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Vehicle To Grid

Prepared for NEDC Partner Meeting

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Overview

- Presentation based on a report prepared for NJDEP, Summer 2021
- Why V2G?
- V2G Opportunities
  - Policy
  - Utility Applications
  - School Buses, Pilots
- Business Models

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Why V2G?

- We need to triple the amount of renewable energy in the grid by 2030 to meet the Biden Administrations 50% emission reduction goal
- We need even more renewables to meet our goal of net zero by 2050
- NJ one of the leader in EVs

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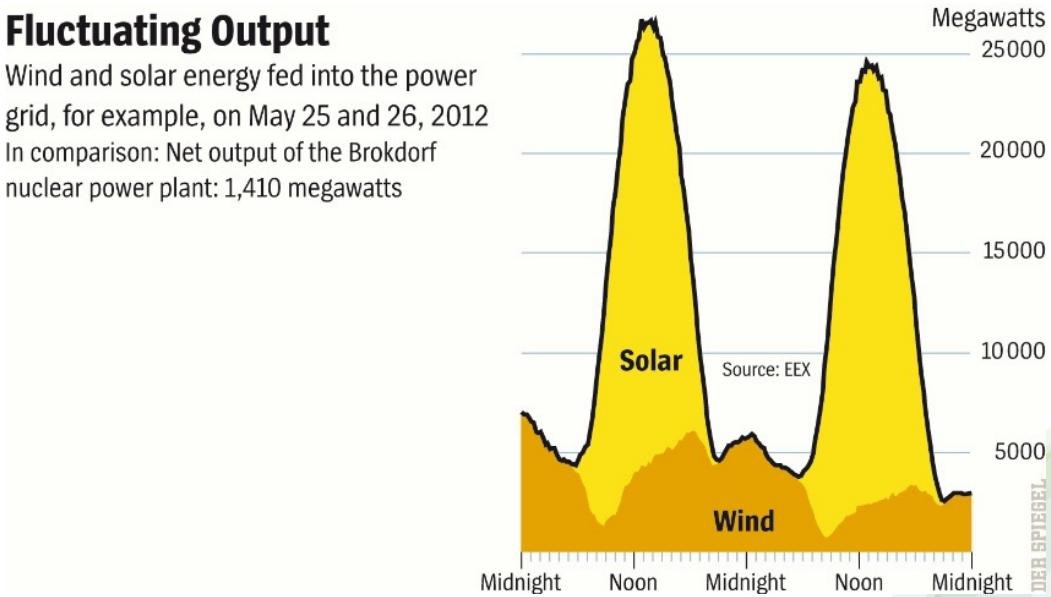
Why V2G?

- Renewables are variable
  - Wind energy peaks in the late afternoon
  - Solar peaks in the middle of the day
- Can address this two ways
  - More Transmission
  - More Energy storge
- There is a tipping point of renewable energy in the grid for which transmission cannot address variability
  - 2018: 0.869 GW battery storage
  - 2050: EIA estimates 59 GW-108 GW need



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Why V2G?

- Energy Storage includes batteries stationary grid storage
- Utility scale battery storage remains expensive
  - 2030: $124-$338/kwh
- Already millions EVs on the Road; some V2G compatible
- Can we make EV batteries act like stationary storage?
- Why now ? – NJBPU, FERC, EV manufacturers, Bidirectional Charging companies

