

The Known Unknowns

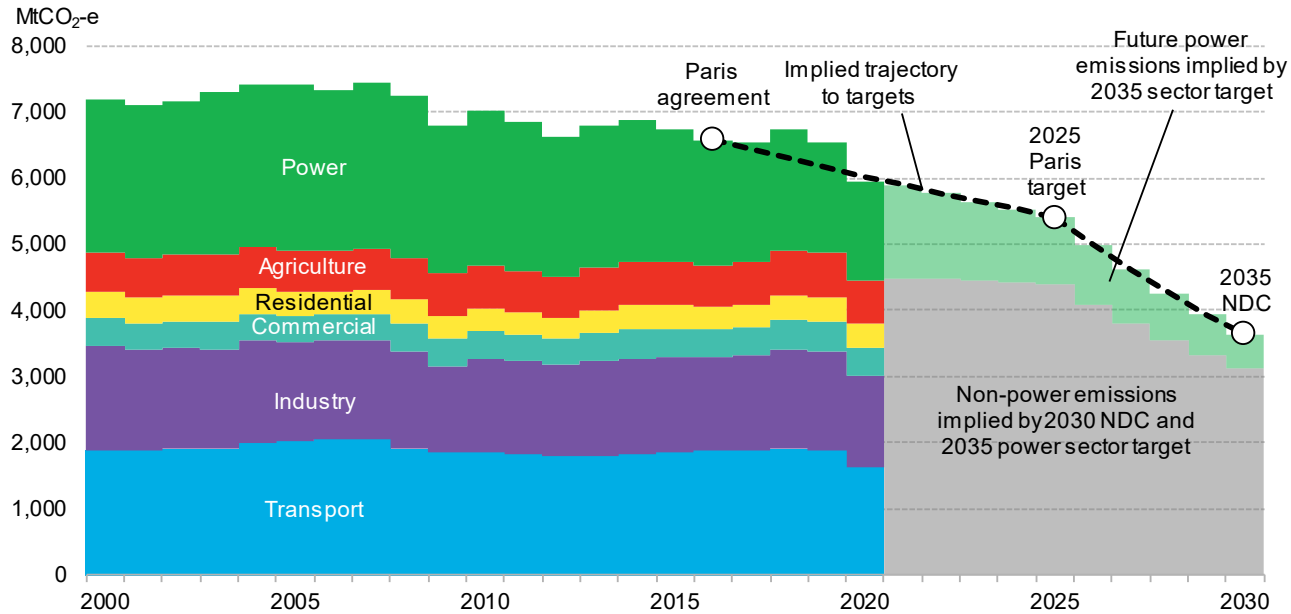
New York Energy Forum

Yayoi Sekine

May 18, 2021

U.S. economy-wide emissions

Historic and future, assuming various targets are achieved



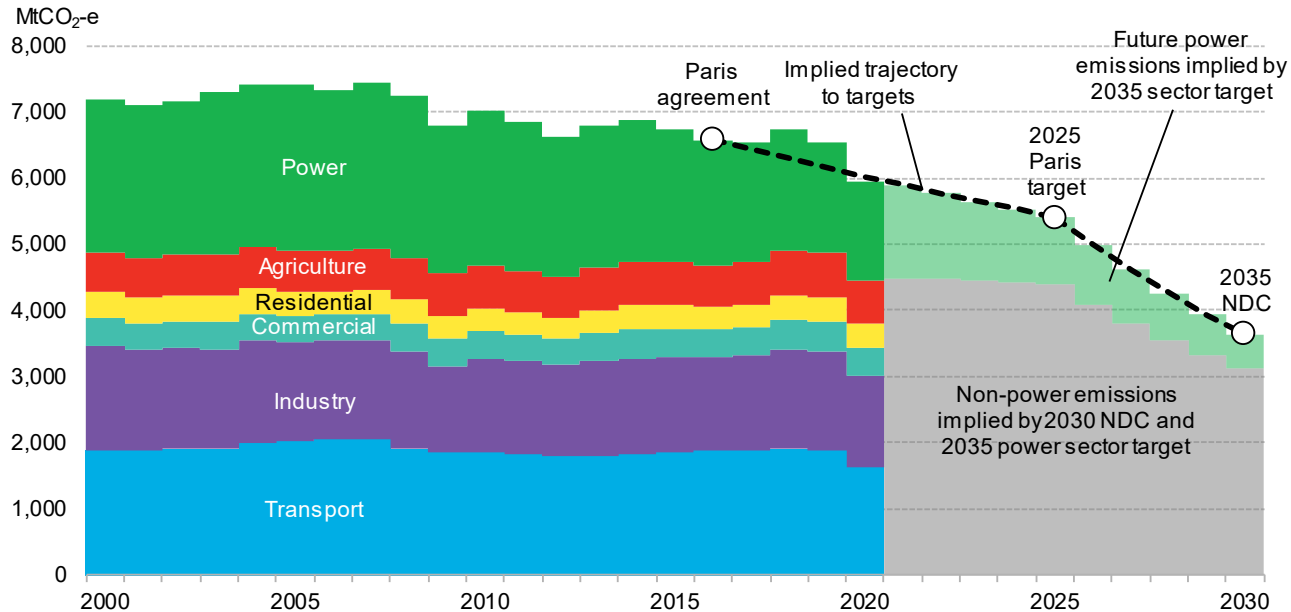
Decarbonizing power is the first and 'easiest' leg of the decarbonization journey...

...and I've been speaking about the first and 'easiest' step of that journey

Source: EIA, EPA, BloombergNEF

U.S. economy-wide emissions

Historic and future, assuming various targets are achieved



Decarbonizing power is the first and 'easiest' leg of the decarbonization journey...

...and I've been speaking about the first and 'easiest' step of that journey

...and it is not that easy!

Source: EIA, EPA, BloombergNEF

**Besides wind and solar vs. gas, there's
much more we need to consider**

Besides wind and solar vs. gas, there's much more we need to consider

Energy storage

Electric vehicles

Grids

Technology "X"

Besides wind and solar vs. gas, there's much more we need to consider

Energy storage

Electric vehicles

Grids

Technology "X"

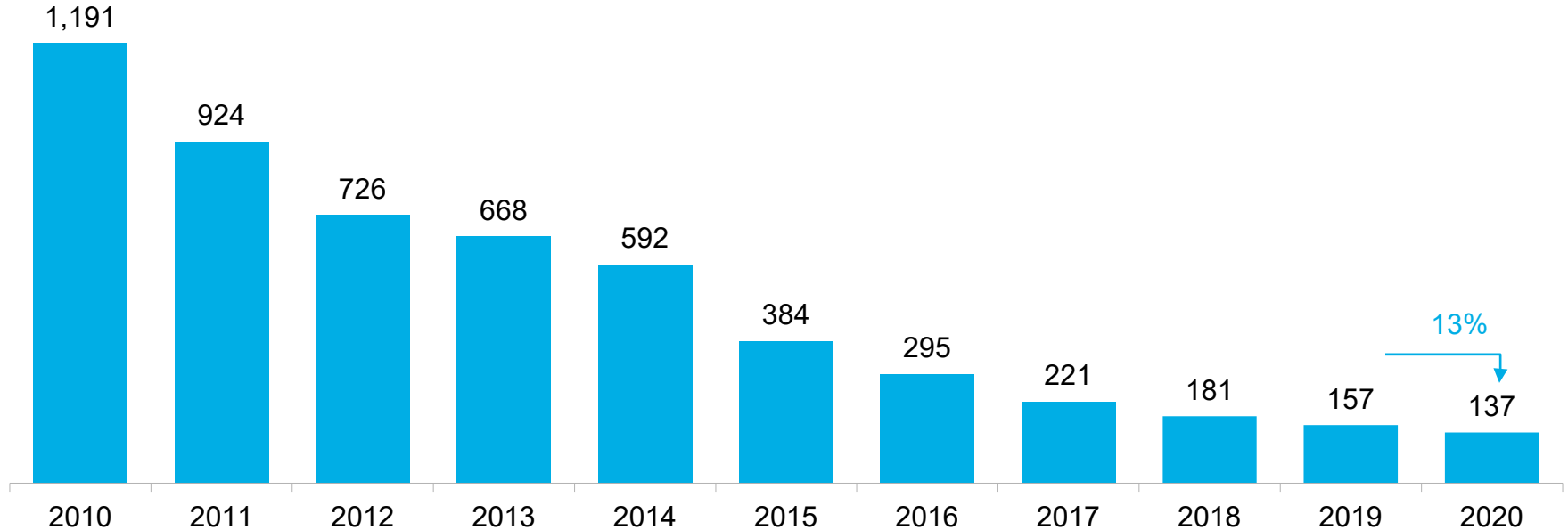


Source: Tesla

Battery costs are falling

Lithium-ion battery price survey results (volume-weighted average)

