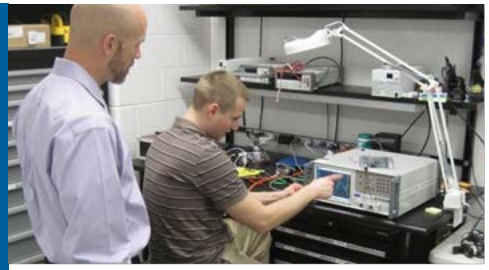
2014 DOE HYDROGEN PROGRAM AND VEHICLE TECHNOLOGIES
ANNUAL MERIT REVIEW

Argonne NATIONAL LABORATORY

EV-SMART GRID RESEARCH & INTEROPERABILITY ACTIVITIES




KEITH HARDY
DOE/ANL EV-Smart Grid Interoperability Center

7 June 2016
Washington, DC

Project ID #VS095

This presentation does not contain any proprietary, confidential, or otherwise restricted information

OVERVIEW

Timeline

- Codes & standards support, grid connectivity R&D and international cooperation initiated in FY 2010
- DOE-EC agree to establish cooperative interoperability centers - Q1, FY 2012
- Argonne IOC launch - Q4, FY 2013
- JRC IOC launch – Q1, FY 2016
- Smart Energy Plaza Ø1 – Q4, FY 2015

Barriers/Challenges

- Universal interface(s) for grid-connected devices that utilize open source solutions for connectivity and communication
- Test tools to verify interoperability
- Low-cost sensing, communication and control components/integrated systems
- Non-biased technical support for standards definition organizations

Budget

- FY2015 - $1605K
- FY2016 - $1400K*

* Does not include GMLC funding

Collaborators

- SDOs, Global InterOP
- Vehicle and EVSE OEMs; utilities
- DOE national labs and JRC-E.C.
- State, Commerce and European Commission

RELEVANCE

- **Lead/actively contribute to numerous standards committees;** PEV-EVSE interoperability; PEV coupler; PEV charge power quality; HD 480vac coupler; off-board DC communication; wireless charging communication, safety and interoperability; EVSE metering
- **Developing enabling technologies for grid integration;** Sensing/metrology components; common integration platform w/open source software; smart charge (sub-meter/load control) adaptor; interoperability compliance tools
- **Facilitating global harmonization of standards/test procedures;** Active member of the joint industry-government Global InterOP team; joint vehicle testing and interoperability projects in the EV-Smart Grid Interoperability Centers at Argonne and the EC's Joint Research Center – Institute for Energy & Transport

MILESTONES

Codes & Standards/Harmonization

SAE/ISO-IEC/NIST/IEEE standards committees[1]

Wireless-EVSE Testing

Sub-metering requirements

Global InterOP Team[1]

US-EU PEV Test Procedures

Sensing & Metrology

EUMD Commercial Form Factors

Embedded Controls & Communication

Common Integration Platform (CIP)

Software Architecture Study

Smart Charge Adaptor[2]

Grid integration Studies

Smart Energy Plaza (workplace charging testbed)

Grid Interaction Lab/HIL

Grid Modernization Lab Consortium[3, 4]

