Communication and Control for Inverters

Presentation for DOE High-Tech Inverter Workshop

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EPRI

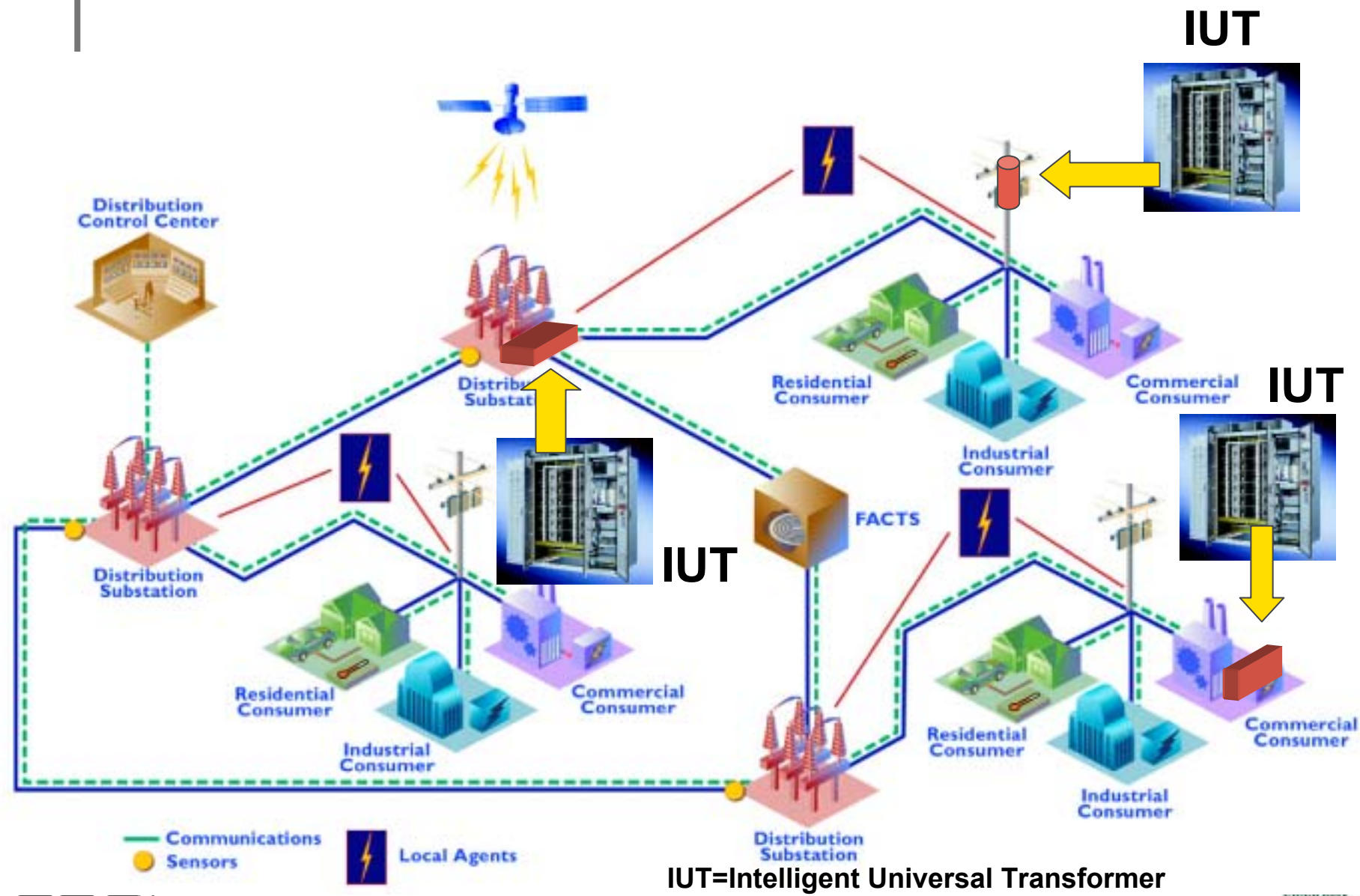
Electricity Innovation Institute

Overview

- Power Electronics in the Distribution System of the Future: Advanced Distribution Automation (ADA™)
- Integrating Distributed Energy Resources* (DER) into Open Communication Architecture Standards for Future Power Systems
- E2I CEIDS Project on DER/ADA Open Communication Architecture Standards

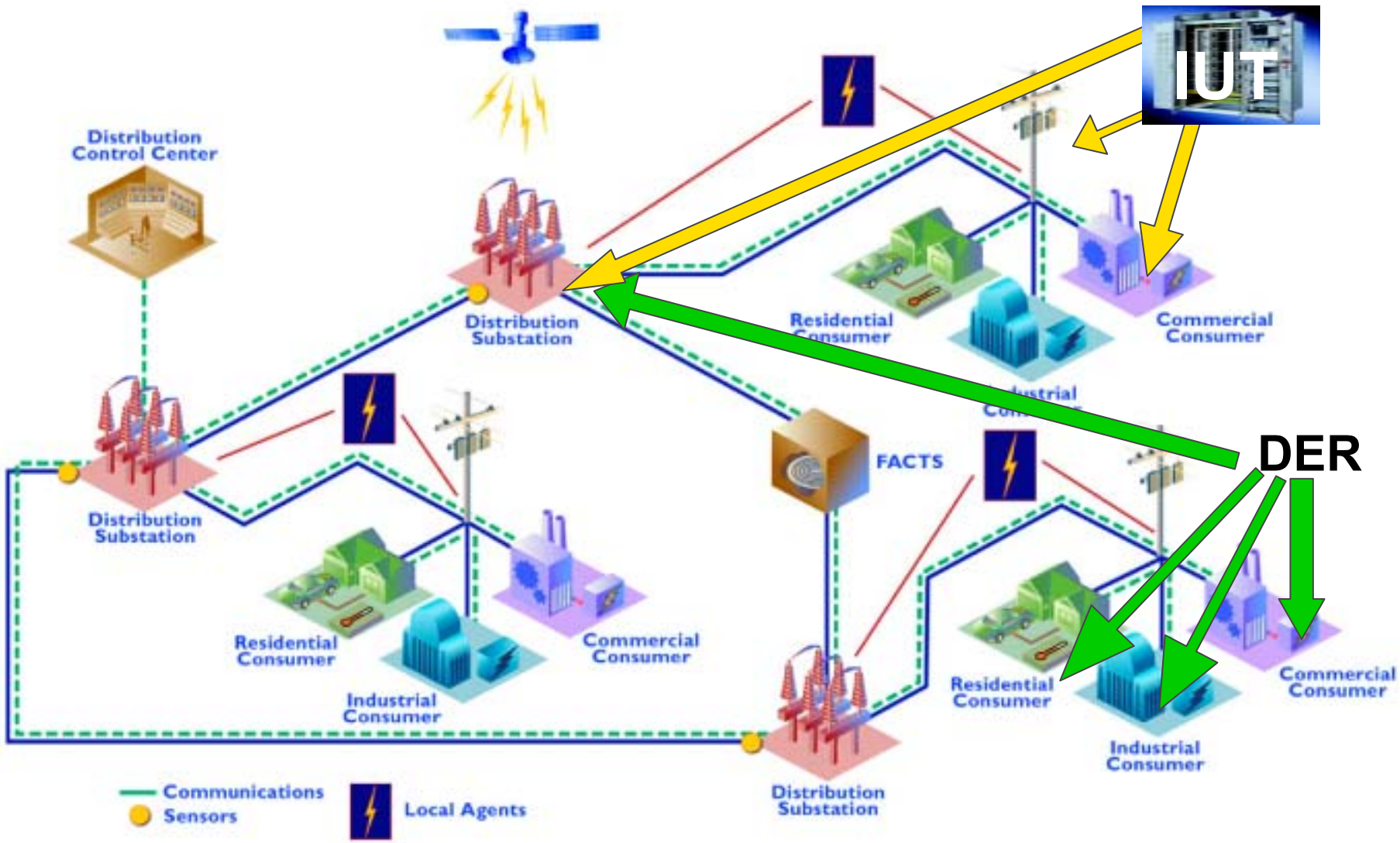
**Specifically, distributed generation and storage*

