



# Sustainable TRANSPORTATION



Energy Efficiency &  
Renewable Energy

## **E-Mobility ... *Perspectives, Challenges and Globalization***

**Die Stadt der Zukunft – Die Zukunft der Stadt  
Amerikazentrum Hamburg**

Keith Hardy  
EV-Smart Grid Interoperability Center  
Argonne National Laboratory  
18 February 2015

# Future of Mobility Depends on ...

- **Transportation options ... personal and public**
- Population density and traffic congestion
- Preferences of the 'millennial generation'
- Fuel availability and cost
- Regulation ... emissions and environmental impact



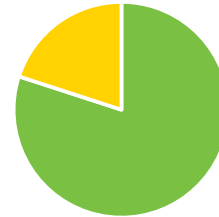
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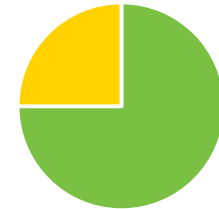


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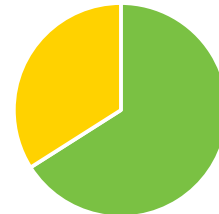
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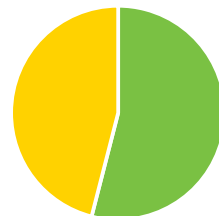
**80%** want to live where they have a variety of transportation options



**75%** say it is likely they will live where they do not need a car to get around



**66%** said access to high quality transportation is one of the top 3 factors in where to live



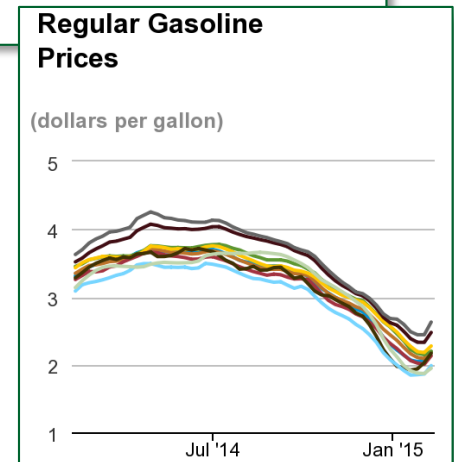
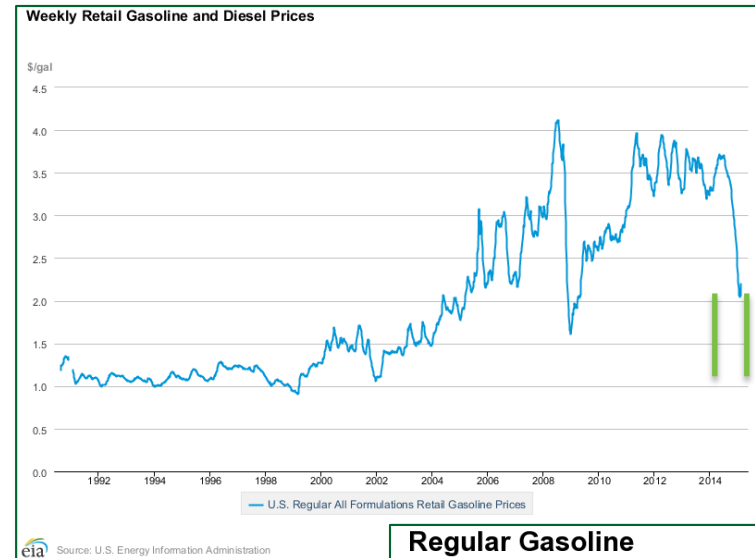
**54%** would move to another city for more and better transportation options

Survey by Rockefeller Foundation and Transportation for America;  
Millennial generation defined as born 1983-2002 (~80M Americans);  
Boston, New York, San Francisco, Chicago, Boulder, Austin



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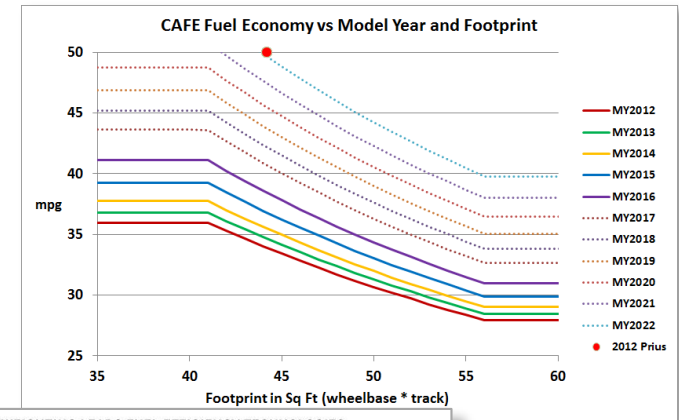
eia Source: Energy Information Administration



