Long-term Procurement for Decarbonization and Reliability

Lessons from 20 years of deregulated power markets in the US

Chris Seiple, December 2021 – Grid Edge Innovation Series

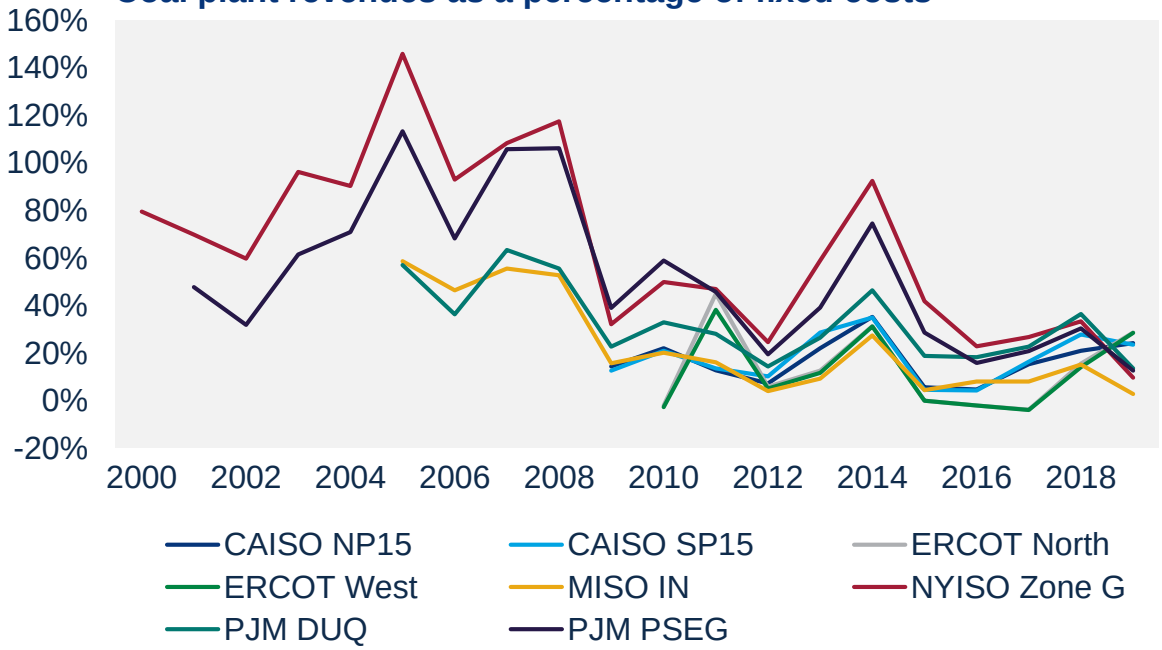
Wood Mackenzie
A Verisk Business

Contents

1. Historic returns on merchant power sector investment

Since 2009 no new coal plants would have earned an adequate return on capital in any market of the US.

Coal plant revenues as a percentage of fixed costs*

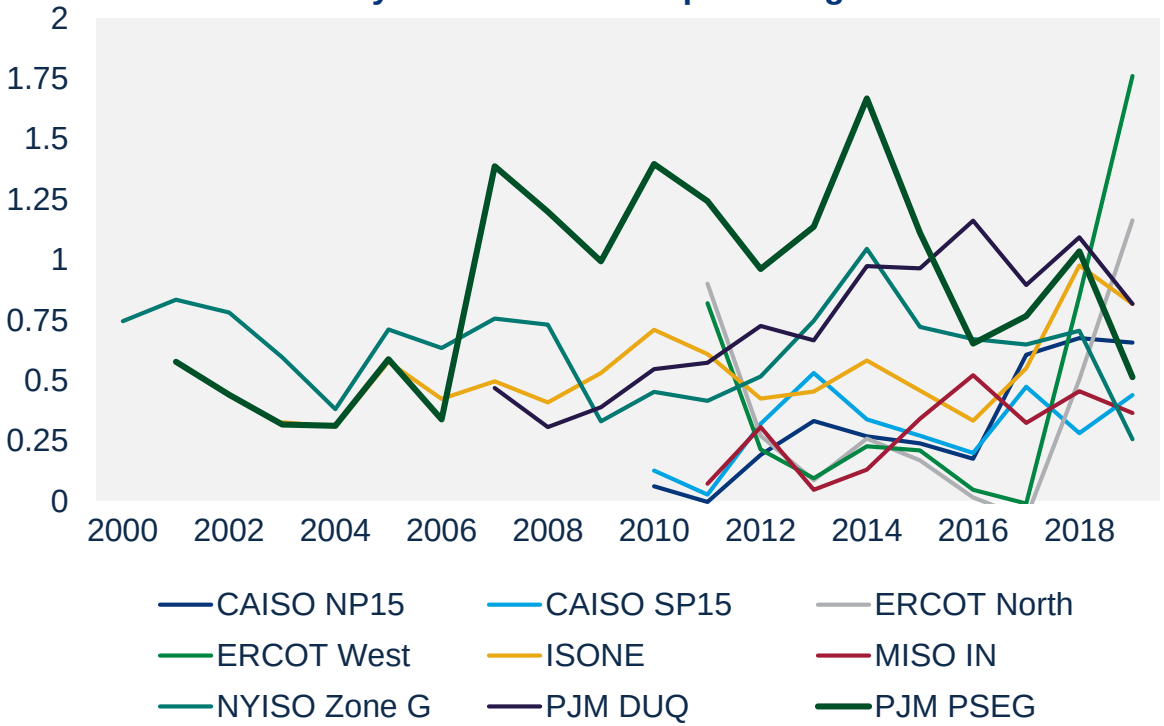


- Over the 2004 to 2008 time period returns on new coal plants in only two regions where there are not many coal plants were positive.
- On average, over the past decade a new coal plant would have recovered only 20% of its overall fixed costs
- These economics resulted in the bankruptcies of Longview Power and Energy Future holdings, which were some of the only merchant coal plants built during this time frame

Source: Wood Mackenzie
*Note: Fixed costs include operating and maintenance expenses, debt service, taxes, and an adequate return on equity. Revenues include energy and capacity payments

Gas combined cycle results have been more mixed, but still PJM-PSEG is the only region providing adequate returns on investment for new plants

Gas combined cycle revenues as a percentage of fixed costs



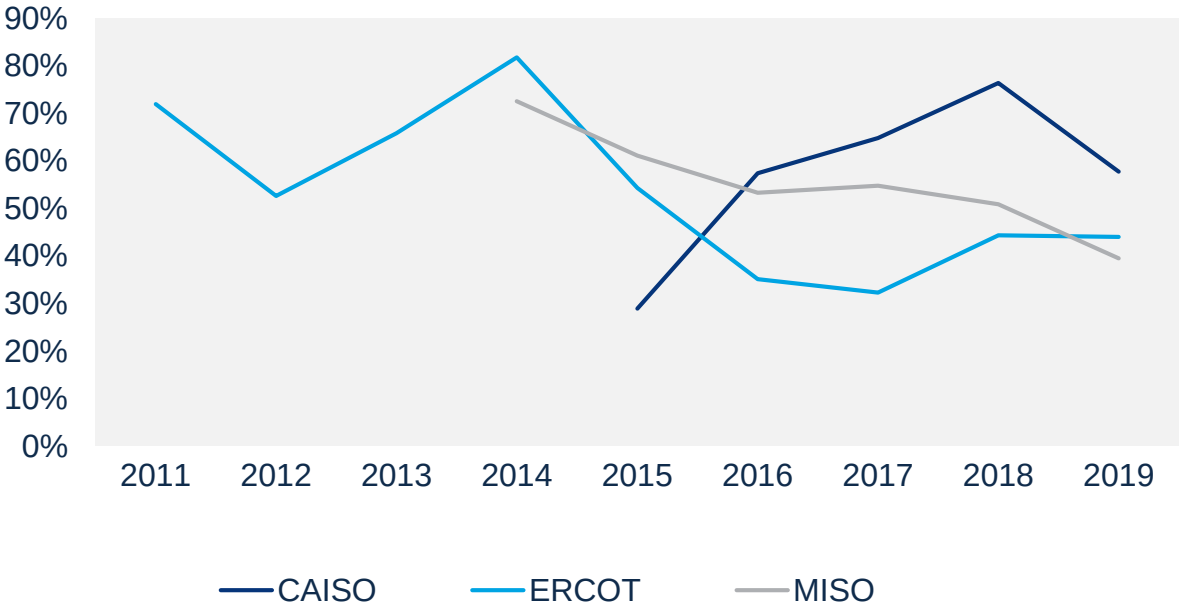
- Over the past decade, in PJM-PSEG a new CC would have earned 105% of its overall fixed costs.
- Except for PJM, in all other regions the new CC would have average recovery of 40% of its total fixed cost
- Trends are largely the same for combustion turbines

- Take a look at regions where PJM plants were recently built

Source: Wood Mackenzie

New wind plants would also not be profitable if they had been dependent on market revenues

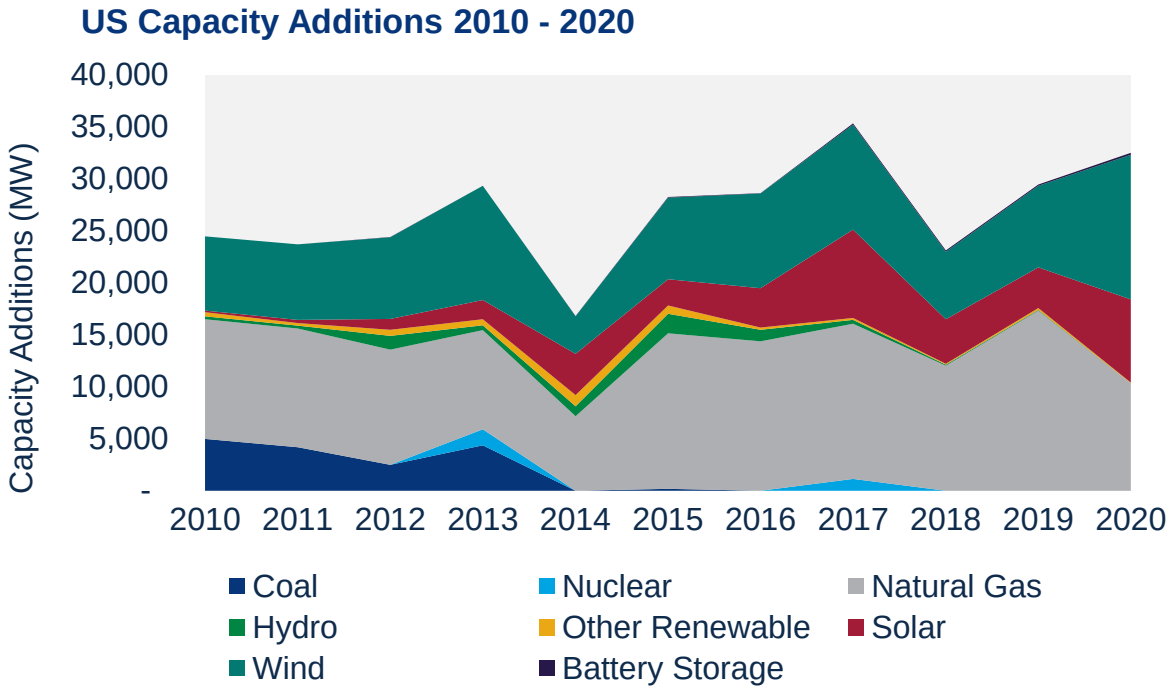
Wind plant revenues as a percentage of fixed costs



- Wind plants have earned an average of 50% of their overall fixed costs back from the market
- Declining costs over this time period have been offset by lower revenues as wind penetration levels grow and congestion has became a more significant issue.
- As individual plant data is not publicly available, the analysis is based on hourly output data at a few plants that are monitored by Wood Mackenzie using our electromagnetic field monitors.

