Vehicle 2 Grid (V2G) Potential for Peak Shaving

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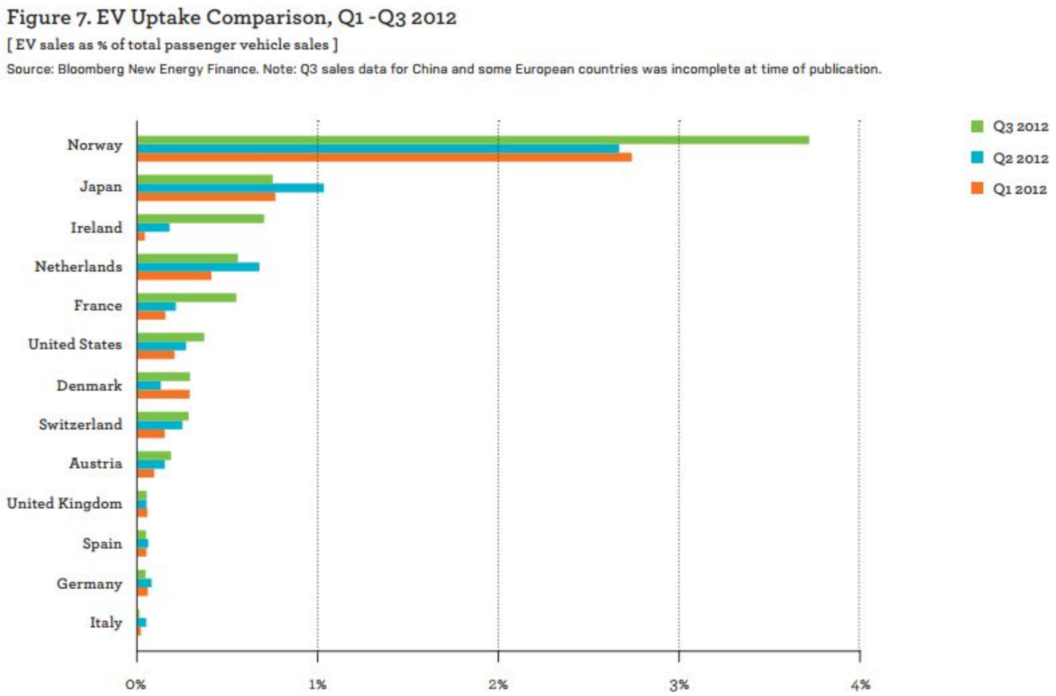
Agenda

1. EV growth
2. Trends
3. Market opportunity overview
4. Project overview
5. Technical Viability
6. Financial Viability
7. Next Steps

