Planning for Electric Vehicle Infrastructure

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GE Energy September 9 , 2011

Overview

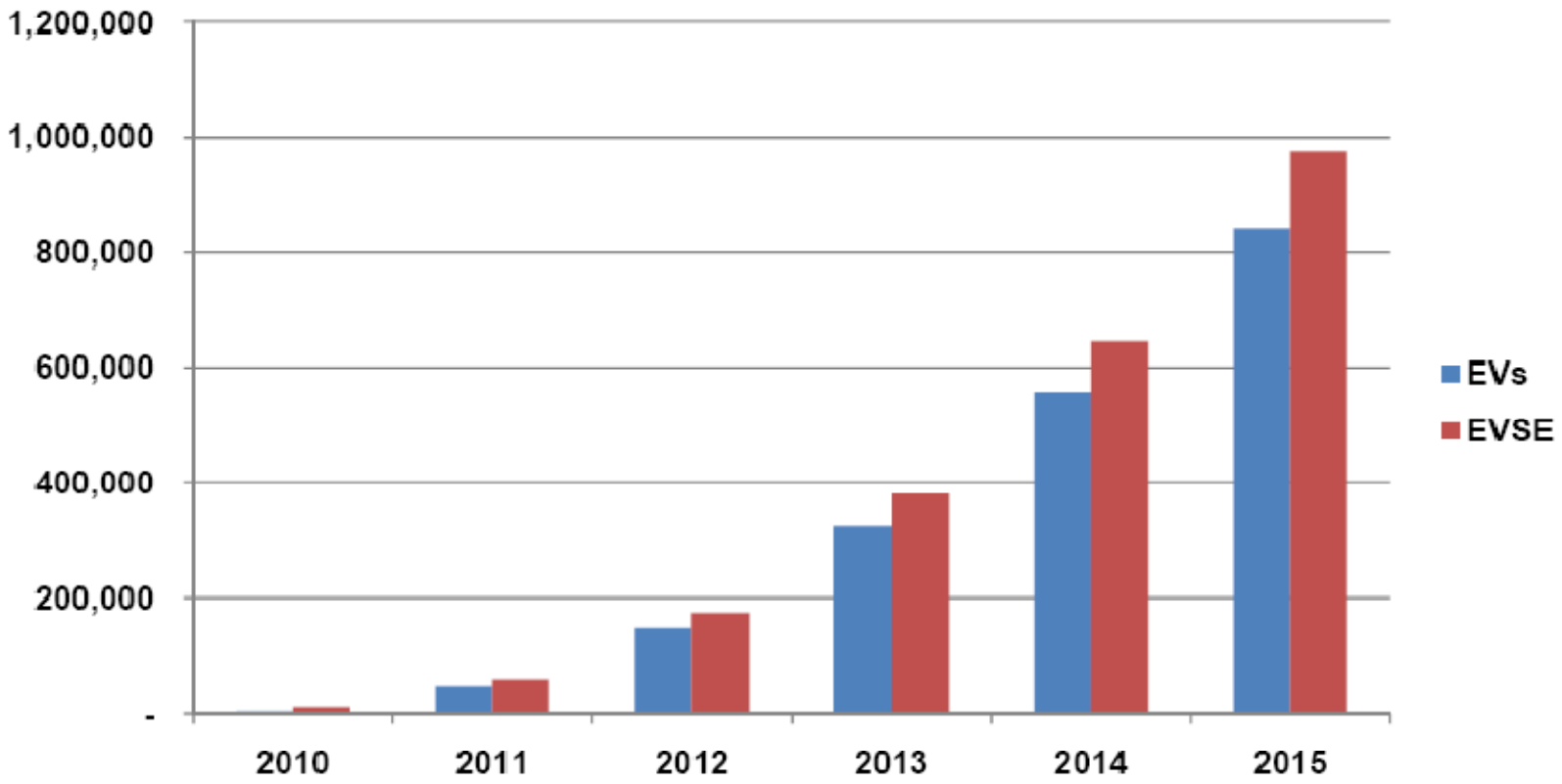
- Key Drivers for Electric Vehicle (EV) Growth
- EV Types and EV Supply Equipment Technologies
- Smart Grid Integration
- Power Distribution System Impact Considerations
- Codes and Standards
- Charging Locations and Scenarios
- Vehicle Charging Considerations
- Future Trends

Key Drivers for EV Growth

- Government Funding and Incentives
  - American Recovery and Reinvestment Act (ARRA) Funding
  - Fuel Efficient Vehicles Tax Incentives for Consumers
  - President Obama called for putting 1 Million EVs on the road by 20
- Auto Manufacturer Activity
  - Auto Manufacturer Incentives - $8B loans for Advanced Vehicle Technologies
  - Production capacity of EV models has ramped to meet 1 Million EVs by 2015
- Environmental Concerns
  - Electric Vehicles (EV) currently produce 2/3 fewer greenhouse g emissions than internal combustion engine (ICE) cars

- Cost of Oil/Gasoline/Petroleum
  - EVs operate at 1/3 the cost per mile of ICE cars
- Battery Technologies
  - Reduced costs
  - Increased power densities