Source: Wood Mackenzie

Despite wholesale power prices being inadequate to support new plants, the US has continued to build new power plants



- Over the past decade, 130 GW of new gas and 16,000 MW of new coal plants have been added to the grid, despite wholesale prices being inadequate to support this investment in all regions except for PJM.

Source: Wood Mackenzie

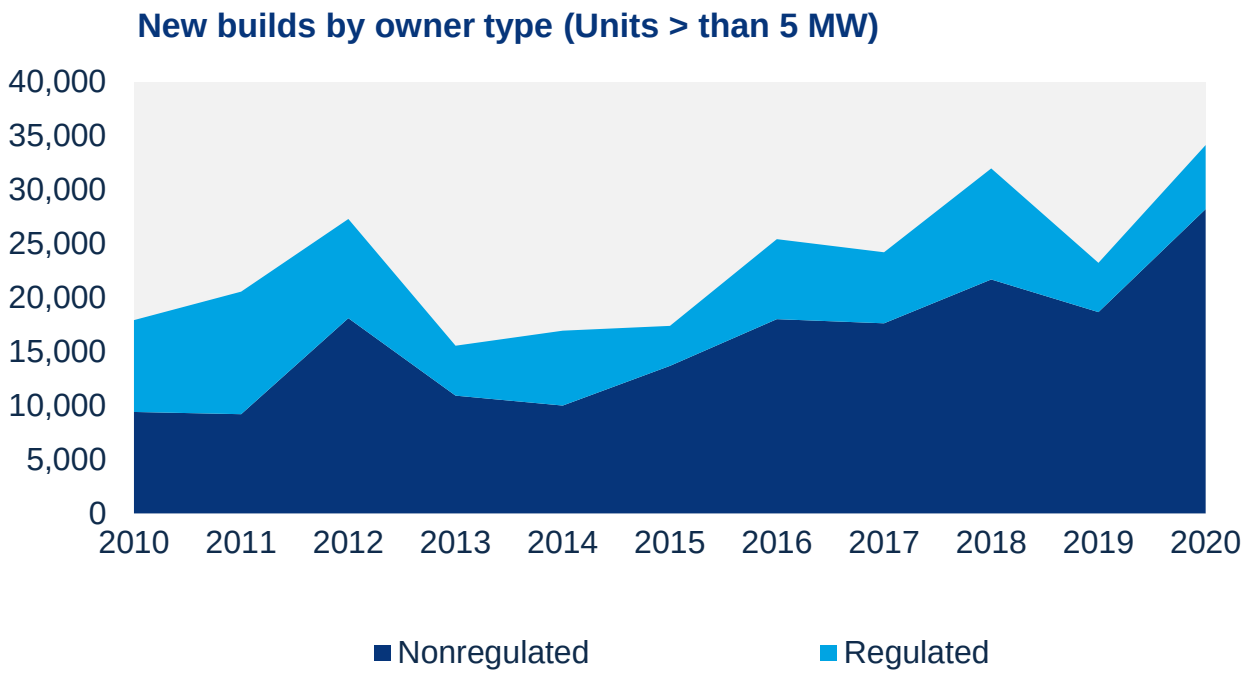
2. How has new investment come into the generation sector with inadequate price signals from the wholesale market

Summary of factors bringing new investment into the power sector despite wholesale power prices that do not support such investments

- Building of new plants by regulated companies that get cost recovery through the regulatory process
- States offering targeted long-term PPA's for new capacity which are only open to new generators to fulfill, not existing generators. And then passing the costs for the new capacity on to retail customers, even in states with deregulated retail markets. (Nuclear in UK)
- Policy mechanisms to support growth of renewables, that result in either long-term purchase power agreements with utilities or provide additional revenues through renewable energy credits
- Corporate buyers seeking to decarbonize their operations willing to pay a premium to wholesale power market prices for new renewable supply
- To a much lesser degree, companies and investors betting on an optimistic scenario for the future which doesn't actually materialize

Source: Wood Mackenzie

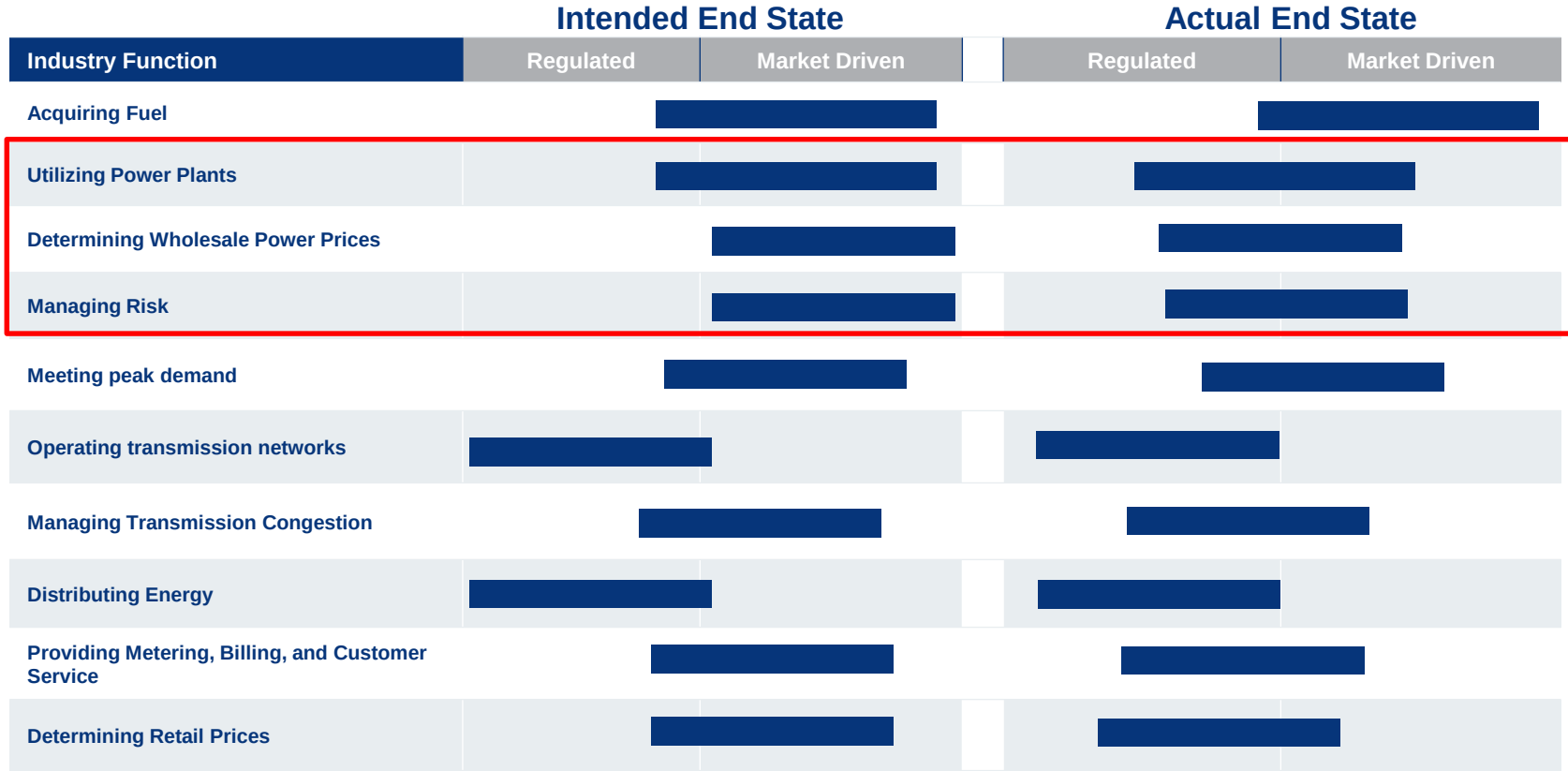
Over the past decade, 30% of capacity added to the grid has been added by regulate owners



- While overall 30% of capacity added to the grid over the past decade has been added by regulated owners, only 12% of renewables have been built by regulated owners
- 75% of the additions by regulated owners took place in the Midwest, Southeast, and WECC

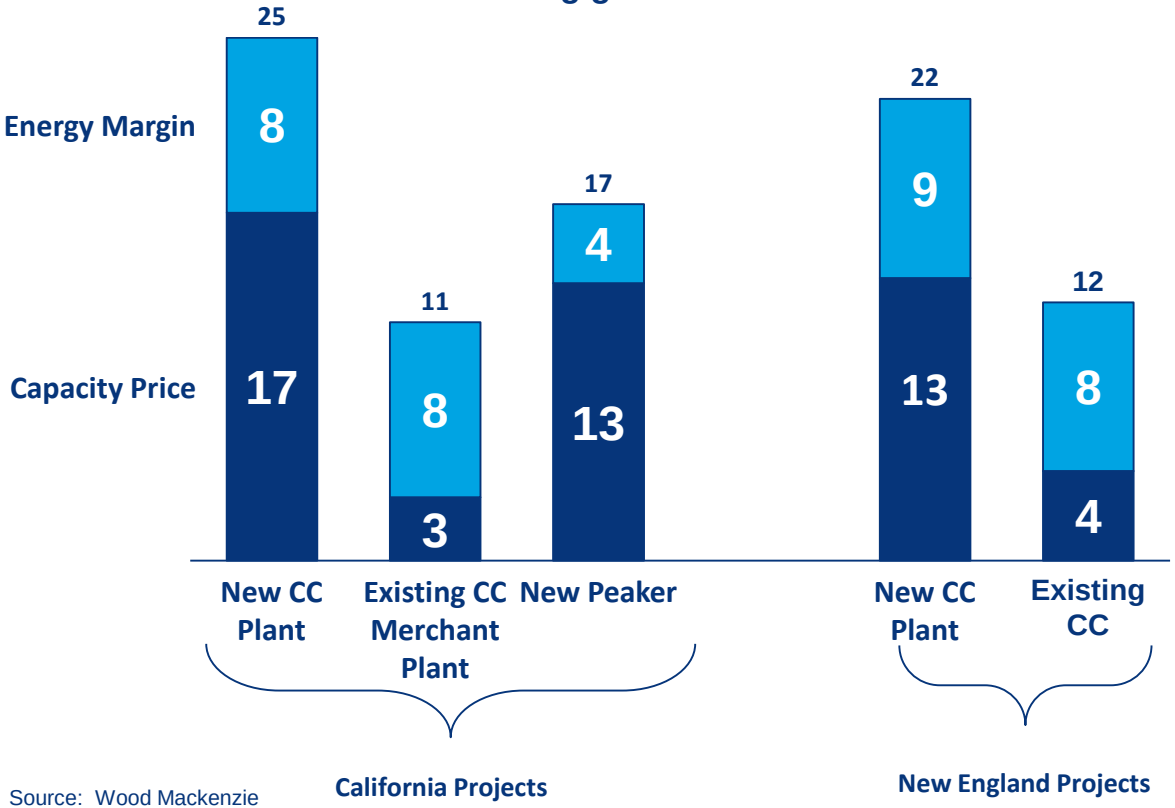
Source: Wood Mackenzie and Velocity Suite.

