



EV Charging Strategies



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Department of Energy and Minnesota Pollution Control Agency

www.PlugInConnect.com

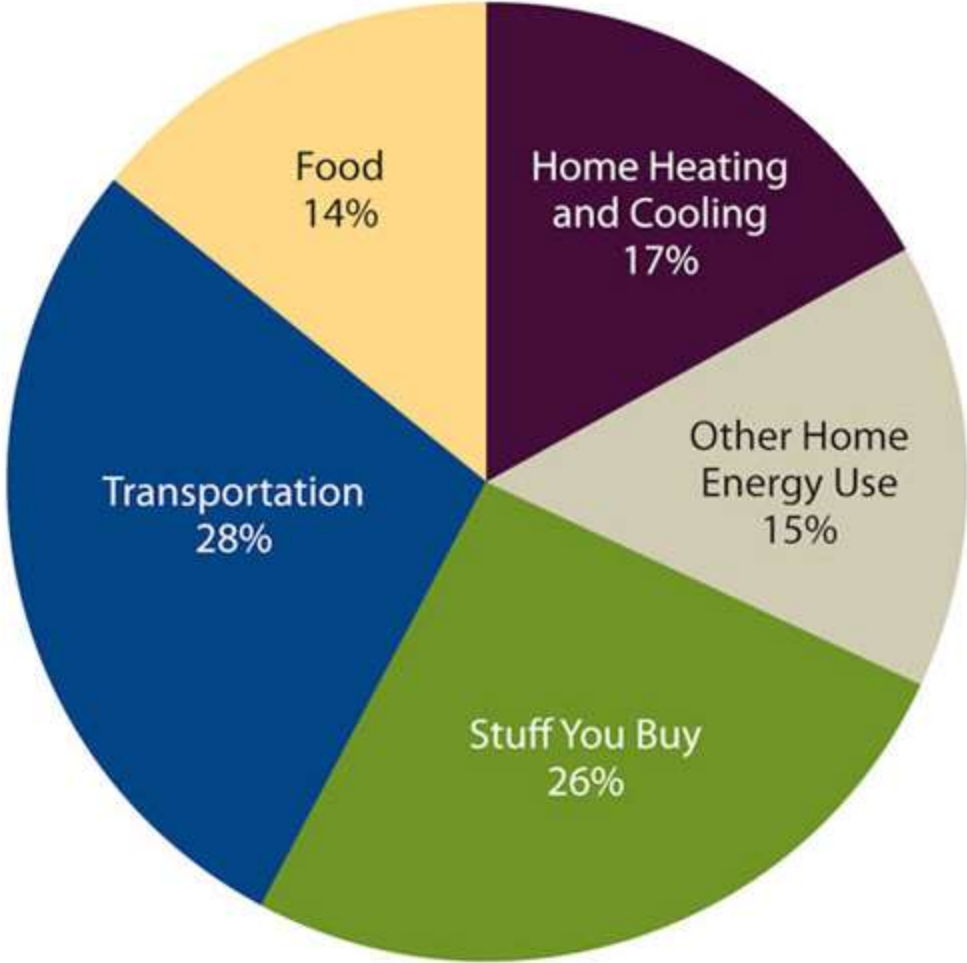
What do I do:

- ▶ Plug-in vehicle market and business development
www.PlugInConnect.com
- ▶ Charging information for condos and apartment buildings
www.MultiHousingCharging.com
- ▶ Charging information for workplaces
www.WorkplaceCharging.com
- ▶ MN Plug-in Vehicle Owners' Circle
www.pluginconnect.com/mnpevowners.html
- ▶ EV market expert at Fresh Energy
www.Fresh-Energy.org