Battery pack price (real 2020 \$/kWh)

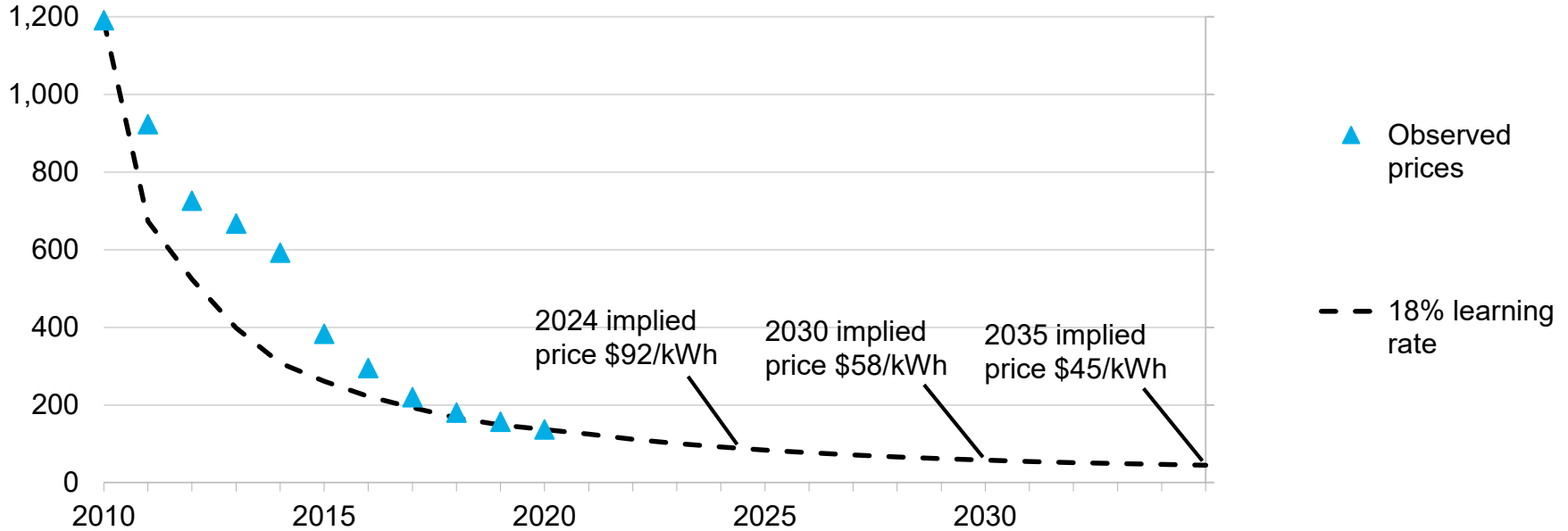


Source: BloombergNEF Note: This is based on the 2019 Battery Price Survey. The 2020 results shown here are a projection.

Battery costs are falling ...and will continue to fall

Lithium-ion battery price outlook

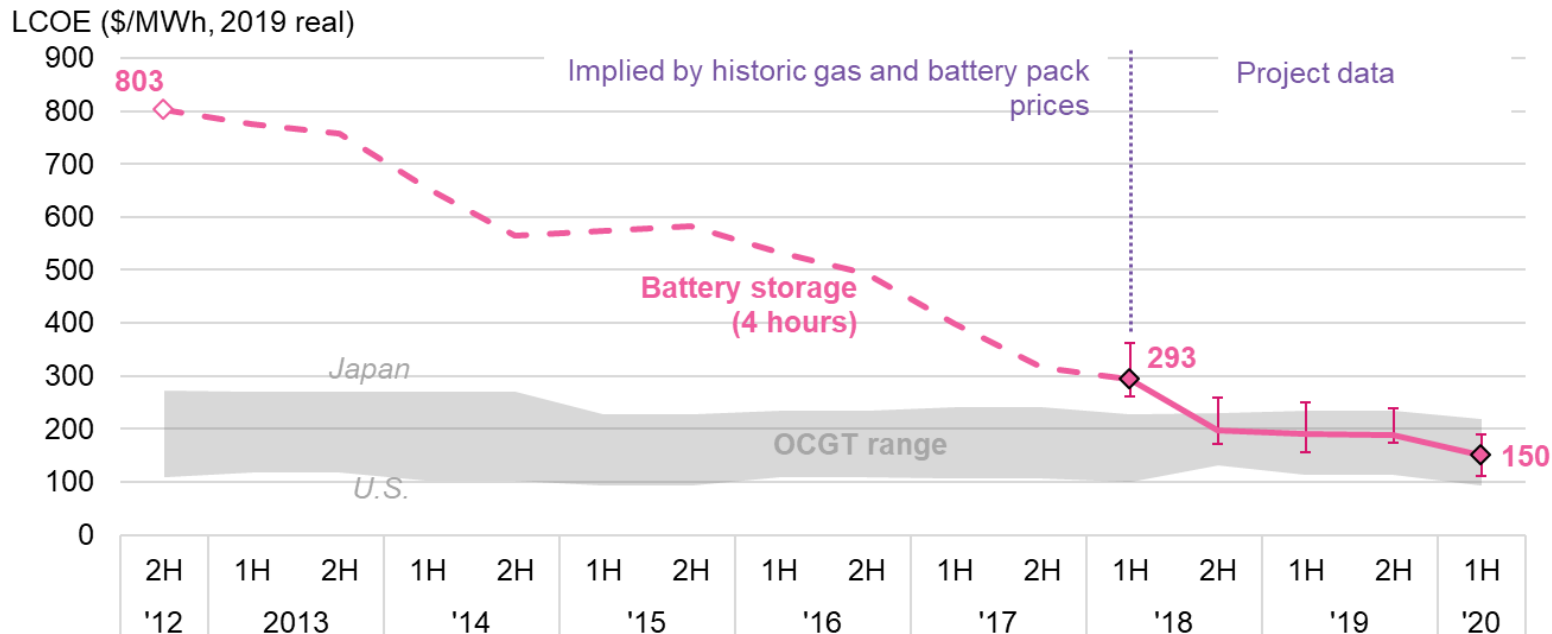
Lithium-ion battery pack price (real 2020 \$/kWh)



Source: BloombergNEF Note: This is based on the 2019 Battery Price Survey.

With falling costs, battery storage can compete on a LCOE basis against gas peakers

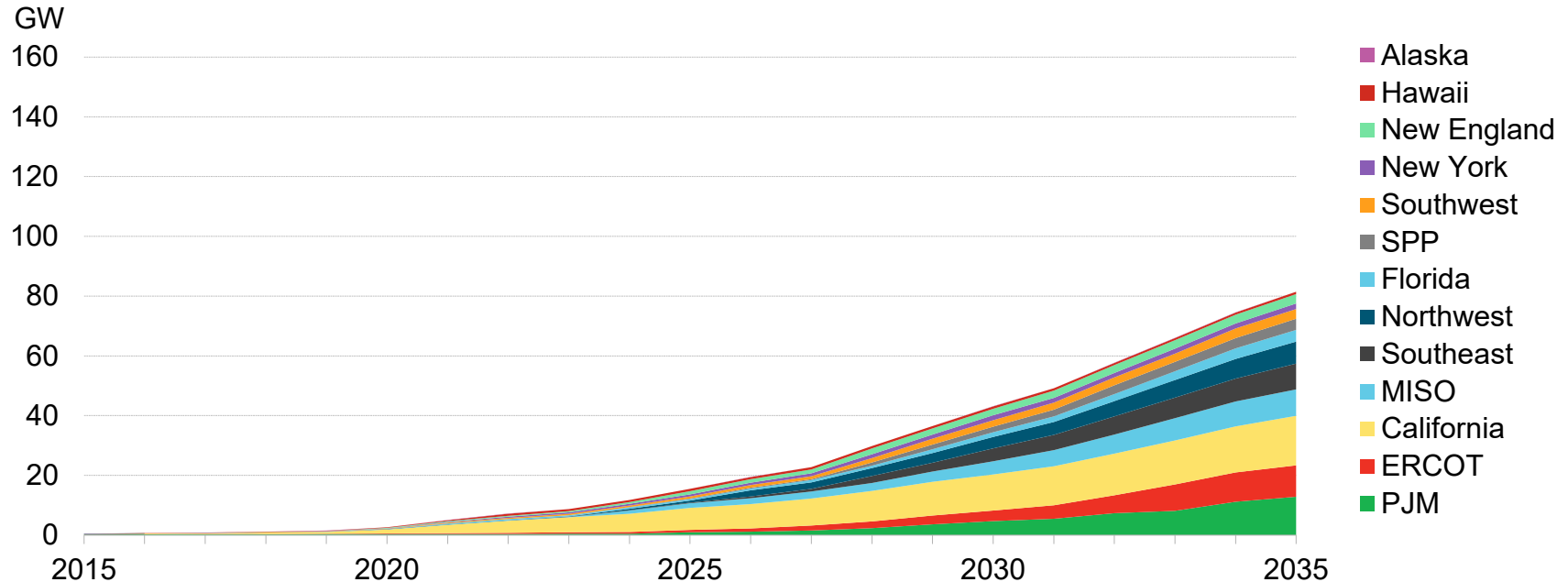
Global levelized cost of electricity (LCOE)



