Welcome to this week's presentation & conversation hosted by the **Canadian Association for the Club of Rome**, a Club dedicated to intelligent debate & action on global issues.

The views and opinions expressed in this presentation are those of the speaker & do not necessarily reflect the views or positions of CACOR.

What Next on V2X in Ontario: Lessons Learned from Pilots.

Our speaker today is Dr. Shivam Saxena, who builds software-based systems to improve the sustainability and resiliency of energy systems. Shivam has delivered > 30 smart energy projects in his career, contributing to > 55 MWh of energy savings, and has built demonstrations for bidirectional electric vehicle charging and blockchain-based energy trading. Shivam has > 12 peer reviewed articles. Shivam founded a clean-tech company, Hero Energy and Engineering, in 2015, and serves as an Assistant Professor in the Department of Electrical and Computer Engineering at the U New Brunswick.

DESCRIPTION: Bidirectional electric vehicles (EVs) can be a vital tool in helping Canada reach its sustainability goals by mitigating emissions caused by the transportation and the electricity generation sectors. However, the lack of real-world demonstration for this technology and assessment of its socio-economic preferences from EV owners prevent its uptake. This talk delves into bidirectional EVs from a techno-socio-economic lens and discusses results from residential and commercial pilots in Ontario (first of their kind) to unlock this technology's value and recommend solutions for its adoption.

The presentation will be followed by a conversation, questions, & observations from the participants.

CACOR acknowledges that we all benefit from sharing the traditional territories of local Indigenous peoples (First Nations, Métis, & Inuit in Canada) and their descendants.

Website: canadiancor.com
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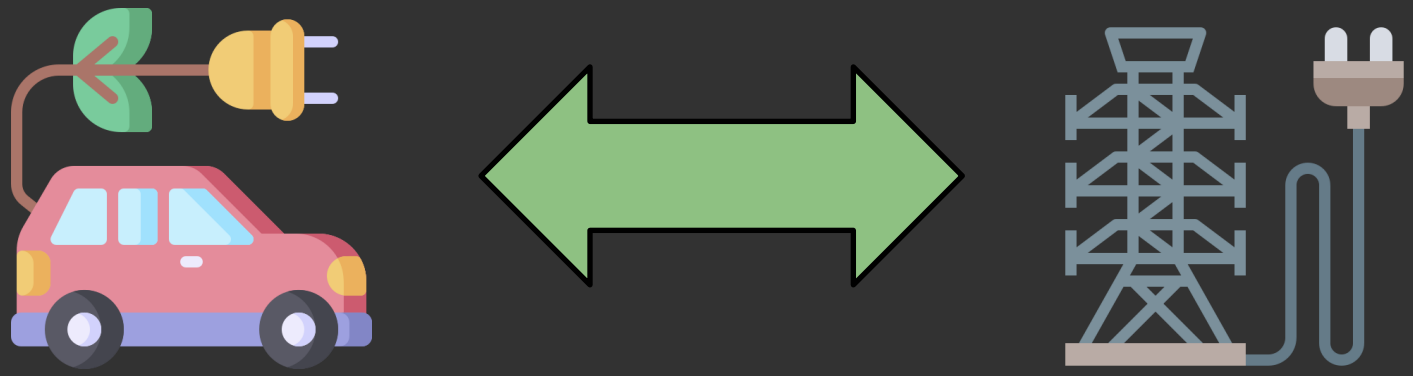
2023 Nov 22 Zoom #172

What Next on V2X in Ontario: Lessons Learned from Pilots



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LASSONDE SCHOOL OF ENGINEERING | YORK UNIVERSITÉ UNIVERSITY

Dr. Shivam Saxena, P.Eng
Nov 22, 2023

Outline

1. About our team (5 minutes)
2. Demystifying V2X and potential opportunities (5 minutes)
3. Evaluating consumer appetite with demos (10 minutes)
4. Project results, challenges, barriers (10 minutes)
5. Economic analysis (5 minutes)
6. Questions

About our team

HERO ENERGY & ENGINEERING

Vendor for DER control solutions
R&D Innovator: IoT, Blockchains, V2X

volta

NFP advancing low-carbon decision making using analytics, intelligence, outreach

LASSONDE SCHOOL OF ENGINEERING | YORK UNIVERSITÉ UNIVERSITY

Expertise in distributed control of DERs and impact assessment of transit electrification

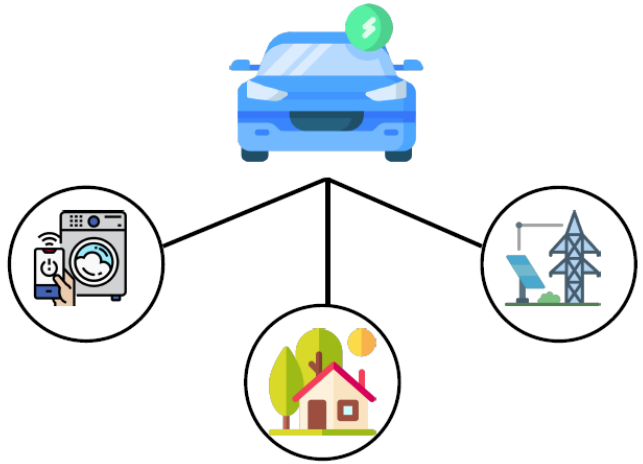
DER – Distributed Energy Resources; NFP – Not for Profit

Aren’t electric vehicles (EVs) batteries on wheels? Welcome to bidirectional charging!

Image Credit: QMerit

Demystifying the ‘X’

What is the ‘X’ in Vehicle to Everything (X) ?



V2L: Vehicle to Load
EV has outlets that appliances can directly plug in to

V2G: Vehicle to Grid
EV exports excess energy to the grid, earning revenue and helping utilities balance the grid

V2H/B: Vehicle to Home/Building
EV reduces energy consumption in building and/or acts as a backup generator in case of grid outage

Opportunities for V2X

Incentives and Outages

Sell stored energy to utility at peak time

Outage proof homes!

