NREL
NATIONAL RENEWABLE ENERGY LABORATORY

# Integrated Network Testbed for Energy Grid Research and Technology Experimentation (INTEGRATE)


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Project ID: VSS167

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

# Background



This activity is part of the DOE EERE Grid Integration Initiative which is focused on ensuring the seamless integration of clean energy technologies into the electrical grid. This cross-cutting effort is funded by multiple EERE programs, including the Solar Energy, Wind/Water, Building, and Vehicle Technologies Offices.

Under the INTEGRATE project, the National Renewable Energy Laboratory (NREL) issued a Request for Proposals (RFP) to support the development and validation of technologies under three topics:

Topic Area 1 – Connected Devices
Topic Area 2 – Communication and Control Systems
Topic Area 3 – Integrated Systems

Technologies developed under this RFP will be installed and evaluated at the Energy Systems Integration Facility (ESIF) located at NREL, which serves as a hub for clean energy technology grid integration activities.

# Overview

## Timeline

- **Project start date: RFP issued 5/22/2014**
- **Project end date: various, each project has an 18-month Period of Performance**
- **Percent complete: 5%**

## Budget

- **Total project funding:**
  - Total DOE share: up to $6.5M
    - Wind/Water: $1.5M
    - Solar: $3.0M
    - BTO: $1.0M
    - VTO: $1.0M
  - Subcontractor share: $6.1M
- **All funding received in FY14**

## VT MYPP Goals/Barriers

- **Collect data on the interaction of electric-drive vehicles with charging infrastructure and the electric utility grid.**
- **Address codes and standards related to vehicle/grid connectivity.**