ADA creates the distribution system of the future



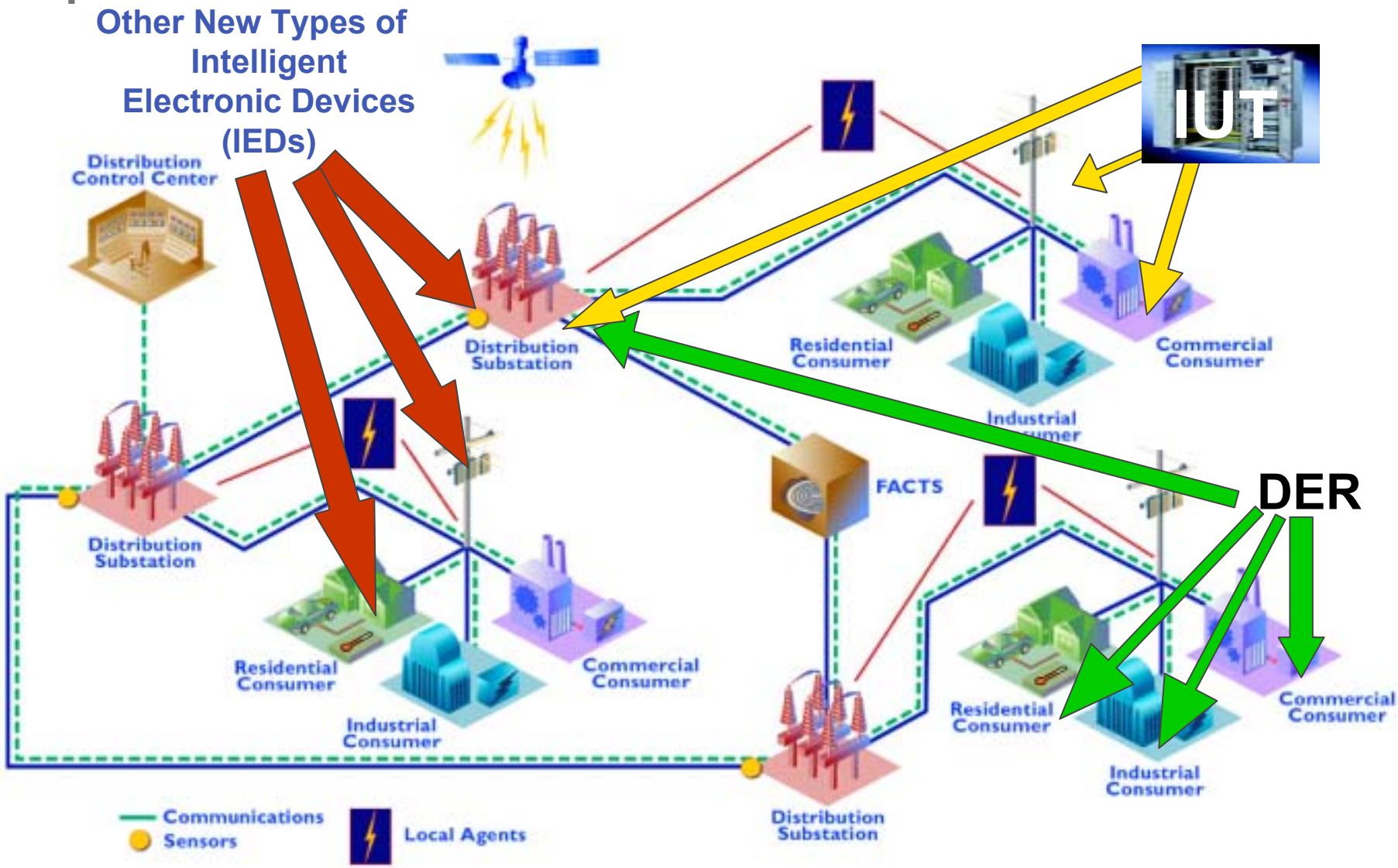
IUT=Intelligent Universal Transformer

DER integration is a component of ADA



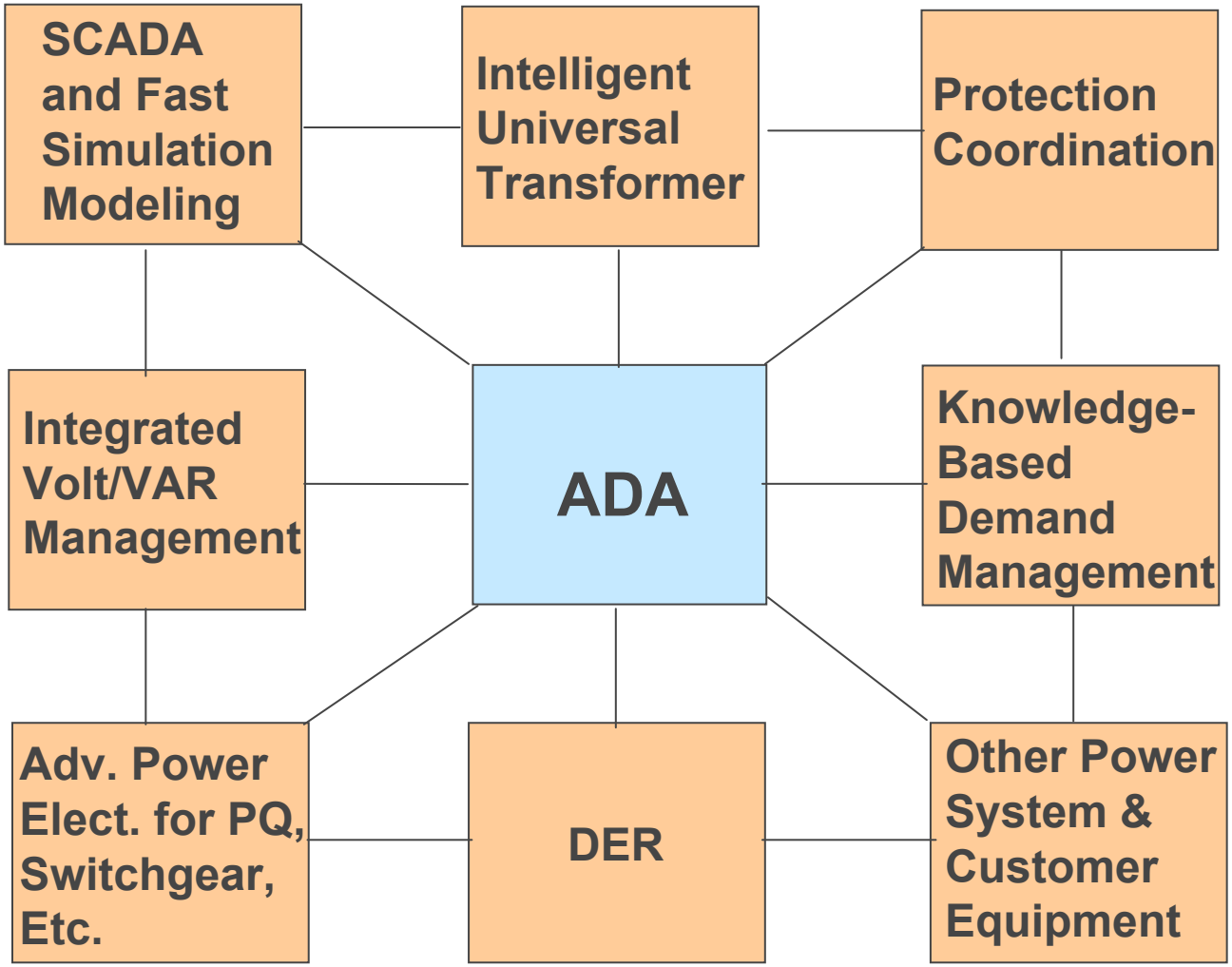
IUT=Intelligent Universal Transformer