F-1.2.2 – Interoperability

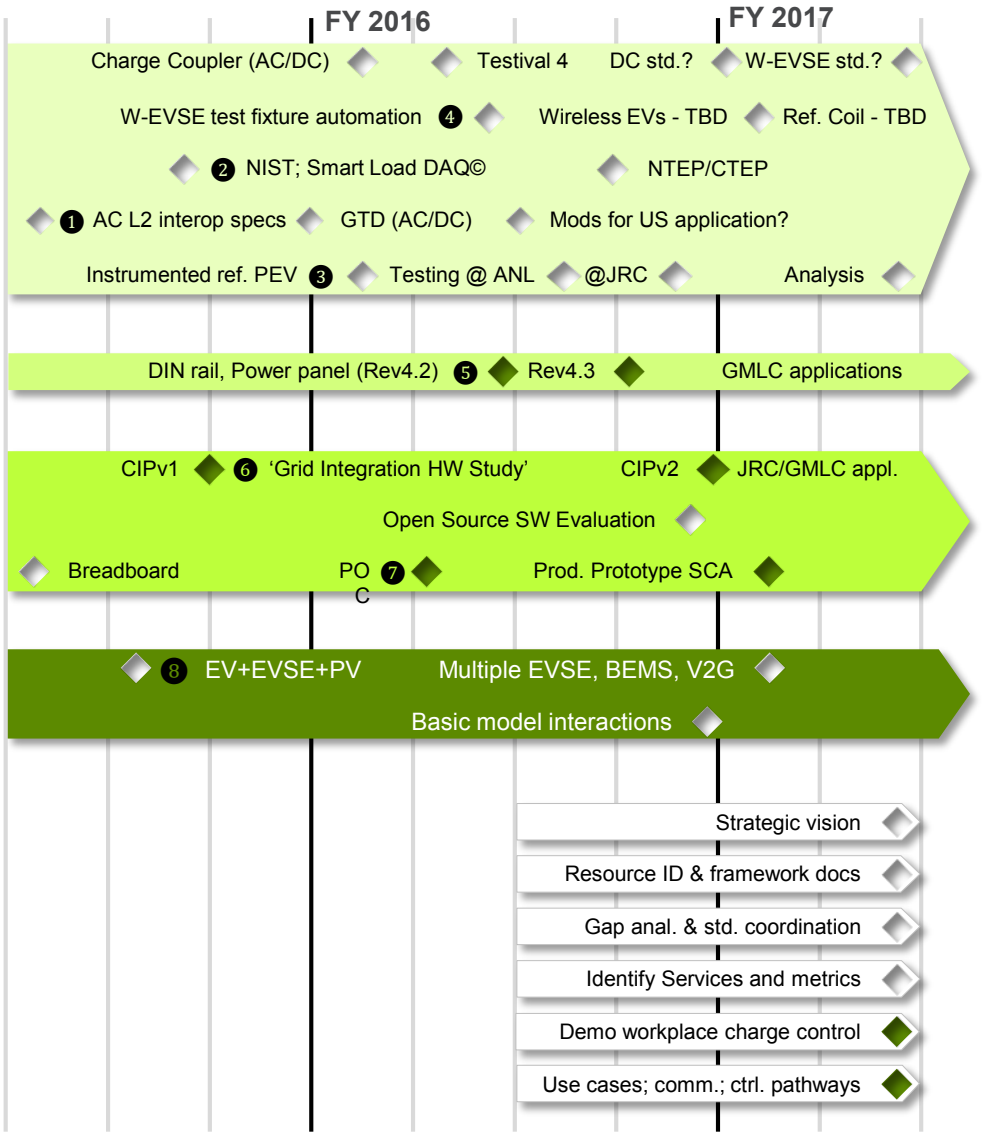
F-1.2.3 – GMLC Testing Network

F-1.4.1 – Std., Test Proc. for Interconnection/Interop.

F-1.4.2 – Def., Std., Test Proc. for Grid Services/Devices

VTO-V2B Integration Pathway

VTO-Sys. Res. Supporting Std. and Interoperability



[1] Estimated; depend on committee schedules [2] Patent applied for [3] Multi-lab projects [4] Initiated after AMR due date

To be integrated in Smart Energy Plaza

MILESTONES

Codes & Standards Committee Support	
Q2 FY 2015	❶ Contributions to Global InterOP – AC L2 interop. Spec and SAE procedures
Q3 FY 2015	❷ Sub-metering requirements; NIST EVSE test device (Smart Load DAQ©)
Q2 FY 2016	❸ Level 2 instrumentation and testing of the BMW i3 REx reference vehicle
Q2 FY 2016	❹ Automated the wireless test fixture; tested OEM prototype vehicle system
Sensing & Metrology	
Q2 FY 2016	❺ EUMD w/Rev4.2 board; power panels and DIN rail formats
Embedded Controls & Communication	
Q3 FY 2015	❻ Common Integration Platform w/open source software; linked PEVs, EVSE, PV, smart meters; visualized power flow
Q2 FY 2016	❼ Proof-of-concept Smart Charge (sub-meter/load control) Adaptor (SCA)
Grid integration Studies	
Q3 FY 2015	❽ Smart Energy Plaza operational with PEVs, EVSE, PV, bldg. sys., smart meters