Support The Grid

Defer grid capacity upgrades (in range of $$B)

Emissions Mitigation

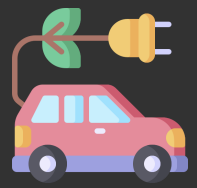
Reduce reliance on fossil fuel generators

Social, Technical, Economical Challenges in V2X

Regulators

Protect consumer: fairness, preferences, consent

EV Owners

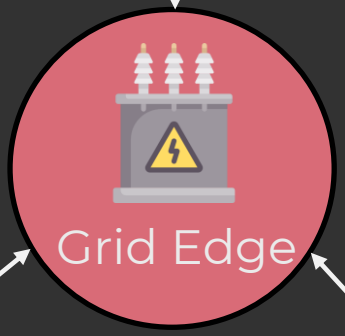


Range reduction and anxiety?

Enhanced battery degradation?

Incentives? Commitments?

Don’t sell my personal data!



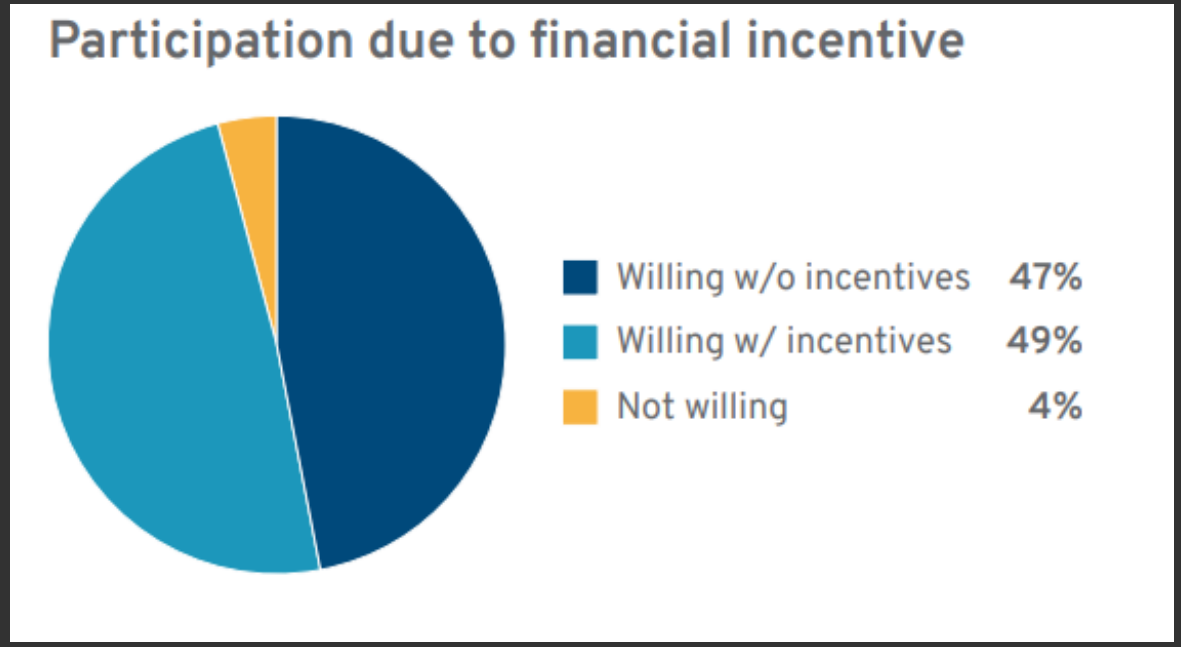
Utilities

Reliable? Car and driver both!

Identify V2X ‘programs’

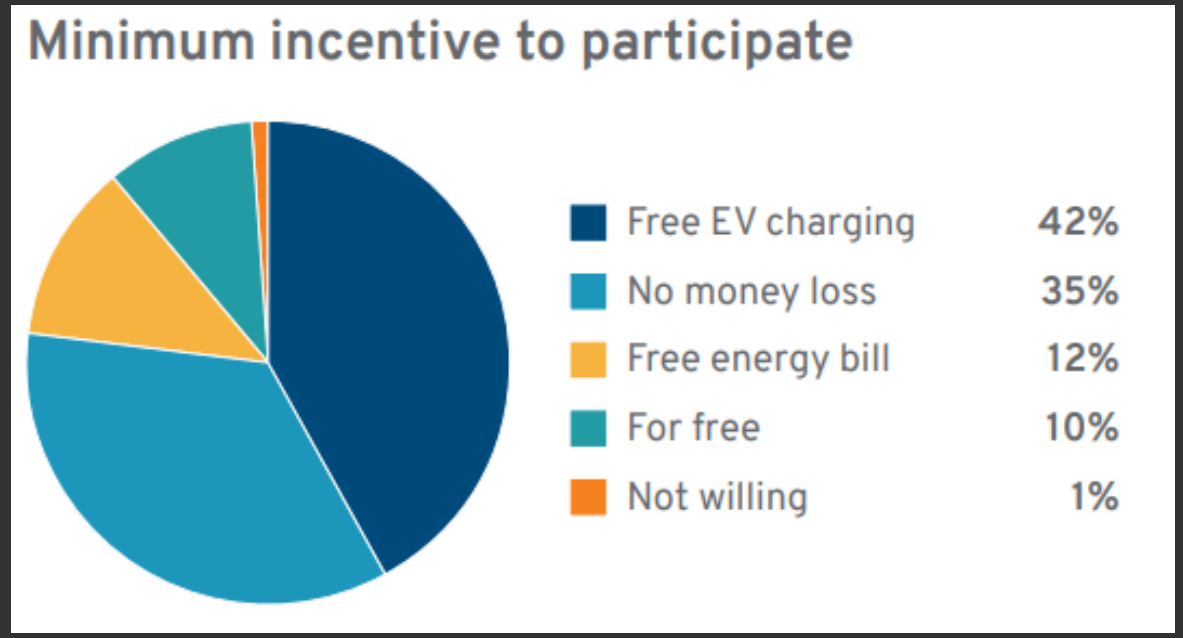
Impact on grid and other rate payers

Let’s start with surveys (1/3)

