Use the global dial-in number in your confirmation email

Lux Research | The Deciding Factor

The Top Technologies Enabling the Net-Zero Grid of the Future

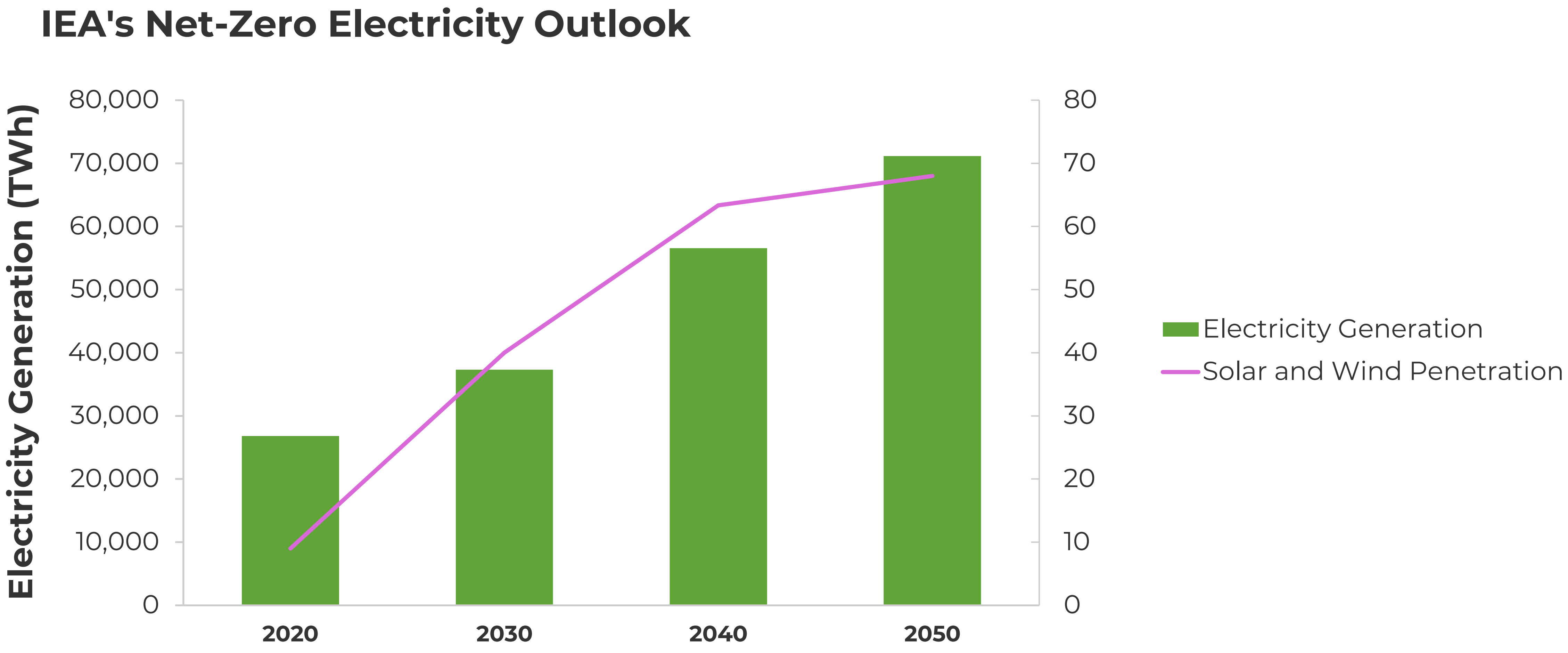
Christopher Robinson
Research Director

Lux Research | The Deciding Factor

Agenda

Challenges in the net-zero power grid of the future

Electrification is a key pathway to decarbonizing the global economy, and we will need a LOT of electricity

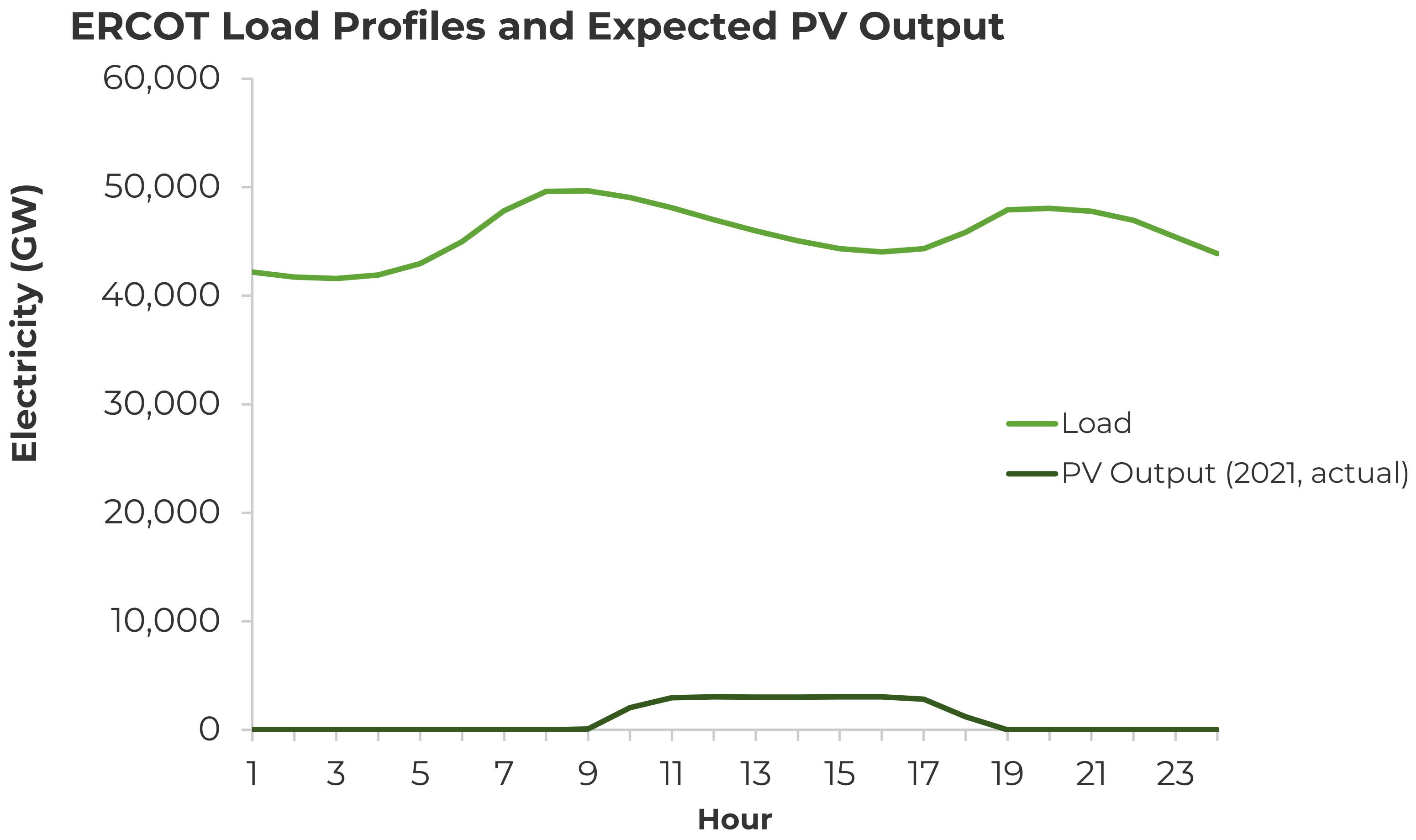


Source: IEA

What happens with a *little* bit of renewables?

