



EV Charging Strategies



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Department of Energy and Minnesota Pollution Control Agency

www.PlugInConnect.com

What do I do:

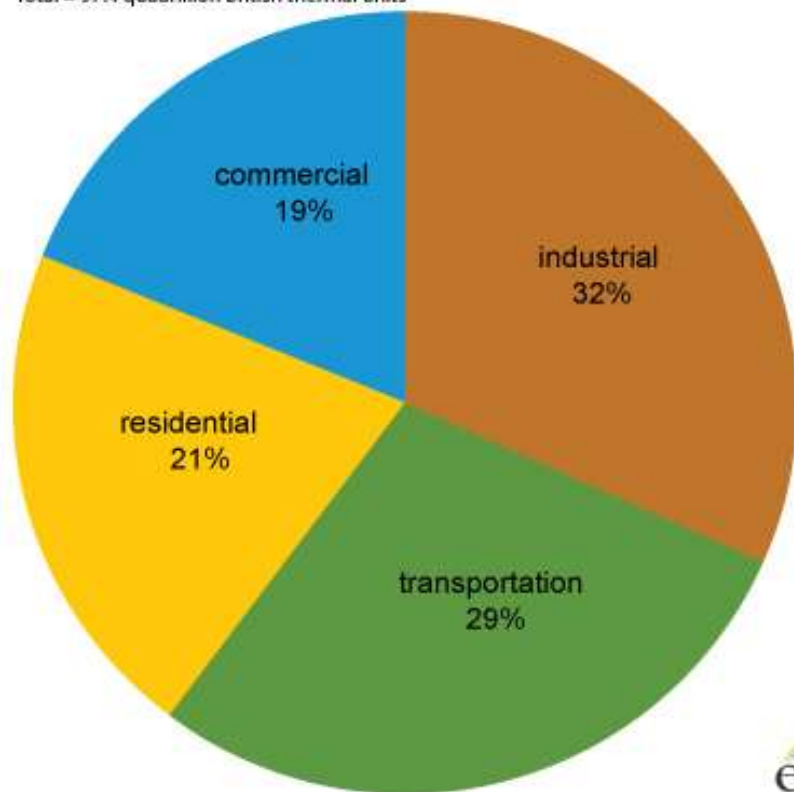
- ▶ Plug-in vehicle market and business development
www.PlugInConnect.com
- ▶ Charging information for condos and apartment buildings
www.MultiHousingCharging.com
- ▶ Charging information for workplaces
www.WorkplaceCharging.com
- ▶ MN Plug-in Vehicle Owners' Circle
www.pluginconnect.com/mnpevowners.html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



Fresh Energy

Share of total U.S. energy consumed by end-use sector in the United States, 2016

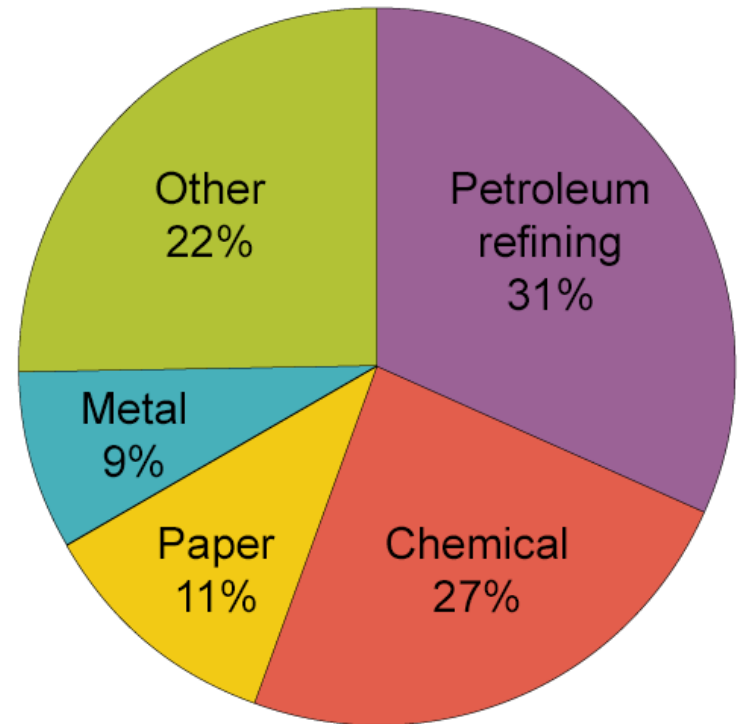
Total = 97.4 quadrillion British thermal units



Note: Sum of individual percentages may not equal 100 because of independent rounding.

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 2.1, April 2017, preliminary data