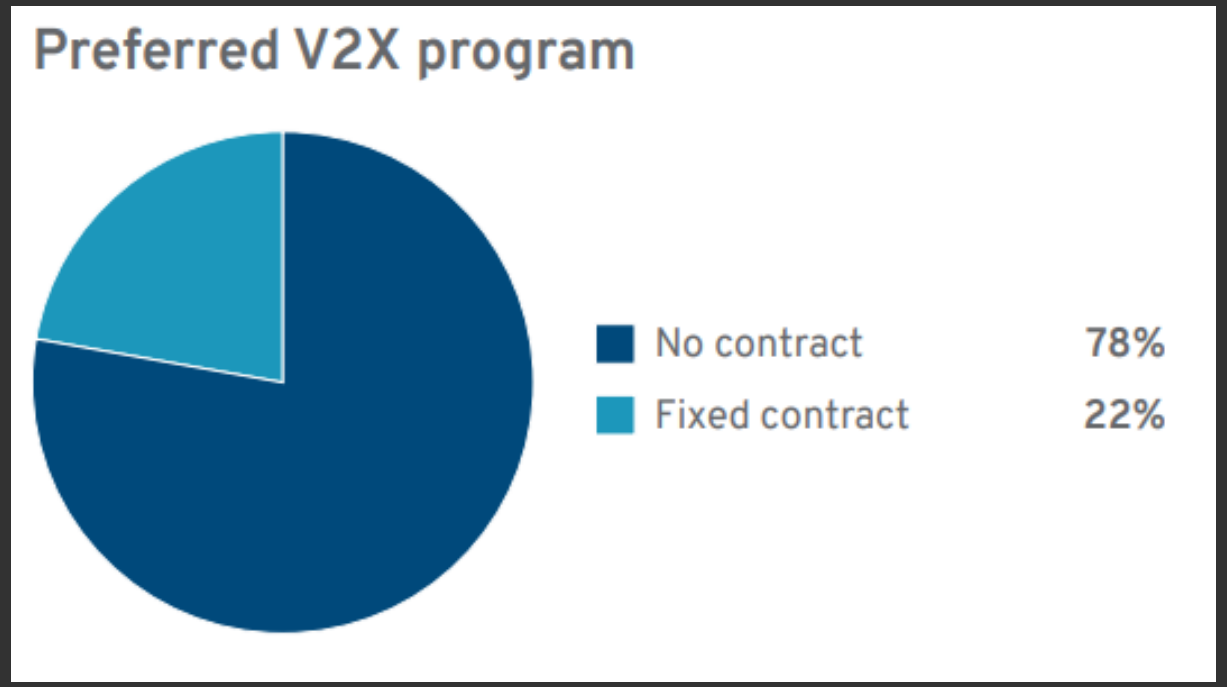


*Participation rises by 80% when told of environmental benefits

Let’s start with surveys (2/3)



Let’s start with surveys (3/3)



Direct feedback

Unreliable range prediction by EV … don't want to get stranded.

No trust in utilities to take liability … if something were to go wrong.

Major degradation issue with V2G … Paying only for my kWh is not enough when my battery is on the line.

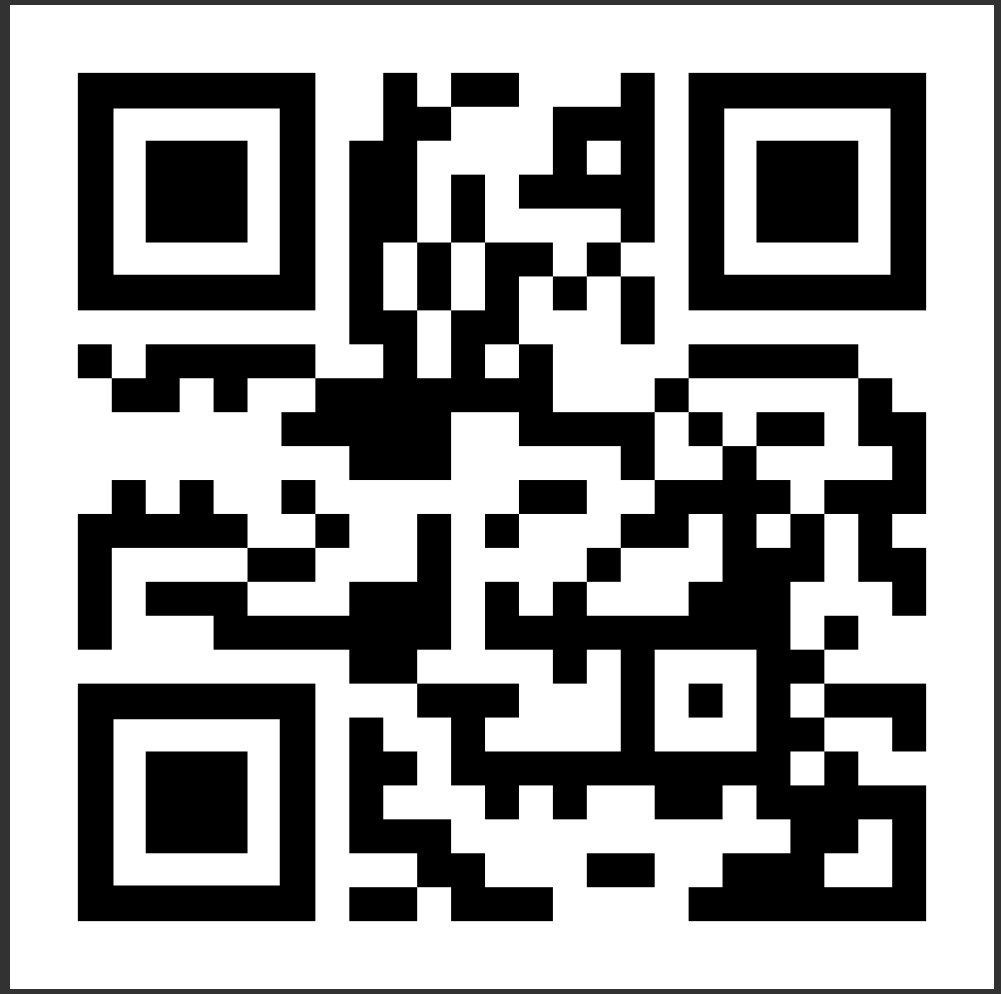
Design of new charging modes to incorporate V2G and demand response*