Source: BloombergNEF. Note: The storage benchmark is a country weighted-average using the latest annual capacity additions. It assumes a daily cycle and includes charging costs at 60% of the wholesale base power price. OCGT: open-cycle gas turbine. The lower (higher) bound of the OCGT range reflects the U.S. (Japan).

In batteries alone, 80GW of storage capacity could be on-line by 2035

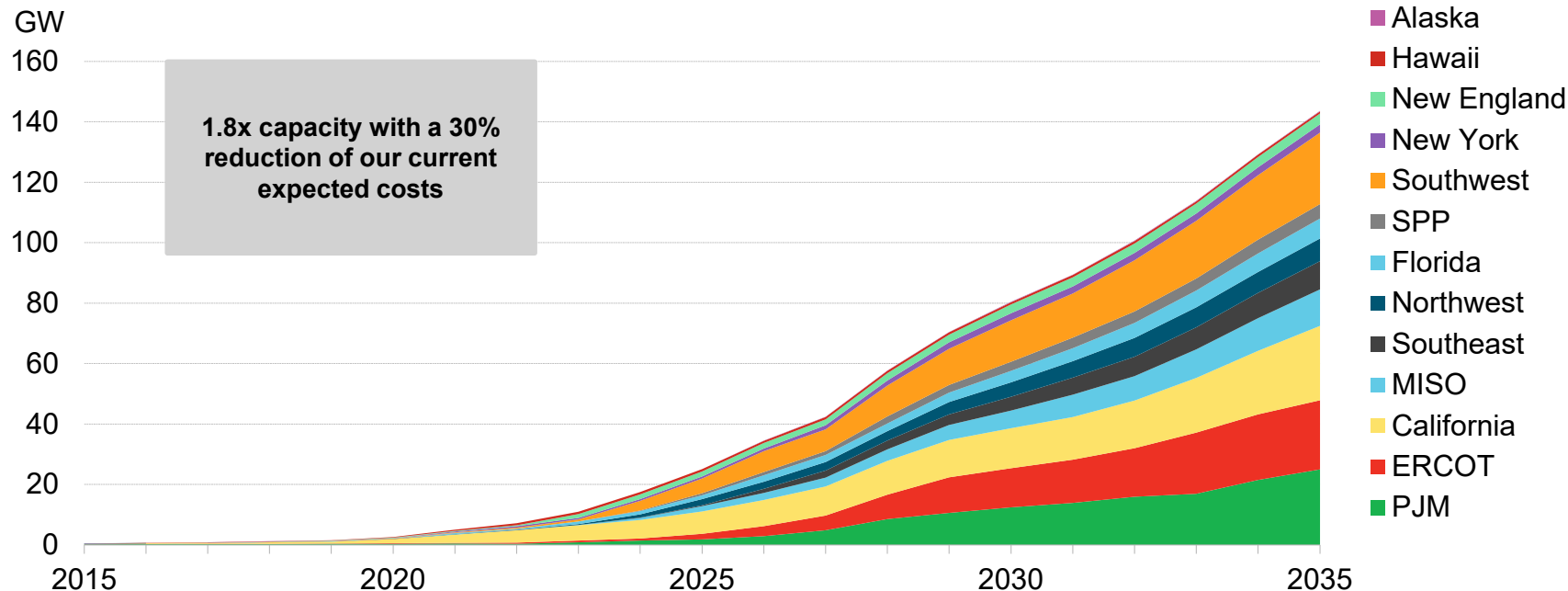
The U.S. cumulative market size by region based on power capacity



Source: BloombergNEF

In batteries alone, ~~80GW~~ 143GW of storage capacity could be on-line by 2035

The U.S. cumulative market size by region based on power capacity



Source: BloombergNEF

There's a fairly known pathway for storage

Energy storage

Electric vehicles

Grids

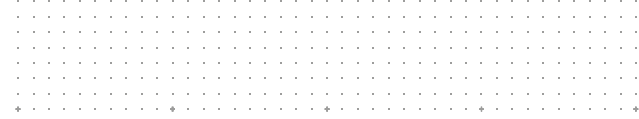
Technology "X"



Known?

Source: Tesla

What about electric vehicles?



Energy storage



Electric vehicles



Grids

Technology "X"

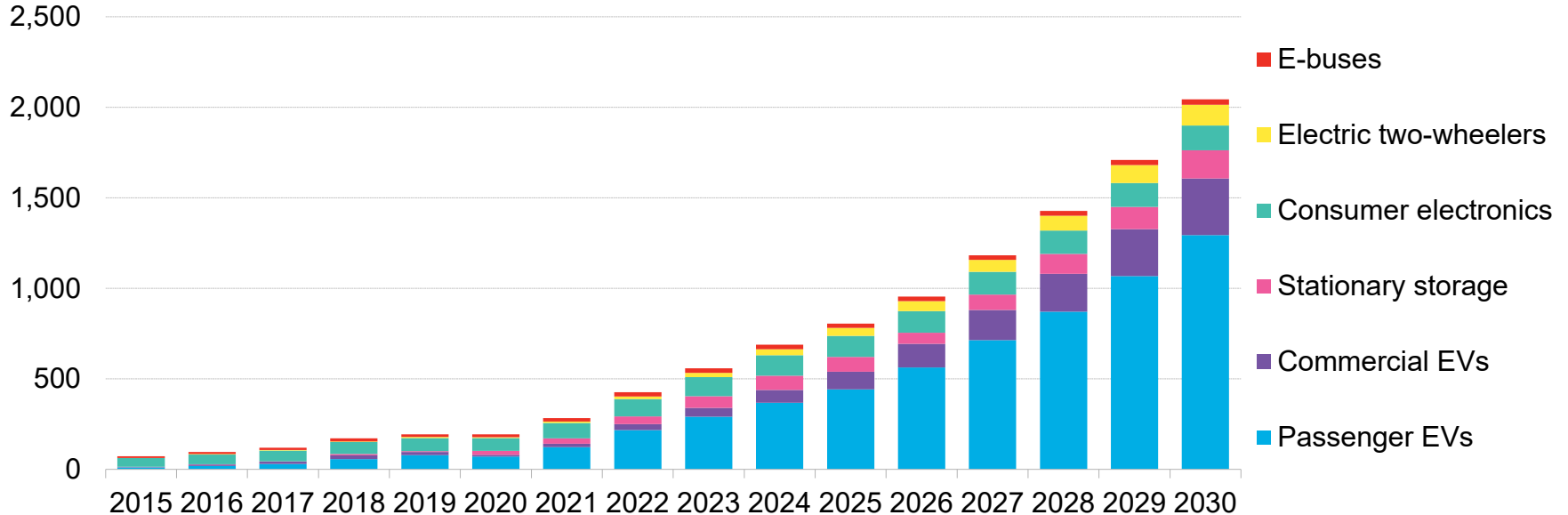
Known?