Other IEDs will be components of ADA

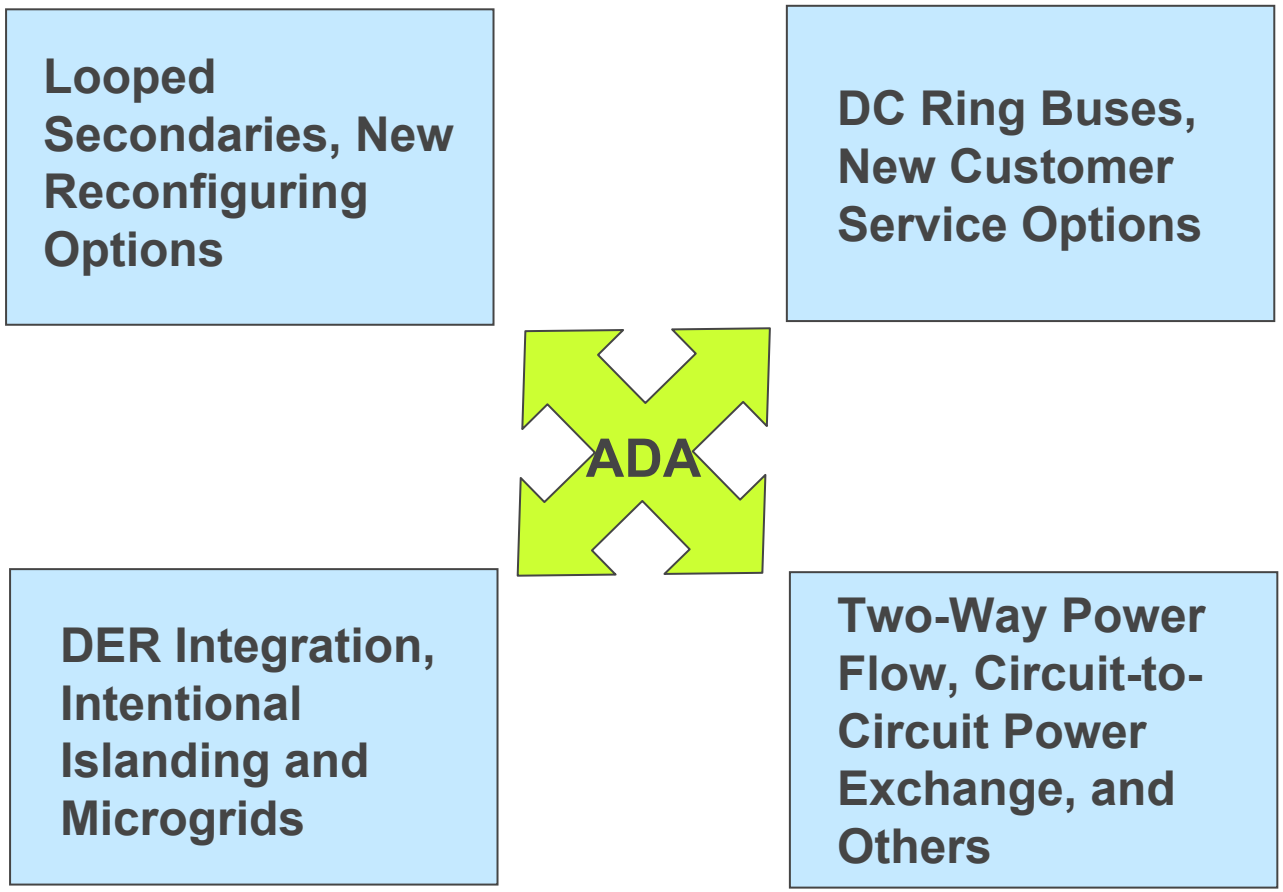


IUT=Intelligent Universal Transformer

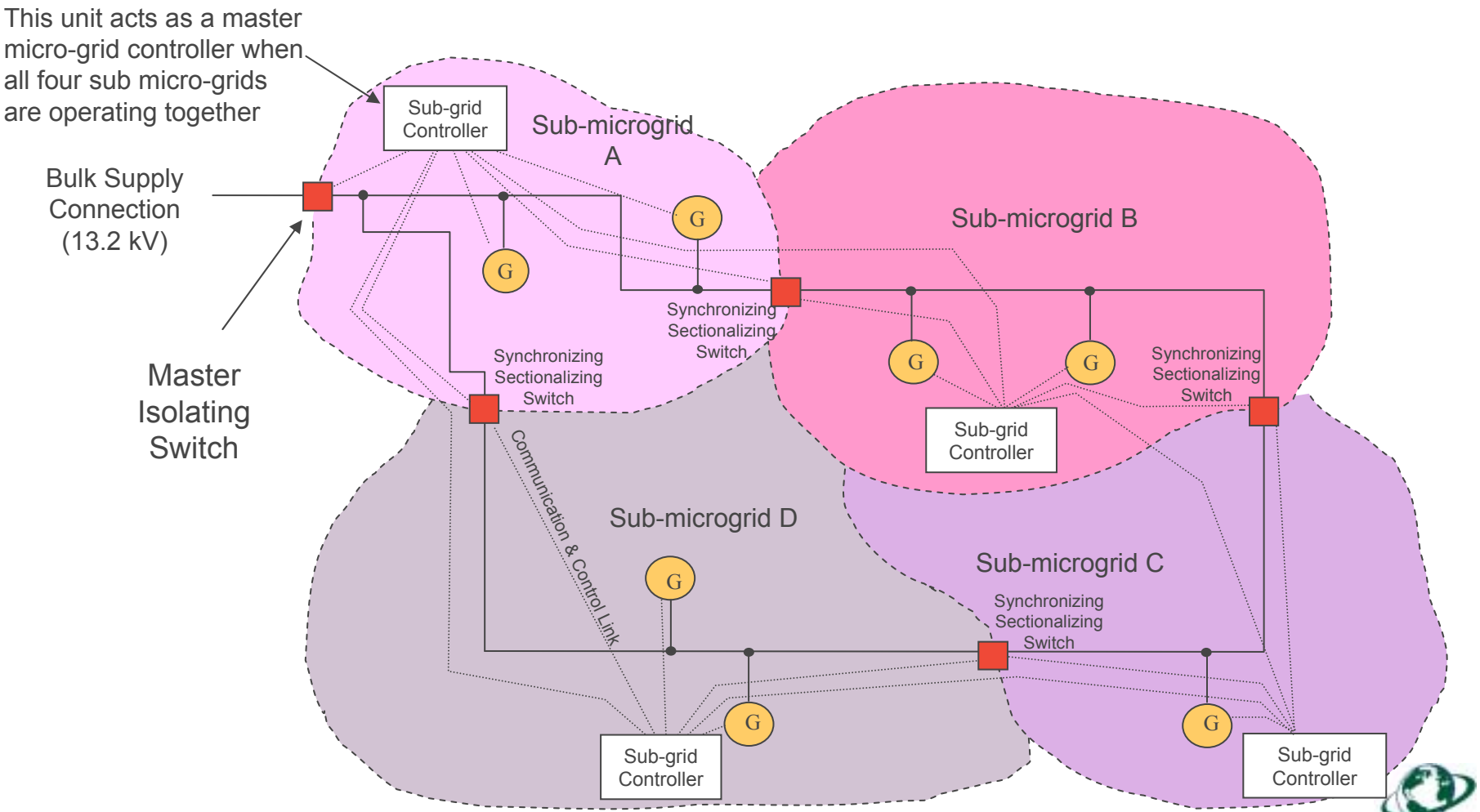
Future Distribution System Components Will Be Intelligent Electronic Devices (IEDs) That Are *Interoperable*