	Charge my EV	Quick Support	Extended Support
Use When	Short on time or not preferred charger	Short on time or not preferred charger	Adequate time and opportunity to plug in
Contract	No Contract	No Contract	Fixed Contract
Transaction Participants	EV pays CPO or EV pays Grid	CPO pays EV or Grid pays EV	CPO pays EV or Grid pays EV
Revenue	Regular Rate	Regular Rate	Regular Rate + DR + Capacity Payment
Penalty	None	None	Revenue forfeit if plug out during DR event

** CPO - Charge Point Operator*

*Saxena, Farag, St. Hilaire, Brookson: A Techno-Social Approach to Unlocking V2X, *IEEE Access vol. 11*

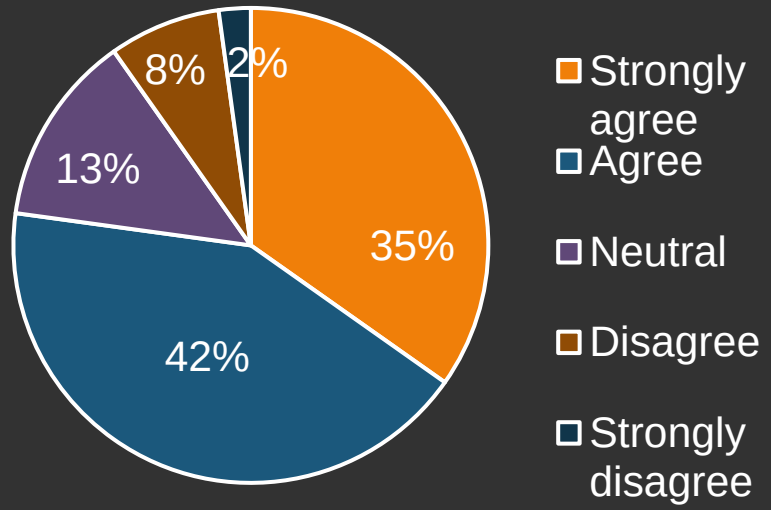
Activity time! Let’s try the app



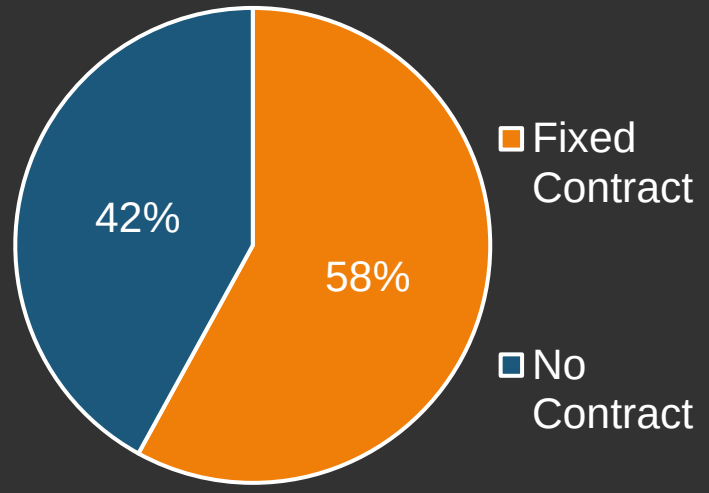
https://v2xhero.web.app/

Digging into the survey responses

App increases motivation to engage in utility V2G program

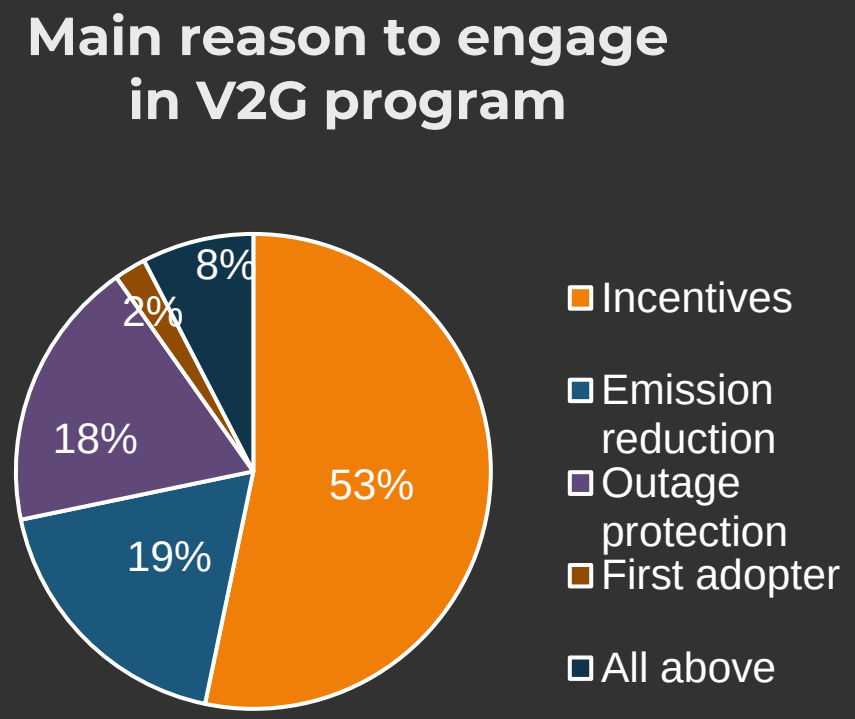


Fixed Contract vs No Contract



*Pre-app: 78% no contract vs 22% fixed

Digging into the survey responses



Results discussion from V2X pilots

Residential Pilot

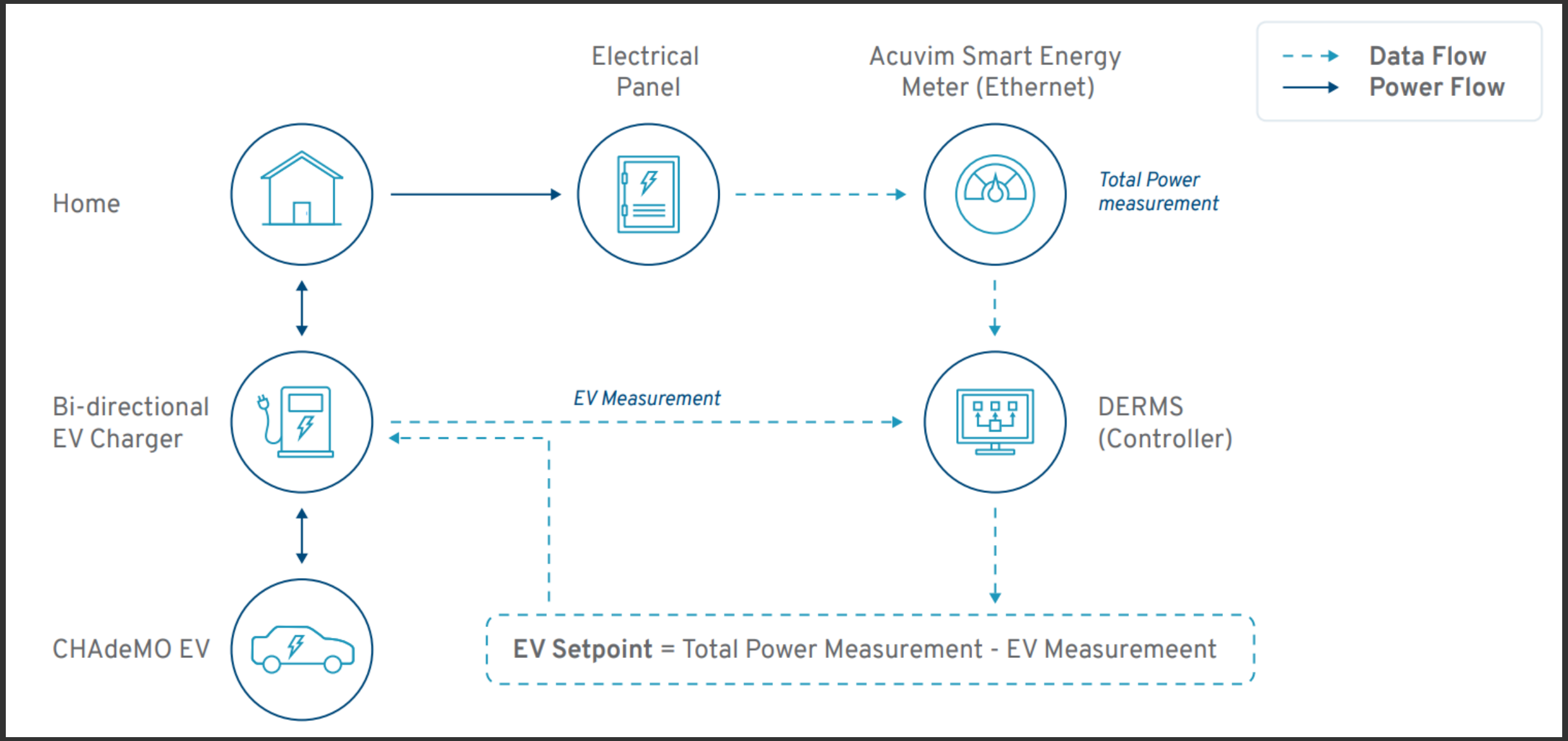
3 Homes across Ontario
2 Chargers: Wallbox Quasar I (7.6 kW) and IKS S06 (6 kW)
2 Vehicles: 2018/2019 Nissan LEAF

Commercial Pilot

Commercial building in Markham, Ontario
Charger: Coritech VGI-30 (30 kW)
DERs: 100 kWh/30 kW battery, 6 kW solar
2 Vehicles: 2018/2019 Nissan LEAF

