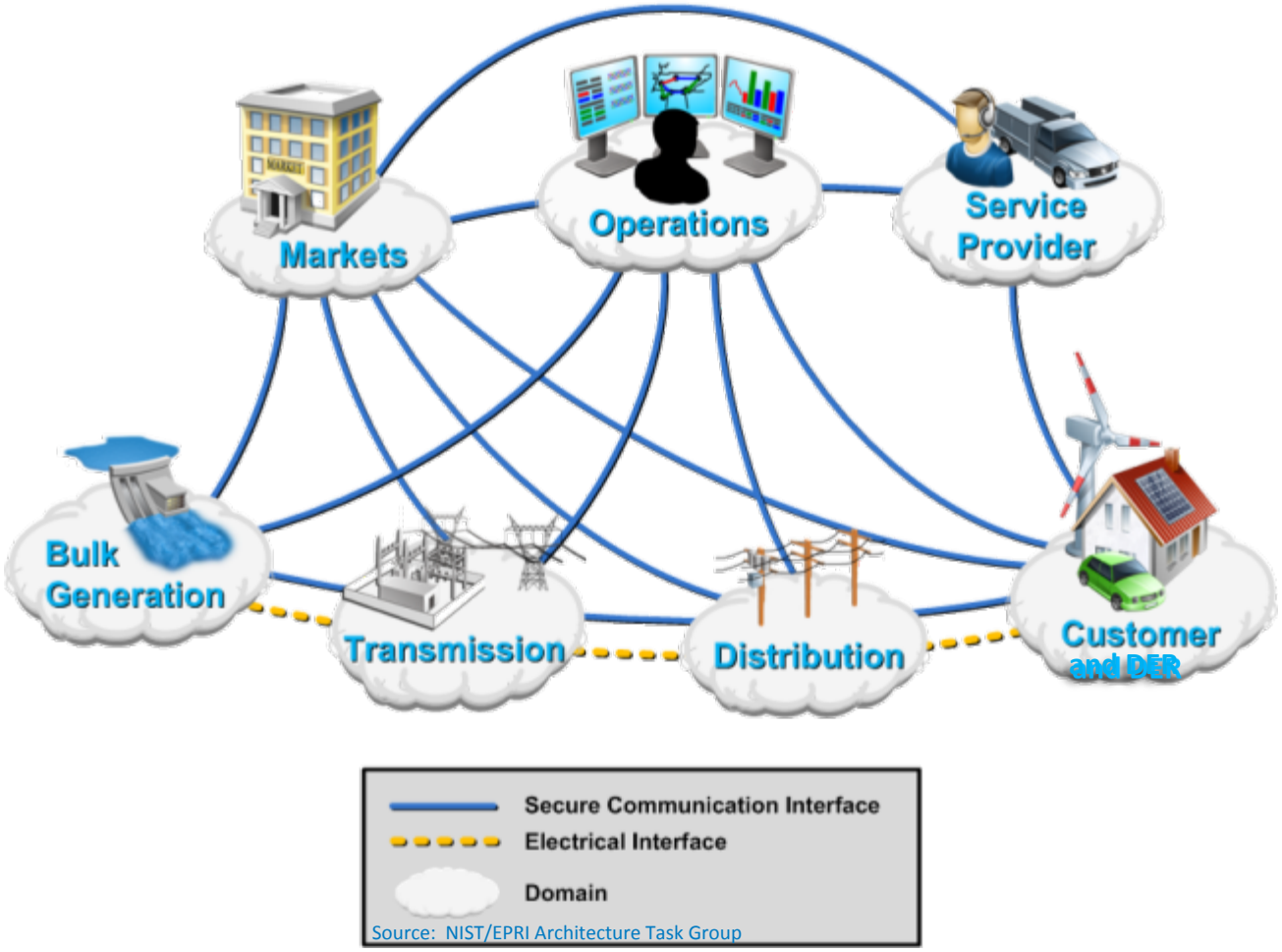
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Smart Grid Overview

Ben Kroposki, PhD, PE
Director, Energy Systems Integration
National Renewable Energy Laboratory

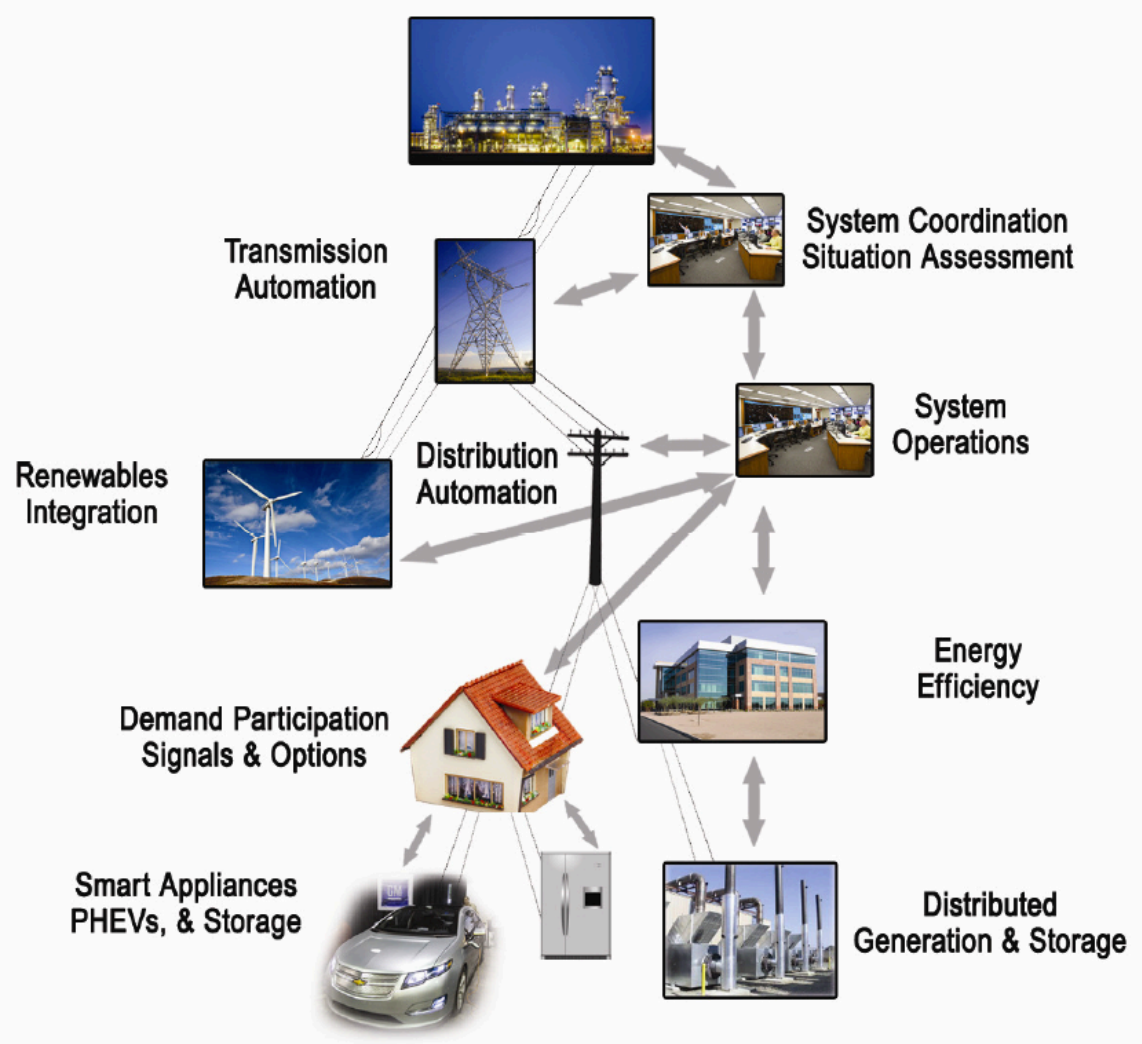
What is the Smart Grid?