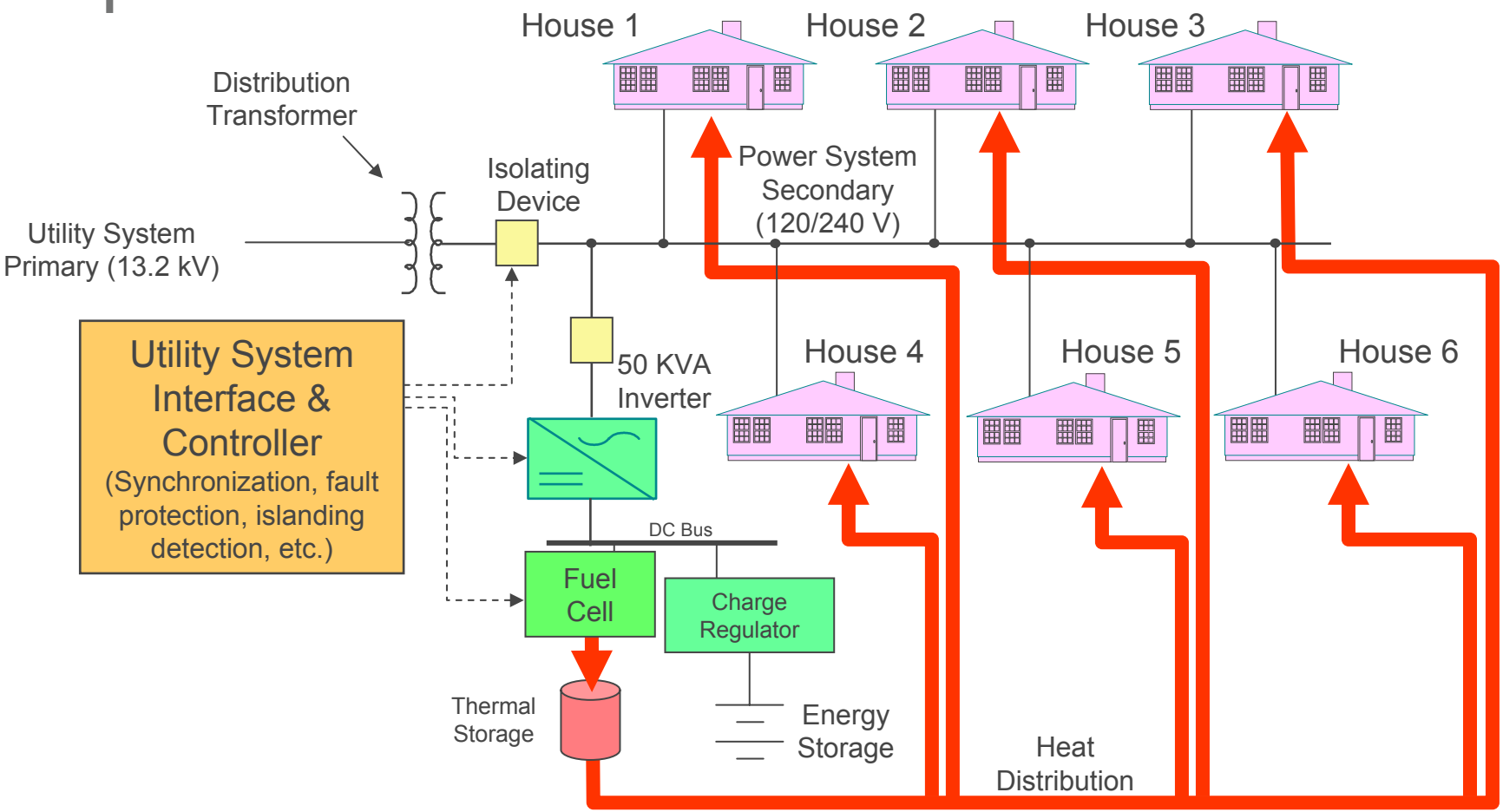
ADA Enables New Electrical System Configuration Concepts—Intelligence is the Key



