EV - Smart Grid Integration

March 14, 2012

If Thomas Edison were here today…

Thomas Edison, circa 1910 with his Bailey Electric vehicle.

EVs…by the Numbers

- ✓ **10.6%** of new vehicle sales expected to be electric-drive by 2015 (Deutche Bank, Sep 2011)
- ✓ **Up to 11 million** EVs on the road by 2020, 65 million by 2030 (EPRI, Dec. 2010)
- ✓ **More than 20** electric-drive vehicle types available to consumers by end of 2012 (GoElectricDrive.com)
- ✓ **Nearly 1.5 million** estimated U.S. charging stations installed by 2017 (Pike Research)
- ✓ **$1,400** average annual savings by switching to an electric vehicle, for the average American driving less than 40 miles daily (www.fueleconomy.gov)
- ✓ **Nearly 54,000** U.S. jobs in the electric vehicle industry as of August, 2011 (NRDC, UAW, National Wildlife Federation, 2011)
- ✓ **36%** reduction in GHG emissions from a plug-in hybrid vs. a conventional vehicle (Argonne National Labs)

Courtesy of EDTA

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The Electric Drive Spectrum

HEV: Hybrid Electric Vehicle

- No plug
- Battery charged from engine & regenerative brakes
- Battery and ICE “share the driving work”

PHEV: Plug-In Hybrid Electric Vehicle

- Battery and ICE “share” the work
- Battery charged from plug & regenerative brakes

EREV: Extended Range Electric Vehicle

- Battery and ICE onboard
- All-electric drive. ICE acts as generator
- Battery charged from plug & regenerative brakes

BEV: Battery Electric Vehicle

- All-electric drive
- No ICE
- Battery charged from plug & regenerative brakes

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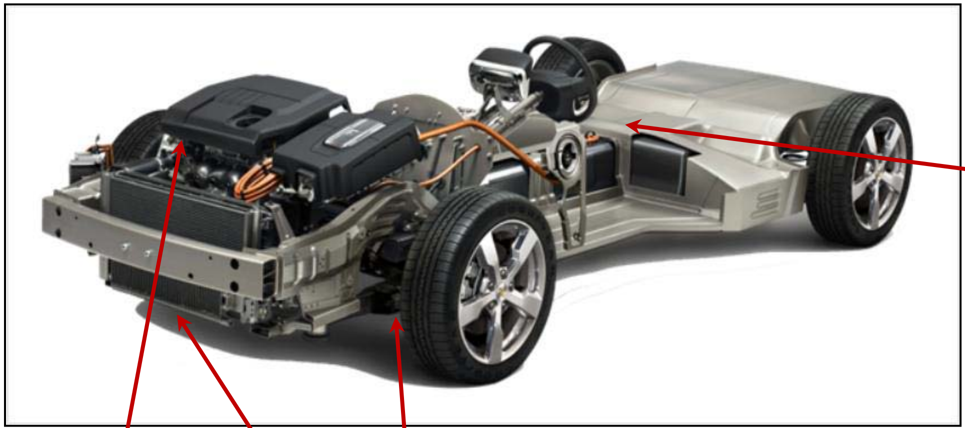
EV Drive Train Comparison

Chevrolet Volt EREV

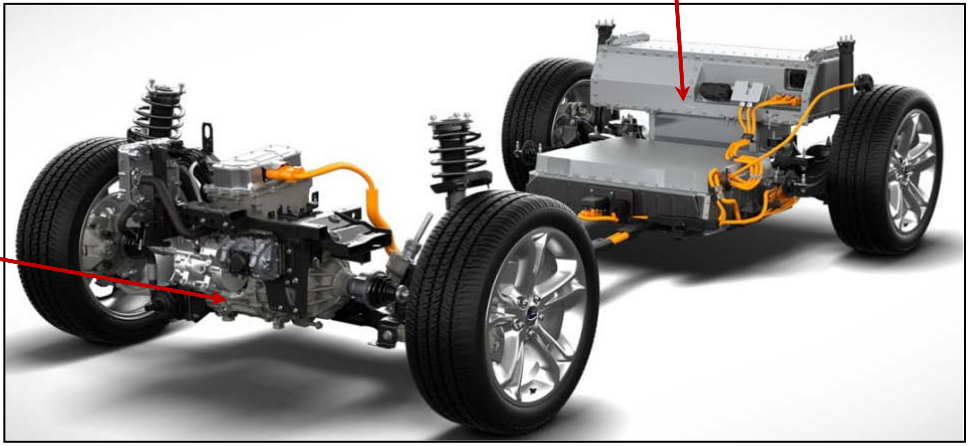


Battery

Range Extender

Electric Motor

Ford Focus BEV



EV Charging Options

- ✓ EVSE: Electric Vehicle Supply Equipment
- ✓ AC Charging:
  - Governed by SAE Recommended Practice J1772
  - Level 1: 120v, up to 1.4kW
  - Level 2: 208/240v, up to 19kW
    - Most vehicles capable of 3kW – 6kW today
  - AC supplied to vehicle, converted onboard
- ✓ DC Charging:
  - 440v DC and up, 55kW or higher
  - Only ChAdEMO standard exists today
    - Minimal vehicle capability
  - SAE standard expected in summer of 2012
  - Concerns with battery life impacts

