



@EVSymposium29
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Electric Vehicle Symposium & Exhibition

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DRIVE ELECTRIC INNOVATION
PROPULSER L'INNOVATION EN MOBILITÉ ÉLECTRIQUE

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NextEnergy is one of the nation's leading accelerators of advanced energy & transportation technologies, businesses & industries.



V2X Testing in Conjunction with FiatChrysler Automobiles

- Three different types of tests used to testing multiple scenarios:
 - Vehicle to Grid (V2G)
 - Vehicle to Building (V2B)
 - Vehicle to Home (V2H)
- Tests utilized:
 - Customized FCA automobiles: four (4) Fiat 500e electric vehicles, each car being powered by a 24 kWh lithium-ion battery
 - Bi-directional DC smart chargers from Coritech Services
 - NextEnergy test platforms, including the Power Pavilion microgrid with 18 kW of PV power generation and NextHome with 3 kW of PV power generation





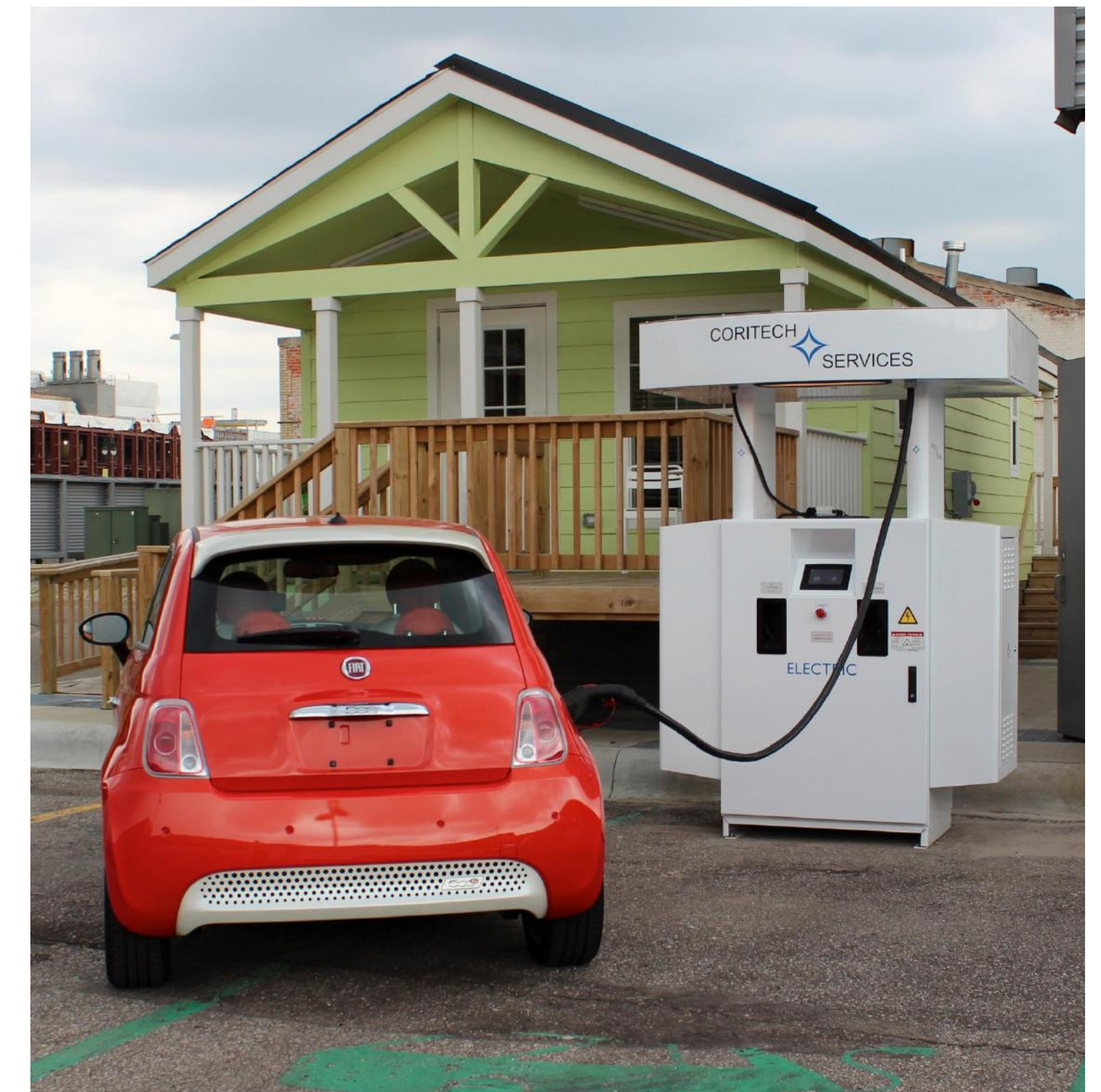
NextEnergy operates three unique microgrids within its 3-acre campus providing industry platforms to demonstrate and test distributed generation, demand response, energy efficiency, electric vehicle infrastructure, smart home and communications within commercial and residential energy applications.