In 2020, solar is just 3% of generation

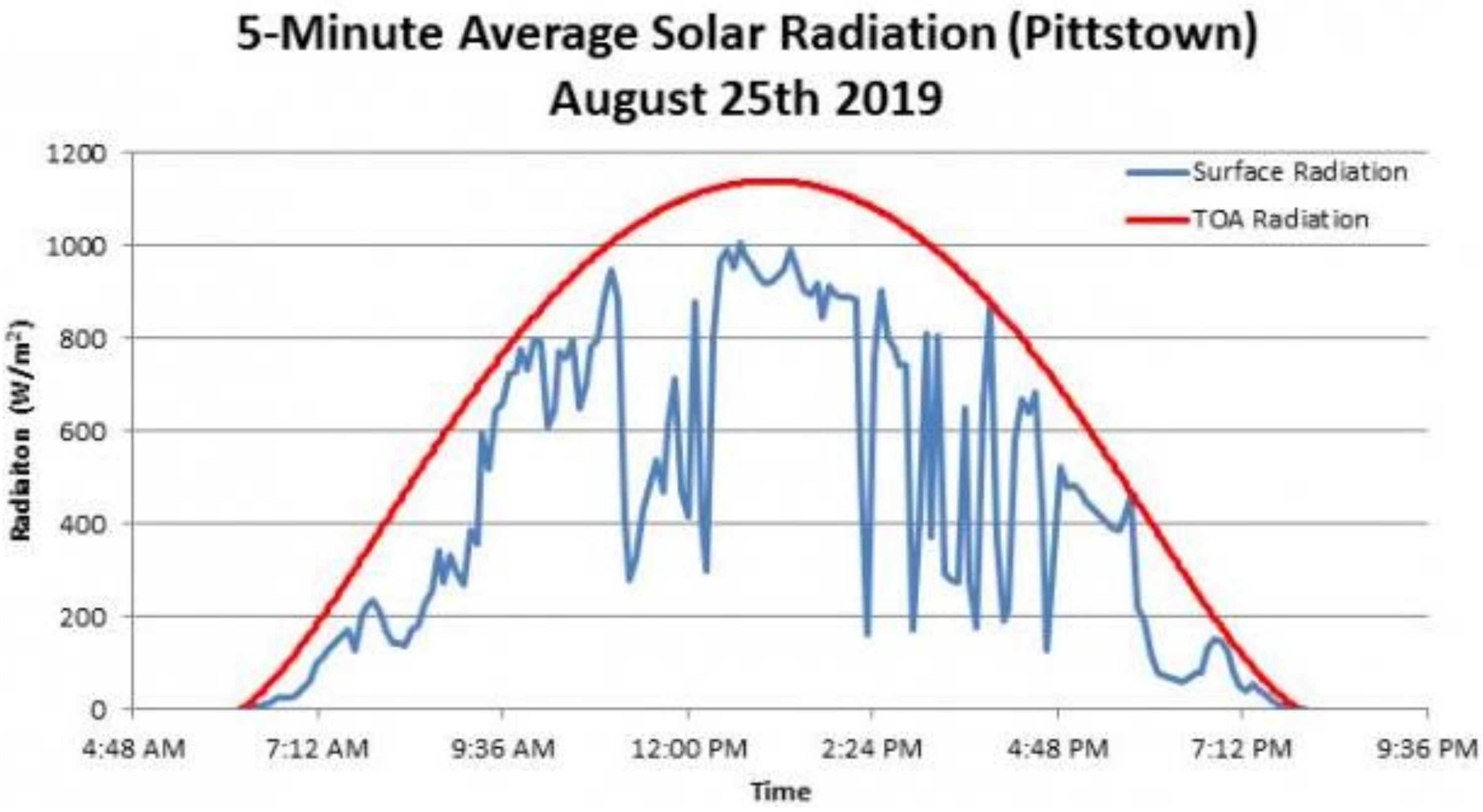
- Too small to impact reliability of the system
- No systemic changes needed



What happens with a *little* bit of renewables?

Biggest challenge is managing short-term intermittency (minutes)

- Need lots of power, but little energy, for managing short-term fluctuations



Data Source: Rutgerss NJ Weather Network

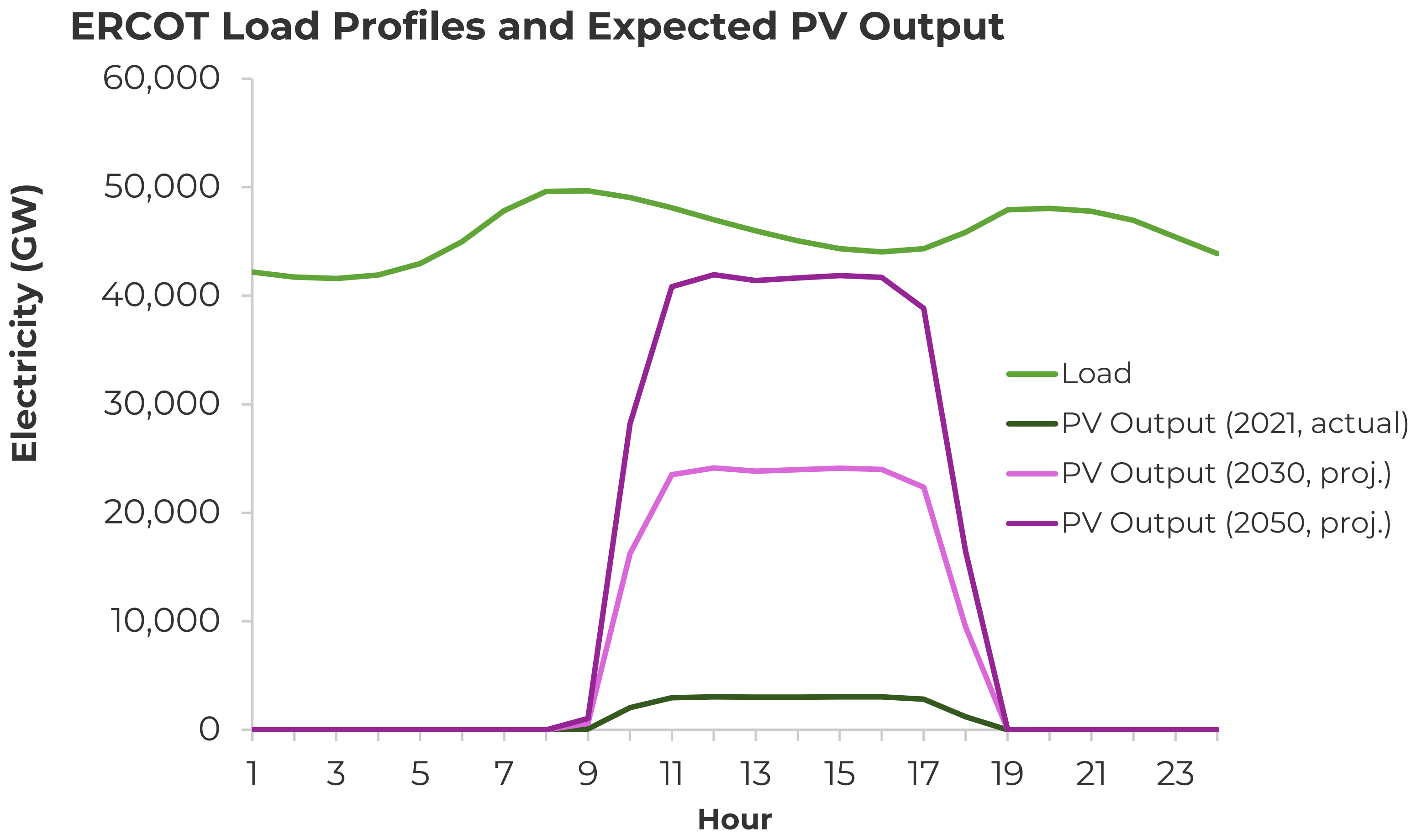
What happens with a *lot* of renewables?

