Enabling Safe Interconnection of Grid Integrated Vehicles

Technical Considerations in Massachusetts

For
The Massachusetts Technical Standards Review Group

By
Matthew Holstein, Sara Parkison, Willett Kempton
EV Research & Development Group
University of Delaware
December 8th, 2020

Outline

I. Who we are

II. Grid Integrated Vehicle Concept

III. Automotive Manufacturer Participation, Ongoing Projects

IV. Vehicles as Grid Assets in MA

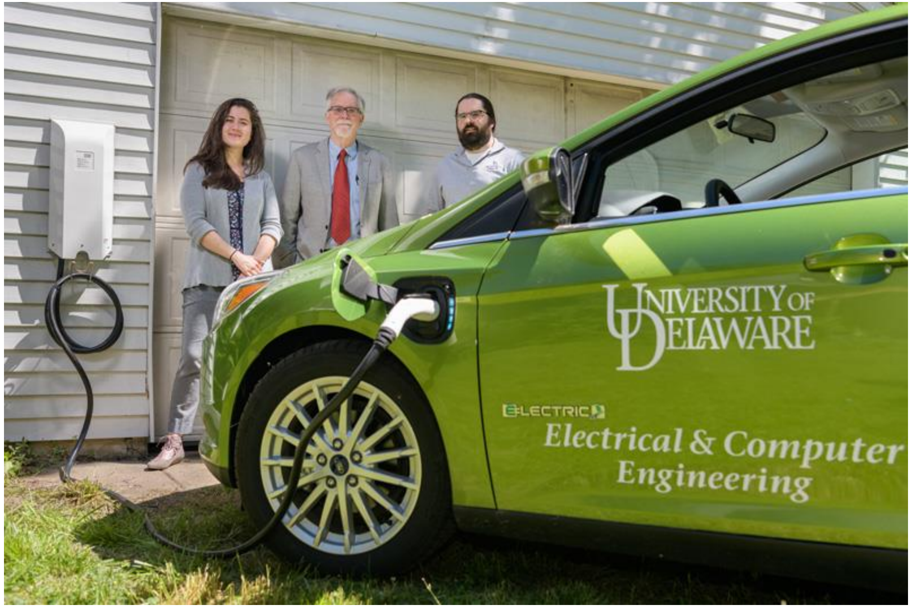
V. Economics of Mobile Storage

VI. SAE Interconnection Standards

VII. Recommendations

Background

- The University of Delaware's Electric Vehicle Research & Development Group (EV Group) has engaged in vehicle-to-grid (V2G) technology innovation and energy policy analysis for over 20 years.
- Competencies
  - Electric Vehicle engineering—design and implementation
  - Electric standards—drafting, review & compliance (IEEE, UL, NEC, IEC, CE)
  - Policies at Federal, State and EU levels
  - Tariffs & market requirements at FERC, RTO/ISO and EDC levels

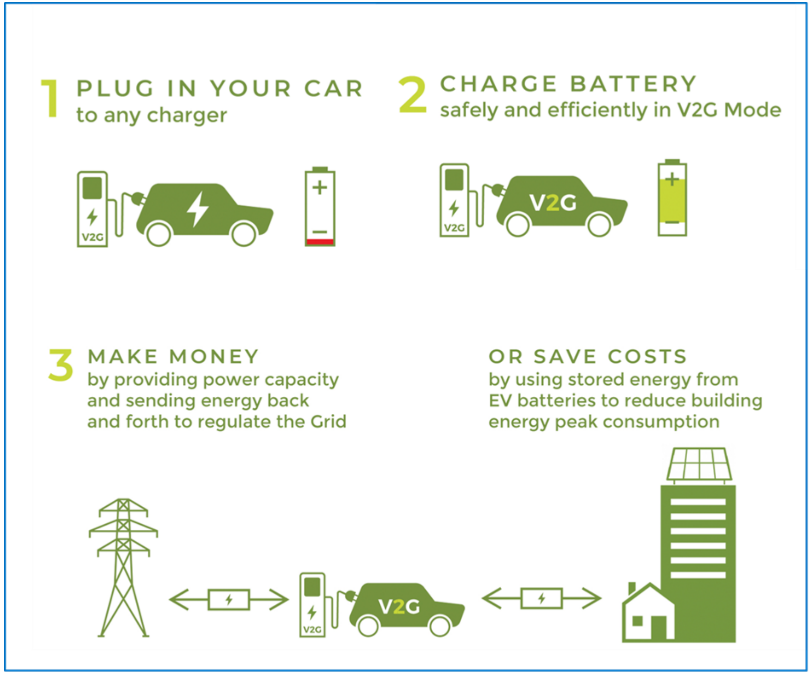


Grid-Integrated Vehicle (GIV) Systems Concept

GIVS can provide a variety of benefits to consumers, ratepayers, and the grid.