Market Opportunity: EV Growth

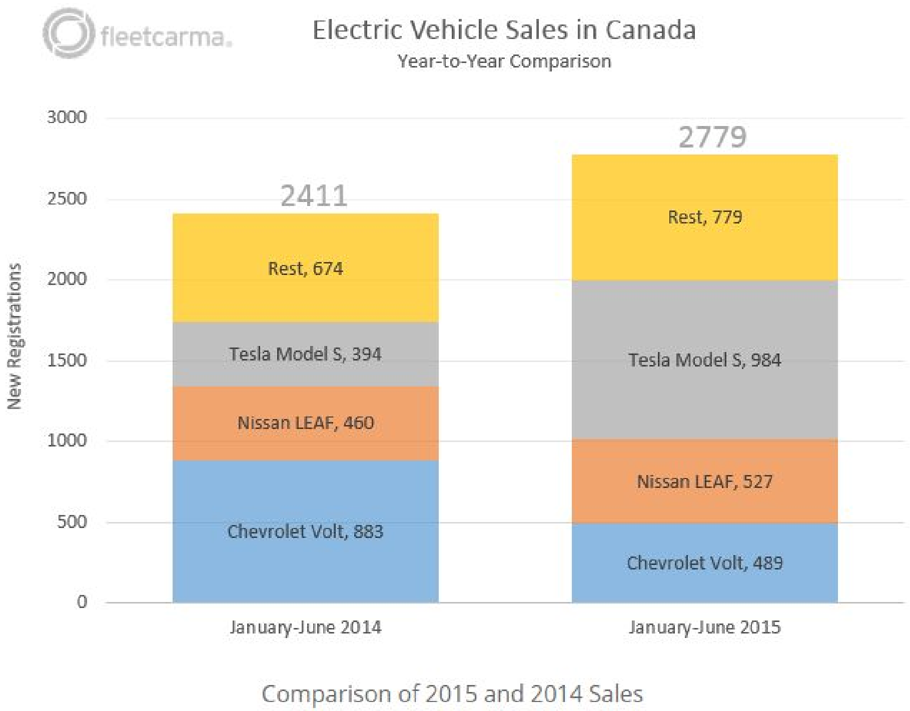
Global EV as % of total new sales



Norway 3.7 %

https://www.iea.org/publications/globalevoutlook_2013.pdf

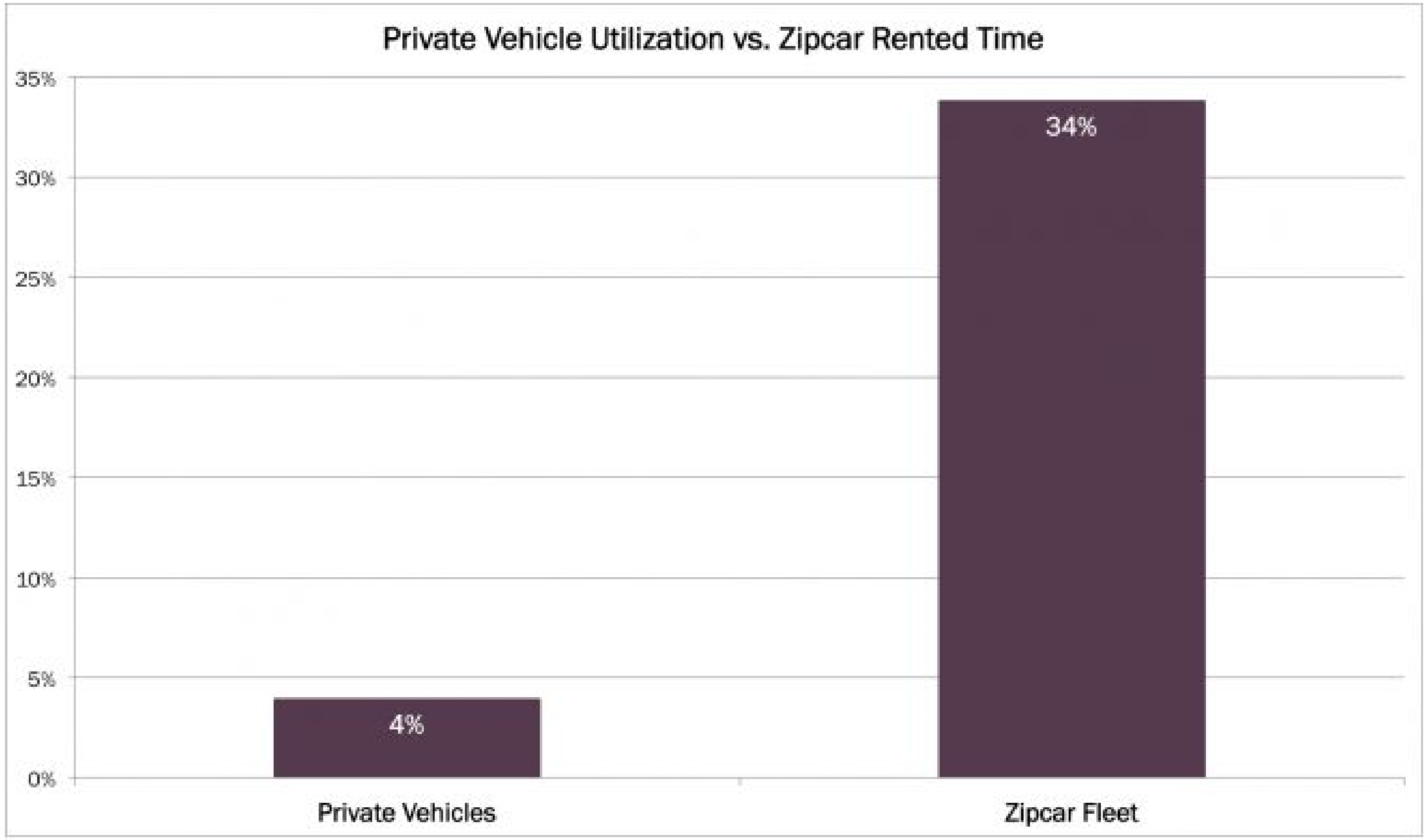
Canada as % of total new sales



Canada 1.4 %*

http://www.fleetcarma.com/electric-vehicle-sales-canada-june-2015/
* http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ58a-eng.htm