FCA V2G + V2B Project:

NextEnergy & FCA set out to determine whether bi-directional charging provides benefit (profit/savings) to FCA, fleet owner and facility owner via participation in grid/building energy management. V2H proof-of-concept also tested





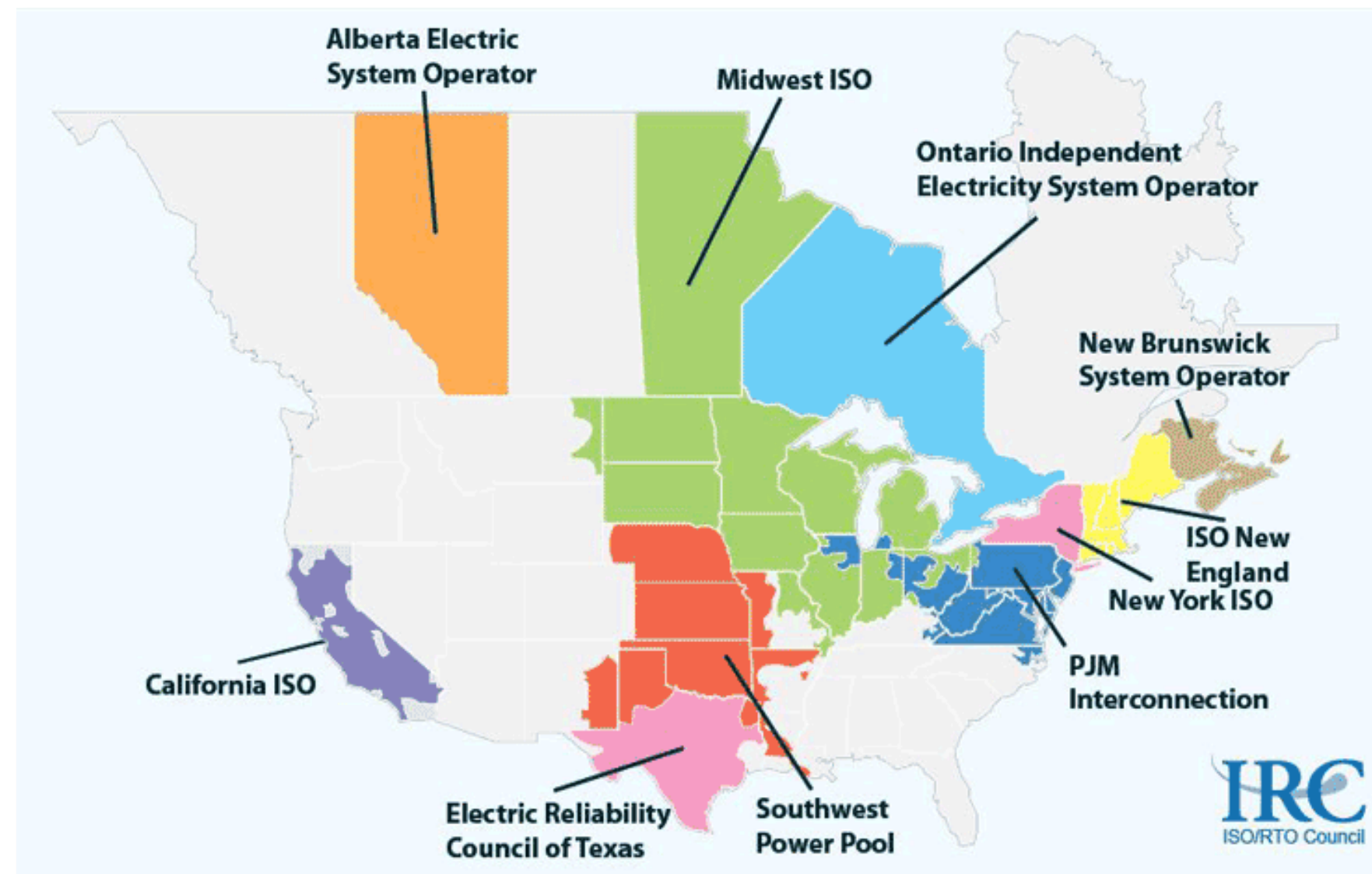
Calculating a V2G Revenue Baseline

- Baseline assumes 6.6 kW bi-directional charging
- Factors used for scenarios:
 - ISO Contract Rate (varied \$10 to \$80 per MWh)
 - Charging / Discharging Rate
 - Vehicle availability (5% to 100% of time)
 - Battery degradation cycles
 - Battery Costs (assumed between \$500 per kWh and \$250 per kWh)
- Utilize different scenarios to generate multiple curves to determine best financial scenario
- Baseline ~\$600 per vehicle per year:
 - Contract rate ~\$50/MWh
 - 6.6kWh charge/discharge
 - ~50% vehicle availability
 - ~3,000 cycles
 - ~\$450/kWh battery cost



Comparison of Costs from Multiple ISOs

An aggregator was used to bid into the markets



Market	Frequency Regulations Market Size (MW), 2009	# Vehicles opportunity (6.6KW, 50% availability)
PJM	1,357	~411k
ERCOT	1,192	~360k
CAISO	623	~200k
MISO	561	~170k
NYISO	506	~153k
ISO-NE	118	~35K
Total	4,375	~1.3M



Key Findings from V2G Studies

- The region has a significant impact on profitability