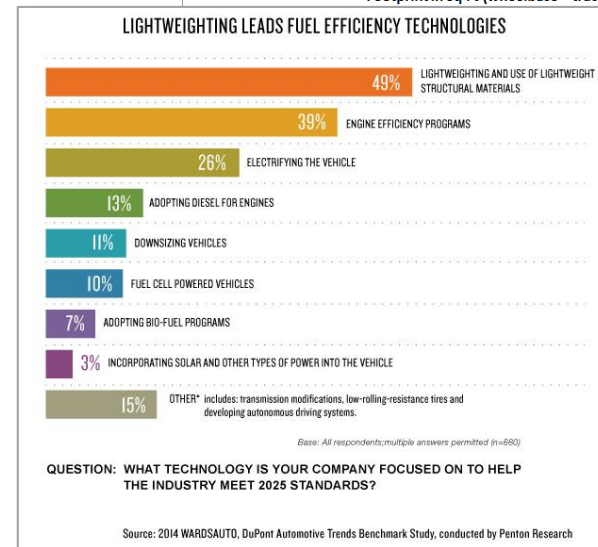


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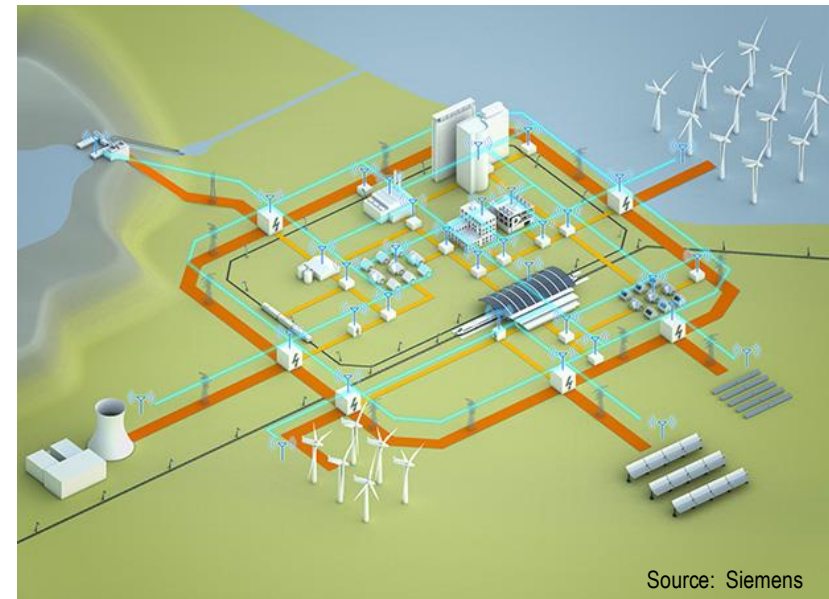


Source: NHTSA Final Rule - 2011



# Role of E-Mobility ... *societal perspective*

- Decrease vehicle emissions and street-level pollution
- Utilize multiple power generation sources with decreasing emissions
- Contribute to local/regional energy management
  - Manageable load (e.g., smart charging, demand response)
  - Energy storage/intermittent power
    - Ancillary services, integration with distributed/renewable energy
    - ‘Behind the meter’ integration with smart buildings/renewables

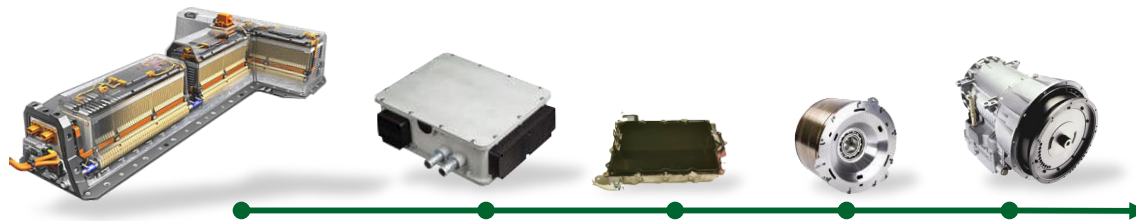


# Federal Incentives for Development/Manufacturing

- Battery and electric drive component and system development
- Component and system manufacturing facilities
- 'Beyond lithium-ion' research in materials/battery chemistry