Fresh Energy

Where the Average American's Carbon Emissions Come From



Union of Concerned Scientist, 2014

MN PEV Owners Circle

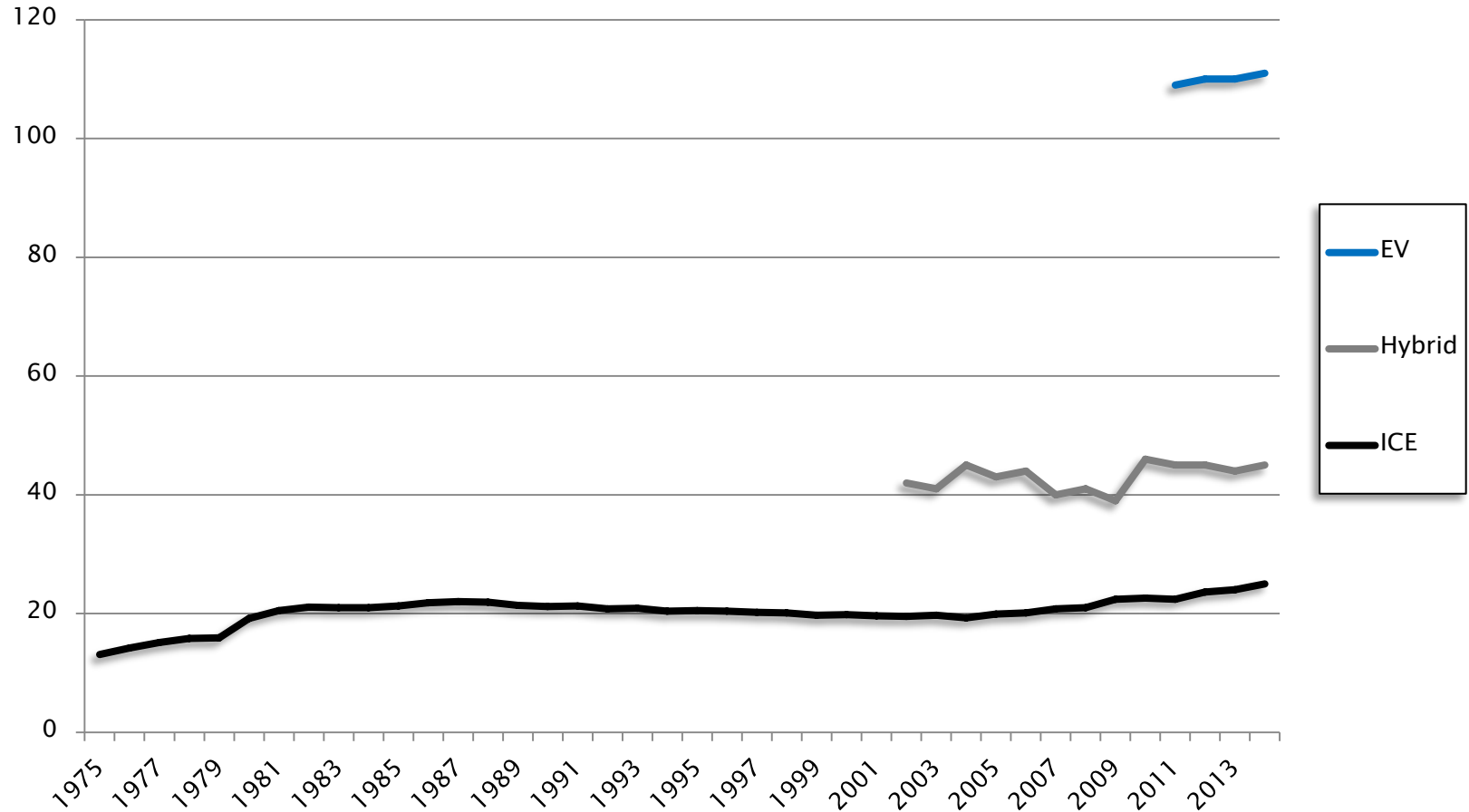


Photos: CERTS and Jukka

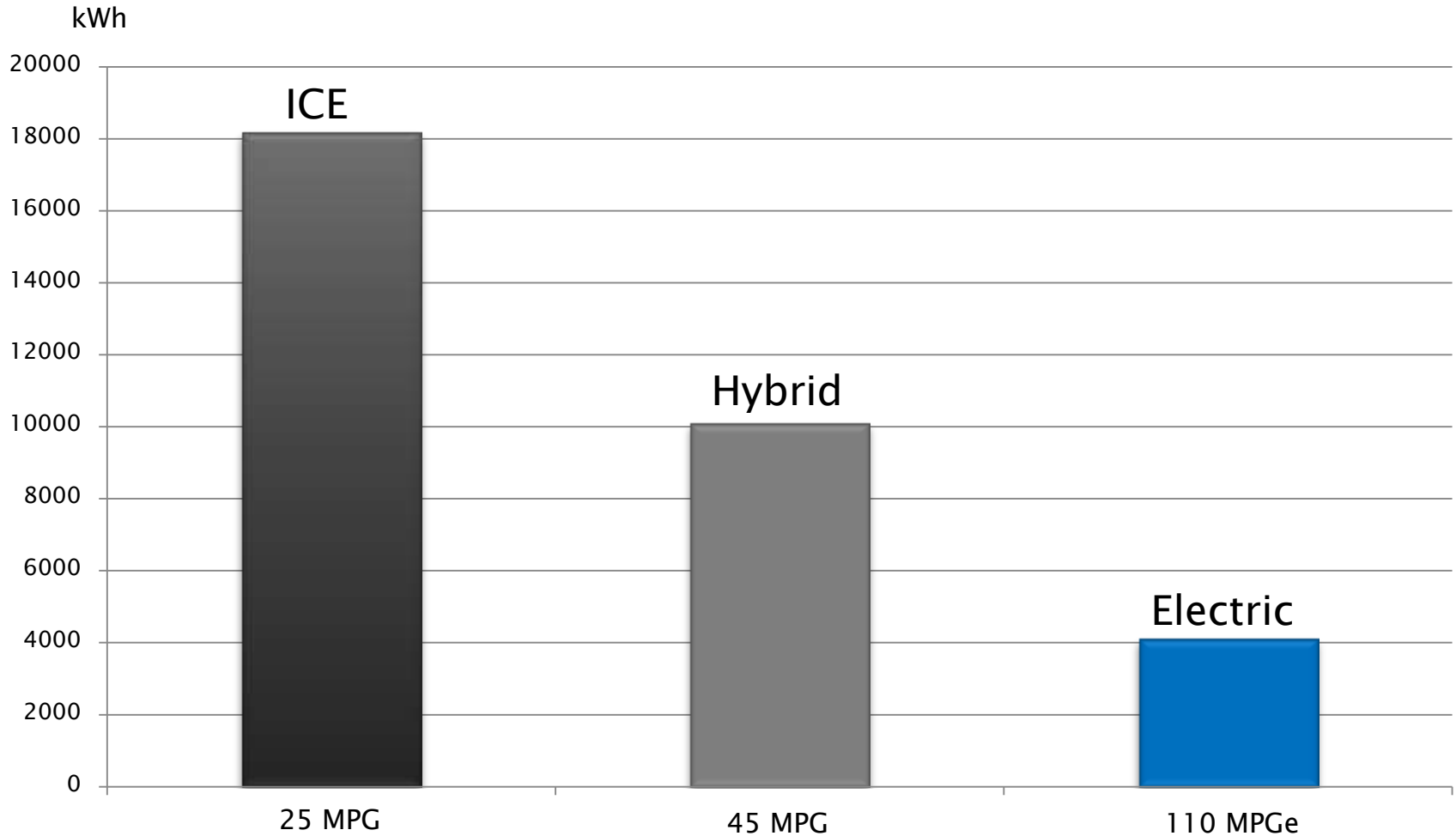
www.PlugInConnect.com

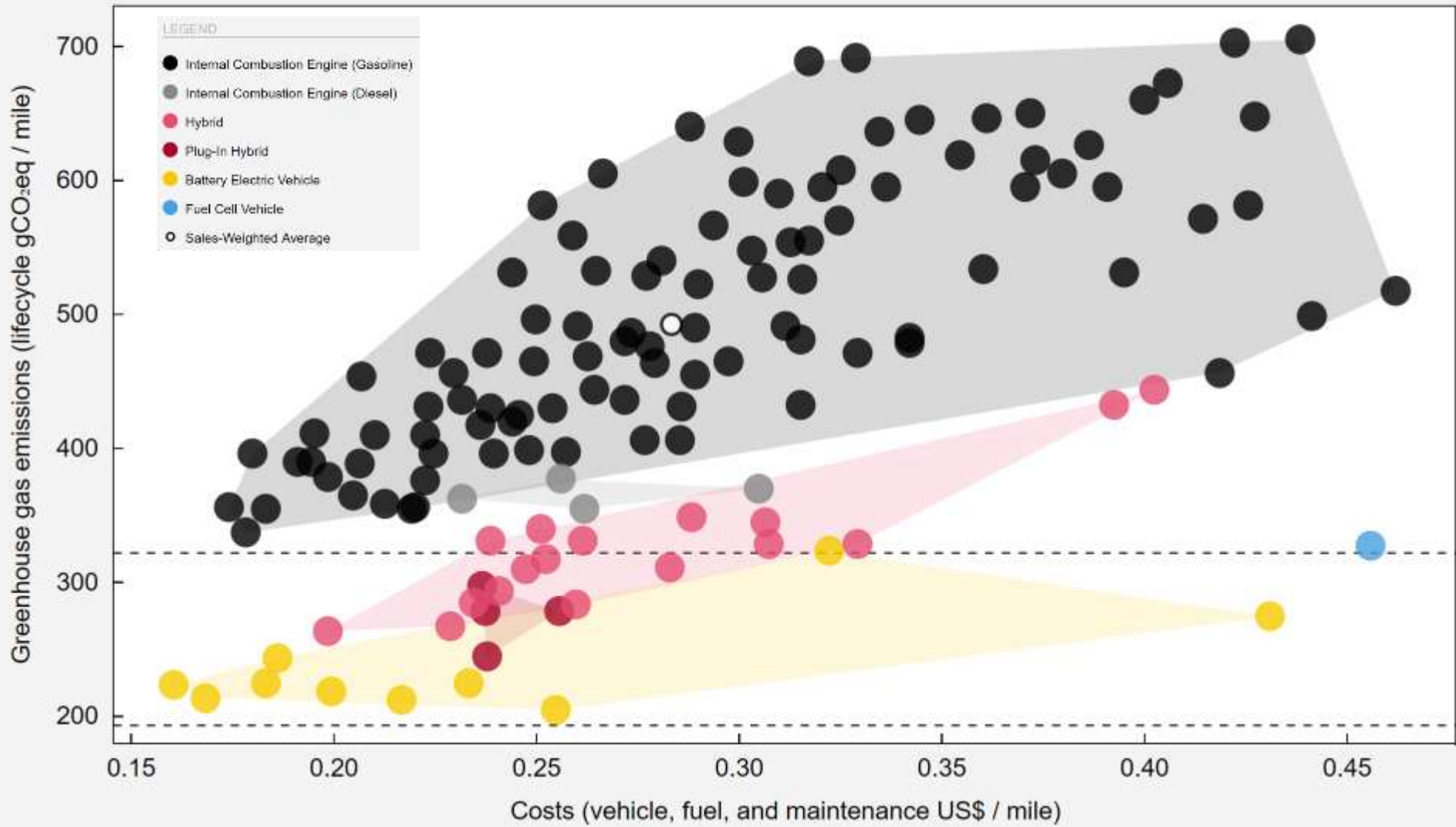
Average fuel economy for new vehicles sold.