Energy use by type of industry, 2010¹

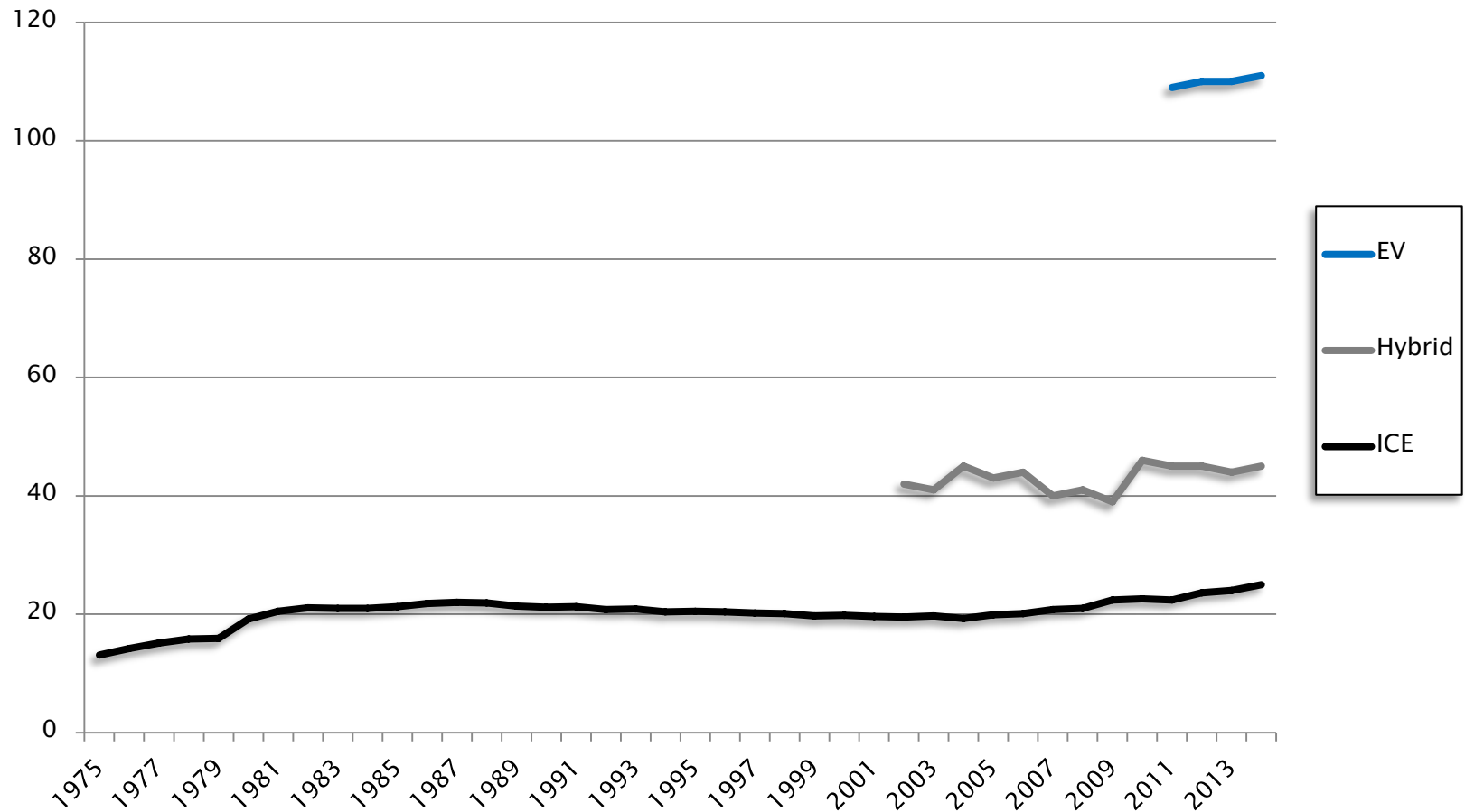


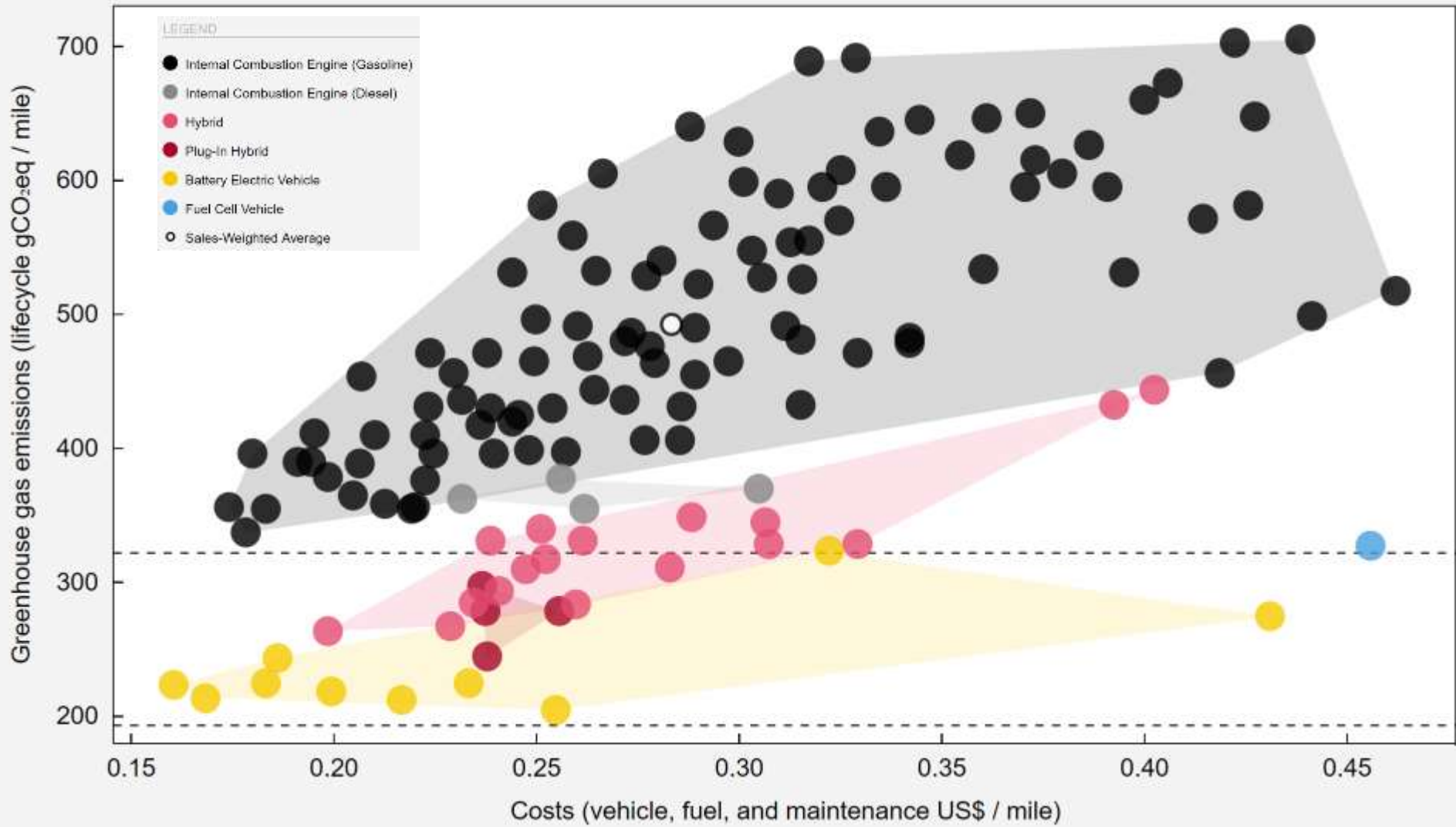
Source: U.S. Energy Information Administration, *Manufacturing Energy Consumption Survey 2010*, Table 1.2 (March 2013)

¹Includes all use of energy and fuels; excludes shipments of energy sources produced onsite.