APPROACH

Develop and verify technology and standards
for grid connectivity and communication

Develop and implement embedded controls using open source software and hardware
to minimize technical barriers for industry

Test communication and control systems in a network of grid-connected devices
to demonstrate behind-the-meter integration of workplace power/energy supply and demand

Support international harmonization
through cooperative initiatives with industry, governments and labs in Europe and Asia

Support Grid Modernization Lab Consortium's
interoperability/grid integration activities

IOC HAS FOCUSED ON INTEROPERABILITY …

Led development of SAE interoperability standards and tools

2013 | 2014 | 2015

Launched DOE EV-Smart Grid Interoperability Center at ANL

Interoperability

Wireless Charging

Standards

Tools

Charge Connector Compliance

Technology

EVSE Fueling Accuracy

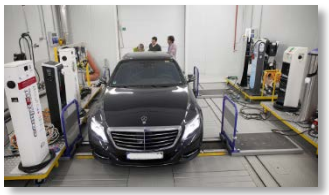
AND GLOBAL HARMONIZATION …

Targeting universal interoperability and compliance methods

2014 — 2015

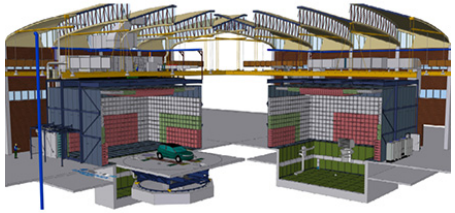
The European Interoperability Centre for Electric Vehicles and Smart Grids

Low Temperature Testing



DC Interop testing

AC Interop testing and equipment evaluation



VELA-9 construction

L2 instrumentation and testing at ANL

Comparative testing at JRC

BMW i3 REx reference vehicle

Global InterOP

Audi, BMW, DAIMLER, FCA, Ford, GM, Opel, PORSCHE, VW, European Commission, Argonne NATIONAL LABORATORY

Interoperability requirements

Open spec; Version control

scienlab electronic systems

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NOW
APPLYING TECHNOLOGY TO GRID INTEGRATION

Harmonize behind-the-meter for workplace energy management

Grid Connectivity and Communication

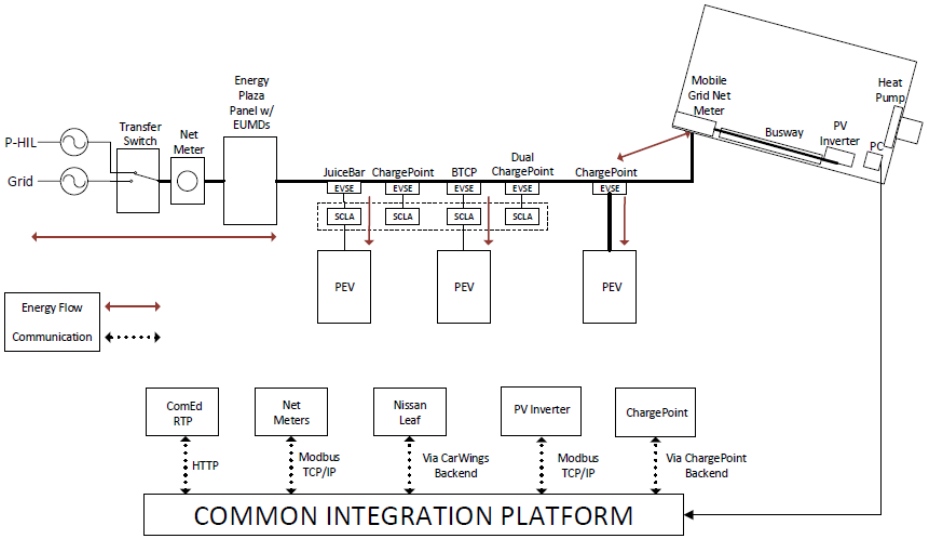
- Test bed for communication and control of grid-connected devices
- Enabling technologies for sensing, communication and control
- Integrated Communication and Control Using IoT Approach