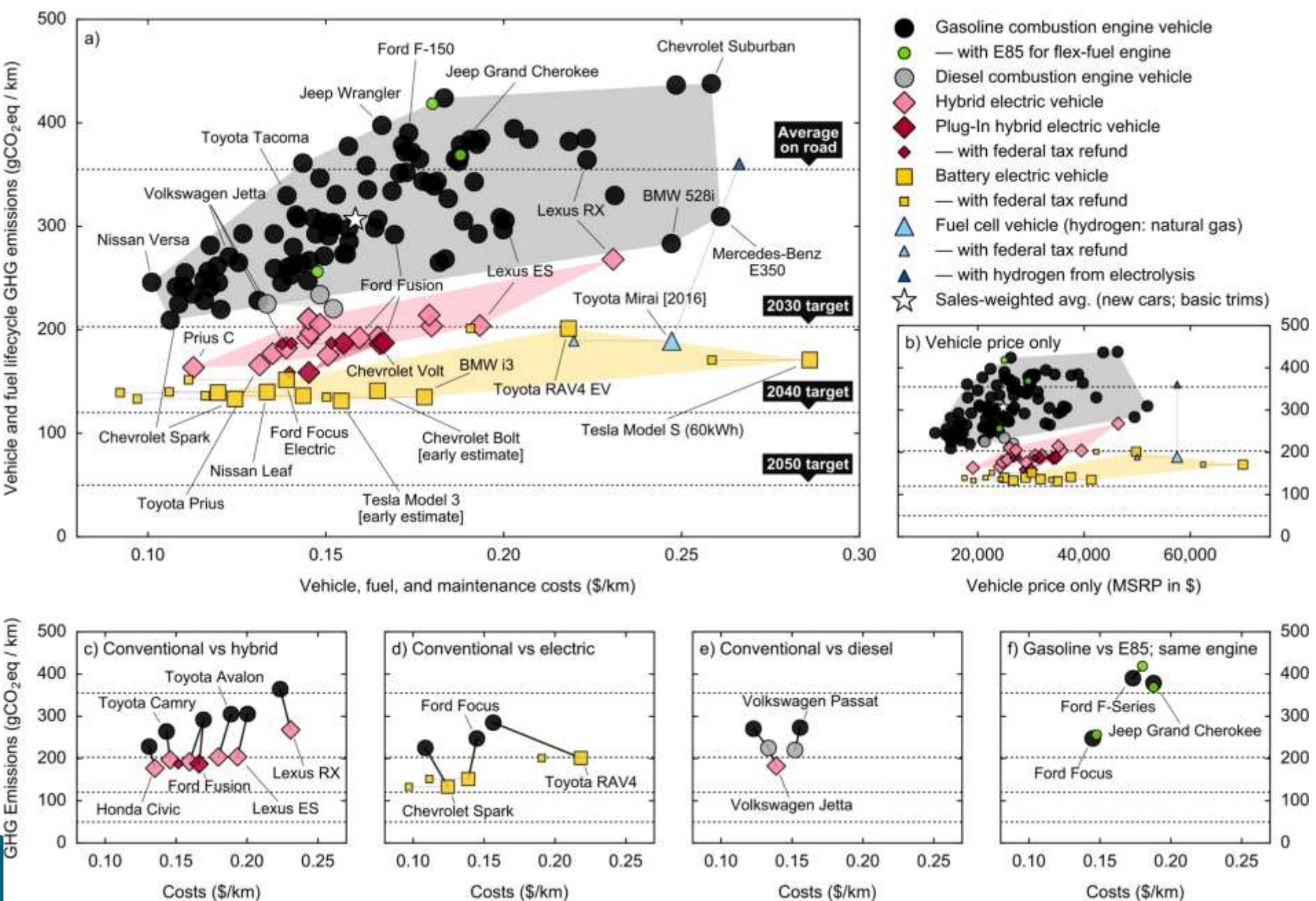
MPG/MPGe



Annual energy consumption







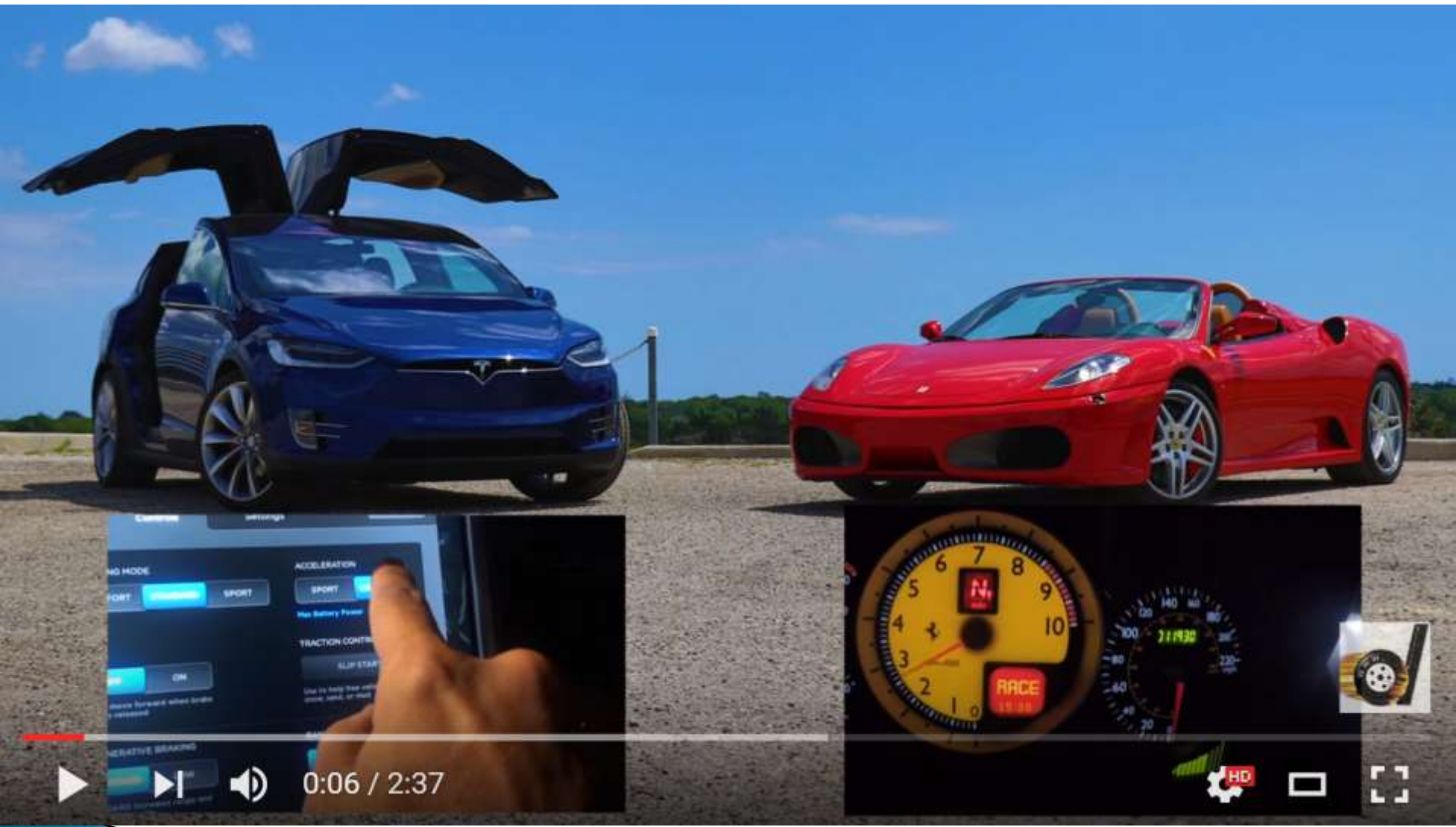
Electric era in transportation is coming.

- ▶ Over 500,000 plug-in vehicles on US roads.
- ▶ About 4000 PEVs in MN. Over 30 million gas free miles in 2016.
- ▶ Very high satisfaction: Over 90% of owners say their next vehicle will be a PEV too.
- ▶ People are hesitant to try new things but we are approaching the tipping point.