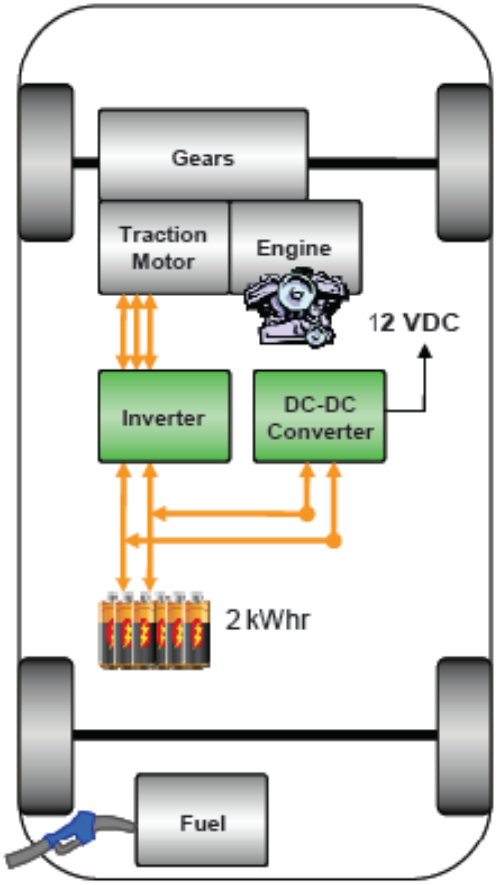
EVs and Charging Stations US: 2010-2015



For every EV sold, we expect there will be 1.5 charging stations

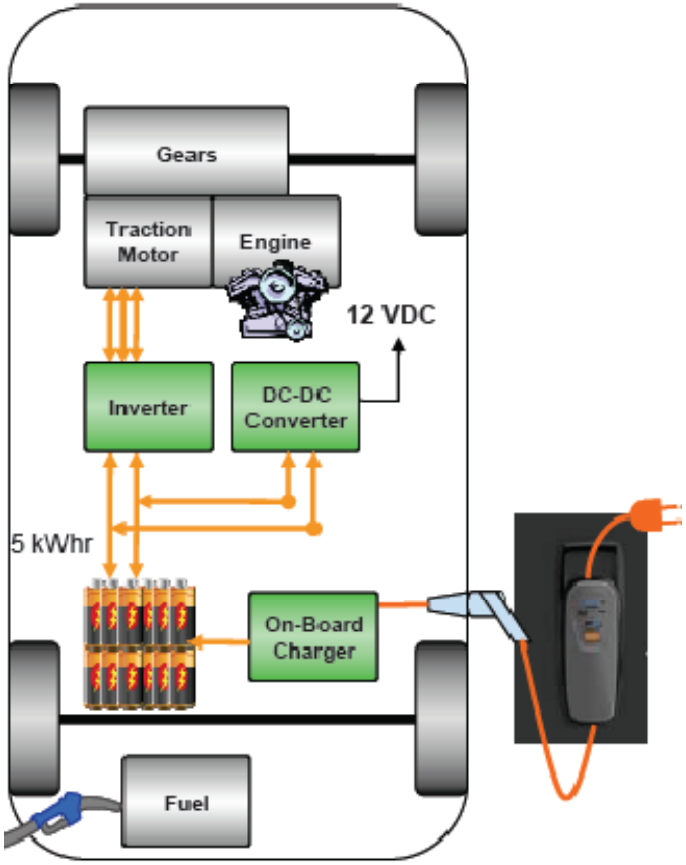
Source: Pike Research

EV Types



Hybrid Electric Vehicles (HEV)

HEVs are powered by conventional or alternative fuels as well as electric power stored in a battery. The battery is charged through regenerative braking and the internal combustion engine.

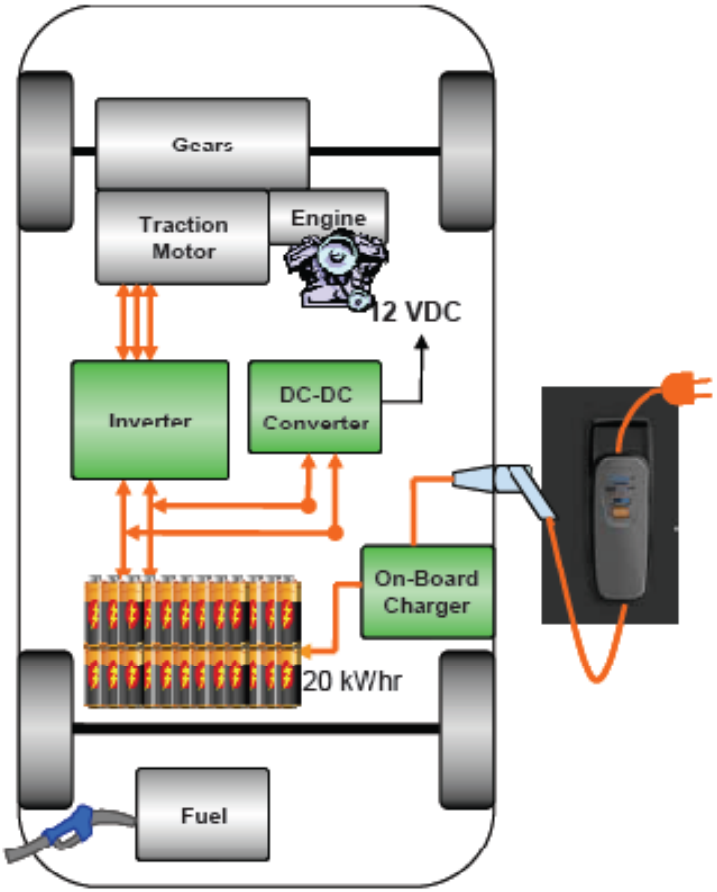


Plug-In Hybrid Electric Vehicles (PHEV)

PHEVs are powered by conventional or alternative fuels as well as electric power stored in a battery. The vehicle can be plugged into an electric power source to charge the battery.