J1772 Level 2 Connector

Proposed J1772 AC / DC Combo Connector





Consumer EV Launches

GM

2011 Chevrolet Volt – 10,000 ($42k)

2012 Volt production up to 45-60k ($40k)

2013 Volt production up to 100k (<$40k)

NISSAN

2011 LEAF Launch – 10,000 ($33k)

10,000 more LEAFs ($35k)

2013 LEAF production up to 100k in U.S.

Ford

Focus Electric Launch – 19 States

C-Max ENERGI PHEV Launch

TESLA

Roadster since 2008 – Over 2,000 sold ($109k)

Model S Launch – 20,000/year ($57k)

Model X Launch ($35k)

TOYOTA

Plug-in Prius Launch – 15 States ($32k)

New RAV4 EV Launch

MITSUBISHI

i Launch ($27k)

BMW MINI

Active E, Mini E Launch - 2012

FISKER

Karma Launch ($100k)

CODA AUTOMOTIVE

CODA Launch ($45k)

All prices are base model MSRPs before federal, state, local, or employer incentives. Leasing options are typically available and competitive (i.e. $350/mo for Volt or LEAF currently).

With many more coming by 2013: SCION, VOLVO, KIA, HONDA, HYUNDAI, smart, BMW i, BMW The Ultimate Driving Machine, Audi, JAGUAR, BYD

2010 2011 2012 2013

Courtesy of EEI

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Commercial (Fleet) EV Launches

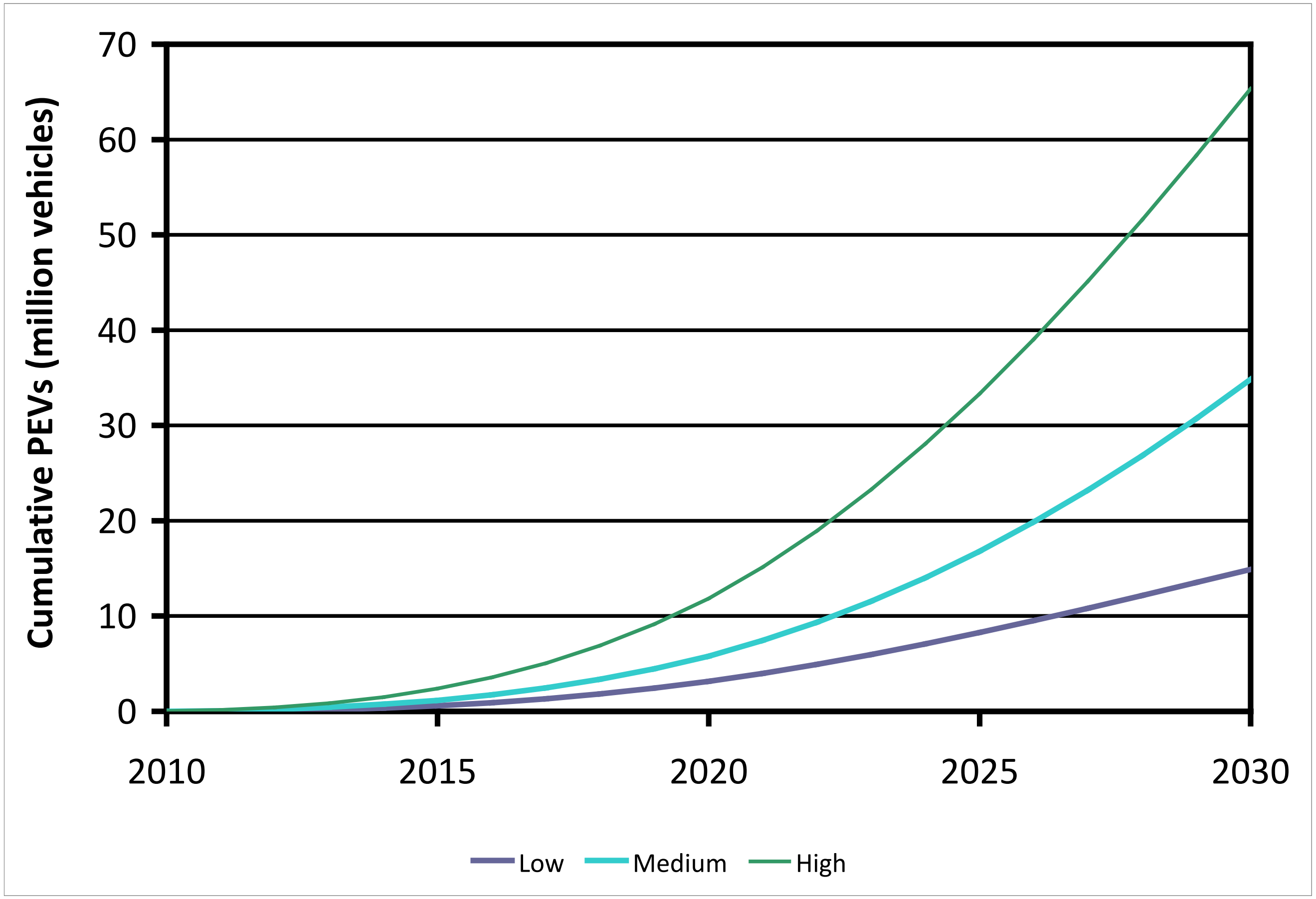
Organizations Already Incorporating These: FedEx, Staples (that was easy), Coca-Cola, pepsi, ups, Department of Defense, General Services Administration, at&t, Frito Lay, duane reade, EEI Edison Electric Institute Member Companies