EV Technology Fun Facts

- ▶ EV drivetrain technology is four times more efficient than the traditional ICE drivetrain
- ▶ Nearly instantaneous heaters provide cozy winter driving
- ▶ Preheating offers a new level of comfort
- ▶ Electric 4WD is more efficient than 2WD
- ▶ More torque means better performance
- ▶ Whisper quiet powertrain moves the world's quickest family sedans and SUVs.
- ▶ DC Fast Charging provides quick range extension
- ▶ Zero local emissions greatly improves the air quality
- ▶ Solar and wind can power your drive
- ▶ Autonomous vehicle technology is advancing fast



EV maintenance advantage

Maintenance Schedule for your 2017 Chevrolet Bolt EV



Certi- fied Service	Mileage																				
	7,500 miles	15,000 miles	22,500 miles	30,000 miles	37,500 miles	45,000 miles	52,500 miles	60,000 miles	67,500 miles	75,000 miles	82,500 miles	90,000 miles	97,500 miles	105,000 miles	112,500 miles	120,000 miles	127,500 miles	135,000 miles	142,500 miles	150,000 miles	
Rotate tires, if recommended for the vehicle, and perform Required Services.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Replace passenger compartment air filter (or 2 years, whichever comes first).			✓			✓			✓			✓			✓			✓			✓
Drain and fill vehicle coolant circuits.																					✓

Maintenance Schedule for your 2016 Chevrolet Cruze Limited



Certi- fied Service	Mileage																				
	7,500 miles	15,000 miles	22,500 miles	30,000 miles	37,500 miles	45,000 miles	52,500 miles	60,000 miles	67,500 miles	75,000 miles	82,500 miles	90,000 miles	97,500 miles	105,000 miles	112,500 miles	120,000 miles	127,500 miles	135,000 miles	142,500 miles	150,000 miles	
Rotate tires, if recommended for the vehicle, and perform Required Services. Check engine oil level and oil percentage. Change engine oil and filter, if needed.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Replace passenger compartment air filter (or 2 years, whichever comes first).			✓			✓			✓			✓			✓			✓			✓
Replace engine air cleaner filter (or every 4 years, whichever occurs first).						✓						✓								✓	
Replace spark plugs and inspect spark plug wires.												✓									
Replace spark plugs. Inspect ignition coils boots. (Applies to: 1.4 L.)								✓							✓						
1.8L Engine Only: Rplce timing belt, idler pulley, and timing belt tensioner (or every 3 years, whichever comes first). (Applies to: 1.8 L.)													✓								
Change automatic transmission fluid, if equipped. If filter is serviceable, change filter. (Applies to: Severe)						✓						✓							✓		
Change manual transmission fluid. (Applies to: Manual, Severe)						✓						✓							✓		
Drain and fill engine cooling system (or every 5 years, whichever comes first).																					✓
Change brake fluid (or every 3 years, whichever occurs first).						✓						✓							✓		
Change clutch fluid (or every 3 years, whichever occurs first). (Applies to: Manual)						✓						✓							✓		
Inspect evaporative control system.						✓						✓							✓		
Inspect engine accessory drive belts for fraying, excessive cracks or obvious damage (or every 10 years, whichever occurs first).																					✓

Plug-in vehicle types

▶ Plug-in Hybrid Electric Vehicle (PHEV) (extended range EV)

- First miles (10–50 miles) electric and then ICE turns on and takes you further (300–500 miles)
- Examples of vehicles: BMW i3 Rex, Ford C-Max Energi, Chevrolet Volt



▶ Battery Electric Vehicle (BEV)

- All miles always electric (Range 80–315 miles)
- Examples of vehicles: Nissan Leaf, BMW i3, Ford Focus Electric, Tesla Model S










Models available in MN



Plug-in vehicles available in Minnesota (December 2016)

Manufacturer									Range			Charging speed (miles/hr)			Performance			
Name	Model	Photo	Seating	PEV Type	Battery size (kWh)	Base MSRP	Federal tax credit	Price after federal tax credit	Electric Range (miles)	Total Range (miles)	Level 2 Charging Rate (kW)	Level 1 120v	Level 2 240v	DCFC 400+v	MPGe/MPG	Top Spd (mph)	Accel. 0-60 mph (sec)	Crash Rating
Audi	A3 E-Tron		5	PHEV	9	\$38,900	\$4,168	\$34,732	17	430	3.3	4	8	N/A	86/39	130	7.6	NR
BMW	i3		4	BEV	33	\$43,600	\$7,500	\$36,100	114	114 (180)	7.4	5	27	166	124 (39)	93	7.0	4 star
BMW	i8		4	PHEV	7.2	\$141,000	\$3,793	\$137,207	15	330	3.3	3	7	N/A	76/28	155	4.2	NR
BMW	X5 xDrive40e		5	PHEV	9	\$62,100	\$4,700	\$57,400	14	540	3.3	2	5	N/A	56/24	130	6.5	NR
BMW	330E		5	PHEV	7.6	\$43,700	\$4,000	\$39,700	14	350	3.7	3	8	N/A	72/31	130	5.9	NR

www.PlugInConnect.com/ mnpevmodels.html

Nissan	Leaf		5	BEV	30	\$30,680	\$7,500	\$23,180	107	107	3.3 or 6.6	5	11 or 22	152	114	90	10.1	5 star
Porsche	Panamera S E-hybrid		2	PHEV	9.4	\$77,000	\$4,752	\$72,248	16	540	3	3	6	N/A	65/25	167	5.2	NR
Porsche	Cayenne S E-hybrid		5	PHEV	10.8	\$93,000	\$5,300	\$87,700	14	480	3	3	6	N/A	65/25	151	5.4	NR
Tesla Motors	Model S		5	BEV	60 - 100	\$68,000	\$7,500	\$60,500	210-315	210-315	10 or 20	4	60	375	101	155	2.8	5 star
Tesla Motors	Model X		7	BEV	75 - 100	\$90,000	\$7,500	\$82,500	238-289	238-289	10 or 20	4	55	341	92	155	3.2	5 star
Toyota	Prius Prime		4	PHEV	8.8	\$27,100	\$4,500	\$22,600	25	640	3.3	6	13	N/A	133/54	155	3.2	NR
Volvo	XC90 T8		7	PHEV	9	\$69,000	\$4,600	\$64,400	14	350	3.3	2	5	N/A	53/25	125	5.9	NR

This table was updated in December 2016 by Jukka Kukkonen, PlugInConnect.