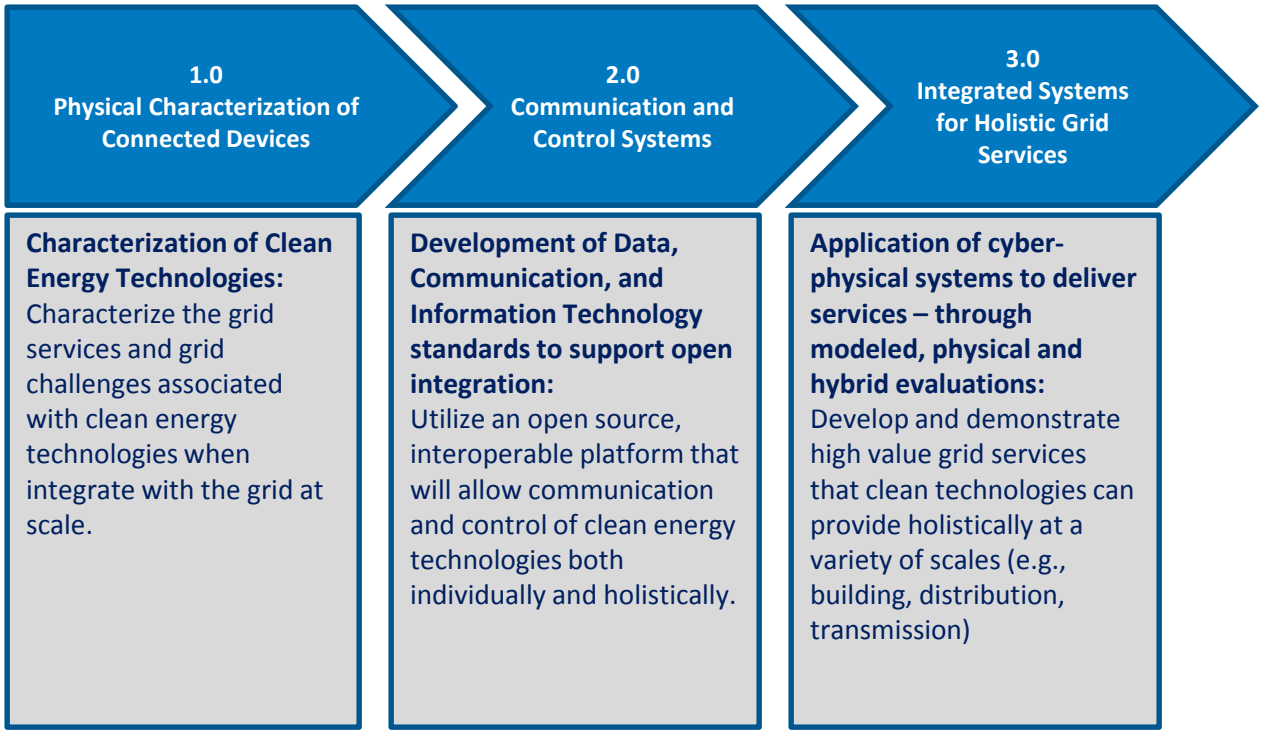
## Partners

- **NREL is partnering with industry, universities, utilities, and other stakeholders.***
- **Project lead: NREL**

* Five projects were selected under the INTEGRATE RFP. At the time this presentation was developed, three of the five subcontracts have been awarded. The partner names of the subcontracts still in negotiation are considered procurement sensitive.

# Relevance

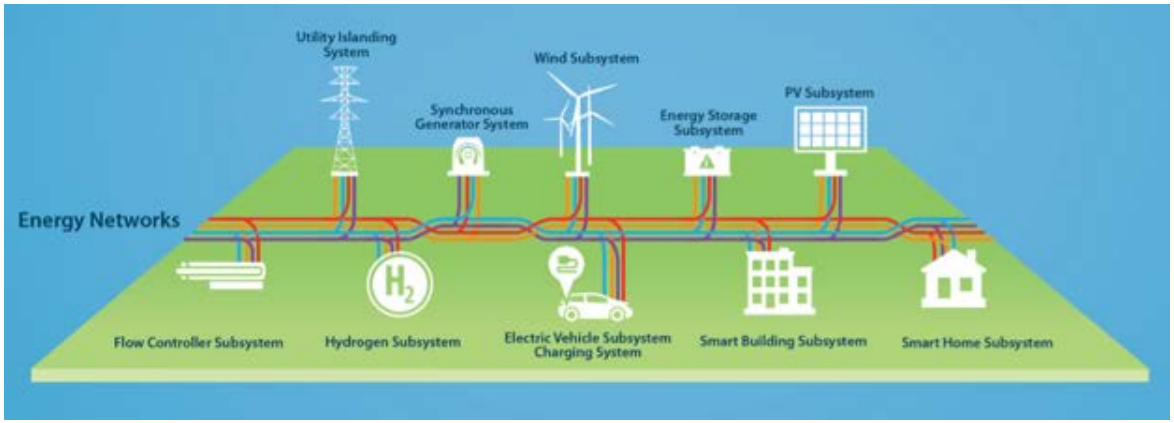
The objective of the INTEGRATE project is to enable clean energy technologies to increase the hosting capacity of the grid by providing grid services in a holistic manner using an open source, interoperable platform. Projects that are part of INTEGRATE will increase the viability, penetration, and deployment of renewable energy technologies by ensuring the reliability and efficiency of electricity generation and use. The INTEGRATE projects will focus on:



# Milestones

| Month/Year | Milestone or Go/No-Go Decision | Description | Status |
|---|---|---|---|
| 12/31/2014 | Milestone | Award INTEGRATE RFP contracts | Delayed – three of five subcontracts fully executed (EPRI Topic Area 1, UDel Topic Area 1 and Omnetric Topic Area 3) |
| 3/31/2015 | Milestone | Begin testing on at least one Topic Area 1 device from INTEGRATE RFP | Complete – Community Energy Storage system commissioned |

# Approach/Strategy




**Topic Area 1:** INTEGRATE projects will characterize the ability of existing clean energy technologies (e.g., small renewable power systems, electric vehicles (EVs), battery energy storage systems, and building appliances/loads) to provide grid services that help to ensure the reliability and efficiency of electricity generation and use. These projects will also help identify the system-level challenges associated with clean energy technologies when integrated into the grid at scale, with the goal of increasing the viability, penetration, and deployment of renewable energy technologies.

**Topic Area 2:** INTEGRATE projects will design, build, and test a flexible, open-source consensus standards-based communication, information, and computation (CIC) infrastructure that supports system-level control and allows for the interoperability of multiple clean technology devices in a secure fashion.