EV Infrastructure

- Wireless EVSE test fixture automation
- NIST HB44 – EVSE electric fuel delivery

ACCOMPLISHMENT

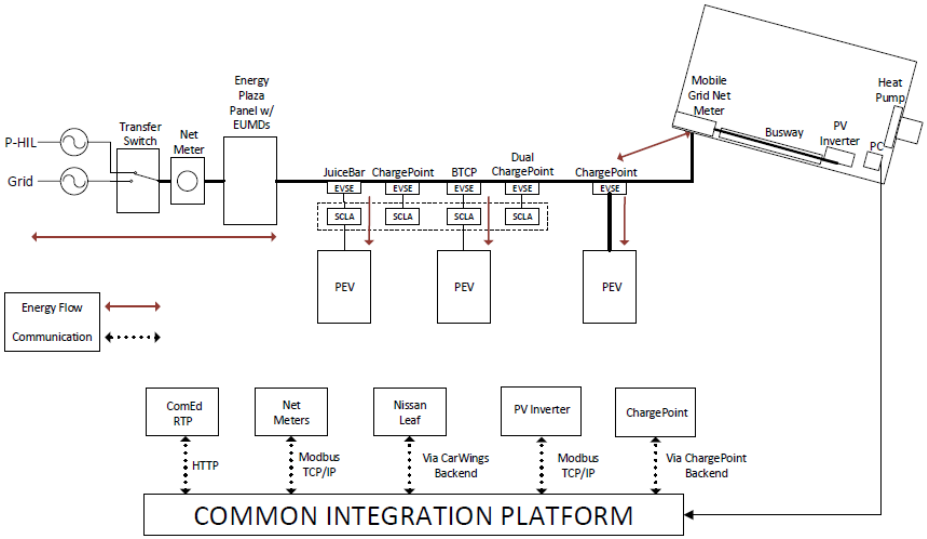
Test bed for communication and control of grid-connected devices



- Networked EVs, EVSE, building systems and PV array
- Focus on open source, integrated communication and control

ACCOMPLISHMENTS

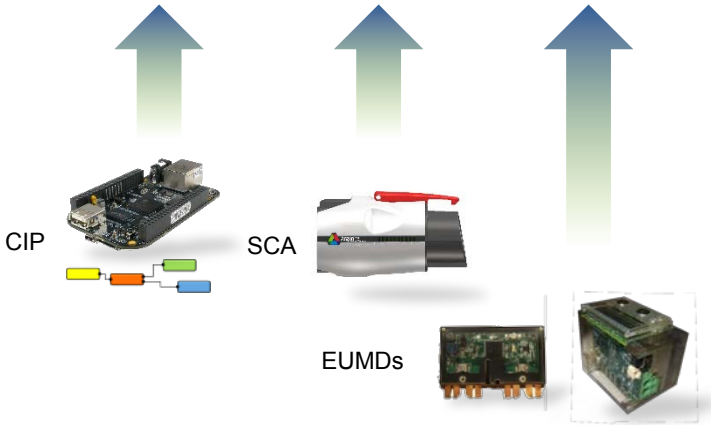
Enabling technologies for sensing, communication and control



Standard Interfaces and Protocols

Embedded Controls

Sensing/Metrology



Common Integration Platform (CIP)
with open source software and hardware

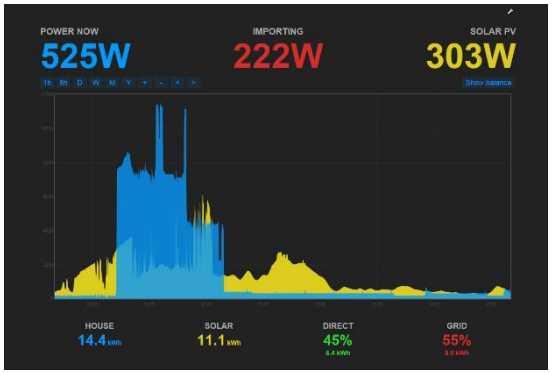
Smart Charge Adaptor (SCA)
for sub-metering, monitoring, load control