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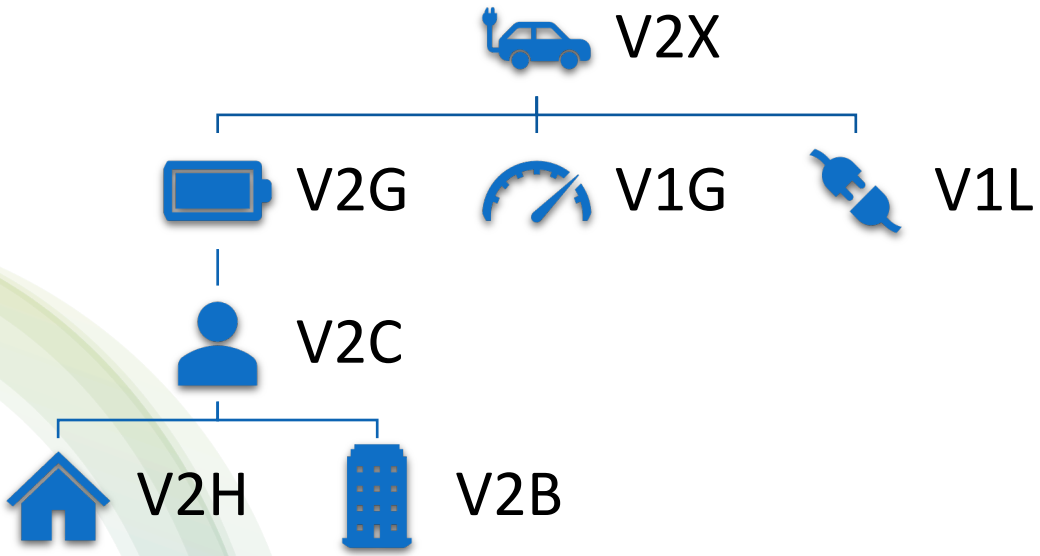
Aside: V2X



- Vocab muddled
- V2G is bidirectional flow between and EV and the Grid
- V2X is umbrella term
  - V2G – Vehicle to grid
  - V2C – Vehicle to customer
    - Vehicle to Home
    - Vehicle to Building
  - V1G- managed charging
  - V1L – vehicle to load
- Some V2G business models are V2C

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Electric vehicle charging infrastructure

	AC Level One	AC Level Two	DC Fast Charge	DC High Power
Power required	1.9kW	2.5 to 19.2kW	50kW	350kW
Charge time	~16 hours	~2-12 hours	~20-40 minutes	~6-8 minutes
Grid connection	Residential	Residential	Public	Direct to grid

Note: Charge time based on a 40kWh battery size. DC High Power — Charge time is applicable when EVs are capable of this charging speed

V2G Opportunities

- Higher plug-in rate
- More like stationary storage
- Opportunities to aggregate – fleets
- Battery aging management – cycling, thermal
- Pilot Cases
  - School Buses
  - Commuter cars for large organizations
- Interest in EVs as emergency back up power/generators
- Business Models - Behind and Infront of the Meter

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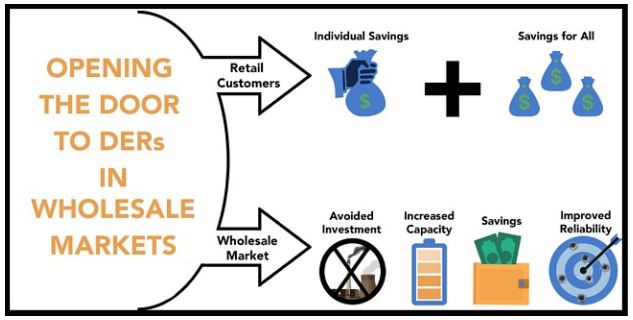

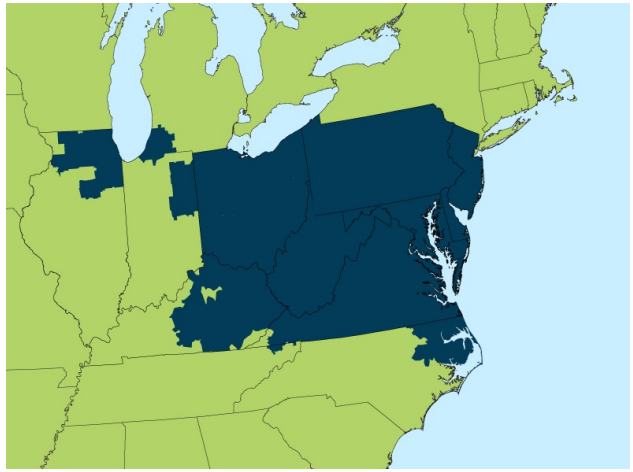

PJM Rules

- Stationary energy storage rules don't yet encourage energy storage well in any ISO
- FERC Order 2222, compliance filing expected February
- EVs as V2G count as Distributed Energy Resources (DER)
- DERs can bid into the market