JCESR

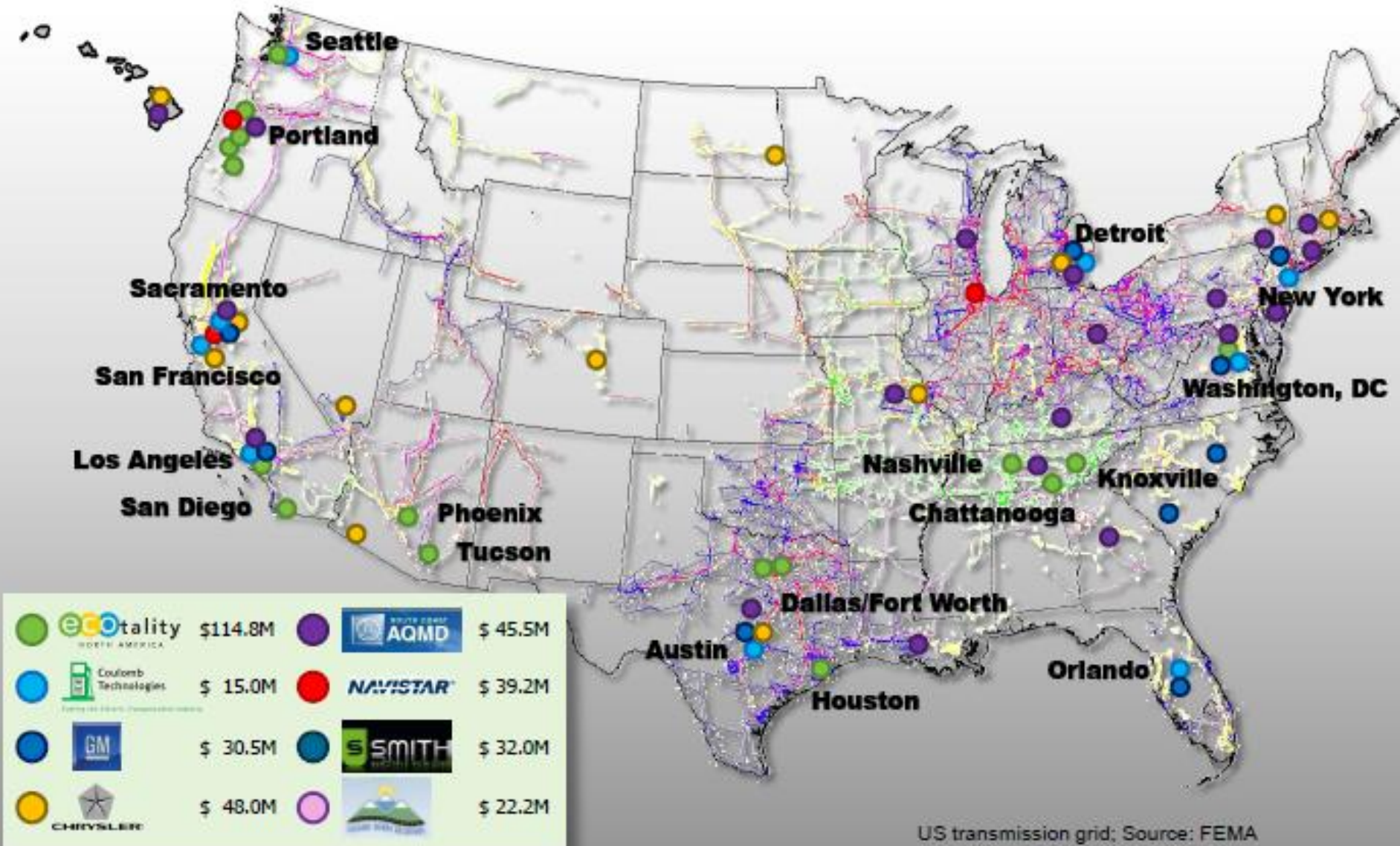


2.4B USD cost share invested in components and manufacturing facilities





# Federal Investments in Charging Infrastructure

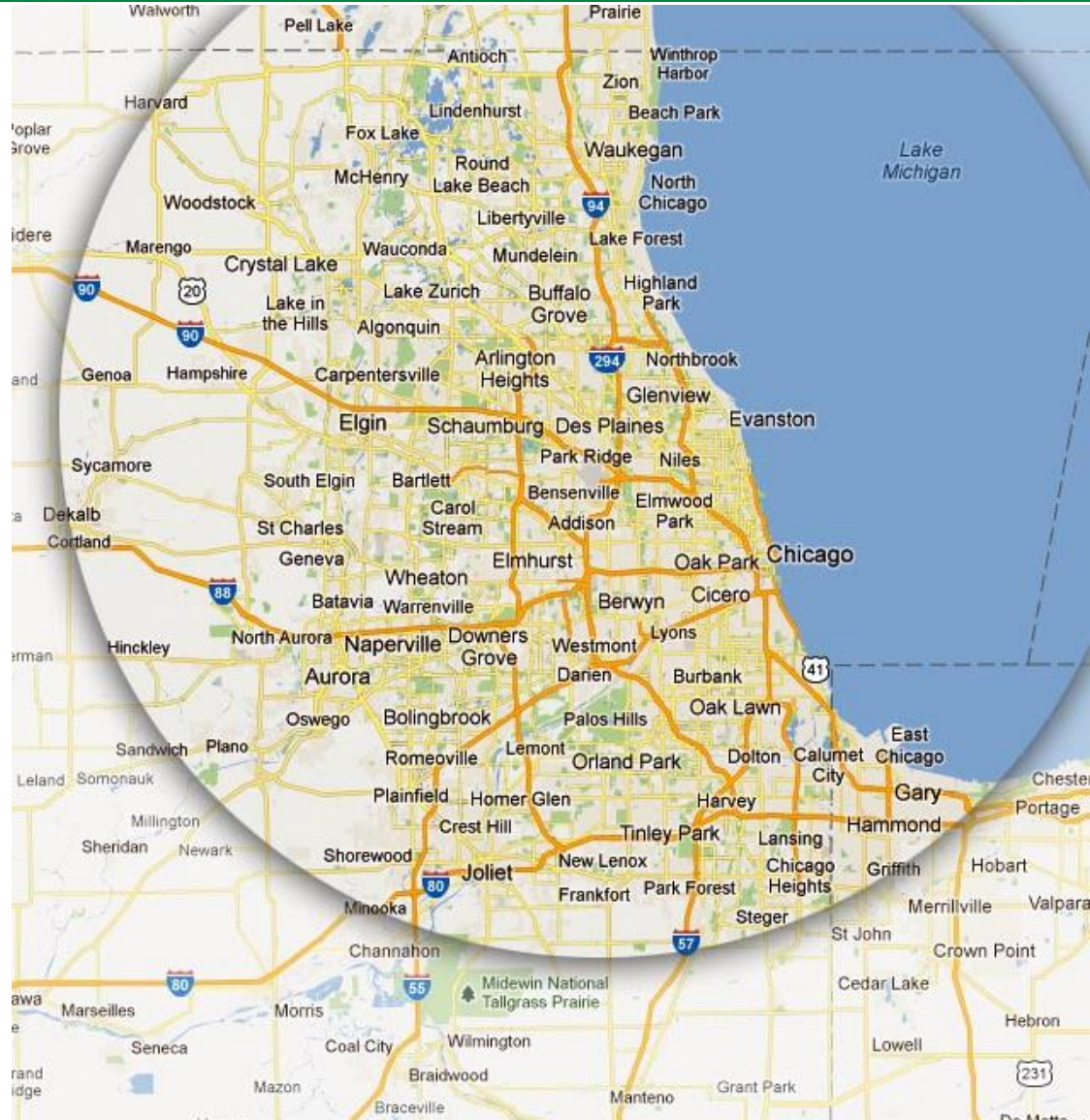


# Federal/State Purchase Incentives

Up to \$14,500 total PEV and residential EVSE incentives in the State of Illinois\*