The **Smart Grid** is the electricity production and delivery system along with consumption *integrated* with communications and information technology

The **Smart Grid** is an automated, widely distributed energy delivery network characterized by a **two-way flow of electricity and information**, capable of monitoring and responding to changes in everything from power plants to customer preferences to individual appliances.

Grid Modernization – Smart Grid Scope



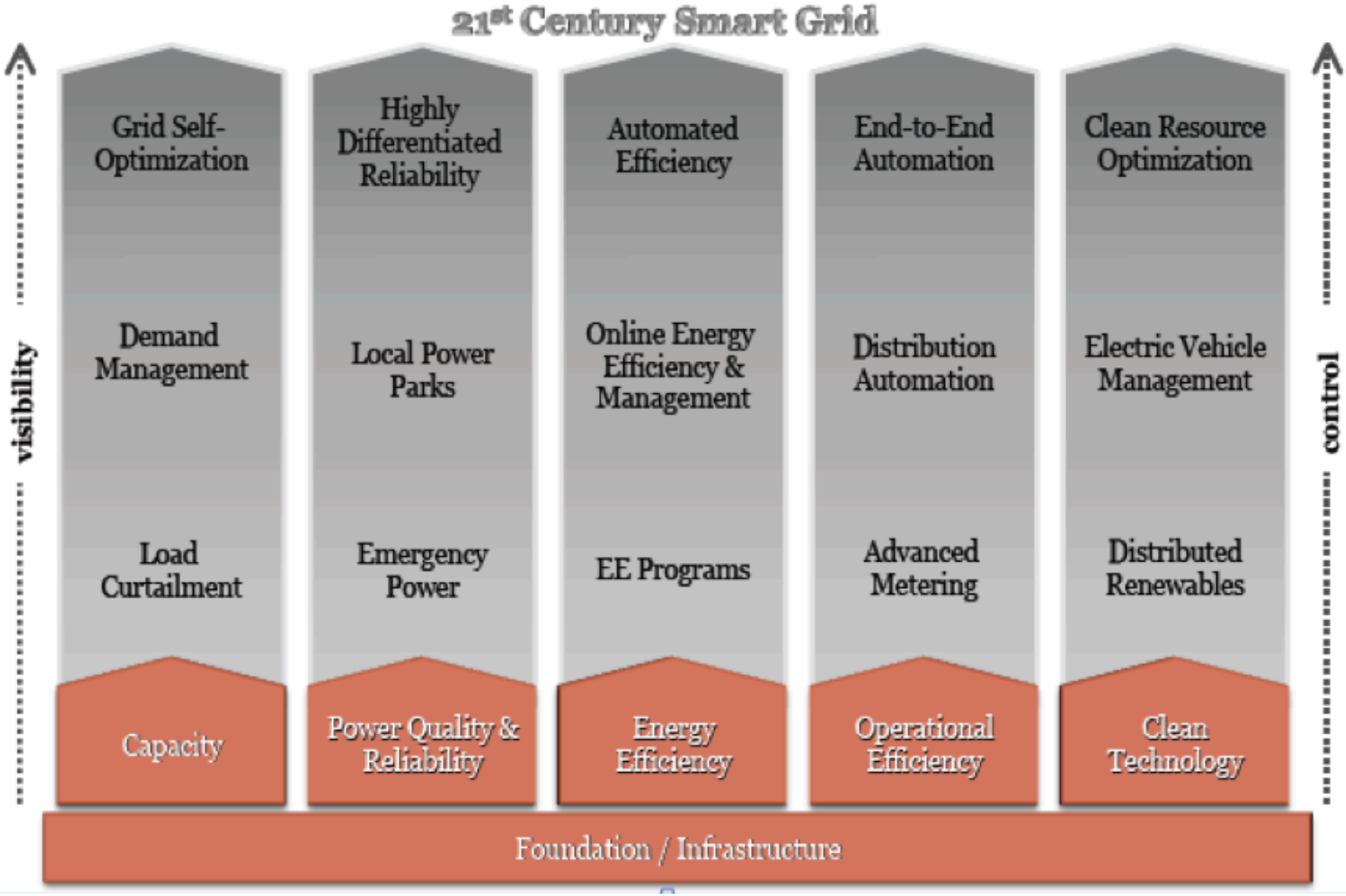
Transmission

Distribution

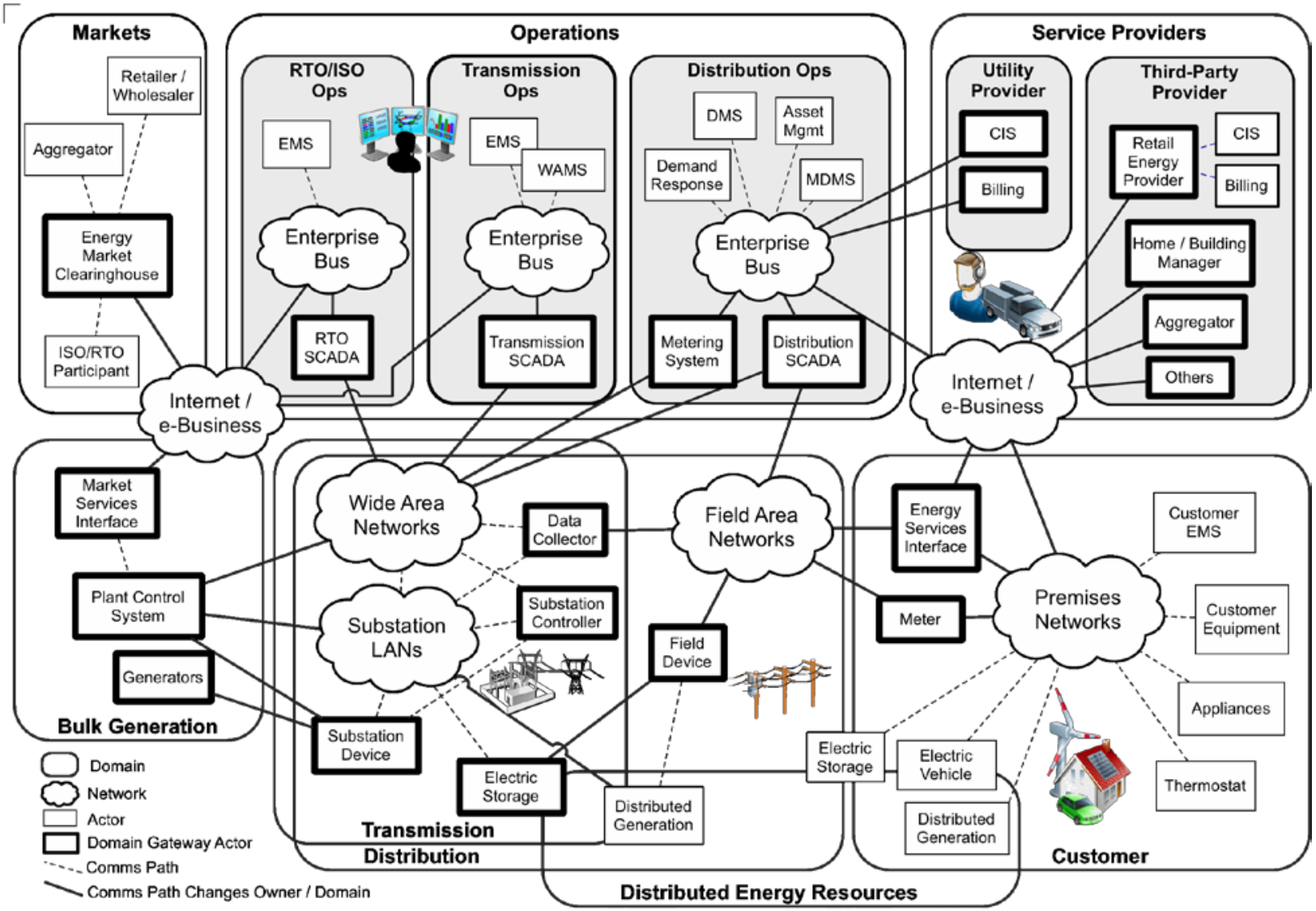
End-Use and DER

2010 Smart Grid System Report, February 2012 http://energy.gov/sites/prod/files/2010%20Smart%20Grid%20System%20Report.pdf

Smart Grid Vision



NIST Smart Grid Roadmap



NIST Framework and Roadmap Release 2.0 http://www.nist.gov/smartgrid/upload/NIST_Framework_Release_2-0_corr.pdf

Smart Grid R&D at NREL

- Development of Smart Grid Interoperability Standards (IEEE 2030) and Interconnection Standards (IEEE 1547)
- Integration of High Penetration of Renewables and Distributed Generation (Modeling, Simulation, Testing, and Analysis)
- Advanced Distribution System Operations (Microgrids and Intentional Islands)
- Control, Testing and Evaluation of dispatchable generation, loads and energy storage (V2G, GridAgents, and Energy Storage Testing)