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V2G Opportunities – Utility applications via NREL

Application	Description	Duration of Service Provision	Typically Valued in U.S. Electricity Markets?
Arbitrage (load shifting, valley filling)	Purchasing low-cost off-peak energy and selling it during periods of high prices	hours	yes
Firm Capacity (peak shaving)	Provide reliable capacity to meet peak system demand	4+ hours	yes, via scarcity pricing and capacity markets, or through resource adequacy payments
Operating Reserves			
• **Primary Frequency Response**	Very fast response to unpredictable variations in demand and generation	Seconds	Yes, but only in a limited number of markets
• **Frequency Regulation**	Fast response to random, unpredictable variations in demand and generation	15 minutes to 1 hour	yes
• **Contingency Spinning**	Fast response to a contingency such as a generator failure	30 minutes to 2 hours	Yes
• **Replacement/ Supplemental**	Units brought online to replace spinning units	hours	Yes, but values are very low
• **Ramping/ Load Following**	Follow longer-term (hourly) changes in electricity demand	30 minutes to hours	Yes, but only in a limited number of markets
Transmission and Distribution Replacement and Deferral (Congestion management)	Reduce loading on T&D system during peak times	Hours	Only partially, via congestion prices
Black-Start	Units brought online to start the system after a system-wide blackout	Hours	No typically compensated through cost-of-service mechanisms

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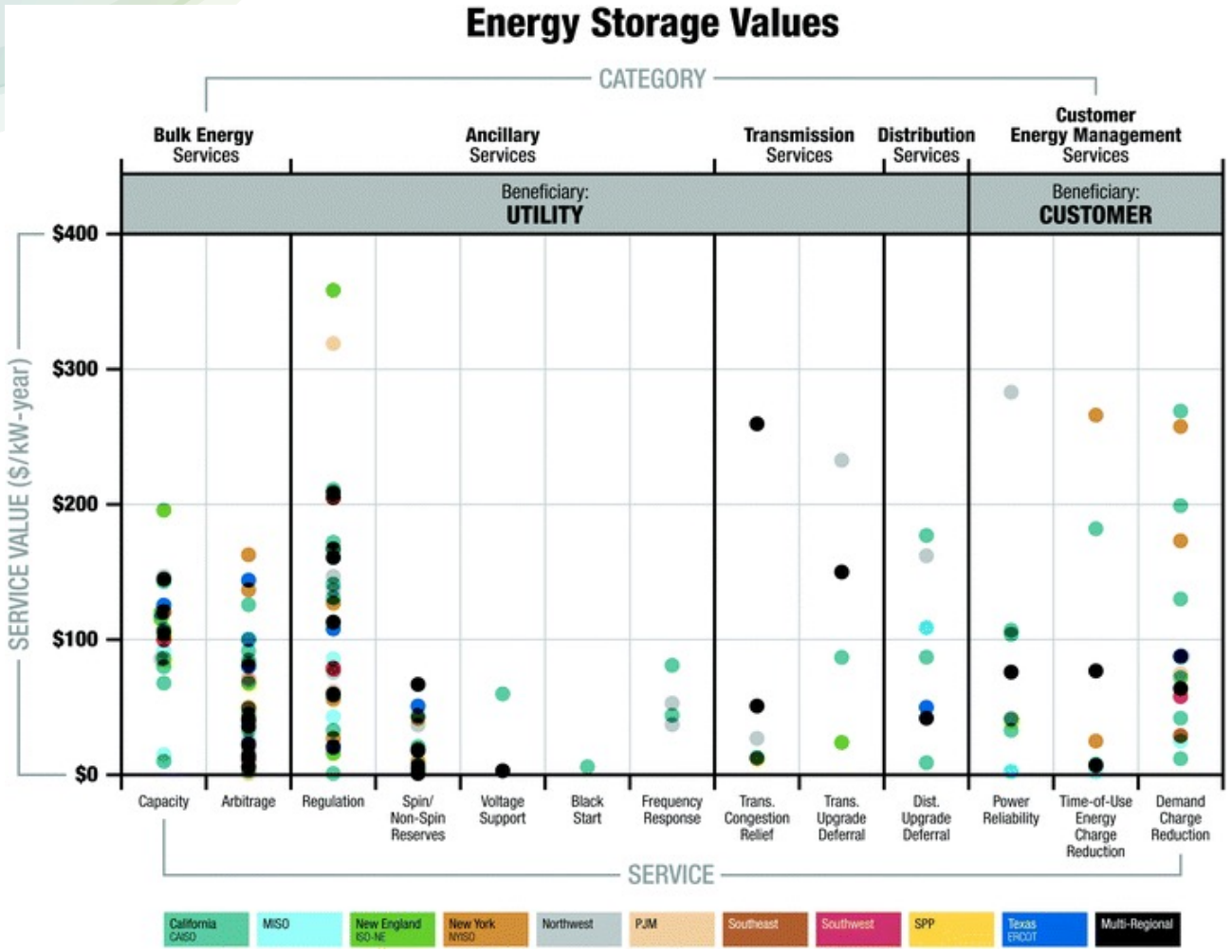
V2G Opportunities – Utility applications graphic