End Use Measurement Devices (EUMDs)
in commercial form factors

ACCOMPLISHMENT

Integrated Communication and Control Using IoT Approach

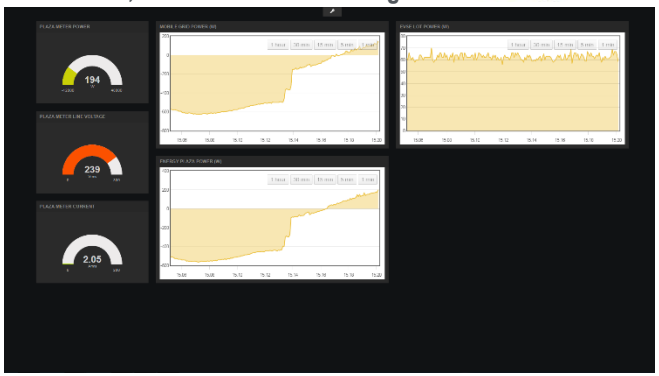
Daily Solar production and EVSE loads



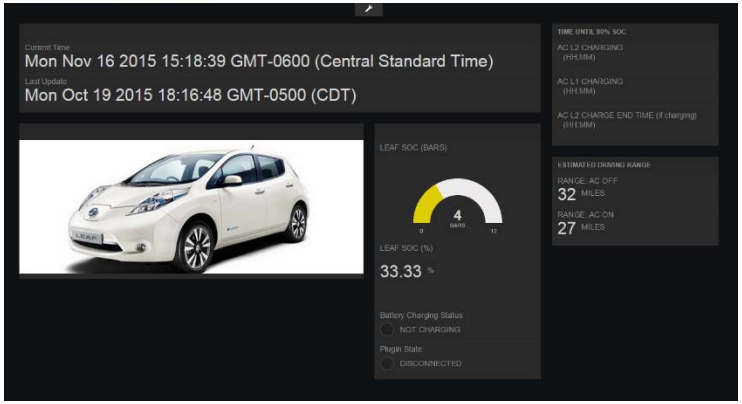
Weekly Solar production and EVSE loads

Production, loads and net to Building 362

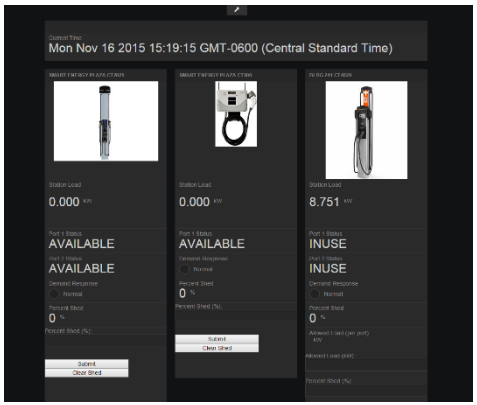
Modbus TCP



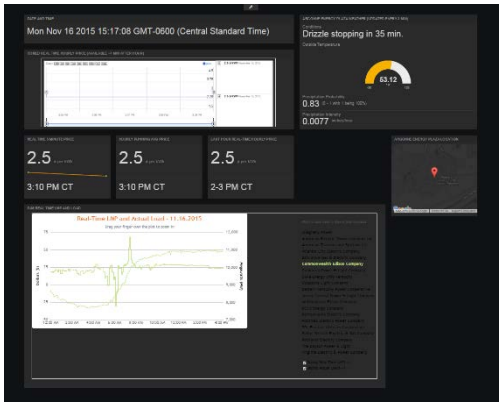
CARWINGS



chargepoint+



ComEd



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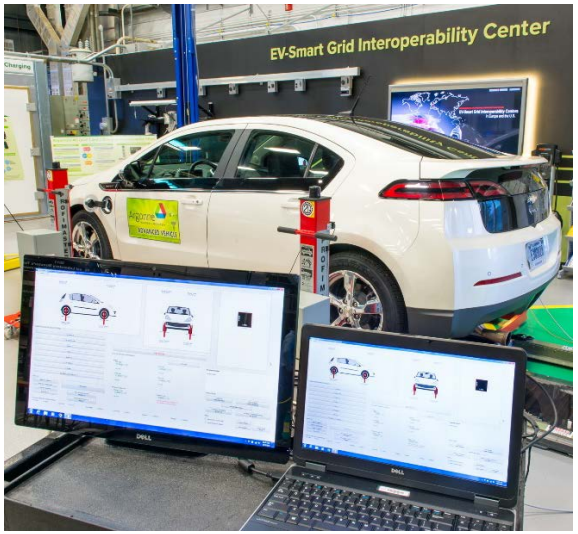
ACCOMPLISHMENTS