Adaptable Microgrid – Breaks Apart into Multiple Regions



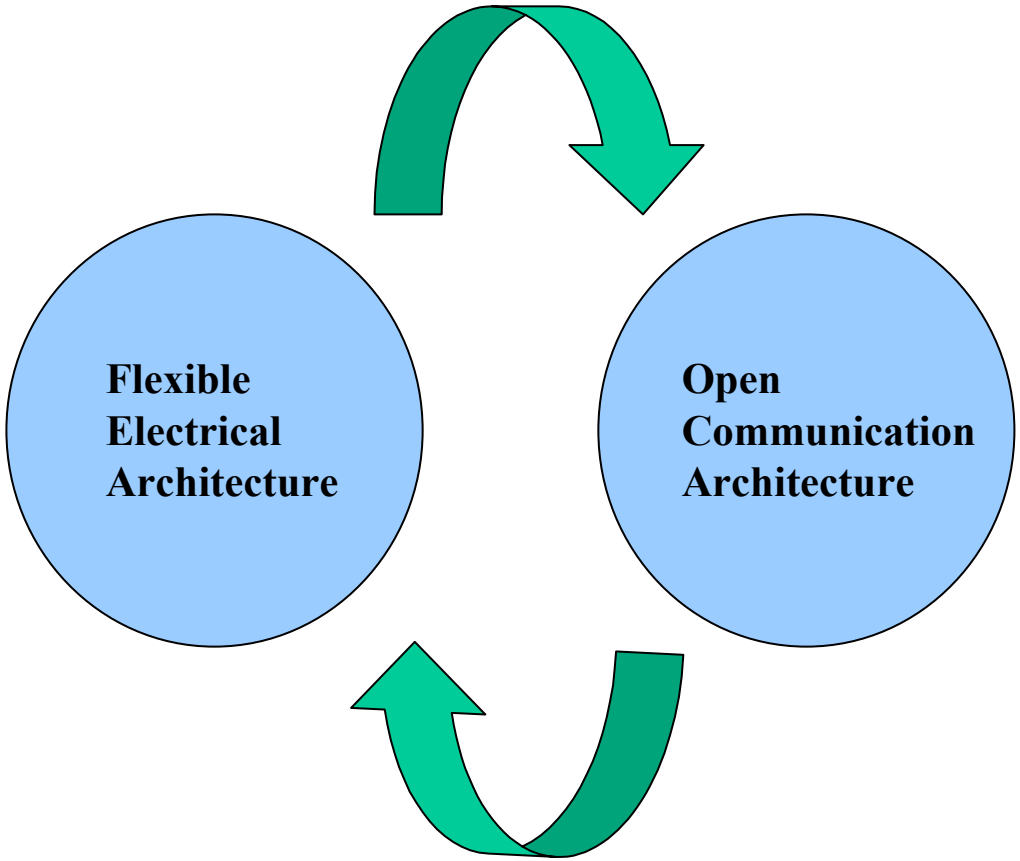
A Six-Home Microgrid



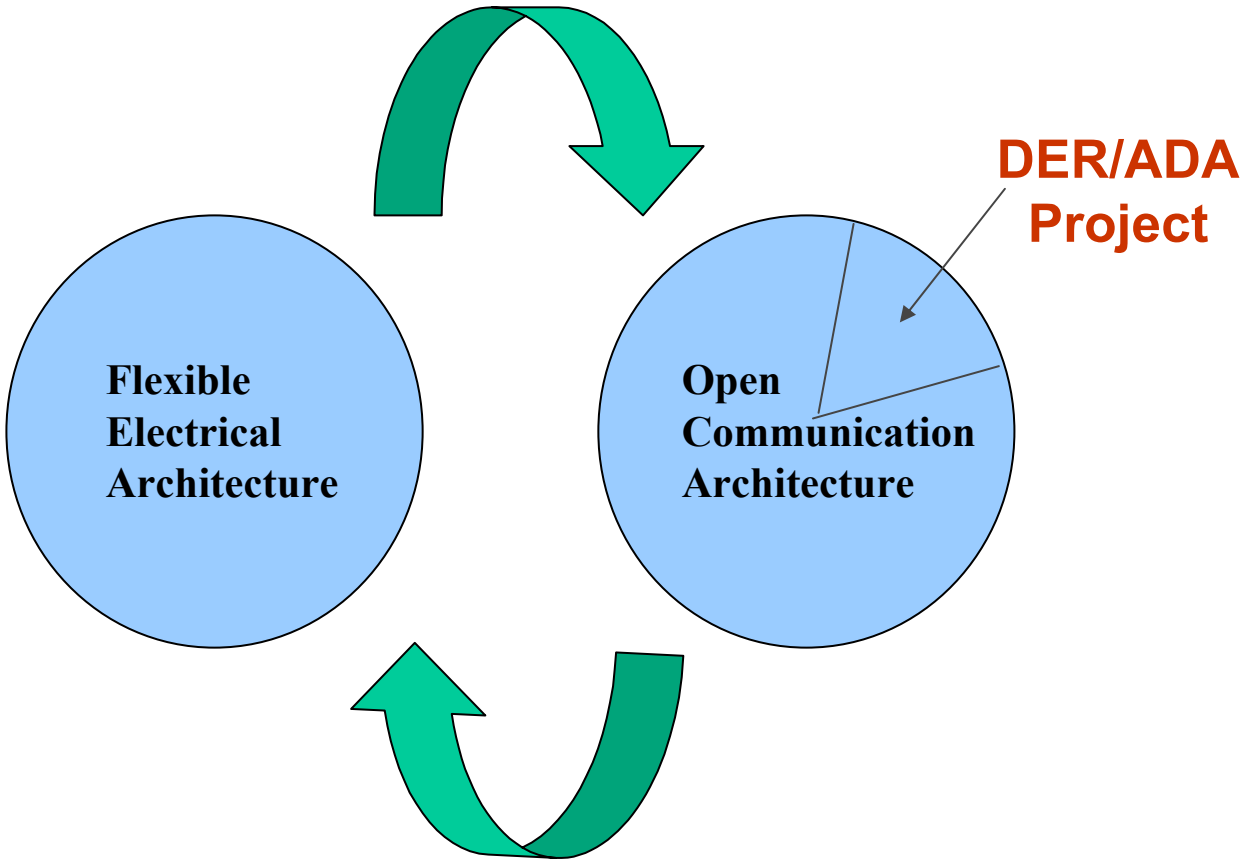
The CEIDS DER/ADA Standards Project Objectives

- **Develop** internationally-promulgated DER communication object model **standards** that will enable the strategic use of DER in ADA for functions such as
  - Routine energy supply, peaking capacity, voltage regulation, power factor control
  - Emergency power supply, harmonic suppression, and disaster recovery operations (e.g., intentional islanding or “microgrids”)
- Establish methodology for standardized object model development
- Coordinate with other related work, identify gaps, and implement plans for filling the gaps via other new project work

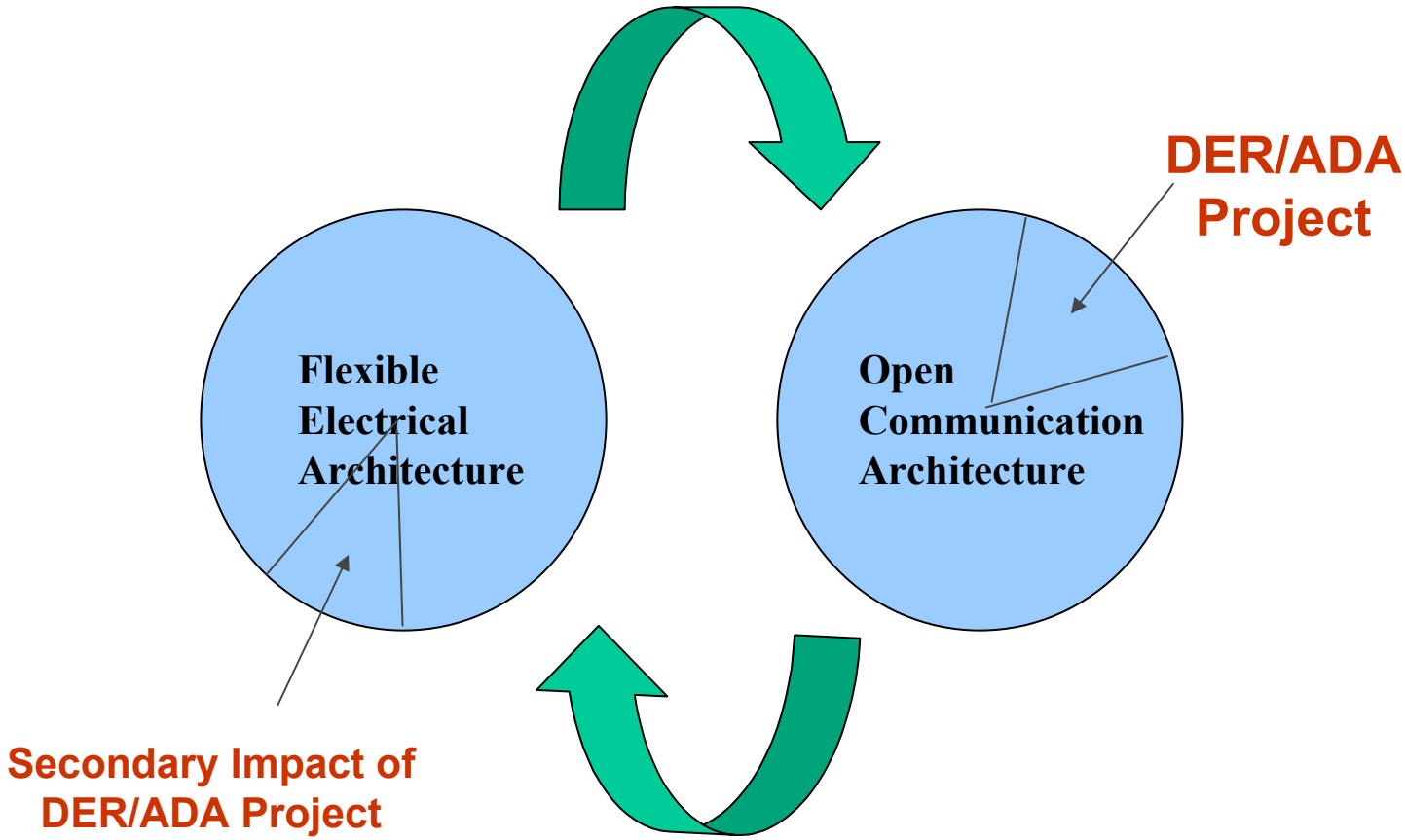
Synergy of Projects: Empowering the Power System