	2010	2011	2012
Smith Electric Vehicles	Newton BEV Truck Available in many applications		
eStar	Navistar eStar BEV Truck Available		
Odyne	PHEV Med. and Heavy Duty Trucks (including Bucket Trucks) Available		
Ford	Transit Connect Electric Van Available		
VIA	EREV Pickup Trucks Available	EREV SUVs & Vans Coming Soon	
Protean Electric		BEV F150 Conversion Coming Soon	PHEV Applications in the Future
EVI Electric Vehicles International	EREV Bucket Truck and BEV Med. Duty Truck & Delivery Van Available		
Boulder Electric Vehicle	Purpose-built BEV Trucks, Vans, and Shuttles Available		
Freightliner			Enova/Freightliner PHEV Truck Coming Soon

2010 2011 2012 2013

Courtesy of EEI

U.S. EV Adoption Forecasts (vehicles "on the road")



- ✓ 2020: 3.14M to 11.84M EVs (1% to 3.9% of total vehicles)
- ✓ 2030: 14.9M to 65M EVs (4% to 17.7% of total vehicles)

Courtesy of EPRI

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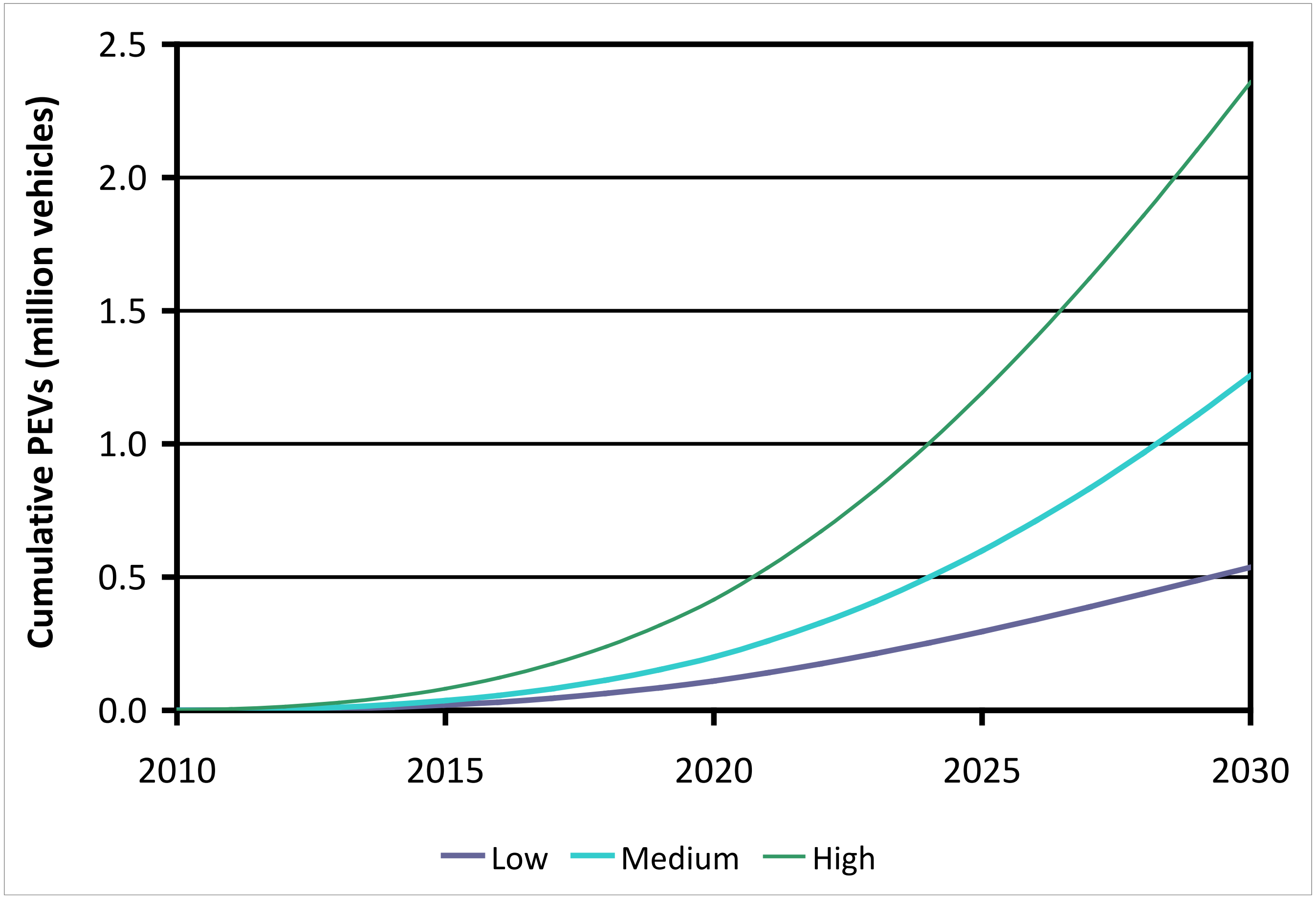
Illinois EV Adoption Forecasts (vehicles "on the road")