- Based on 2013 prices, larger markets are more profitable: PJM and ERCOT were specific target markets
- Regions with more renewables or higher consumption increased the need for more grid balancing
 - NextEnergy anticipates 2016 prices and renewable penetration would change which markets are most profitable
- Battery degradation has significant impact on economic value of V2G through opportunity loss
 - During testing, batteries were capped with upper and lower states of charge, which varied by battery age; aging batteries had narrower ranges
 - Average loss was 10% of total revenue due to battery aging

$$\text{Opportunity Loss (\$)} = (\text{Max Charge Rate} - \text{Power Responded}) \cdot \text{Duration of Signal} \cdot \text{Electricity Price}$$

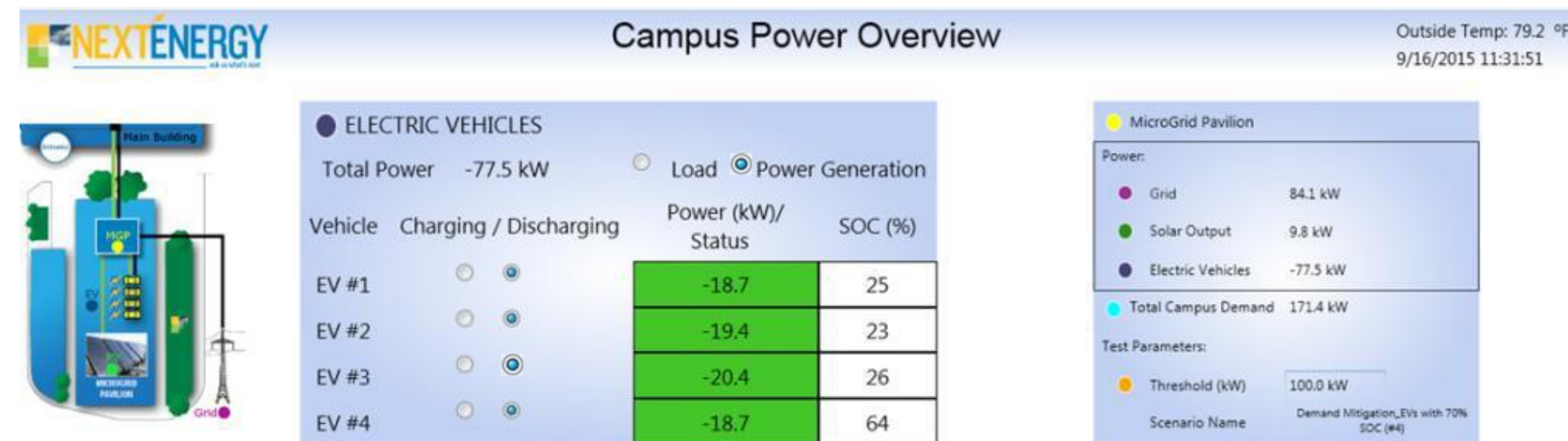
- Battery ages faster at peak times when more signals are sent to support the grid (no time to cool battery)
- Aggregator service fees also have the potential to have a significant impact on revenue model (fees range 20% to 25% depending on location and aggregator)



Identifying V2B Opportunities

The study was designed to test arbitrage shifting electricity prices using V2B as the energy storage and to test the business case for demand mitigation with EVs