- Bring down TCO of EVs
- Turn an uncontrolled influx of demand (EVs) into a controlled load
- Mitigate the variability that high integration of renewables can cause
- Provide a cheaper, readily-available storage resource for grid services

Technology is proven and maturing, with OEMs producing V2G-enabled vehicles and aggregators realizing market value.



Courtesy NUVVE

UD “Demand-side Resource”
PJM regulation: $1,200 / EV / year

Energinet.dk Primary reserves market, earning €1,600/EV/year

Testing 3-phase charging standards at National Renewable Energy Lab, Golden, CO

Examples of GIV Systems in Operation

UK, Commercial GIV Fleets, multiple grid services – installed 2019/2020

Participating OEMs

OEM= Original Equipment Manufacturer,
(i.e. Automotive Manufacturers)

- BMW (AC V2G demonstrations)
- Honda (Pre-production EVs with AC V2G built-in)
- Nissan Europe (selling Leafs & eNV200s warrantied for V2G via DC)
- The Lion Electric (selling AC V2G busses)
- BYD (40 kW AC V2G demonstration, 28 transit buses)
- Bluebird (DC V2G buses, pre-production)
- Renault (mass produced AC V2G capable vehicle)

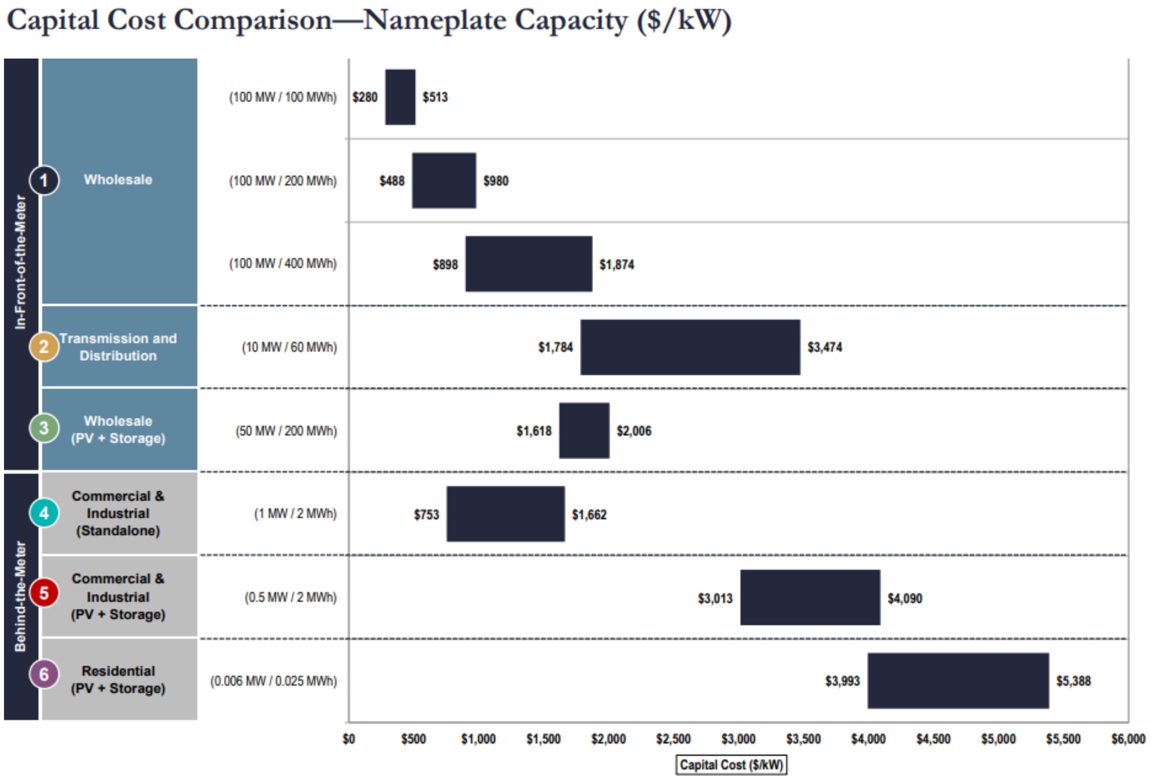
Most of the above have done detailed studies of effect on warranty and battery life and decided that is not a problem.