**Topic Area 3:** INTEGRATE projects will investigate and demonstrate how clean energy technologies can work together holistically to provide grid services and increase the hosting capacity of these technologies on the grid. The projects will develop and test solutions through real and simulated installations that demonstrate high-value grid services that clean energy technologies can provide at a variety of scales (e.g., building, distribution, transmission).

**Technologies developed under all three Topic Areas will be installed and validated in the ESIF.**

# Approach/Strategy

## Selected Projects

### Topic Area 1 (Connected Devices)

- **EPRI:** The project will test the ability of a set of connected devices to provide grid services. The primary focus is on standardizing device services for various clean energy technology types and developing communication interfaces to improve the ability of intelligent electronic devices to supply grid services.
- **University of Delaware:** The project will evaluate the ability of vehicle-to-grid (V2G)–capable bidirectional EVs to provide grid services, as well as to implement and test open protocols for coordination of those services.

### Topic Area 2 (Communication & Control Systems)

- **Subcontractor TBA:** This project will provide and demonstrate an end-to-end framework of CIC technologies, integrating operation of different domains within distribution systems (distribution management systems, demand response service, residential appliance scheduling) through open source software tools.

### Topic Area 3 (Integrated Systems)

- **Omnetric Corporation:** The project will demonstrate an Open Field Message Bus (Open FMB) platform that will enable the grid to effectively support large-scale complex operations, such as with distribution systems at electric utilities, which allow for an integration and wider penetration of renewable, clean energy resources.
- **Subcontractor TBA:** The project will deploy and demonstrate an integrated distribution grid management solution, using Active Network Management (ANM) to enhance grid capacity and services for renewable energy by more fully utilizing existing network assets.

# Electric Power Research Institute (EPRI)

| Topic Area | Technology Area(s) |
|---|---|
| **1 – Connected Devices** | Thermostats, pool pumps, EV chargers, photovoltaic (PV) inverters, community battery energy storage |

## Approach / Strategy

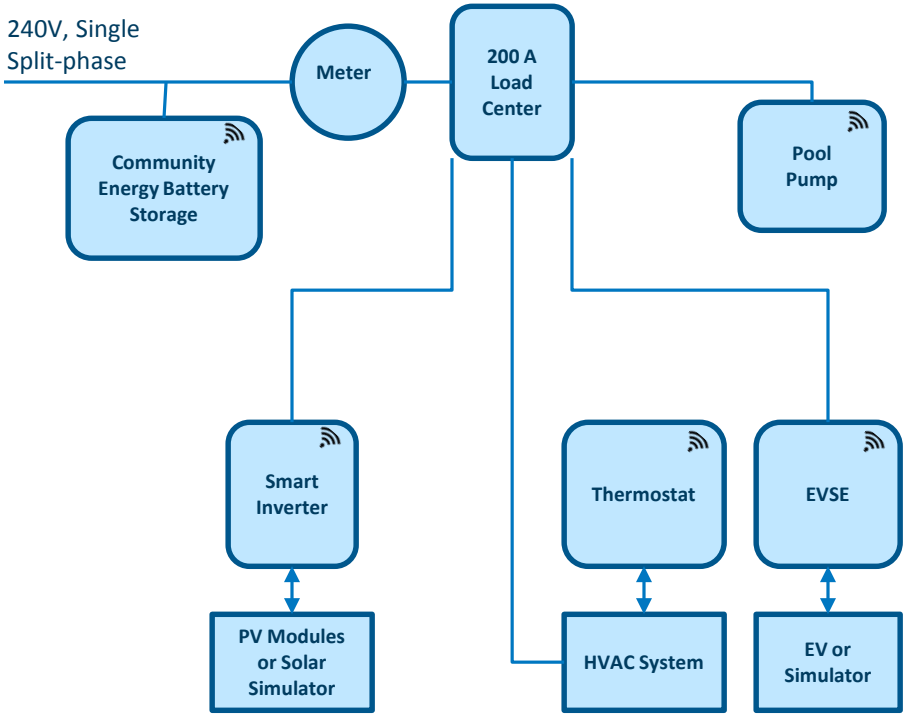
**Project Title:** Cohesive Application of Standards-Based Connected Devices to Enable Clean Energy Technologies

**Project will provide and test a set of key connected devices in terms of their performance of needed grid-supportive services**. Connected devices include thermostats, pool pumps, EV chargers, PV inverters, and community battery energy storage. The individual grid-supportive functionalities provided by these products will be tested in the context of higher-level goals, in which the devices are capable of functioning in concert, working together to enable more clean energy technologies on the grid.