Average fuel economy for new vehicles sold.

MPG/MPGe





Electric era in transportation is coming.

- ▶ Over 650,000 plug-in vehicles on US roads.
- ▶ About 5500 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.

Sales forecasts

November /
2016

Different possible adoption curves

— Base case curve

- Meets general fleet emission targets

— Regulatory-driven curve

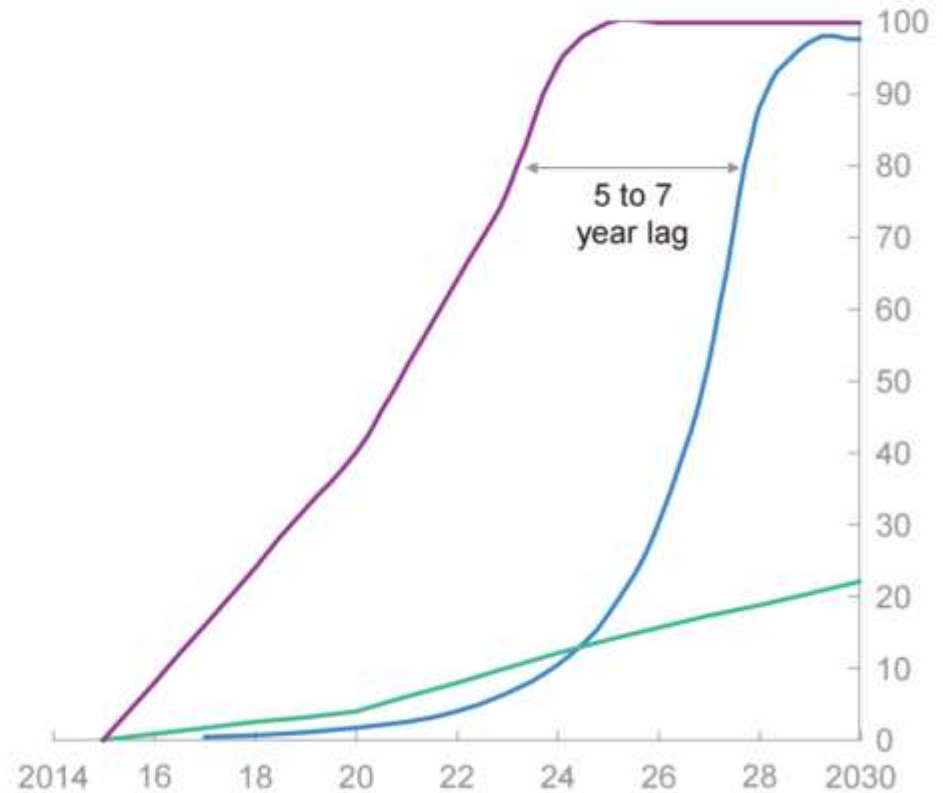
- 100% of light vehicle sales to be electric by 2025 (e.g., Seamless Mobility)
- Based on Norway's intentions

— Innovation and imitation curve

- Assuming early adopter and imitation effect
- Speed of adoption and imitation based on historic sales, and the relative cost of ICE versus EV's

Electric vehicle as share of car sales

Percent



SOURCE: BNEF and McKinsey analysis

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



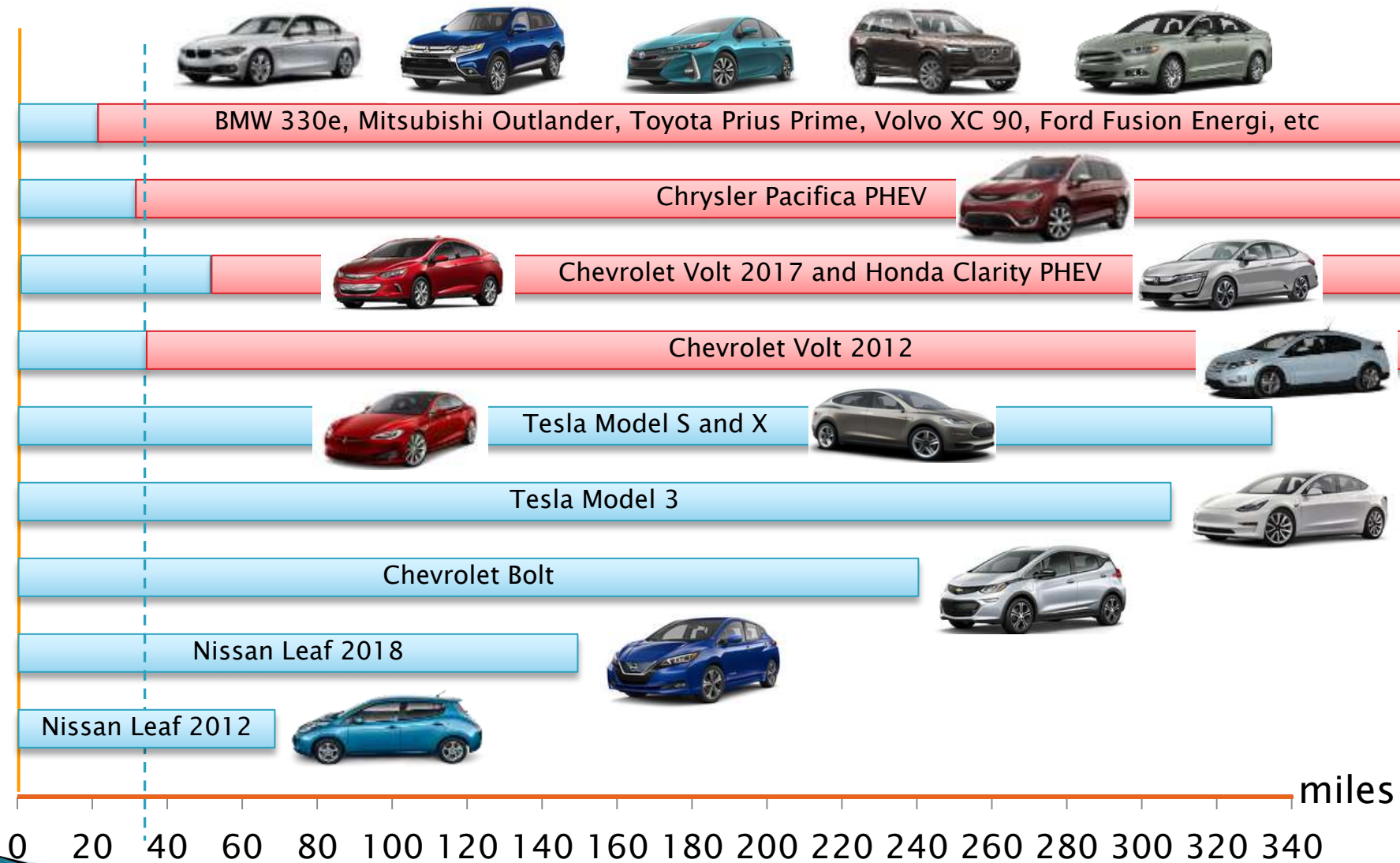
| Certi- fied Service | Mileage | | | | | | | | | | | | | | | | | | | | |
|---|-------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---|
| | 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: Replace 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). | | | | | | | | | | | | | | | | | | | | | ✓ |

