Batteries, Renewables, and Electrification of Transport

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EXECUTIVE SUMMARY

Reasonable penetration projections of batteries and renewables are not expected to disrupt Vistra's core businesses and could lead to attractive investment opportunities

BATTERIES

- Price of batteries is forecast to decline to ~$200/kWh by 2020
- Many of the most economic applications of batteries involve pairing with traditional generation
- Grid-scale batteries are *complementary* to existing baseload and low-cost cycling generation
  - Lithium ion batteries currently have ~4 hours of storage; batteries will still require a sustainable source of charge
  - Adding load during periods when baseload and low-cost cycling generation is online will help to smooth energy prices and thus revenue streams for these generation sources
  - *New* peaking generation investments will likely be increasingly preempted by battery storage (5-10 year time frame); however, batteries will always require a source of charging and will compete with sunk investments in existing generation
- **Vistra has attractive opportunities to participate in battery storage at accretive returns**
  - Vistra has two of the best sites for battery storage in CA, which is the most attractive market for batteries
  - Any such investment would be *modest* as overall battery penetration is forecasted to be low in the next 10 years

RENEWABLES

- Given low resource potential, RPS requirements are more likely to drive renewable development, with the highest penetration rates in CA and NY where Vistra has a limited presence

ELECTRIFICATION OF TRANSPORT

- Reductions in battery storage costs are increasing attractiveness of electric vehicles ("EVs")
  - In the ~10-15 year time frame, EVs may represent a significant source of power demand growth, helping to offset demand reductions from demand response and energy efficiency

BATTERIES

RENEWABLES GROWTH

ELECTRIFICATION OF TRANSPORT

KEY TAKEAWAYS

BATTERY VALUE PROPOSITIONS

Multiple value streams contribute to battery economics for both in front of the meter ("FTM") and behind the meter ("BTM") applications; optimal configuration depends on value stream

VALUE STREAMS

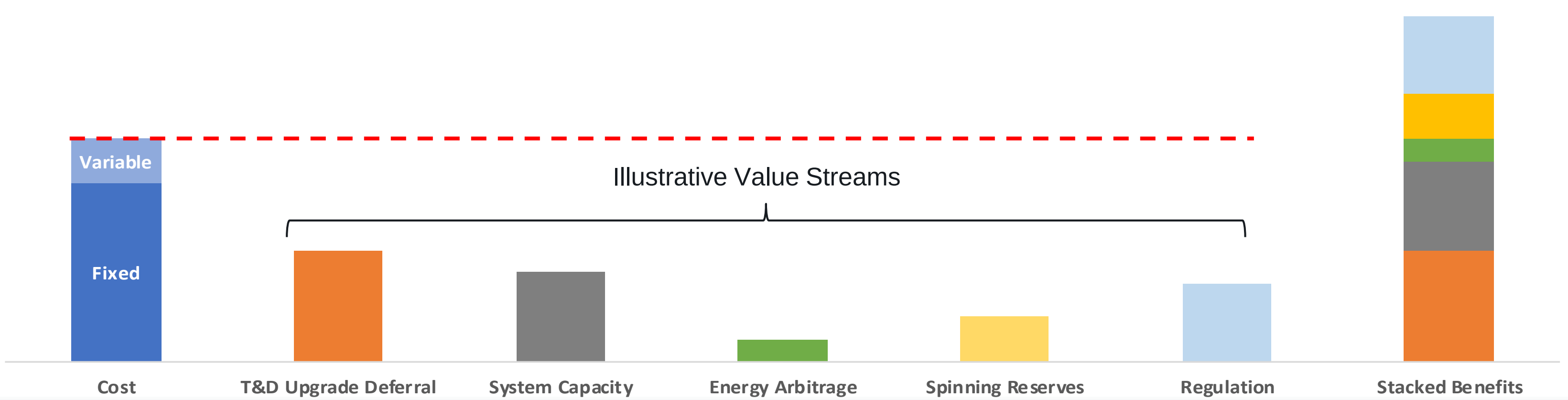
	Value	Type	Storage Can:
FTM	Energy Price Arbitrage	Optimization	• Charge when power prices are low / discharge when power prices are high
FTM	Ancillary Services	Optimization	• Provide frequency regulation, load following, reserves, etc.
FTM	Policy Incentives	Financial	• Batteries may qualify for investment tax credit ("ITC"), bonus depreciation, and other incentives / subsidies by state / market / locality
FTM	Black Start	Reliability	• Restart offline thermal power plants
FTM	Voltage Regulation	Quality	• Absorb power to balance reactance in the grid
FTM	Defer Investment in Transmission & Distribution ("T&D")	Reliability	• Install at T&D bottlenecks to avoid the need to invest in additional T&D infrastructure
FTM	Renewable Integration	Optimization, Reliability	• Avoid curtailments of renewables and reshape their output to match supply and demand
FTM	Capacity / Peaker Replacement	Reliability	• Provide system capacity similar to a peaking plant
BTM	Avoid Demand Charge	Financial	• Offset peak demand and lower demand charges
BTM	Pair with BTM Solar	Optimization, Reliability	• Optimize output of BTM solar plants and avoid curtailment
BTM	Power Reliability / Quality	Quality, Reliability	• Allow customers to avoid service interruptions due to grid events