- Five driver habit profiles developed by FiatChrysler that they collected in previous research
- Test scenarios included three pricing scenarios:
 - Time Of Use pricing (TOU), capped at 100 kW of grid energy for arbitrage
 - Demand Mitigation
 - Real-time energy pricing
- DC bi-directional charger utilized:
 - AC/DC converter moved from vehicle to EVSE, reducing vehicle costs
 - 3.3kW, 6.6kW and 19.2kW discharge rates tested
- During test scenarios, 1,739 kWh of energy was used, of which 30 kWh was generated by solar, the remaining generation came from combinations of four EV discharging and the grid



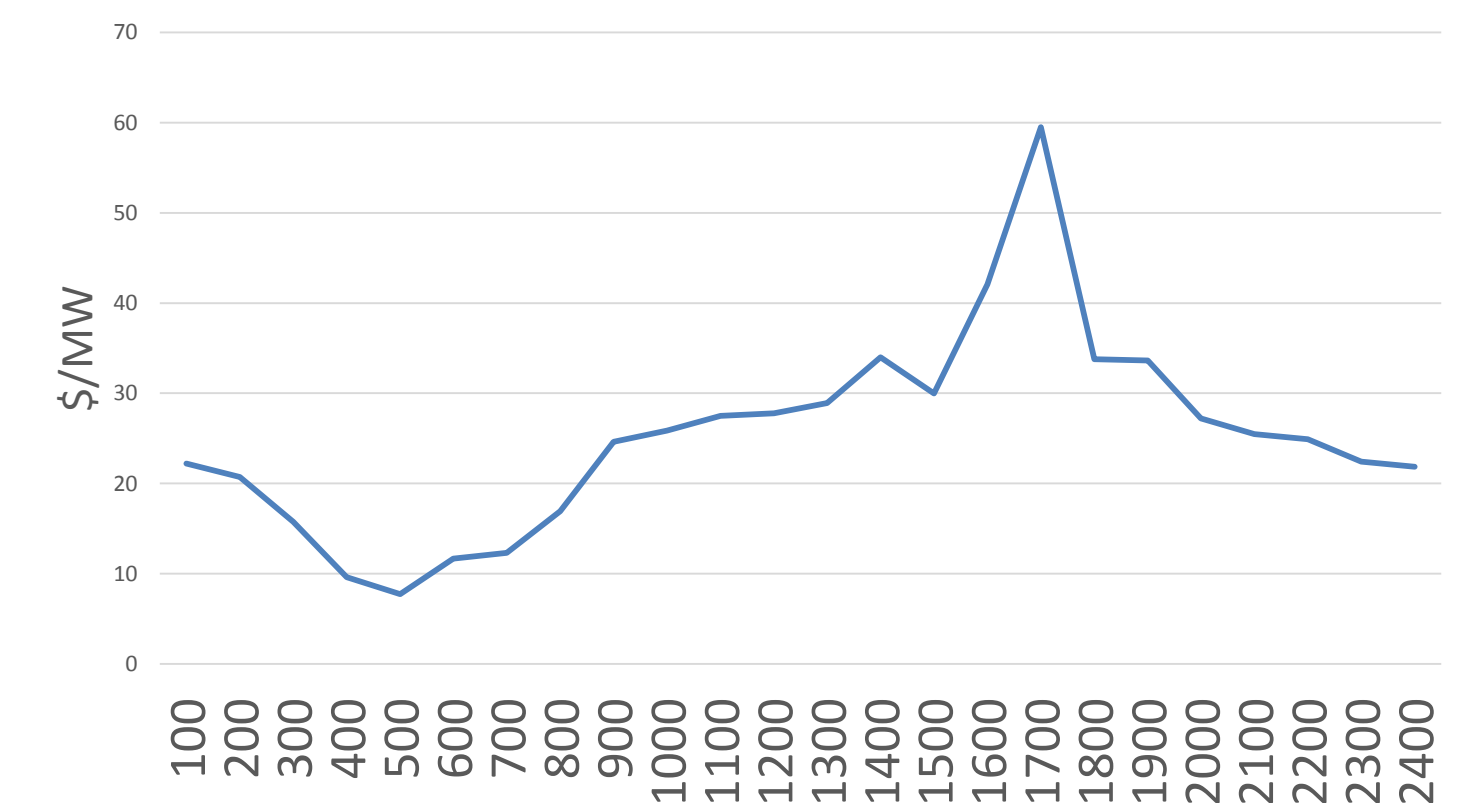
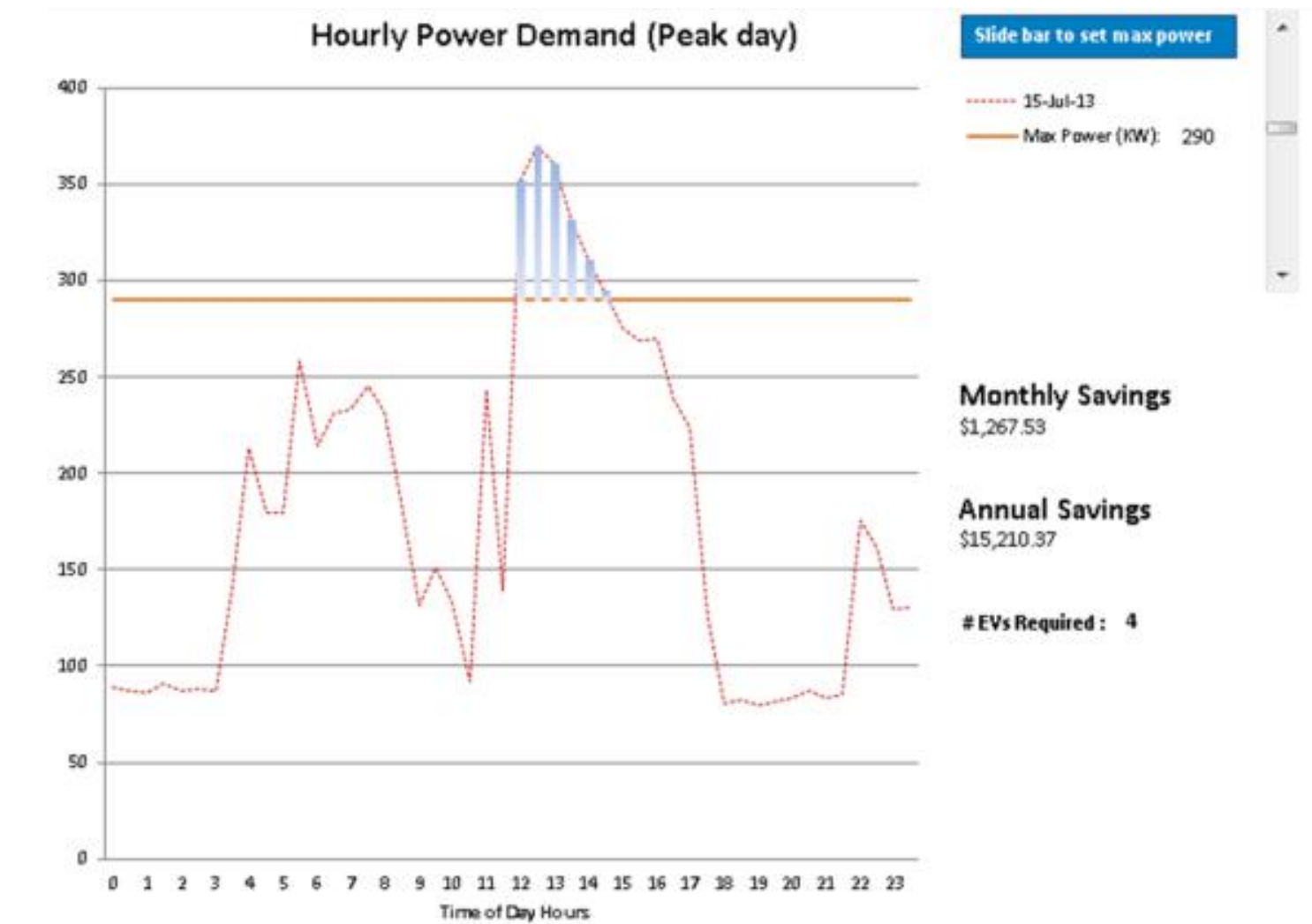
Vehicle Side