Reprinted from Balducci, Patrick J., et al. "Assigning value to energy storage systems at multiple points in an electrical grid." *Energy & Environmental Science* 11.8 (2018): 1926-1944.

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Charging Equipment

- Previous lack of bidirectional charging equipment
- Newcomers with UL approval – Fermata Energy, Wallbox, Rhombus Energy Solutions, Ford
- Still commercializing
- Not all EVs are V2G capable
  - Data communication limit

Company	Description
Fermata Energy	FE-15 bidirectional Charger, 15 kW
NUVVE	• Single Phase AC Charger - NUVVE Power port 19.2 kW (AC J1772)
	• Three-Phase AC Charger – 99kW (AC J3068)
	• 60 kW V2G Bidirectional Charger – NUVVE DC Heavy-Duty Charging Station (DC CCS1)
	• 125 kW V2G Bidirectional DC Charger - NUVVE DC Rapid HD Charging Station (DC CCS1)
Proterra	• 75 kW, 150 kW, 250 kW, 500 kW Charging System with bidirectional V2G capability, dispenser
	• 150 kW Charging System with bidirectional V2G capability, dispenser
	• 250 kW Charging System with bidirectional V2G capability, dispenser
	• 500 kW Charging System with bidirectional V2G capability, dispenser
	• Dispenser Charging System with bidirectional V2G capability
Wallbox	Quasar Charger, DC, 7.4 kW
Rhombus energy solutions	bi-directional 125 kW DC fast charger (operates NUVVE software)
	bidirectional 60 kW charger – AC to DC (operates NUVVE software)
Ford	Ford Charge Station Pro, 80-amp bi-directional charger

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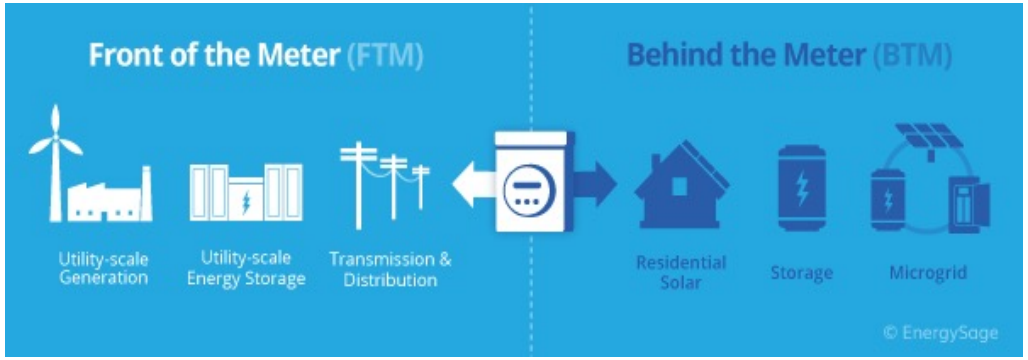
Business Models