Vehicles as Grid Assets in MA

- GIVs have battery and power conversion equipment (charger and motor drive), can have second use as grid storage
- Average light vehicle is parked 95% of the time, typically near a plug
- Can be dispatched to participate in:
  - Utility DR programs or peak-reduction
  - In Massachusetts, the Clean Peak Program
  - Wholesale markets at ISO-NE level
- Several of these services could be stacked to realize full value
- MassCEC's ACTNow program encourages and provides funding for V2G projects to explore these avenues

	Service	Gross Annual Revenue Range (Per 100 kW bid)	Hours per year needed or standby
BTM	Arbitrage	$500 - $3,000	2,200
BTM	Customer Peak Reduction	$0 to $2,500	100
DTO	Deferral of Distribution Upgrades	?	70
RTO	Capacity	$3,000 - $7,000	?
RTO	A/S Regulation	$5,000 - $18,000	8760 (or bid 24*n)
RTO	A/S Spinning Reserves	$2,500 - $4,000	8760 (or subset)

(Approximate Numbers)

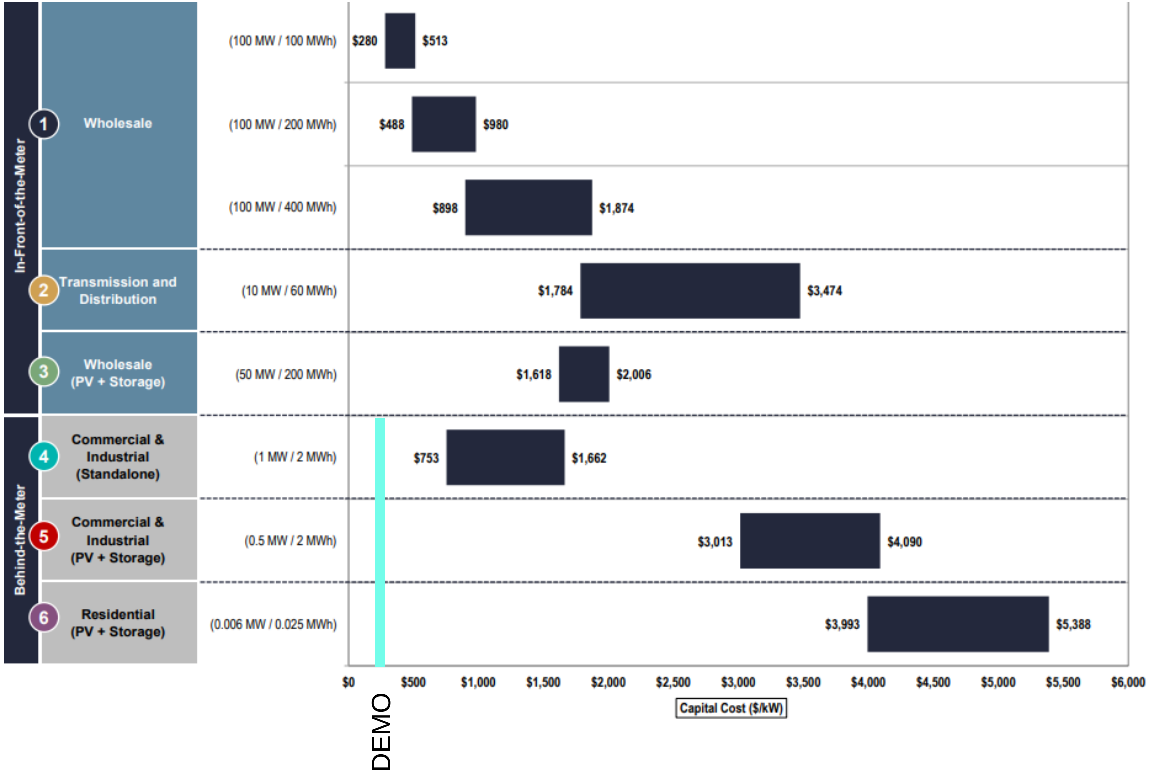


Stationary Storage is Expensive

Capital Cost: $300 – 5K / kW

Lazard LCOS v5.0, 2019

Capital Cost Comparison—Nameplate Capacity ($/kW)