- ✓ 2020: 110k to 410k EVs (1% to 3.6% of total vehicles)
- ✓ 2030: 537k to 2.4M EVs (3.9% to 17% of total vehicles)

Courtesy of EPRI

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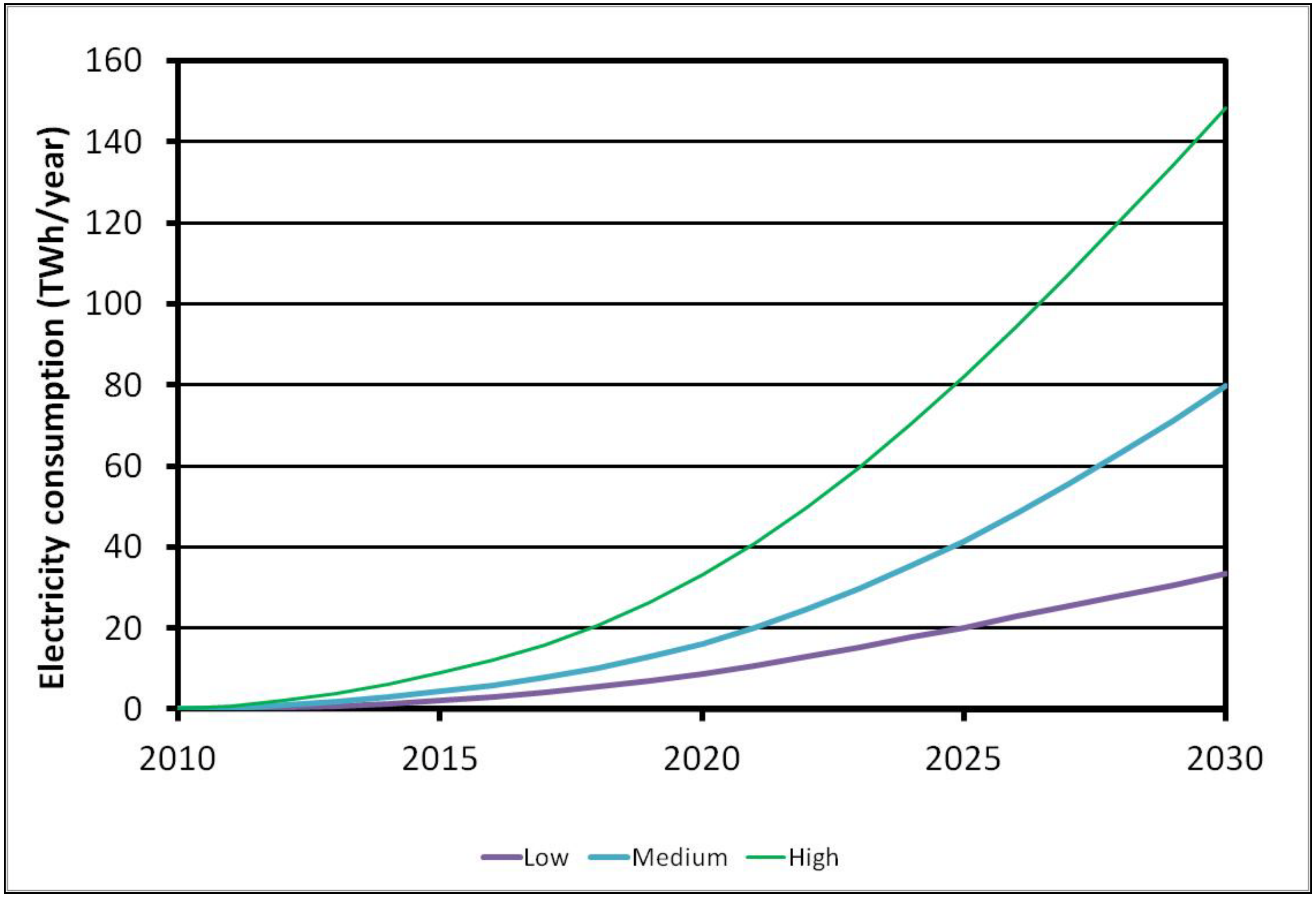
U.S. Annual Electricity Consumption from EVs