- 1) V2B retail approach – manage peak usage for a building. Does not require load aggregation. “V2C”
- 2) Demand response – aggregation and participation in market
- 3) DER resource – similar to demand response but new rules TBD
- Injecting directly into the electrical grid, ie acting like utility scale storage, requires significant coordination



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School Buses

- Successful pilots
- Cost Challenge – Electric School Buses more expensive than diesel
- Costs coming down
- State Gov’t interested in exploring grant support for ESBs
- Most electric buses V2G capable
- Some business models easier to execute than others

BLUE BIRD

Thomas BUILT BUSES

THE LION ELECTRIC CO.

V2G + ESB	ESB	Diesel	Company
$331,317.25	All V2G	$104,010.00	Thomas Built Buses
$358,165.00	All V2G	$97,305.00	Blue Bird Buses
~$365,000	All V2G	NA	Lion Buses

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Summary

- V2G is an opportunity to remain a leader in EVs, clean tech
- All vehicles are going to be electrified
- Now is the time
  - NJ BPU creating energy storage rules
  - FERC creating energy storage rules
  - Car manufactures making V2G capable EVs
  - More Bidirectional Charging availability
- New V2G friendly rules at BPU level, FERC/ISO level coming soon

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Carnegie Mellon University

BLUE BIRD

NUVVE

Thomas BUILT BUSES

THE LION ELECTRIC CO.

Supplemental - Pilots

year	Type	Charger	EV	Description	Other Parties Involved	State	ref
2017	V2G	NUVVE	various	"INVENT" bidirectional chargers on UCSD campus street with 50 EVs; GIVE aggregation software	UCSD, Nissan, Mitsubishi Motors, Hitachi, BMW, NREL, PG&E, SDG&E, SUNSPEC Alliance	CA	[26] [27]
2018	V2B	Fermata Energy	Nissan LEAF	"Nissan Energy Share Pilot", Nissan north American headquarter and design center	Nissan	CA TN	[28] [29] [30]
2018	V2G	NUVVE	LionC Bus	5 buses at White Plains school district	ConEdison, Lion Electric, National Express, First Priority Group	NY	[31]
2019	V2G	Proterra	Jouley Bus	Phase 1 of Dominion Energy's Electric School Bus Program (50 buses deployed as of 5/2021)	Proterra, Dominion Energy, APEX, Thomas Built Buses, (Sonny Merryman Inc)	VA	[32] [33]

Supplemental - More Pilots

year	Type	Charger	EV	Description	Other Parties Involved	State	ref
2019	*V2B	Fermata Energy	Nissan LEAF	Peak shaving for industrial customer	Danville Utilities, EIT facility	VA	[13]
2020	V2G	Proterra	Jouley Bus	1 electric School bus at Beverley Public Schools	Highland Electric Transportation, National Grid, Thomas Built Buses (New England Transit)	MA	[34] [35]
2021	V2G	NUVVE	Blue Bird Type C bus	Commercial Whole fleet at Pekin Public School District and Hollis Consolidated School District	Bus-2-Grid Initiative (Future Green Energy Consortium),	IL	[37]
2021	*V2G	Proterra	Jouley Bus	6 electric school buses at Ann Arbor Public Schools & Roseville Schools	DTE Energy, Thomas Built Buses (Hoekstra Transportation)	MI	[38]
2021	V2G	NUVVE	ESB + EV	Commercial “Levo Mobility LLC”, an infrastructure venture that will offer fleet-as-a-service for school buses, last-mile delivery, ride hailing, ride sharing municipal services and more	Stonepeak Partners LP, Evolve Transition Infrastructure LP	CA	[39]