Market Opportunity: Vehicle Utilization

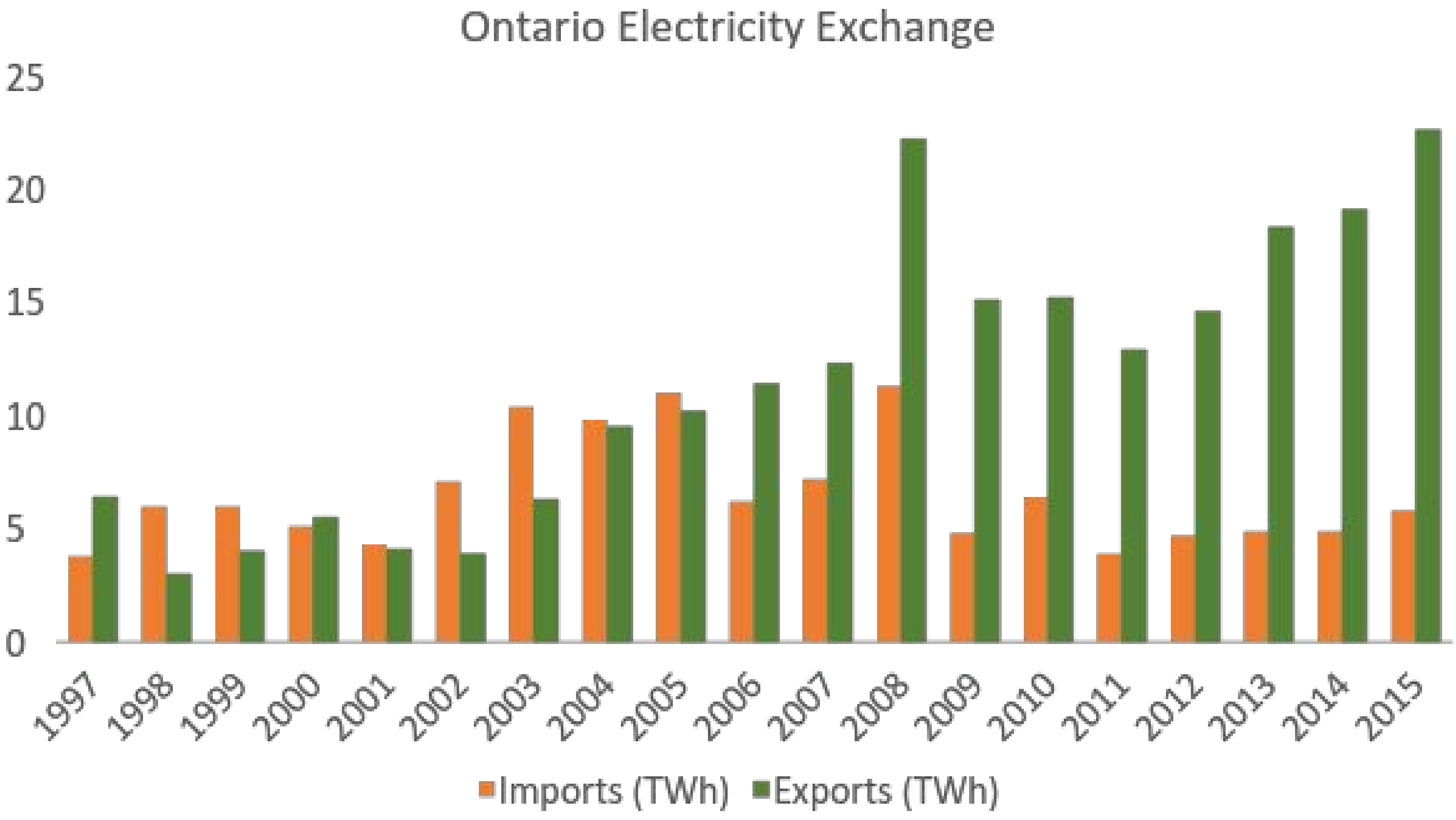


Independent Owners 4%
Car share services 36%

Rest of the time car is parked

http://ark-invest.com/webx0/how-many-cars-can-one-zipcar-replace

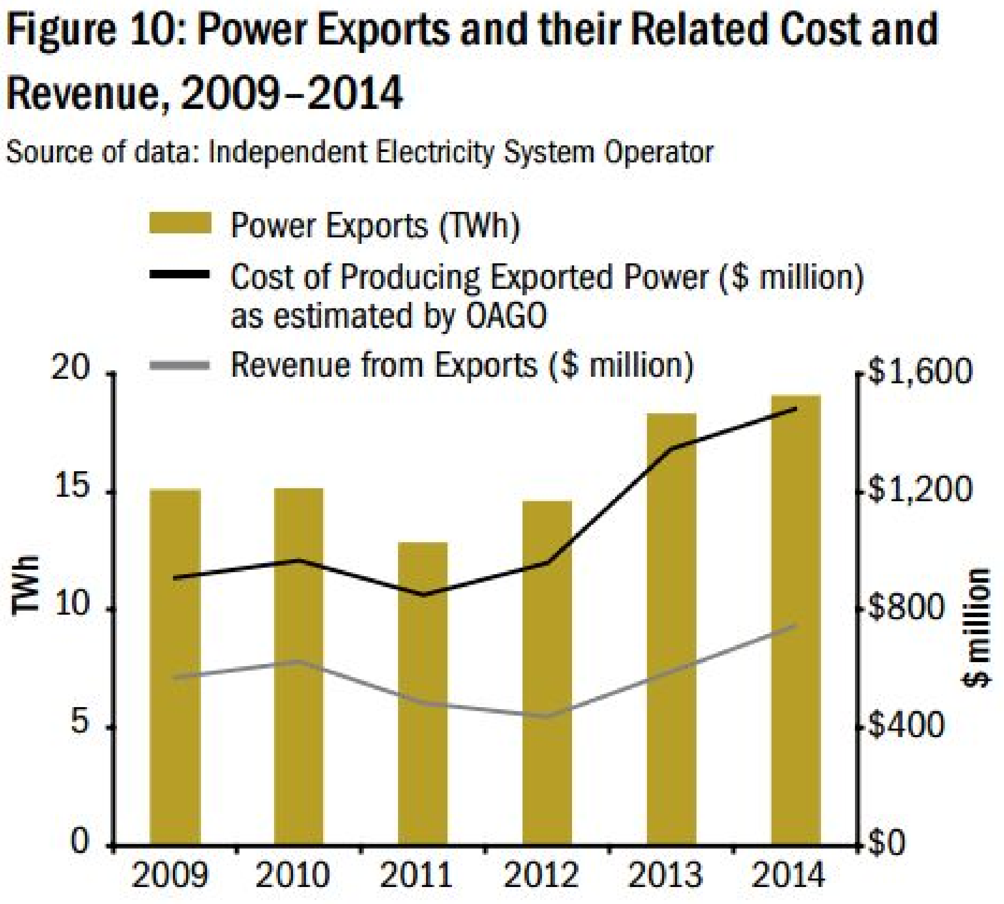
Market Opportunity: Utility

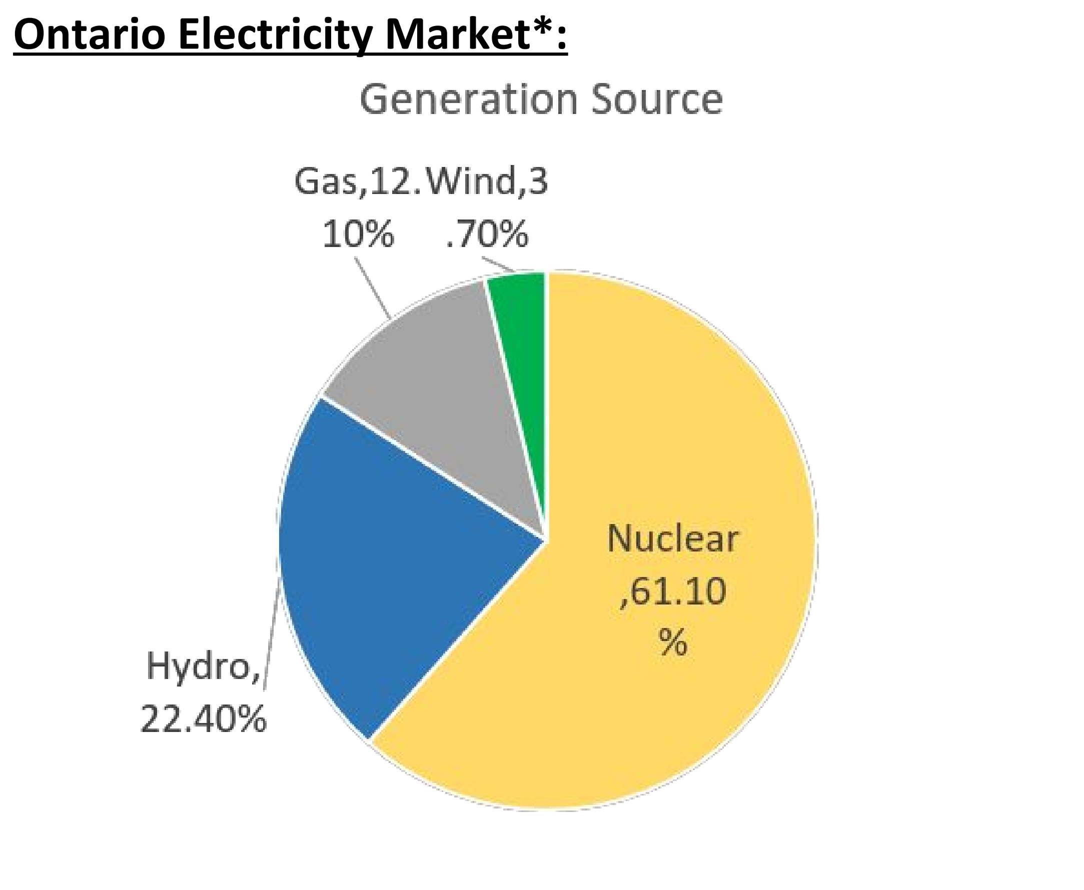


Why is Ontario Importing Electricity and how much do we make by exporting it?

Data from http://www.ieso.ca/Pages/Power-Data/Supply.aspx

Market Opportunity: Utility





http://www.auditor.on.ca/en/reports_en/en15/3.05en15.pdf

*http://www.ontarioenergyreport.ca/

Market Opportunity: Utility

Generation Type	Characteristics
Nuclear	Expensive to shut down, pre-paid contracts
Wind	Produced when demand is low, not used by grid. Expensive contracts
Hydro	Dispachable
Natural Gas	Dispachable
Solar/ Biofuel	Expensive contracts, <1%

Bottom Line:

- Ontario paid $339 Million from 2009-2014 to generate excess power. (Approx $68 M/ yr)
- Ontario paid $32.6 Million in 2014 alone for exporters to take our power
- Ontario paid $117 Million in 2014 to turn off generators
- 8.9 MWg (47%) of Ontario exports related to surplus power
- 2.81 MWh surplus expected in 2032
- And we imported electricity at peak price

217 Million / yr to give away electricity

How can we make money and be efficient???

What is the business case to use EVs to help with peak shaving of load for a commercial building?