**Building Management
System Side**



Key Findings from V2B Studies

- Aggregation is key to economic benefits
- 19.2kW bi-directional charging not necessary, but more beneficial due to faster energy transfer
- Demand mitigation proved most profitable scenario:
 - Battery degradation is significantly lower than V2G and somewhat lower than TOU
 - Demand charges can represent up to 60% of electricity bill
- TOU benefits are best in areas where there are big differences in peak/off-peak prices (best when $> \$0.10/\text{kWh}$ difference)
- Similarly, Real-Time pricing best with big differences in peak/off-peak prices but DC fast charge required

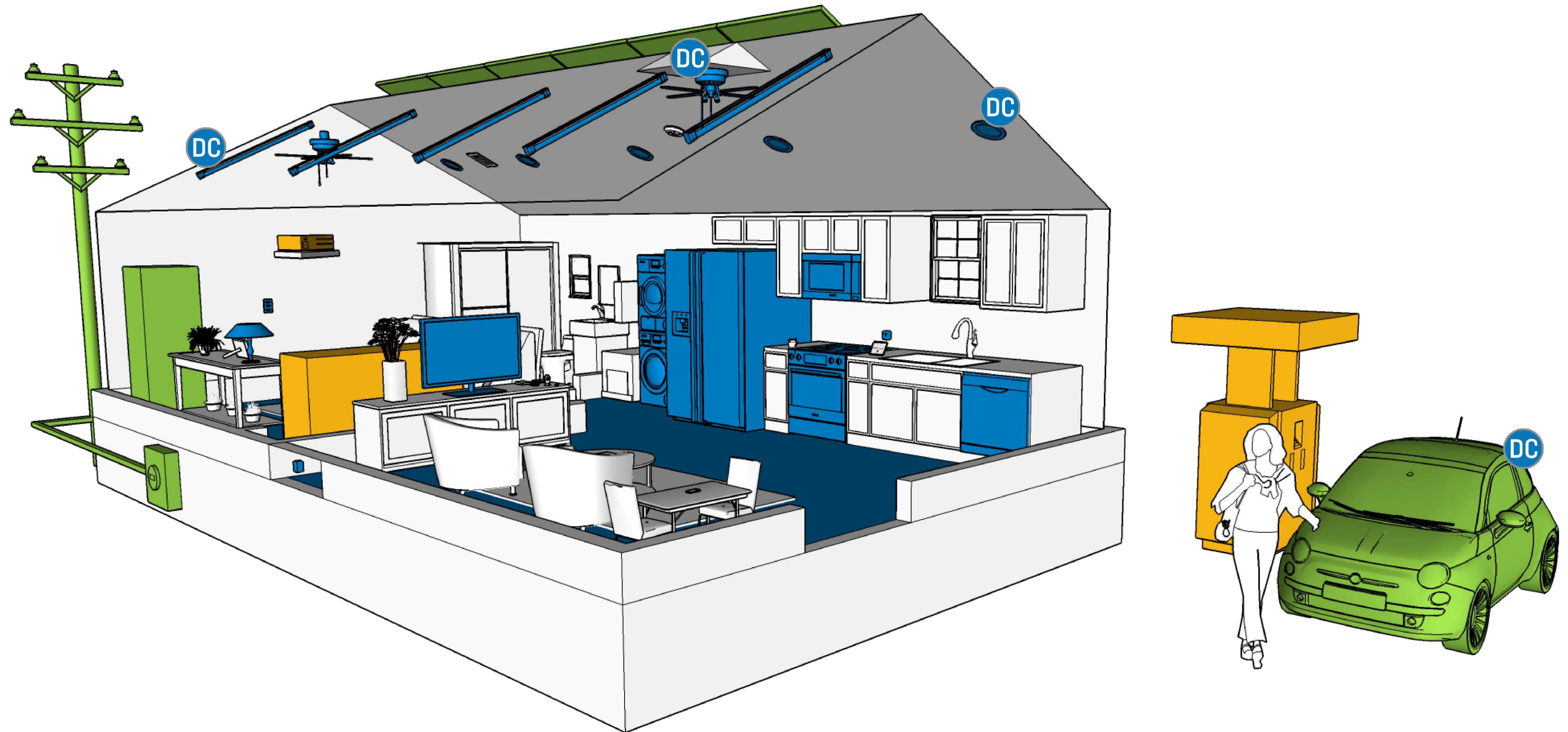




NEXTHOME

a DC Connected House

NextHome is part smart home, part distributed generation and part direct current (DC) that operates as a “living lab” within NextEnergy’s testing and validation platforms and allows industry partners to leverage multiple IoT frameworks and a residential microgrid.