Source: Tesla, Lockheed Martin, R&D World

Electric vehicle demand driving majority of demand for batteries

Annual lithium-ion battery demand by application

GWh/year



Source: BloombergNEF

Passenger EV could hit price parity in the mid-2020s

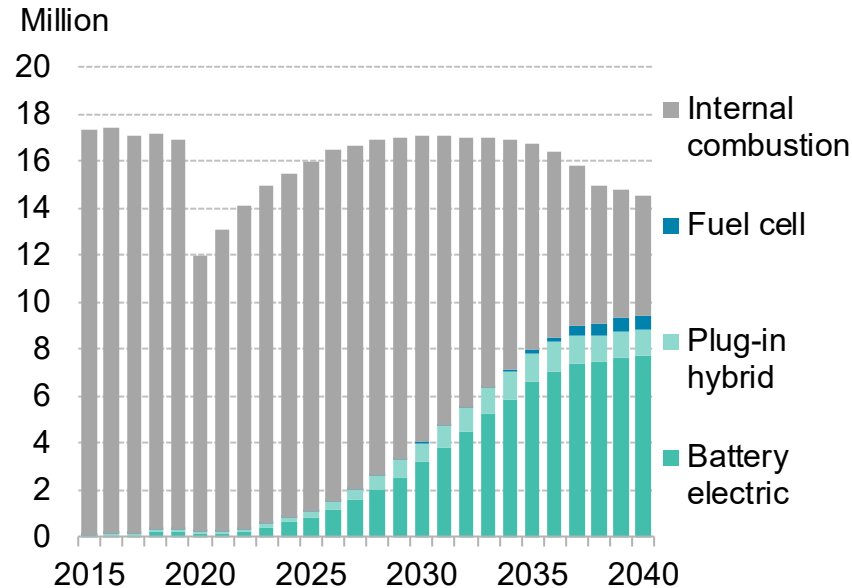
Upfront price parity year

Segment	U.S.	EU	China
Small	2024	2027	2026
Medium	2024	2023	2022
Large	2023	2022	2030
SUV	2023	2024	2033*

Source: BloombergNEF's "When Will EVs Be Cheaper Than Conventional Vehicles?". Note: We assumed the same real world driving range for EVs globally: small = 200 miles; medium = 250 miles; large and SUVs = 300 miles. (*) In China many smaller cars are classified as SUVs, thereby reducing the segment-average price.

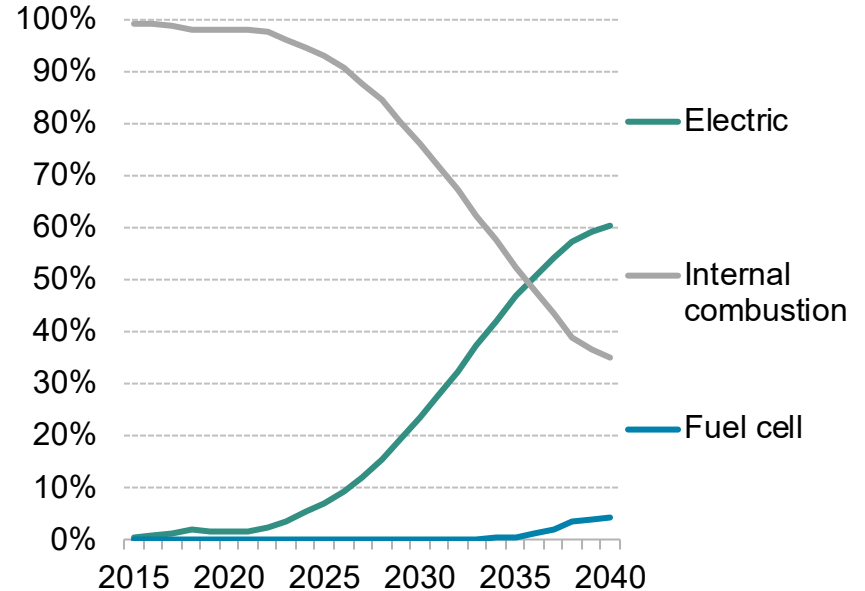
The U.S. passenger EV sales are growing

U.S. annual passenger vehicle sales by drivetrain



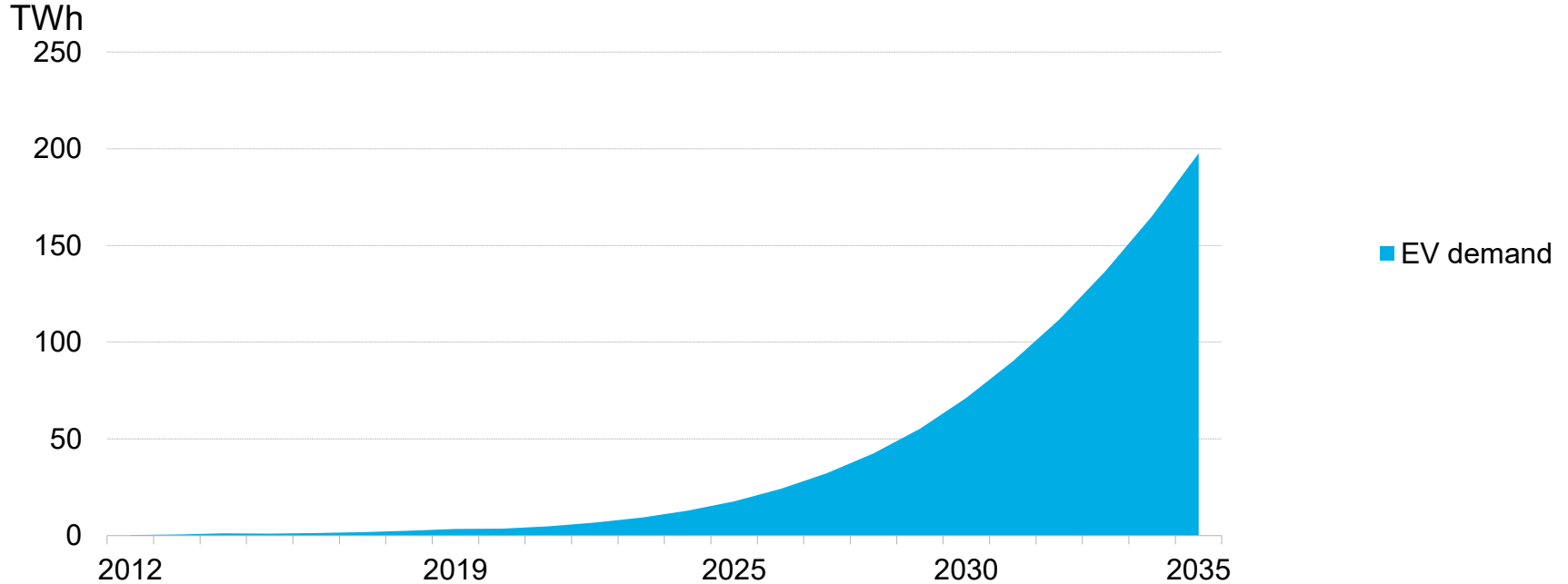
Source: BloombergNEF. Note: Electric contains battery electric and plug-in hybrid.