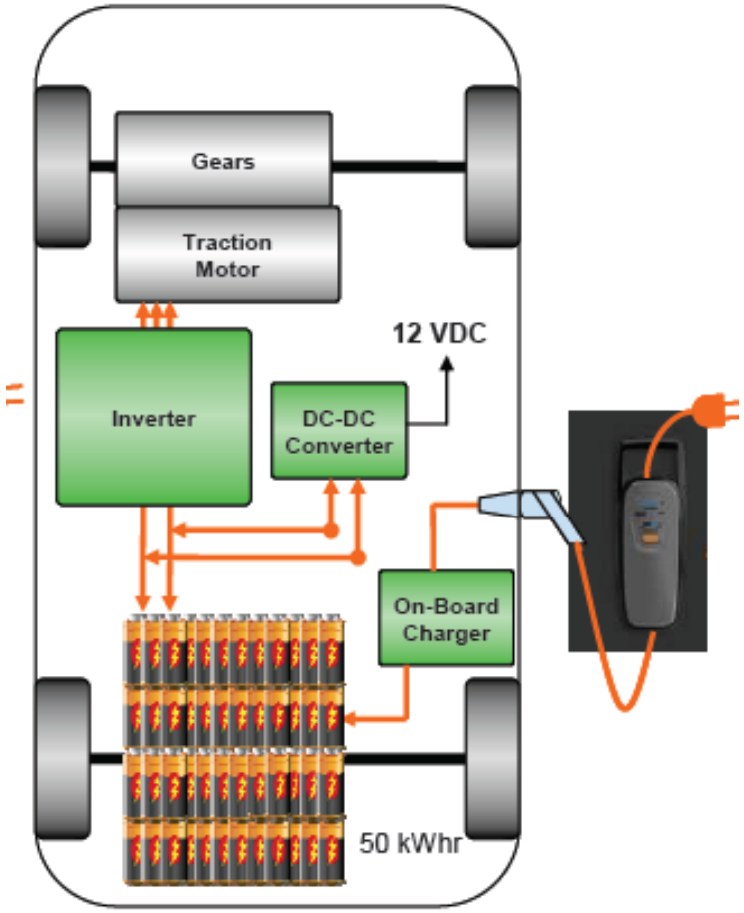
Source: Diagrams by Lear Corporation, BPI Conference 2010

EV Types



Extended Range Electric Vehicles (EREV)

Same as PHEVs with larger battery pack



Battery Electric Vehicle (BEV)

EVs use a battery to store the electric energy that powers the motor. EV batteries are charged by plugging the vehicle into an electric power source. EVs are sometimes referred to as battery electric vehicles (BEVs).

Source: Diagrams by Lear Corporation, BPI Conference 2010

Battery Pack in EVs

- Battery size (capacity) measured in kilowatt hours (kWh)
- Lithium-ion Battery
  - Common in consumer electronics
  - Installed in most new PHEVs and BEVs
  - Good high temperature performance
  - Best in energy density
  - High power to weight ratio
  - Low self-discharge

EV Types

HEV
BEV

Toyota Prius

PHEV/EREV

Chevrolet Volt
Battery:16 kWh lithium-ion
Charge Time: 10 hrs (120V)
4 hrs (240V)
Electric Range: 25 – 50 miles
Gas Tank: 9.3 gals

Nissan Leaf
Battery: 24 kWh lithium-ion
Charge Time: 20 hrs (120 V)
8 hrs (240 V)
Electric Range: 62-138 miles,
Gas Tank: N/A

Auto Manufacturer Activity

2010		2011		2012		2013		2014	
BYD e6	EV	Aptera	PHEV	Fisker	PHEV	Ford Sedan	PHEV	Ferrari Hybrid	PHEV
Chery S18	EV	Aptera	EV	BMW MegaCity	EV	Volkswagen E-UP	EV		
Chevy Volt	PHEV	BMW Active E	EV	Chrysler 200c	EV	Volkswagen Golf	PHEV		
Coda Automotive	EV	Ford Focus EV	EV	Chrysler Town	PHEV	Volkswagen Jetta	PHEV		
Fisker Karma	PHEV	GM Crossover SUV	PHEV	Fiat 500 BEV	EV	Volkswagen Sedan	EV		
Mitsubishi i MiEV	EV	Mercedes BlueZero	PHEV	Ford Escape	PHEV				
Nissan LEAF	EV	Mini-E	EV	Ford Focus	PHEV				
Peugeot Ion	EV	Opel Ampera	PHEV	Geely EK-1	EV				
Pininfarina Blue Car	EV	Renault Fluence ZE	EV	Hyunda PHEV	PHEV				
Reva Sedan	EV	Renault Kangoo ZE	EV	Hyundai i10	EV				
Smart EV	EV	Toyota Prius	PHEV	SAIC	EV				
Tesla Model S	EV			Tesla Model S	EV				
Think City	EV			Volvo V-70	PHEV				
				VW Golf VII	PHEV				
				SAIC	PHEV				

Source: Pike Research – EVSE

PHEV: Plugin Hybrid Electric Vehicles

BEV: Battery Electric Vehicles

EV Equipment Supply (EVSE) - Charging Stations

- Supplies electric energy for the charging of batteries in PHEVs and BEVs
- Charging times vary based on:
  - ✓ How depleted the battery is
  - ✓ How much energy the battery holds
  - ✓ Amount of power in kilowatts (kW) provided to the battery