STACKED VALUE STREAMS

BATTERY ECONOMICS

- **To be economic today, battery projects require multiple sources of value**
  - Market structure rules may limit the ability to capture full value
  - Impossible to capture 100% of individual value stream
  - Usage of batteries will impact lifetime cost
- **Battery projects that are built adjacent to existing generation capacity will allow for the greatest optionality and value stacking proposition**

ILLUSTRATIVE COSTS VS. STACKED BENEFITS



Taken individually, value streams often do not cover the cost of battery projects
When combined, value streams may cover the cost and required returns

ATTRACTIVENESS OF BATTERIES BY MARKET

VISTRA ENERGY

Today, California is the most attractive market for batteries, followed by New York

Value	CAISO	NYISO	ERCOT	ISO-NE	PJM
FTM					
Energy price arbitrage	●	○	◐	◔	○
Ancillary Services	●	◐	○	◐	◐
Policy Incentives	●	●	○	◐	○
Defer Investment in T&D	●	●	◐	◐	◐
Renewable Integration	●	◐	◕	◐	◐
Capacity / Peaker Replacement	●	◐	◔	○	○
BTM					
Avoid Demand Charge	●	●	○	◕	◐
Pair with BTM Solar	●	◐	◔	◐	◐
Power Reliability / Quality	●	◐	◐	◐	◐

BATTERIES COMPLEMENT EXISTING GENERATION

VISTRA ENERGY

BACKGROUND

- **Batteries are often supportive of existing generation**
  - Daily cycle requires charging on a day-to-day basis
- **Baseload coal, nuclear, and low-cost gas plants can benefit to the extent that batteries:**
  - Charge overnight and raise off-peak prices
  - Smooth/eliminate extremely low priced hours from high renewable penetration
- **Near term, batteries are most likely to threaten investment in new peaking plants**
  - Short duration storage may allow peaking plants to provide non-spinning reserves (instant start)
- **Penetration estimates are low relative to the size of markets**

BATTERY PENETRATION ESTIMATES BY MARKET[1]

	MW			% Installed Generation		
	2018 Operating Storage Capacity	2018 Projects in Development	Potential 2028 Storage Capacity	2018 Operating Storage Capacity	2018 Projects in Development	Potential 2028 Storage Capacity
CAISO	234	610	4,450 - 8,804	0.45%	1.12%	8.6 - 16.9%
PJM	335	220	475 - 6,886	0.64%	0.42%	0.3 - 4.1%
NYISO	1	115	200 - 2,364	0.00%	0.22%	0.5 - 4.1%
ERCOT	103	10	250 - 2,125	0.20%	0.02%	0.3 - 2.8%
ISO-NE	46	43	160 - 954	0.09%	0.08%	0.5 - 2.7%

[1] Base case estimates developed using fundamental modeling of projected cost decline curves and value propositions by market; high case estimates assume solar-like growth in battery penetration, despite the lack of ITC availability, or other incentives in most locations, for standalone batteries.