EV Owner

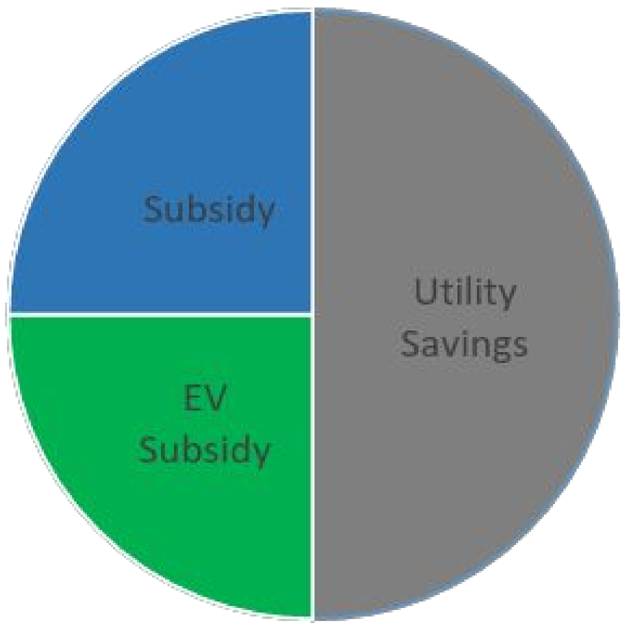
Building Owner

Utility

$$

Financial Viability: Hypothesis

Cost Incentives

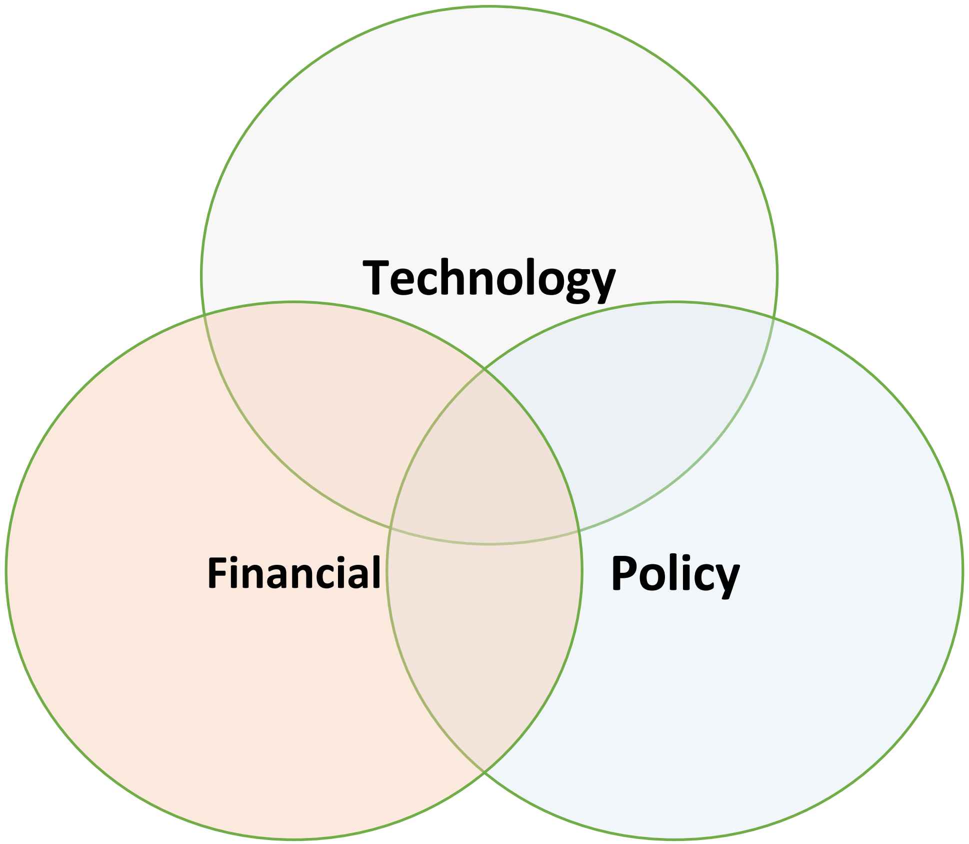


Utility Savings:

Of the total amount the utility saves, half goes to incentivize the property owners for infrastructure expend and the other half to EV owners taking excess electricity out of the grid when supply is high.

Everyone wins???

Project Approach



<u>Simulation Pilot:</u>

1. Assume average commercial building
2. Assume attached parking lot

<u>Answer Questions:</u>

1. How many EVs are needed to impact peak demand?
2. Is there a financial incentive for owners/ utilities and building owners to participate?
3. What policy can impact EV use for peak shaving?

Project Plan

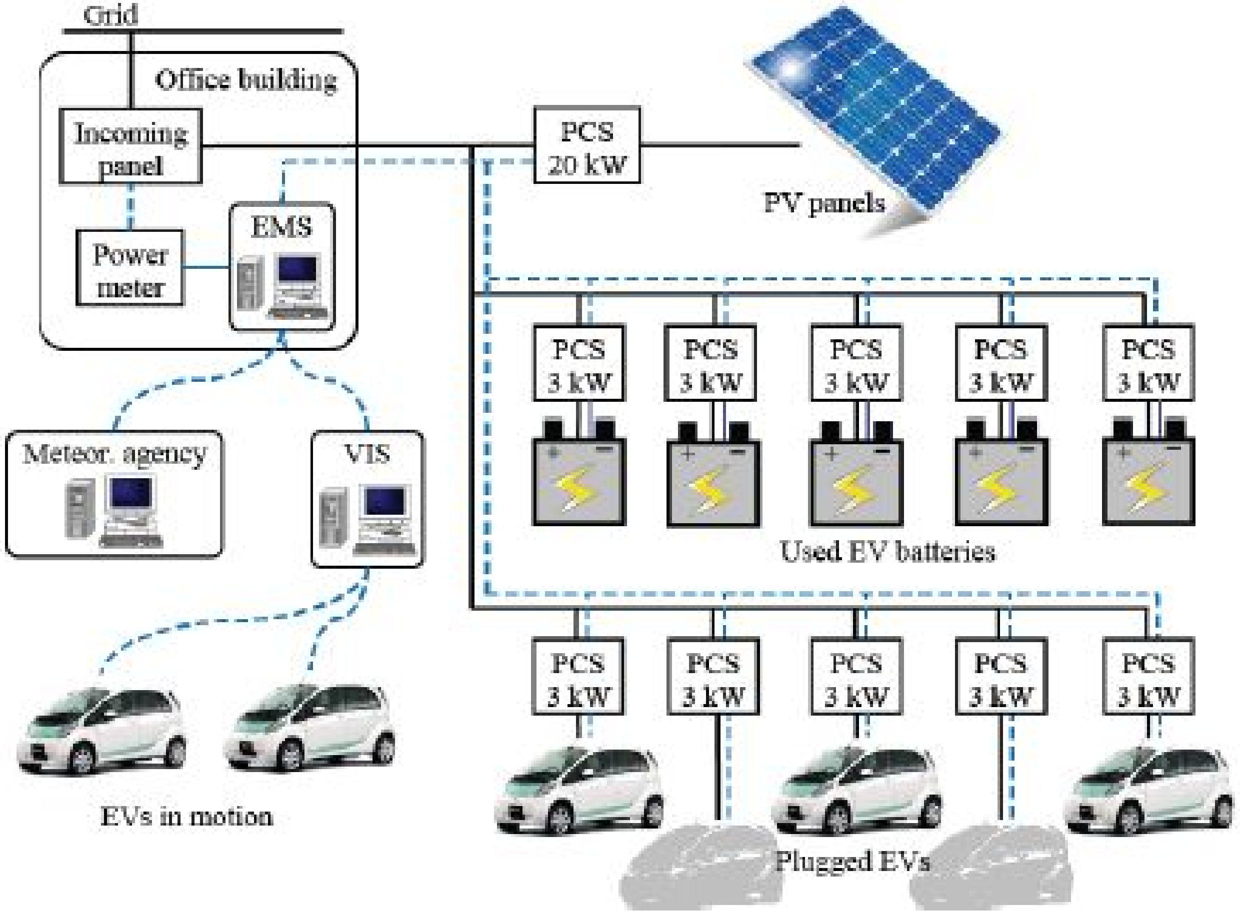
Analysis Criteria	EV Owner	Building Owner	Utility	Phase
Technical Viability	Viable	Viable	Viable	Phase 1
Financial Incentive	In progress	In progress	In progress	
Non-Financial Incentive	In progress	In progress	In progress	
Policy / regulations	In progress	In progress	In progress	
Constraints	Not started	Not started	In progress	Phase 2
Technical Recommendations	Not started	Not started	Not started	Phase 3
Policy Recommendations	Not started	Not started	Not started	
Financial Recommendations	Not started	Not started	Not started	