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EVSE Charging Levels

Level 1 - 120V AC Single Phase

- Rated Current: 12, 16 amps
- Rated Power: 1.44, 1.9kW

Level 3 - 480V AC Fast Charger

- Rated Power up to 50 – 60 kW

Level 2 - 240V AC Single Phase

- Rated Current ≤ 80 amps
- Rated Power: ≤ 19.2kW

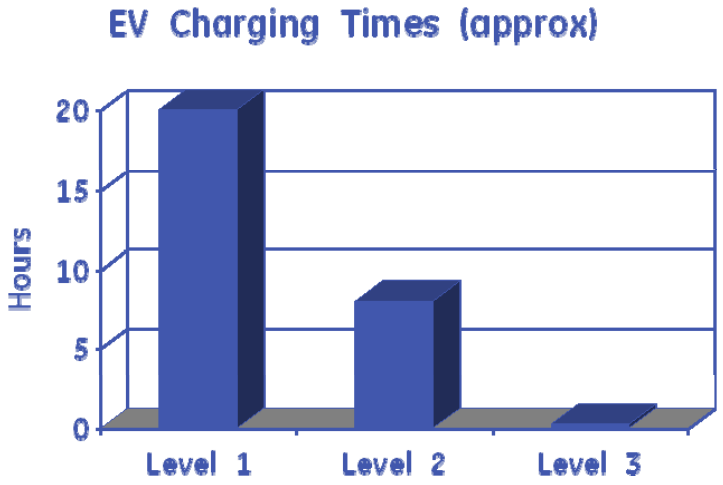
EVSE Charging Levels and Durations

Level Type	Service Level	Application Opportunity	Power (kW)	Charge Duration (hrs)
Level 1	120 V, 15 A	Home	1.4	18
Level 2	240 V, 15 A	Home	3.3	8
Level 2	240 V, 30 A	Home/Public	6.6	4
Level 3	480 V, 167 A	Public/Private	50 – 70	0.3 – 0.8

Example: Nissan Leaf
- **24 kWh battery**
- **100 mile range**

Level 1 = 20 hours
Level 2 = 8 hours
Level 3 = 30 mins

Source: NissanUSA web site



Basic Components of EVSE





Enclosure

- *Charging post*
- *Wall-mounted*
- *Pole-mounted*

Indentification
(RFID)

Cord
And Coupler

Permanently fixed for Level 2

Controller

Zigbee SEP 1.x or HomePlug

Smart Meter
(optional)

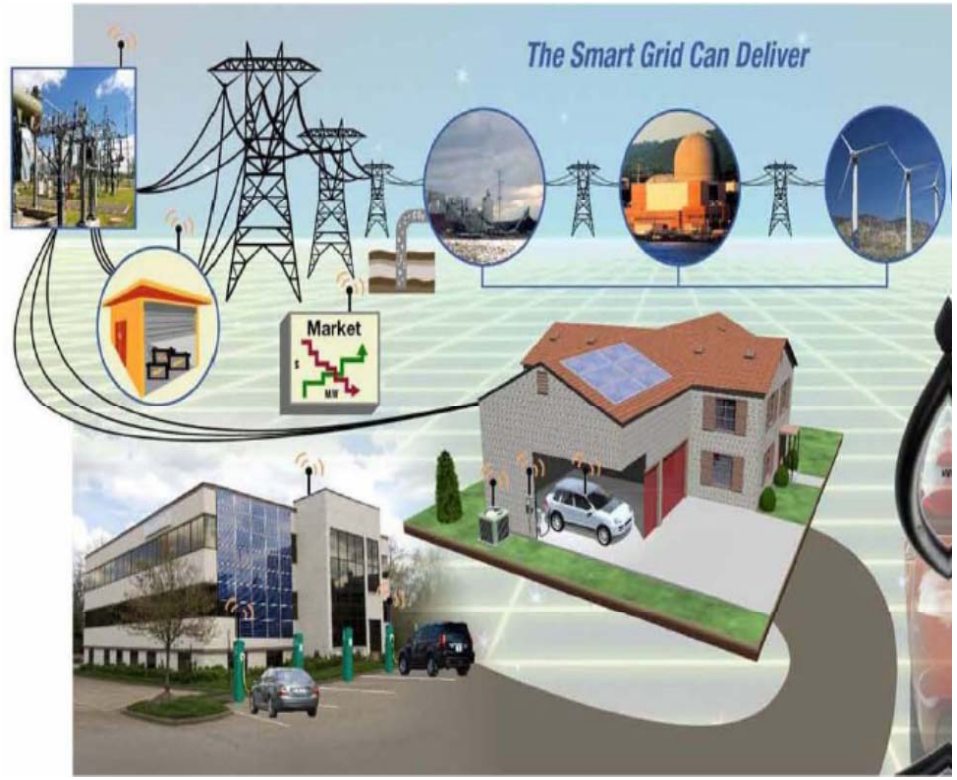
- *Wireless Mesh*
- *Point-to-point*
- *PLC*

Communication

- *IP-Based*
- *WAN (cellular)*

Smart Grid Integration - Smart Charging

- Utilize communication networks to control charging and to indicate EVSE connection to the grid
  - Cellular
  - Internet
  - AMI/Smart Meter
  - Zigbee/HomePlug
  - Wi-Fi