**Focus on standardization of device services and communication interfaces (CEA-2045 & DNP3) will improve the ability of intelligent electronic devices to supply grid services**.

## Project Partners

- PowerHub Systems (Community Battery Energy Storage)
- Fronius (PV Inverter)
- ClipperCreek (EV Charger)
- Emerson (Thermostat)
- Pentair (Pool Pump)



# University of Delaware

| Topic Area | Technology Area(s) |
|---|---|
| **1 – Connected Devices** | Electric Vehicles |

## Approach / Strategy

**Project Title:** Open V2X at ESIF

**The project will perform tests to evaluate the ability of V2G-capable bidirectional EVs to provide grid services, as well as to implement and test open protocols for coordination of those services.** The goals of the Open V2X at ESIF project are:

1) to **characterize the ability of V2X assets to increase the hosting capacity** of the grid and to provide grid services, and

2) to **support open, practical, interoperable platforms** in a way that enables renewable power and sustainable transportation technologies.

## Project Partners

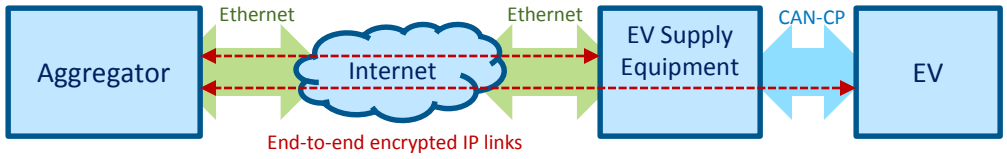
- NRG Energy
- TransPower (Heavy-duty vehicle manufacturer)
- AutoPort (Vehicle conversion and service company)

## EV Testing

The project will carry out the following tests of grid-integrated vehicles (GIV):

- Basic Device Characteristics (e.g., power quality, harmonics, and power factor as a function of battery state of charge)
- ISO-controlled response to signal (utility control of active power)
- Autonomous, local-measurement response to grid conditions
- Integration with solar PV system
- Efficiency of GIV system (measure of cost of providing a grid service)
- Robustness to transients and faults
- Usability of standard Application Programming Interface
- Standards-based tests: Compliance with IEC 61851-1 Annex D, SAE J3068, IEEE 1547, J3072, and final J3068 standard

**Physical and Logical Network Connections**



# Subcontractor TBA (Utility Research Organization)

| Topic Area | Technology Area(s) |
|---|---|
| **2 – Communication and Control Systems** | Communications<br>Data Management<br>Energy Management Systems |