Photos and information sources: Manufacturers' websites and www.fueleconomy.gov

More info: www.pluginconnect.com/MNpevmodels.html

Upcoming models

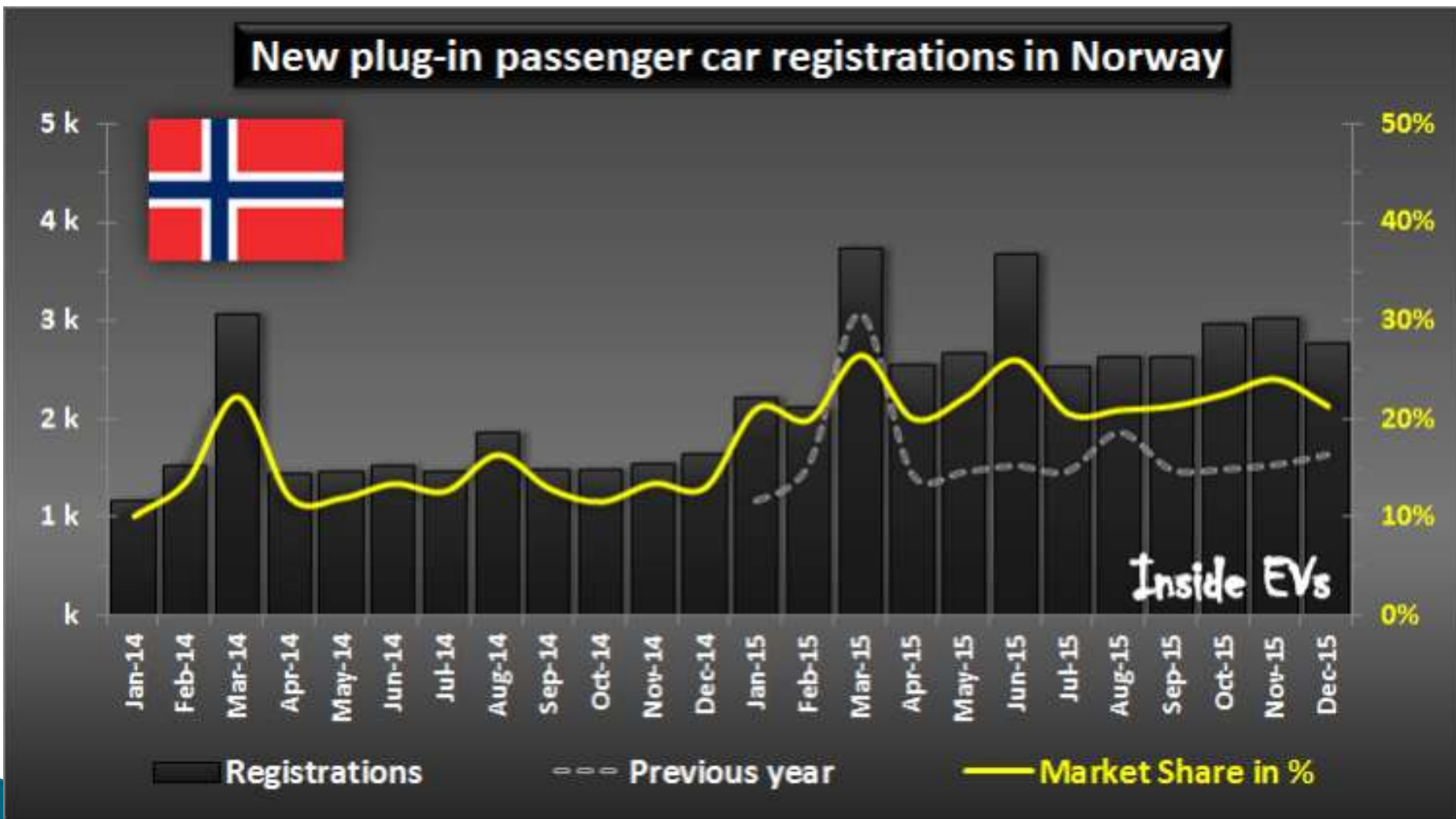


Tesla Model 3

- ▶ 400,000 reservations in 2 weeks!
- ▶ 200 miles range, \$35,000, 0–60 under 6sec. Options: AWD, Autopilot, Supercharging
- ▶ Deliveries start early 2018
- ▶ Competition out early 2017
Chevrolet Bolt and Nissan Leaf 2.0



Success stories



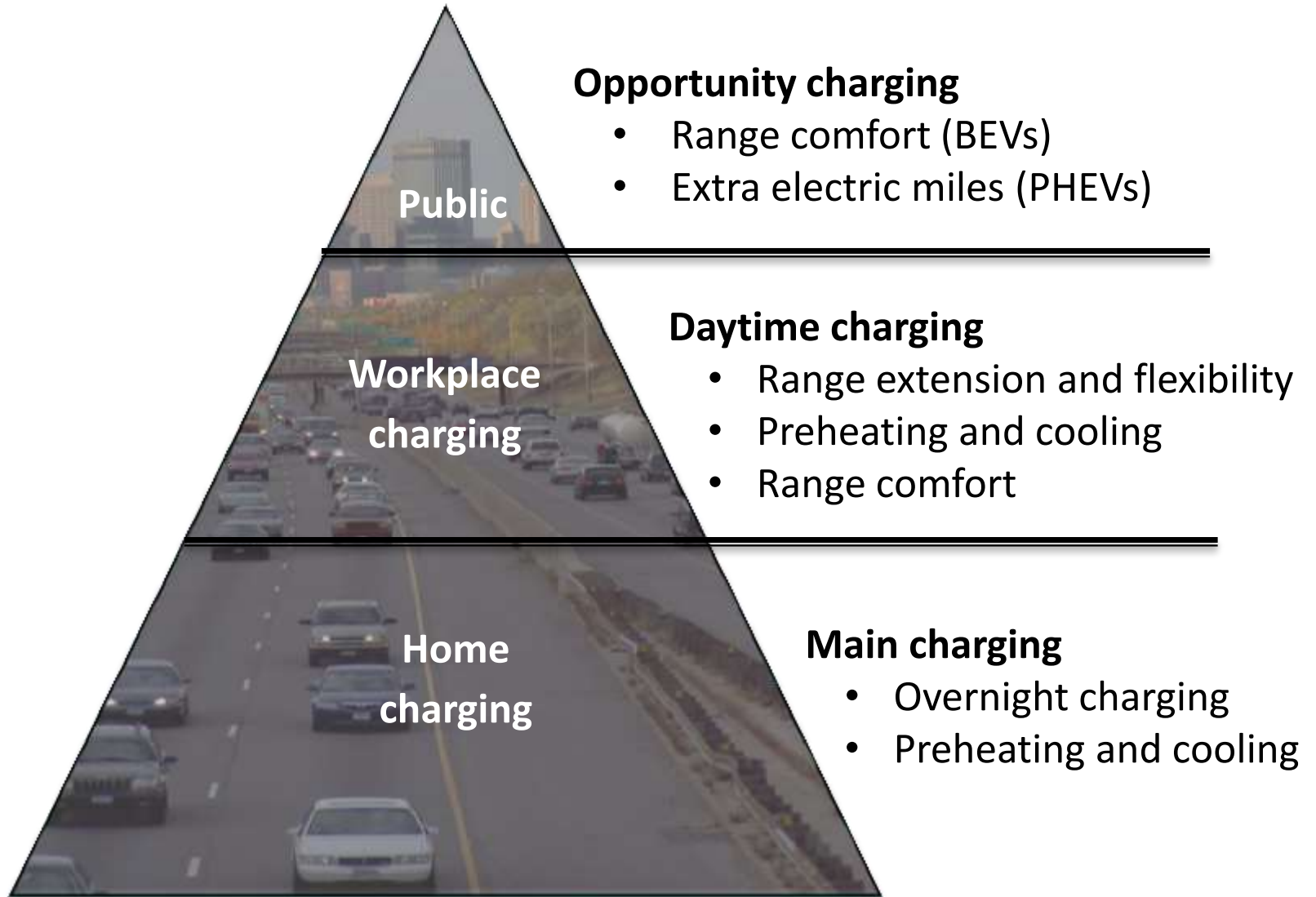
US Large Luxury Car sales

Model	2015 Sales	2014 Sales	% Change
Audi A7	7721	8133	-5.07%
Audi A8	4990	5904	-15.48%
BMW 6-Series	8146	8647	-5.79%
BMW 7-Series	9292	9744	-4.64%
Jaguar XJ	3611	4329	-16.59%
Lexus LS	7165	8559	-16.29%
Mercedes-Benz CLS-Class	6152	6981	-11.88%
Mercedes-Benz S-Class	21934	25276	-13.22%
Porsche Panamera	4985	5740	-13.15%
Tesla Model S	26566	18480	43.76%
Total	100562	101793	-1.21%

PHEV version sold 59% of Outlander sales in Europe



Charging patterns



How to charge an EV?