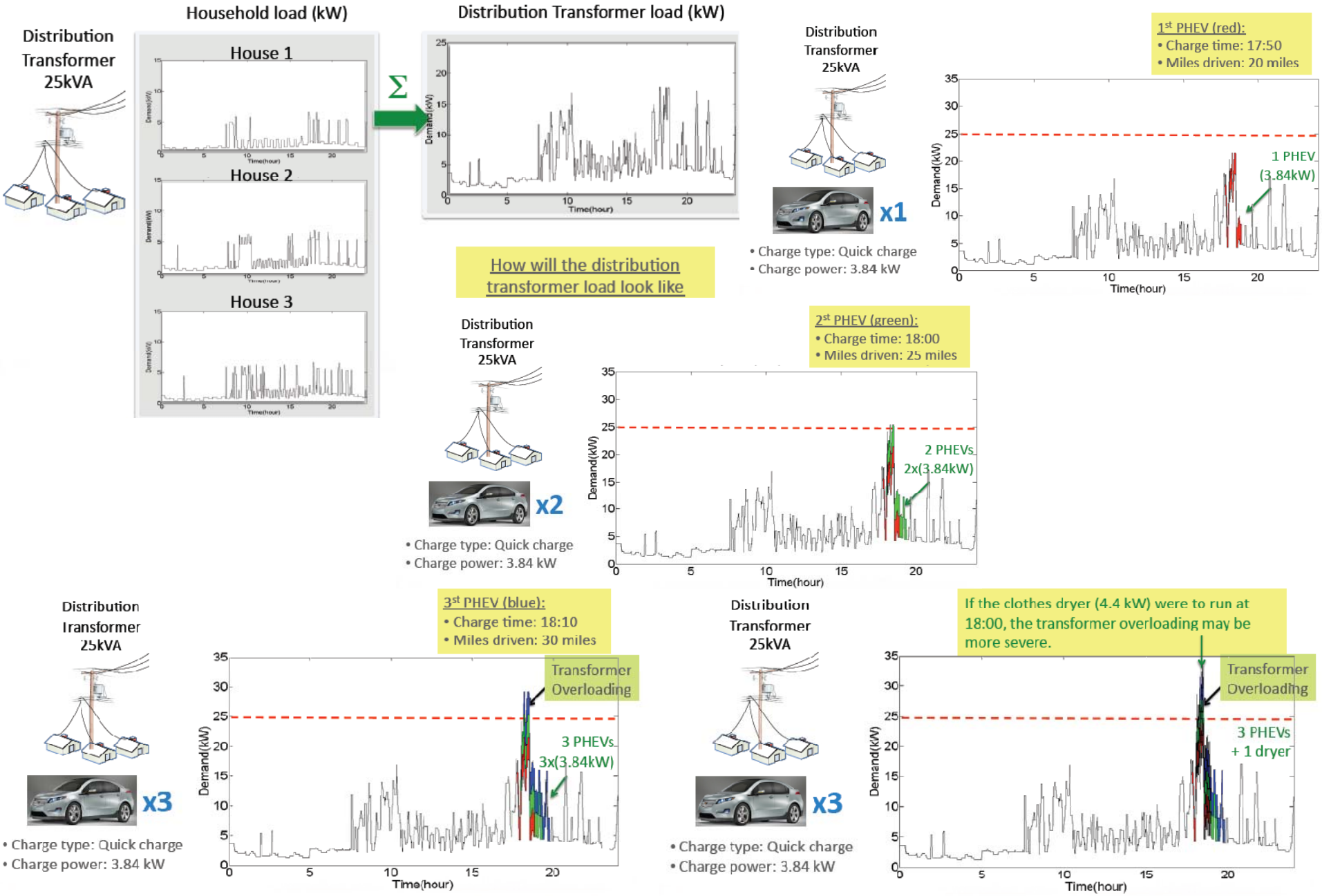


- Utilities will be able to manage vehicle charging to prevent power distribution issues
  - Demand Response
  - Rate Structures

Impact of PEVs on Distribution Systems

- EVs will impact distribution system infrastructure at some location, depending upon:
  - Size, timing, and duration of charging
  - Consumer charging behavior:
    when and where
- Charging EVs will create new peak for transformer load with possible overloading
  - Reducing its operating efficiency
  - Reducing its life

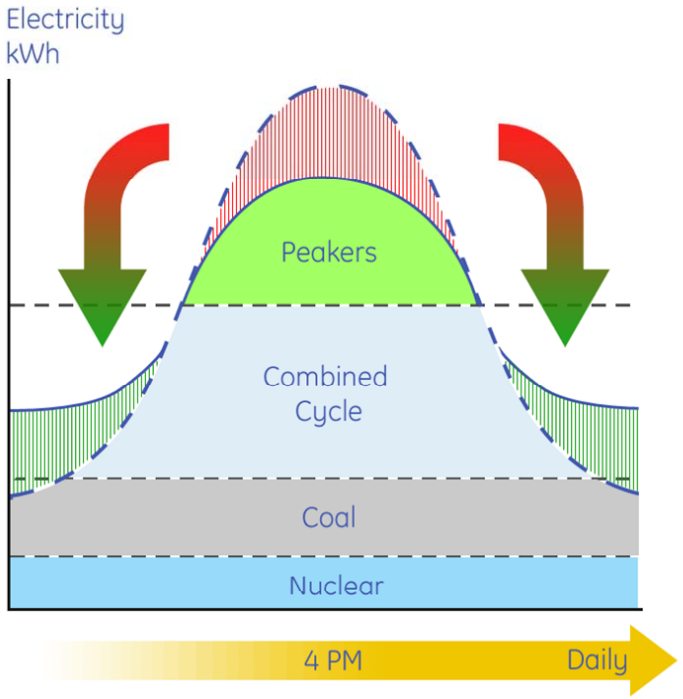
Impact of PEV Charging on Residential Load



Source: Saifur Rahman, Advanced Research Institute at Virginia Tech, 2010

Impact of PEVs on Distribution Systems

- Demand Response can potentially mitigate any infrastructure impacts of PHEVs:
  - Rates structures: TOU, CPP
  - Direct Control
  - Smart – Charging management system
- Controlled charging can provide a way to defer investments for system upgrades