- ✓ 2020: 8.8 TWh to 33.3 TWh
- ✓ 2030: 33.1 TWh to 148.4 TWh

Courtesy of EPRI

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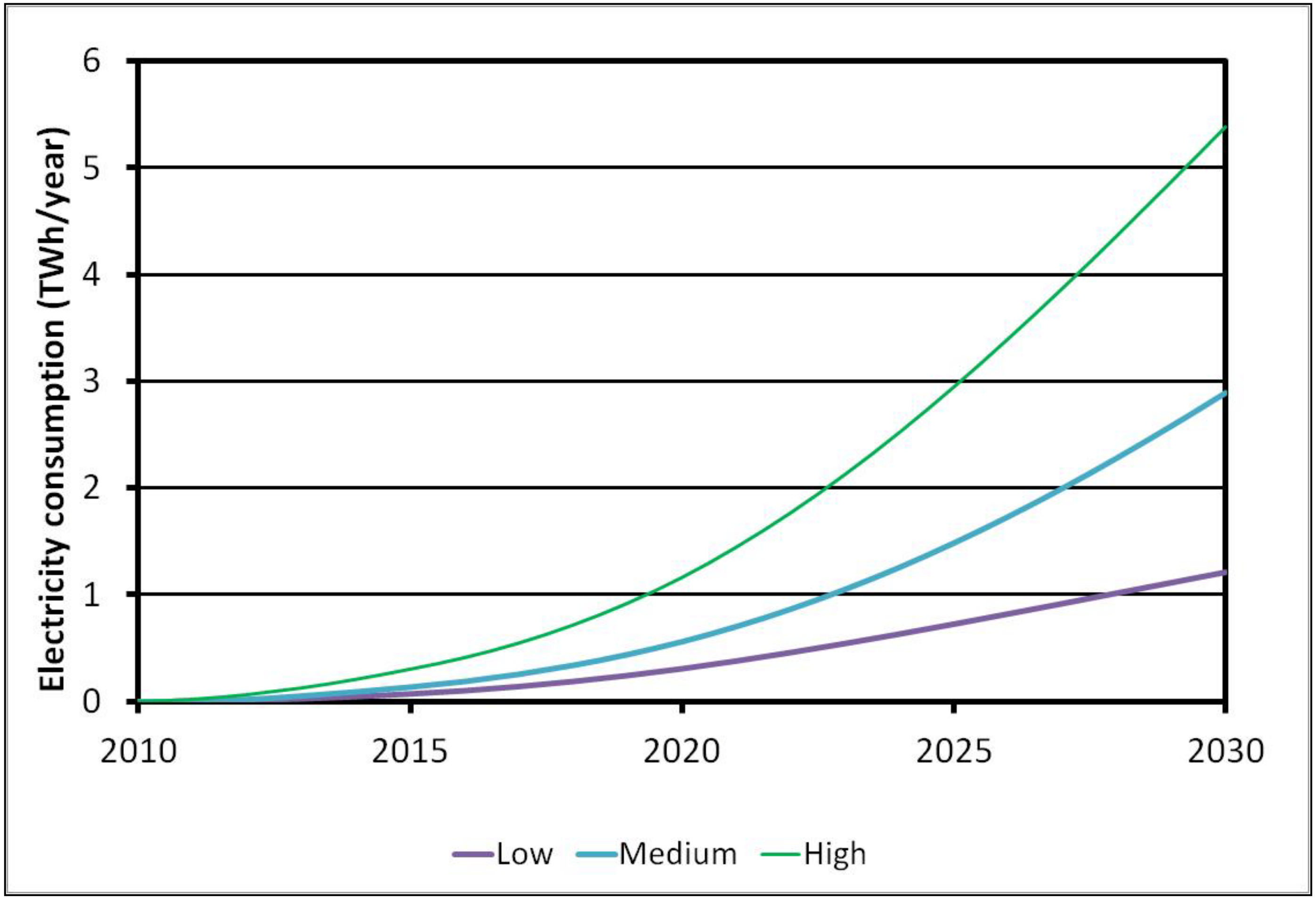
Illinois Annual Electricity Consumption from EVs



- ✓ 2020: 0.3 TWh to 1.2 TWh
- ✓ 2030: 1.2 TWh to 5.4 TWh

Courtesy of EPRI

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So what are we doing about it?

ComEd EV Readiness Focus Areas

Grid Impacts
- Local distribution
- System capacity

Policy
- Legislation
- Advanced rates & metering
- Public charging

Collaboration
- Policy makers
- Municipalities
- Businesses
- Consumers
- Car dealers
- EVSE providers
- Other stakeholders

Customer Experience
- In-home charging
- Workplace and public "Opportunity" charging

Market Research
- Early adopter preferences
- Local adoption rates

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ComEd-EPRI Distribution System Impacts Study

- ✓ Studied two feeders on ComEd's system using actual system data
- ✓ Various EV battery sizes (4kWh – 24kWh)
- ✓ Multiple levels of EV penetration (2% - 30%)
- ✓ Level 1 and Level 2 charging at various times of day, including:
  - Peak
  - Off-peak
  - Diversified
- ✓ Analyzed impacts on various distribution system components
- ✓ Incorporated identified PEV and consumer charging characteristics