U.S. share of annual passenger vehicle sales by drivetrain



Electric vehicle uptake would increase power demand

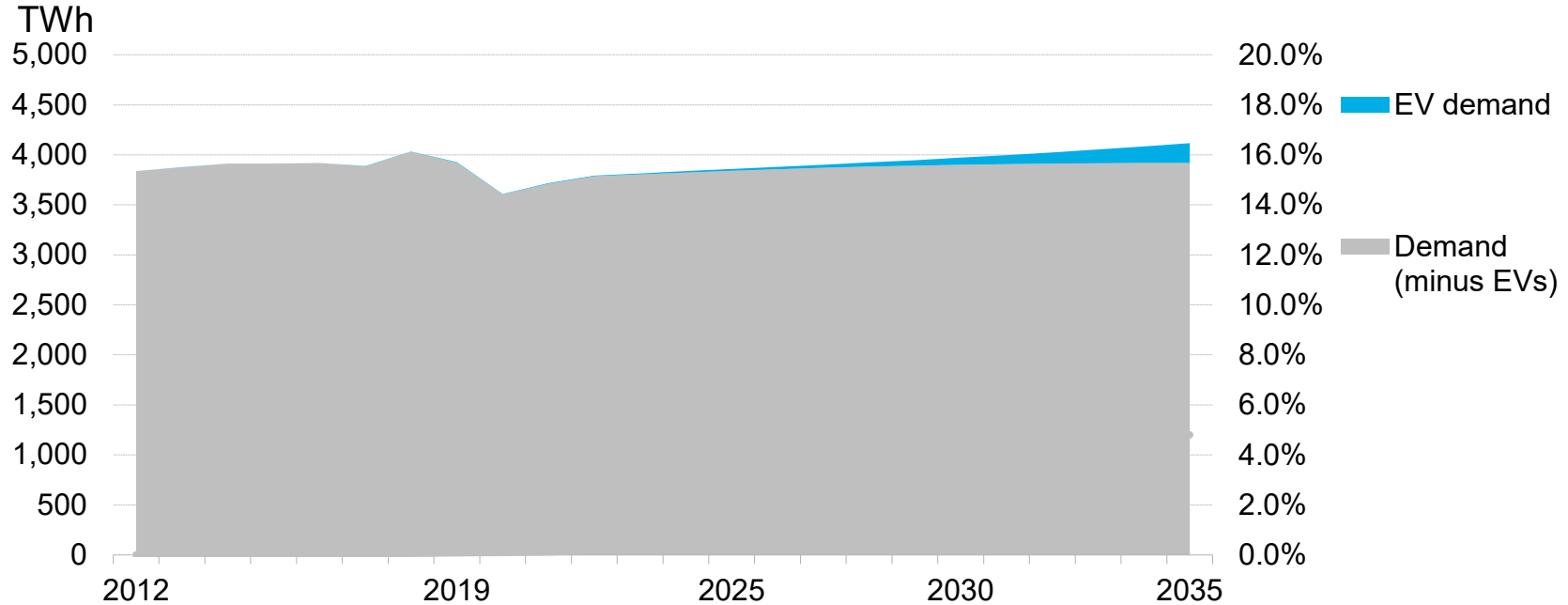
U.S. EV electricity demand



Source: BloombergNEF

...Although not by a lot by 2035

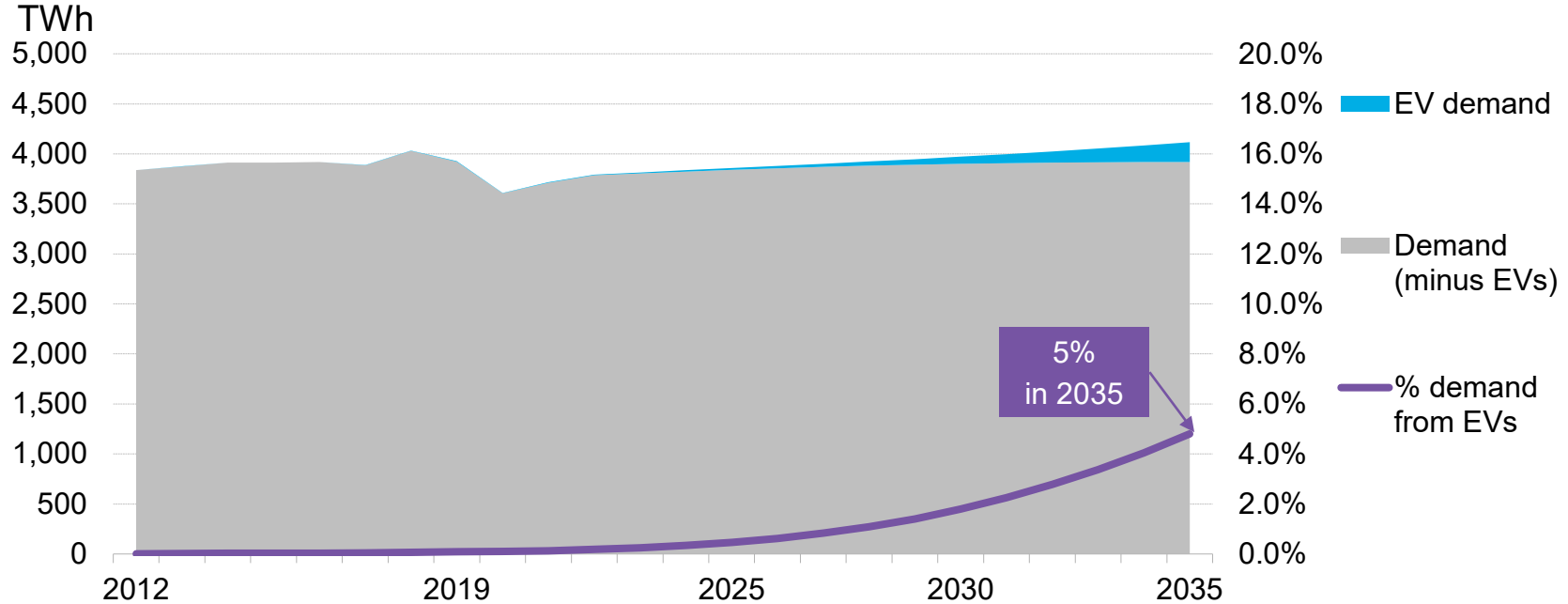
U.S. electricity demand



Source: BloombergNEF

...Although not by a lot by 2035

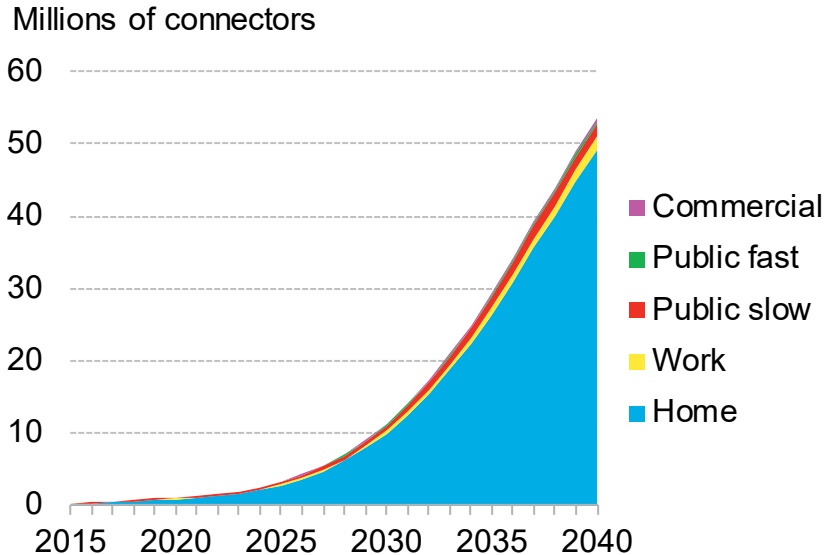
U.S. electricity demand



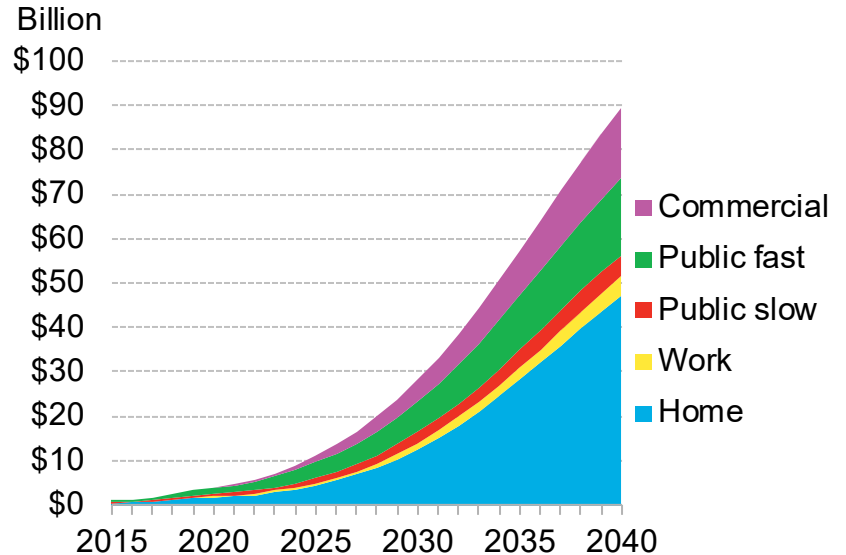
Source: BloombergNEF

But major investments in charging infrastructure will be needed

Cumulative U.S. charging infrastructure demand forecast, by location



Cumulative U.S. charging infrastructure investment, by location



Source: BloombergNEF. Note: Analysis is using the latest forecast numbers for passenger vehicles and van – home charging. For more details, see our “Charging Infrastructure Forecast Model” ([web](#)). For details on our base case forecast, see our “Long-Term Electric Vehicle Outlook 2020” ([web](#) | [terminal](#)).