In 2050, solar is now 33% of generation

- High potential for outages due to low extended periods of low renewables output and high load

Systemic changes are required in how we plan and operate the electrical grid

- This requires some technologies that are not used at scale today



We don't have much time to innovate, based on net-zero targets

~2010

Small amounts of renewables

No systemic changes required

Short duration storage is needed to quickly keep voltage and frequency of the grid within an acceptable range.

~2020s

Larger amounts of renewables

Some changes required

Energy storage is needed for load shifting, moving excess generation from the middle of the day to the evening hours when demand spikes.

~2030s

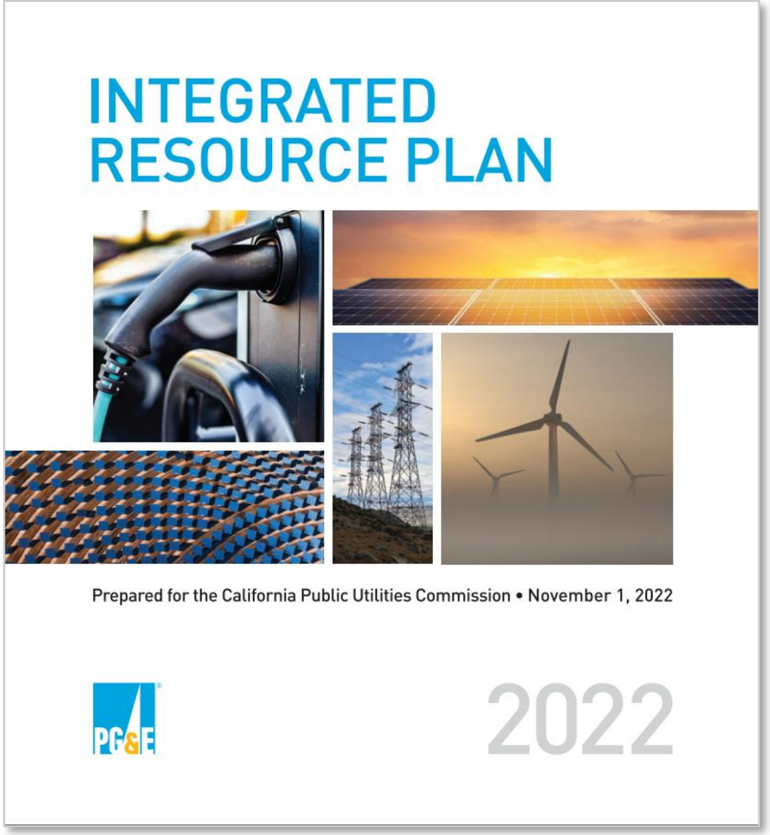
Zero-carbon grids

New technologies needed

This also requires a systemic change in how utilities plan and operate.

Technologies for the net-zero grid

Integrated Resource Plans are where battles over net-zero grids will be decided

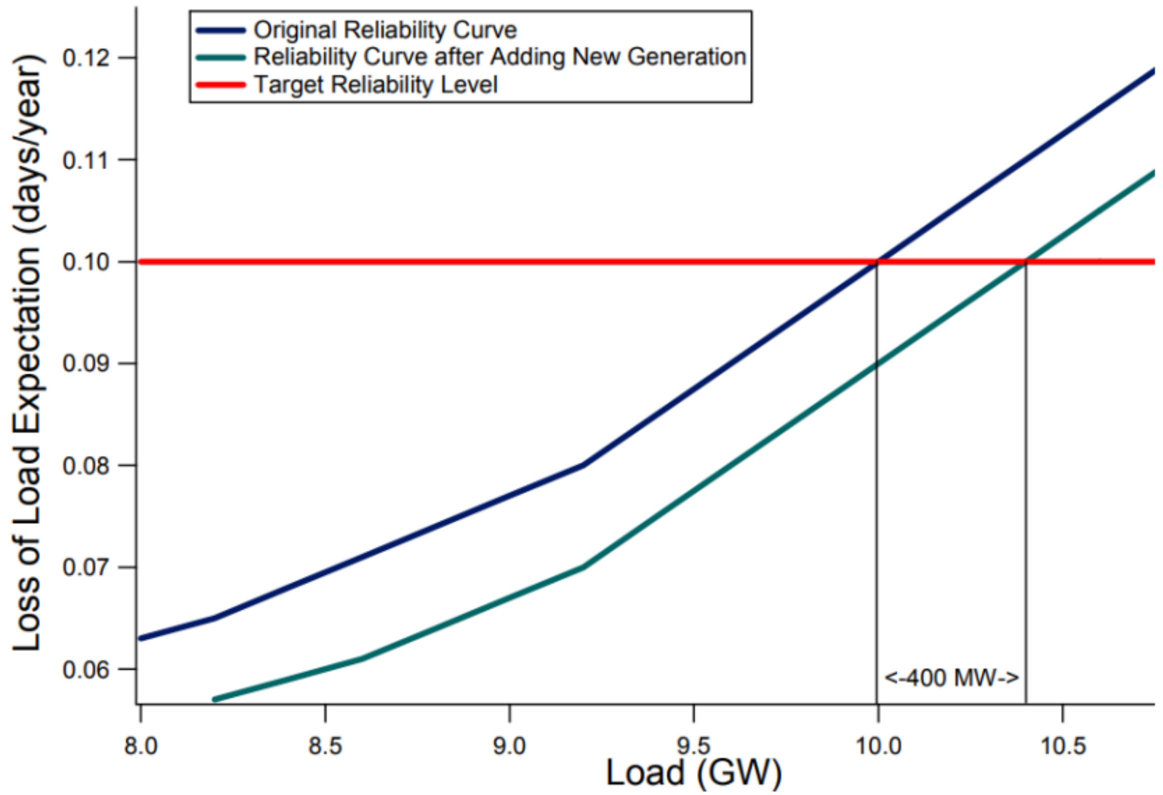


Effective load carrying capability (ELCC) is a critical concept for reliability

$$ELCC = \frac{Increased\ load\ that\ can\ be\ reliably\ served}{Nameplate\ capacity}$$

For example, assume we consider adding solar with a nameplate capacity of 1,000 MW.

