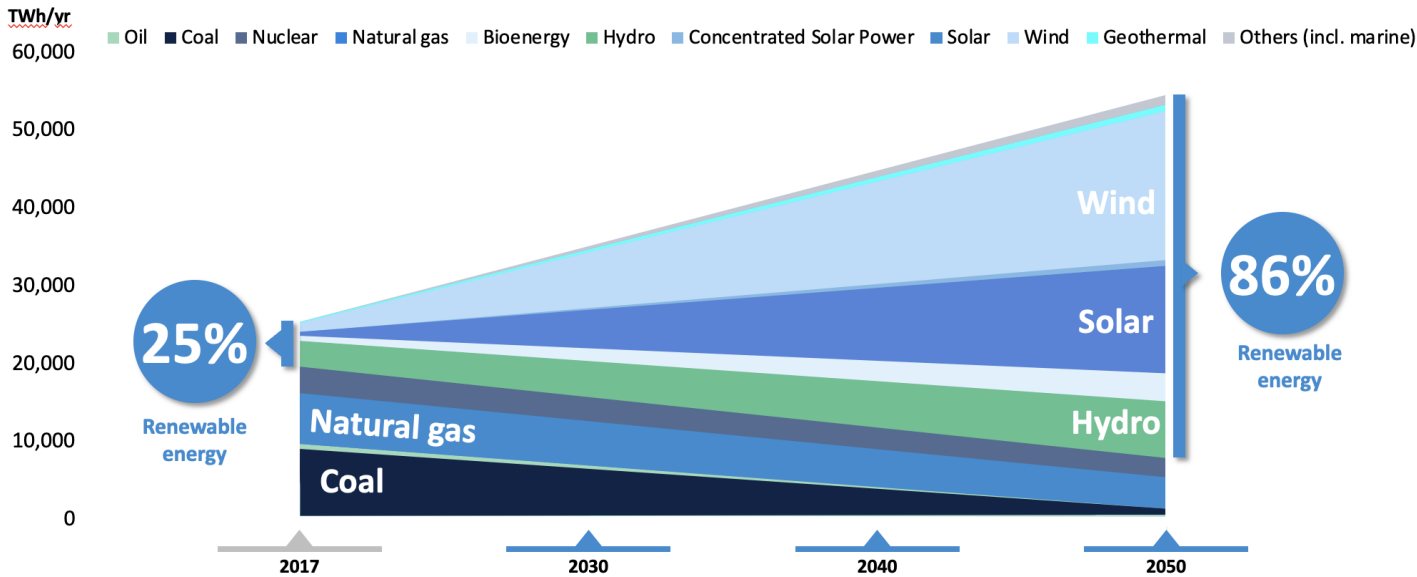


Controllable Loads for Ancillary Services

Green Hydrogen and Beyond

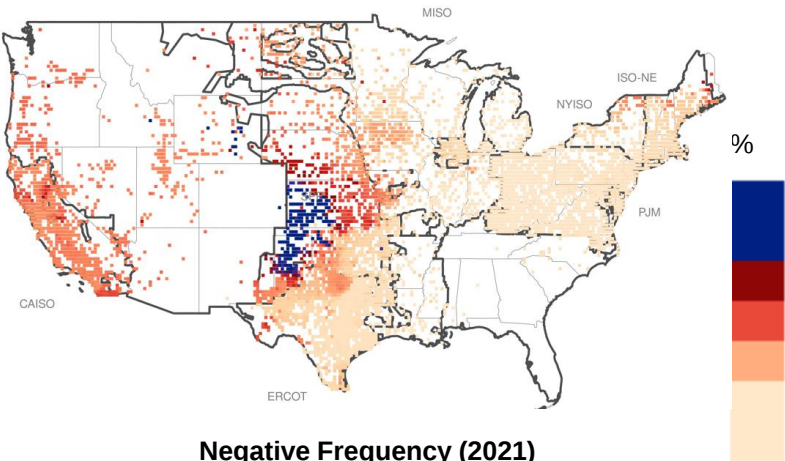
Market Forces: Increased Renewables Share and Negative Pricing