ERCOT: UPTON 2 BATTERY PROJECT

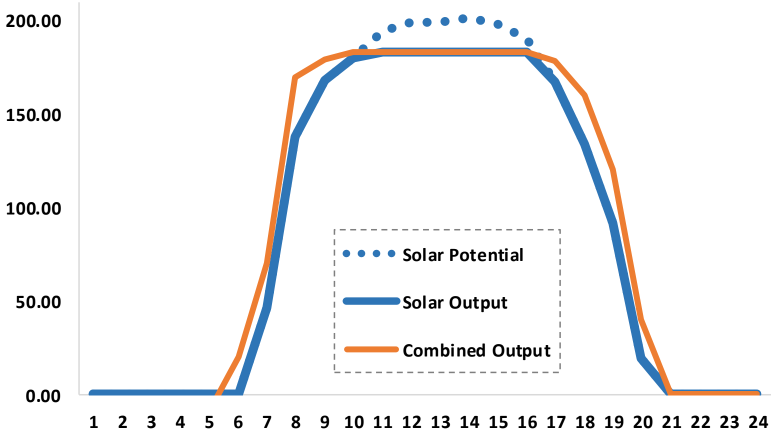
VISTRA ENERGY

PROJECT DETAILS

- **Upton 2 Battery Project**
  - Located adjacent to solar facility
  - 10 MW / 42 MWh lithium ion batteries
  - Estimated COD: Q4 2018
  - Estimated unlevered returns: Mid to high teens
- **Upton 2 Solar Plant interconnect is for 180 MW; however, the plant is capable of producing nearly 200 MW during peak solar hours**
  - With batteries, some of this extra generation will be captured and discharged at peak times
  - Batteries can also be charged from grid at low power prices (*i.e.*, at night) and discharged in the morning
- **Attractive returns given its:**
  - Eligibility for the Investment Tax Credit and bonus depreciation
  - Ability to use excess solar generation that would have otherwise been clipped
  - Energy arbitrage opportunities
  - Low site and substation costs
  - Potential integration with retail product offerings

UPTON 2

ILLUSTRATIVE OUTPUT (Hourly MW)