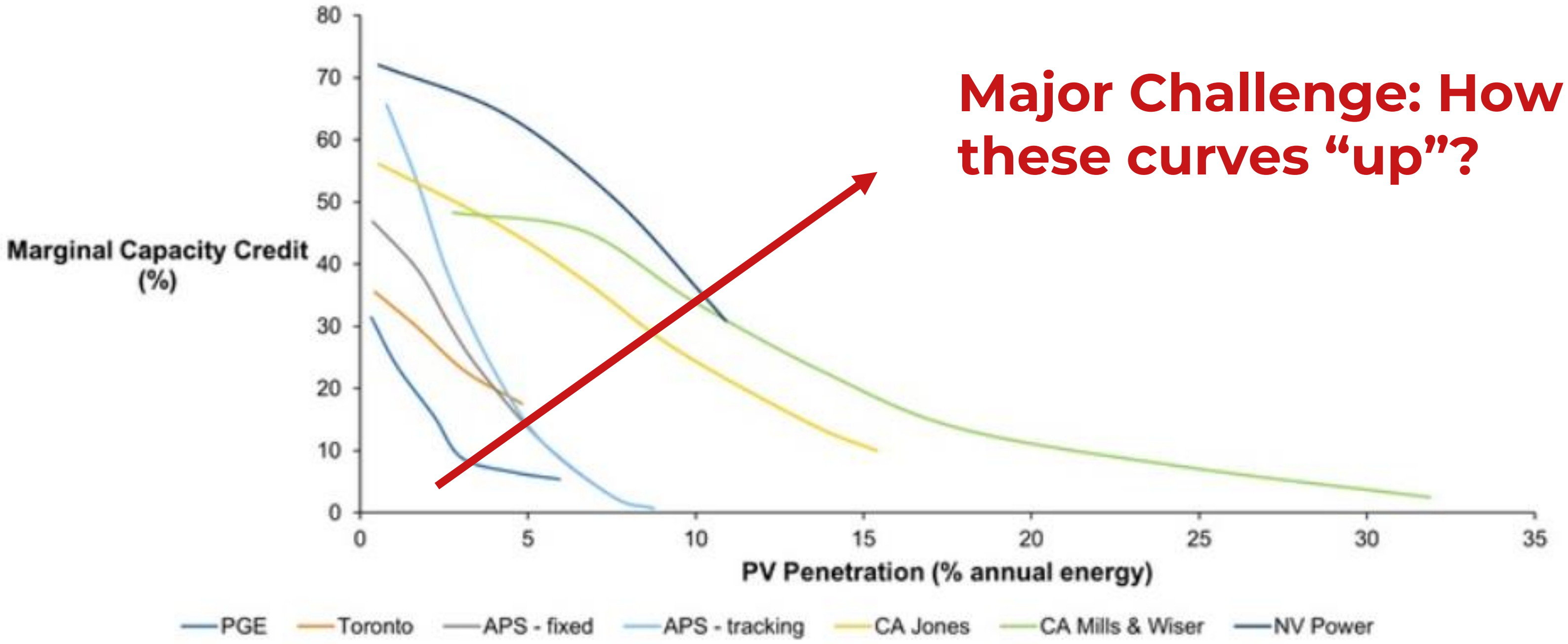
$$ELCC = \frac{400\ MW}{1{,}000\ MW} = 40\%$$



Source: NREL "Comparing Resource Adequacy Metrics"

ELCC isn't constant and typically decreases for renewables with increasing renewables penetration

Figure 5: The Capacity Credit Measures the Load that a Generator Can Reliably Serve

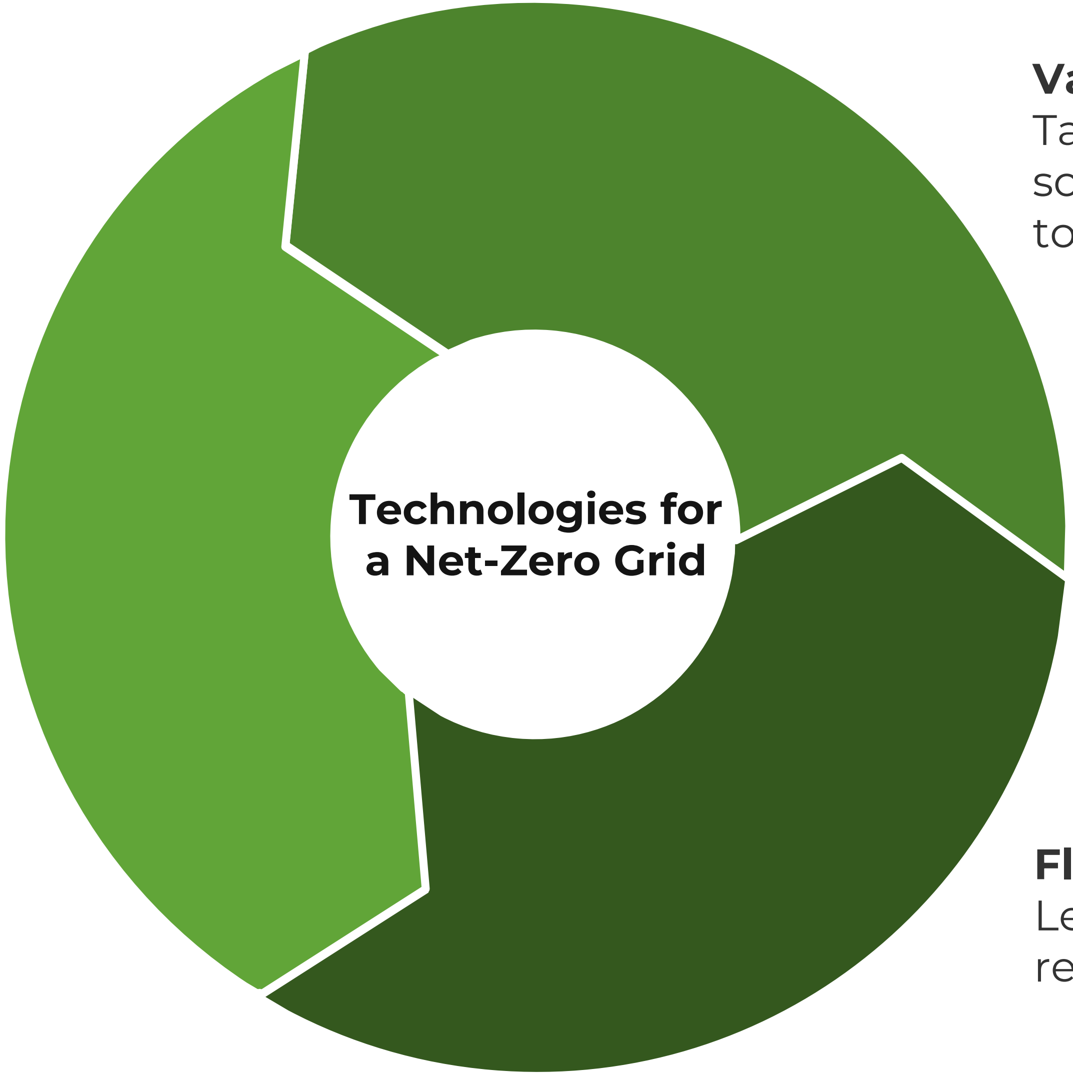


Major Challenge: How can we push these curves "up"?