Depressed power prices can inhibit the buildout of new renewable generation

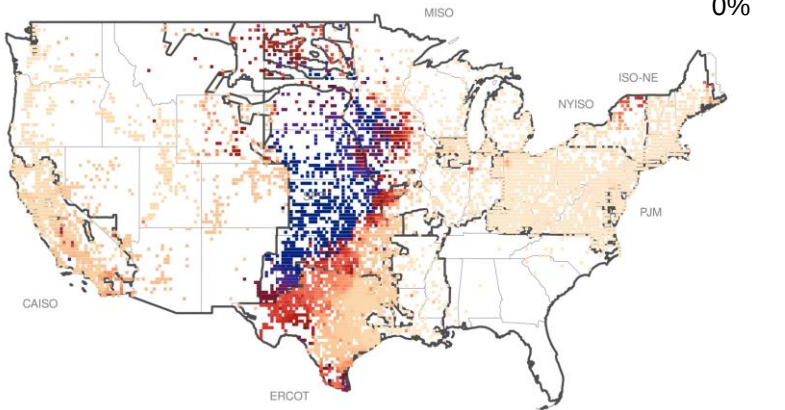


Renewables mix is expected to grow to over 85% of electricity generation by 2050

Negative Frequency (2017)



Negative Frequency (2021)