BATTERIES

RENEWABLES GROWTH

ELECTRIFICATION OF TRANSPORT

KEY TAKEAWAYS

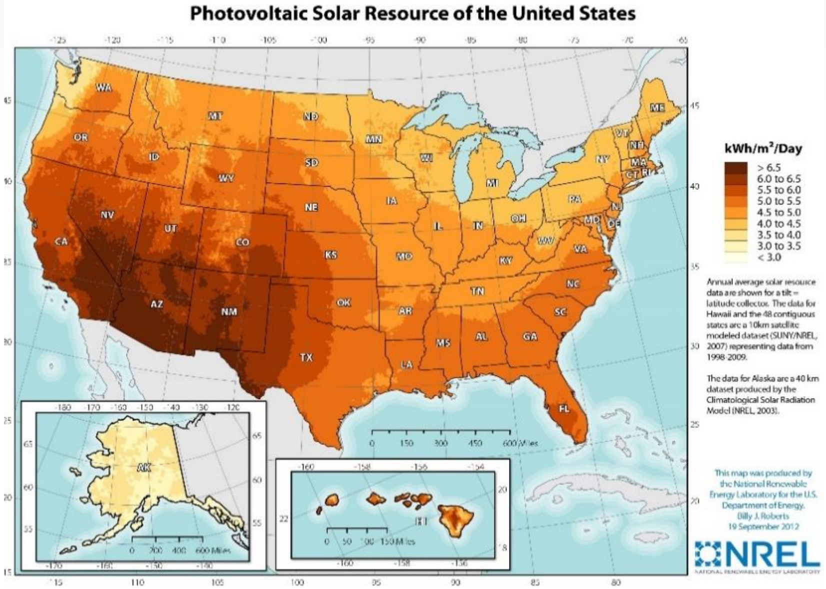
SOLAR AND WIND RESOURCE PATTERNS

VISTRA ENERGY

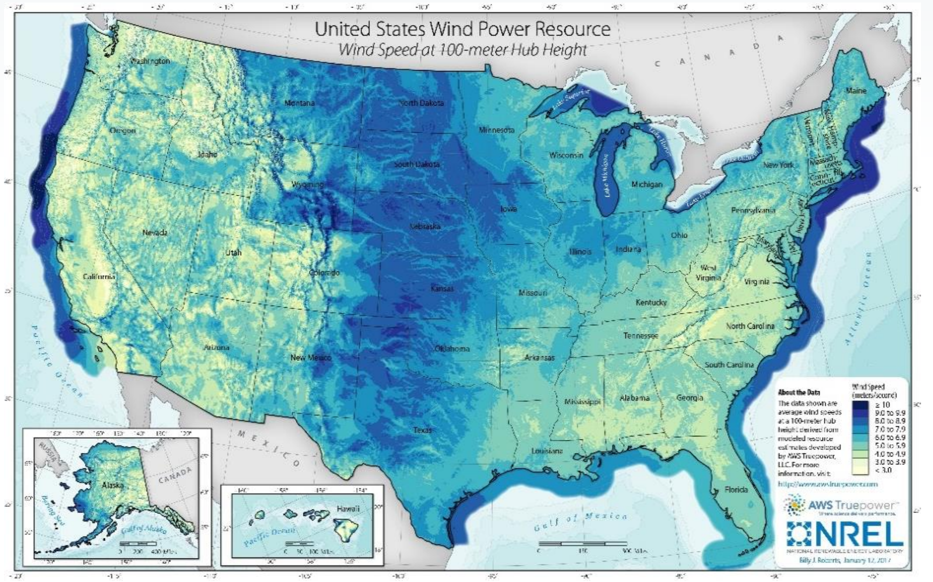
RENEWABLE RESOURCE OVERVIEW

- **Most areas with high solar and wind resource potential in the US are located far from population centers, and the PJM and ISO-NE regions have relatively low resource potential for both wind and solar**
- **In areas with low resource potential, RPS requirements are more likely to drive renewable development, whereas economics are more likely to drive requirements in areas with high resource potential**
  - RPS policies have driven 70-90% of the growth in renewables in the West, Mid-Atlantic, and Northeast, but in Texas and the Midwest, growth has far outstripped RPS requirements, largely due to attractive wind economics

SOLAR RESOURCE POTENTIAL



WIND RESOURCE POTENTIAL



RPS REQUIREMENTS AND FUTURE GROWTH

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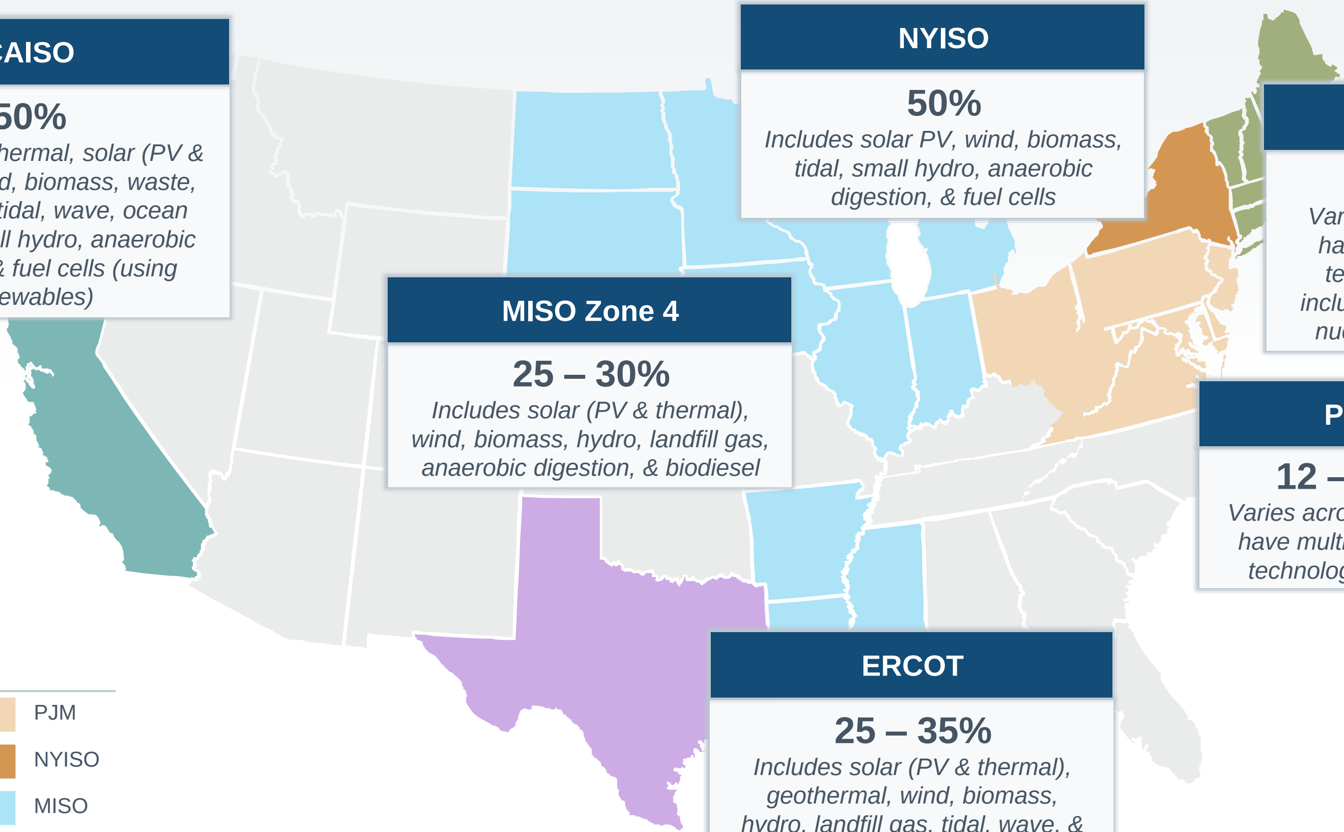
Given current RPS requirements, California and New York are expected to have the highest renewables penetration by 2030