Source: Lux Research "The Grid of the Future: Mapping the Path to a Grid Powered by Renewables"

Three solutions are needed to enable zero-carbon electricity

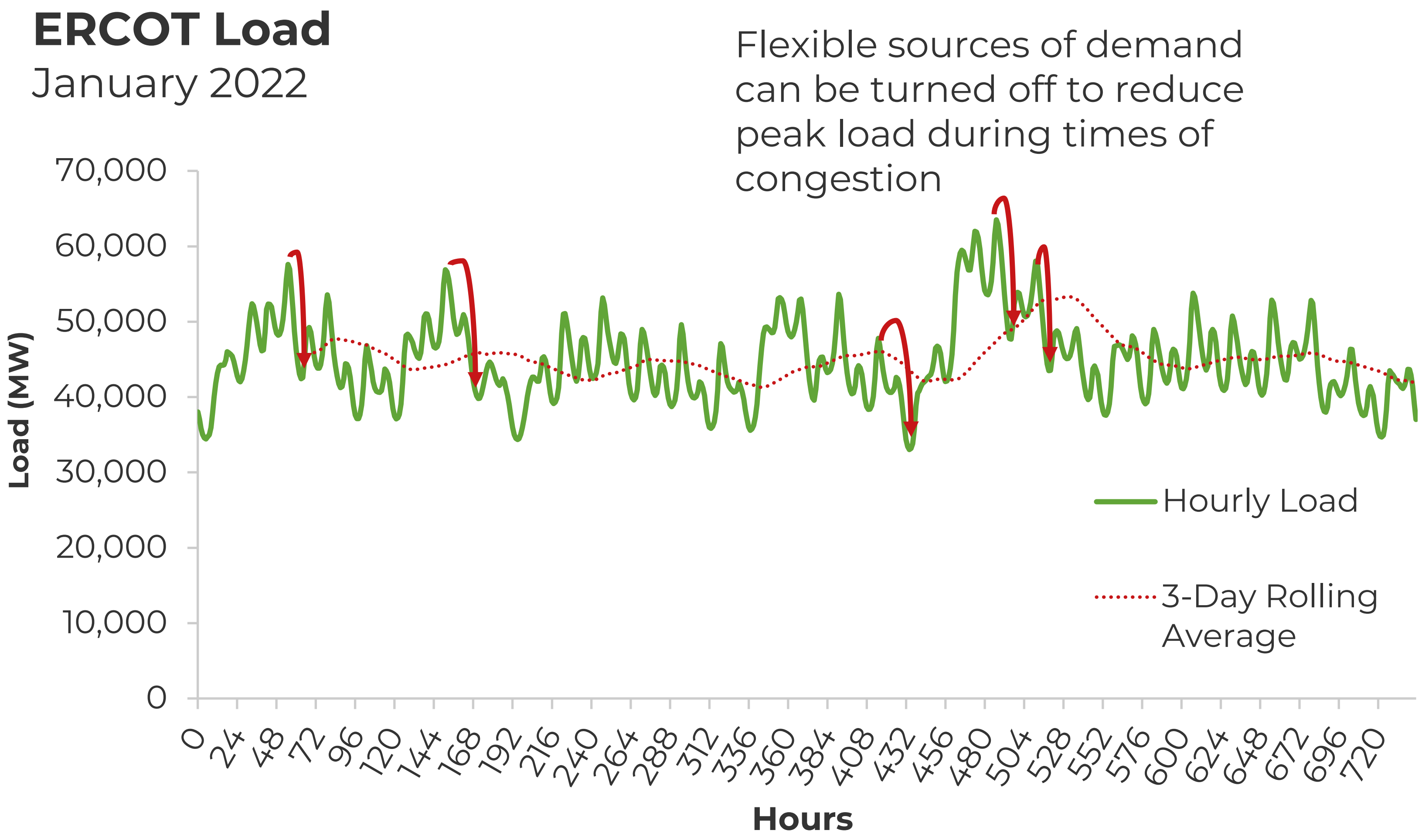
Long-duration Energy Storage
The ability to store electricity for days, weeks, or even months at a time



Variety of generation
Tapping into a variety of sources of generation to improve reliability

Flexible Demand
Leveraging flexibility reduces peak load

Step 1: Flexible Demand

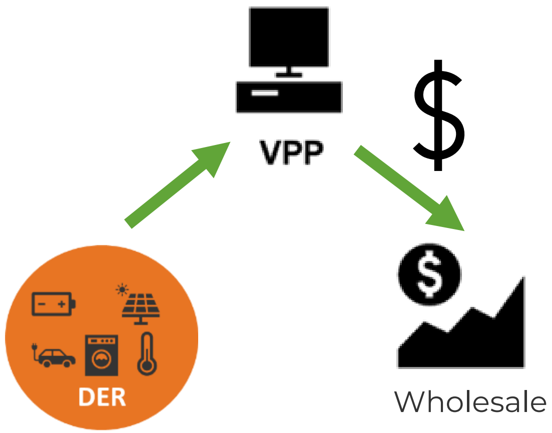


Key Technologies

DERMS
Bidirectional EV charging
Load forecasting
DER Marketplaces
Smart Devices / Meters
Microgrids
Behind-the-Meter Storage
Demand Response

Step 1: Flexible Demand

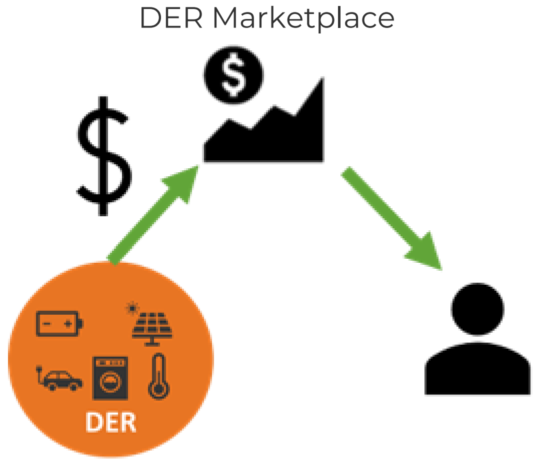
Virtual Power Plant



Most established solution, highly scalable, and fits within current regulatory frameworks

Indirectly benefits grid reliability and lacks strategic control of DERs by grid operators

DER Marketplaces



Provides transparent signals on available capacity from DERs

Faces some regulatory barriers and requires a significant change for grid operators

Step 1: Flexible Demand

Project traDER

The project included two wind generators, 134 electric storage heaters from Kaluza and two domestic scale batteries from SMS. Over one year, more than 23,600 trades occurred, trading 26 MWh of electricity, enabling the participation of 74 assets located in the ANM zone in the balancing market.