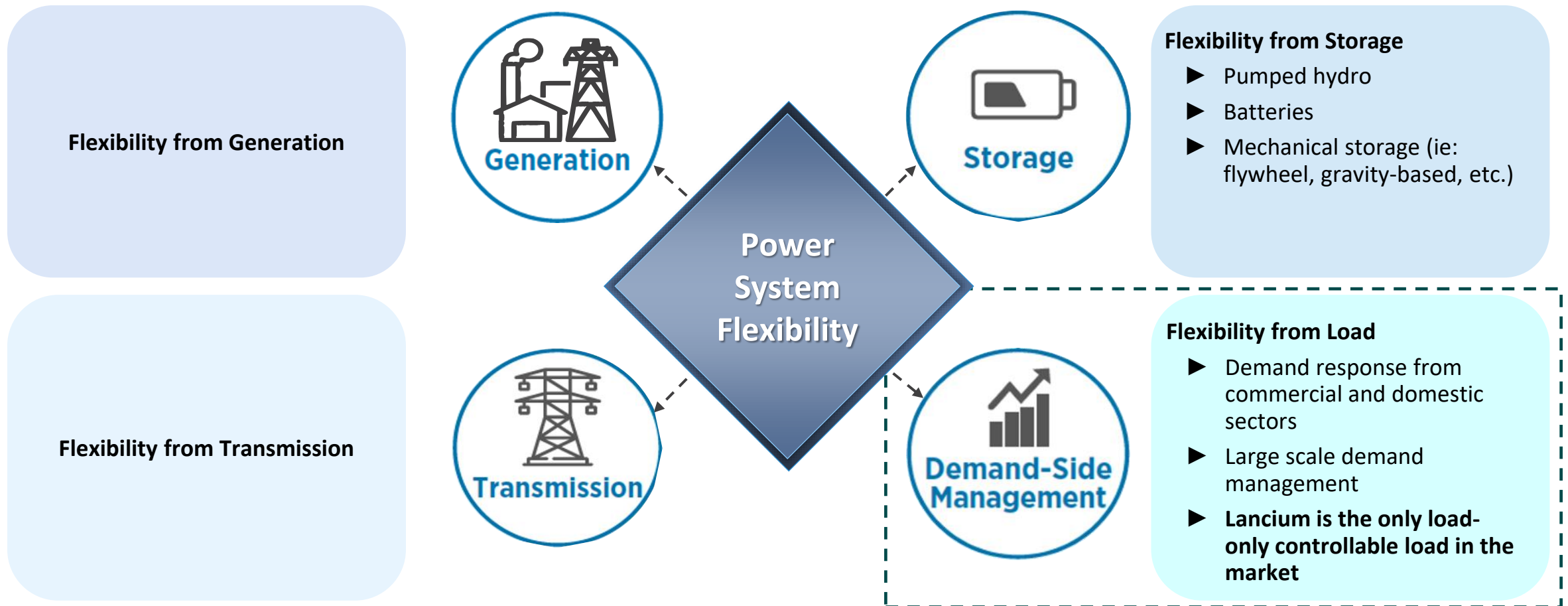


Flexibility in the Grid is Essential to a Net Zero Future

Technological options and solutions for power system flexibility

Supply Solutions

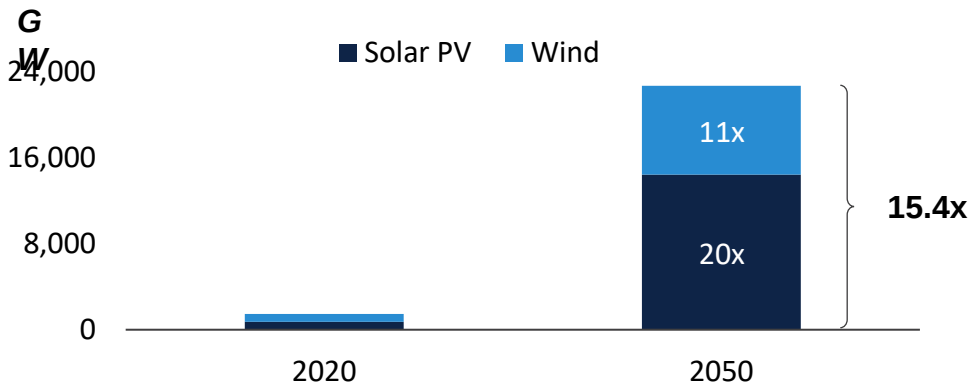
Demand Solutions



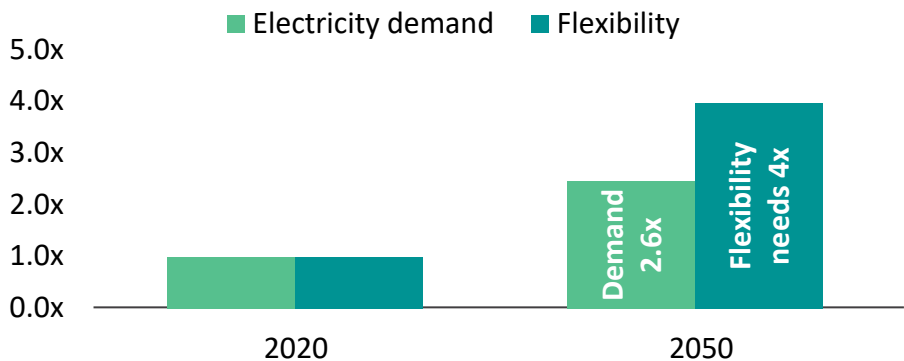
Batteries and Demand Response Will Become the Primary Sources of Flexibility