Forecasted 2030 Renewables Penetration of Overall Generation[1]



CAISO
50%
Includes geothermal, solar (PV & thermal), wind, biomass, waste, landfill gas, tidal, wave, ocean thermal, small hydro, anaerobic digestion, & fuel cells (using renewables)

NYISO
50%
Includes solar PV, wind, biomass, tidal, small hydro, anaerobic digestion, & fuel cells

ISO-NE
30 – 40%
Varies across states; all have multiple types of technology included, including large hydro and nuclear in some cases

MISO Zone 4
25 – 30%
Includes solar (PV & thermal), wind, biomass, hydro, landfill gas, anaerobic digestion, & biodiesel

PJM
12 – 20%
Varies across states; all have multiple types of technology included

ERCOT
25 – 35%
Includes solar (PV & thermal), geothermal, wind, biomass, hydro, landfill gas, tidal, wave, & ocean thermal

ISO states

- CAISO
- ERCOT
- ISO-NE
- PJM
- NYISO
- MISO

Source: Berkeley Lab, DSIRE, McKinsey, & PA Consulting.

[1] Certain state RPS requirements have targets for specific technologies (principally for solar and wind).

BATTERIES

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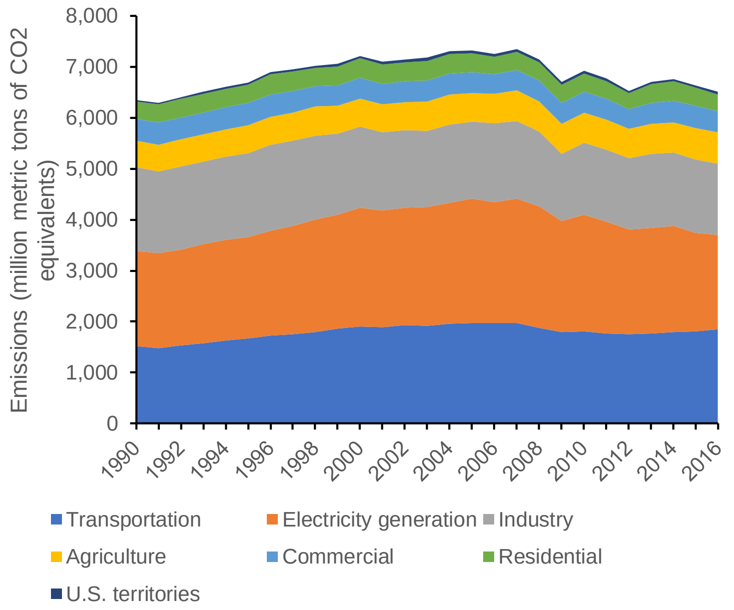
CHANGING ENVIRONMENTAL LANDSCAPE