Scottish & Southern Electricity Networks TRANSMISSION

ELECTRON

KALUZA

CATAPULT Energy Systems

ELEXON

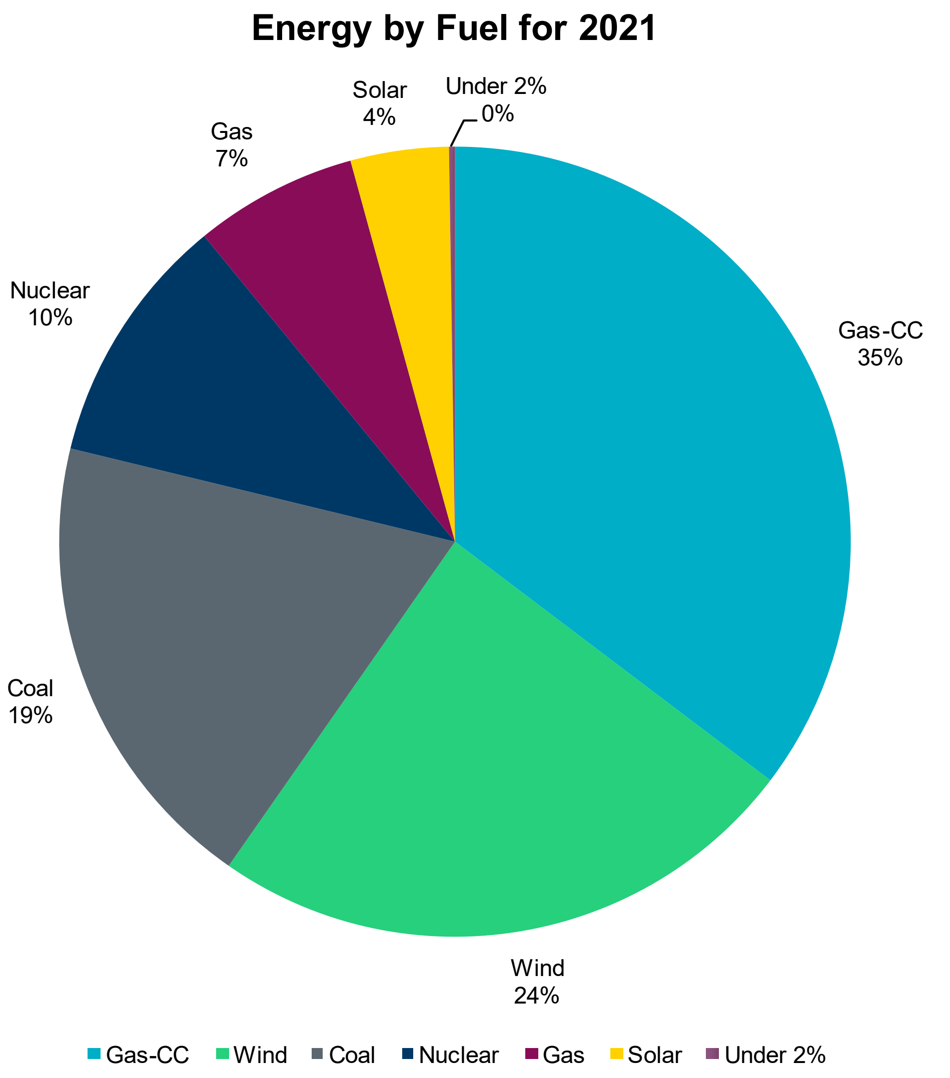
eDF

LUX TAKE

This is a robust solution for controlling many different asset types, and is notable for using DSO signals to automate dispatch.

Step 2: Variety of Generation

Winter 2021
Low gas capacity due to weather issues was offset by other sources of generation, mostly wind, nuclear, and coal



Key Technologies
Floating Solar
Marine Energy
Offshore Wind
Geothermal
Advanced Nuclear

Source: ERCOT

Step 2: Variety of Generation

Marine Power

Harvesting energy from wave and tidal motion

Varies with wave height and tides

Geothermal Power

Using geothermal heat to power turbines

Near-flat generation profile

Nuclear Power

Thermal power plants using fission for heat

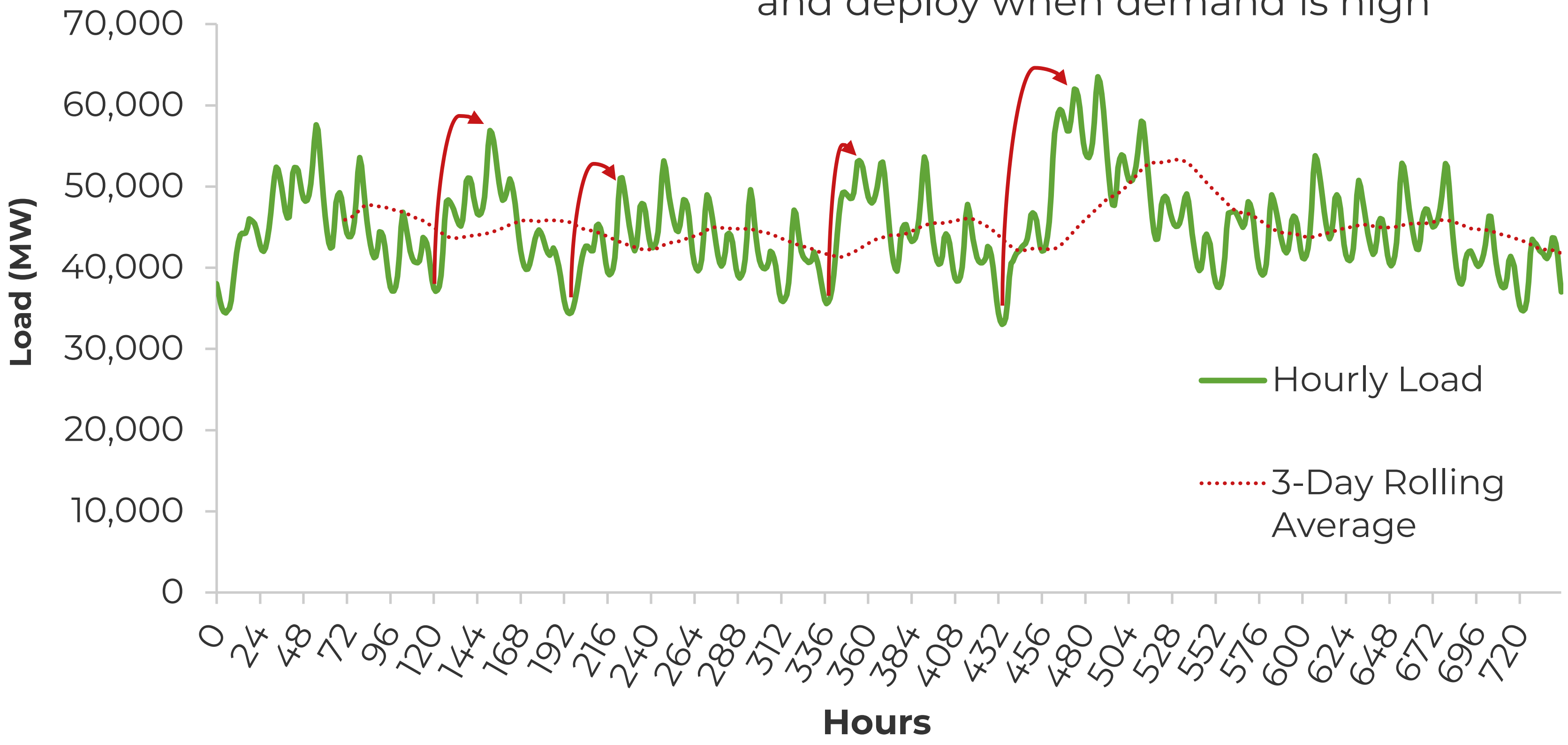
Flat generation profile

Image Source (left to right): CorPower, Gretar Ívarsson,NuScale

Step 3: Long-Duration Energy Storage

ERCOT Load
January 2022

Energy storage can stow renewable energy produced when demand is low and deploy when demand is high



Key Technologies
Flow Batteries
Zinc-Air Batteries
Compressed Air Energy Storage
Liquefied Air Energy Storage
Iron-Air Batteries
Electrolyzers
Hydrogen Storage
Hydrogen/Ammonia-Fired Turbines

Step 3: Long-Duration Energy Storage

The Levelized Cost of Storage (LCOS) is a simplified way of comparing the costs of different battery technologies

$$ {}^{\$}/_{kWh_{lcos}} = \frac{\sum Discounted\ Lifetime\ Costs}{\sum Discounted\ Lifetime\ Energy} = \frac{\sum_{t=0}^{t_{project}} \frac{\$_{installed} + \$_{maintnance} + \$_{replacement}}{(1 + \%_{discount\ rate})^t}}{\sum_{t=0}^{t_{project}} \frac{E_{storage} \times n_{cycles/year} \times \eta_{roundtrip}}{(1 + \%_{discount\ rate})^t}} $$

Promising long-duration storage chemistries ideally also feature:

- Decoupled power and energy characteristics
- Low materials and maintenance costs
- Long project lifetime