## Approach / Strategy

**Project Title:** End-to-End Communication and Control System to Support Clean Energy Technologies

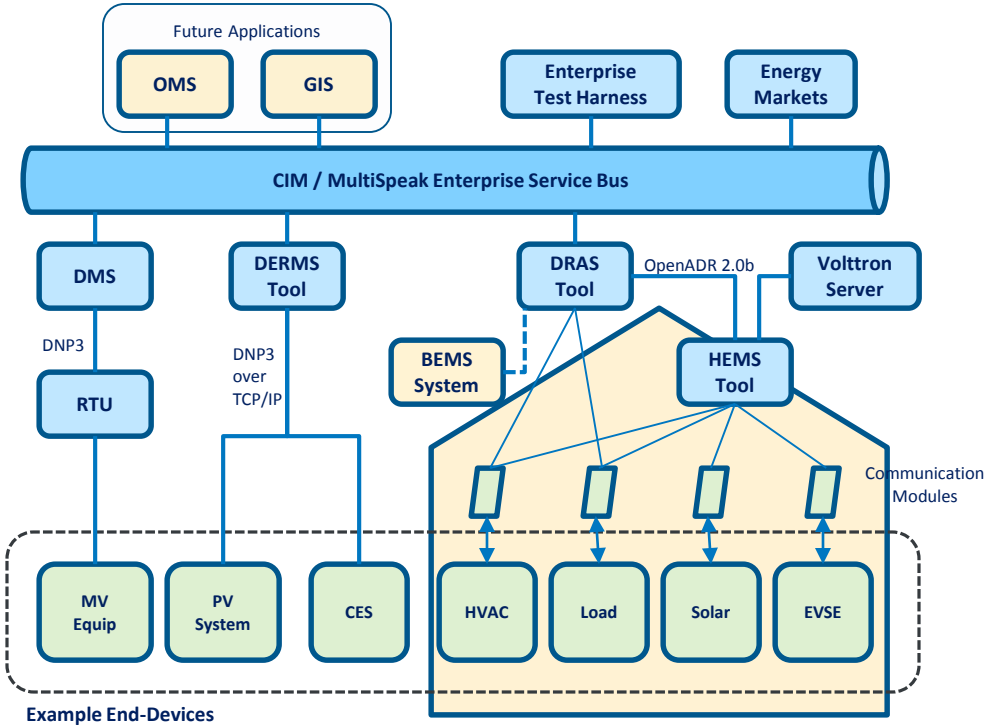
**Project will advance intelligent control of devices by integrating operation of different domains within distribution systems (DMS, demand response service, residential appliance scheduling) through open source software tools.**

The proposed CIC system is architected in a fashion that is consistent with that of an electric utility.

**The framework includes an enterprise integration test environment, commercial, Advanced Distribution Management System (ADMS), open software platforms, open Home Energy Management System (HEMS) platform, communication modules, and applications.**

## Project Partners

- ADMS provider
- HEMS provider
- OpenDERMS provider
- Business management consultant




This project incorporates open standards in a mixed standard environment. OpenADR2.0b, Common Information Model (CIM), MultiSpeak®, CEA-2045, IEC61850-90-7, and DNP3 will co-exist, much as they might at a utility in the near future.

# Omnetric Group

| Topic Area | Technology Area(s) |
|---|---|
| **3 – Integrated Systems** | Grid Management<br>System Controls<br>Communications |

## Approach / Strategy

**Project Title:** Distributed Intelligence Platform Reference Architecture Demonstration

**The project will demonstrate an Open FMB platform that will enable the grid to effectively support large-scale, complex operations, such as with distribution systems at electric utilities, which allow for an integration and wider penetration of renewable, clean energy resources**. The proposed solution will be validated using two use cases:

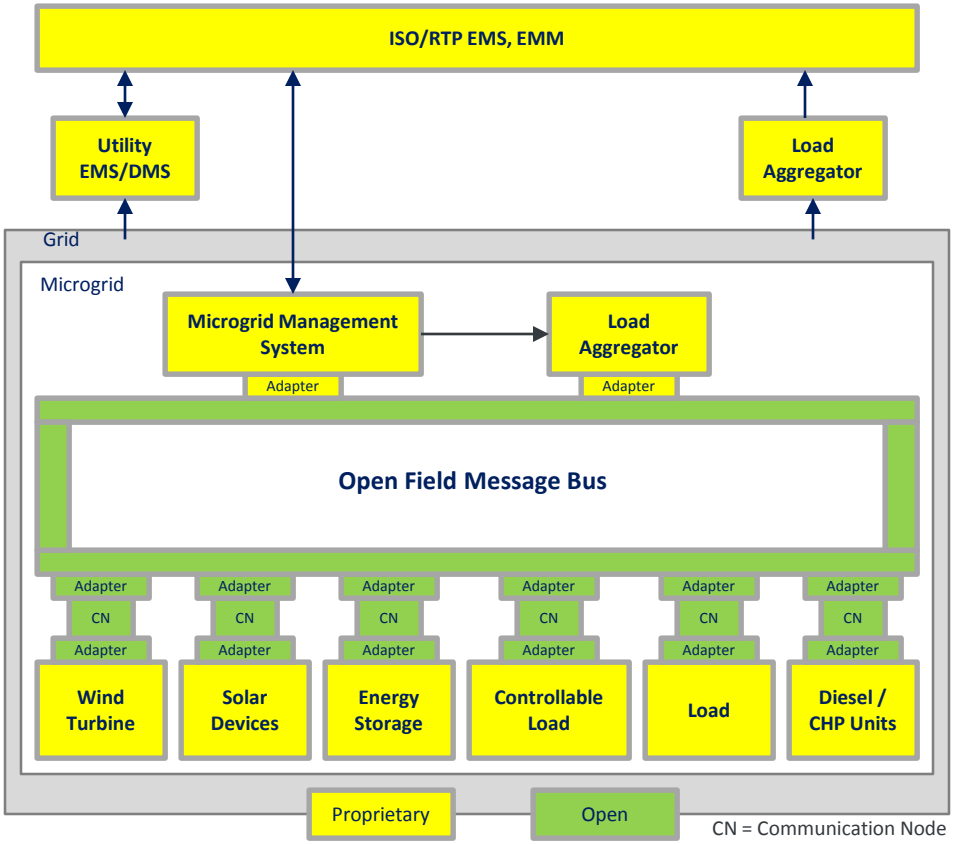
**Use Case 1:** Cost/benefit analysis comparing the baseline system with different designs incorporating the Open FMB architecture/control.