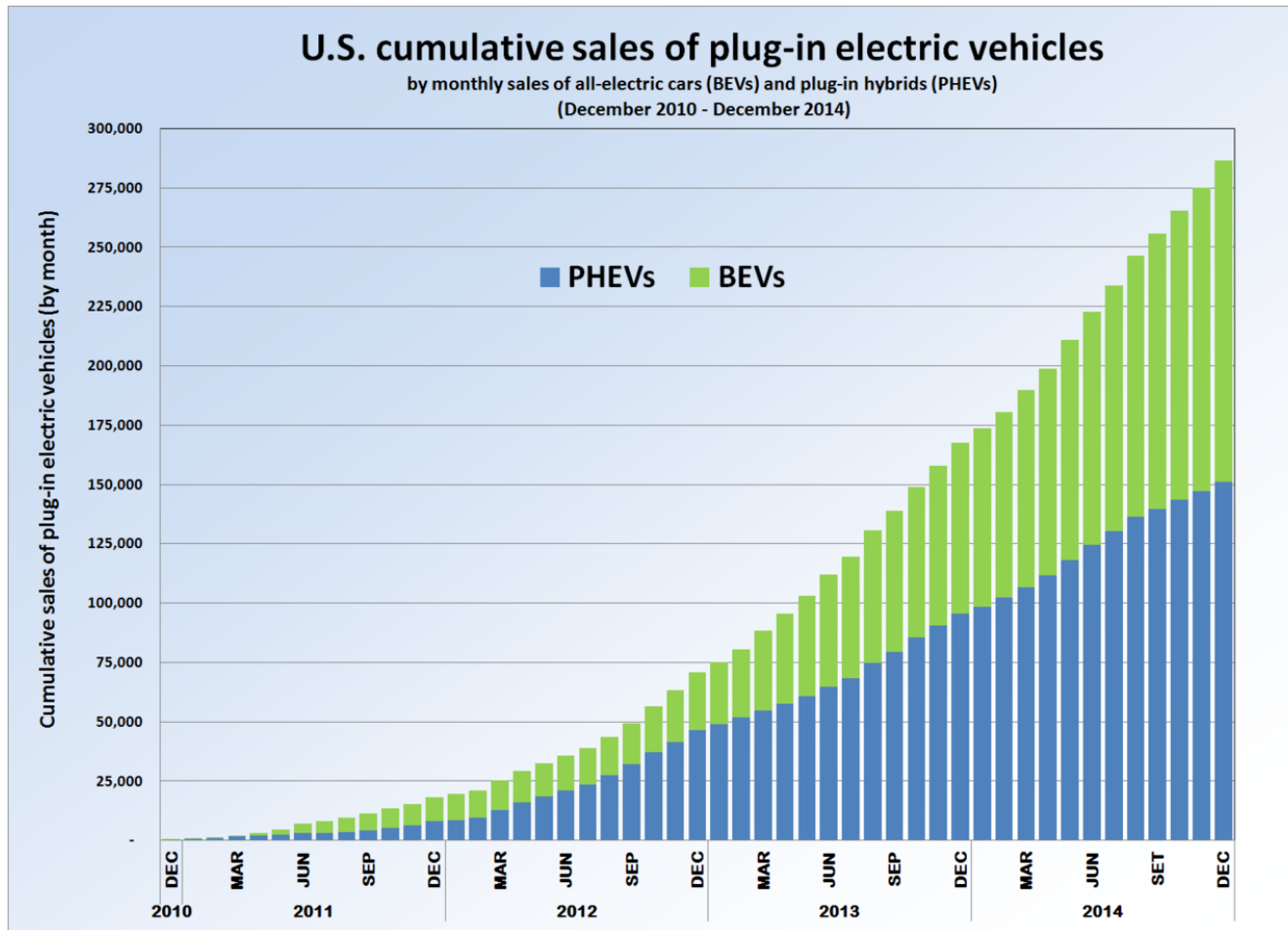
| Type Incentive   | Benefit  |
|--|--|
| Fed. Plug-In Electric Vehicle Tax Credit                     | \$2,500 to \$7,500 tax credit for purchasing an EV, depending on vehicle's battery capacity and weight   |
| IL Alternative Fuel Vehicle (AFV) & Alternative Fuel Rebates | 80% rebate up to \$4,000 for purchasing an electric vehicle  |
| IL Electric Vehicle Supply Equipment Rebates                 | Covers 50% cost of installation and equipment for a Level 2 charger station, up to \$3,000 per non-networked station; double for networked station |
| IL Electric Vehicle (EV) Registration                        | Annual registration fee discounted to \$18 for EVs, compared to \$101 for a conventional car   |

\* Incentives vary by State





# PEV Sales ... 1% US market share by Q1 2015



Nissan Leaf  
EV sales leader



GM Volt  
PHEV sales leader

Public access:  
9,122 stations  
22,849 outlets

Source: US PEV Sales 2010 2014 by Mariordo (Mario Roberto Durán Ortiz)