Grid of the future – power system flexibility

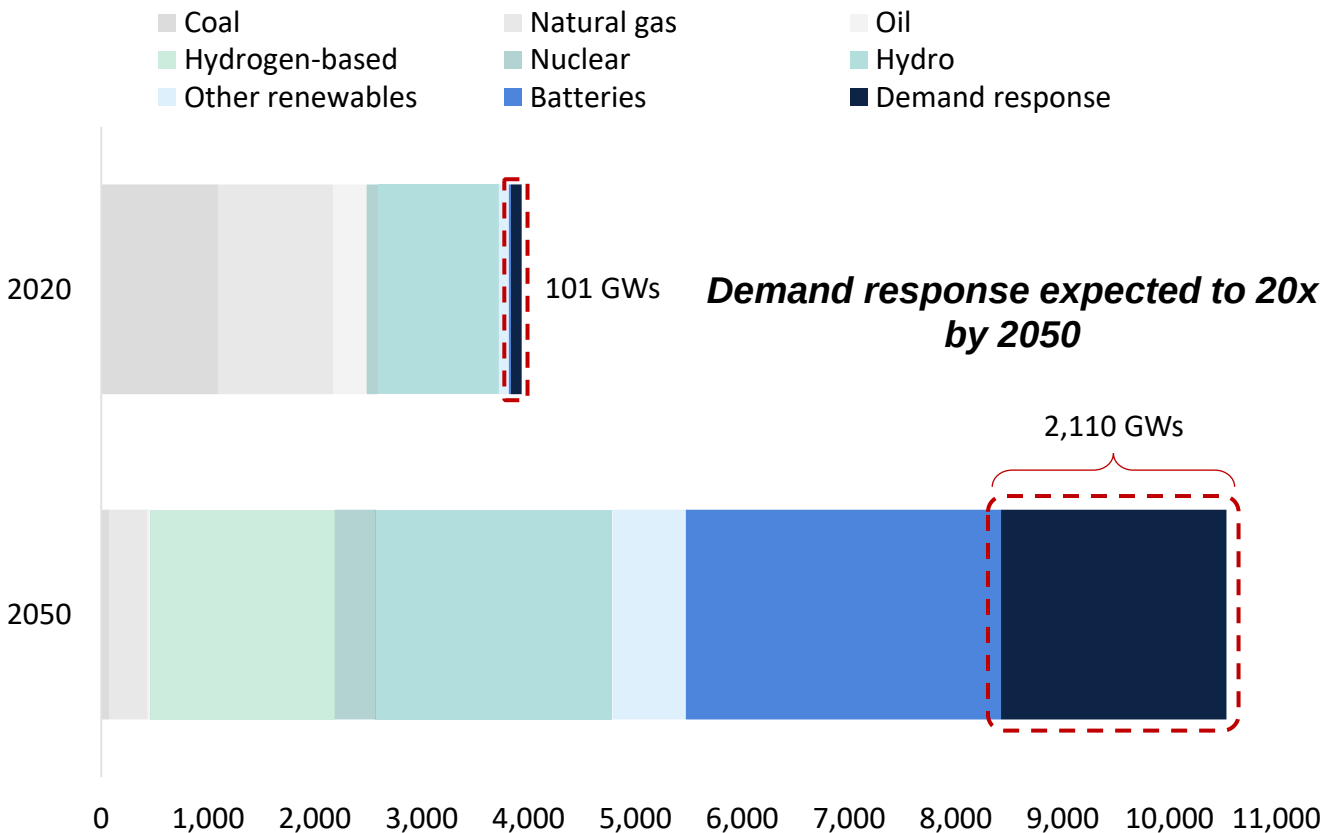
Solar and Wind Capacity Additions¹



Electricity System Flexibility Needs²



Electricity System Flexibility by Source¹



With solar and wind capacity expected to increase >15x, power system flexibility will need to increase 4x

ERCOT's Growing Need and Market Value for Ancillary Services

Overview of Ancillary Services products at ERCOT



Types of Ancillary Services

Regulation Service

Generators providing Regulation receive a signal from ERCOT every four seconds to increase or decrease output

Responsive Reserve Service

Capacity from generators or load resources that is reserved from the energy market in order to be readily available to respond to frequency events