Choose your ride!



miles

Plug-in vehicle types

▶ Plug-in Hybrid Electric Vehicle (PHEV)



- First miles (10–50 miles) electric and then ICE turns on and takes you further (300–500 miles)
- Examples: Chevrolet Volt, Mitsubishi Outlander PHEV, Toyota Prius Prime



▶ Battery Electric Vehicle (BEV)

- All miles always electric (Range 80–335 miles)
- Examples: Chevrolet Bolt, Nissan Leaf, BMW i3, Tesla Model S, X










Models available in Midwest



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

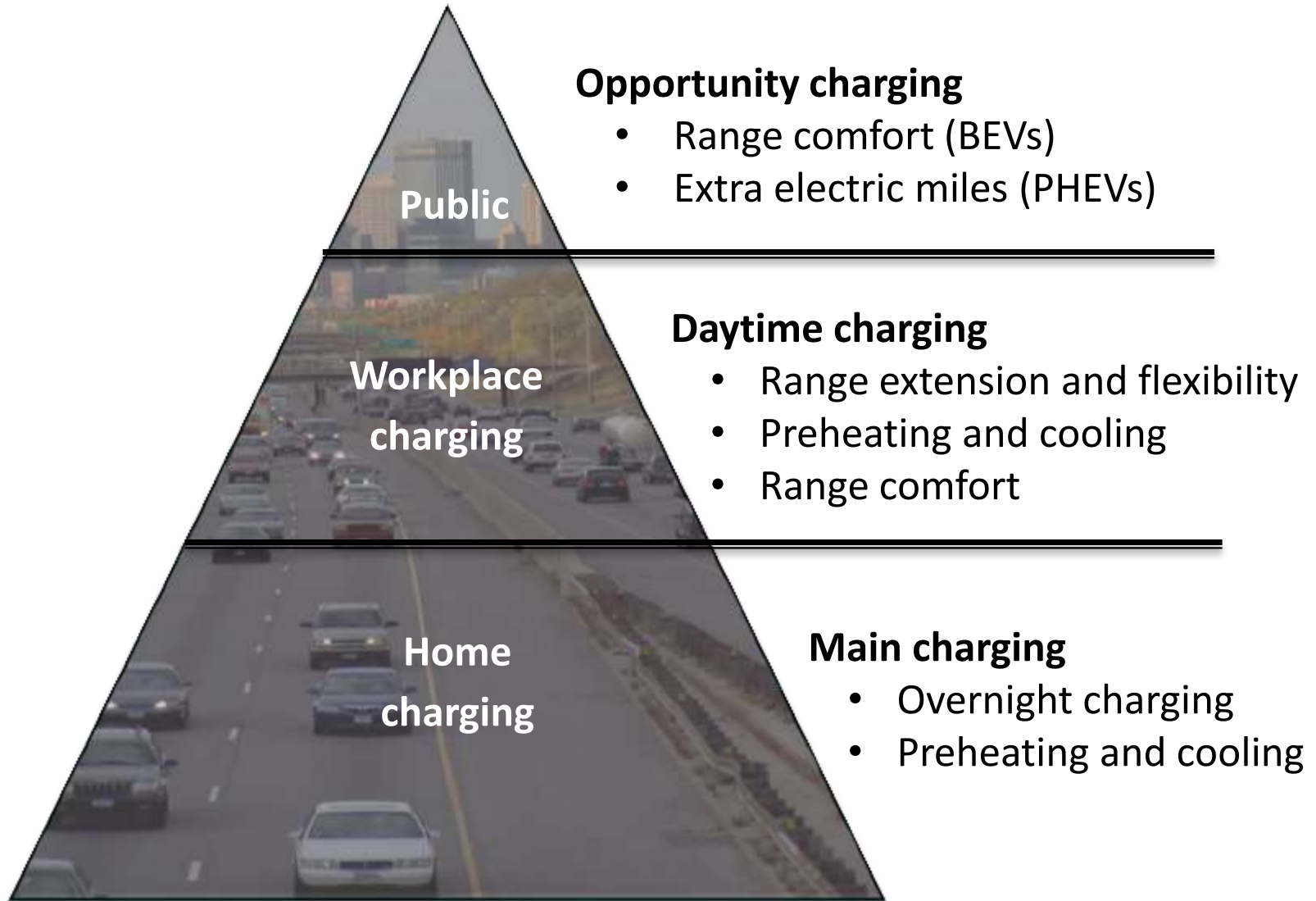
| | | | | | | | | | | | | | | | | | | |
|--------------|---------------------|---|---|------|----------|----------|---------|----------|---------|---------|------------|---|----------|-----|--------|-----|------|--------|
| Nissan | Leaf |  | 5 | BEV | 30 | \$30,680 | \$7,500 | \$23,180 | 107 | 107 | 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

Charging patterns



How to charge an EV?