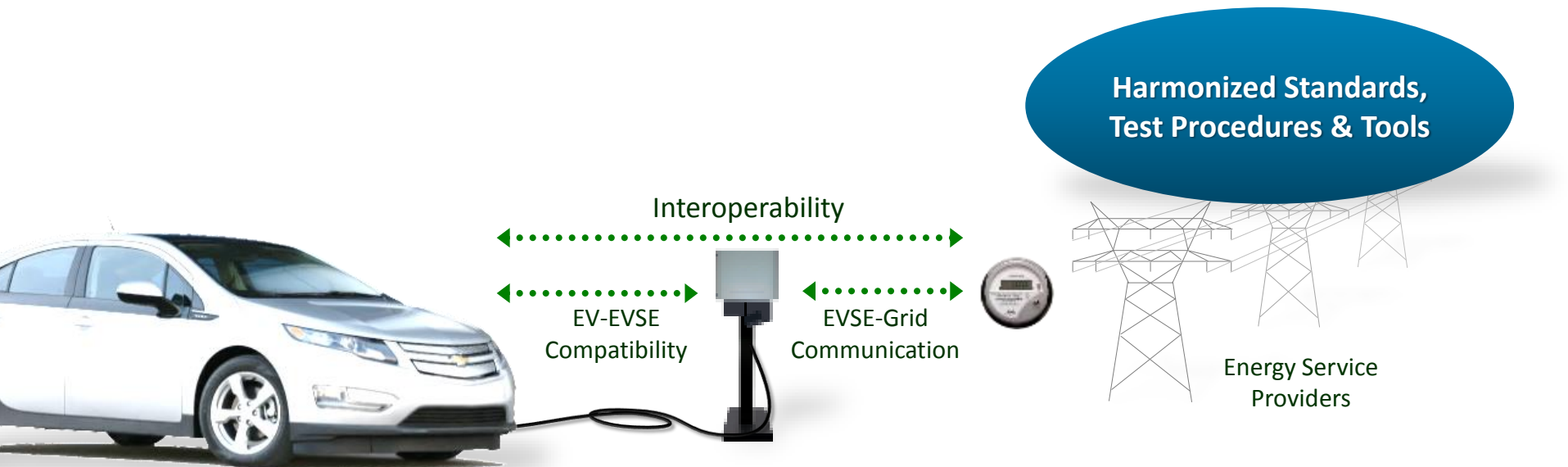
Source:  
DOE Alt Fuels Data Center

# PEV-Grid Integration an Enabler for Societal Benefits

## Interoperability key to integration

*the ability to charge conveniently, safely and securely ... anywhere, anytime ... with no extraordinary actions required by the vehicle operator*

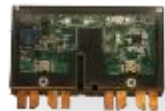
- Standards were developed independently ... harmonization or translation is required at the grid interfaces
- Test procedures and tools are needed to verify compliance





# Enabling Technologies

- Standards and technology are directly linked
- Full functional integration requires harmonization of standards or new technology to adapt physical interfaces and translate message protocols
- Necessitates development of metrology, communication controller hardware and protocol translation software



Metrology;  
sub-metering



Communication controllers  
& messaging protocols



Charge  
couplers

Technology  
Development to Enable  
Grid Integration



# EV-Smart Grid Interoperability Centers

## Fulfilling Transatlantic DOE-JRC Agreement

- Establish cooperative centers to harmonize PEV and battery test procedures; PEV interoperability

## Facilitating Global Standards

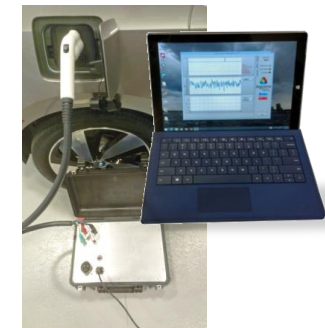
- Aligning harmonization efforts in EU and US
  - Led development of US (SAE) interoperability standards, test procedures and tools
  - Instrumental in the 'Global InterOP Team' to develop universal requirements and 'golden test device'

## Developing Enabling Technology

- Communication control modules licensed
- Interoperability standards verification tools transferred to industry
- Engineering compact sensing, measurement and communication

## Expanding to Support DOE Grid Integration

- Integrated energy management of PEVs, buildings, renewables and storage



# EV-Smart Grid Interoperability Centers



## Harmonization of standards, technology and test procedures



DOE-JRC Agreement



ANL EV-Grid Integration lab



JRC VeLA-7 lab



JRC Cold Chamber



ISO/IEC15118-SAE Meeting and Festival



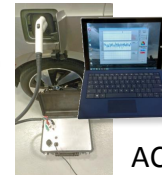
Embedded Controls



Sensing/Metrology



Standards Development and Verification Tools



AC Interoperability (SAE J2953)



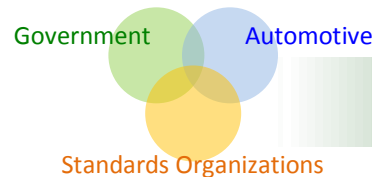
PEV Compliance (SAE J1772)



PEV test procedures



Government Funding



Global EV Interoperability Requirements Specifications for a 'Golden Test Device'

# Argonne's Interoperability Center

## Focus on standard connectivity and communication

2012

2013

2014



DOE-JRC agreement  
(November 2011)



Official launch  
(July 2013)

*Drafted SAE J2953 Interoperability Standards  
[requirements and test procedures]*



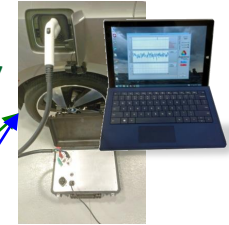
*Developed SpEC module  
[EV-EVSE-grid communication]*



*Licensed for  
Smart charging;  
High power DC  
power system for  
PEV/EVSE emulation*



*Developed  
Interoperability  
Compliance  
Tools*



*Developed  
Charge Coupler  
Compliance Tool*





## Supporting Global InterOP team; PEV test procedures

2014

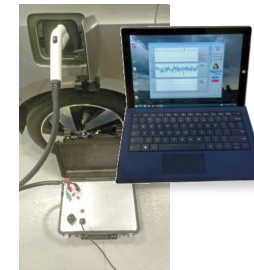
2015

Interoperability testing; universal requirements and non-proprietary 'Golden Test Device' specification