Residential pilot timeline

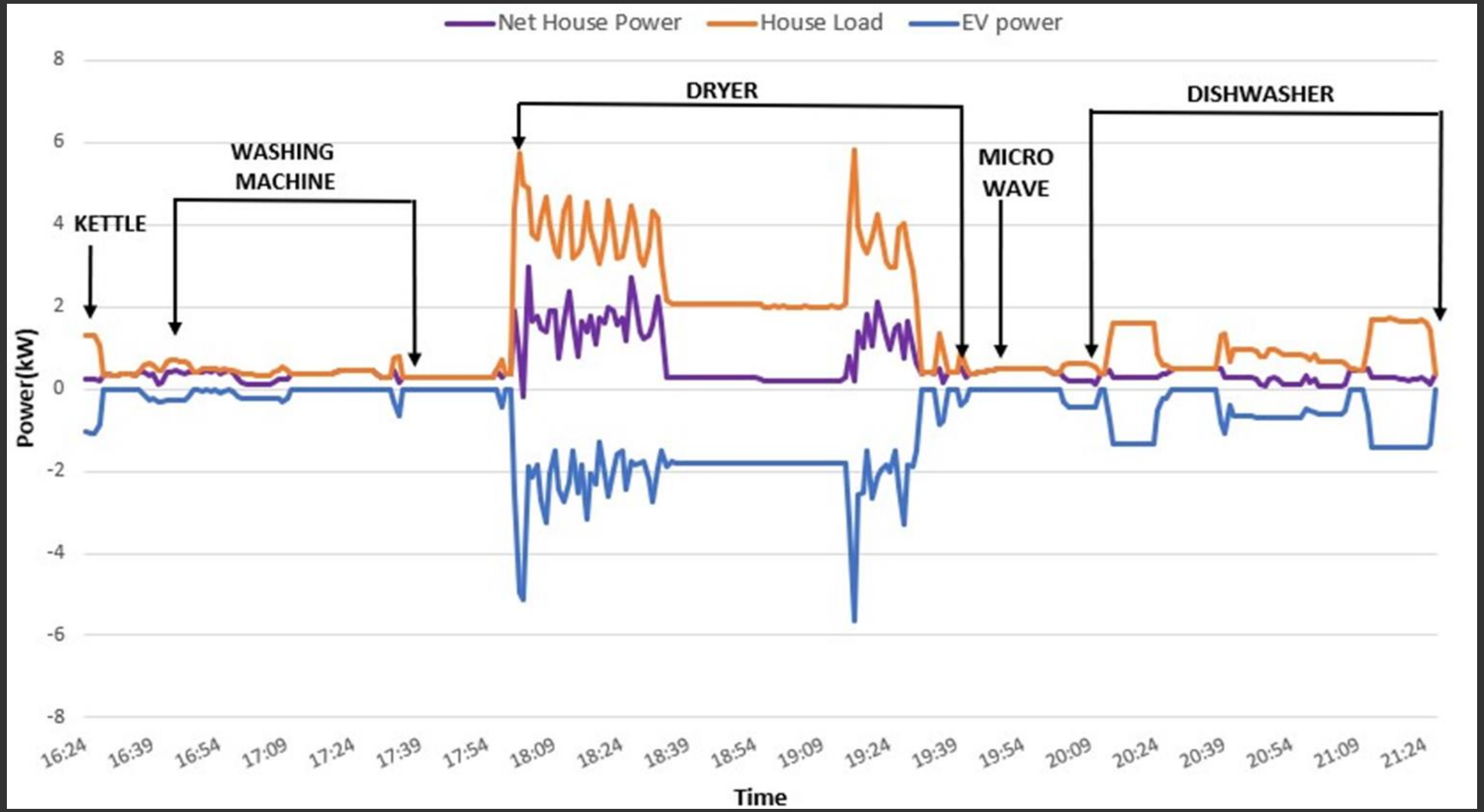
Getting a homeowner V2X ready



Costs for the homeowner

Line Item	Cost
Bidirectional charger	Roughly $1000/kW $8000 for residential
Installation cost (adding 240V service in garage, disconnect, permit)	$2,025
Energy Meter (revenue grade - Acuvim L Series)	$1293.98 (only needed for zero export connection or backup)
Utility Fees (Offer to connect, bidirectional meter)	$437.41
TOTAL	**$11,756.39**