Custom test tools



Wireless EVSE Test Fixture Automation
Field probe positioning and data synchronization

NIST HB44 – EVSE Electric Fuel Delivery
Test procedure and tool development

ACCOMPLISHMENT

Instrumented (Level 2) and tested PEV reference vehicle*

- ☑ Direct Fuel Flow
- ☑ Cooling System Temperatures
- ☑ Exhaust Temperatures
- ☑ 3 Phase Motor Voltage
- ☑ High- & Low-Voltage Current & Voltage
- ☑ Direct Axle Torque
- ☑ HV Battery Cell & Module Temperatures & Voltage
- ☑ Interior Temperatures
- ☑ Broadcast and Diagnostic CAN

- **Energy consumption (fuel + electricity)**
- **Emissions**
- **Performance**
- **Vehicle operation and powertrain strategy**
- **US and world driving cycle tests; ~400 signals captured**
- **Comparative testing to be performed at JRC-E.C. (Ispra)**

* For more detail, see ‘Advanced Technology Vehicle Lab Benchmarking’, Project ID #VSS030

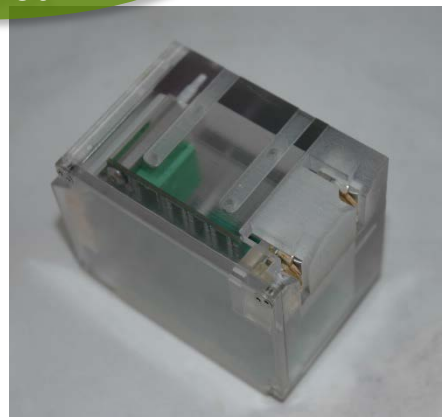
ACCOMPLISHMENT

End Use Measurement Devices (EUMDs) in commercial form factors

Rev4.2 board applicable to all devices shown

60A Service Disconnect

Power panel – dual slot



DIN rail

ACCOMPLISHMENT

Smart charge adaptor (SCA)

Communication/ Monitoring

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ACCOMPLISHMENT

Smart charge adaptor (SCA)