- Development of Conformance Test Protocol for Smart Grid Technologies (Interoperability and Operations)
- Analysis of Smart Grid Projects www.smartgrid.gov

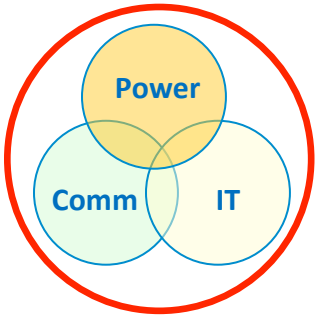
IEEE 2030 – Smart Grid Interoperability

Using the successful implementation model of IEEE 1547 – Interconnection of DR

IEEE Standard 2030

Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS) and End-Use Applications and Loads

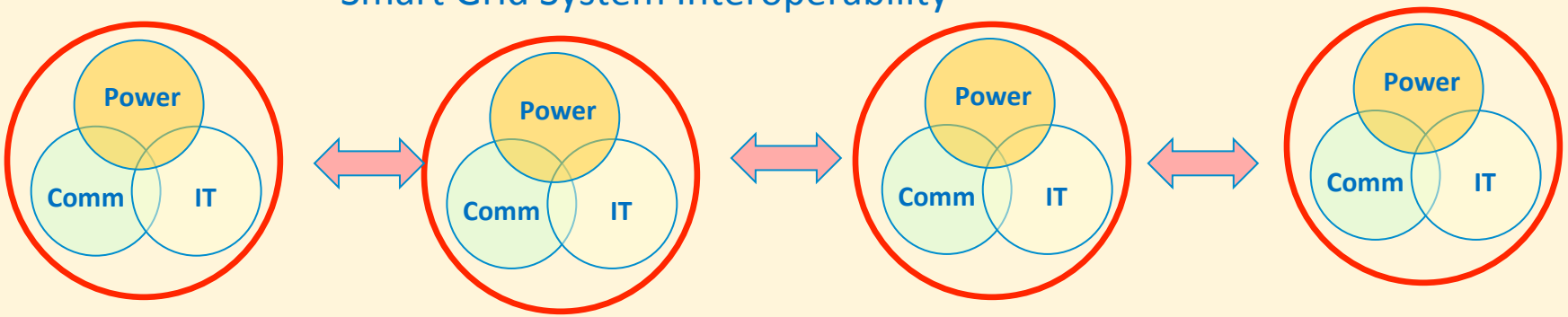
- Provides guidelines in understanding and defining smart grid interoperability of the electric power system with end-use applications and loads
- Focus on integration of energy technology and information and communications technology
- Achieve seamless operation for electric generation, delivery, and end-use benefits to permit two way power flow with communication and control
- Address interconnection and intra-facing frameworks and strategies with design definitions
- Expand knowledge in grid architectural designs and operation to promote a more reliable and flexible electric power system



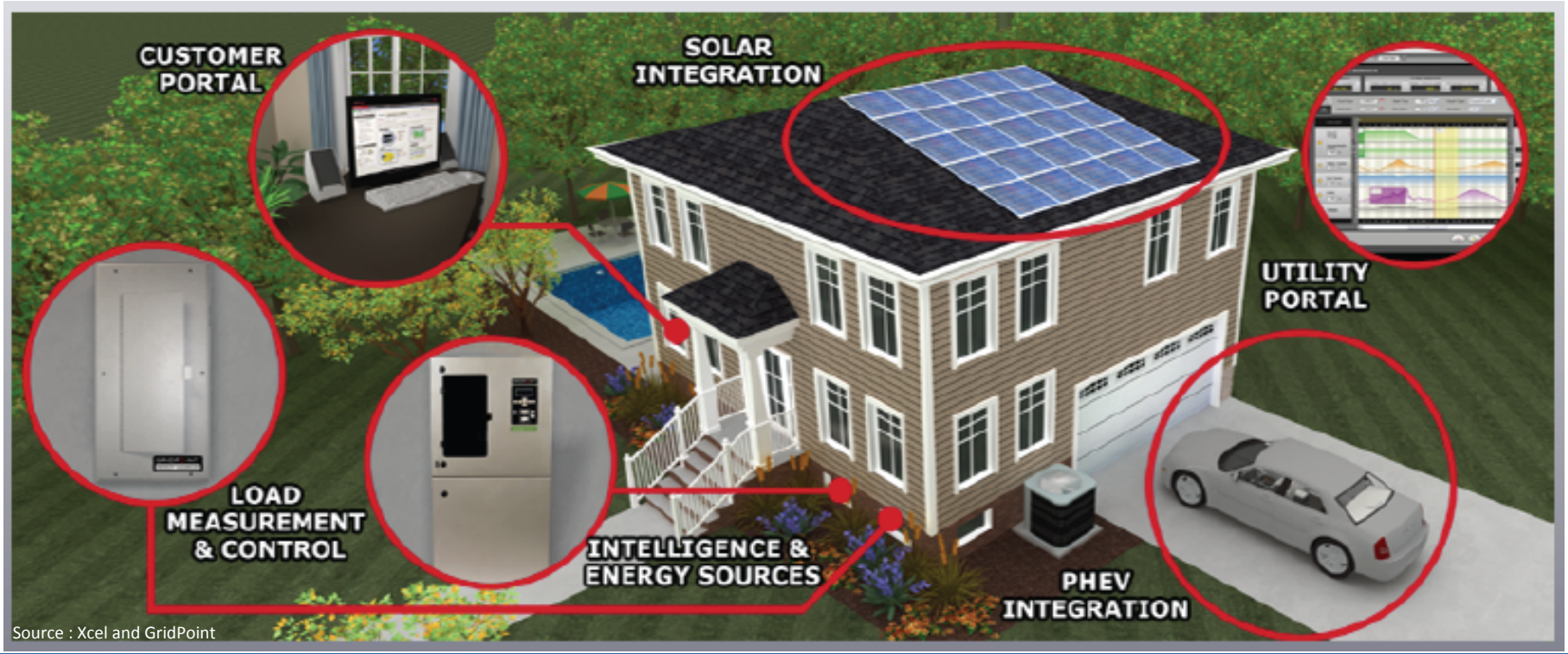
The published standard is available from http://www.techstreet.com/cgi-bin/detail?doc_no=ieee%7C2030_2011;product_id=1781311