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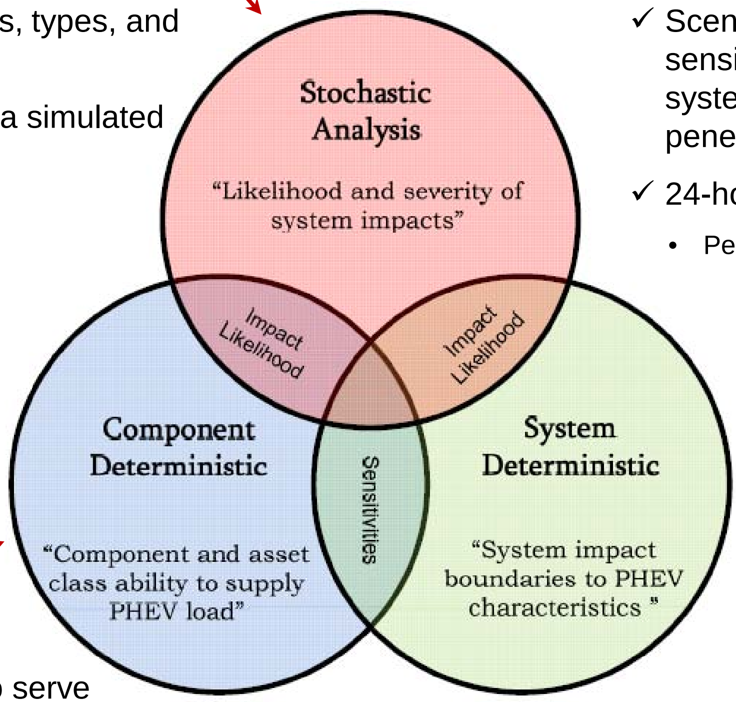
Analysis Methodology

Stochastic Analysis

- ✓ Assess likely impacts of PEV charging load, on the circuit considering both spatial and temporal diversity
- ✓ Randomly assigned PEV locations, types, and charge profiles
- ✓ Multiple test cases modeled over a simulated year

System Deterministic

- ✓ Identifies the system response to forced system-wide PEV penetration/charging scenarios
- ✓ Scenarios are designed to show system sensitivity to PEV characteristics in addition to system impact boundaries under increasing penetration