Technical Feasibility: A Case Study

Whole view of the developed demonstration test bed

Used batteries from EVs

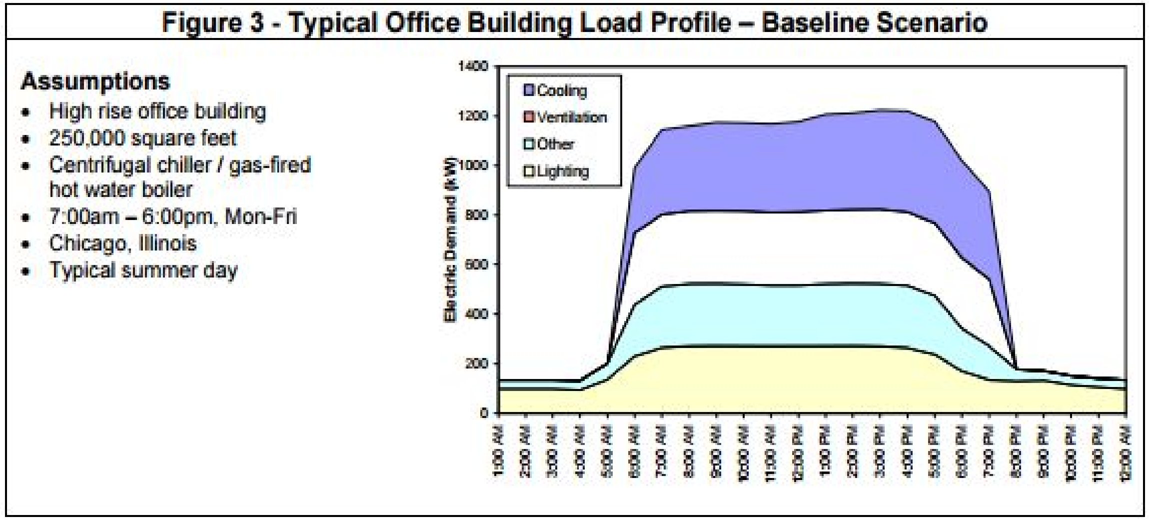
Charging pole



Mitsubishi Motors Corp.: M-tech Labo

Technical Viability: Assumptions

1. Building Load Profile



2. Electricity Price

Electricity Price	(₵/kWh)
Base:	8.3
Mid:	12.8
Peak:	17.5

3. Car Specifications

EV Model	Charging Power [kW]	Battery capacity [kWh]
2013 Fiat 500e 120V	1	24
Nissane Leaf 240V	3.3	24
2014 Honda Fit EV 240V	6.6	20
Tesla Model S 240V	20	85

Source: http://www.iluvtrees.org/wp-content/uploads/2009/05/iltofficebuildingprofile.pdf

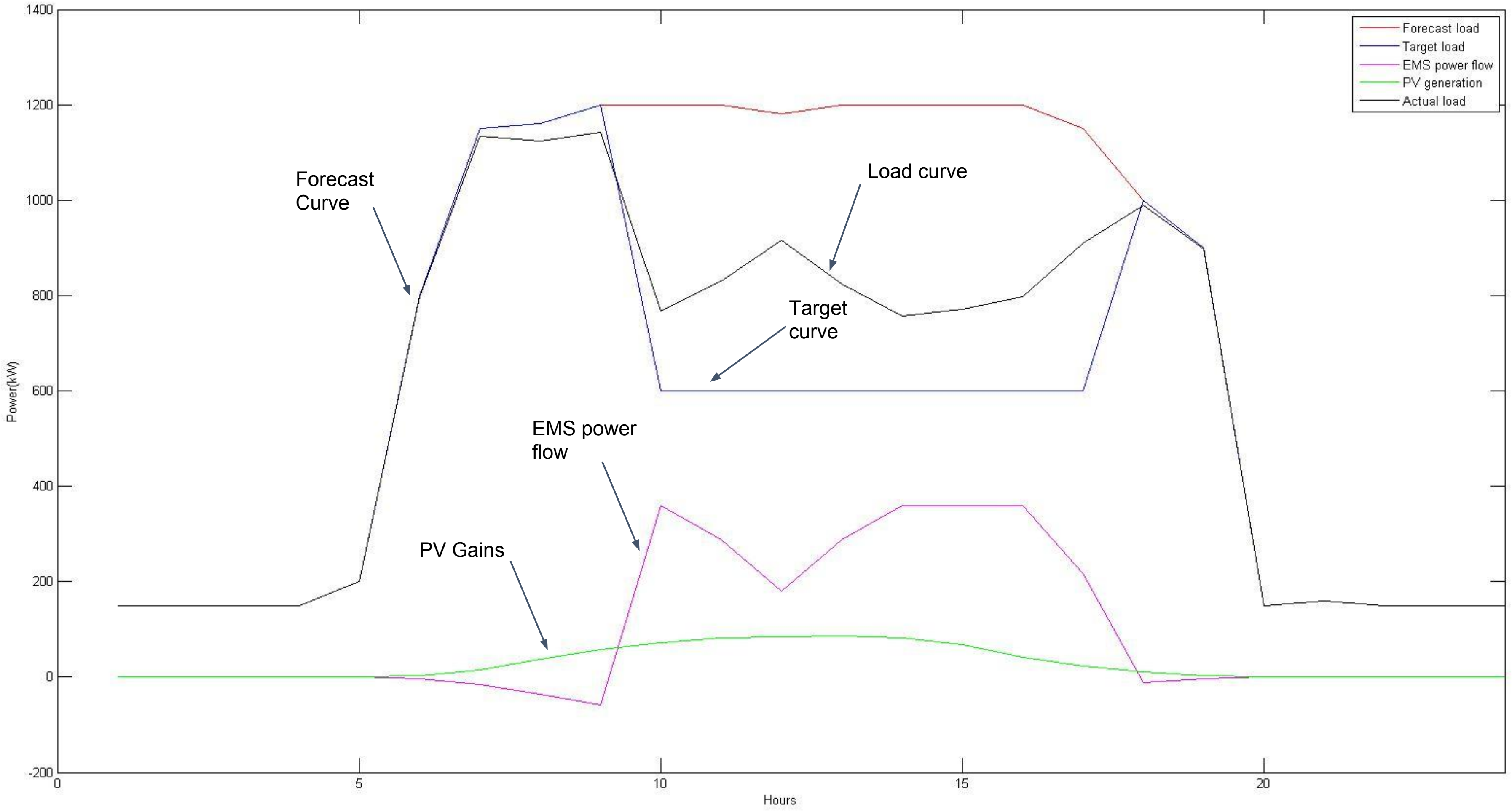
Technical Viability: Findings

EV Model	2013 Fiat 500e 120V	Nissane Leaf 240V	2014 Honda Fit EV 240V	Tesla Model S 240V
Charging Power [kW]	1	3.3	6.6	20
Battery capacity [kWh]	24	24	20	85
# EV's for energy load:	410	410	492	116
# EV's for peak power:	600	182	91	30