Achieving Smart Grid Interoperability

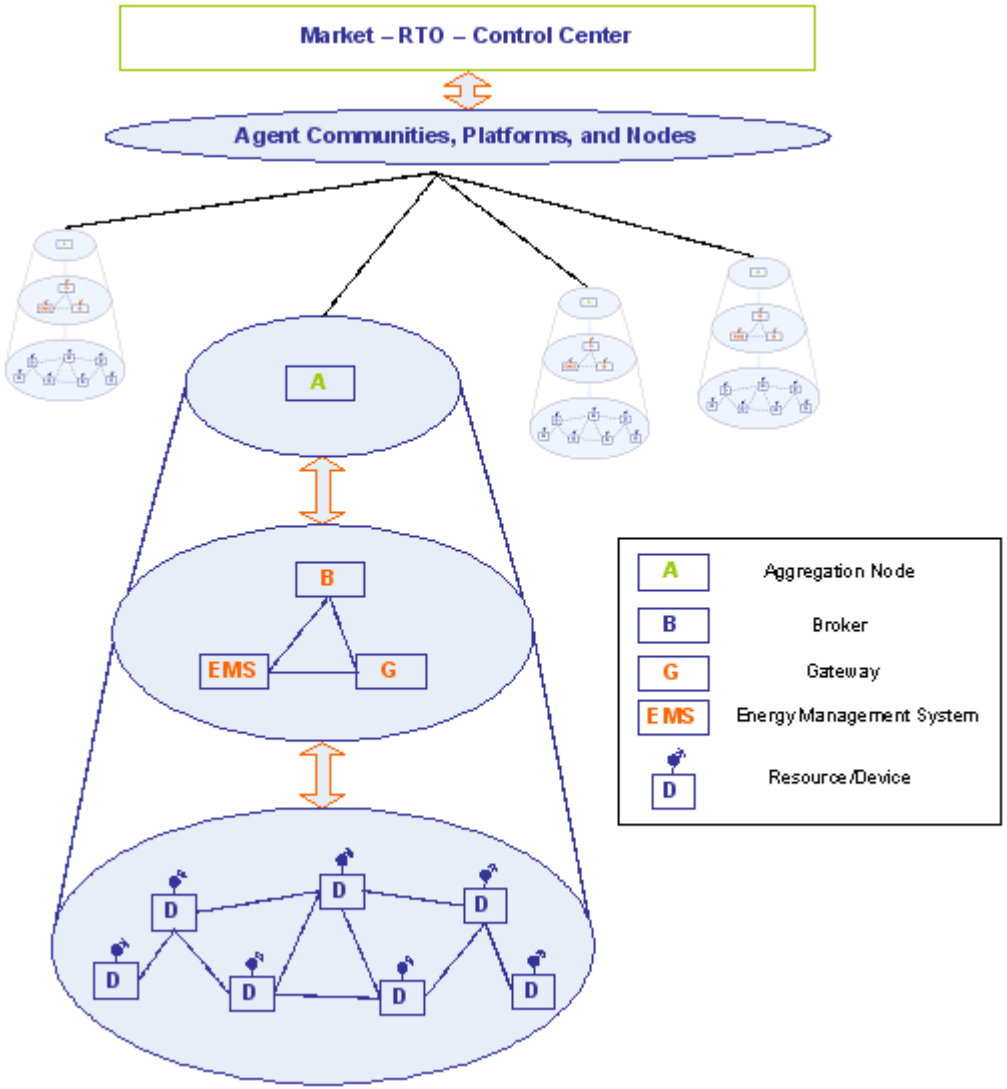
Smart Grid System Interoperability



Smart Grid Device Interoperability



GridAgent Testing and Applications

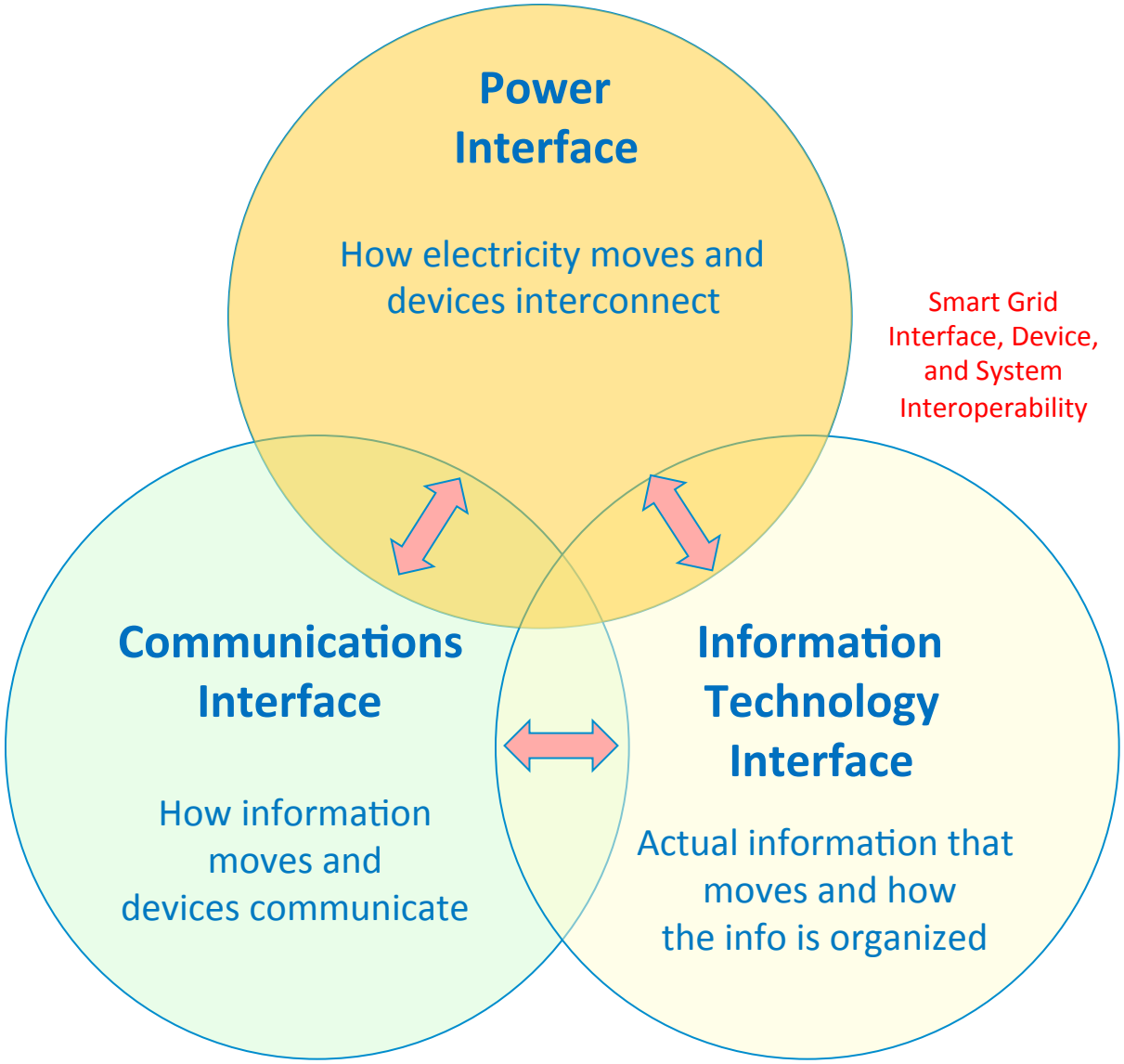


GridAgents are two-way communications and control devices that manage assets based on their properties and hierarchical relationships