Prototype EU/US AC Interoperability Test Equipment

DC interoperability

| PEV | Year       | Type       | USA  | EU   | USA  | EU   |
|-----|------------|------------|------|------|------|------|
| 1   | Charging   | Mechanical | Pass | Pass | Pass | Pass |
|     |            | Safety     | Pass | Pass | Pass | Pass |
| 2   | Dynamic    | Indefinite | Pass | Pass | Pass | Pass |
|     |            | Mechanical | Pass | Pass | Pass | Pass |
| 1   | Charging   | Safety     | Pass | Pass | Pass | Pass |
|     |            | Dynamic    | Pass | Pass | Pass | Pass |
| 2   | Indefinite | Dynamic    | Pass | Pass | Pass | Pass |
|     |            | Safety     | Pass | Pass | Pass | Pass |

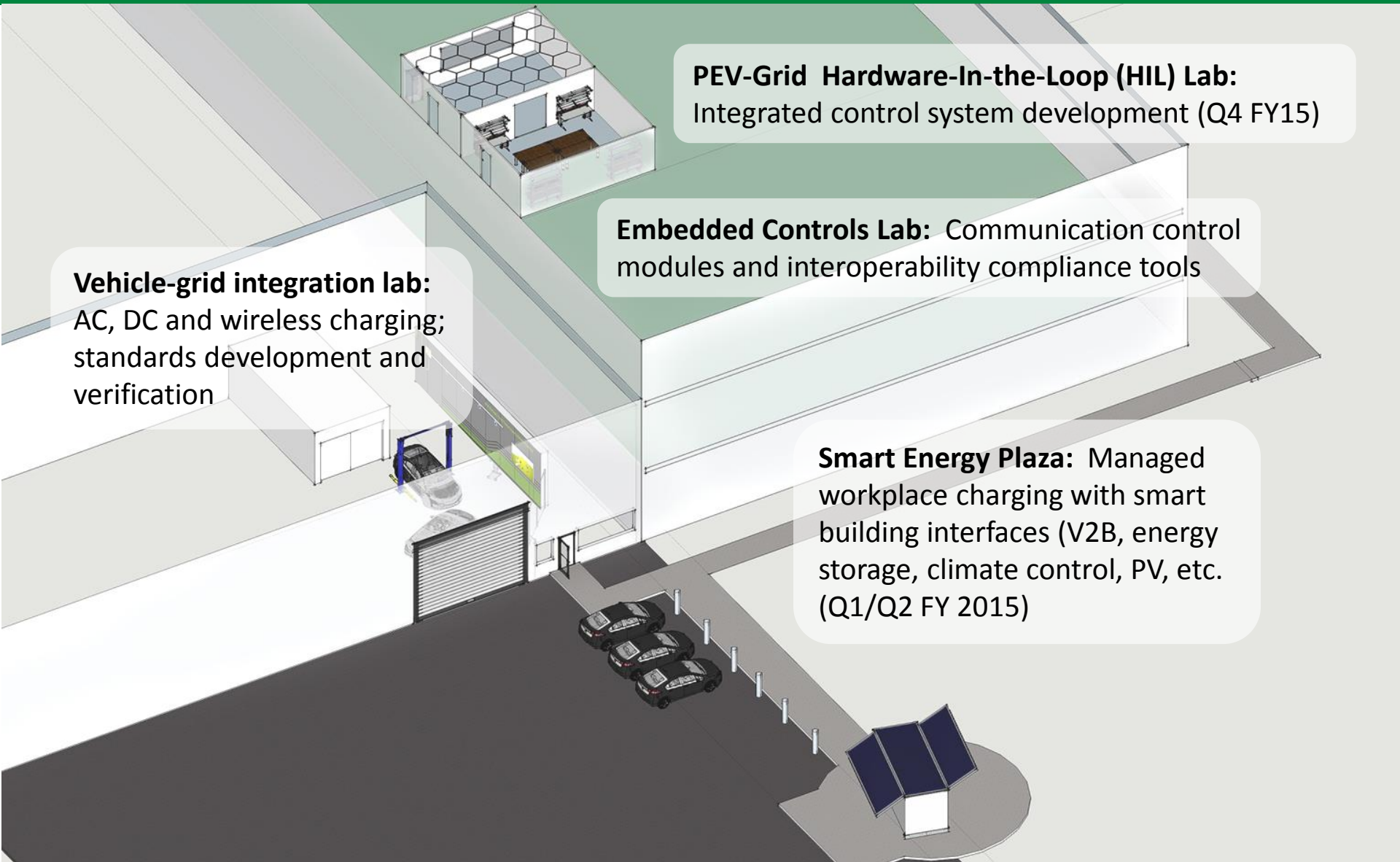


Reference vehicle testing at Argonne and JRC-Ispra



Recommendations to harmonize EU and US PEV test procedures

# Expansion for PEV-Grid Integration



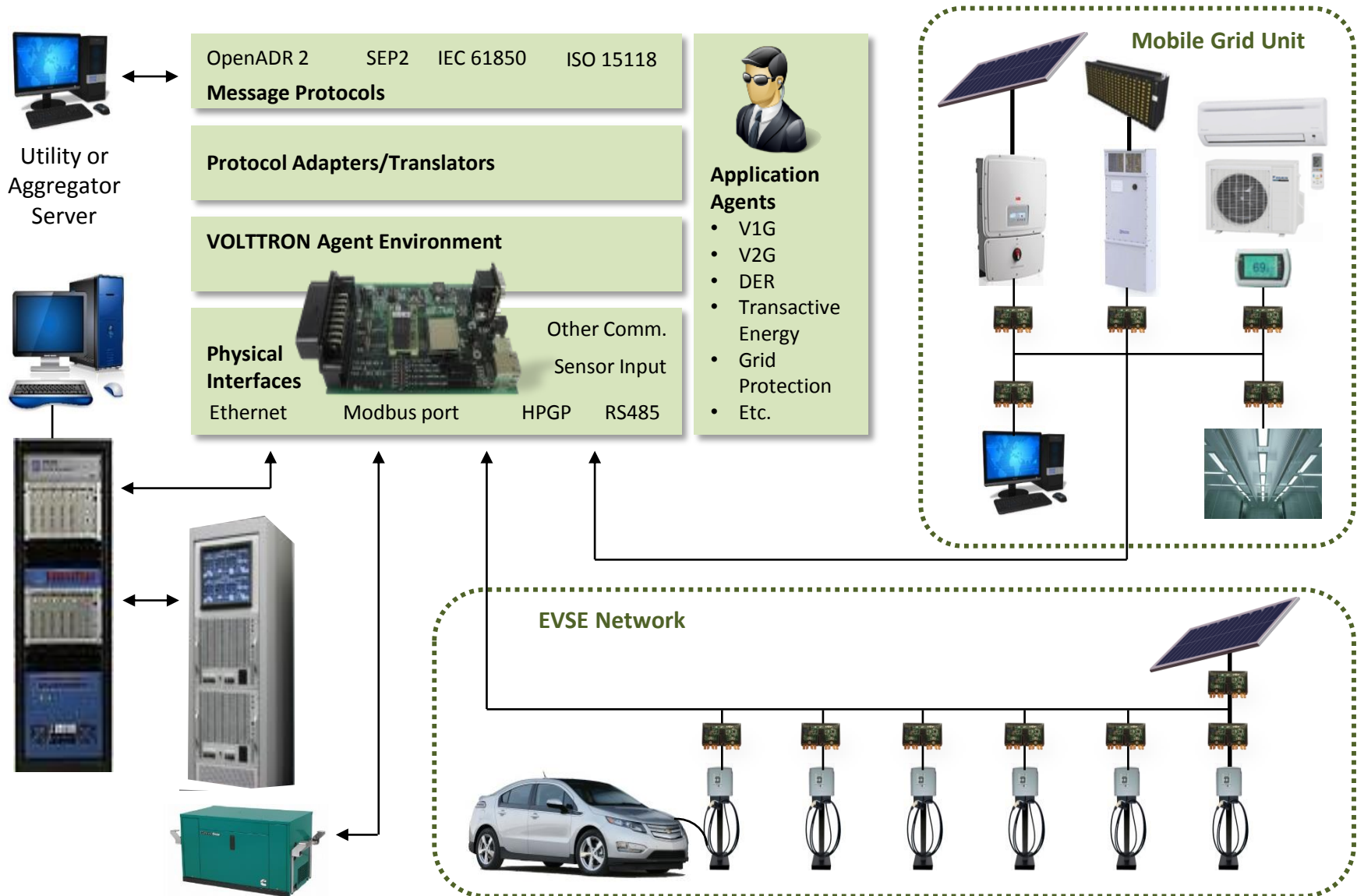
**PEV-Grid Hardware-In-the-Loop (HIL) Lab:**  
Integrated control system development (Q4 FY15)

**Embedded Controls Lab:** Communication control modules and interoperability compliance tools

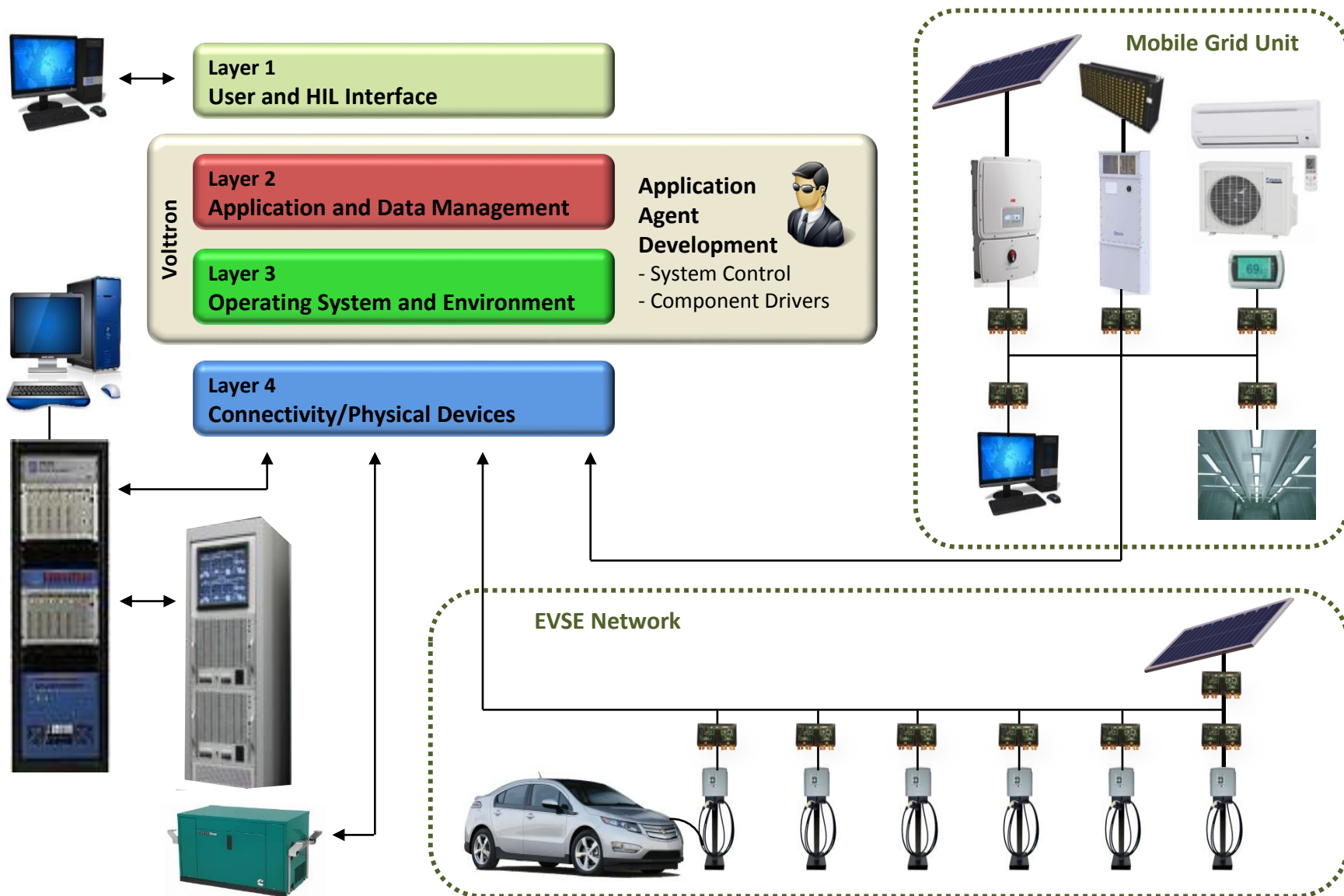
**Vehicle-grid integration lab:**  
AC, DC and wireless charging;  
standards development and verification