Manual Load Control

SCA Proof of Concept

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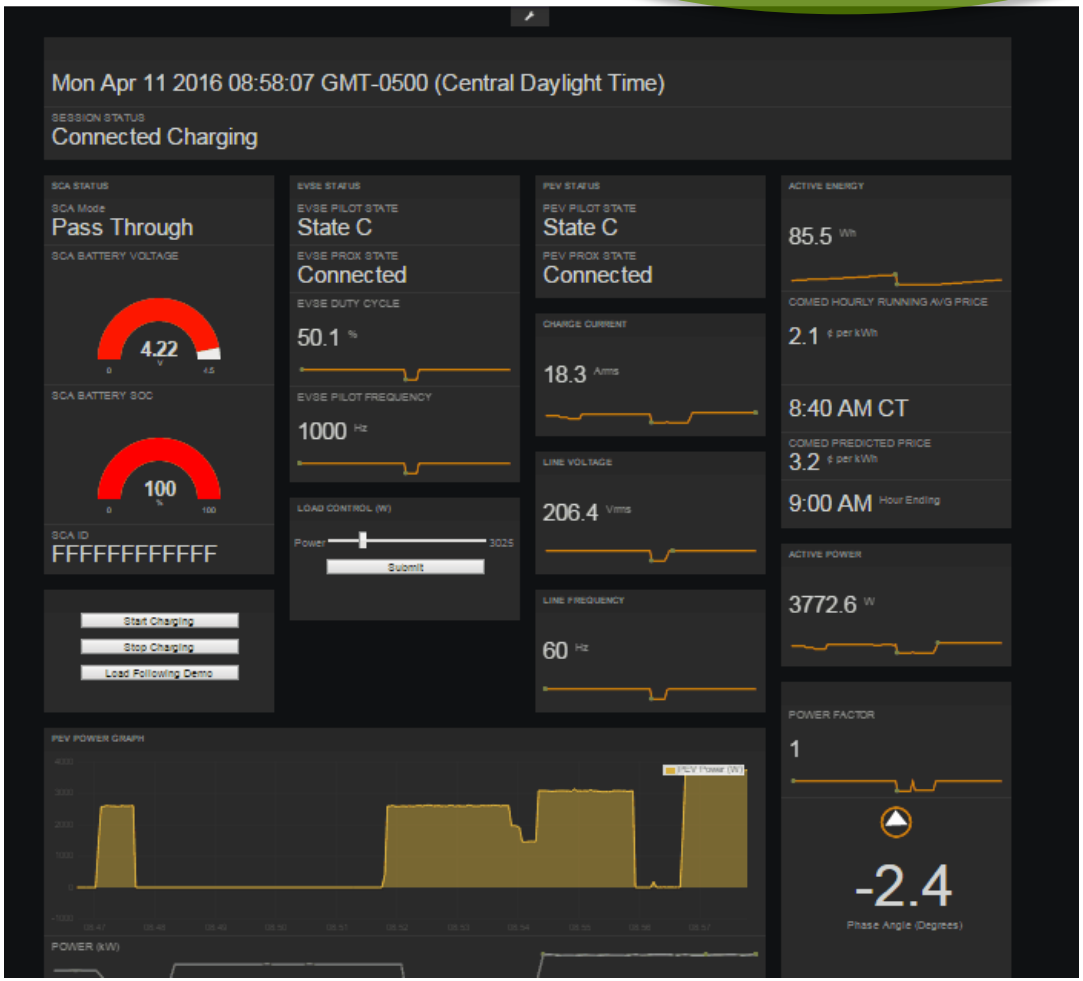
ACCOMPLISHMENT

Smart charge adaptor (SCA)

Automated Load Following

SCA Proof of Concept



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REVIEWER COMMENTS

Project was not reviewed last year

COLLABORATION WITH OTHER INSTITUTIONS

Codes & Standards/Harmonization

- Standards activities/committees – SAE, IEEE and NIST committees
- Global InterOP Team – Audi, BMW, Daimler, FCA, Ford, GM, Opel, Porsche, VW, JRC-E.C.
- US-EU PEV Test Procedures – JRC-E.C.

Sensing & Metrology

- EUMD – 2G Engineering, Magnetic Sensor Systems

Embedded Controls & Communication

- Smart Charge Adaptor – CAD, ITT Canon, CEC/CPUC

Grid Modernization Lab Consortium

BNL, INL, LBNL, LLNL, NREL, ORNL, PNNL, SNL

REMAINING CHALLENGES AND BARRIERS

Open source solution(s) for integrating grid-connected devices
- Minimize barriers to implementing smart energy management

Low-cost, universal components for grid integration
- Sensing, communication and control

Lack of interconnection/interoperability test equipment
- Equipment manufacturers will not invest in new product development until the standards, test requirements and test procedures are adopted … and industry commitment is clear
- Initiatives such as Global InterOP focus efforts, demonstrate commitment and facilitate harmonization of standards

Non-biased technical support for standards committees

FUTURE WORK

Codes & Standards/Harmonization

SAE/ISO-IEC/NIST/IEEE standards committees[1]