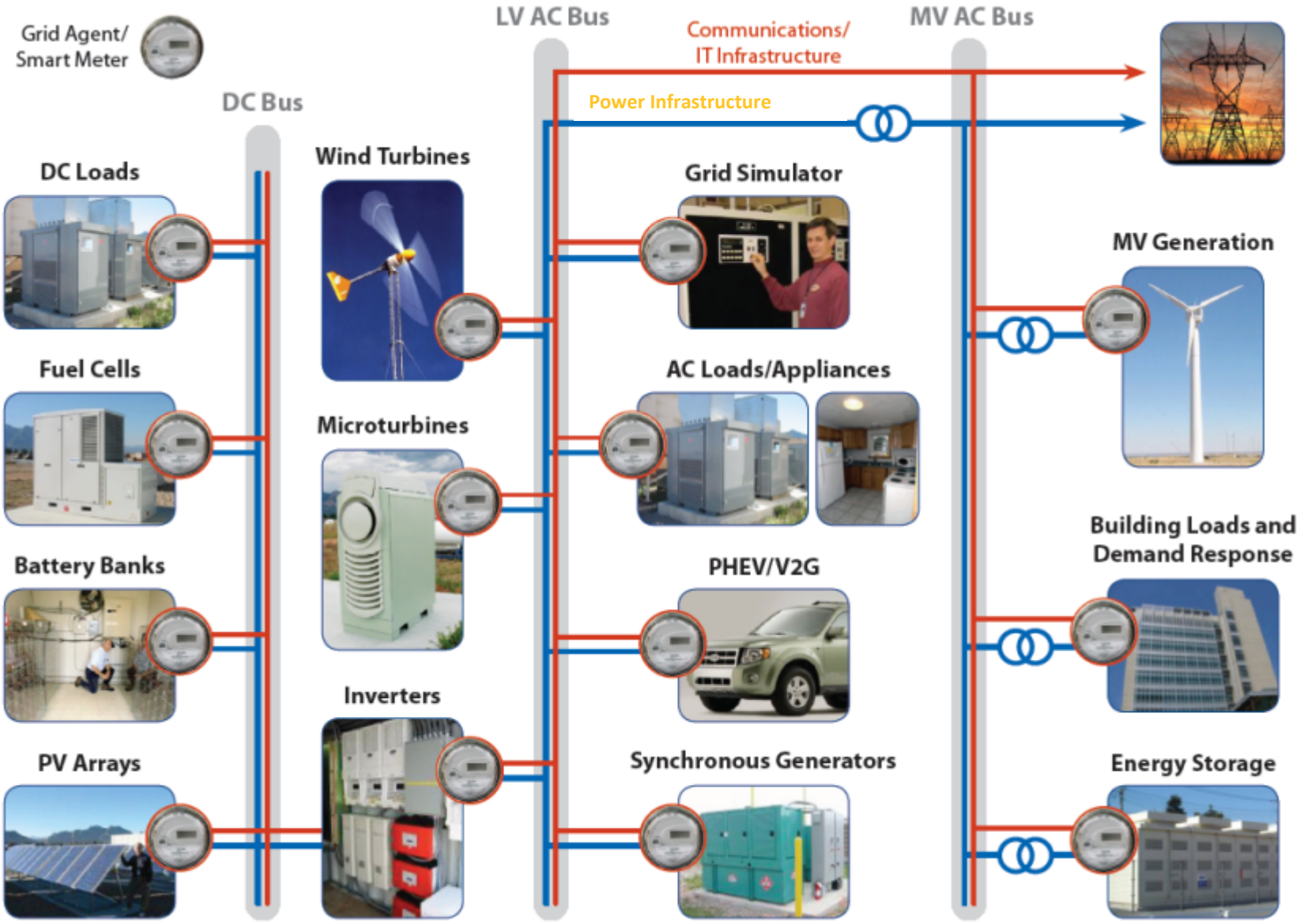
NREL is evaluating GridAgents for use with controlling distributed energy systems

Smart Grid Testing

- **Accelerate development and adoption of Smart Grid technologies**
- **Develop consensus-based standard test protocol**
- **Develop interoperability testbeds**
- **Achieve interoperability between interfaces and devices**