**Use Case 2:** Demonstration of Open FMB with load and power forecasting to improve operations of the distribution grid (e.g., load balancing).

* In addition to the ESIF demo, the Open FMB platform will be tested at two utility sites.

## Project Partners

- Omnetric Group is a joint venture between Siemens & Accenture Company
- Duke Energy (MacAlpine Microgrid Site, Raleigh, NC)
- CPS Energy (Joint Base San Antonio, TX)
- University of Texas at San Antonio (solar forecasting)



# Subcontractor TBA (ANM Solution Provider)

| Topic Area | Technology Area(s) |
|---|---|
| **3 – Integrated Systems** | System Controllers<br>Communications |

## Approach / Strategy

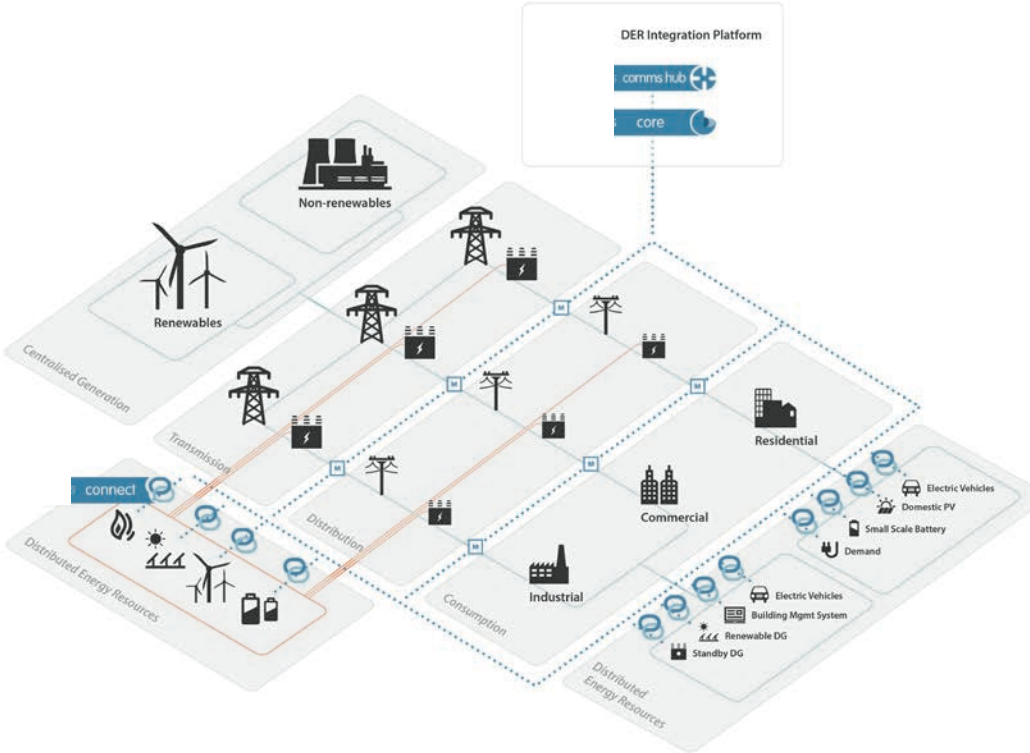
**Project Title:** Demonstrating Active Network Management INTEGRATion