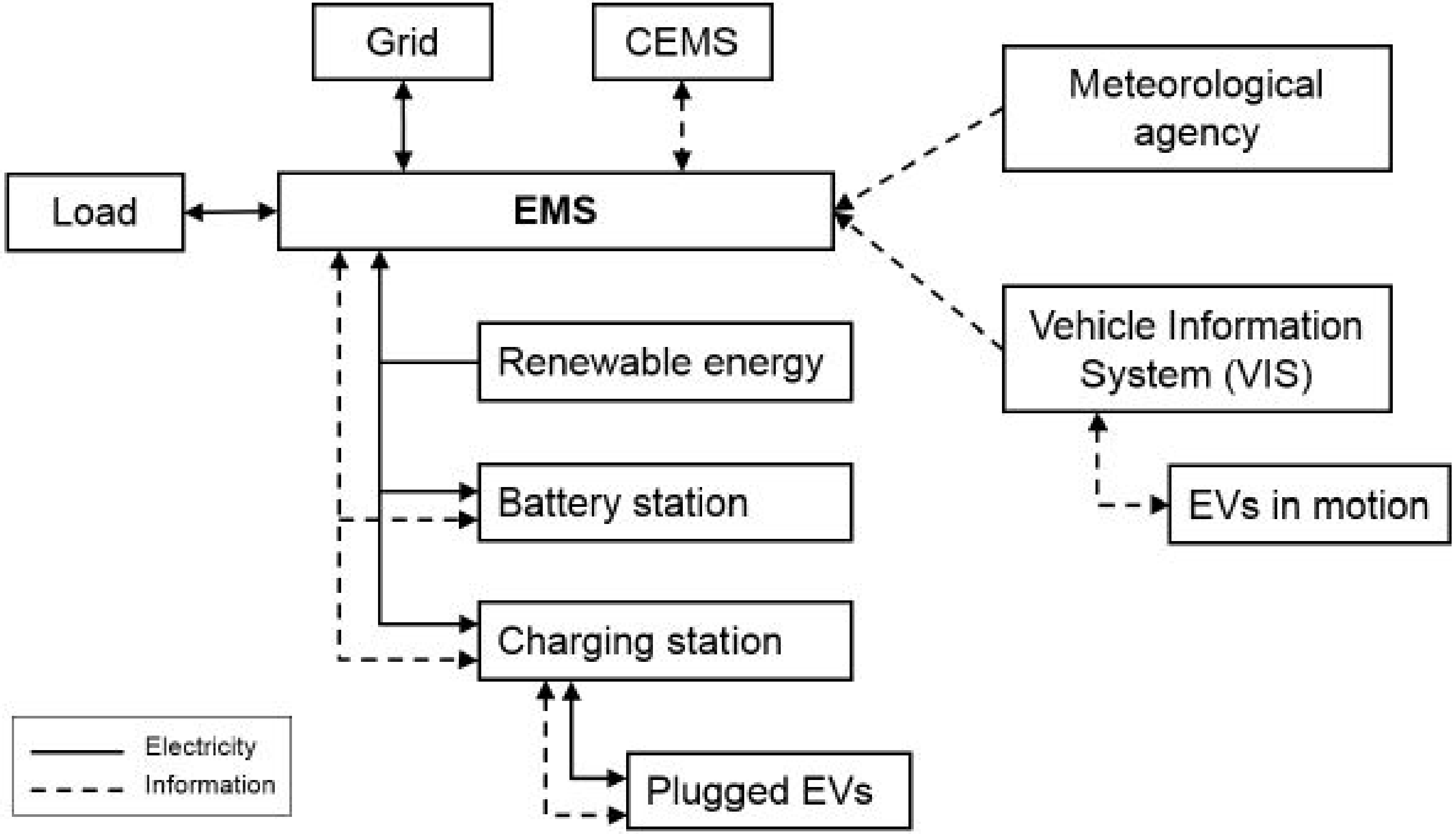
Technical Viability: Simulation Tools

```
Plan_curve = zeros(24, 1);
Real_curve = zeros(24, 1)
PV_size = 100; % PV rating of 100kW array
EV_num = 20;


Load = dlmread('load_curve.txt'); % Read in the building's forecast load curve
Target = dlmread('target_curve.txt'); % Read in the target curve
EVs = dlmread('EV_availability_curve.txt'); % Read in the EV availability curve
PV = dlmread('PV_generation_curve.txt'); % Read in the forecast PV generation curve

for i = 1:24
    EV_draw = EVs(i, 1)*EV_num*20; % The maximum connected EV power draw, assumed to be 20kW/EV
    EV_cap = EVs(i, 1)*EV_num*20*0.9; % The maximum connected EV discharge capacity, assumed efficiency of 90%
    PV(i, 1) = PV(i, 1)*PV_size;

    if (Load(i, 1) - PV(i, 1) > Target(i, 1)) % Load demand is higher than target
        if (Load(i, 1) - PV(i, 1) - Target(i, 1) < EV_cap) % If power required is less than max EV
            Plan_curve(i, 1) = abs(Load(i, 1) - PV(i, 1) - Target(i, 1)); % EMS discharges from EVs to reach target
        else
            Plan_curve(i, 1) = EV_cap; % EMS discharges from EVs at max capacity
        end
        Real_curve(i, 1) = Load(i, 1) - Plan_curve(i, 1) - PV(i, 1);
    end

    if (Load(i, 1) - PV(i, 1) == Target(i, 1)) % Load demand and target demand are equal
        Plan_curve(i, 1) = 0; % EMS remains idle
        Real_curve(i, 1) = Load(i, 1) - PV(i, 1);
    end

    if (Load(i, 1) - PV(i, 1) < Target(i, 1)) % Load demand is less than target
        if (Load(i, 1) - PV(i, 1) - Target(i, 1) < EV_draw) % If the difference is less than the max EV charging rate
            Plan_curve(i, 1) = -abs(Load(i, 1) - PV(i, 1) - Target(i, 1)); % EMS charges EV's with the excess power
        else
            Plan_curve(i, 1) = -EV_draw; % EMS charges EVs at max power rate
        end
        Real_curve(i, 1) = Load(i, 1) - PV(i, 1);
    end
end
```