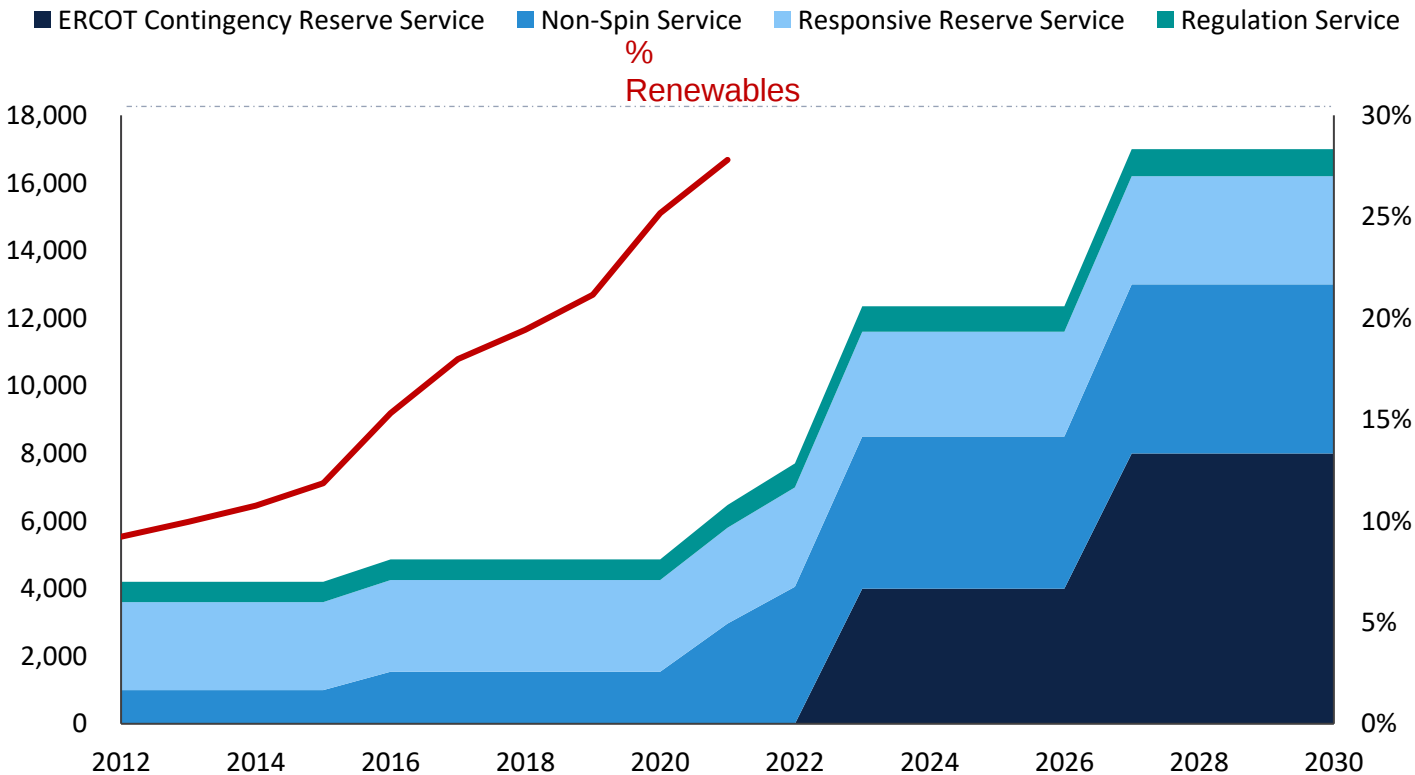
Non-Spin Reserve Service

Capacity that can be started in 10 or 30 minutes to cover forecast errors or ramps

ERCOT Contingency Reserve Service (ECRS)

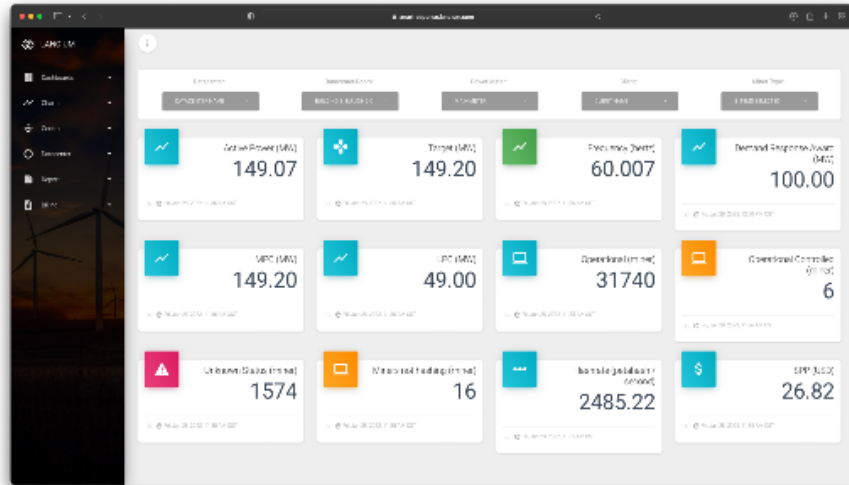
Capacity that can be sustained for two consecutive hours to cover sustained ramps in net Load

Average Hourly Ancillary Service Volume (MWs)



Lancium Smart Response® Solutions

End-to-end integrated energy management solution



Lancium Smart Response® communicates with the grid in real-time to adjust load based on several factors:

- ✓ Grid supply/demand balance
- ✓ Power market prices
- ✓ Ancillary Services commitments
- ✓ Load matching with zero-carbon energy