Results: Load Following with zero export to utility grid



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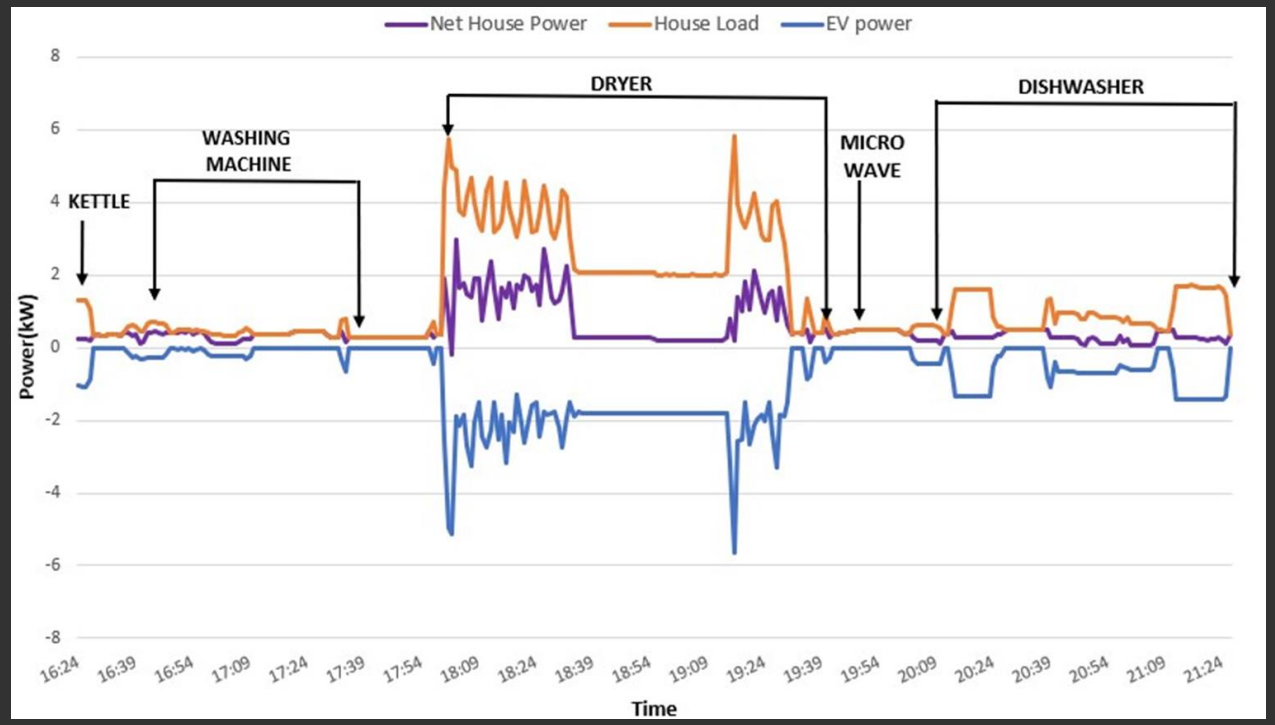
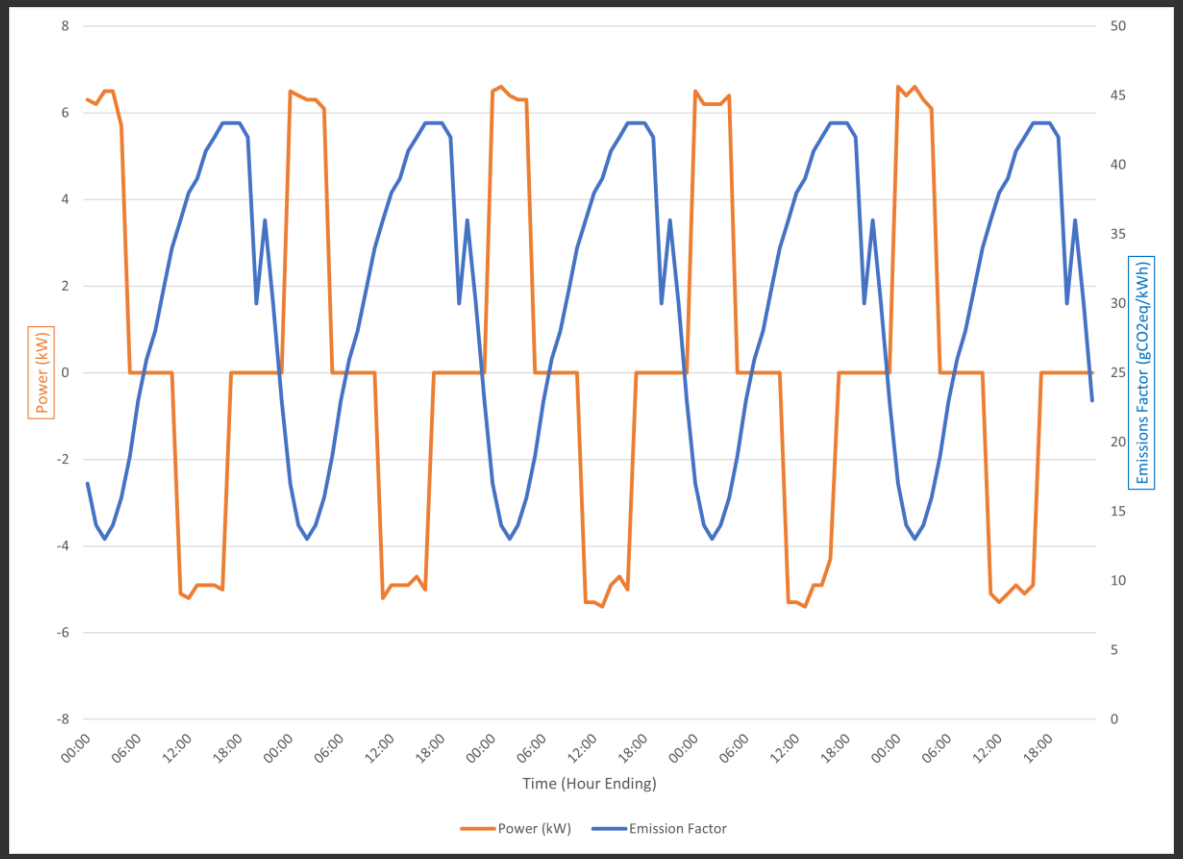