Identifying Opportunities for V2H

- V2H can be harder to quantify:
 - What is value of resiliency to homeowner?
 - Assuming planning to have exportable power into home, then economics will be compared to a home generator
 - Home generators price range is \$800 (gasoline, portable) to \$4,000 within installation on pad
- V2H requires a smart inverter (could be separate, in EVSE, in vehicle)
 - How to justify the cost of changes to the vehicle or higher cost EVSE?
 - Once smart inverter is installed, gateway to residential energy storage



Comparing V2X Opportunities

	Demand Charge Mitigation (V2B)	V2G	Arbitrage (V2B)	Demand Response (V2B)	V2H
Battery Life Impact	Minimal	High	Moderate	Moderate	Minimal
Value Implications	High value with multiple EVs	High value up to 1 million vehicles	Better with larger battery EVs (>25 KWh) and higher spread TOU pricing	Better with larger battery EVs (>25 KWh)	Better with larger battery EVs (>25 KWh) to serve emotional benefit as backup generator

- **V2G:** Daily interaction potential to significantly impact battery, fast charging needed to aggregate fewer vehicles
- **Arbitrage (V2B):** Fast charge not required, aggregated EVs is required
- **Demand Response (V2B):** potential to offer greater economic value during demand response events, if the vehicles are used for V2B applications (not just shutting off charging)
- **V2H:** potential EV purchase demand driver, particularly in regions with high renewable penetration and significant spread in TOU pricing



V2X Integration into Smart Cities

Four main stakeholders benefit from V2X in context of a Smart City

- Automakers:
 - Justification for bigger battery investments
 - “Software as a Service” investments
 - Potential partnerships beyond traditional Tier 1 and infrastructure suppliers
- Transportation Service Providers:
 - Potential for increased revenue per vehicle
 - Potential for lower maintenance costs
 - Potential for premium siting/location of access points within urban areas
- Utilities:
 - Potential influence location of infrastructure which can increase reliability of grid, to enter into unique programs with customers, and provide new products
 - Potential partnerships in new segments: transportation system providers, vehicle manufacturers, aggregators, and others
- Government:
 - Improved attraction of transportation service providers that support congestion mitigation goals
 - Potential to improve city resiliency
 - Branding/marketing/other environmental target benefits



Car Sharing Energy Usage

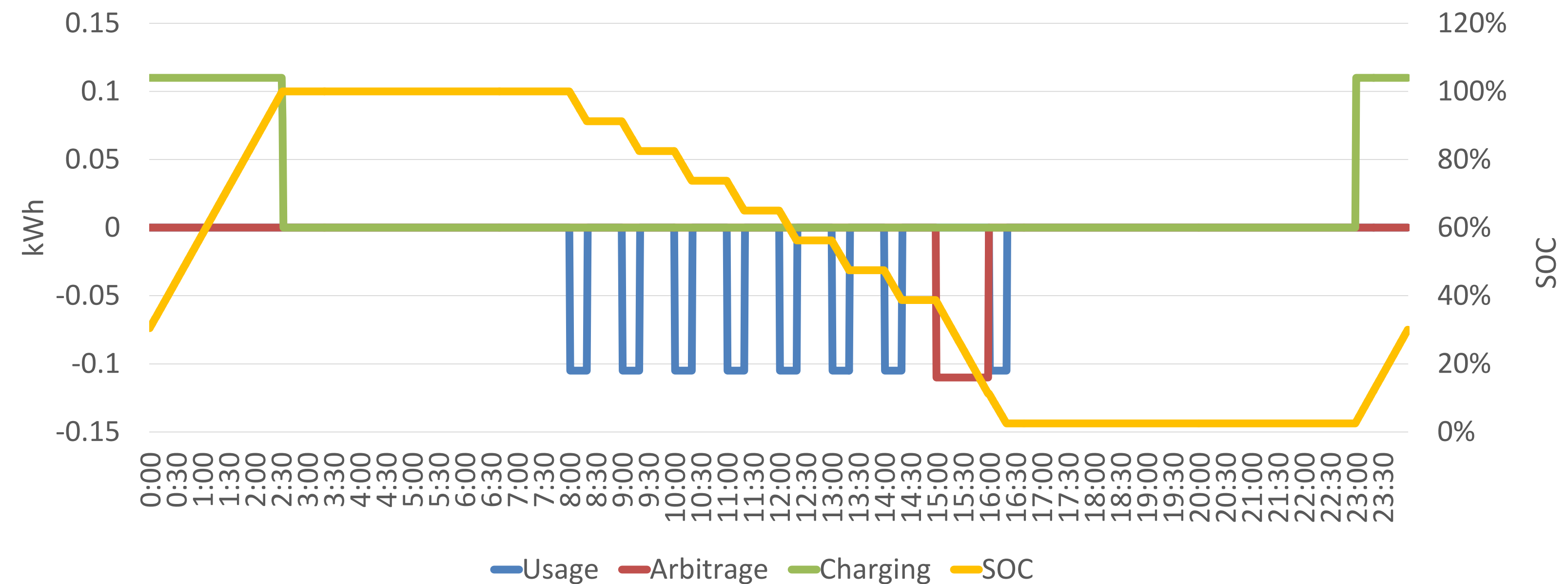
- Vehicles rented 6-8 hours/day
- Vehicles driven 5-7 miles each hour
 - Based on above, vehicles are driven 30-56 miles/day
- Average utilization 35-45% per day
- Average monthly revenue per vehicle: \$1,600
 - Daily revenue per vehicle: \$51.61/day
- 24 kWh battery
- 300 wh/mile consumption
 - 1.5 kWh to 2.1 kWh consumed per trip
 - 16.8 kWh consumed for 56 miles