**The Project Team will build a flexible plug-and-play distribution grid management solution based on existing commercial products.** The proposed Distributed Energy Resource (DER) integration platform leverages an existing ANM system and Smart Energy Platform.

**The Project Team will deploy and demonstrate an integrated, flexible, and innovative solution to enhance grid hosting capacity and services for renewable energy through coordination of renewable energy generators and other forms of DER.**

## Project Partners

- Consumer energy research institute
- Public utility
- Energy provider
- Smart grid consortium



# Mix of Technologies

The INTEGRATE demonstrations will evaluate connected devices/equipment, CIC technologies, as well as integrated systems incorporating multiple DER and communication and control systems.

| | Connected Devices / Equipment | | | | | | | | | | | CIC | | | Integrated Systems | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Topic Area | RE Systems (e.g., PV, wind) | Grid Connected Vehicles | Inverters | Fuel Cell Systems | Combined Heat & Power (CHP) | Battery Energy Storage | Thermal Energy Storage | Lighting | Refrigeration | Heating/Cooling Systems | Home Appliances | Other Connected Devices | Communications | Control Systems | Cybersecurity | Smart Home EMS | Campus EMS | Microgrid EMS | Distribution System Control |
| Topic 1 Projects | ✓ | ✓ | ✓ | | | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | | | | |
| Topic 2 Projects | | | | | | | | | | | | | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| Topic 3 Projects | ✓ | ✓ | ✓ | | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

# Technical Accomplishments and Progress

- RFP issued 5/22/2014, closed 7/22/2014
- Projects selected 9/11/2014
- Subcontract negotiation Q1/Q2 FY15
- First subcontract executed 1/30/2015
- First project kick-off meeting held 3/6/2015
- Commissioning of Topic Area 1 devices began 3/31/2015

# Response to Previous Year Reviewers' Comments

N/A – New Start

# Collaboration and Coordination with Other Institutions

| Topic Area | Project | Subcontractor | Project Partners |
|---|---|---|---|
| 1 – Connected Devices | Cohesive Application of Standards-Based Connected Devices to Enable Clean Energy Technologies | Electric Power Research Institute, Inc. | • PowerHub Systems<br>• Fronius<br>• ClipperCreek<br>• Emerson<br>• Pentair |
| | Open V2X at ESIF | University of Delaware | • NRG Energy<br>• TransPower<br>• AutoPort |
| 2 – Communication & Control Systems | End-to-End Communication and Control System to Support Clean Energy Technologies | Subcontractor TBA (Utility Industry Research Organization) | • ADMS provider<br>• HEMS provider<br>• OpenDERMS provider<br>• Business management consultant |
| 3 – Integrated Systems | Distributed Intelligence Platform Reference Architecture Demonstration | Omnetric Corporation | • Omnetric is a joint venture between Siemens & Accenture Company<br>• Duke Energy<br>• CPS Energy<br>• University of Texas at San Antonio |
| | Demonstrating Active Network Management INTEGRATion | Subcontractor TBA (ANM Solution Provider) | • Consumer energy research institute<br>• Public utility<br>• Energy provider<br>• Smart grid consortium |

# Proposed Future Work

- INTEGRATE project demonstrations will take place over the next 18 months.
- Technologies outlined above will be installed and evaluated at the ESIF located at NREL.

# Summary

- NREL is supporting the development and validation of technologies under the INTEGRATE RFP.
- Five projects selected under three Topic Areas (1 – Connected Devices, 2 – Communication and Control Systems, and 3 – Integrated Systems).
- The technologies developed under these projects will be installed and evaluated at NREL's ESIF. These demonstrations will take place over next 18 months.