House Loads: **6.91 kWh**

EV Discharge: **4.37 kWh**

Net Energy: **2.53 kWh**

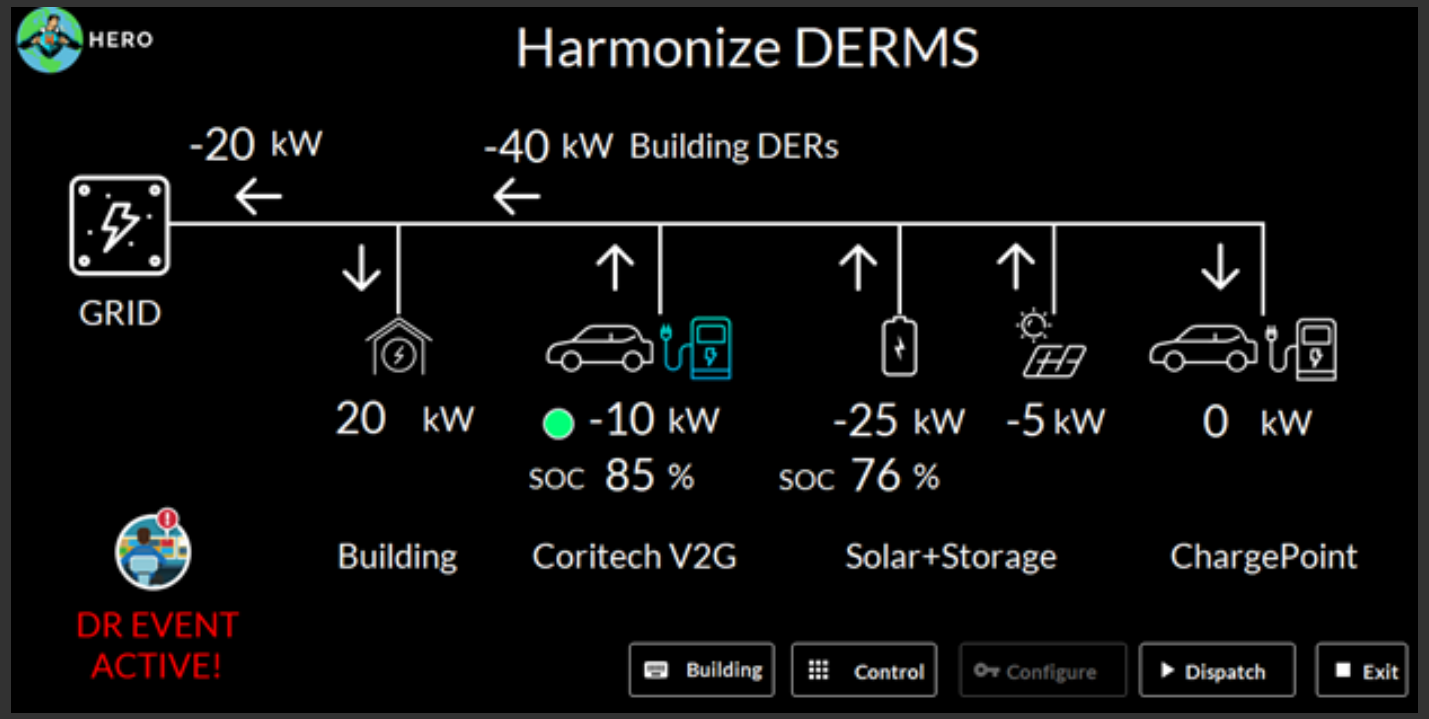
Results: 5-day emissions arbitrage test*