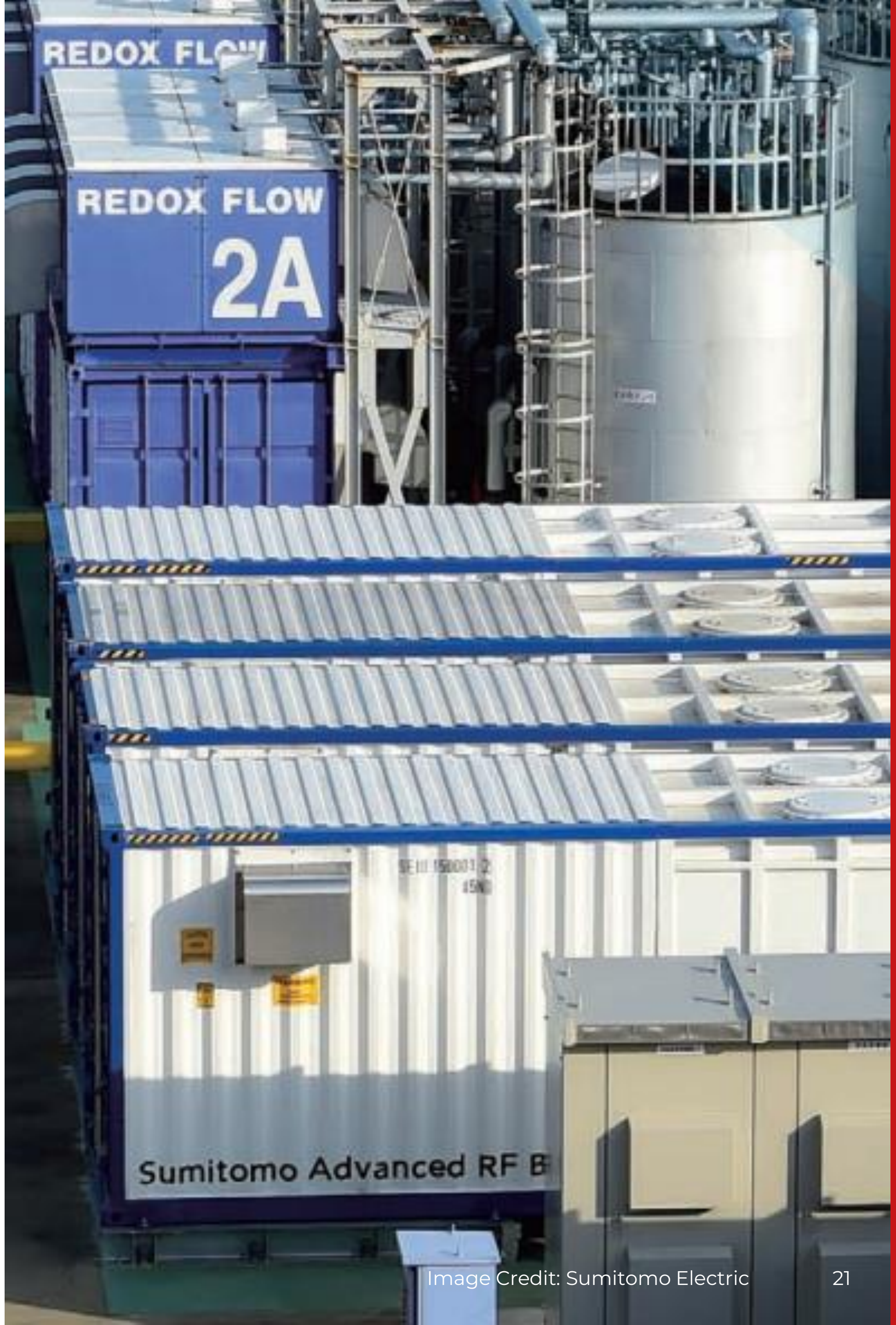
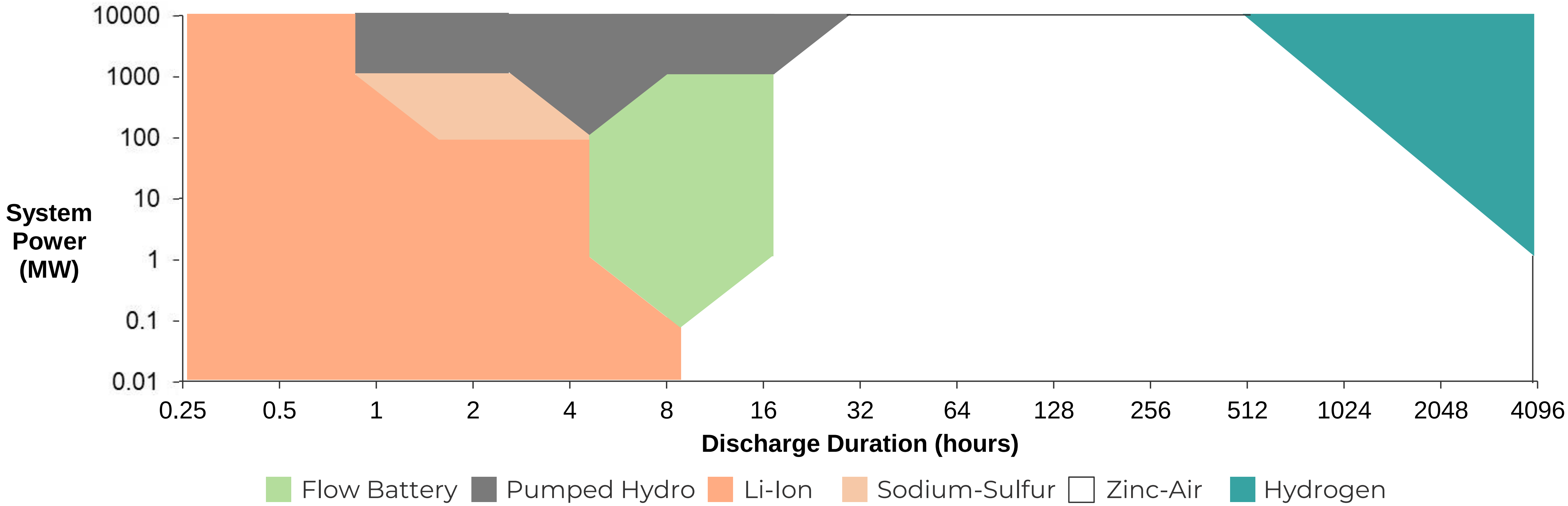
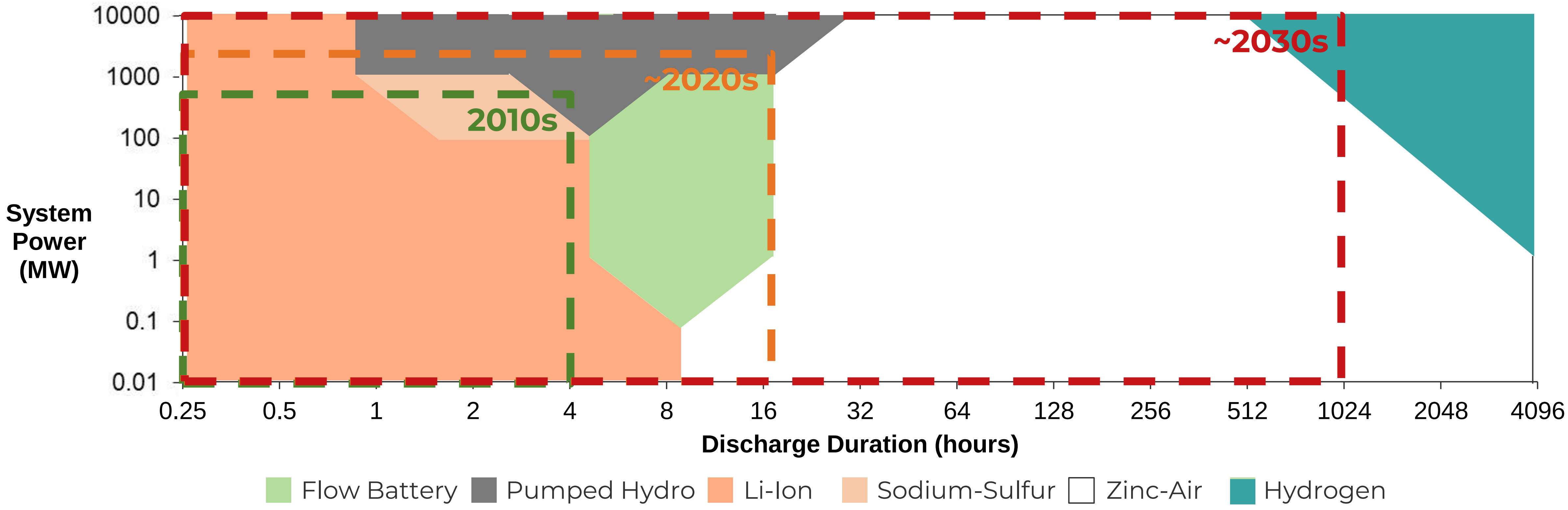