Codes and Standards

- National Electric Code (US)
  - ✓ Article 625 covers wiring methods, equipment construction, control, protection and EVSE location
- Society of Automotive Engineers (SAE)
  - ✓ SAE J1772: EV Conductive Charger Coupler
  - ✓ SAE J2293: Energy Transfer System for EVs
  - ✓ SAE J2836: Use Cases for Communications between EVs and

    the Power Grid
- Underwriters Laboratories (UL) Standards
  - ✓ UL 2594: Outline for investigation for EVSE
  - ✓ UL 2231:Personnel Protective Devices

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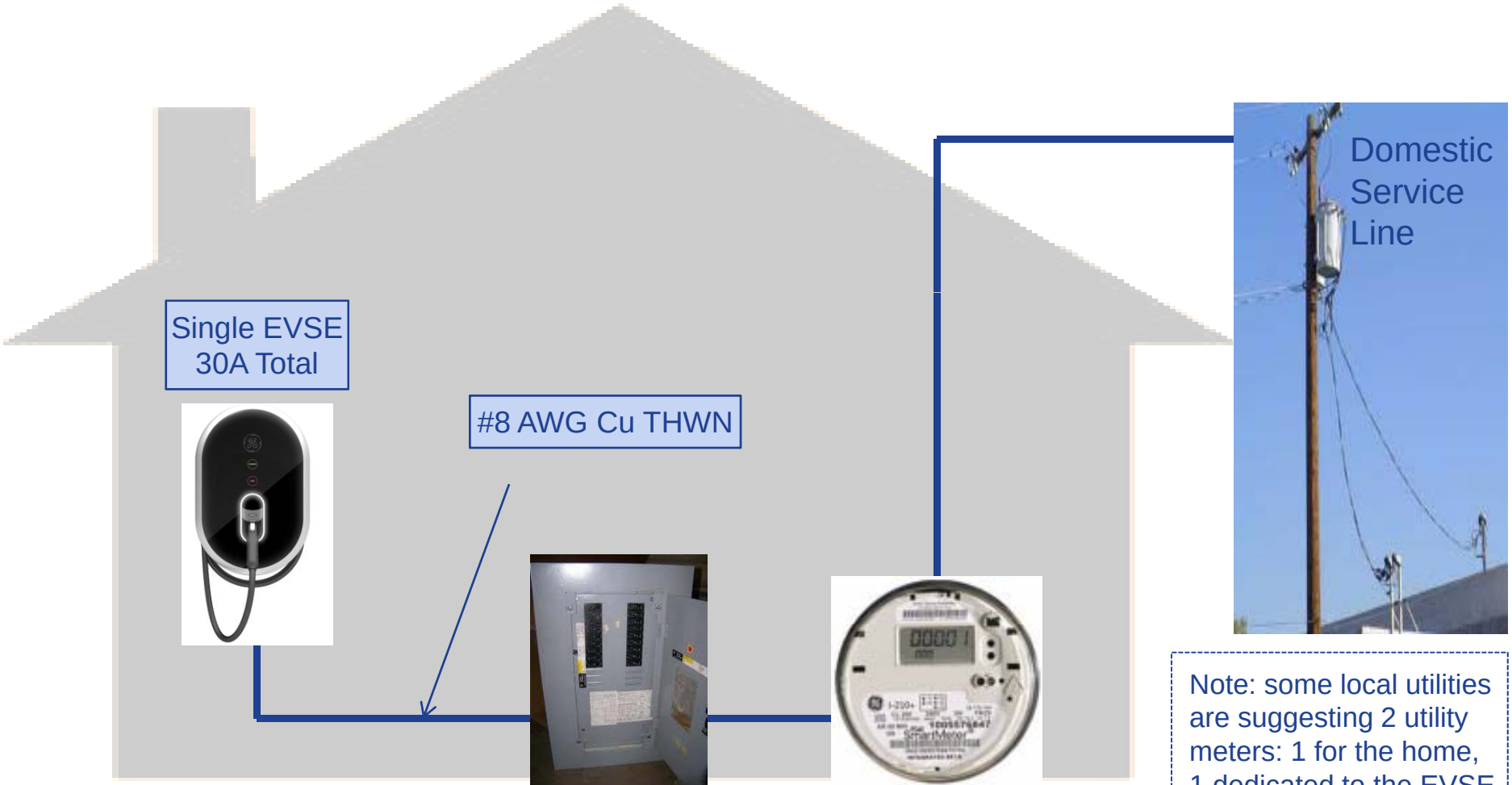
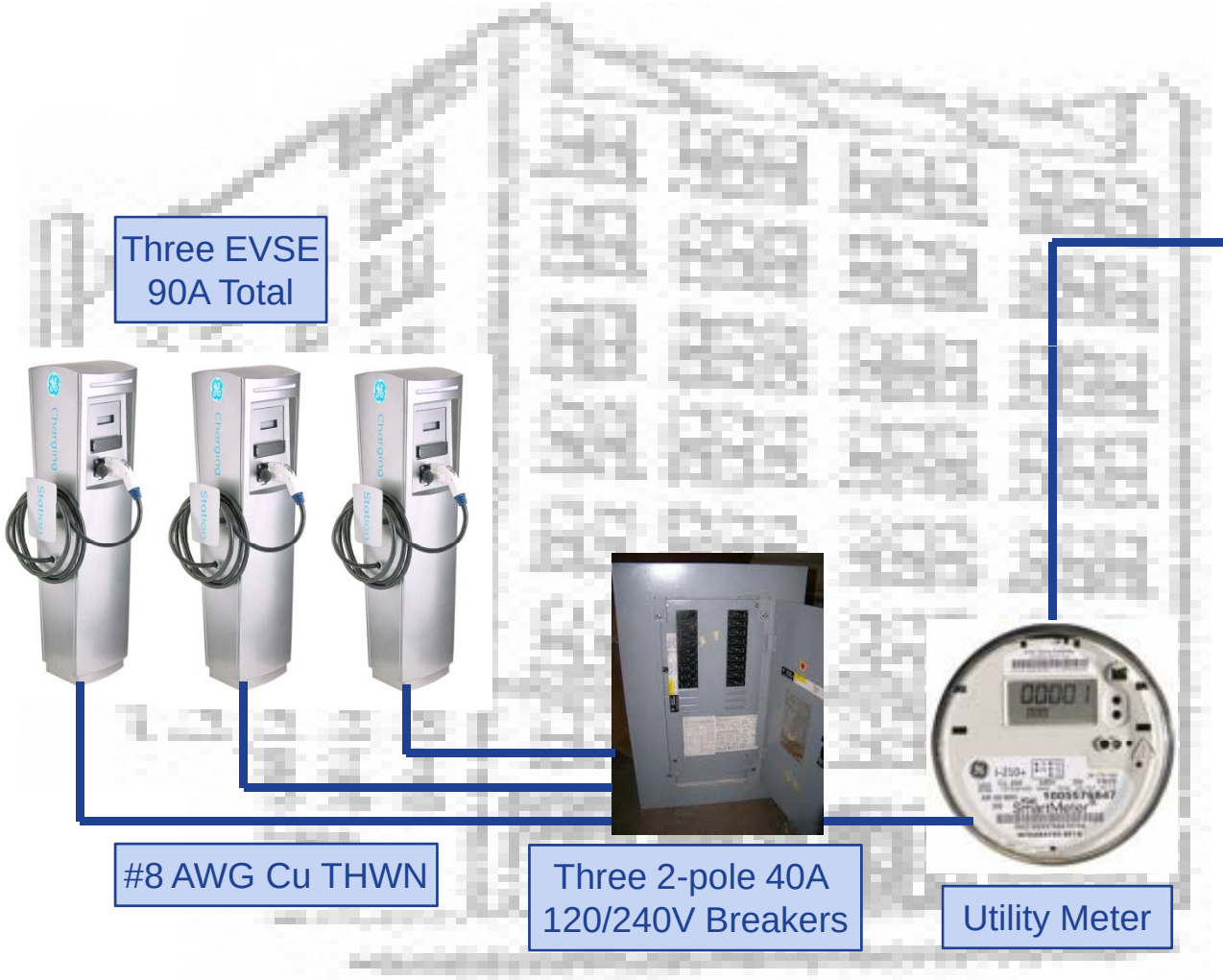
Electrical Example – Residential