- ✓ 24-hour peak-day simulations
  - Penetration levels, charging levels, time of day



Component Deterministic

- ✓ Identifies the available capacity to serve additional load for each circuit component
- ✓ The available capacity is the difference between the thermal rating and peak load
- ✓ Available capacity for each element is normalized based on number of customers served

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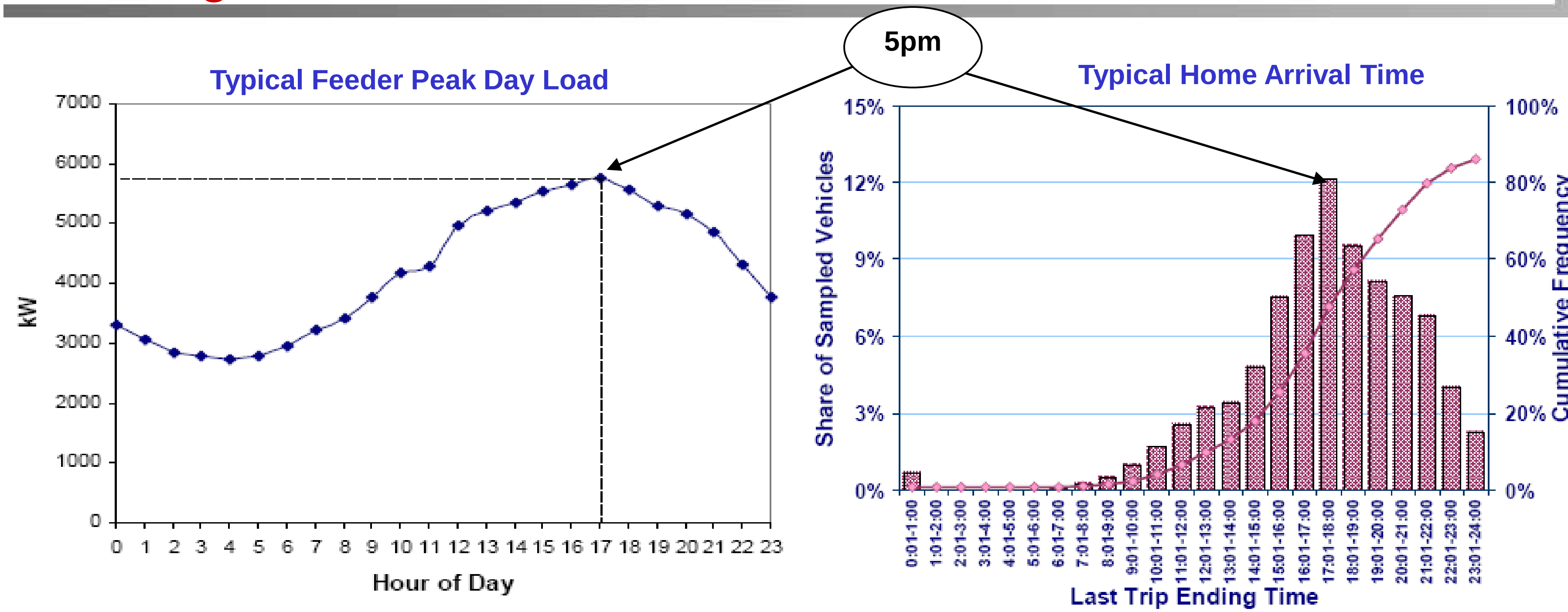
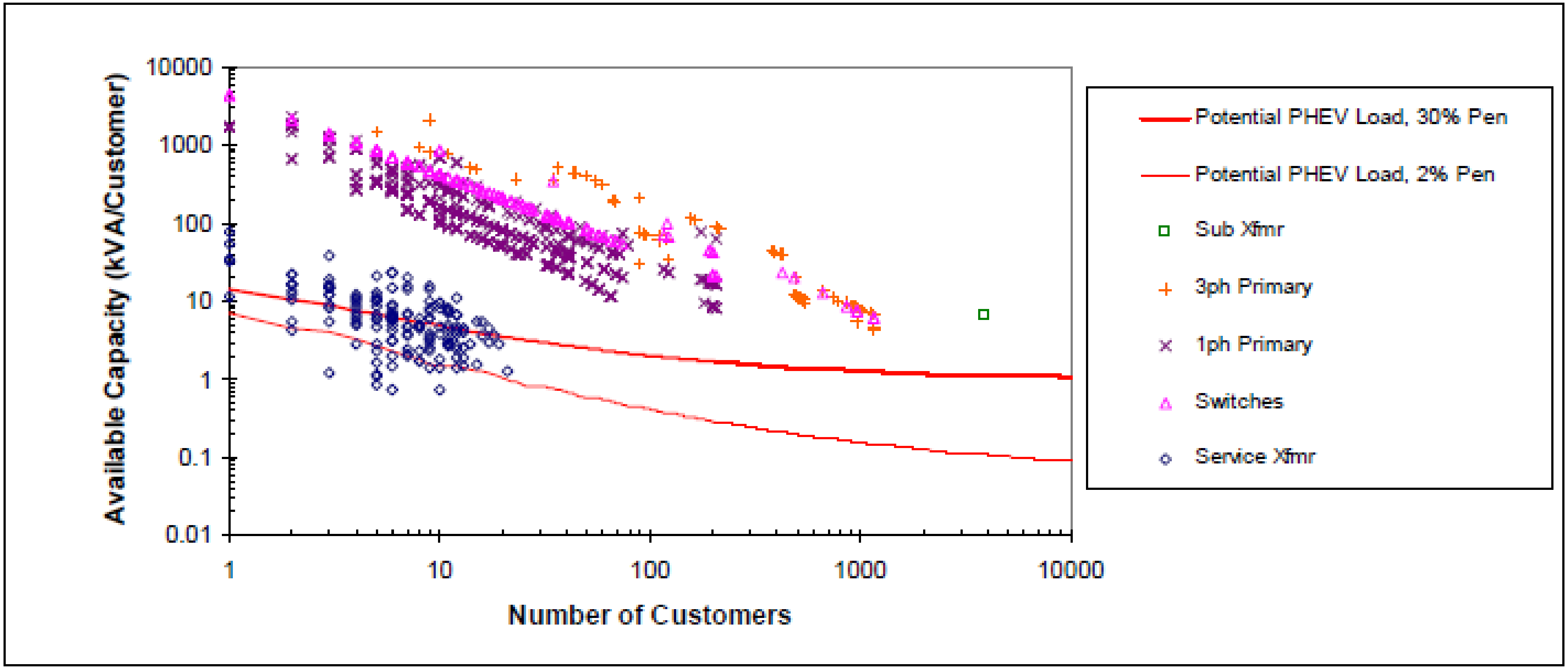
Findings