Level 1
120 Volt



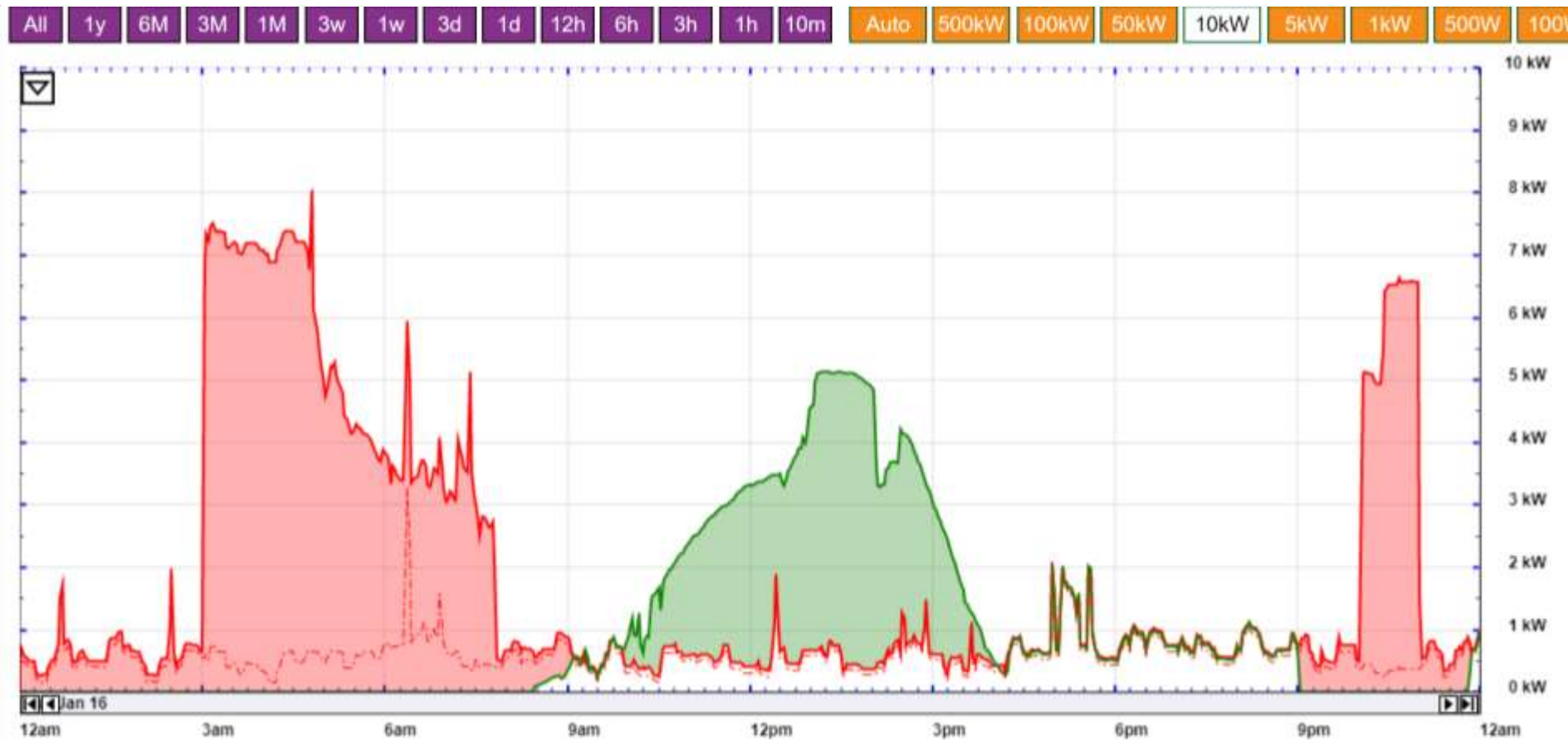
Level 2
240 Volt



DC fast charge

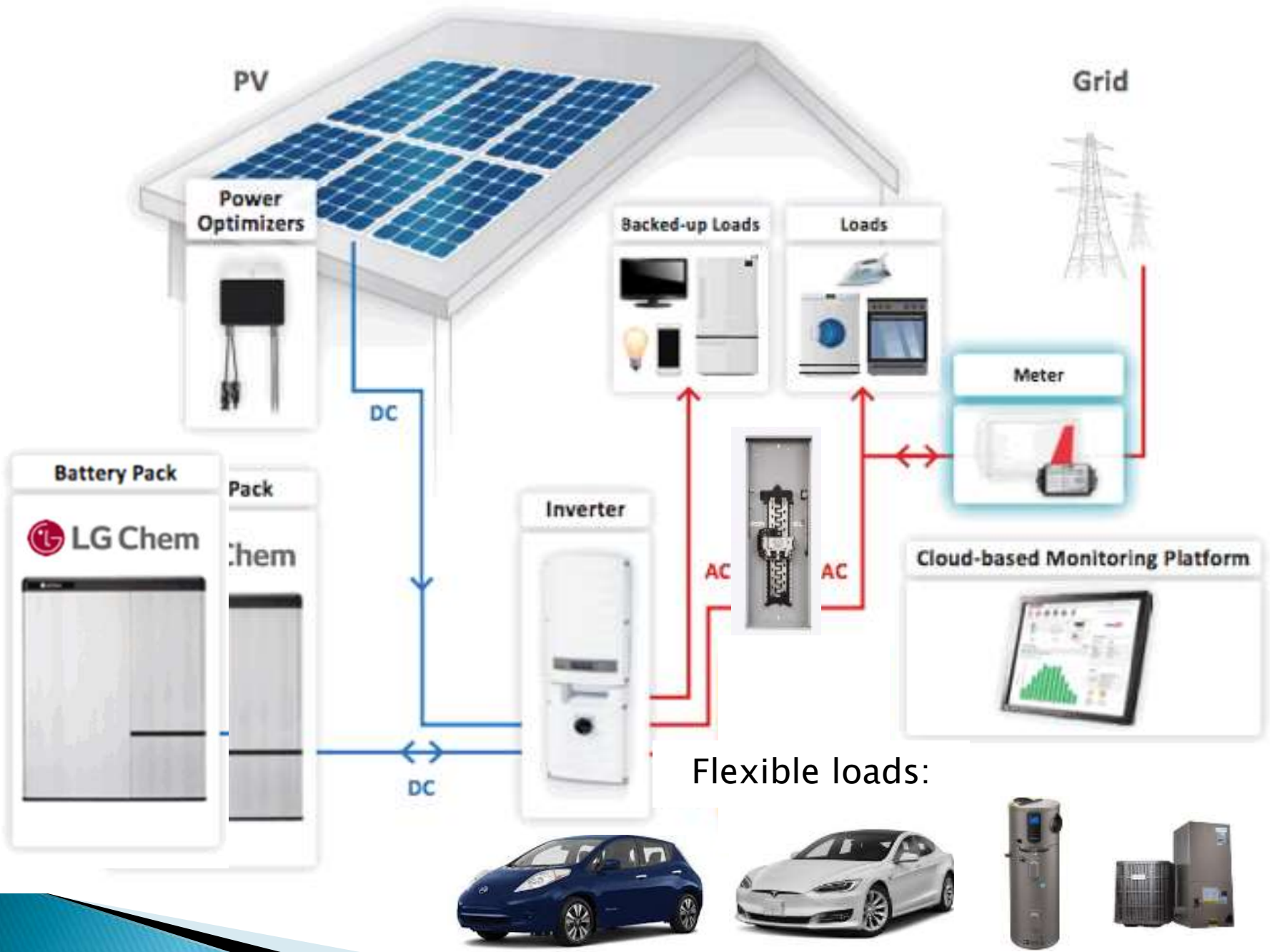


Residential household



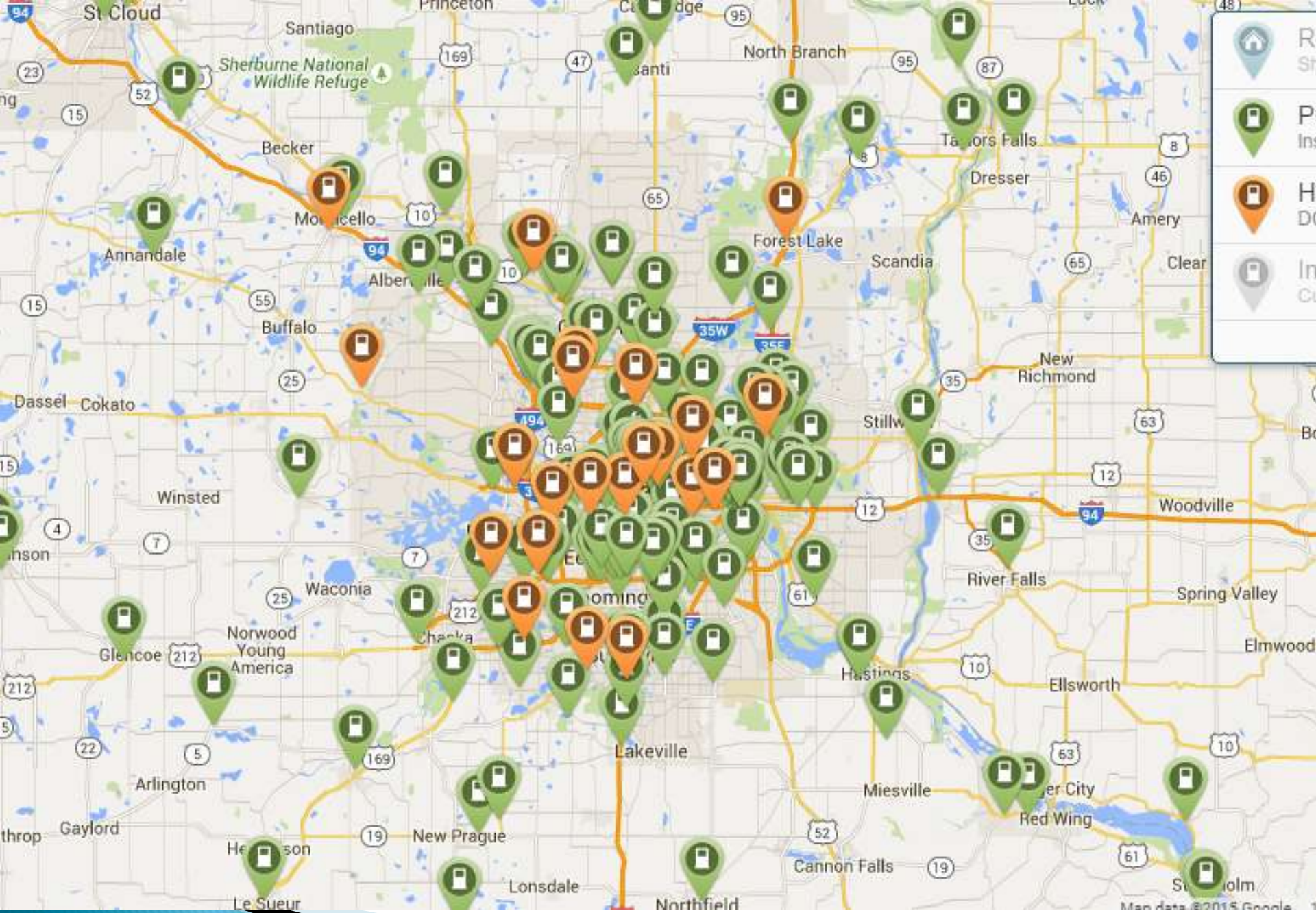
Graph:
Jukka Kukkonen

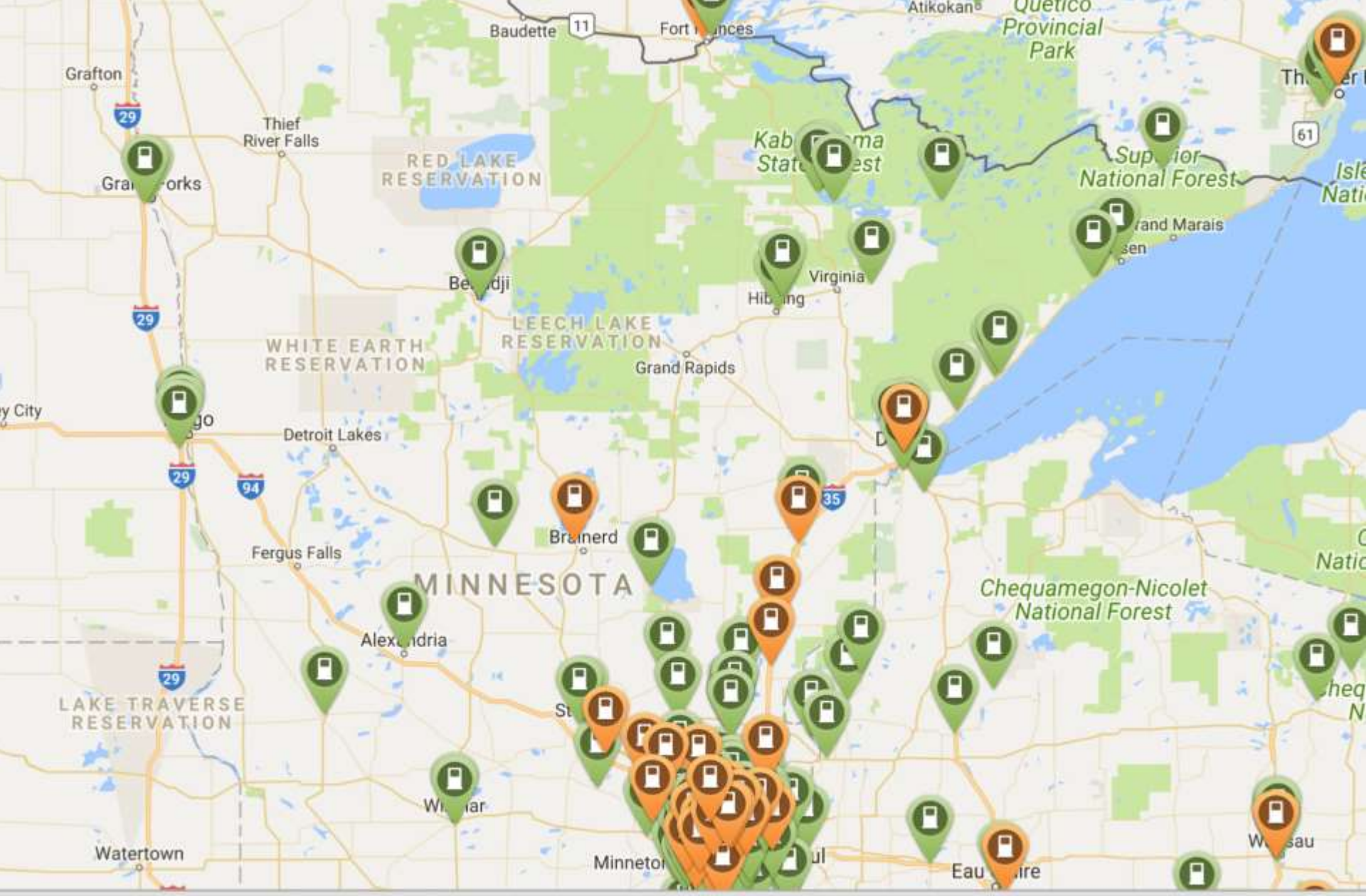
www.PlugInConnect.com



Flexible loads:







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

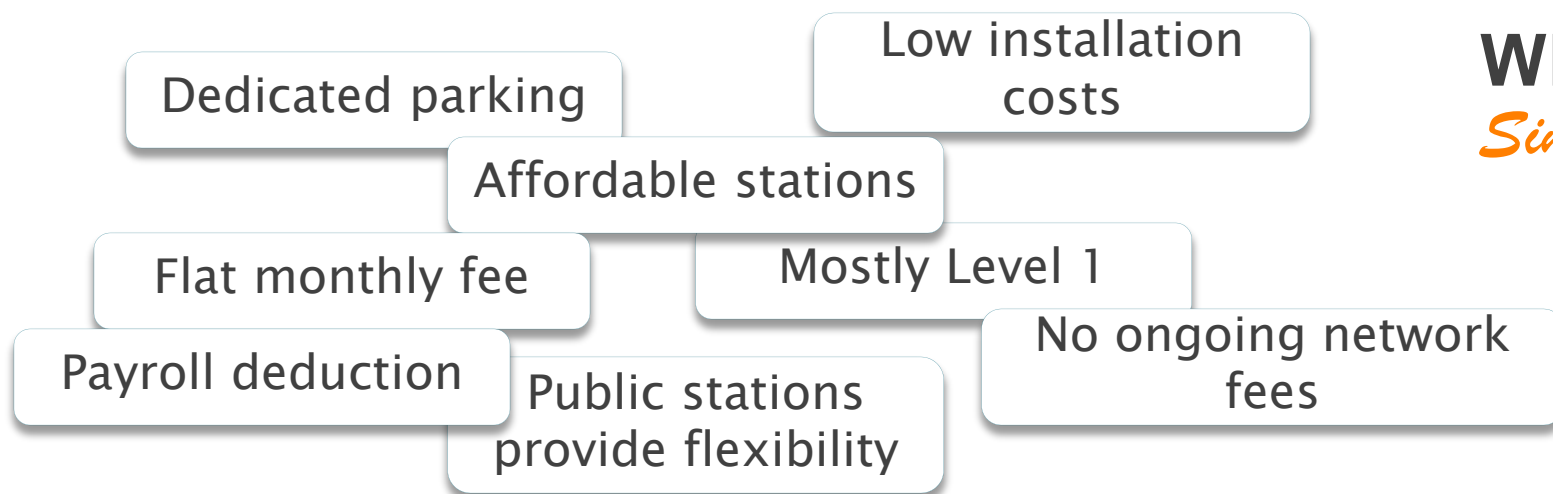
- ▶ Residential buildings
 - 3 % of parking spots
 - 208/240V 40A circuit breaker
 - Conduit that can carry 208/240V 80A wiring
- ▶ Cost estimates:
 - \$53 for single family homes
 - \$110 for multi housing buildings

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.com tools

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, discuss and plan for PEV charging infrastructure. The worksheet does not cover all options or concerns, 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:

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

Metering and payment system for electricity usage

For Level 1 charging:
If the resident will drive an EV (Level 1 charging will require less than a 3000W public, the charge is most likely to be installed in a common area for charging power is less than 1000W. The resident will likely to use the standard energy measurement from the Power and Energy Calculator tool and use a local monthly or quarterly payment schedule based on that. Once a year the resident and management should talk to see if the residents' vehicle usage will have changed or if the residents' availability. If either of both parties has information with relevant future payment info, they should talk with existing residents. More information about that can be found in the Level 1 charging section below.

For Level 2 charging:
Level 2 charging supplies over 3000 watt charging power. It provides more flexibility for the resident and a resident probably higher level of usability in daily energy usage. If the resident's daily energy needs is fairly high, the parties could talk use the worksheet and related tools from the Power and Energy Calculator tool and use a hard monthly/quarterly payment schedule, based on that.