Synergy of Projects: Empowering the Power System



Synergy of Projects: Empowering the Power System



The DER/ADA Standards Project: Develop International Industry Standards for Information Exchange Models for DER in ADA

Obtain inputs to develop the standards

Develop international standards

Implement standards in DER equipment (encourage adoption)

Technical Input from Standards Working Groups, Vendors, Integrators, Utilities, and Other Stakeholders

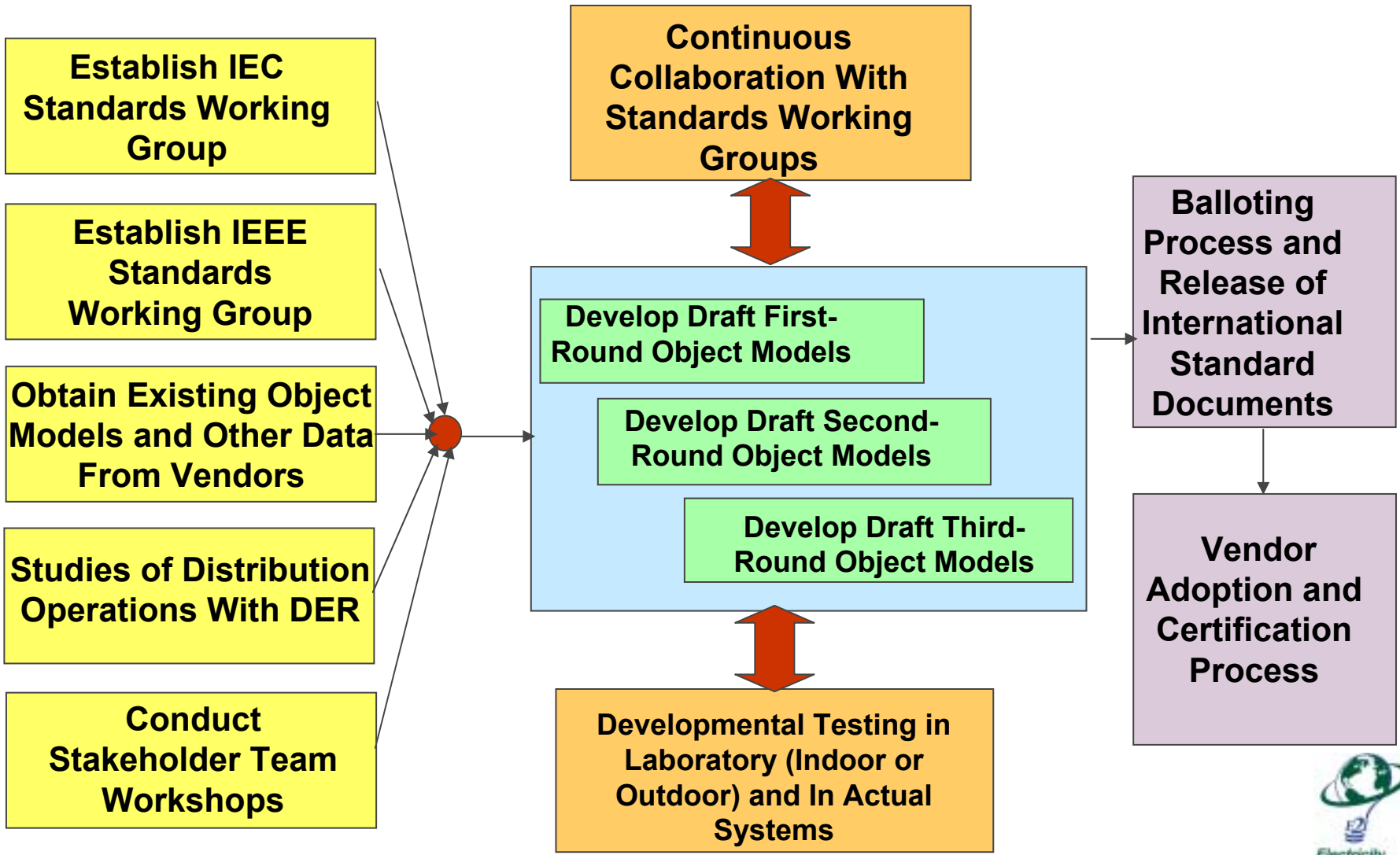
Developmental Testing in Lab and Field

Studies of ADA Operations with DER

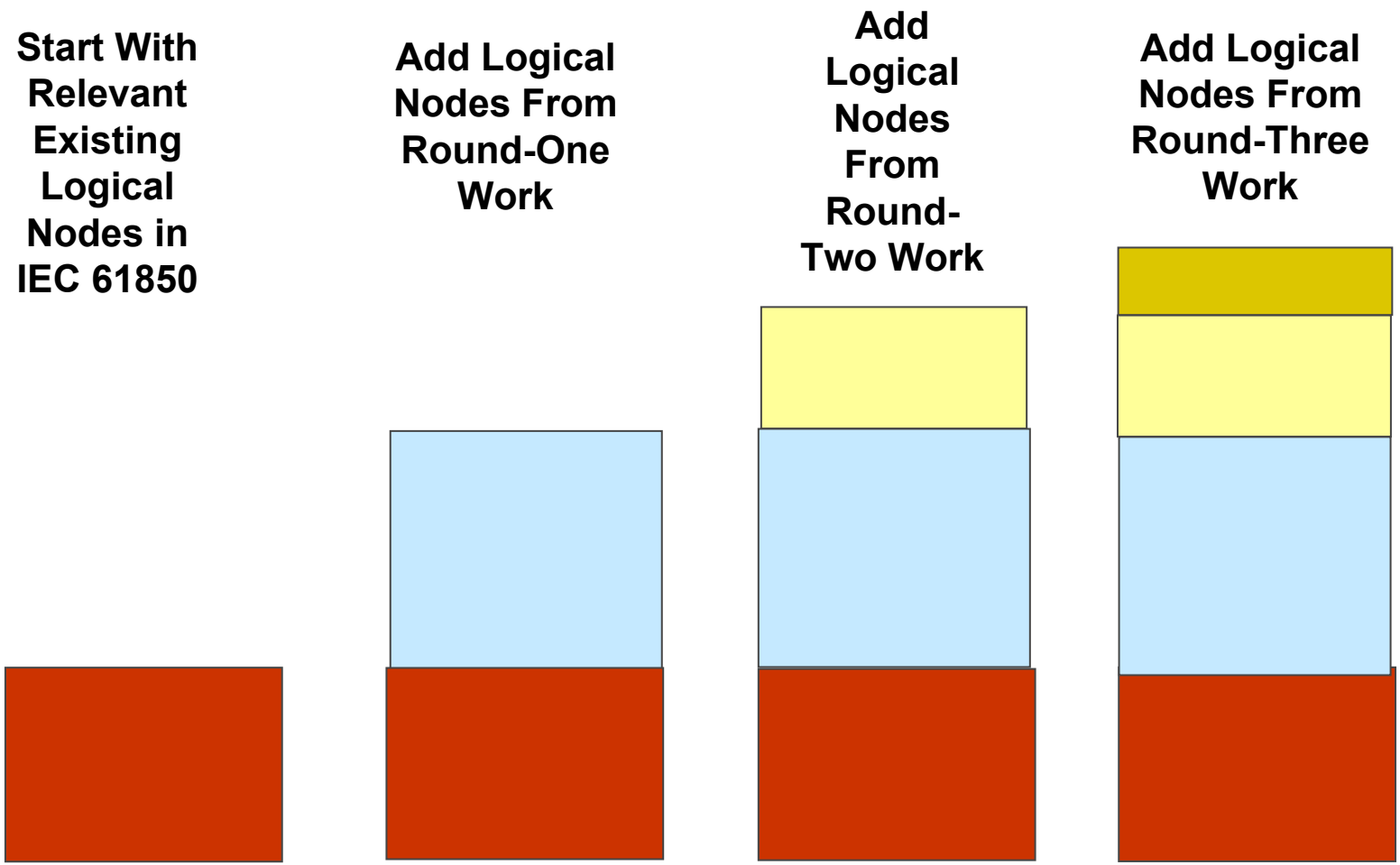
The Project Goal: International Standardized Information Exchange Models for DER in ADA