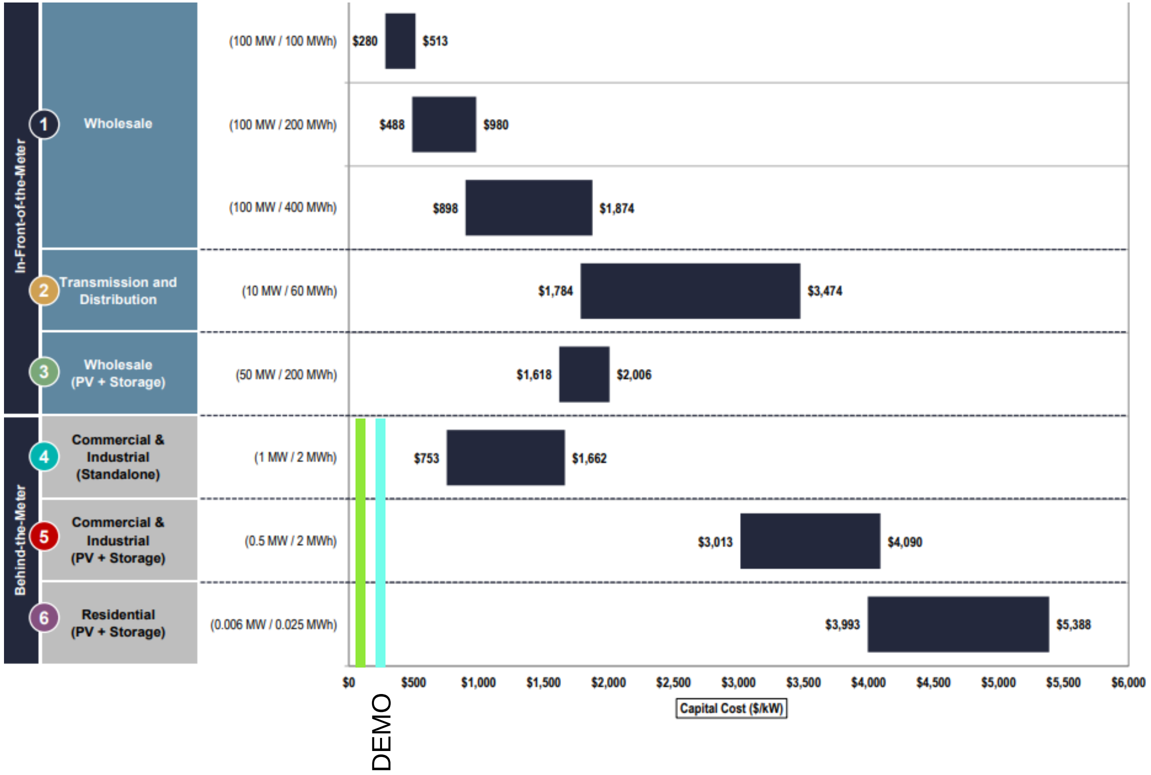


EV Storage is not Expensive

EV Storage Demo:
$227 / kW

Lazard LCOS v5.0, 2019

Capital Cost Comparison—Nameplate Capacity ($/kW)