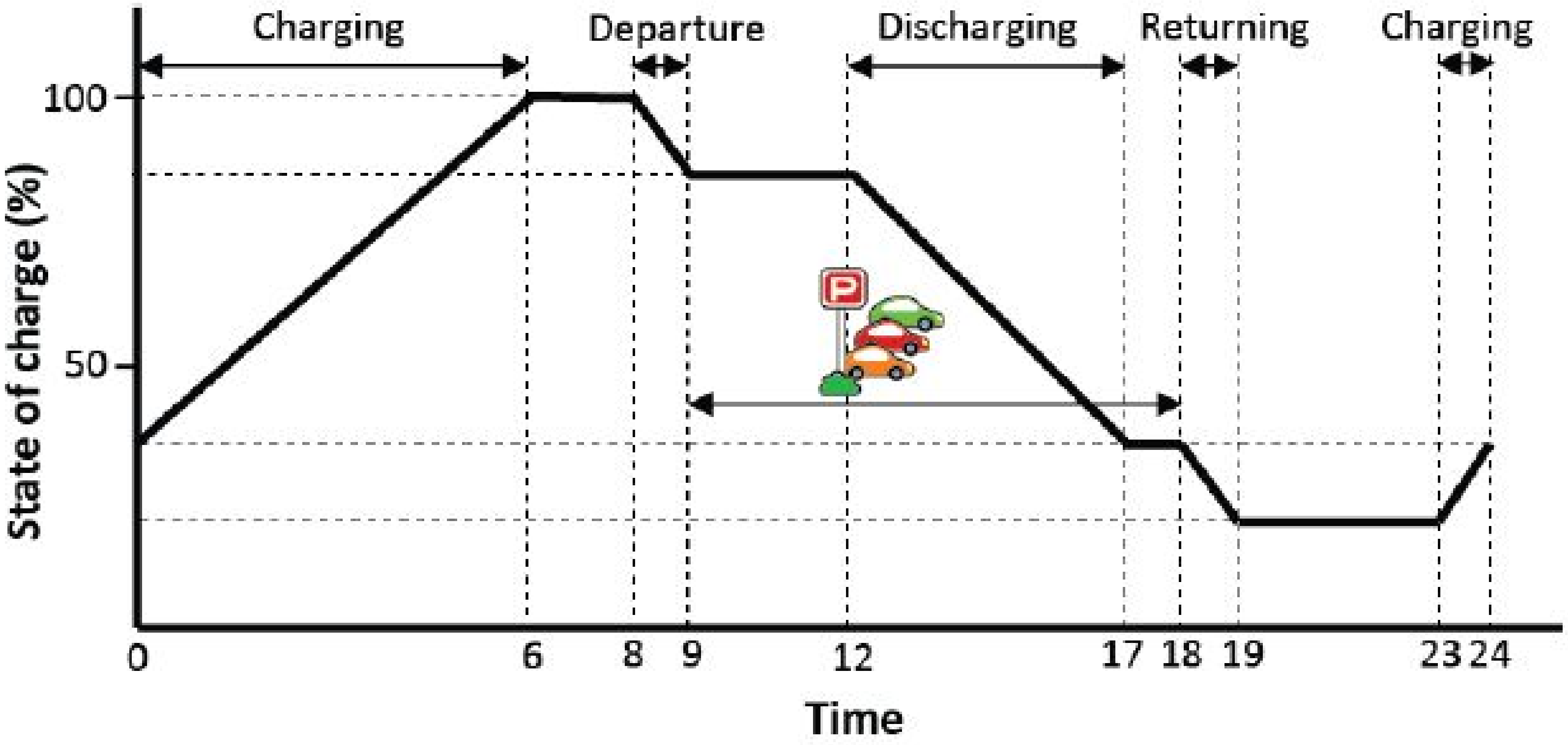
Technical Viability: Simulation Findings



Technical Viability: Energy Management System



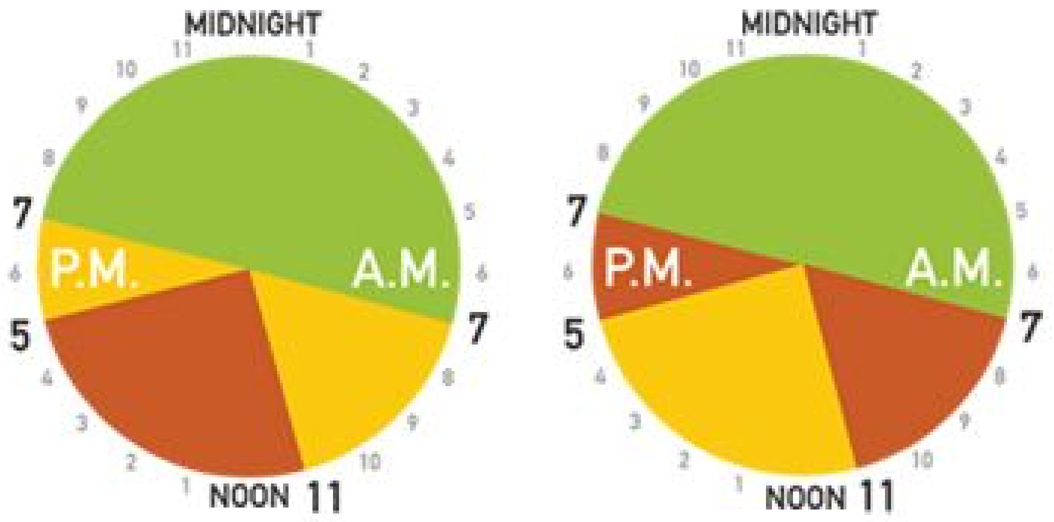
Technical Viability: State of Charge (SOC) profile



Electricity Pricing

Time of Use:

- 8.3 cents (off-peak)
- 12.8 cents (mid-peak)
- 17.5 cents (on-peak)



Tiered Pricing

- 9.9 cents until threshold; 11.6 cents afterwards

Contracts

- fixed rate + Global Adjustment charge

Ontario’s Current Regulatory Climate

Policy	Modernized Electric Vehicle Incentive Program	Peaksaver Plus	Capacity-Based Demand Response	Industrial Conservation Initiative
Administrator	Min. of Transportation	Hydro One + LDC	IESO	IESO
Instrument	Rebates for EV purchases.	Free thermostat in exchange for LCD controlling temperature.	Participants compensated for “dispatchable loads”; at IESO’s request.	Participants charged based on contribution to top 5 peaks per year.
Objective	EV proliferation	Peak shaving	Peak Shaving	Peak Shaving

Ontario's Electricity Sector Players

Ministry of Energy: *develop ON's generation, transmission, energy related facilities*

Ontario Energy Board: *set rates, issue licenses to participants*

Hydro One: *maintain and operate 97% of transmission network*

Ontario Power Generation: *operate province's generation assets; 60% of generation*

Independent Electricity System Operator: *forecast demand, connect generation, manage new and existing generation and wholesale contracts, ensure reliability*

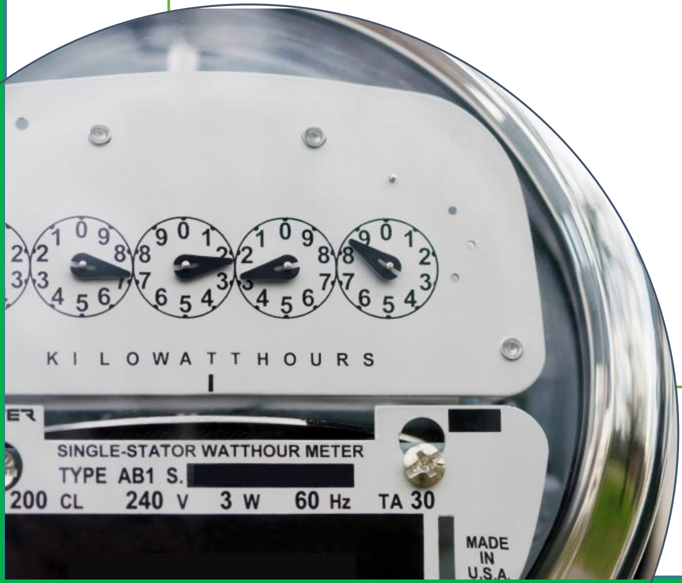
Local Distribution Companies: *operate distribution network, deliver power to customers*