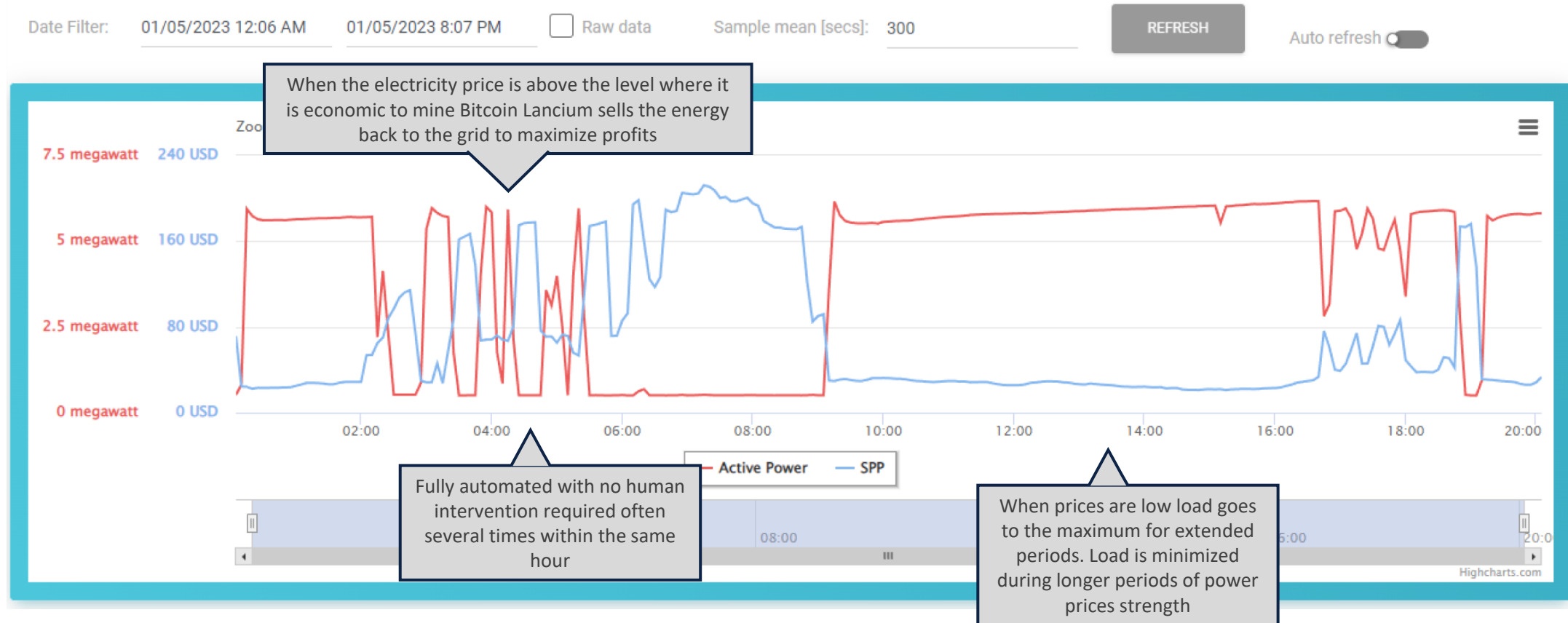
Deployed at our Lancium Clean Campus as well as at several large Bitcoin mining facilities in Texas

- ✓ Proven technology that is patented
- ✓ Allows energy-intensive applications to ramp their power consumption up or down in as little as 5 seconds
- ✓ Lancium Smart Response® dashboards give end-users real-time visibility into their environment

Lancium is actively developing additional interfaces with conventional data center loads and other potential applications

Smart Response Real Use Case

Curtailing load in response to market prices above a pre-determined threshold



Smart Response systematically controls mining in response to real-time power prices