The effort to deregulated US markets got stuck halfway in between a regulated and deregulated market structure



In “deregulated wholesale markets”, we’ve seen differentiated pricing for new capacity versus existing capacity

Economics for new versus existing generation ~2010 time frame

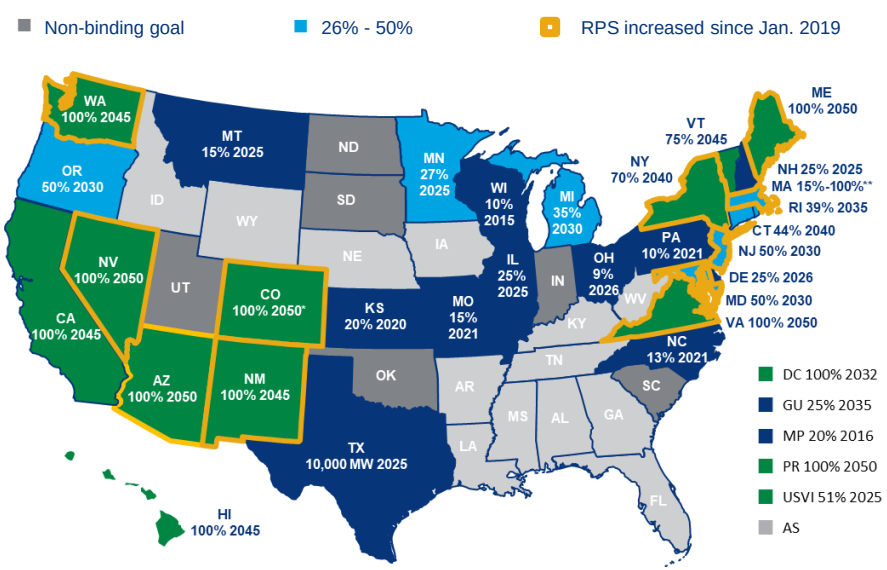


- State led resource procurements offering PPA’s for new capacity, but not allowing existing capacity to bid has been one way new capacity has gotten built
- The long-term contracts offered have been at prices nearly twice the level of revenues received by existing generators
- In the case of New England, the CT DPUC estimated building the new capacity would save CT ratepayers $509 million by reducing energy and capacity prices
- In the case of California, the process is more subtle but the result is also ensuring some level of oversupply

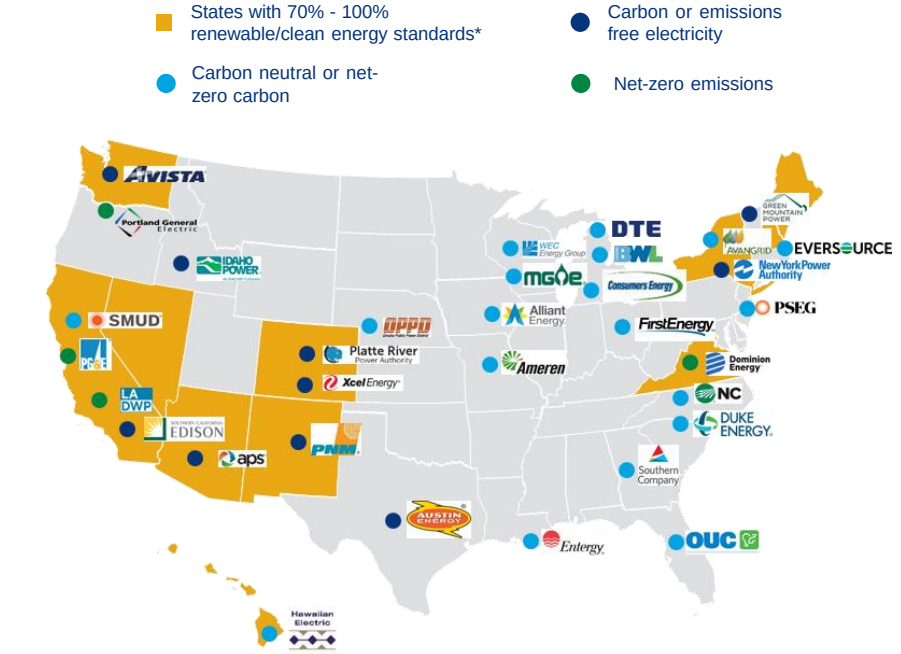
Source: Wood Mackenzie

Renewable mandates also offer separate pricing mechanisms for new capacity

Renewable and clean energy standards by state

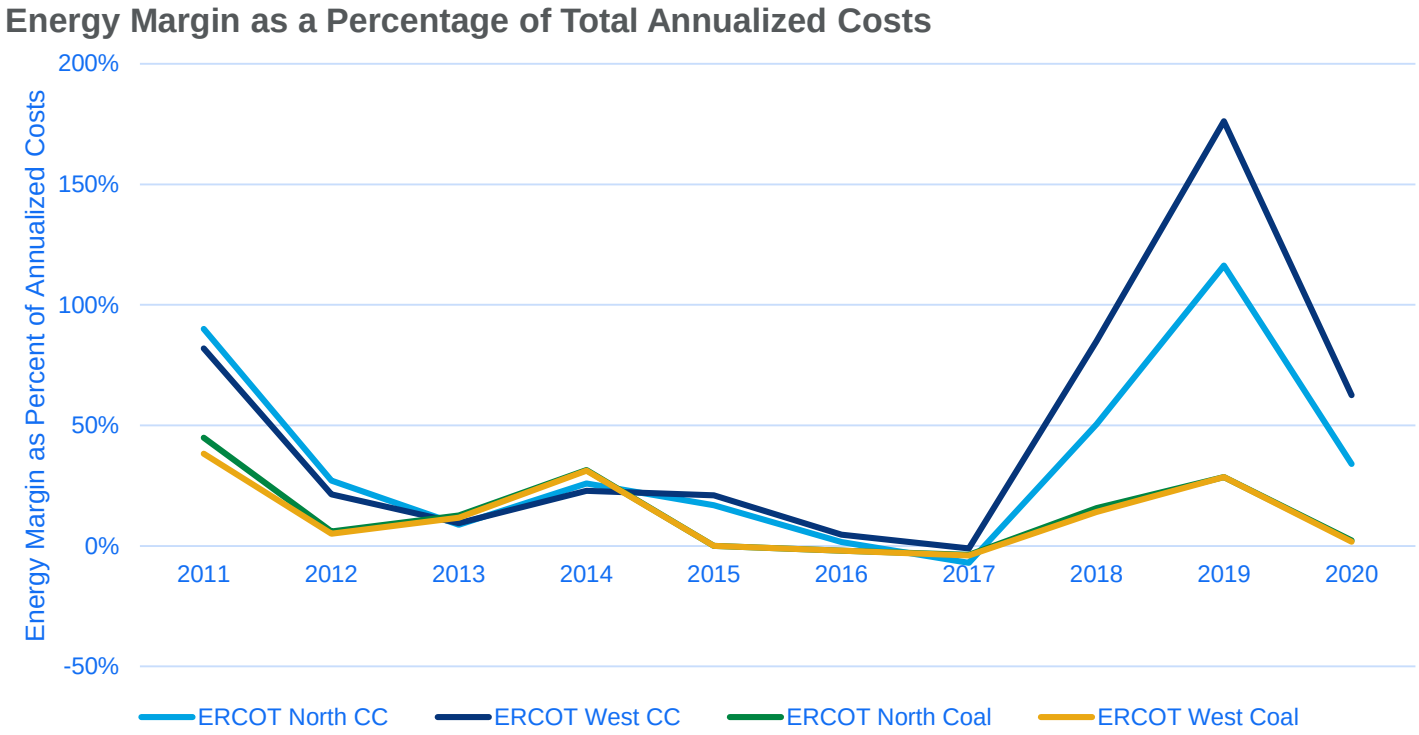


33 utilities with 100% carbon or emissions free goals



Source: Wood Mackenzie; Smart Electric Power Alliance (SEPA)
*CO goal of 100% clean energy requirement for qualifying retail utilities with 500k customers or more
**MA goal of 15% renewables by 2020 and an additional 1% each year after

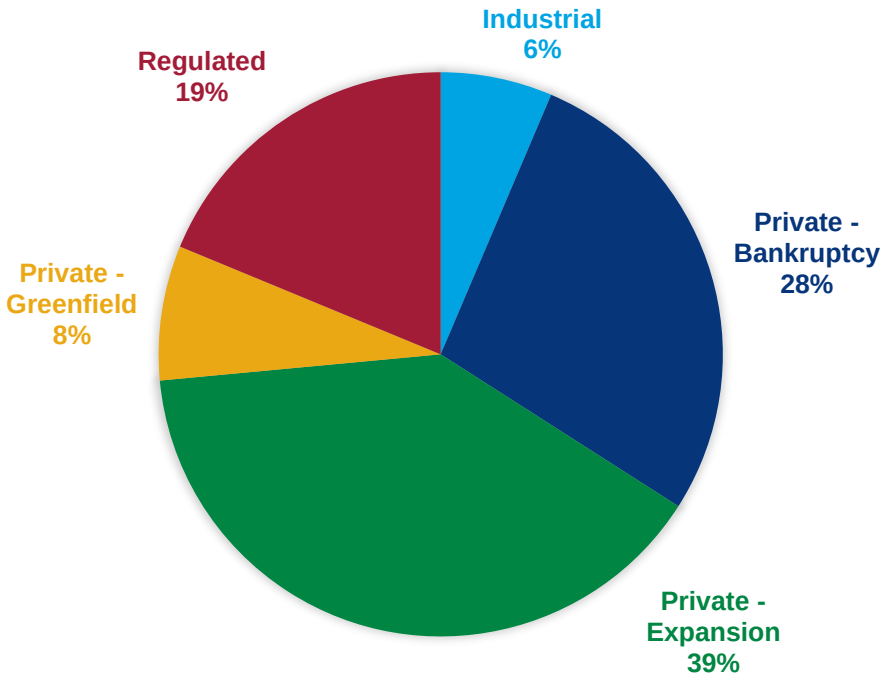
ERCOT Deep Dive: In all years of ERCOT market operation except 2019, energy revenues were insufficient for a new generator to earn an adequate return on capital



Source: Wood Mackenzie

In the case of ERCOT, investors betting on “the rosy scenario” also contributed to the low margins and resulted in bankruptcy for the investors

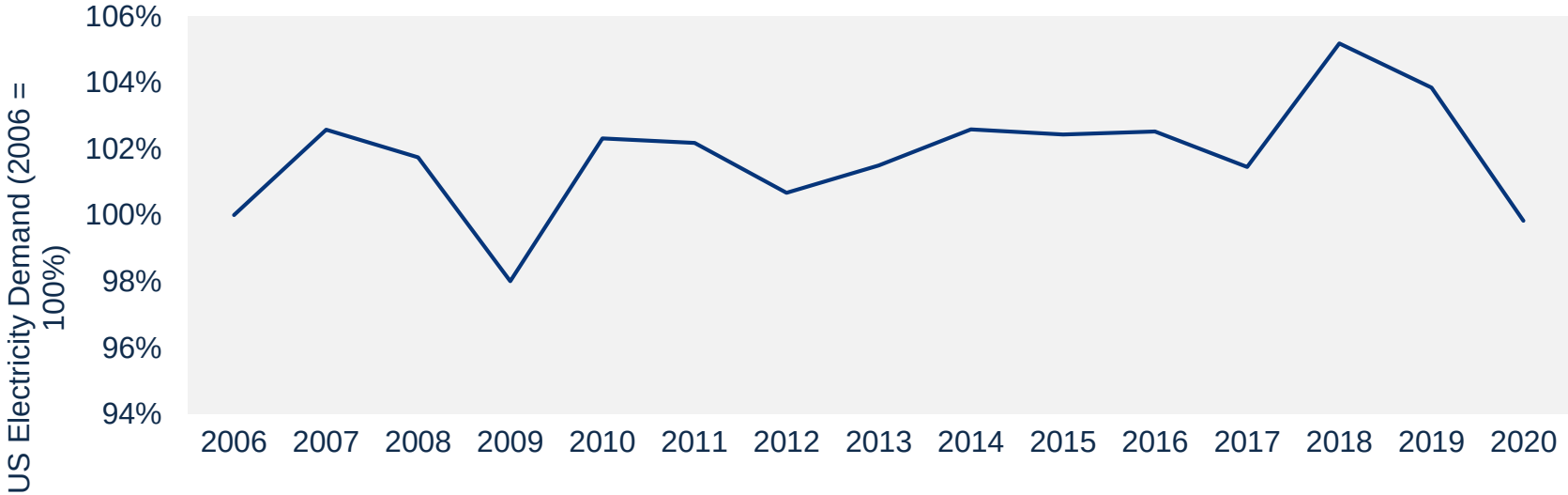
CC and CT New Builds by Owner Type Since Start of Nodal Market in ERCOT