Net Metering

- feed excess electricity from personal generation into the distribution grid
- customer receives bill credit
- accounts for ~ 7 MW of additional capacity over 500 projects

Eligibility

- excess electricity fed to distribution system in exchange for bill credit
- must be generated solely from renewable resource
- < 500 kW



Policy Barriers

- Renewable Energy **only** for net metering

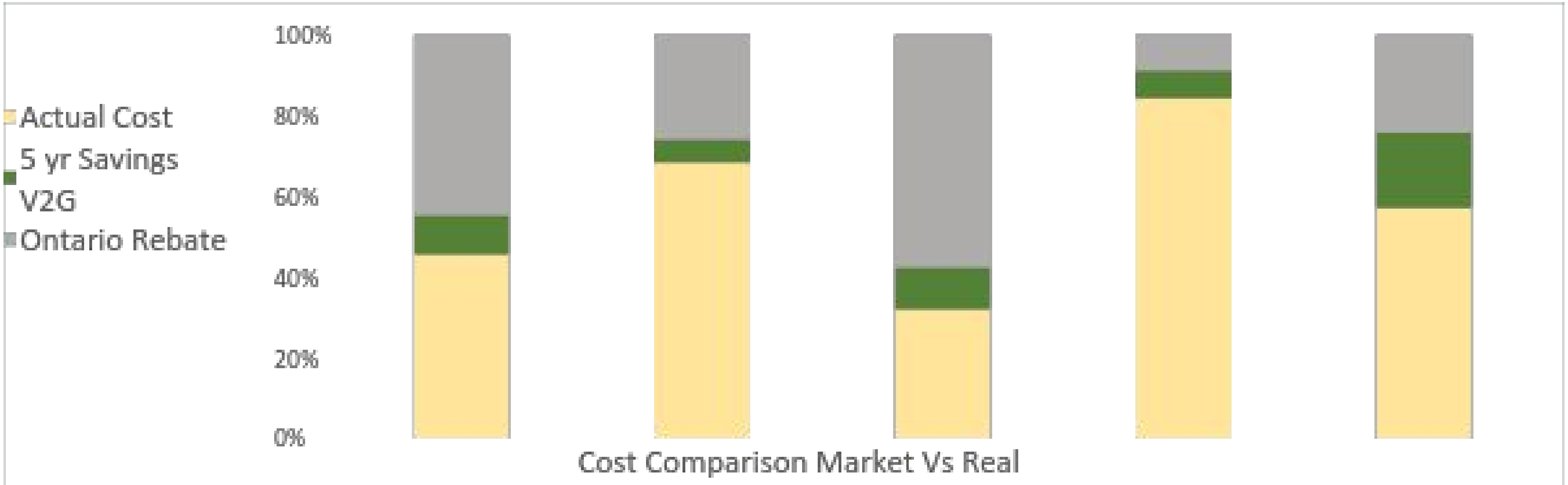
- Aligning policy objectives with policy instruments
    - “Create the spirit of the regulation, not the rule of the regulation, man!”

      \- Aman Chahal (B.Eng, MBA, M.A.)

- Additional management operations for IESO and LDCs

Financial Viability: EV Owner

Cost Component	2013 Fiat 500e 120V	Nissan Leaf 240V	2014 Honda Fit EV 240V	Tesla Model S 240V	Tesla Model 3
Market value	$ 18,995.00	$ 32,698.00	$ 14,730.00	$ 95,300.00	$ 35,000.00
Ontario Rebate	$ 8,500.00	$ 8,500.00	$ 8,500.00	$ 8,500.00	$ 8,500.00
5 yr Savings V2G	$ 1,834.56	$ 1,834.56	$ 1,528.80	$ 6,497.40	$ 6,497.40
Actual Cost	$ 8,660.44	$ 22,363.44	$ 4,701.20	$ 80,302.60	$ 20,002.60

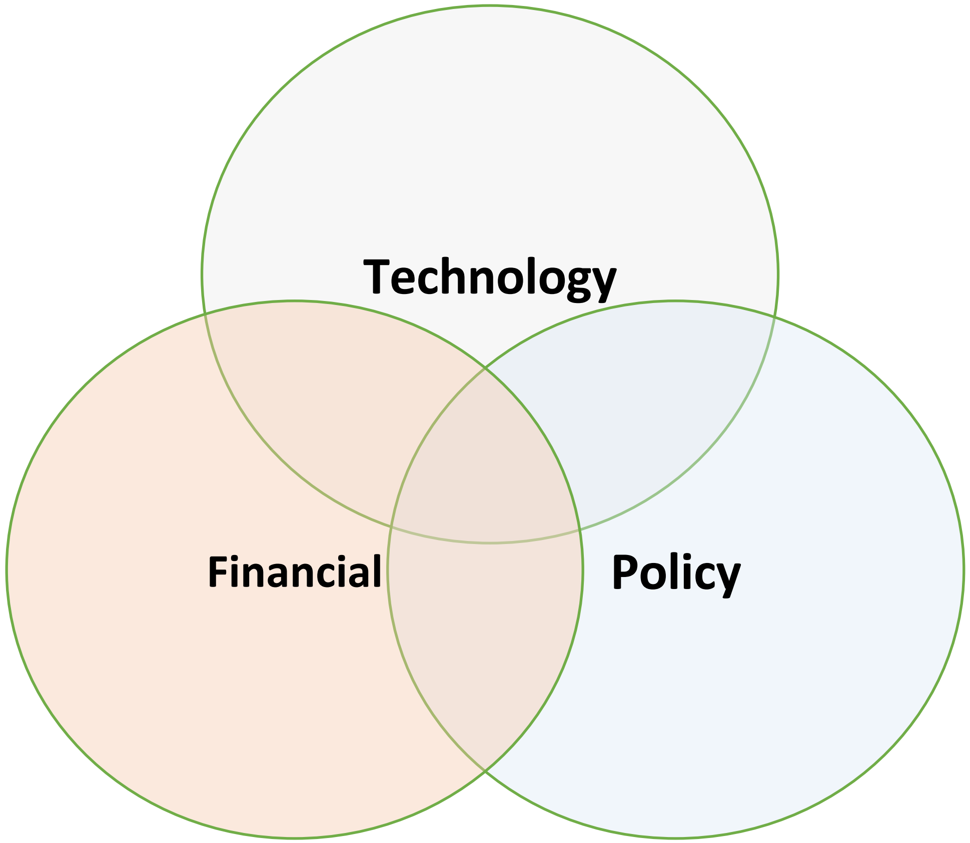


Next Steps

Technical:
1. Firm up assumptions
2. What is the lifetime impact on the EV battery

Financial:
1. Cost of infrastructure
2. Cost of electricity saved by Evs
3. Impacts on electricity imported

Policy:
1. Policy that currently exists
2. How can incentives be designed
3. Regulatory issues to resolve



Thank You

Questions?

Questions for the Class:

1. What are some important challenges/ factors in maintaining a V2G Energy Management System (EMS)?

2. What regulations would discourage EV owners to participate in an electricity market as described?

3. What concerns would the utility have in incentivising such a program?

4. Why would building owners want to add infrastructure to participate?

5. What technologies would be needed to ensure safe exchange of electricity?

6. Why would policy makers be motivated to encourage such a market?

7. How cool is the Tesla model 3?