Level 1
120 Volt



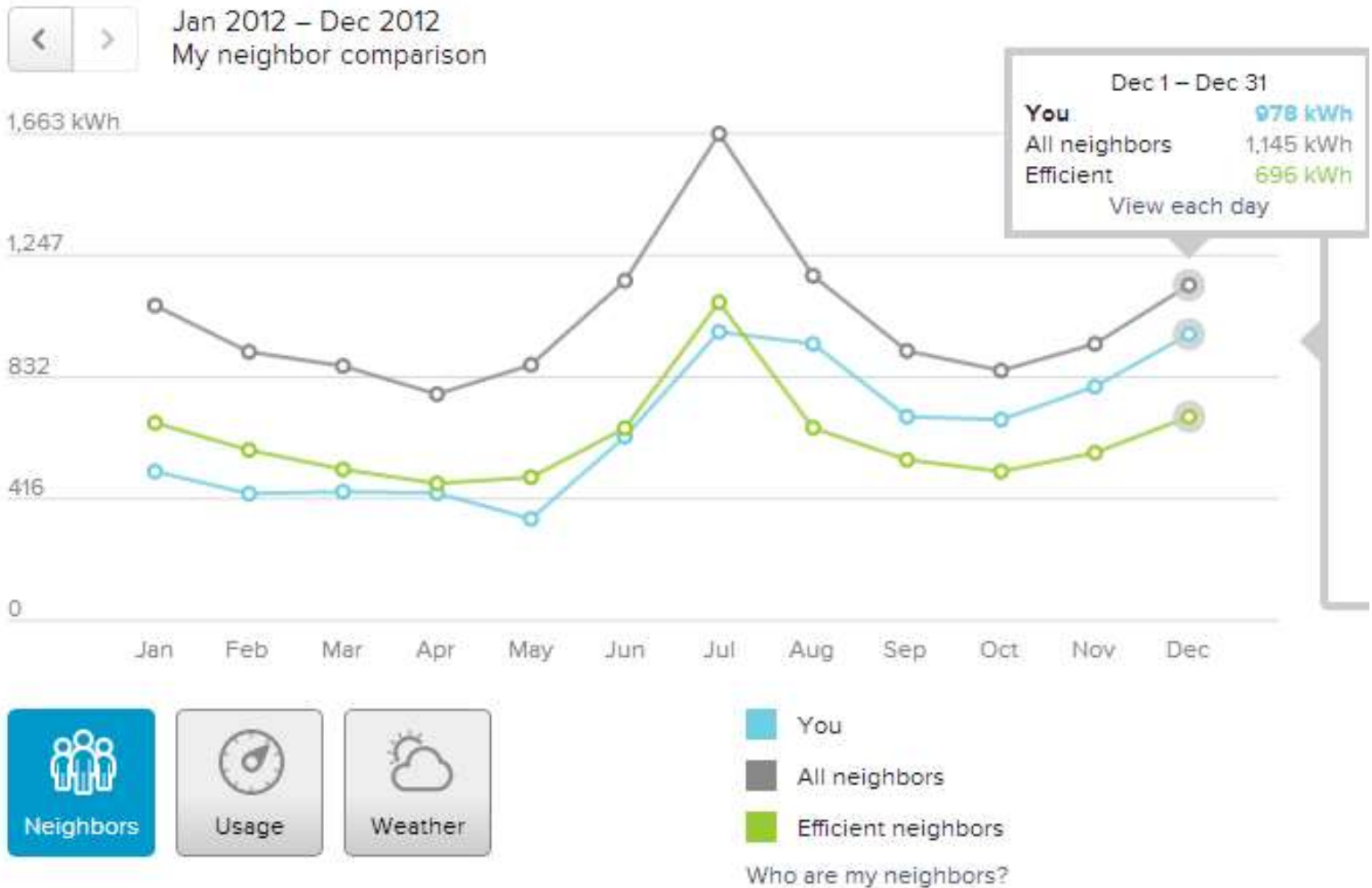
Level 2
240 Volt

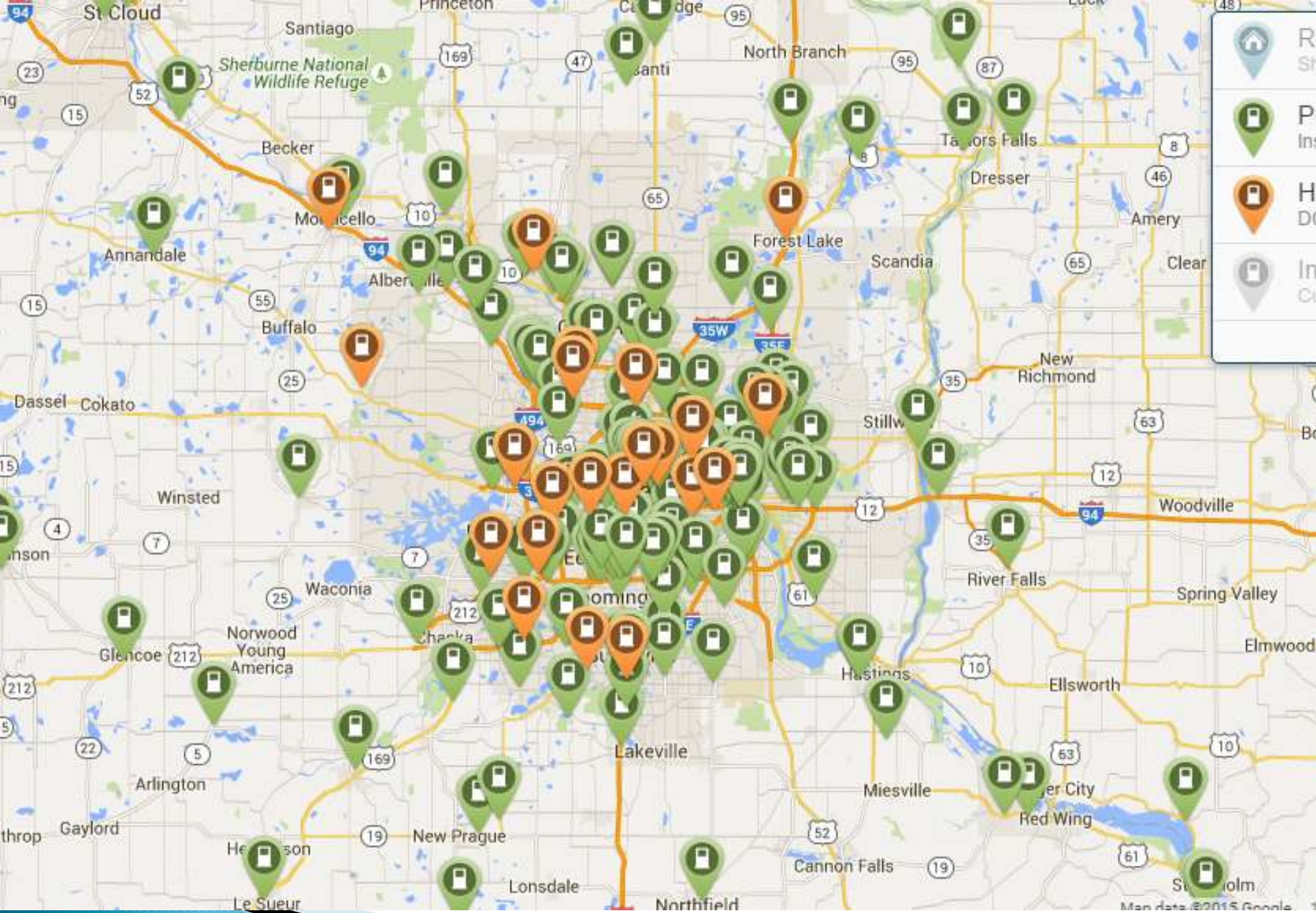


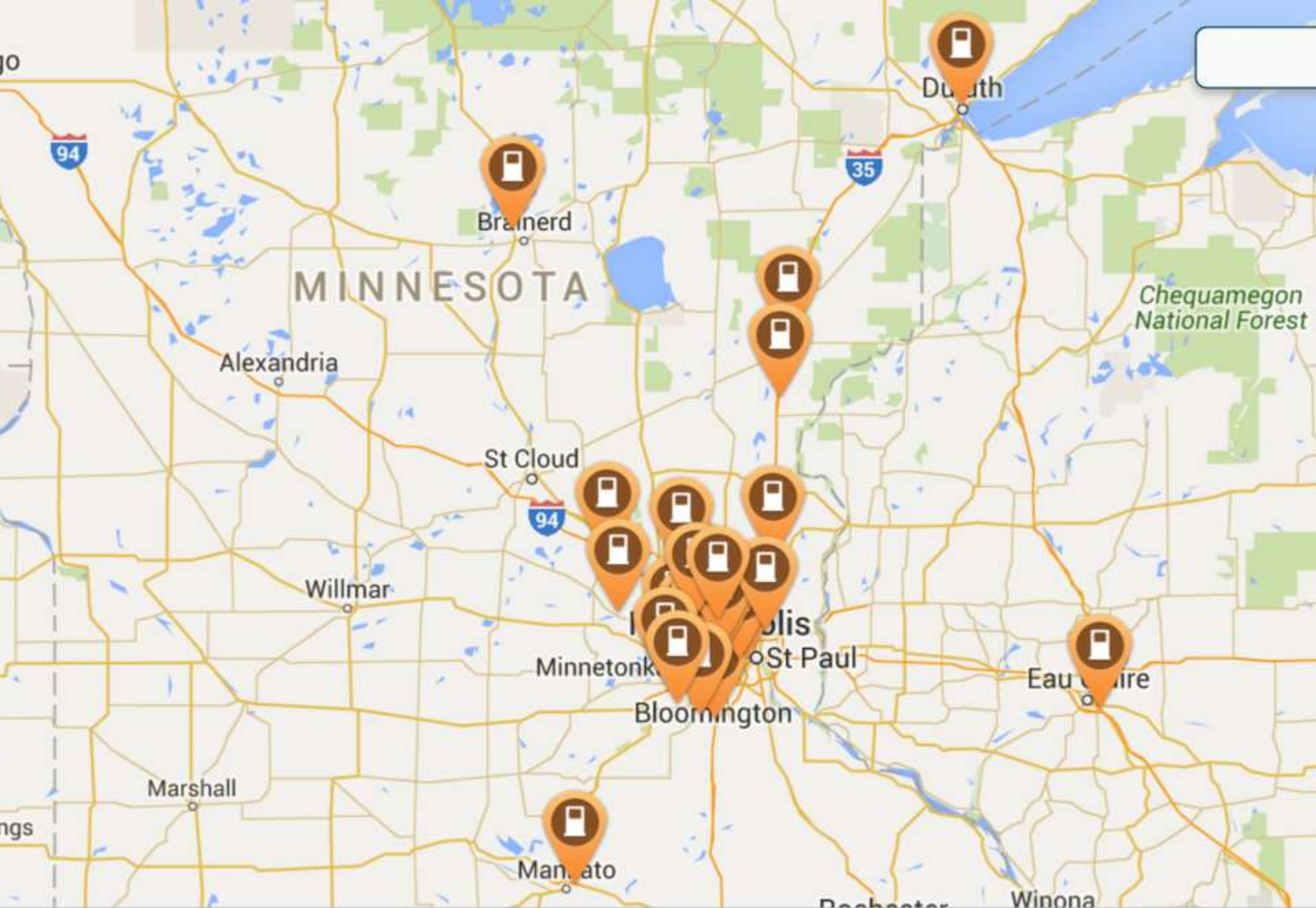
DC fast charge



Real life energy costs example







PEV vs. ICE household math test assumptions and answers 😊

- ❖ 11,000kWh/year
- ❖ 13,500miles/year
- ❖ 1.8 drivers/household
- ▶ 24,000miles/year
- ❖ 25MPG
- ▶ 970 gallons
- ❖ 33.7 kWh/gallon
- ❖ 33,000kWh
- ❖ 3 miles/kWh
- ▶ 8,100kWh
- ▶ 25%
- ❖ \$2.5 /gallon
- ▶ \$2,425
- ❖ \$0.07
- ▶ \$570
- ▶ \$1855

EV Charging for Multi-Housing and Commercial Properties



BENEFITS FOR BUILDING OWNERS / MANAGERS

- ▶ New service product
- ▶ Client attraction and retention
- ▶ Future proofing the property
- ▶ LEED points
- ▶ Property value increase
- ▶ Green credentials and publicity

How to future proof your property?

California Green Building Standards Code 2014

- ▶ Residential buildings
 - 3 % of parking spots
 - 208/240V 40A circuit breaker
 - Conduit that can carry 208/240V 80A wiring
- ▶ Cost estimates:
 - \$53 for single family homes
 - \$110 for multi housing buildings



LEED v4 Credit 8, Green Vehicles

1 Point for Green Parking and Electric Vehicle Charging

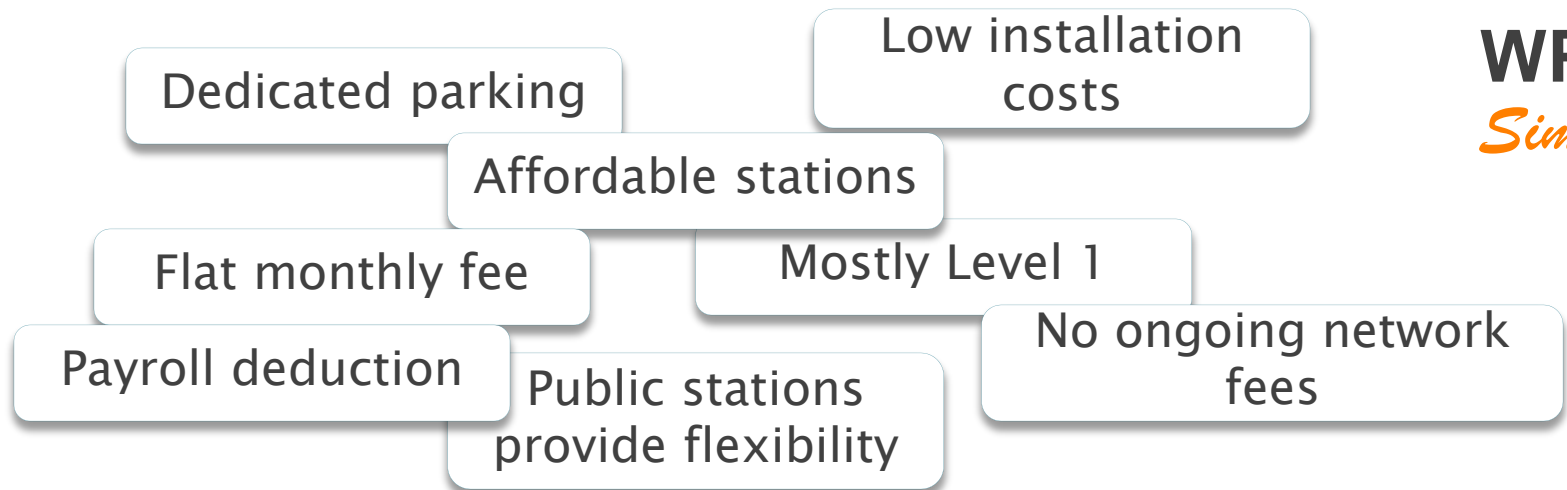
- ▶ Designate 5% of all parking spaces for green vehicles
- ▶ Install Electric vehicle Supply Equipment (EVSE) in 2% of all parking spaces used by the project.
- ▶ The EVSE must:
 - Be Level 2 (208/240V) or higher
 - Use standardized connector (J1772)
 - Be networked and be capable of participating in a demand-response program or time-of-use pricing to encourage off-peak charging.

Considerations

- ▶ Electrical service
- ▶ Breaker panel capacity
- ▶ Future expansion
- ▶ Proximity to the electrical service
- ▶ Safety
- ▶ Cord management
- ▶ Connectivity
- ▶ Lighting
- ▶ Signage



Workplace Charging Simple concept



WPC
Simple

Resources



MultiHousingCharging.com

HOME PAGE EV OWNERS HOAS BLDG OWNERS/MGRS UTILITIES TOOLS AND RESOURCES ABOUT US

Practical processes to PEV charging.

AN INCREASING NUMBER OF PROPERTIES ARE ADDING EV CHARGING AS A NEW AMENITY