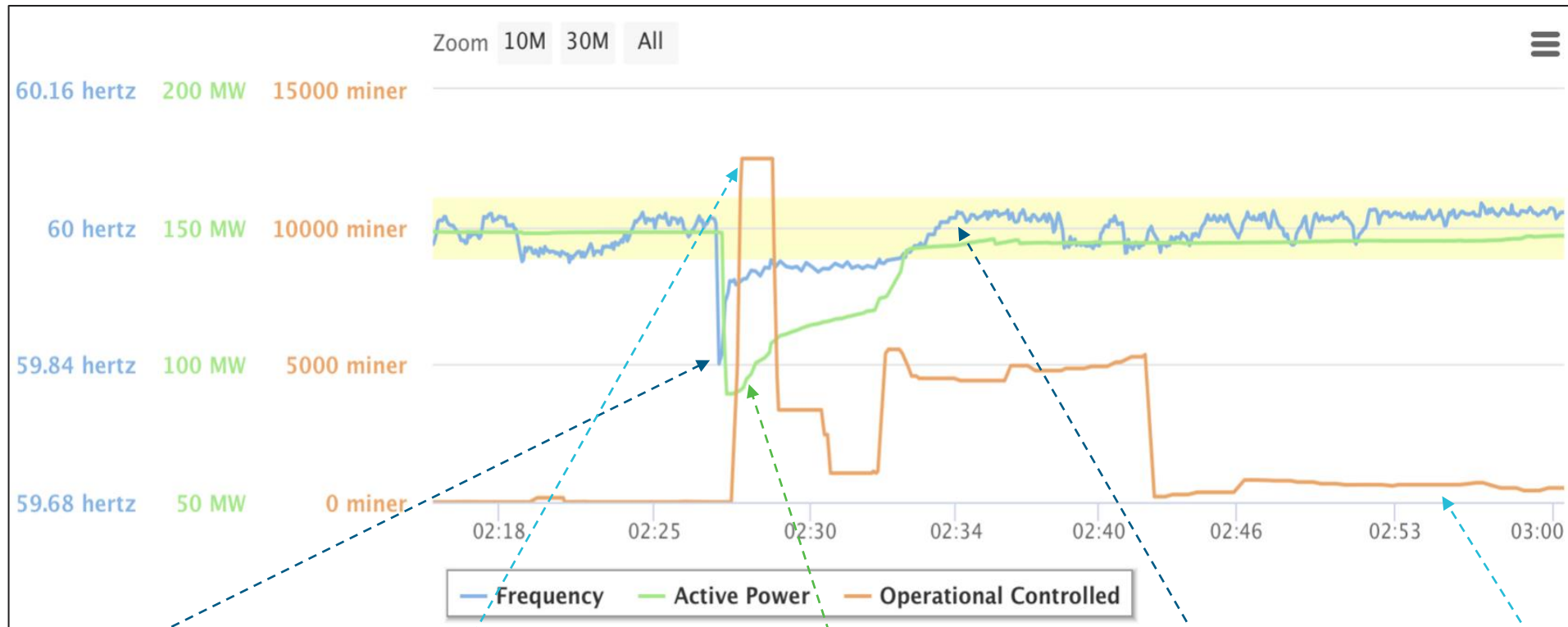
*Graph represents the largest mining site currently operating in the U.S.

Lancium Smart Response™ Stabilizes Power Grids – Real Use Case

Automatically detect undesired grid frequency and power down miners in seconds



LANCIUM



Grid frequency went down from 60 Hz to undesirable low level of 59.84 Hz

Smart Response™ detects the undesired frequency and power down more than 12,000 miners.

Active Power consumption is lowered from 150 MW to less than 100MW in seconds.

Frequency comes back to normal levels due to power consumption reduction.

Smart Response™ turns miners back on once frequency is reestablished.

- **The price at which a load is indifferent about providing AS depends on:**
 - The net value produced by the load (ie, “break-even” price)
 - The probability of being turned down, ie, likelihood of AS deployment
 - The opportunity cost of being obligated to run to provide AS rather than liquidating energy at a high RTM price
- **Historical deployment (hourly, seasonal) is approximately 15% for REGUP and <1% for RRS, NSPIN**
- **Without real-time co-optimization of energy and AS, AS awards are physical obligation to provide (beware of SASM). AS Bids are submitted in DAM, but energy settles in RTM**

Illustrative Example
Breakeven Price = \$100/MWh

Hour Ending	AS Award	AS Price	RTM Energy Price
6	RRS	2	20
7	REGUP	500	50
8	RRS	2	20
9	NSPIN	2	30
10	NSPIN	2	35
11	RRS	2	40
12	RRS	10	45
13	NSPIN	10	50
14	RRS	15	55
15	NSPIN	25	60
16	RRS	25	80
17	-	-	120
18	-	-	250
19	-	-	180
20	NSPIN	10	50

Green Hydrogen is a Significant Controllable Load Opportunity



Large Consumers of Power

By 2025, an additional 3,205 MW of electrolyzers dedicated to green hydrogen production will be deployed globally, representing a 1,272% increase



Enabling Reduced Emissions Footprint

Electrolysis itself does not produce any emissions other than hydrogen/oxygen



Individually Controllable

Modular electrolyzer design allows more flexibility and turn-down to avoid high prices and provide ancillary services