EV Storage is not Expensive

EV Storage Demo: $227 / kW

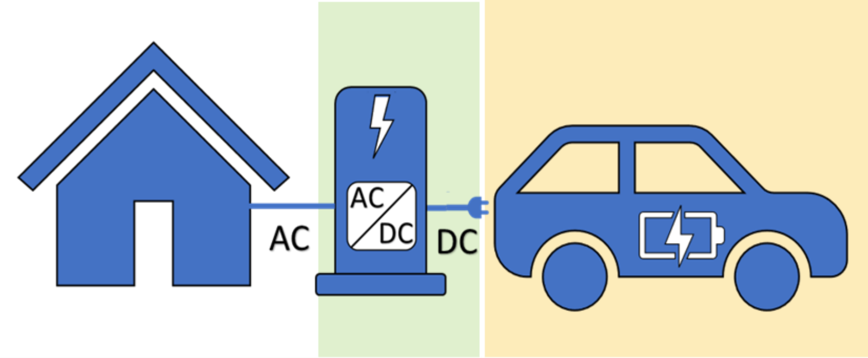
OEM production $45/kW

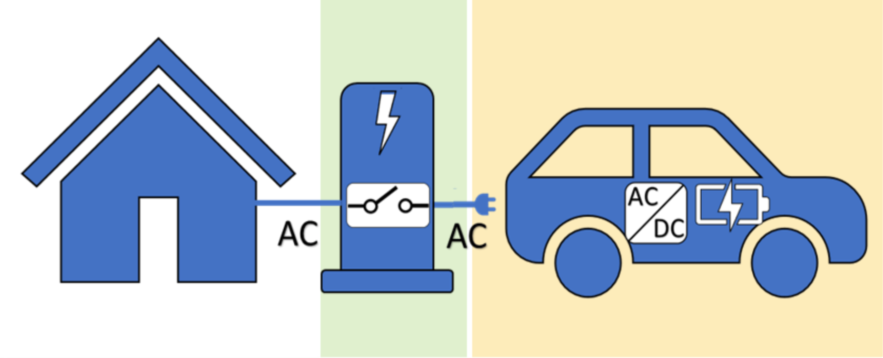
Lazard LCOS v5.0, 2019

Improving EV Storage Economics

"V2G AC Resources represent a potentially lower-cost form of mobile storage that supports renewable integration and improves vehicle-grid integration for the purposes of distribution planning."
– Auto Alliance in submission to CA PUC.

- Bidirectional (V2G), **higher revenue.**
  - 13x revenue of controlled charging depending on local markets, but more complex (Thingvad et al 2016).
- Higher power per car, **higher revenue.**
  - Charging power is key (more kW in/out), may not need bigger kWh battery.
- On-board (AC) charger, **lower capital cost.**
  - AC charging 1/3 to 1/2 cost of DC charging equipment
  - Auto Alliance indicates need for 5-year lead time from design to mass production of AC GIVs.
  - Regulators must demonstrate markets will be accessible
- An alternative, non-UL safety standard is required for AC V2G **market access**

	DC GIV System	
		
Interconnection Standard	**UL 1741** (Based on IEEE 1547)	
Certifying Institution	**OSHA-NRTL**	

AC GIV System		
		
	UL 2594	**SAE J3072** (Based on IEEE 1547)
	OSHA-NRTL	**OEM**

Courtesy of UD

Three components relevant to interconnection: Car, charging station, and inverter. Location of inverter is key.

AC/DC = Inverter

DC vs. AC System Interconnection

- DC GIV systems have the inverter located in the charging station.
  - Can interconnect using **existing standard frameworks** (UL 1741 based on IEEE 1547) that **assume interconnecting devices are stationary**.
  - UL 1741 assumes 1) the inverter in the device is permanently affixed onsite, 2) building wiring standards are appropriate, and 3) that the device can be certified to meet UL 1741 by an OSHA-NRTL.
- AC GIV systems have the inverter located on the car.
  - It is mobile storage and cannot meet UL 1741 requirements
  - Cannot be certified by OSHA-NRTL (outside Federal jurisdiction)
  - **Without a parallel framework, AC cannot apply to interconnect in MA**

SAE J3072 - Mobile Inverter Certification

- For EV AC interconnection, the inverter is in the car and may be a different inverter for different charging sessions – the “mobile inverter” problem
- SAE J3072 solves this by having EVSE and EV handshake, then the EV must provide evidence that it is compliant with relevant UL1741 standards (including IEEE1547); if not, no backfeeding allowed
- Adopted as appropriate for interconnection in Delaware law, and now under evaluation in California, New Jersey, and Prince Edward Island
- Recognition of SAE J3072 as an appropriate interconnection standard is essential for AC EV interconnection in MA

Comparison of V2G Regulatory Progress

Adopted or Available	MA	NY	DE	NJ	CA	Denmark
Controlled Charging	✓	✓	✓		✓	✓
DC Projects	✓		✓		✓	✓
AC Projects		✓	✓			✓
ISO Participation	✓		✓			✓
Backfeeding	✓		✓		✓	✓
SAE for AC Interconnection	✓		✓			✓ (Parallel Standard)
Credit-for-export	✓		✓			✓
Utility directive to investigate V2G	✓	✓	✓	✓	✓	

Recommendations for Market Entry in MA

- [x] Modify Common Technical Standards Manual (MA Joint Utilities) to recognize both stationary and mobile storage systems (i.e. GIVs).
- [x] Adopt SAE J3072 into the Common Technical Standards Manual to facilitate the interconnection of AC GIVs.
- [x] Begin a TSRG subcommittee review process to investigate V2G in MA
- [ ] Create an AC V2G demonstration project as a proof of concept for these standards

University of Delaware

Thank You.

For further information, email:

matholst@udel.edu

parkison@udel.edu

willett@udel.edu

Or visit:

https://crew.udel.edu/v2g/

University of Delaware