- Vast majority of wind and solar resource additions over the past decade have benefited from purchase power agreements
- Building by munis and cooperates has continued, not dependent on recovering their costs from the market
- In addition to bankruptcies of newly built plants, market conditions helped to contribute to ExGen Texas Power write down and Energy Future Holdings bankruptcy
- Financial performance of additional new capacity is not known due to assets either being privately held or integrated in larger portfolios of assets

Source: Energy Velocity and Wood Mackenzie

Electricity demand is not growing, so new capacity has a greater chance of creating oversupply and depressing prices for existing capacity



Source: Wood Mackenzie

3. What lessons does this provide for the future

Many of the factors in place over the past 20 years will still be in place in the future

- **Building by Regulated Utilities** -- Little political drive or support to further deregulate electricity markets currently
- **Differentiated pricing for new versus existing capacity** -- In such a capital intensive industry with political sensitivity, where the overall costs are much higher than the short-term marginal cost, substantial customer and political benefit exist for offering differing prices for new versus existing capacity to keep prices lower
- **Mandates to drive further renewable penetration and new builds supported by corporate buyers** -- There will be a continued drive to add supply, not because of growing demand, but to replace existing generation to decarbonize power portfolios. This by definition will help drive oversupply in the market.
- Things that might be different: (1) growing demand; (2) State REC program

Not all markets are created equal: Factors influencing market rules and risks

	NEPOOL	PJM	California	New York	ERCOT	Florida	Colorado
Multi-State Market	✓	✓					
Retail prices not driven by wholesale prices						✓	✓
Incumbent utilities own merchant generation		✓			✓		
Strong, politically connected IPP lobby		✓	✓	✓			✓
ISO supportive of fair and non discriminatory market	✓	✓			✓		

- Would a federal clean energy mandate or SREC program change this

Source: Wood Mackenzie

Key Implications

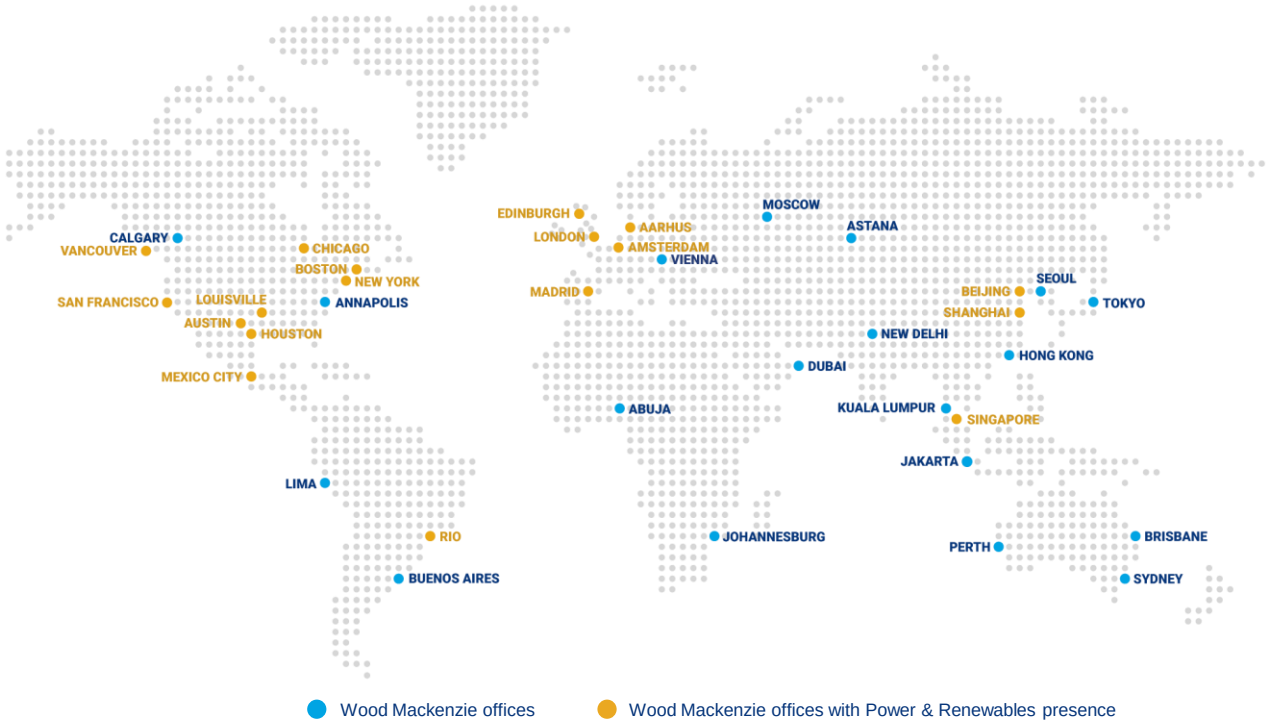
- Efforts like Order 2222 remain incredibly important to help define and provide an avenue for revenue generation for grid edge related investments
- Equally important is a political advocacy strategy that pushes for programs that provide a reliable revenue stream over prolonged periods of time for capital intensive investments
- The investments that focus the most on end use customer value, or take advantage of new rules related to monetizing the value of deferring distribution investment, may prove most resilient.
- It’s dangerous to assume that future wholesale market prices will be based on prices required to incent new investment in the power sector. High probability that there remains some level of differentiation between “new” and existing capacity.

About Wood Mackenzie

We provide commercial insight and access to our experts leveraging our integrated proprietary metals, energy and renewables research platform.

Wood Mackenzie is ideally positioned to support consumers, producers and financers of the new energy economy.

- Acquired Genscape, MAKE and Greentech Media (GTM)
- Leaders in the energy transition and cross-commodities
- Over 600 sector-dedicated analysts and consultants globally
- Located close to customers and industry contacts



Defining America's DER Footprint

Scoping the Size, Dynamics, and FERC 2222 Impact

Ben Hertz-Shargel, December 2021 – Grid Edge Innovation Series

Wood Mackenzie
A Verisk Business

Key takeaways

1. DERs will make up 41% of capacity additions from 2022-2026, almost all of which is zero-carbon
2. Government and infrastructure investors hold key levers to the success of DERs and electrification
3. DERs participate as emergency capacity today, but must transition to economic participation to support the energy transition
4. Commercial-scale resources are the likely benefactors of FERC Order 2222, with residential and DR resources largely left behind

Agenda

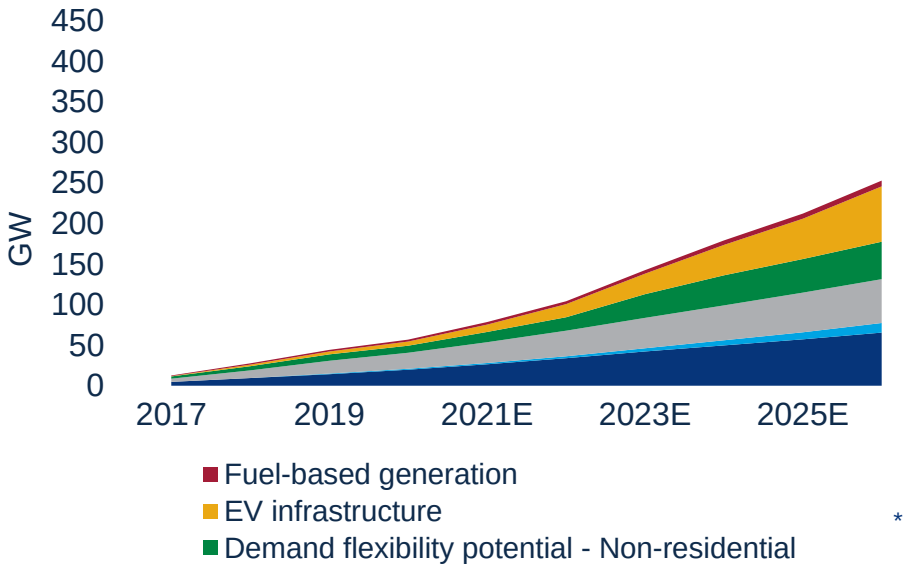
1. The DER market: Size, opportunities, and risks
2. Transition from emergency to economic flexibility
3. FERC Order 2222 impact

1. The DER market: Size, opportunities, risks

175 GW of new DER capacity and flexible demand potential will be deployed from 2022 to 2026, 41% of total capacity additions

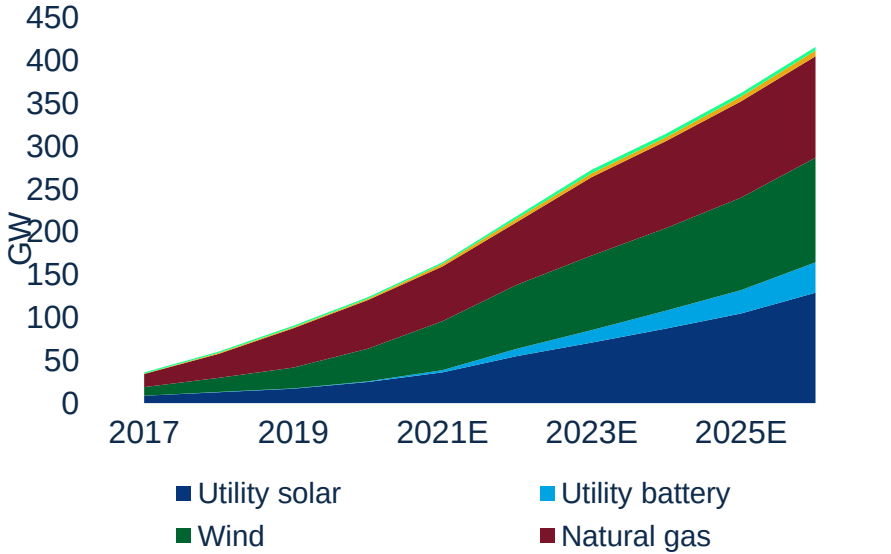
23% of total capacity additions over this period will come from distributed solar and EV infrastructure

US DER capacity by DER type (2016-2026E)



*

US bulk generation capacity additions by fuel type (2017-2026E)