Consistently Use Power

Steady power draw means units can respond to grid signals in real-time



Interruptible

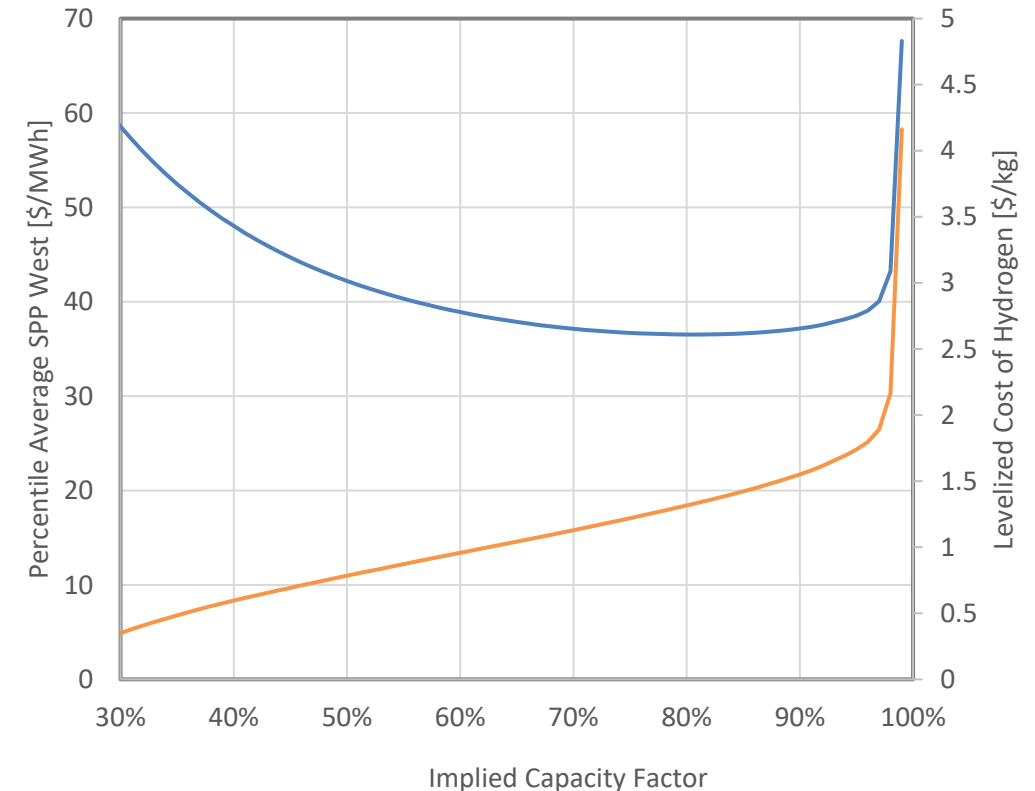
Electrolyzers can be turned down without significant impact to energy intensity

Hydrogen Production as a Controllable Load

Operating Hydrogen Electrolyzers as Controllable Load Resources Greatly Reduces the Cost of Production



- We have identified two electrolyzer technologies that have operational characteristics to be controlled as a CLR (PEM, AEM)
- The combination of providing AS (earning revenue) and responding to real-time prices (avoiding costs) can make green hydrogen cost competitive with conventionally produced hydrogen on a levelized cost basis, especially with PTC
- High frequency of negative/low electricity prices allows green hydrogen to be cost-competitive even with lower capacity factors (70-90%, see chart right)
- Smart Response can be used to match green hydrogen production with zero carbon energy production



- Off-take Problem: end-markets and transportation infrastructure are not present at scale
- Coastal export-oriented projects don't benefit from as high occurrence of negative pricing, require economies of scale
- Inland projects may benefit from lower electricity costs, but transportation cost/capacity is a limiting factor
- Green Ammonia is a viable solution to the off-take problem, as storage, transportation, and markets for ammonia already exist, and markets for ammonia are coincident with low electricity prices in much of the US. However...
- Seemingly attractive pricing nodes throughout Middle America do not have the transmission/distribution capacity available for MW-scale loads
- New interconnections increase both cost and timeline for loads
- Regulated service territories can't generally offer rate structures needed for green hydrogen economics to pencil out
 - Tend to offer fixed rates with no/limited exposure to the wholesale market
 - IOUs need to file rate case for new rate structures
 - Co-ops, non-profit by definition, have little incentive to enter novel commercial agreements that could incur additional costs to their other owner-customers