Study results are a direct-value bi-product

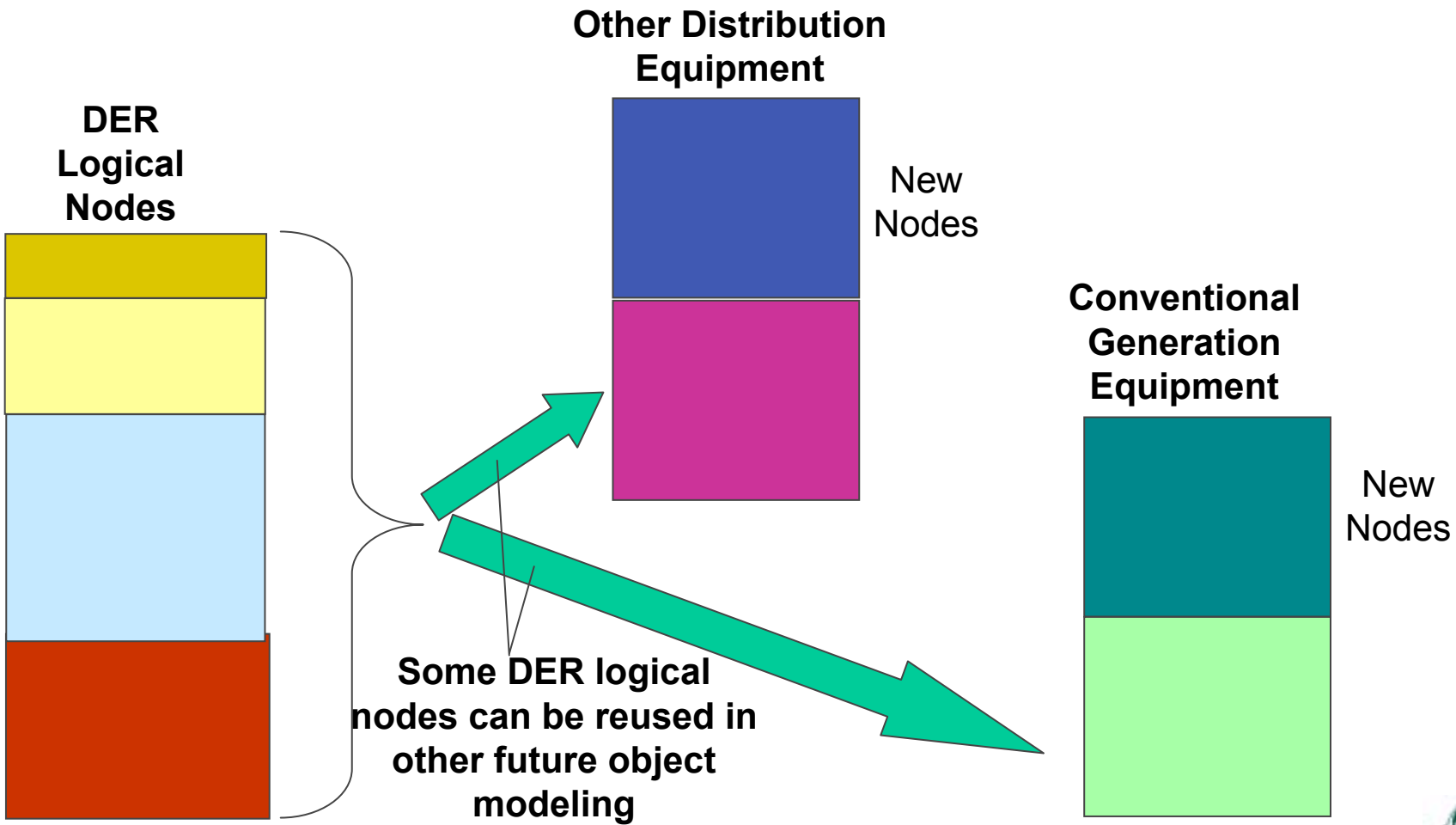
DER/ADA Standards Project Plan



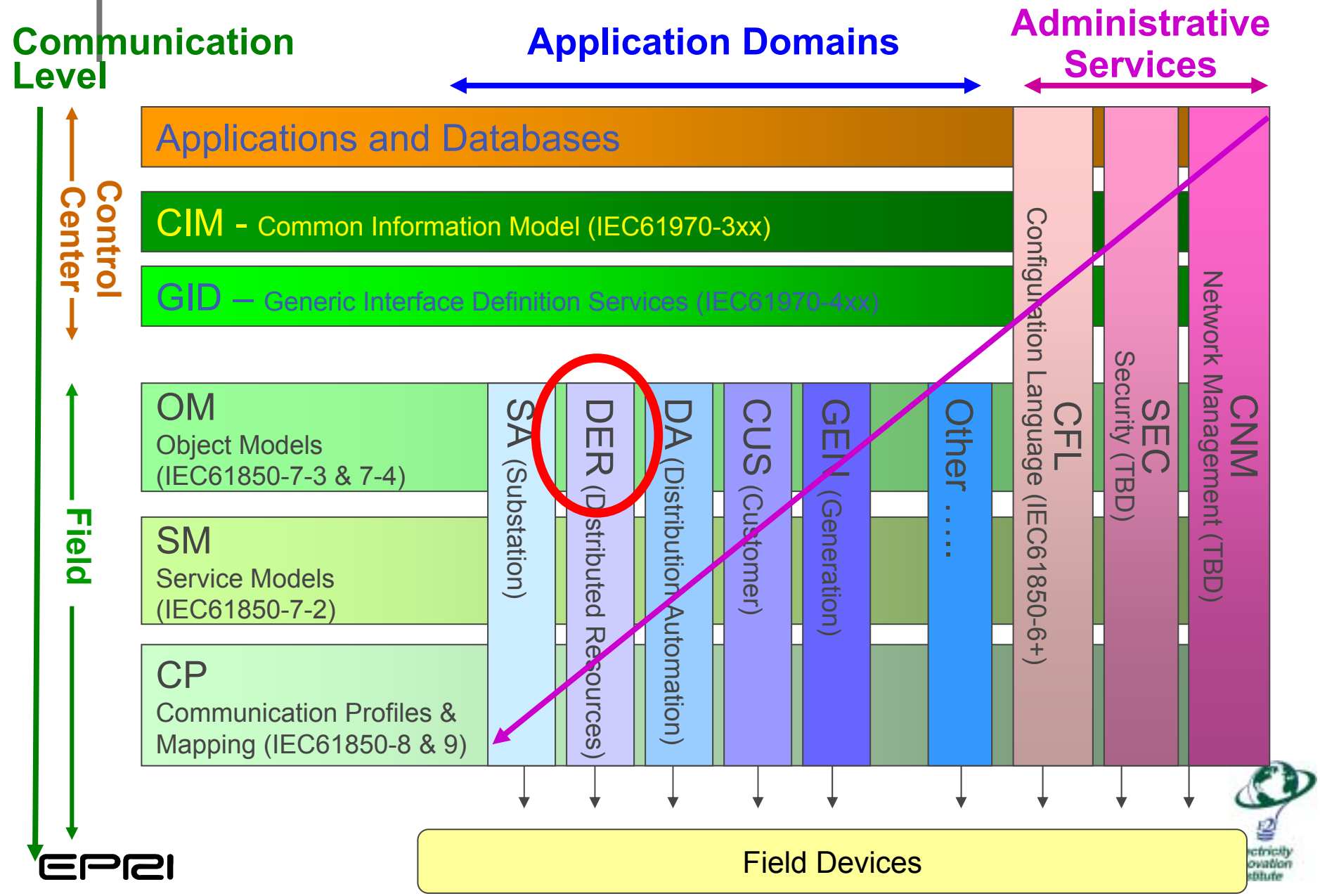
Standards Documents Will Be Built Up Incrementally