	Gasoline Costs (March 2016)	Fuel Costs for 56 Miles per Day	Off-Peak Electricity Costs	16.8 kWh Charge
Detroit	\$2.16	\$4.32	\$0.04165	\$0.70
New York	\$2.45	\$4.90	\$0.0136	\$0.22
San Diego	\$2.84	\$5.68	\$0.230	\$3.86

Using Car Sharing Vehicles for V2X

Can both 24 kWh battery (80 mile range EV) and 60 kWh (200 mile range EV) be advantageous for arbitrage?

- 24 kWh battery leaves only 6.6 kWh for arbitrage per day and potential for very low state of charge
- Battery degradation likely
- Need better understanding of consumer usage of car sharing and availability for arbitrage and charging

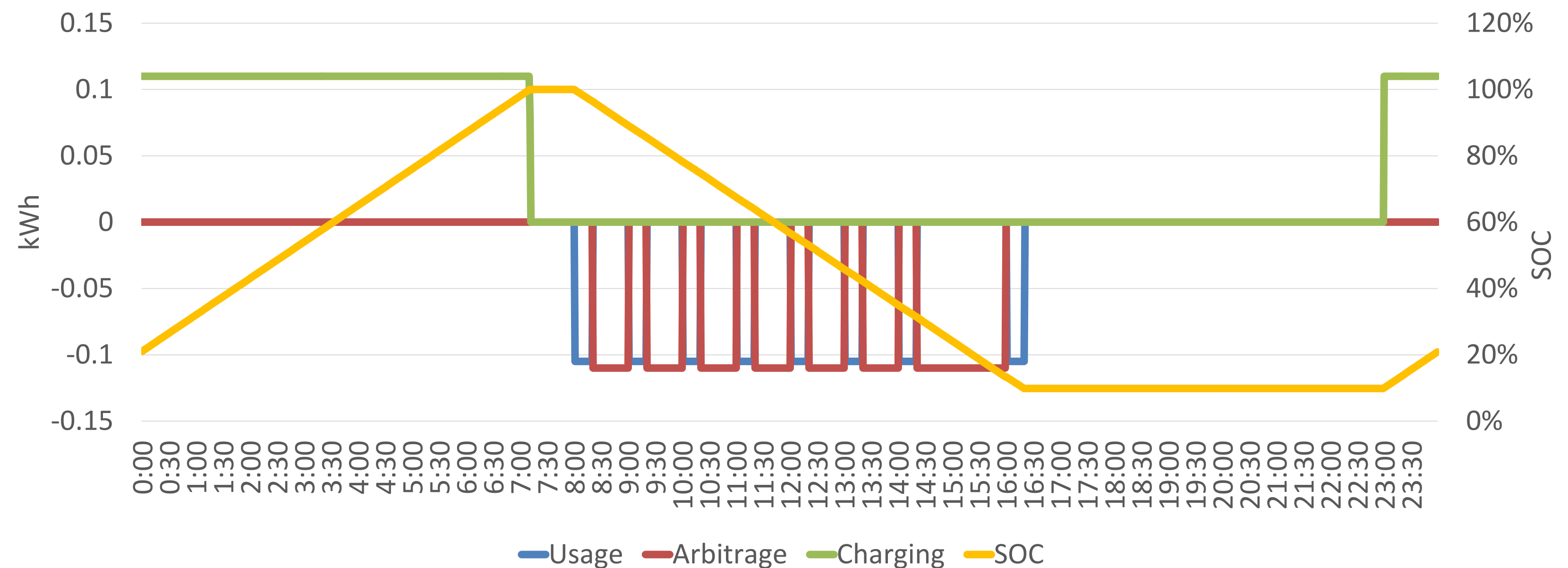




Using Car Sharing Vehicles for V2X

200 mile range EVs look promising for V2X in car sharing but many hypotheses left to test

- 60 kWh battery leaves about 37 kWh for arbitrage per day with SOC never below 10%
- Logistics of V2X has to be better understood
- Battery degradation is a significant question with this scenario
- Vehicle aggregation likely to be key





Thank you!

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