- ✓ Local distribution equipment is most vulnerable, particularly at high penetration
  - 240v, 30A (Level 2) charging at system peak, at higher penetration levels (30%)
- ✓ Impacts from 120v (Level 1) charging are negligible
- ✓ Clustered adoption increases potential for local impacts

Thermal Impacts Analysis



Peak Hour Available capacity for each asset at 240v, 30A EV charging load and 30% penetration

- ✓ Assets with fewer customers are more susceptible
  - As number of customers increases, so does spatial diversity of EV charging
- ✓ Substation transformers and primary conductors are more likely to have ample capacity, even at higher penetration levels

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ComEd's Foundational Principles of EV Integration

- ✓ Utility must be notified of Level 2 or greater EV charging before it is installed.
- ✓ Time-variable rates for EV charging provide significant benefits to customers and the grid
  - Such rates should be applied to the whole house
  - Separate metering and rates for EV charging are not necessary
- ✓ EV charging equipment should be the integration point between the EV and the grid - not the vehicle
- ✓ EV charging equipment must be "smart"
  - Capable of two-way communications with the grid
- ✓ ComEd's Smart Grid will enable greater EV benefits
  - Real-time information for both consumers and ComEd
  - More control over electricity use and costs
  - Improved grid load management

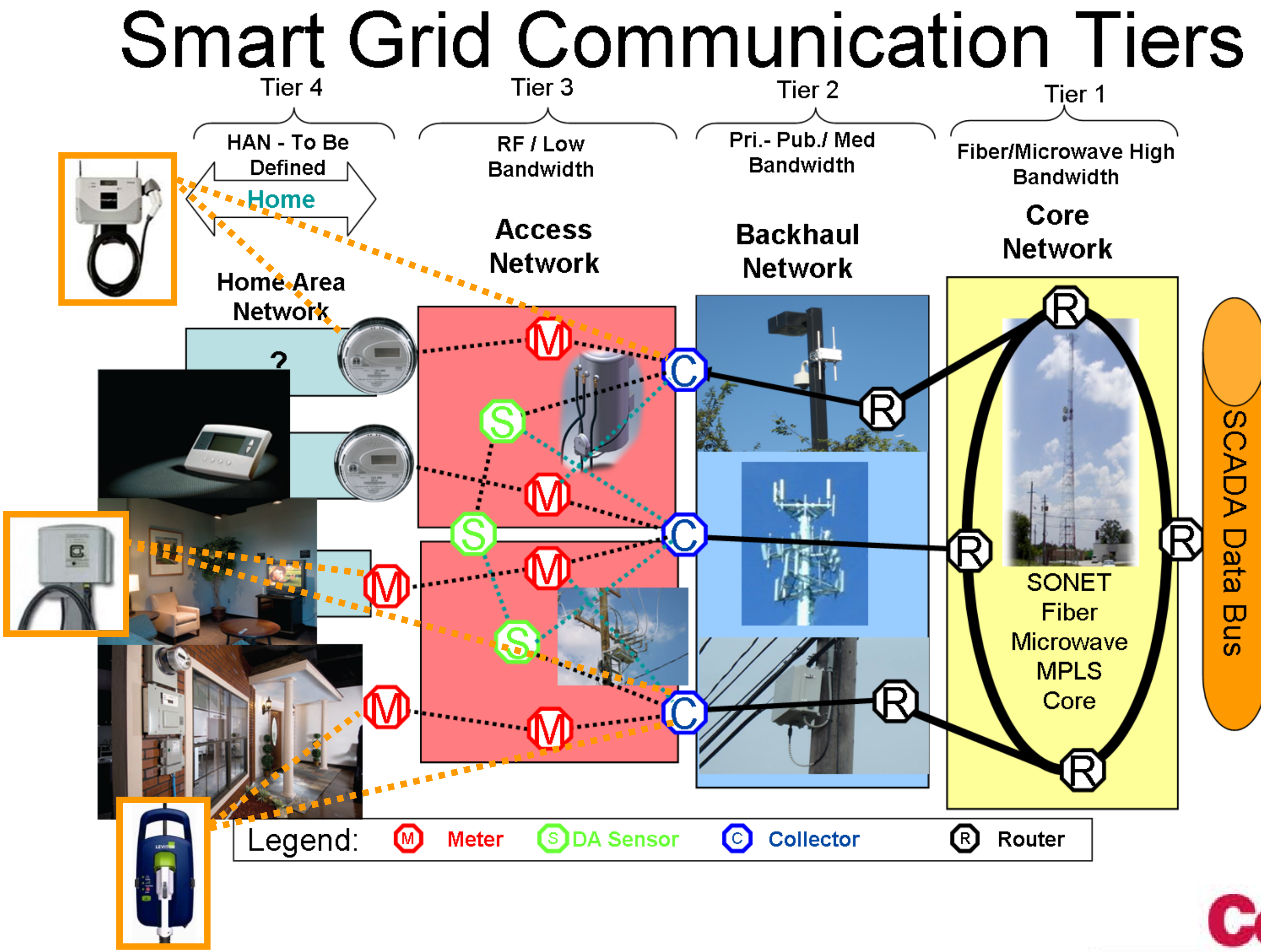
Benefits of Time-Variable Rates for EV Charging

- ✓ A residential customer served under Rate BESH in 2009 could potentially have saved up to 67% on their EV charging costs, compared with rate BES
- ✓ Time-variable rates for EV charging can help avoid increasing peak demand at significant EV penetration levels; and can reduce annual electric costs for EV owners
- ✓ Such time-variable rates offer financial incentives for that encourage load shifting or energy conservation by customers
  - Encourages customers to lower their electric usage during high-cost periods or shift usage to lower-cost periods.
- ✓ Additionally, the correlation between market price and consumption tends to result in more efficient use of generation, transmission, and distribution systems.

Smart EVSE

- ✓ The integration point between the EV and the grid should be the EVSE
  - While EVs are mobile, EVSE represent stationary load at a known point on the distribution system
- ✓ Both residential and commercial EVSE need to be “smart”, meaning the charging station must support communications with the grid and remote management of EV charging by the utility
- ✓ EVSE should perform as a node on the smart grid
  - Need to interact with other systems such as smart metering, in-home devices, and distribution automation to:
    - Improve utility load management
    - Increase customer choice and control
    - Do these things in as automated a way as possible
- ✓ Communications must be via established, open protocols
  - No proprietary networks!

Smart Grid Integration of EVSE



Conclusions

- ✓ A modern electric grid, such as Advanced Metering Infrastructure (AMI) with its two-way communications, facilitates the adoption and sustainability of electric vehicles
- ✓ Time variable rates coupled with AMI and in-home devices give consumers greater control over their electric usage, while minimizing grid impacts
- ✓ The two-way communications of an AMI network supports intelligent EVSE that allows consumers to automatically set EV charging based on electricity price signals
- ✓ Smart Grid Integration of EVs enables:
  - Real-time information about loading on the electric distribution system
  - Automatic notification to ComEd when the load on individual system components, such as transformers, reaches a level that requires attention
  - Upgrade of overloaded equipment before it fails, benefitting both EV owners and their neighbors

ComEd is investing $2.6B over the next 10 years to modernize the electric grid, including full AMI deployment to all of our nearly 4 million customers

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