Electric vehicles are likely to happen, but ‘positive’ grid contribution is uncertain

Energy storage



Known?

Electric vehicles



Known?

Grids

Technology “X”

Source: Tesla, Lockheed Martin, Electrive, R&D World

Grids are central to the transition, and under-appreciated

Energy storage



Electric vehicles



Grids



Technology "X"

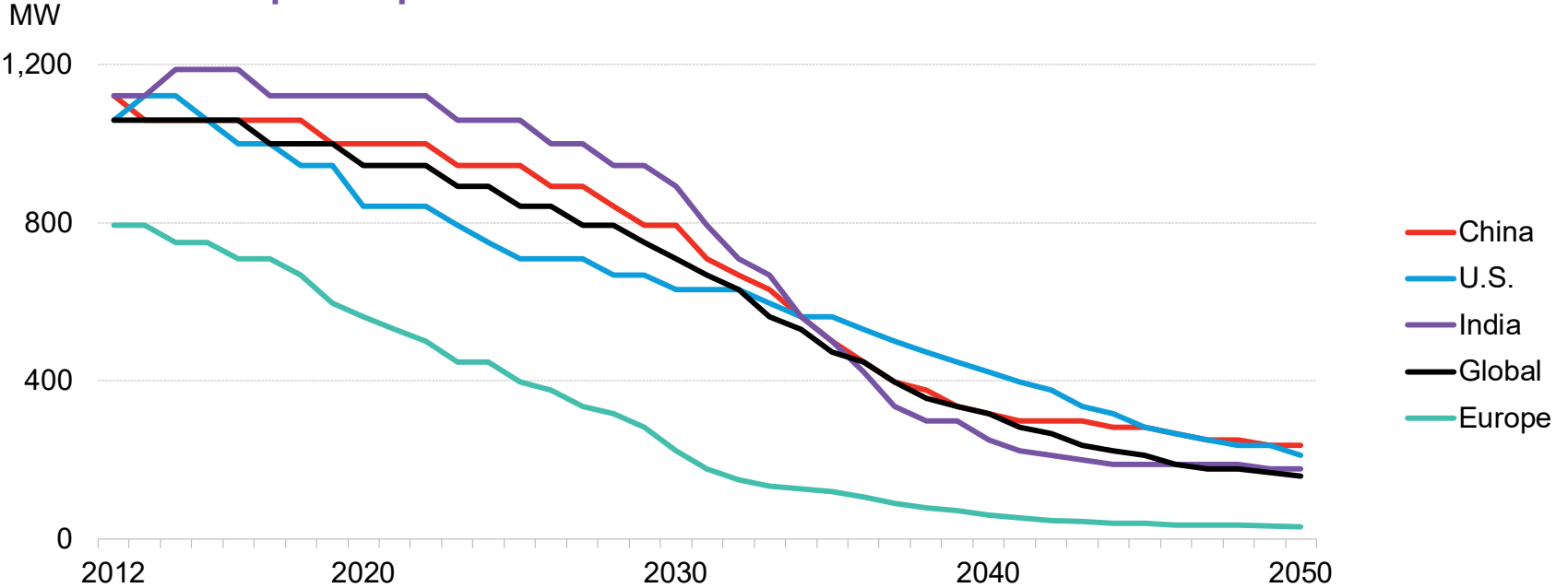
Known?

Known?

Source: Tesla, Lockheed Martin, Electrive, R&D World

Power plants are becoming smaller, more and more of them will be added

Size of median power plant

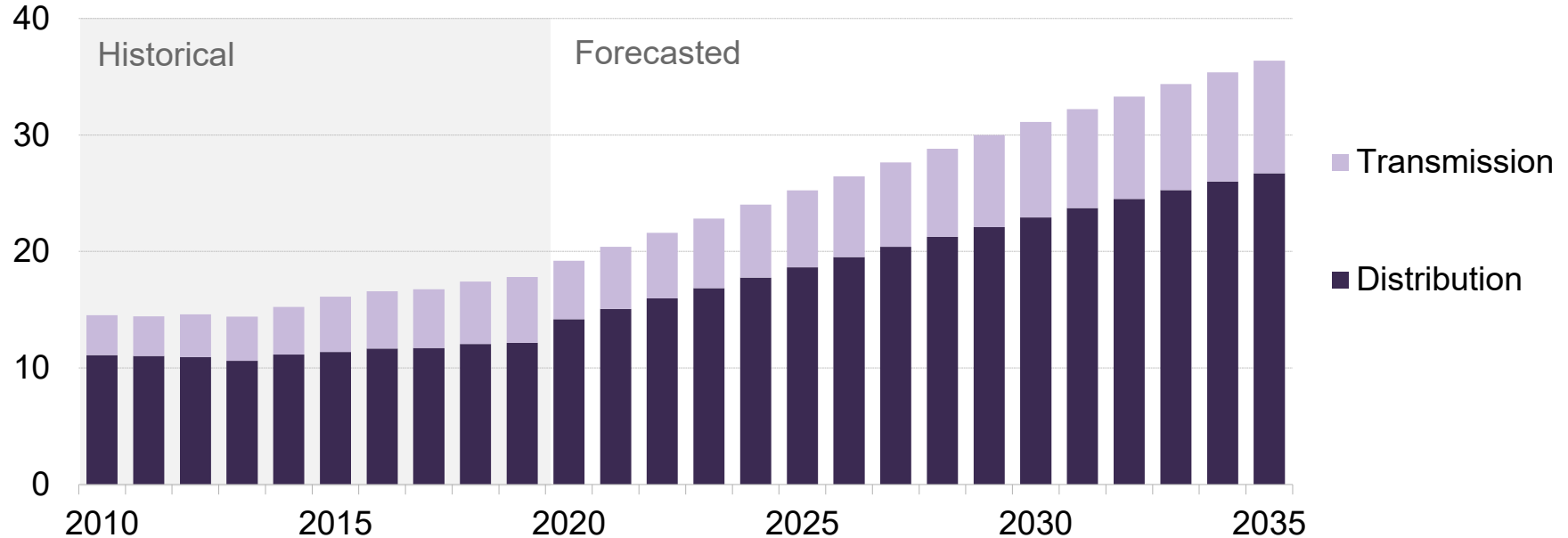


Source: BloombergNEF

Grid investment needs to ramp up significantly

U.S. expenditure on asset replacements

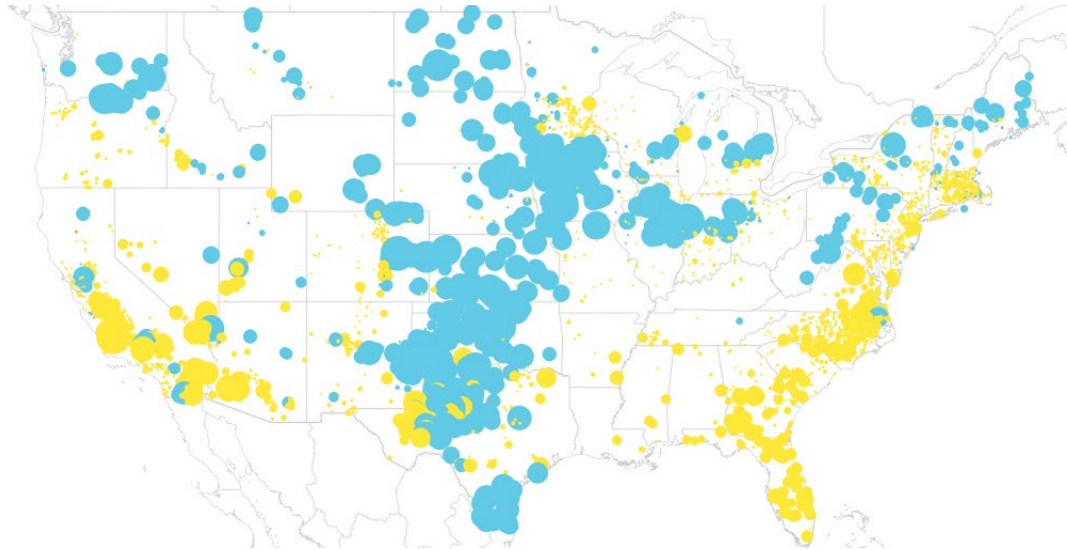
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Source: BloombergNEF