A growing number of people are choosing to drive electric vehicles and plug-in hybrids. These vehicles need to be charged at home rather than filled up at the gas station. In single family homes, EV charging systems are very straightforward to choose and install. Multi housing charging (MHC) can



WorkplaceCharging.com

HOME EV OWNERS EMPLOYERS BLDG OWNERS/MGRS UTILITIES RESOURCES ABOUT US

Workplace EV charging provides value to all stakeholders

Multi Housing Charging worksheet

Multi Housing Charging worksheet

The following worksheet and related tools are designed to help plug-in electric (PEV) vehicles and multi-housing property management calculate, describe and plan for PEV charging infrastructure. The worksheet does not cover all options or scenarios, but is designed to be a practical tool for some of the most important considerations.

Charging level decisions

Use the Charge Level Energy Calculator tool to calculate the charging costs and energy needs and energy needs.

Based on the power and energy calculations, the worksheet needs like to exist:

- 1. Level 1 (120V AC) standard household outlet
- 2. Level 2 (208VAC, 48A/100A and 60A/110VAC)
- 3. Other charging infrastructure

Metering and payment system for electricity usage

For Level 1 charging:
If the resident will plug in his/her EV charging with a standard household outlet, the charge is metered to individual units. For charging with a standard household outlet, the charge is metered to individual units. For charging with a standard household outlet, the charge is metered to individual units. For charging with a standard household outlet, the charge is metered to individual units.

For Level 2 charging:
Level 2 charging supplies over 1000 watts charging power. It provides more flexibility for the resident and a flexible payment system. For charging with a standard household outlet, the charge is metered to individual units. For charging with a standard household outlet, the charge is metered to individual units.

For Level 3 charging:
Level 3 charging supplies over 1000 watts charging power. It provides more flexibility for the resident and a flexible payment system. For charging with a standard household outlet, the charge is metered to individual units. For charging with a standard household outlet, the charge is metered to individual units.