Electrical Example – Retail Application



Ensure that capacity of panel board and service are not exceeded.
Select conductor size according to the NEC.

Electrical Example – Hotel

Service Switchboard or Switchgear

Fourteen EVSE 242A Total

SFLA 175AT/250AF

SGDA 350AT/400AF Panel

112.5kVA Dry Transformer

#8 AWG Cu THWN

Fourteen 2-pole 40A 120/208V Breakers

2/0 Cu THWN

Ensure that capacity of panel board and service are not exceeded. Select conductor size according to the NEC.

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Charge Couplers

Coupler assembly (SAE J1772)

- Connector
- Inlet

Coupler pin configuration

- AC Power (L1)
- AC Power (L2)

Up to 80 amps, 240V AC, 19.2kw

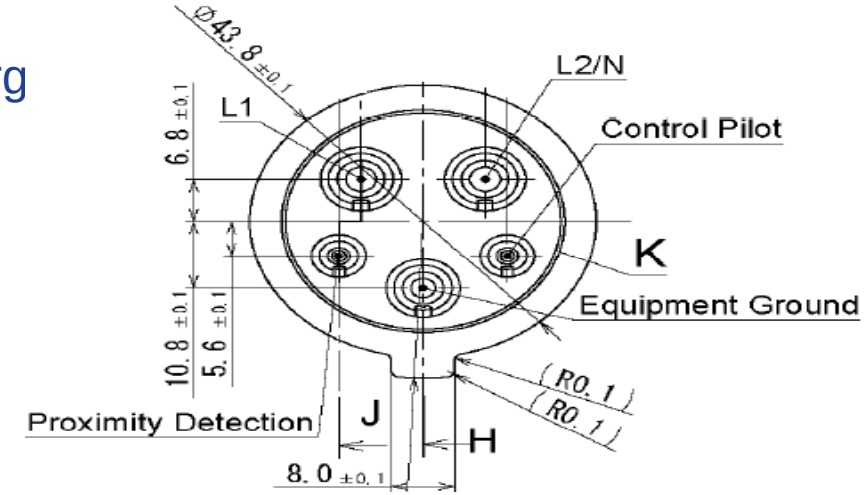
- Equipment ground

Control pilot

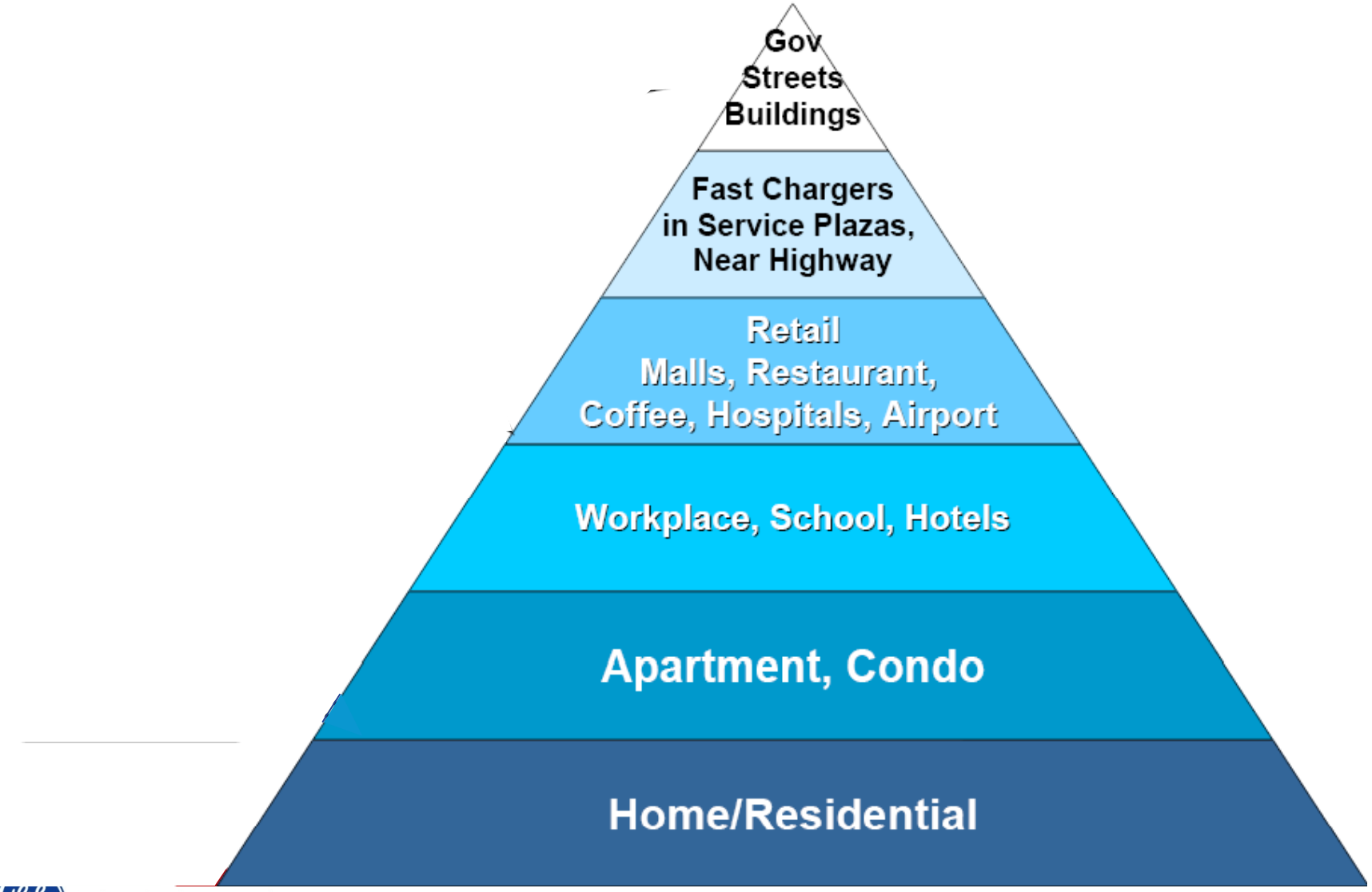
- Verification of vehicle connection
- Supply equipment ready to supply energ
- PEV ready to accept energy
- Ventilation requirements
- Supply equipment current capacity
- Equipment ground present

Proximity Detection

- Indicates to vehicle that plug is present to prevent drive away



Charging Station Locations



Source: Palmer Electric, Winter Park, FL

Charging Scenarios

Infrastructure Deployment Guidelines

- Reference Codes and Standards
  - ✓ NEC, Local building codes, regulatory agencies, permitting
- Charging station characteristic
  - ✓ Level Type, location, quantity
- Utility Integration
  - ✓ Smart Metering, Demand Response, Smart Grid