If either a public or private residential with the electric metered level. This should talk with meter level of existing holder. Use page 7 on the Metering and Payment System table below as an existing user option, and the following page to plan pricing and rates. To do this, you need to consider an electricity when it is metered in a public utility, require (EVSE) and metering installation. The electricity cost is a fair way and for you which of the above would be possible on your grounds, and which installation costs would be for different options. Pricing issues are more used by an expert at the meter level.

The parties should also consider the ability to set themselves into a charging station on EVSE and ask if the utility company the space support to resources available to assist in the process. The parties should also explore the time-of-day option. If available, and agree on how the resident will set up for charging time to take advantage of the lower off-peak rates.

This worksheet was developed as part of the Metering and Payment System Worksheet tool developed by the U.S. Department of Energy, Idaho Falls, Idaho, August 2013. For more information visit www.MultiHousingCharging.com.

Multi Housing Charging.com tools

Power and Energy Calculator tool

The resident will have a standard parking spot in their existing space. Many power distribution and safety rules in existing systems and installation planning, because of the new equipment loads to be installed, needs to be considered by the existing system designer for the electrical service. Or the user, the resident or management team will talk about the existing situation and determine if there is an option to install a dedicated charging spot which through to the electrical service designer information to meet a level 2 charging.

Does the resident have a dedicated parking spot that is used to be electric use?
If there is a new or existing spot, please specify the location:
Do the electrical services meet the requirements?

Resident and management of the charging station or EVSE:
Level 1 charging:
If the existing electrical service is charging, the existing management will check on the high quality EVSE charging station that can be used for charging for the EV. The resident will also have to consider charging for the charging.

Level 2 charging:
If the existing electrical service is charging, the existing management will check on the high quality EVSE charging station that can be used for charging for the EV. The resident will also have to consider charging for the charging.

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Multi Housing Charging.com tools

Metering and Payment System table

This table is designed to help plug-in electric (PEV) vehicles and multi housing property management calculate, discuss and plan for PEV charging infrastructure. The table is not intended to be a comprehensive table, but rather a starting point.

How can PEV's use and other users benefit from the metering system?
There are several options for metering in a public utility. The metering system will be installed in a common area for charging power is less than 1000W. The resident will likely to use the standard energy measurement from the Power and Energy Calculator tool and use a local monthly or quarterly payment schedule based on that. Once a year the resident and management should talk to see if the residents' vehicle usage will have changed or if the residents' availability. If either of both parties has information with relevant future payment info, they should talk with existing residents. More information about that can be found in the Level 1 charging section below.

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The parties should also consider the ability to set themselves into a charging station on EVSE and ask if the utility company the space support to resources available to assist in the process. The parties should also explore the time-of-day option. If available, and agree on how the resident will set up for charging time to take advantage of the lower off-peak rates.

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Metering and Payment Systems Table

Power and Energy Calculator tool

Multi Housing Charging.com tools

Metering and Payment Systems table

| Description | Who does billing | Charging events payment | Common utility metering rules | Installation needs | Active ongoing costs | How the metering works | Risks | Comments |
|---|------------------|-------------------------|-------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| 1. Metering in a common area for charging | Utility | Monthly | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules |
| 2. Metering in a common area for charging | Utility | Monthly | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules |
| 3. Metering in a common area for charging | Utility | Monthly | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules |
| 4. Metering in a common area for charging | Utility | Monthly | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules |
| 5. Metering in a common area for charging | Utility | Monthly | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules |
| 6. Metering in a common area for charging | Utility | Monthly | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules |
| 7. Metering in a common area for charging | Utility | Monthly | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules |
| 8. Metering in a common area for charging | Utility | Monthly | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules | Standard metering rules |

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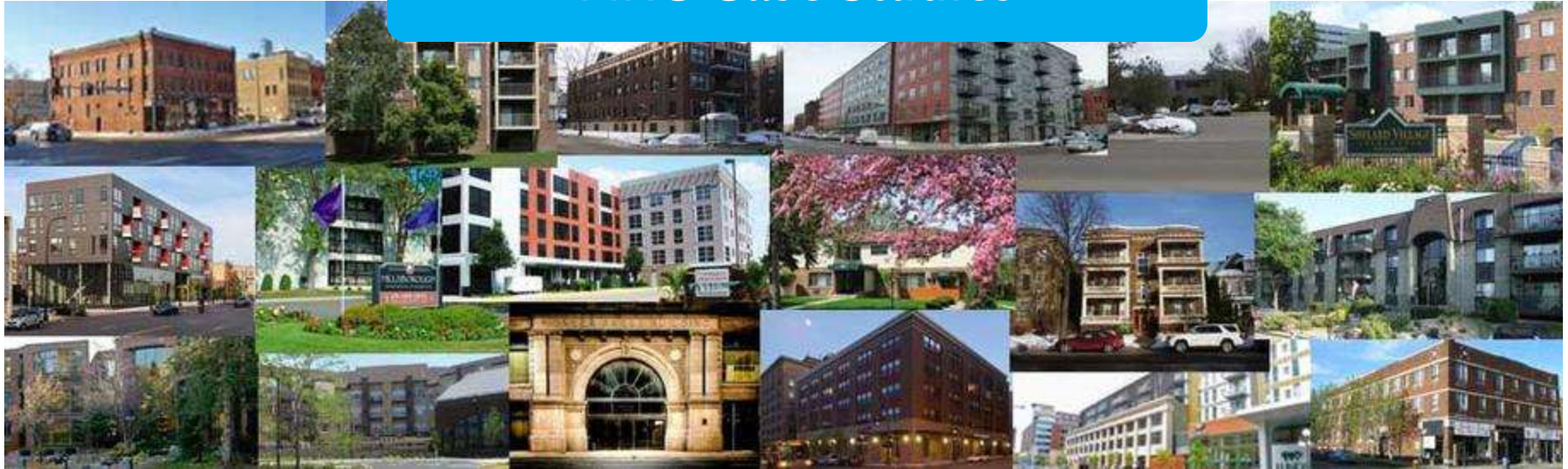
Metering and Payment Systems table

| | 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 |

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