The property should also consider the ability to offer incentives to encourage residents to use EV charging. This includes offering incentives to encourage residents to use EV charging. This includes offering incentives to encourage residents to use EV charging.

This worksheet was developed as part of the following research project: National Science Foundation Grant #1031200, Multi-Housing Charging Infrastructure, Plug-In Connect, Inc. www.plugincorconnect.com

Worksheet 1.1

Parking labels
The resident will have a designated parking spot in their designated area. The property manager should ensure that the parking spot is clearly marked and that the resident is aware of the location. The property manager should ensure that the parking spot is clearly marked and that the resident is aware of the location.

Level 1 charging
Level 1 charging is the most common type of charging. It uses a standard household outlet and provides a charging rate of approximately 2 miles per hour. Level 1 charging is the most common type of charging. It uses a standard household outlet and provides a charging rate of approximately 2 miles per hour.

Level 2 charging
Level 2 charging is a faster type of charging. It uses a 240V outlet and provides a charging rate of approximately 10 miles per hour. Level 2 charging is a faster type of charging. It uses a 240V outlet and provides a charging rate of approximately 10 miles per hour.

Level 3 charging
Level 3 charging is the fastest type of charging. It uses a 480V outlet and provides a charging rate of approximately 30 miles per hour. Level 3 charging is the fastest type of charging. It uses a 480V outlet and provides a charging rate of approximately 30 miles per hour.

The PEV will be installed and used in the following manner:

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Worksheet 1.2

Assumptions for charging
Level 1 charging is the most common type of charging. It uses a standard household outlet and provides a charging rate of approximately 2 miles per hour. Level 1 charging is the most common type of charging. It uses a standard household outlet and provides a charging rate of approximately 2 miles per hour.

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Metering and Payment Systems Table

Power and Energy Calculator tool

MultiHousingCharging.com tools

Description	Main uses	Common features	Installation needs	Active ongoing costs	Time of installation	Risks	Costs
1. Residential EV charging	EV charging	Standard household outlet	Level 1	No	1-2 hours	None	None
2. Commercial EV charging	EV charging	240V outlet	Level 2	Yes	1-2 days	None	None
3. Public EV charging	EV charging	240V outlet	Level 2	Yes	1-2 days	None	None
4. Fleet EV charging	EV charging	240V outlet	Level 2	Yes	1-2 days	None	None
5. Multi-unit residential EV charging	EV charging	240V outlet	Level 2	Yes	1-2 days	None	None
6. Multi-unit commercial EV charging	EV charging	240V outlet	Level 2	Yes	1-2 days	None	None
7. Multi-unit public EV charging	EV charging	240V outlet	Level 2	Yes	1-2 days	None	None
8. Multi-unit fleet EV charging	EV charging	240V outlet	Level 2	Yes	1-2 days	None	None

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MultiHousingCharging.com tools

Power and Energy Calculator tool

This tool is designed to help you calculate the power and energy needs of your PEV charging infrastructure. It includes a calculator for power and energy needs, and a table of common charging scenarios.

Power and Energy Calculator

Power (kW) = Voltage (V) x Current (A)

Energy (kWh) = Power (kW) x Time (h)

Example: A 240V outlet with a 30A circuit can provide 7.2 kW of power. If you charge for 4 hours, you will use 28.8 kWh of energy.

Scenario	Power (kW)	Energy (kWh)
Level 1 (120V, 15A)	1.8	7.2
Level 2 (240V, 30A)	7.2	28.8
Level 3 (480V, 60A)	28.8	115.2

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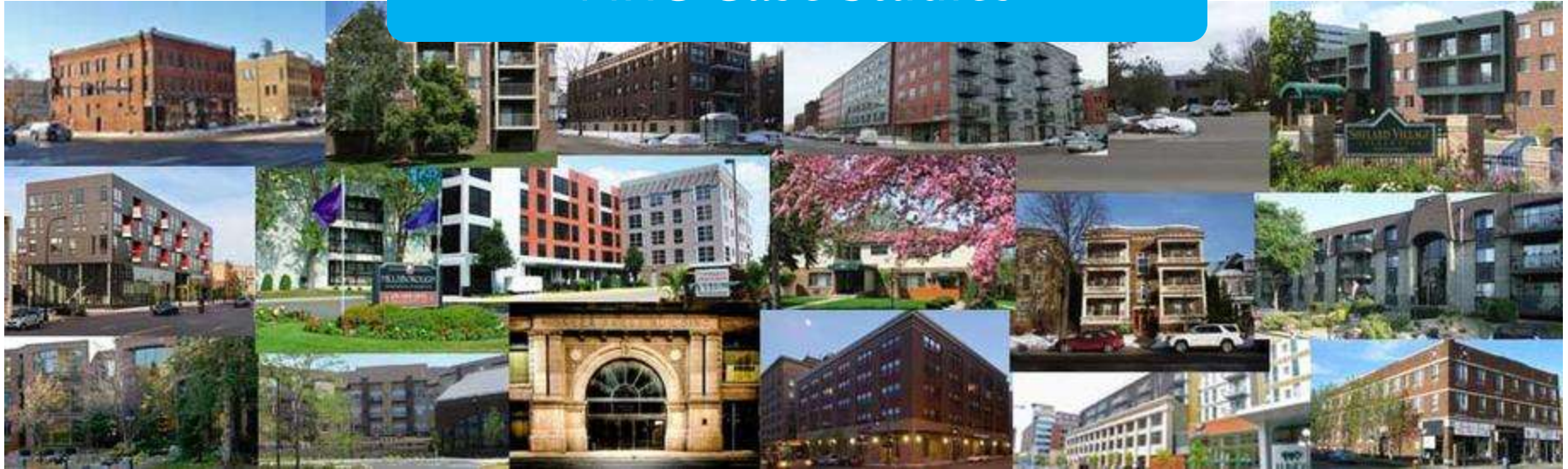
Metering and Payment Systems table

	Description	Who does billing	Components needed	Communication connections	Installation costs	Extra ongoing costs	Time of Day metering possible	Pros	Cons
1	Connected to homeowner's existing meter	Utility	Conduit and wiring	No	Low	No	Yes	Simple, no extra costs	None
2	New, EVSE dedicated, utility meter	Utility	Meterbox, meter, conduit and wiring	Utility company covers	Moderate, depending on utility company setup charges	Monthly service charge from utility	Yes	Relatively simple, utility does the metering and billing	Some extra installation and ongoing costs
3	Submetering	Building manager	Meterbox, meter, conduit and wiring	Depending on the type of meter used	Higher, extra cost from submeter	Potentially communication costs, billing labor	Yes	As accurate as utility metering	Building manager has to do the metering and billing
4	Flat billing with annual submetering based adjustment	Building manager	Meterbox, meter, conduit and wiring	Depending on the type of meter used	Higher, extra cost from submeter	Potentially communication costs	Yes	As accurate as utility metering in the long term, but less billing labor than option 3	Building manager has to do the metering and billing
5	Flat billing with estimate	Building manager	Conduit and wiring	No	Low	No	No	Simple, cheap system	Inaccurate, no time of day option, does not take into account charging outside of home
6	Third party system and billing	Service provider	Conduit, wiring and advanced EVSE	Yes	Varies based on the service provider	Yes, often consisting of flat annual service fee + percentage of billing	Yes	Simple for building manager and user, provides more data, enables multiple users	Expensive, ongoing costs can in some cases be more than electricity costs

Sharing experiences

- ▶ Over 20 case studies from the Twin Cities

MHC Case Studies



www.multiphousingcharging.com/case-studies.html

Let's dive in

- ▶ Choose the location
- ▶ Figure out the charging functions: home, workplace, fleet, corridor, destination...
- ▶ Who will use it?
- ▶ Which stations would you use?
- ▶ How will users pay for the service?
- ▶ Who do you partner with to make this happen?
- ▶ Future expansion?
- ▶ Stakeholder benefits.

Societal benefits of PEVs

- ▶ Less energy produced and used
- ▶ Local energy
- ▶ Cleaner air
- ▶ Curing our oil addiction
- ▶ Renewable energy options
- ▶ Energy education



Q&A + 0

For more information visit:

PlugInConnect.com

MultiHousingCharging.com

WorkplaceCharging.com

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