- Site Planning Considerations
  - ✓ Power Requirements – Transformer, Panelboards
  - ✓ Installation cost vary greatly with distance to power
  - ✓ Communications, Internet
- Charging Applications
  - ✓ Charging Payment Methods

Customer Interface

- Owners to manage their EV Charging
  - Locate closest charging stations
  - Track vehicle charging
  - Schedule EV charging
  - Energy use, cost data, GHG emissions sav
- Point of Sale
  - Fee-based
  - Credit Card transactions
  - EV Charging Network Subscription

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Vehicle Charging Considerations

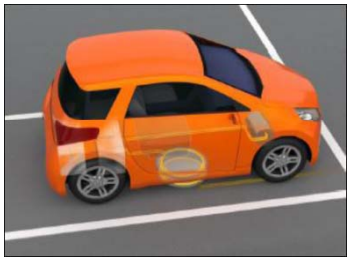
- Range Anxiety
  - Limited driving range with current battery technology
  - Strategic locations of charging stations
- Availability of service technicians to maintain Evs
- Installation Permitting Process
- EV Affordability
  - Battery is the biggest cost of EV/PHEV retail price
  - Battery Life and battery packaging
- Utility and Grid Challenges
  - Managing peak recharging and impact on transformers
  - Smart Grid technology and utility rates structures will alleviate potential stress on the grid

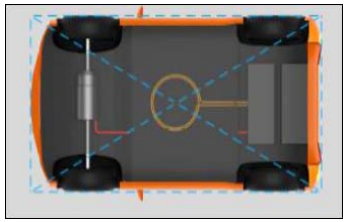
Future to Prepare For…


solar forest parking station

EV Charging by Solar, Wind?

Inductive Charging vs Cord system ?





Electric Vehicles as Batteries Supplying the Grid? (Vehicle-to-Grid)

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Thank You!

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