**Smart Energy Plaza:** Managed workplace charging with smart building interfaces (V2B, energy storage, climate control, PV, etc. (Q1/Q2 FY 2015)

# Focus on Harmonized Grid Interfaces

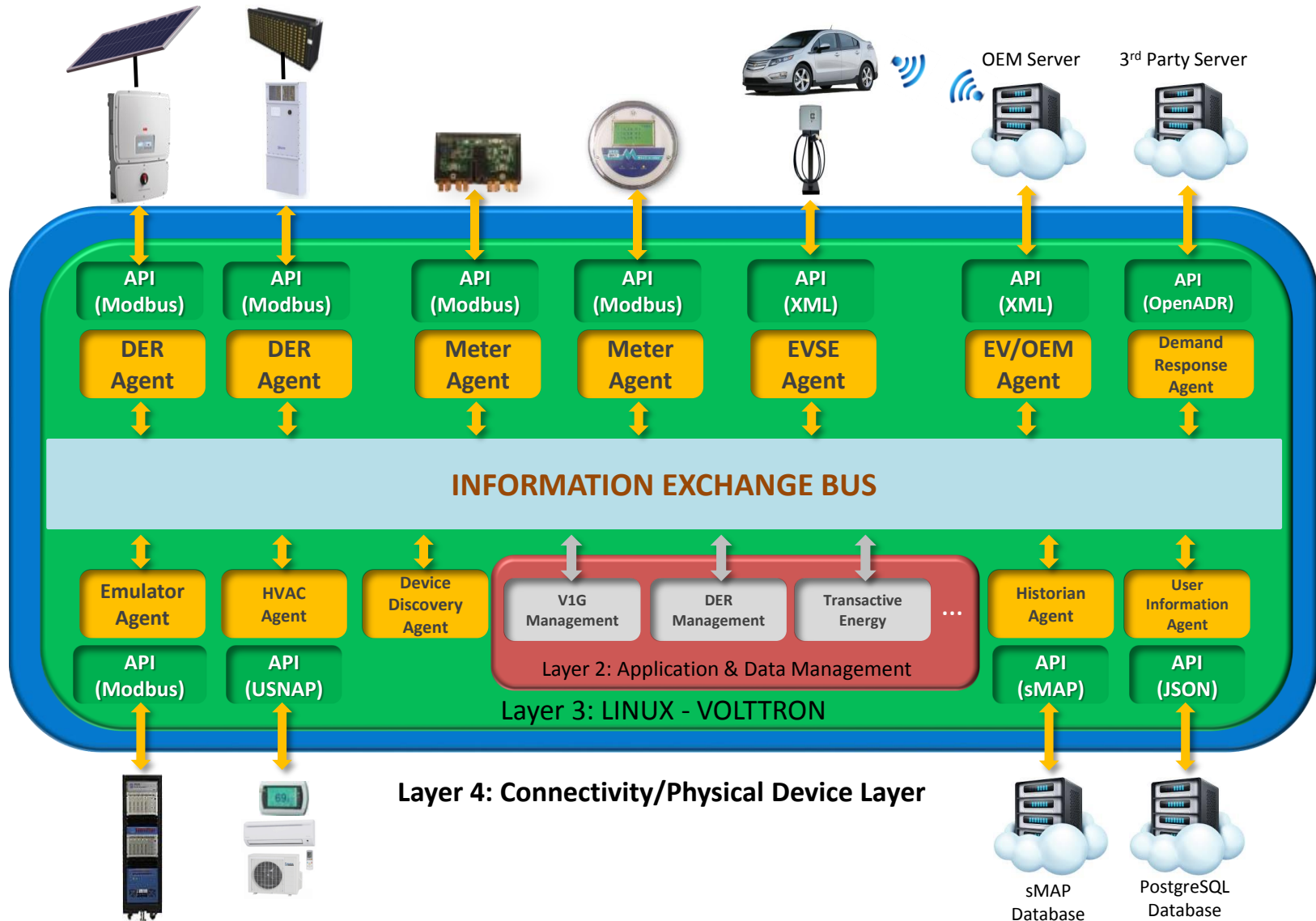


# Common Integration Platform





# ... Enables Smart Energy Management



# Globalization Efforts

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## US-EU

- EV-Smart Grid Interoperability Centers
  - PEV and battery test procedures; PEV-EVSE interoperability
  - Protocol translators (SAE and ISO communication standards)
  - Smart charge adaptors (to network legacy 'dumb' EVSE)

## US-Germany

- Global InterOP Team
  - AC & DC interoperability requirements, test procedures and tools

## US-Asia

- EV-Smart Grid Interoperability Centers (TBD)