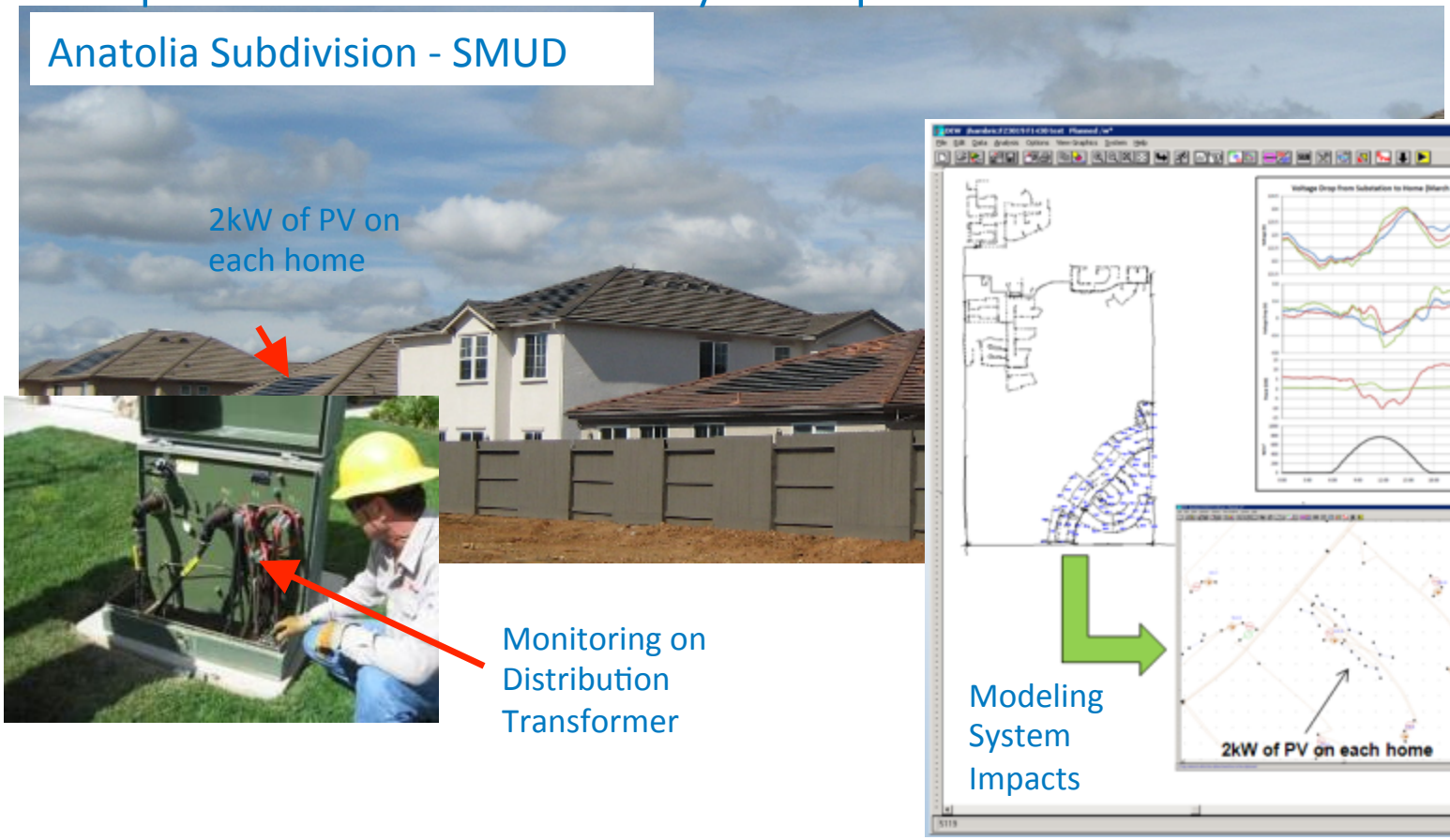


NREL Smart Grid Testing



Integration of Renewables into the Smart Grid

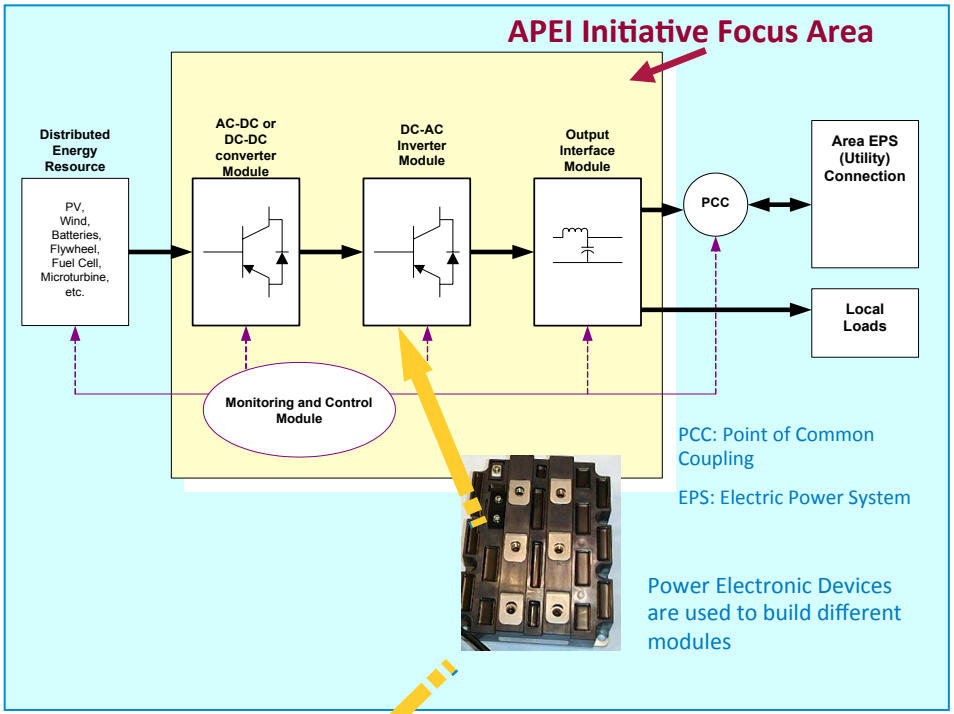
- NREL is working with several utilities to evaluate distributed PV grid impacts
- Monitoring performance and modeling distribution feeder impacts and incorporation of renewables in system operation

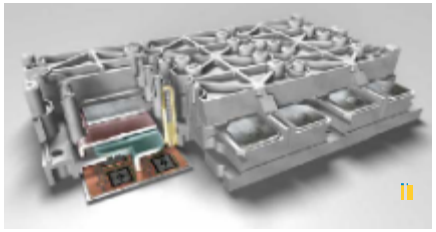


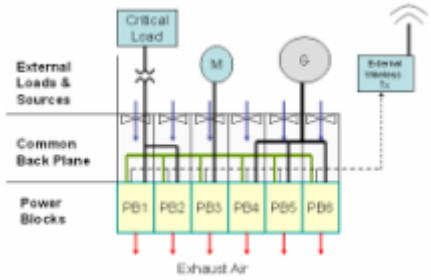
Smart Distributed Energy Interfaces

Advanced Power Electronics Interfaces

- NREL is working with the California Energy Commission and several industry partners to develop a standardized, highly integrated, **modularized power electronic interconnection technologies** that will come as close as possible to "plug-and-play" for distributed energy resource (DER) platforms.
- The goal is to develop power electronics technology that improves and accelerates the use of DER systems.
- Reduce costs for DER and interconnections by developing standardized, high production volume, power electronic modules.