High quality renewable resources are often remote

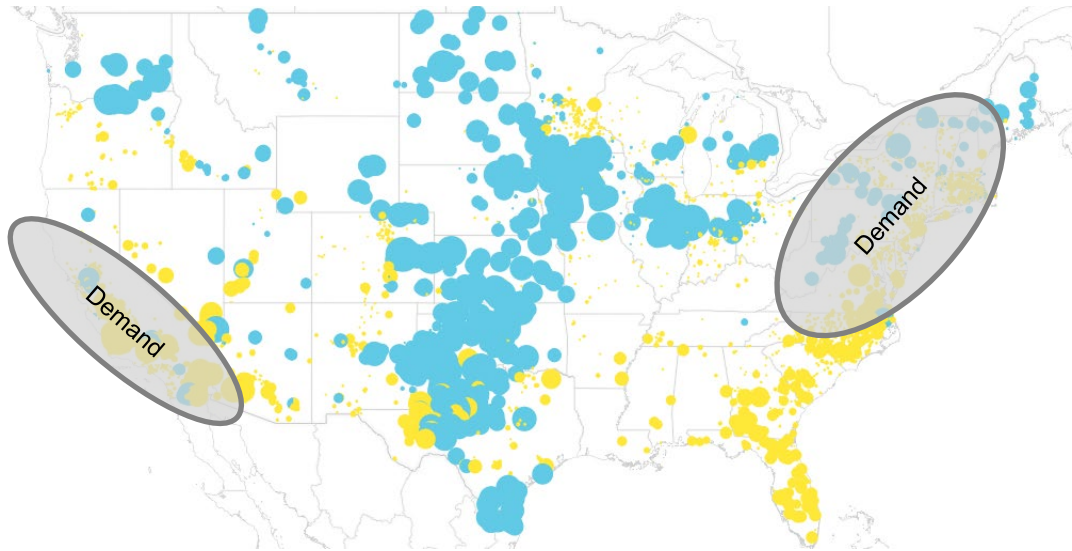
U.S. renewable resources and demand



Source: BloombergNEF

High quality renewable resources are often remote

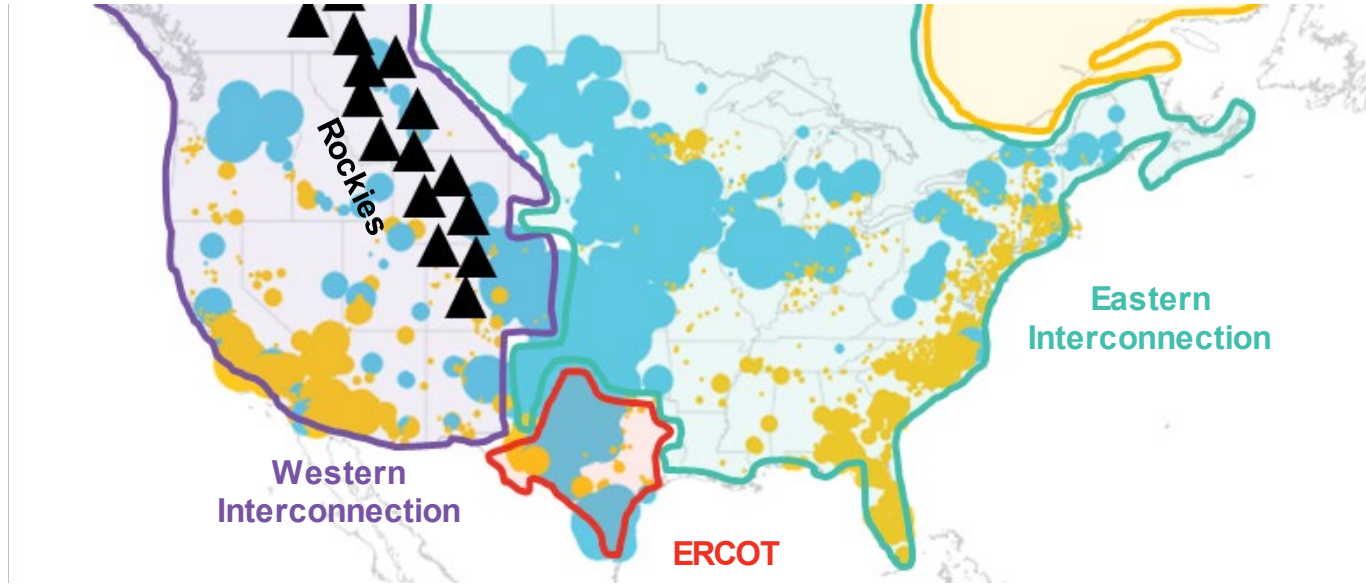
U.S. renewable resources and demand



Source: BloombergNEF

High quality renewable resources are often remote

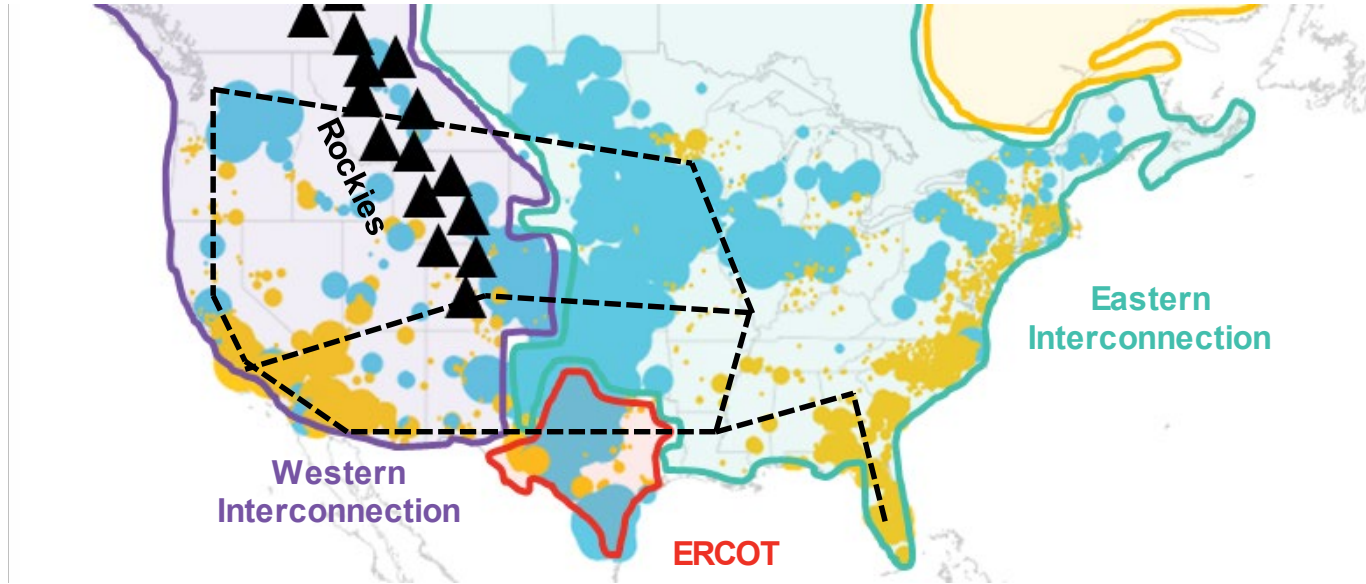
U.S. Interconnection regions and wind and solar generation



Source: BloombergNEF

High quality renewable resources are often remote

Studied U.S. macrogrid



Source: BloombergNEF, NREL

More investment in grids is necessary with more ambitious clean power goals

Energy storage



Electric vehicles



Grids



Technology "X"



Known?

Known?

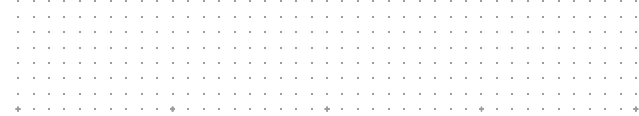
Known?