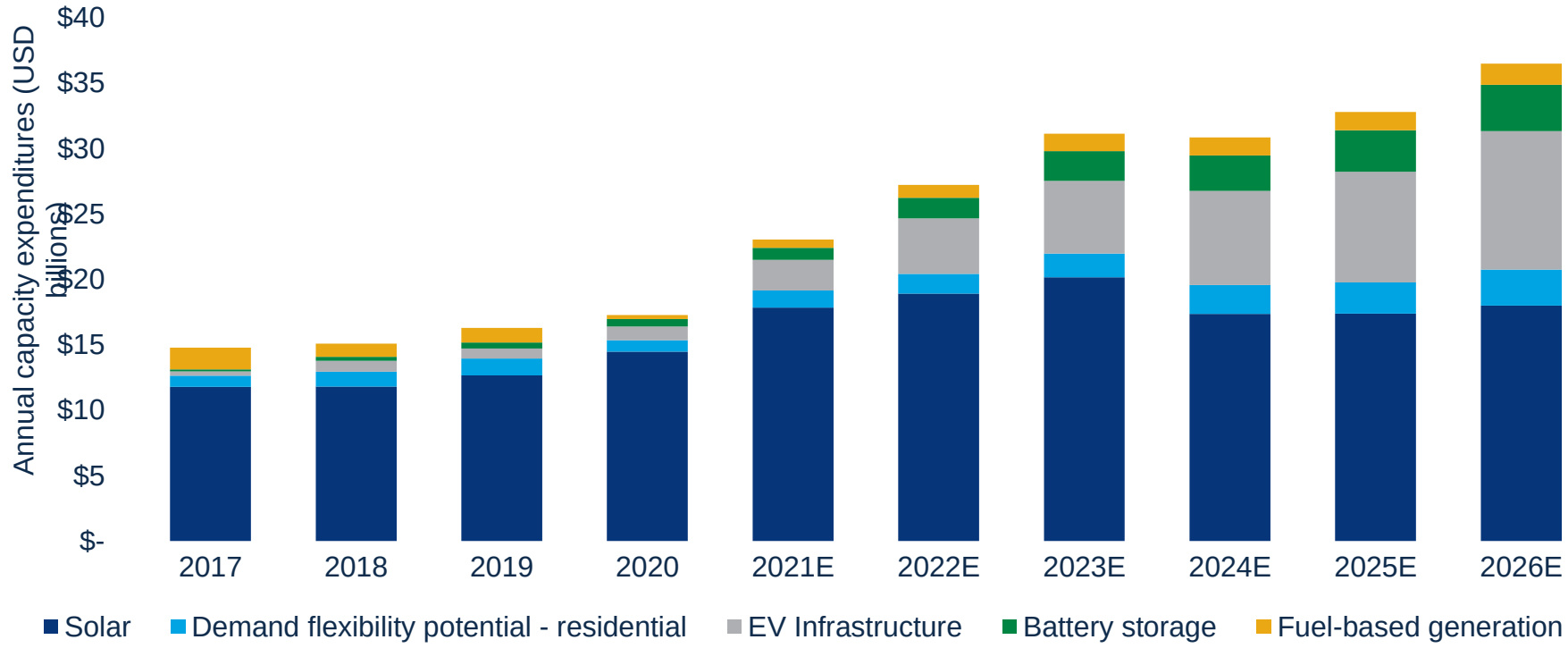


Source: Wood Mackenzie Energy Storage Service, Grid Edge Service, US Distributed Solar Service, and North American Power Service

From 2021E-2026E, cumulative capital investment in DERs will reach $181 billion

Commercial EV infrastructure, residential battery storage and smart thermostats will push spending to a new peak in 2026

Annual capital expenditure by resource, 2017-2026

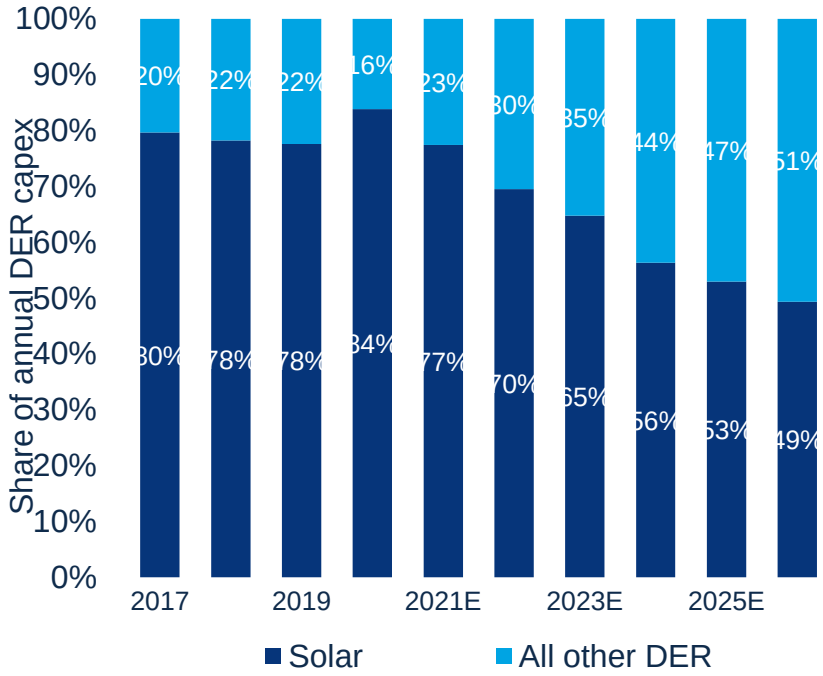


Source: Wood Mackenzie Energy Storage Service, Grid Edge Service, and US Distributed Solar Service

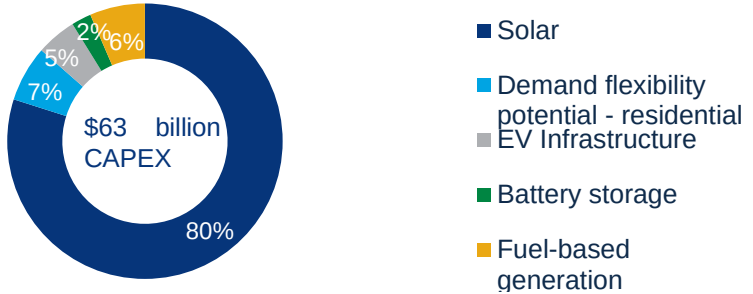
Investment in DER will diversify as non-solar DER installation grows

Capital expenditures on solar will contract to 49% of the DER market by 2026

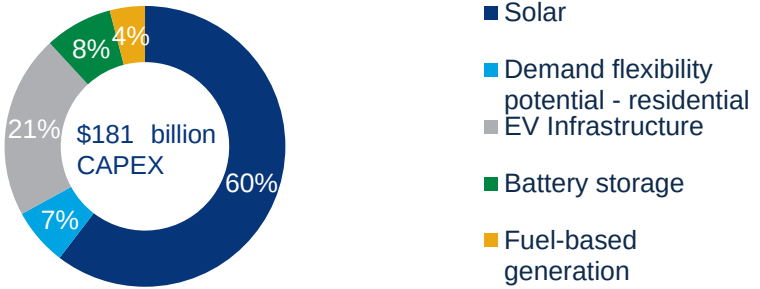
Annual capital expenditure by resource, 2017-2026E



Share of capital expenditures by resource, 2017-2020



Forecasted share of capital expenditures by resource, 2021E-2026E



Source: Wood Mackenzie Energy Storage Service, Grid Edge Service, and US Distributed Solar Service

Government incentives and regulation offer the DER market a steady path through economic and environmental uncertainty

Opportunities

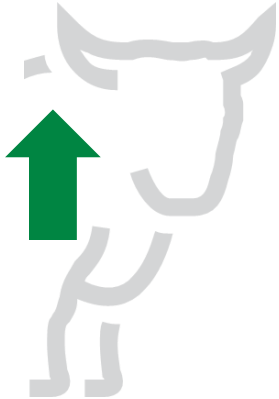
1. Federal and state incentives
2. Readiness of climate and infrastructure capital
3. Enactment of beneficial FERC Order 2222 reforms
4. Extreme weather
5. Expansion of BYOD and DR pre-enrollment in utility programs
6. Integration of DER, connected home, and energy markets

Risks

1. Persistent inflation or other COVID economic effects
2. Saturation of hosting capacity
3. FERC Order 2222 entrenchment of barriers
4. Resilience fears drive generator rather than zero-carbon DG demand
5. Phase-out of net metering and reduced energy export rates

Source: Wood Mackenzie Energy Storage Service, Grid Edge Service, and US Distributed Solar Service

Electrification faces technology and execution risks, while a prolonged global energy crunch presents both opportunity and risk



Opportunities

1. Federal and state incentives
2. Global fuel scarcity
3. Readiness of climate and infrastructure capital
4. Building energy and appliance codes
5. Electric space and water heating demand response programs
6. Unification of dynamic EV rates and managed charging programs

Risks

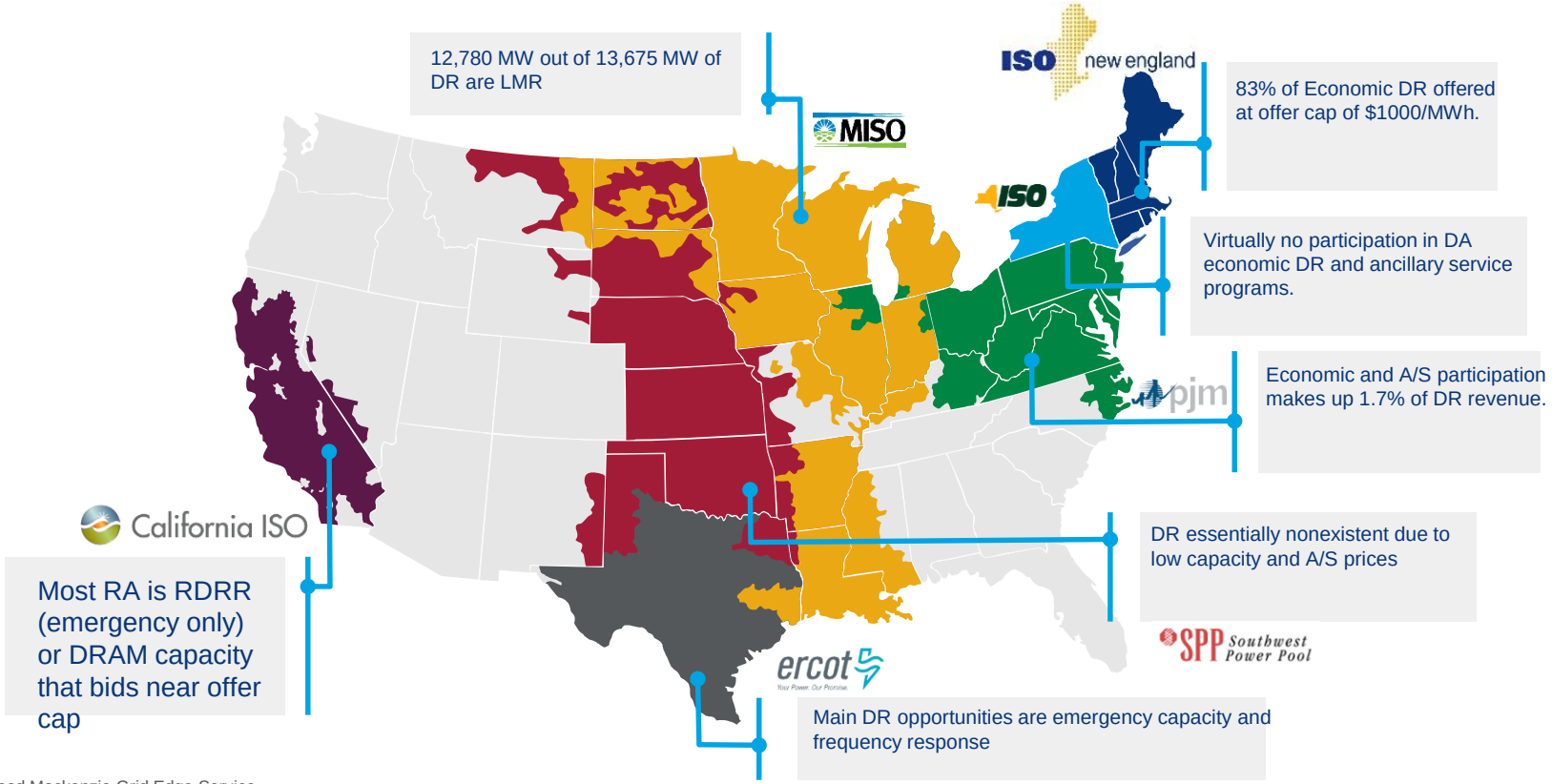
1. Failure for heat pumps to come down the cost curve
2. Lack of customer education on upfront cost vs TCO
3. Return to low natural gas prices
4. Fragmented and unprofitable charging networks
5. Supply chains and production limitations
6. Failure of aging utility infrastructure

Source: Wood Mackenzie Energy Storage Service, Grid Edge Service, and US Distributed Solar Service