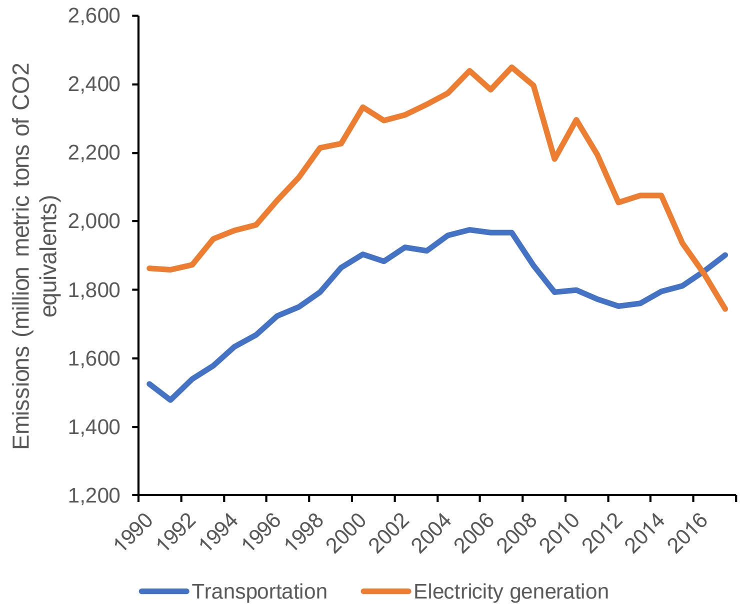
BACKGROUND

- **The Transportation and Power sectors are the leading sources of greenhouse gas ("GHG") emissions[1] in the United States**
- **In 2016, the Transportation sector overtook the Power sector as the largest contributor of GHG emissions**
  - Driven in part by coal-gas switching and an increase in renewables generation
  - Each EV that replaces an internal combustion engine vehicle results in a 3x savings in greenhouse gases

TOTAL GHG EMISSIONS BY SECTOR



GHG EMISSIONS: TRANSPORT > POWER



[1] GHG includes carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur, hexafluoride, and nitrogen trifluoride. SOURCE: EPA and EIA.

ELECTRIC VEHICLES

VISTRA ENERGY

BACKGROUND

- **Battery advancement will impact Electric Vehicles**
  - Improvements in battery storage costs, duration, and energy density, which have improved storage economics on the wholesale side, are making EVs more competitive
- **EVs, ride-sharing, and automation is a virtuous cycle that we see playing out over the next ~10-15 years**
  - Over the next ~5 years, EVs as a source of power demand will help to offset demand reductions from demand response and energy efficiency
  - In the ~10-15 year time frame, EVs may actually represent a significant source of power demand growth
- **EV penetration confined primarily to metropolitan areas, particularly on the coasts**
- **Continued EV penetration will be affected by:**
  - Low gas prices and easing fuel economy regulations
  - Availability of charging infrastructure
  - Improvements to driving range
  - Increased model availability

OPPORTUNITY FOR EV PENETRATION

EVs as % of US Motor Vehicle Fleet	EV Annual Load (TWh)	% of Overall Load
5%	60	2%
10%	121	3%
20%	242	7%
30%	363	10%
40%	484	13%
50%	605	16%
60%	726	20%
70%	847	23%
80%	968	26%
90%	1,089	29%
100%	1,210	33%

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- Grid-scale batteries have *modest penetration* forecasts and are *complementary* to existing baseload and low-cost cycling generation
- Renewable penetration in PJM and ISO-NE will likely be driven by RPS requirements and should not impact Vistra's core assets
- Reductions in battery storage costs are increasing the attractiveness of electric vehicles ("EVs"), which will only increase electric demand
- Vistra has a variety of opportunities to participate in battery storage and renewables at accretive returns and with high cash flow conversion

END SLIDE