Day	Energy (kWh)		Emissions (kgCO2eq)		Cost ($)	
	CHG	DCHG	CHG	DCHG	CHG	DCHG
1	31.2	-30.0	0.46	-1.19	2.56	-5.10
2	32.6	-29.6	0.47	-1.17	2.59	-5.03
3	32.1	-30.6	0.48	-1.22	2.63	-5.20
4	31.5	-30.1	0.47	-1.19	2.58	-5.11
5	32.0	-30.4	0.48	-1.21	2.62	-5.17
Sum	158.4	150.7	2.36	5.98	1298	25.61
Net	7.7		-3.62		-12.63	

*If discharging energy into loads that would have paid retail time of use rates

Commercial Pilot: Test Setup and Results



Field Tests: 22

Energy Generated: 3.12 MWh

Peak Load Reduction: 1.75 MWh

V2G Peak Reduction: 0.24 MWh

V2G Plug-In Time: 165 hrs

Lessons Learned

Lack of V2X awareness across energy sector

Interconnection process not standardized

No incentives for V2X at present

Poor conversion efficiency at < 2 kW

Seal charger doors shut for ventilation

V2X Barriers to Adoption: A word from utility executives

Who educates the public?

Not many EVs are V2X compatible

What about the battery warranty?

Lack of certified bidirectional chargers

What does a V2X program look like?

Pathways to overcoming V2X barriers

CCS bidirectional standard in final draft!

Mitigates reliance on ChaDeMo (Nissan LEAF)

Commitment to V2X from EV OEMs

Volkswagen, Kia

Regulatory advancement in California (Bill SB 233)

All light duty EVs and school buses must be bidirectional by **2027**

CCS – Combined Charging System; OEMs – Original Equipment Manufacturers

V2G Economic Modeling

Table 1: Projected Number/specification of BEVs in Ontario and forecast V2G program power and energy impact

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
NUMBER OF BEVS IN ONTARIO	105.1 K	154.4 K	223.0 K	336.3 K	505.2 K	715.0 K	971.2 K	1269.7 K	1610.1 K	1985.1 K
NUMBER OF V2G PROGRAM PARTICIPANTS	5.3 K	15.4 K	33.4 K	67.3 K	126.3 K	214.5 K	339.9 K	507.9 K	724.6 K	992.5 K
BATTERY CAPACITY PROFILE	70	72	74	76	79	81	84	86	89	91
FORECAST DELIVERABLE MW	27	80	173	348	654	1110	1759	2628	3750	5136
FORECAST DELIVERABLE MWH/DAY	99	301	671	1389	2687	4700	7671	11805	17347	24476
FORECAST AVAILABILITY DAYS PER YEAR	100	100	100	100	100	100	100	100	100	100

Table 2: Various Input data for the V2G program in Ontario

	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032
DISTRUBTION SYSTEM DEFERRAL ($/KW-YR)	78	80	81	83	84	86	87	89	91	92
ON-PEAK MARKET PRICE ($/MWH)	165	170	175	180	185	191	197	203	209	215
AVERAGE CAPACITY PAYMENT $/MW-DAY	162	165	169	172	175	179	182	186	190	194

V2G Economic Analysis

Residential

High cost of bidirectional chargers ($1000/kW) the major barrier.

At current Ontario rates ($0.20/kWh peak), EV participants would incur $1.4B of loss over 10 years, or $463 per person

To break even, **incentives would need to be raised to $0.53/kWh**, or, charger cost decreased to 65%. Raising incentives negatively affect regular ratepayers.

What's next?

Pilot Development in Ontario

6000+ eligible EVs in Ontario (140 MWh).

15 EV owners already recruited

Cross-provincial Research

V2X opportunity analysis in Ontario and Atlantic Canada, specifically for underserved communities

Further knowledge dissemination

20K+ YouTube views
1 Journal published
3 Journals in draft

Thank you!

Multiple V2X projects on the go

IESO Grid Innovation Fund (2021-2023)
Demand response, blockchains, user privacy

Zero Emissions Vehicle Awareness (2021-2023)
Residential demo and engagement

LDC of Tomorrow Fund (2021-2023)
Grid interconnection and economic analysis

Halifax HCi3 Climate Fund (2022-2024)
Resiliency and uptake in underserved areas