2. Transition from emergency to economic flexibility

DERs today participate in wholesale markets as emergency demand response

Restricted to DR participation, DERs are unwilling or unable to participate economically



Source: Wood Mackenzie Grid Edge Service

Transition from emergency to economic flexibility will be key to decarbonization

Customers stand to reduce costs while accommodating increased renewables and electrification

Factors driving urgency for economic participation

1 Supply intermittency

- 37% renewable penetration in 2030
- Day-ahead forecasting errors and production swings in real-time.
- Reliance on high cost and carbon-intensive reliability unit commitment and peaking capacity

2 Hosting capacity

- Transmission and distribution hosting capacity constraints
- 750 MW of generation capacity and 200 GW of storage in RTO interconnection queues today
- Queue times averaging 3.5 years.
- Simple rules of thumb to determine hosting capacity

3 Electrification

- 65 TWh of incremental building heat electrification by 2030
- EV charging peak load contributions of 1 GW in PJM and >2 GW across WECC

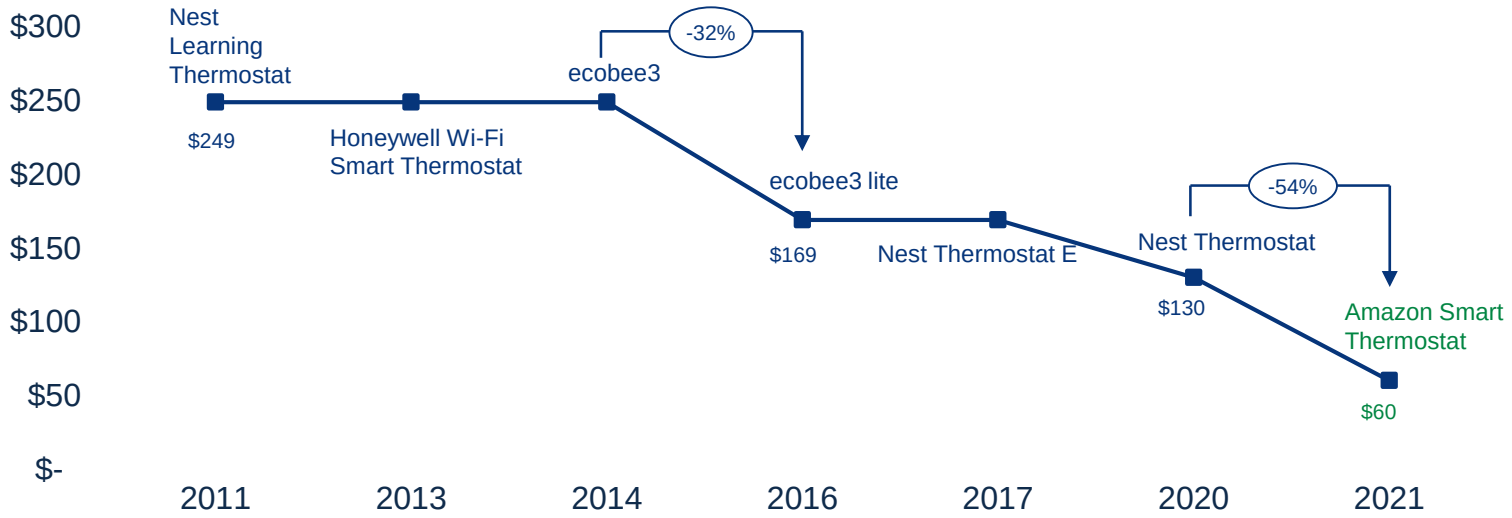
4 Reliability

- DERs invoked only when shortage conditions are imminent
- Economic participation prevents shortage conditions from developing

Source: Wood Mackenzie Grid Edge Service; LBNL, *Queued Up*, May 2021

Amazon Smart Thermostat offers tremendous potential for residential demand flexibility

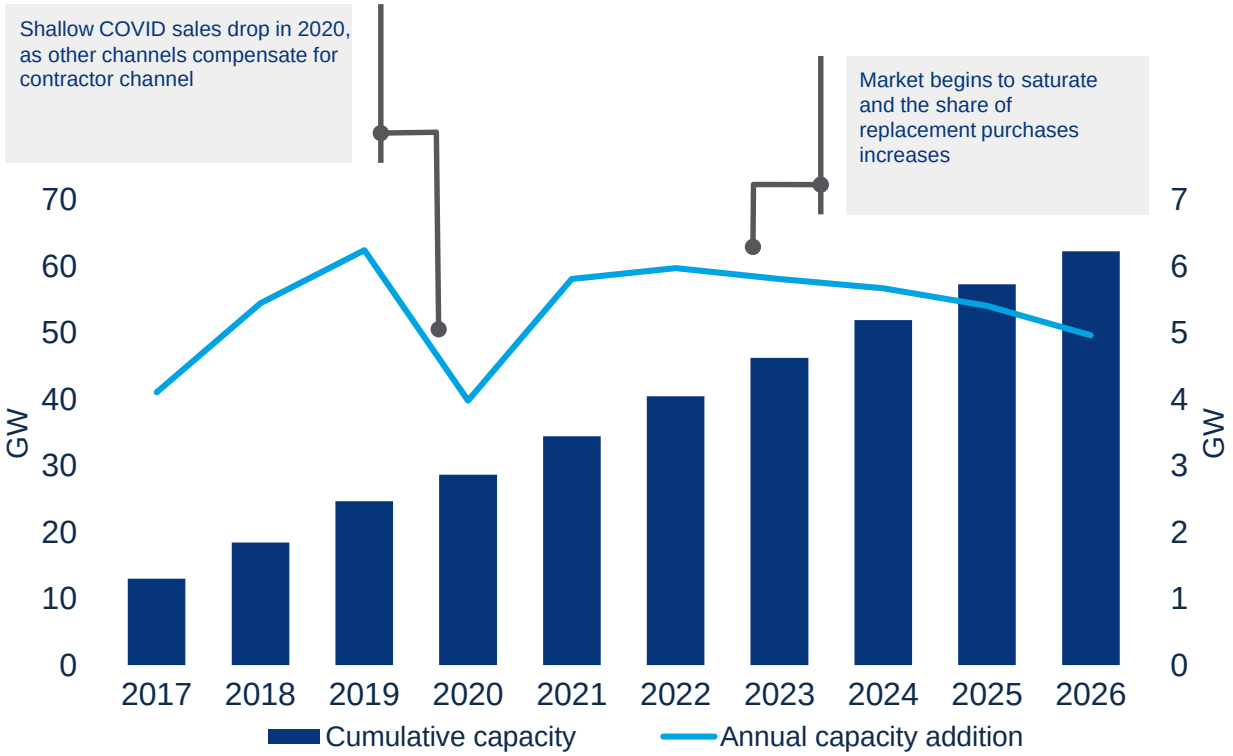
Smart thermostat minimum cost



Source: Wood Mackenzie Grid Edge Service

Flexible capacity from smart thermostats reaches 62 GW by 2026

Cumulative and annual flexible capacity



Flexible capacity per device will decrease through 2026

1. Lasting work-from-home behavior
2. Dispatch based on net peak load, rather than gross peak load.
3. Increased frequency of net peaks and therefore dispatch

Flexible capacity will begin increasing by 2030 in northern regions as grids become winter-peaking

Source: Wood Mackenzie Grid Edge Service

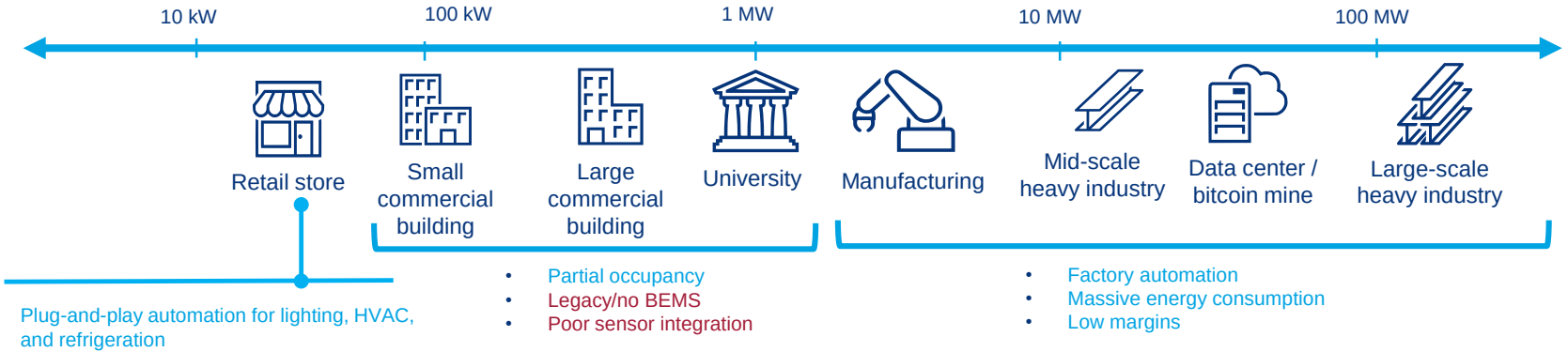
Commercial economic demand flexibility can ride the wave of ESG and resilience-driven solutions

The diversity of C&I flexibility needs will support a diverse ecosystem of solutions and providers

Drivers of C&I demand for flexibility solutions

Revenue **Resilience** **ESG**

Varying scales and opportunities for economic flexibility



Source: Wood Mackenzie Grid Edge Service

Competition to provide C&I flexibility solutions grows dramatically

Microgrid developers to software pure-plays will compete for market share, with differing capabilities and sales channels

Asset development

Asset operation

Segments

DER developers
- Focused on developing and operating integrated projects

Energy solution providers
- Manage large wholesale market portfolios, but look to develop integrated energy and asset solutions on-site

Energy retailers
- Start from energy procurement relationships and look to upsell on solutions

Aggregators
- Specialize in managing large portfolios of C&I sites, managing but not developing onsite assets

DER operators
- Software pure-plays, specializing in asset optimization to maximize multiple on- and off-bill value streams

A global competition for the US market

Global player	Subsidiary
Centrica plc	Centrica Business Solutions
Enel	EnerNOC
Shell	MP2
LS Power	CPower
EDF Renewables	PowerFlex

Source: Wood Mackenzie Grid Edge Service

3. FERC Order 2222 impact

FERC 2222 aims to open markets for distributed energy resource aggregations

Tariff compliance areas

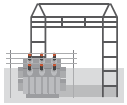
1. New **Distributed Energy Resource Aggregator** market participant model
2. New **Distributed Energy Resource Aggregation (DERA)** resource model
3. 100 kW minimum size
4. Locational requirements
5. Distribution factors and bidding parameters
6. Information and data requirements
7. Metering and telemetry requirements
8. Coordination between RTO, utility, aggregator, and retail regulatory authority
9. Modification to assets in an aggregation
10. Market participation agreements

FERC, Order No. 2222, Docket No. RM18-9-000

Likely key outcomes of FERC Order 2222

Meaningful steps forward, but key barriers and uncertainty remain

No DER left behind



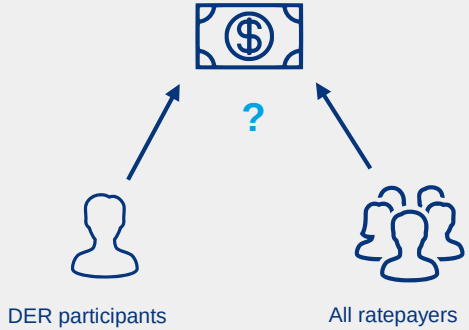
Easier interconnection

Bidirectional participation

Metering & telemetry a decisive hurdle

Uncertainty for utilities

- Reliability
- Execution
- Cost recovery



Commercial DERs are likely winners, residential and demand response losers

Winner

Commercial-scale resources

- ✓ Dedicated submetering
- ✓ Bidirectional participation
- ✓ Heterogeneous aggregations