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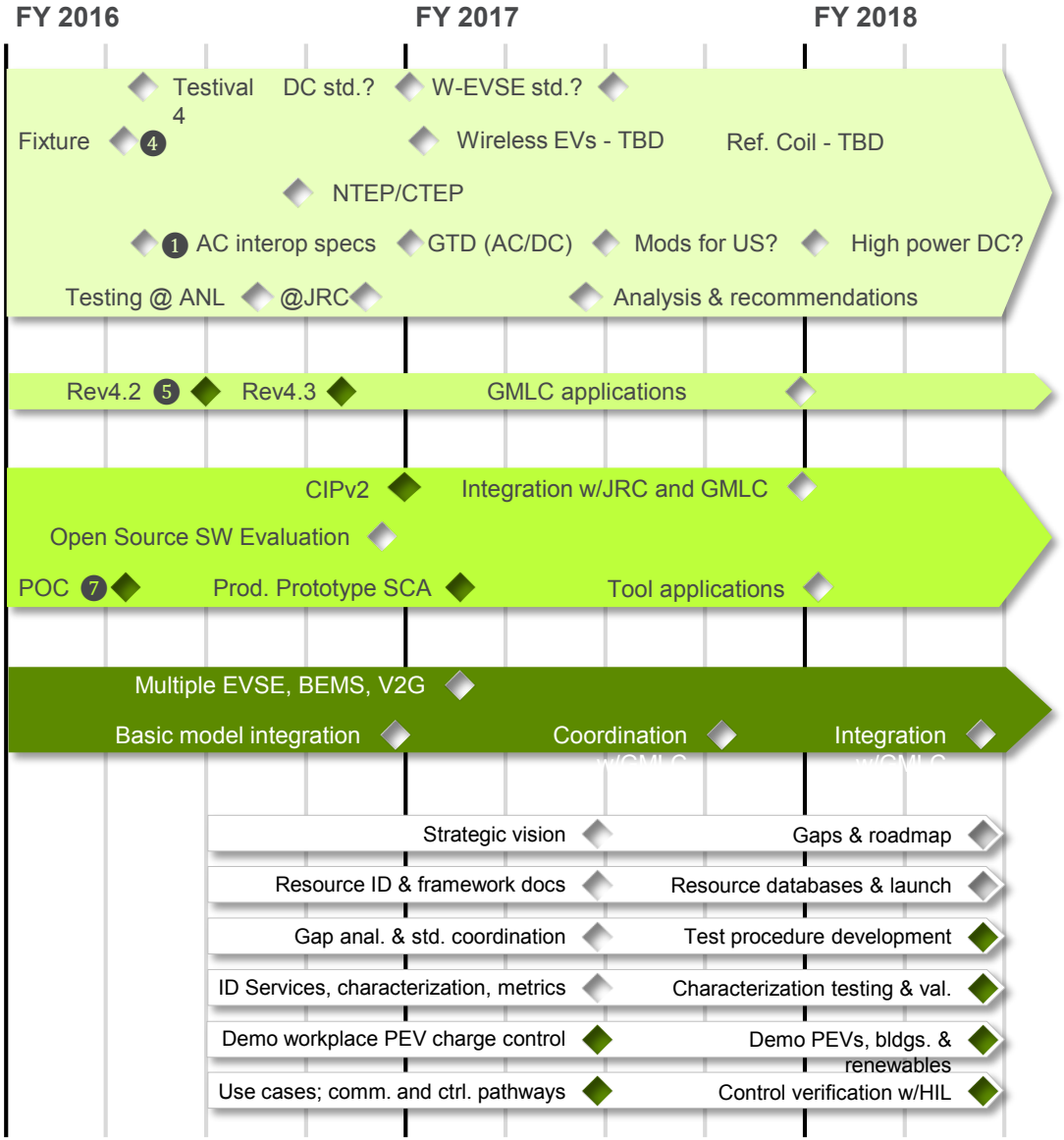

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◆ To be integrated in Smart Energy Plaza

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SUMMARY

- **Relevance** – Developing and verifying standards and technology in cooperation with industry; working relationships with global manufacturers and research institutions are facilitating global harmonization of standards, test procedures and equipment.
- **Approach** – Activities are aligned with the SDOs, industry and the Grid Modernization initiative; enabling technologies developed for vehicle interoperability are being applied to grid integration.
- **Technical accomplishments and progress** – Substantial progress in tools and technology to support standards and harmonization
  - Tools: wireless test fixture automation; NIST EVSE fuel delivery measurement device; L2 instrumented reference PEV; workplace charging testbed
  - Technology: CIP w/open source software; EUMDs in commercial form factors; prototype SCA
- **Collaboration** – Well-connected with industry and government agencies
- **Future work** – Well-grounded continuing activities; emphasis on grid integration