Source: Tesla, Lockheed Martin, Electrive, R&D World

Technology “X”: Technologies that may be needed for the next-stage decarbonization

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

Technology “X”: Technologies that may be needed for the next-stage decarbonization



Carbon capture
and storage

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

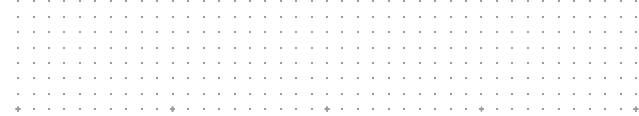
Technology “X”: Technologies that may be needed for the next-stage decarbonization

Carbon capture
and storage

Hydrogen from
electrolysis

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

Technology “X”: Technologies that may be needed for the next-stage decarbonization



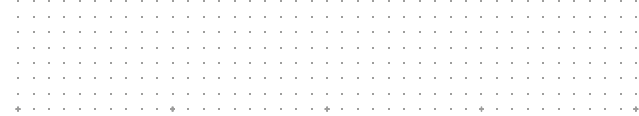
Carbon capture
and storage

Hydrogen from
electrolysis

Small modular
reactors

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

Technology “X”: Technologies that may be needed for the next-stage decarbonization



Carbon capture
and storage

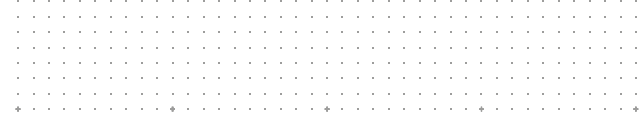
Hydrogen from
electrolysis

Small modular
reactors

Advanced
geothermal

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

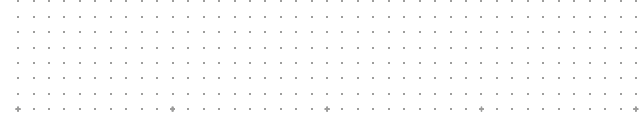
Technology “X”: Technologies that may be needed for the next-stage decarbonization



	Carbon capture and storage	Hydrogen from electrolysis	Small modular reactors	Advanced geothermal
Is it carbon-free?				
It is firm?				
It the U.S. currently a leader in this field?				
How mature is it?				

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

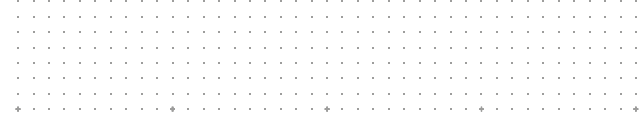
Technology “X”: Technologies that may be needed for the next-stage decarbonization



	Carbon capture and storage	Hydrogen from electrolysis	Small modular reactors	Advanced geothermal
Is it carbon-free?	Yellow			
It is firm?	Green			
Is the U.S. currently a leader in this field?	Yellow			
How mature is it?	Yellow			

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

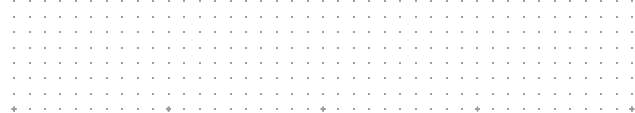
Technology “X”: Technologies that may be needed for the next-stage decarbonization



	Carbon capture and storage	Hydrogen from electrolysis	Small modular reactors	Advanced geothermal
Is it carbon-free?	Yellow	Green		
It is firm?	Green			
Is the U.S. currently a leader in this field?	Yellow	Red		
How mature is it?	Yellow			

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

Technology “X”: Technologies that may be needed for the next-stage decarbonization



	Carbon capture and storage	Hydrogen from electrolysis	Small modular reactors	Advanced geothermal
Is it carbon-free?	Yellow	Green	Green	
It is firm?	Green	Green	Green	
Is the U.S. currently a leader in this field?	Yellow	Red	Green	
How mature is it?	Yellow	Yellow	Orange with dotted pattern	

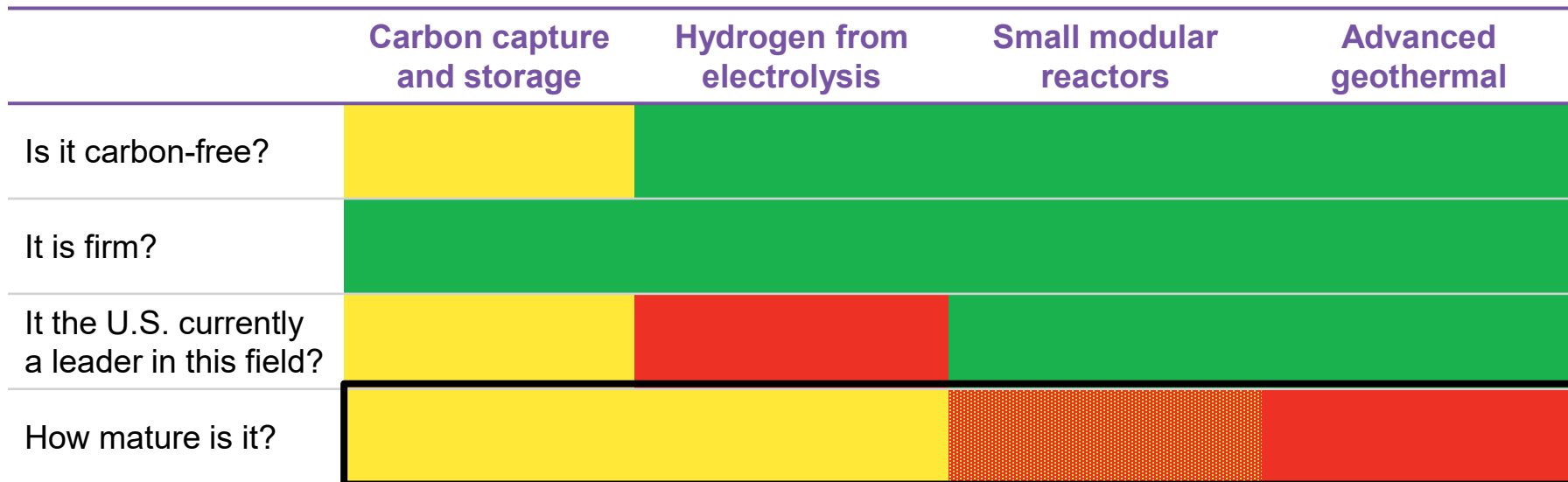
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Technology “X”: Technologies that may be needed for the next-stage decarbonization

	Carbon capture and storage	Hydrogen from electrolysis	Small modular reactors	Advanced geothermal
Is it carbon-free?	Yellow	Green	Green	Green
It is firm?	Green	Green	Green	Green
Is the U.S. currently a leader in this field?	Yellow	Red	Green	Green
How mature is it?	Yellow	Yellow	Orange (dotted)	Red

Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

Technology “X”: Technologies that may be needed for the next-stage decarbonization



Source: BloombergNEF. Note: Green = Strength, Yellow = Neutral, Red = Weakness.

There are more knowns than unknowns, but we'll need to the unknowns!

Energy storage



Known?

Electric vehicles



Known?

Grids



Known?

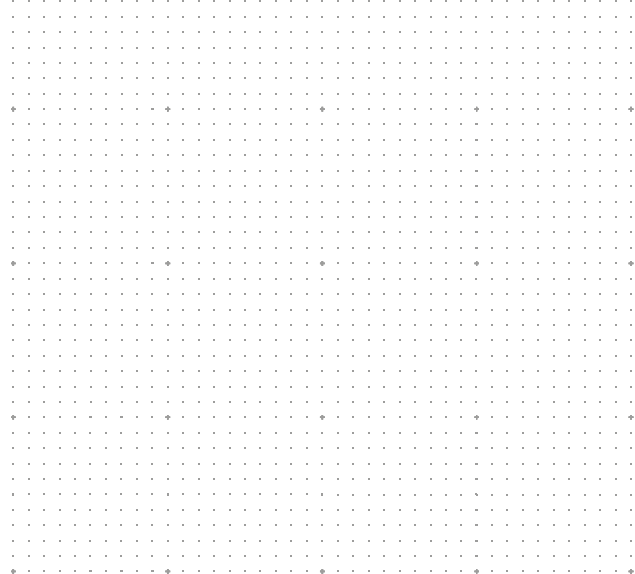
Technology "X"



Unknown?

Source: Tesla, Lockheed Martin, Electrive, R&D World

Thank you!



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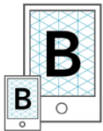
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We help commodity trading, corporate strategy, finance and policy professionals navigate change and generate opportunities.

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