Loser

Residential resources

- ✗ Participation tied to retail meter
- ✗ Single node restrictions
- ✗ Ancillary service limitations

Loser

Demand response / EE

- ✗ Lack of frequent dispatch baselines
- ✗ Lack of short-duration, seasonal capacity options
- ✗ Inconsistent treatment of EE as asset and LMI

The EV charging ecosystem

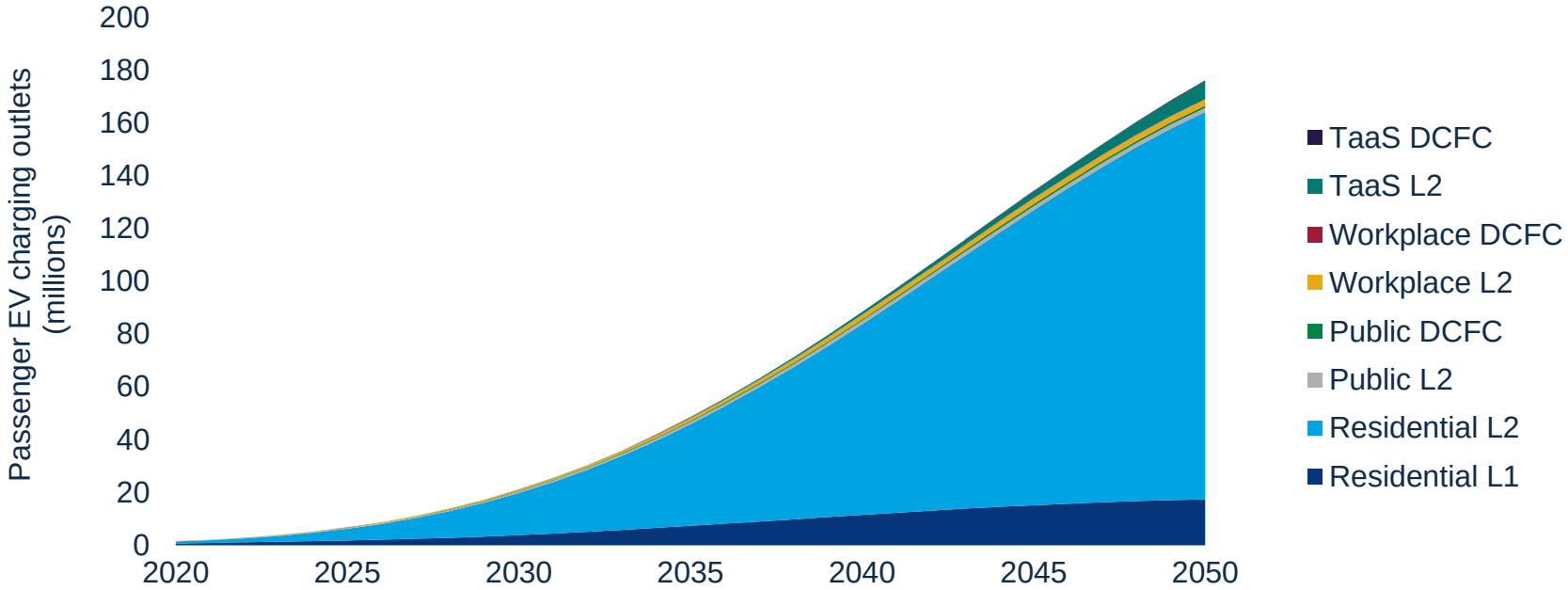
Grid Edge Innovation Series

Kelly McCoy, December 2021

Wood Mackenzie
A Verisk Business

Residential charging will continue to play a dominant role in EV charging, driven by cost, convenience and increasing multi-unit dwelling access

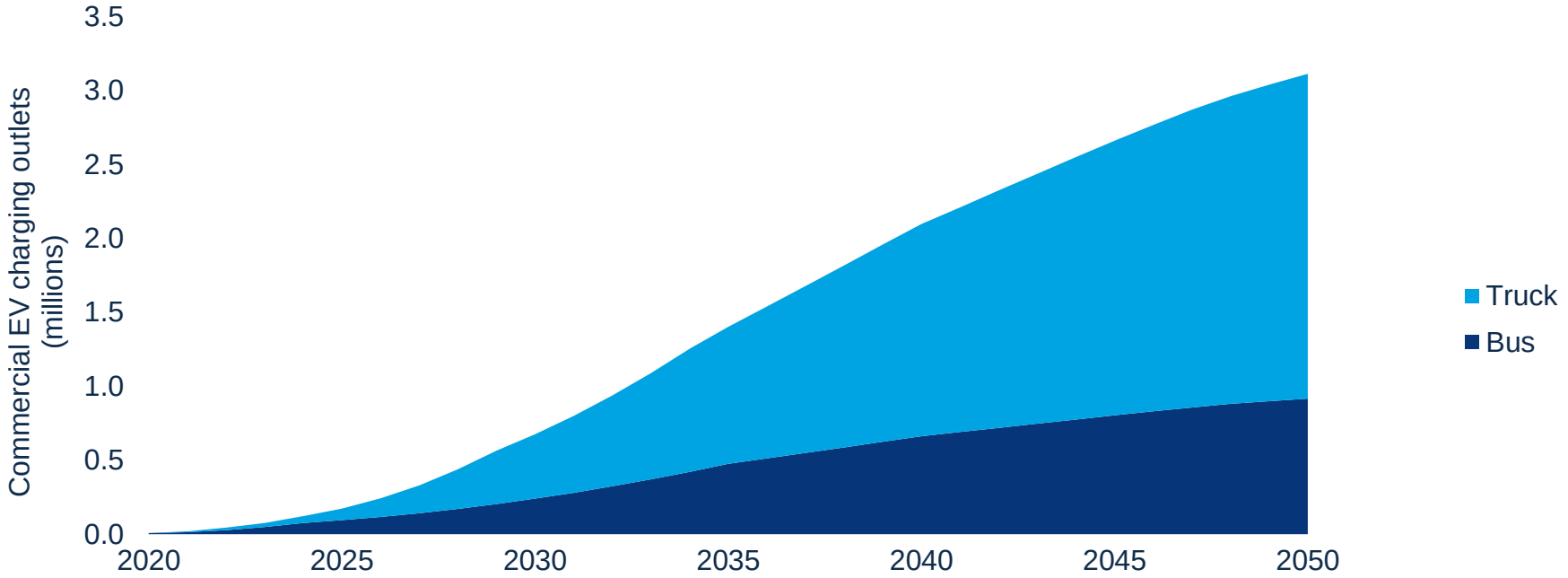
Cumulative passenger EV charging outlets, North America 2020-2050



Source: Wood Mackenzie Grid Edge Service. H1 2021 EV charging outlet forecast

Meeting commercial EV charging needs will require a greater variety of charging locations and technologies

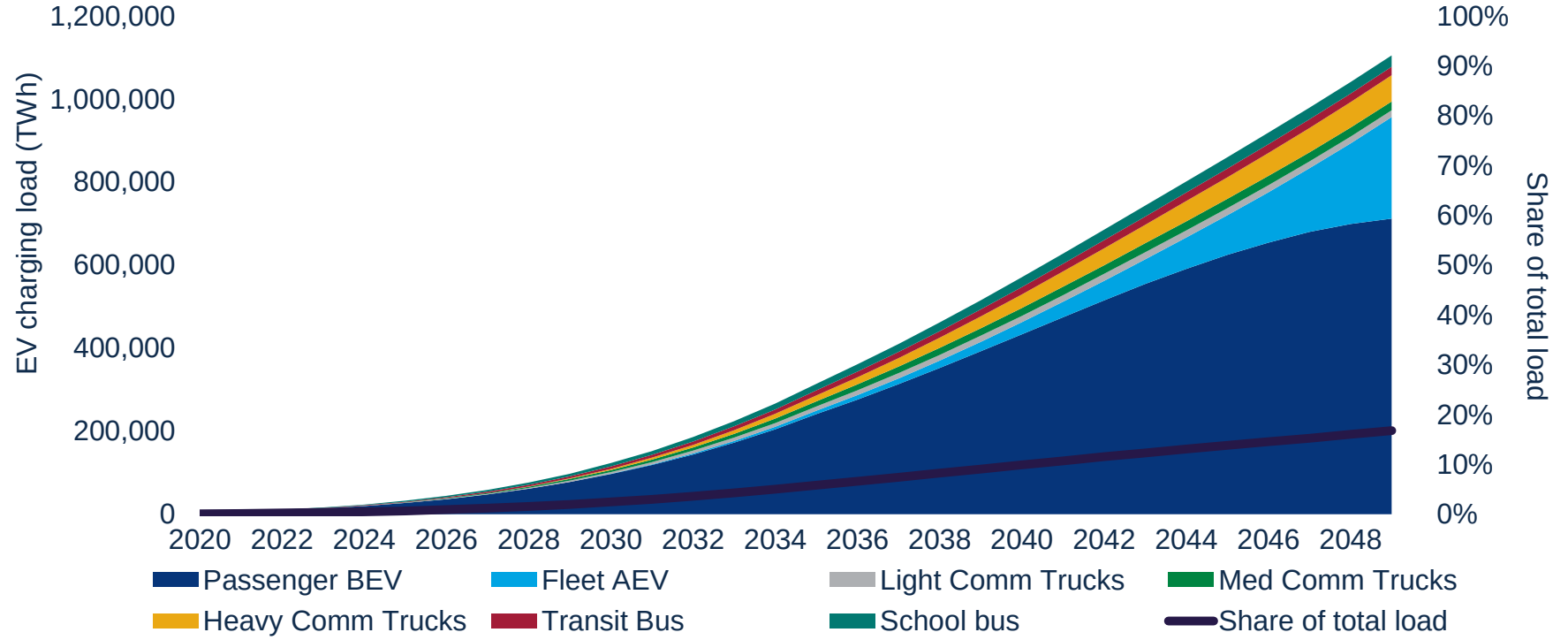
Cumulative commercial EV charging outlets, North America 2020-2050



Source: Wood Mackenzie Grid Edge Service. H1 2021 EV charging outlet forecast

EV charging load will represent 18% of North American electricity demand by 2050

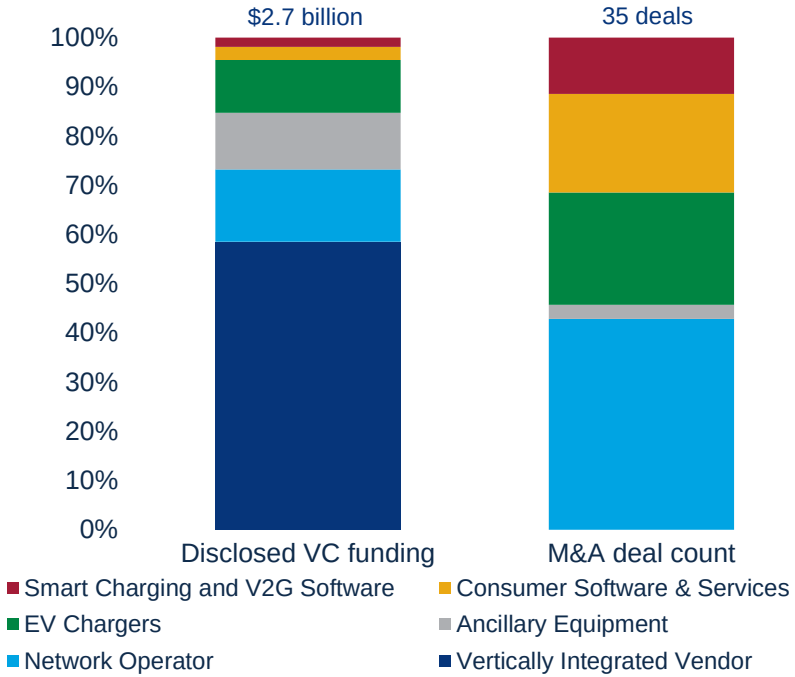
EV charging load and share of total demand in North America, 2020 - 2049