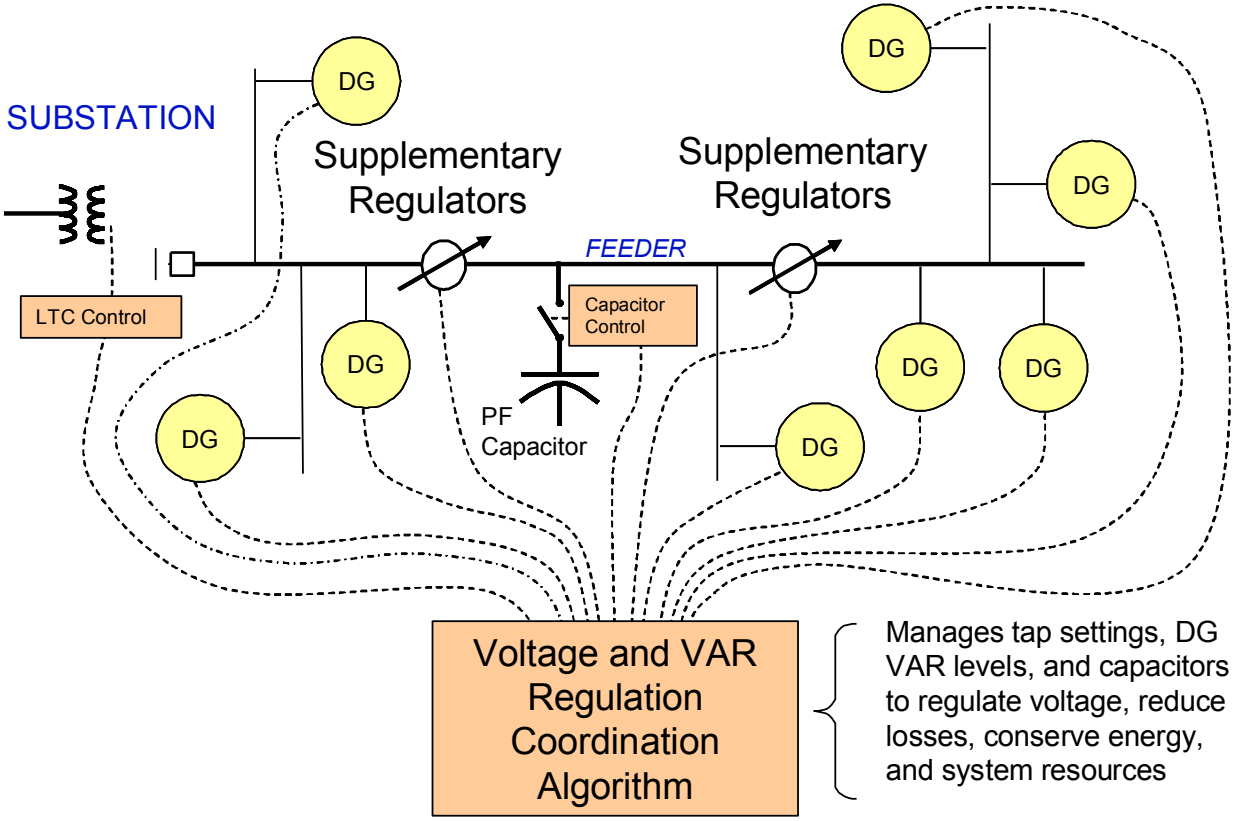






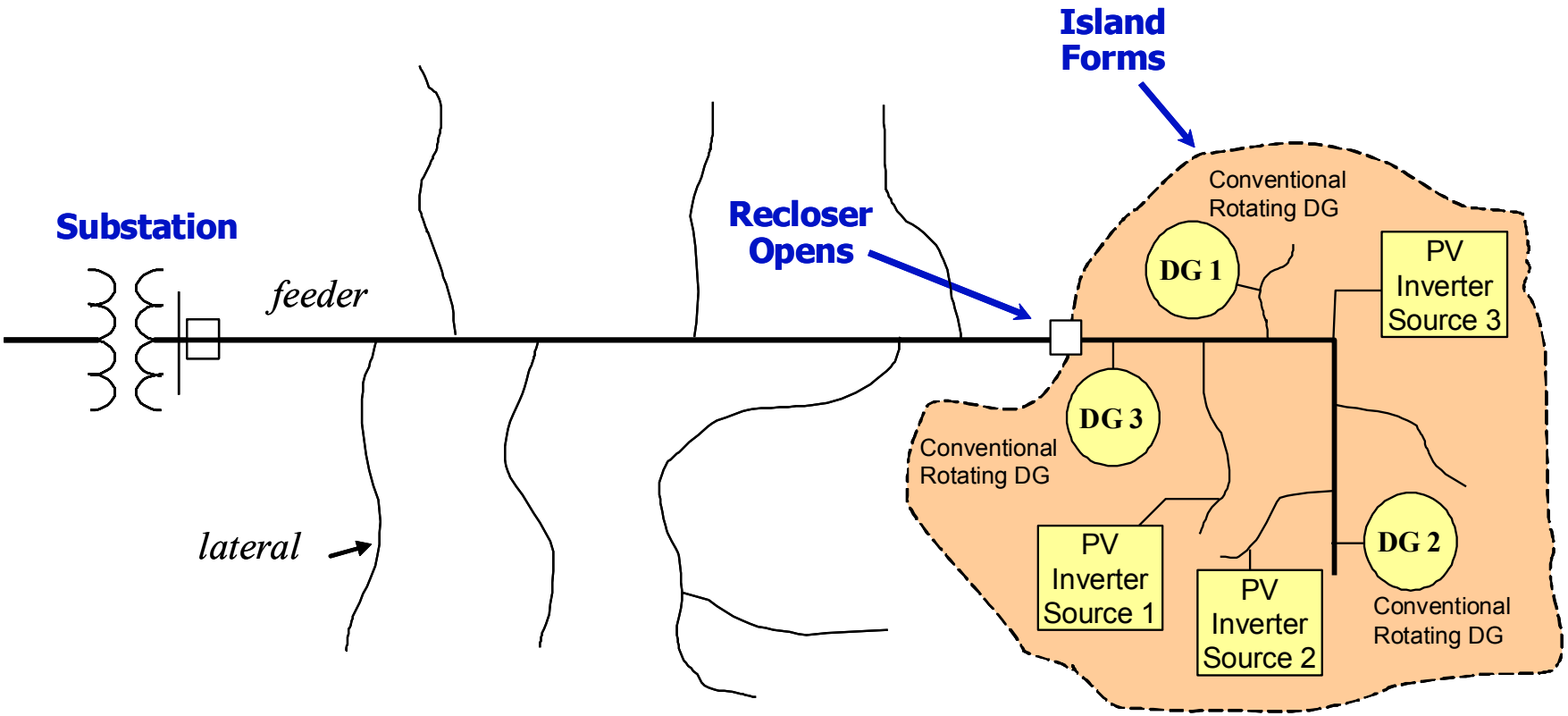
Smart Grid – Advanced operations

At high penetration levels, DG needs to actively participate in grid functions like voltage regulation. NREL is evaluating advanced DG operations