Image Credit: Sumitomo Electric

Step 3: Long-Duration Energy Storage



Step 3: Long-Duration Energy Storage



Technology opportunities in the net-zero grid

Technologies to build the net-zero grid

Flexible Demand

- DERMS
- Bidirectional EV charging
- Load forecasting
- DER Marketplaces
- Smart Devices / Meters
- Microgrids
- Behind-the-Meter Storage
- Demand Response

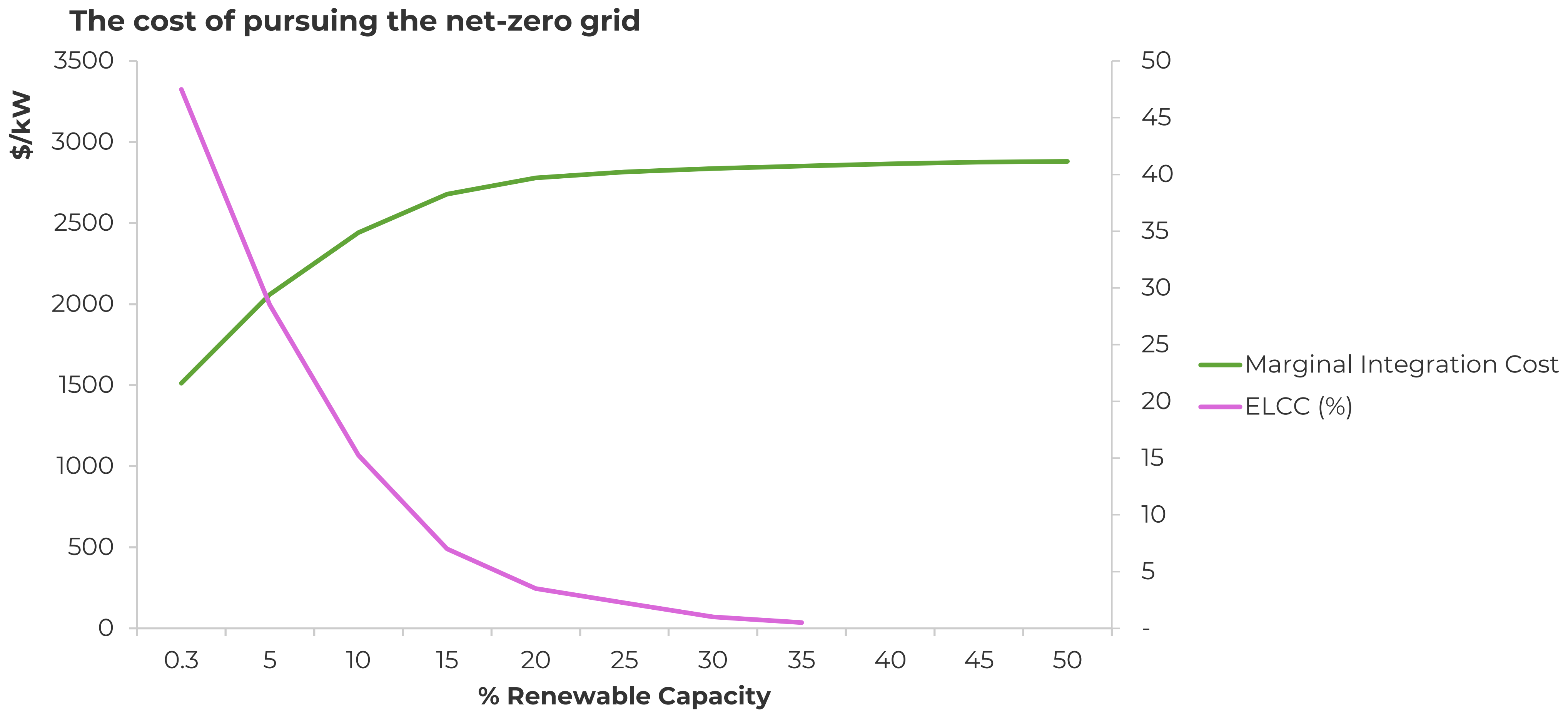
Variety of Generation

- Floating Solar
- Marine Energy
- Offshore Wind
- Geothermal
- Advanced Nuclear

Long-Duration Energy Storage

- Flow Batteries
- Zinc-air Batteries
- Compressed Air Energy Storage
- Liquefied Air Energy Storage
- Iron-Air Batteries
- Electrolyzers
- Hydrogen Storage
- Hydrogen/Ammonia -Fired Turbines

Electricity will get more expensive – forget too cheap to meter!



Pursue novel sources of flexibility

Today, demand response programs and VPPs are primarily responsible for providing flexibility

- **California's Emergency Load Reduction Program** unlocks DER flexibility without the need for an aggregator
- **AutoGrid and Zum** partnered to create a 1-GW VPP using electric school buses and bidirectional charging

In the future, marketplace-based solutions providing visibility into the status of BTM DERs to leverage their flexibility

- **Greensync's deX** provides DSOs with a software platform to enable DER marketplaces

Consider long-duration storage technologies for energy storage needs today to pilot novel opportunities

1 Flow Batteries

2 MWh / 8 MWh system for a CA microgrid

2 Mechanical Storage

50 MW / 300 MWh system leveraging existing transmission infrastructure

3 Hydrogen Storage

MHI's ammonia-fired turbine would provide gas-like reliability

Image Source (left to right): Sumitomo Electric, Highview Power,

Key Takeaways

1 **Effective Load Carrying Capability (ELCC) is a crucial concept to consider for net-zero grids**

2 **Utilities should plan for increased demand flexibility via EV charging, distributed solar, and BTM energy storage**

3 **Opportunistically pursue long-term projects with regulatory support and leveraging existing infrastructure**

Thank you

A link of the webinar recording will be emailed within 24–48 hours.

UPCOMING WEBINARS

JANUARY 24

Market Opportunities in Emerging Consumer Health and Wellness Ecosystems

JANUARY 31

Understanding the Global Cultural Trends That Will Shape Consumer Decision-Making in 2023

FEBRUARY 21

Sustainability Driving New Business Models in Manufacturing

EMAIL

questions@luxresearchinc.com

VISIT

www.luxresearchinc.com

READ

http://www.luxresearchinc.com/blog/

LuxResearch

@LuxResearch

Lux Research | The Deciding Factor