Source: Wood Mackenzie Road Transport Commodities 2021 Outlook

EV infrastructure VC and M&A activity summary

Disclosed VC investment value and completed M&A deal count, 2010 – 2020*

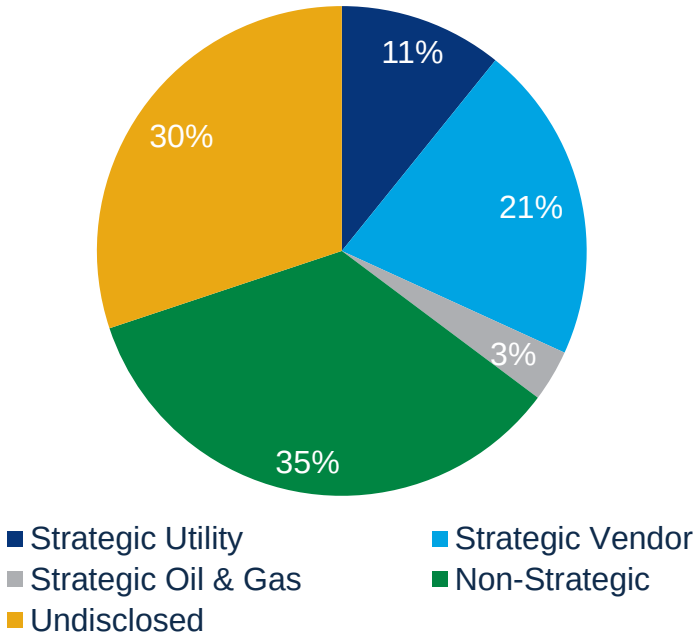


- Grid edge VC and M&A activity over the last decade shows a trend towards **flexibility** and **electrification**, as energy storage, EV charging infrastructure and customer energy management make up 73% of tracked grid edge VC deals.
- In the early years of the decade, investment was heavily focused in submarkets that increase access to chargers, while investment in the consumer software and services and smart charging and V2G submarkets picked up in the second half of the decade.
- M&A activity in the EV infrastructure market did not begin until 2011. Since then, 35 deals have been completed, 28 of which have been made by strategic vendors and utilities. Echoing trends in the early years of VC activity, two-thirds of acquisitions were of vendors that increase access to chargers,

Source: Wood Mackenzie Grid Edge VC and M&A database

VC investment in EV infrastructure vendors

EV infrastructure VC deals by type of investor

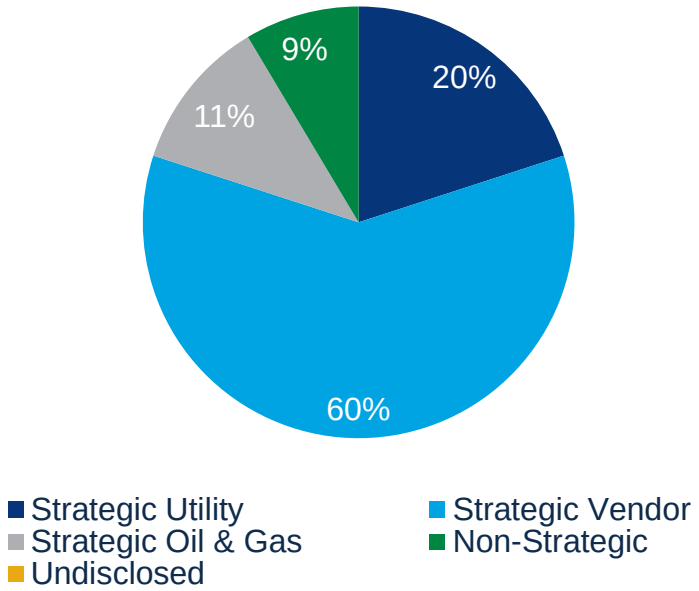


- **Non-strategic investors** have primarily invested in scalable business opportunities, which so far has included **vertically integrated vendors**, **EV charger manufacturers** and **network operators**.
- The two largest groups of **strategic vendor investors** were automakers and their venture arms and manufacturers of vehicle and-or charging related products. This group invested the most in **vertically integrated vendors**, **EV charger manufacturers** and **consumer software and services**.
- Half of **strategic utility** investors were based in Europe, while only 36% were based in the U.S. Utilities were one of the largest investors by deal count in **smart charging and V2G** vendors, reflecting on of their biggest concerns about EVs: peak load management.
- **Oil and gas investors** did not begin to lead EV infrastructure VC rounds until 2017. All oil and gas investors that led investment rounds are based in Europe. This group invested mainly in **ancillary equipment** and **EV charger manufacturers**.

Source: Wood Mackenzie Grid Edge Service

Acquisitions of EV infrastructure vendors

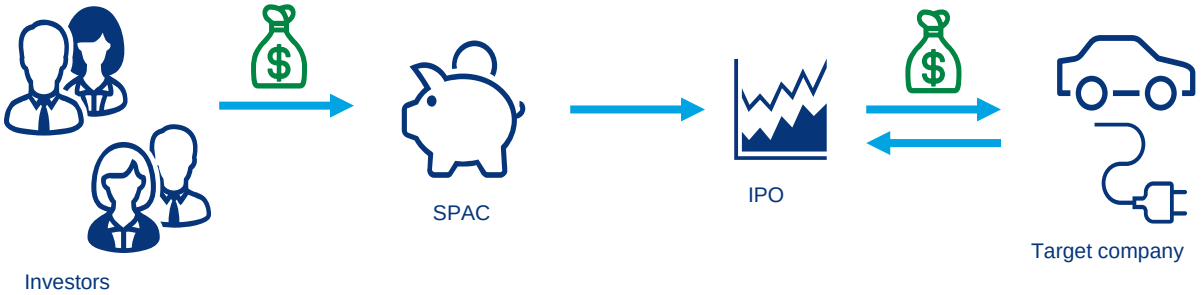
EV infrastructure M&A deals by type of acquiring firm



- Since 2011 there have been 35 completed M&A deals in EV infrastructure submarkets.
- 80% of acquisitions have been done by strategic **vendors** and **utilities**. These companies are using acquisitions to enter and/or strengthen their position in the EV charging market or complement other products and services they offer in the flexibility realm, such as storage or demand response.
- Acquisitions by **utilities** are not driven by a desire to grow geographically but rather to expand product and service offerings. All acquisitions by utilities were made in Europe. Only one acquisition by a utility so far has been in the smart charging submarket.
- Strategic **oil and gas** firms have only completed four acquisitions of EV infrastructure companies. Oil and gas firms use acquisitions to fill gaps in products and services across the EV charging value chain, embracing the shift that is threatening their centuries-old businesses.

Source: Wood Mackenzie Grid Edge Service

What is a special purpose acquisition company (SPAC) and why have so many clean energy companies merged with them?



Simplified SPAC process:

1. Investors put money into a special purpose acquisition company (SPAC).
2. The SPAC goes public via an initial public offering (IPO), essentially becoming a publicly traded “blank check company.” Funds are held in a trust account used to redeem public shares or fund the de-SPAC process.
3. A target company is identified within the two-year timeframe and, if additional capital is required, a private investment in public equity (PIPE) is raised.
4. The merger is approved by shareholders. The target becomes public in the process and the stock exchange ticker changes.

Source: Wood Mackenzie Grid Edge Service

The 33 clean energy SPAC mergers tracked by Wood Mackenzie have a combined post-SPAC valuation of over $68 billion*

Electric vehicles, vehicle technology and batteries

Passenger vehicles

Lordstown, Fisker, Faraday Future, Lucid

Passenger and commercial vehicles

Arrival, ADVENT, Canoo, XLFleet

Commercial vehicles

Hyliion, Hyzon, ELMS, Nikola, The Lion Electric Co., XOS, Lightning eMotors, Proterra

Vehicle technology

Luminar, Ouster, Velodyne LiDAR

Batteries and energy storage

EOS, ESS Inc. Catalyzing a cleaner future, microvast, MP Materials, QuantumScape, stem, ROMEO Power Technology

EV charging infrastructure

Vertically integrated vendors

chargepoint

Network operators

EVgo, VOLTA

EV chargers

EVBox, Tritium, wallbox

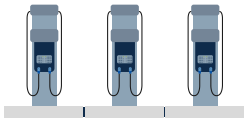
Smart charging and V2G

NUVVE

Source: Wood Mackenzie Grid Edge Service

*Note: based on SPAC investor presentations at time of announcement

2021 EV charging trends



Emphasis on providing fleet services

- Automakers and network operators began offering fleet advisory services that include electric fleet planning, charger procurement and installation, software to manage the fleet and chargers, DER integration and vehicle integration with site load.

Automakers become energy services providers

- Several traditional automakers went all in on EVs, with three wading into the energy services water. These OEMs have developed expertise in battery manufacturing, fleet management and, more recently, residential charging solutions that are laying the groundwork for them to become energy services providers.

Vehicle-grid integration is enabling new financing mechanisms, making electrification financially sustainable

- Several transit and school bus V2G deployments were successfully piloted in 2021, despite V2G not having clear regulatory or market support. Some developers have begun offering financing solutions that incorporate potential V2G revenues, unlocking financial sustainability that previously had not been available.

Source: Wood Mackenzie Grid Edge Service

License

Ownership Rights

All reports are owned by Wood Mackenzie, protected by United States Copyright and international copyright/intellectual property laws under applicable treaties and/or conventions. User agrees not to export any report into a country that does not have copyright/intellectual property laws that will protect Wood Mackenzie's rights therein.

Grant of License Rights

Wood Mackenzie, hereby grants user a personal, non-exclusive, non-refundable, non-transferable license to use the report for research purposes only pursuant to the terms and conditions of this agreement. Wood Mackenzie retains exclusive and sole ownership of each report disseminated under this agreement. User agrees not to permit any unauthorized use, reproduction, distribution, publication or electronic transmission of any report or the information/forecasts therein without the express written permission of Wood Mackenzie. Users purchasing this report may make a report available to other persons from their organization at the specific physical site covered by the agreement, but are prohibited from distributing the report to people outside the organization, or to other sites within the organization.

Disclaimer of Warranty and Liability

Wood Mackenzie has used its best efforts in collecting and preparing each report.
Wood Mackenzie its employees, affiliates, agents, and licensors do not warrant the accuracy, completeness, correctness, non-infringement, merchantability, or fitness for a particular purpose of any reports covered by this agreement. Wood Mackenzie, its employees, affiliates, agents, or licensors shall not be liable to user or any third party for losses or injury caused in whole or part by our negligence or contingencies beyond Wood Mackenzie's control in compiling, preparing or disseminating any report or for any decision made or action taken by user or any third party in reliance on such information or for any consequential, special, indirect or similar damages, even if Wood Mackenzie was advised of the possibility of the same. User agrees that the liability of Wood Mackenzie, its employees, affiliates, agents and licensors, if any, arising out of any kind of legal claim (whether in contract, tort or otherwise) in connection with its goods/services under this agreement shall not exceed the amount you paid to Wood Mackenzie for use of the report in question.

Europe	+44 131 243 4400
Americas	+1 713 470 1600
Asia Pacific	+65 6518 0800
Email	contactus@woodmac.com
Website	www.woodmac.com

Wood Mackenzie™, a Verisk business, is a trusted intelligence provider, empowering decision-makers with unique insight on the world's natural resources. We are a leading research and consultancy business for the global energy, power and renewables, subsurface, chemicals, and metals and mining industries. **For more information visit: woodmac.com**