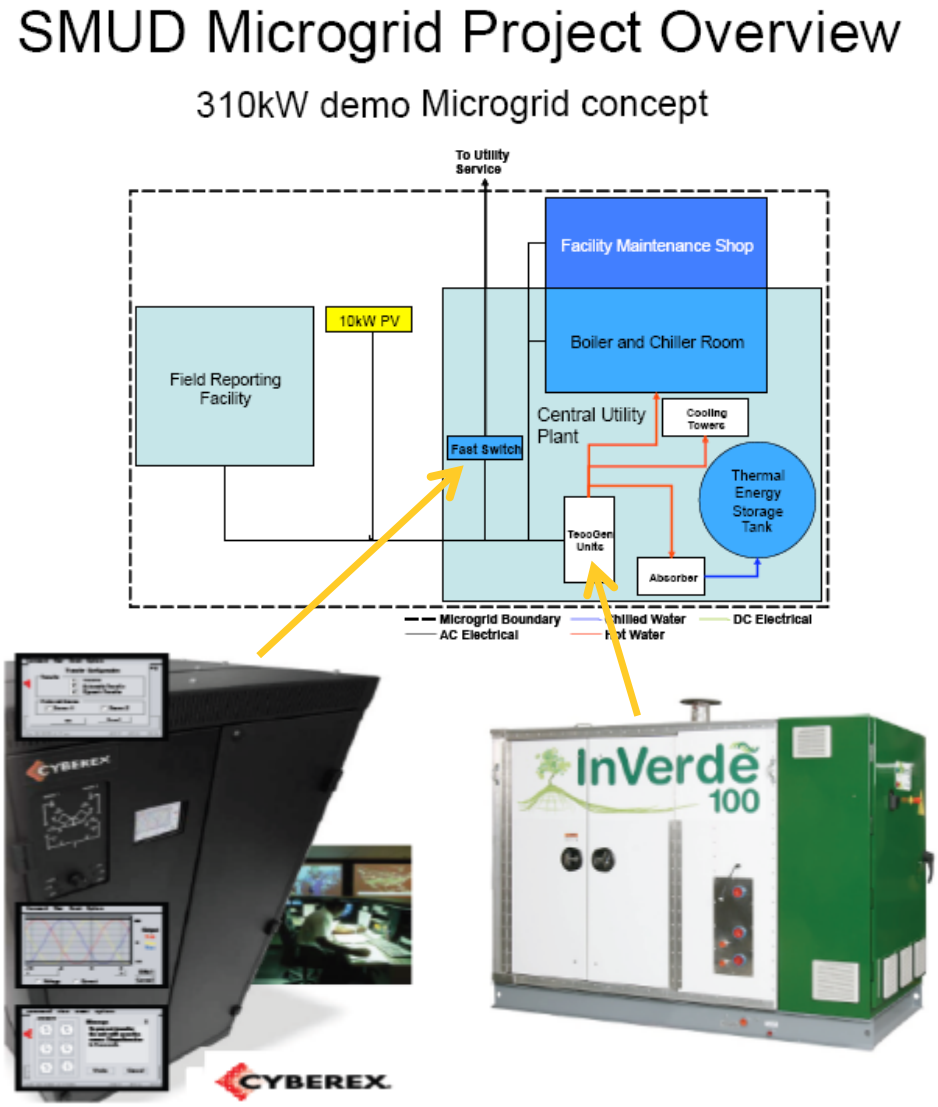
Microgrids – Advanced operations

Distributed PV needs to integrate with other DG and Energy Storage to form Microgrids for increased reliability.
NREL has the ability to model and test microgrids.



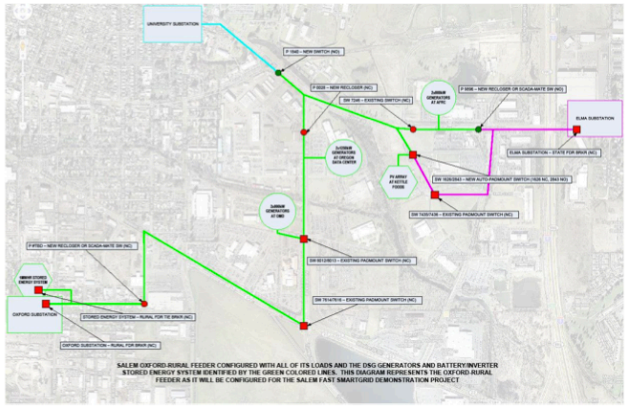
MicroGrid Testing for SMUD

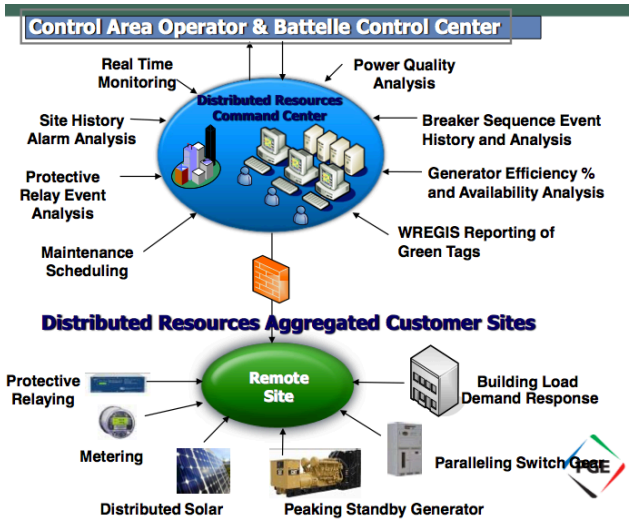
- Sacramento Municipal Utility District (SMUD) is installing a microgrid at their headquarters
- NREL completed testing of newly developed microgrid switch technology from Cyberex and two 100kW Tecogen CHPs with inverter/droop control
- NREL power testing of microgrid configurations reduces risk of operational performance



Portland General Electric Microgrid

High Reliability Zone Map





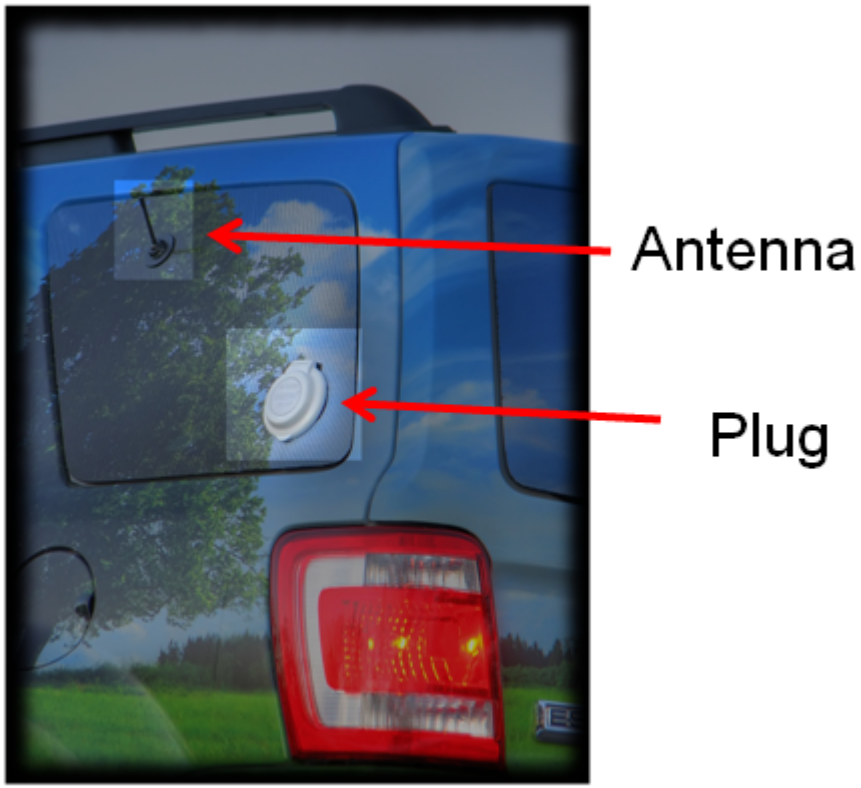
Smart Inverter

Energy Storage

V2G Testing and Applications

NREL conducts testing EV and PHEVs for Vehicle-to-Grid (V2G) application

Developing Standard test protocol for V2G



Smartgrid.gov

SmartGrid.gov is a resource for information about the Smart Grid and government-sponsored Smart Grid projects. The information on SmartGrid.gov helps consumers and stakeholders understand the basics of a Smart Grid and the range of Smart Grid technologies, practices and benefits.

Thank you

Ben Kroposki

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http://www.nrel.gov/esi