Some of our DER logical nodes will be reusable in future object models for other equipment



Our Standards Will Be Part of a Larger Body of International Open Communication Architecture Standards



IEC Working Group 17

- Working Group Title: "Communications Systems for Distributed Energy Resources (DER)"

  Provide one international standard that would define the communication and control interfaces for all DER devices

  – Simplify DER implementation from a technical standpoint
  – Reduce installation and maintenance costs
  – Enable new system-level ADA options, such as microgrids
  – Increase the functionality (capabilities) and value of DER in utility distribution system operations
  – Improve reliability and economics of power system operations

Target Dates

	PQ	Wind	DER	Hydro
First CD (Committee Draft)	2004-07	2004-10 (Second CD)	2005-02	2005-02
CDV (Committee Draft for Voting)	2005-02	2005-06	2005-10	2005-10
FDIS (Final Draft of International Standard)	2006-01	2006-04	2006-10	2006-10
IS (International Standard)	2006-04	2006-06	2007-02	2007-02

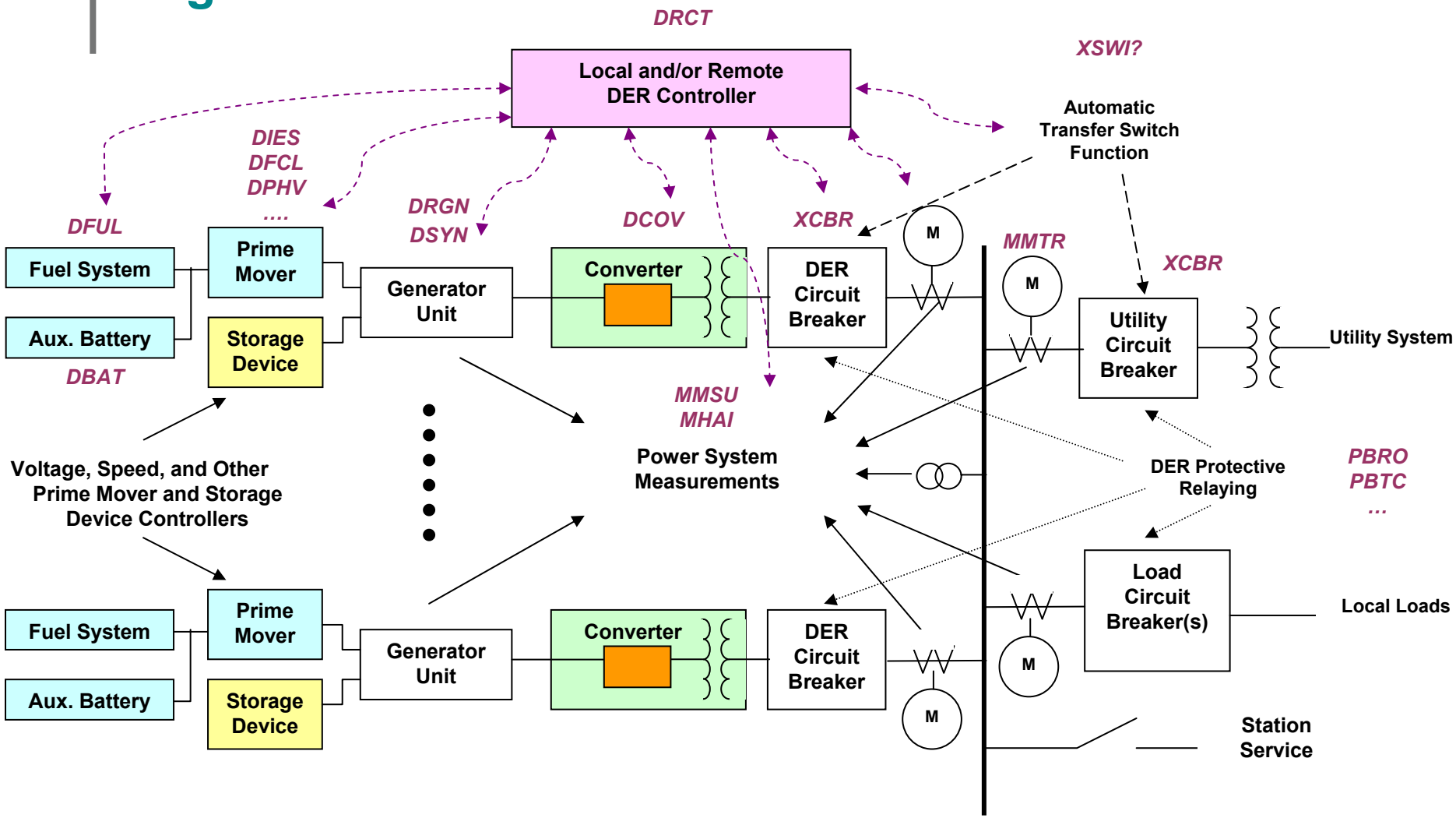
Example Results: List of DER Logical Nodes

(LNs with tan background are new; other LNs already exist in IEC61850)

Logical Node	Description
	DER Device Characteristics
DRCT	*DER Controller*
DRGN{n}	*DER Generator Characteristics and Control (units 0 – n)*
DSYN{n}	*DER Synchronization: GSYN0-n = Generator Unit*
{Multiple LNs} Prime Mover or Storage	*DER Prime Mover or Storage Device Characteristics and Control (e.g. DIES, DFCL). This LN varies, depending upon the DER technology*
DCOV{n}	*DER Converter/Inverter Characteristics: CONV0-n = Converter/Inverter Unit. This LN varies, depending upon the need for a converter/inverter*
DFUL	*Fuel Systems*
DBAT	*Battery Systems*
	Electrical Power System Measurements
MMSU{n}	DER voltage, current, frequency, & var measurements: e.g. MMSU0 = DER Alternator; MMSU1 = local power; MMSU2 = utility power. This LN is similar to MMXU, but contains additional attributes related to statistics
MMXU{n}	DER voltage, current, frequency, & var measurements without statistical information. Alternative to MMSU. (MMXN if single phase)
MHAI{n}	Power System Harmonics (MHAN if single phase)
MMTR{n}	DER Energy Meters: MMTR0 = Total generation; MMTR1 = Net generation; MMTR2 = Transferred to power system; MMTR{m} = submetering

Logical Node	Description
	Circuit Breakers
XCBR{n}	DER Circuit Breakers: XCBR0 = Load Breaker; XCBR1 = Common Coupling Breaker; XCBR2 = Interface Point Breaker; XCBR3-n = DER Generator Unit Breakers
	Protection Function
PBRO{n}	DER Protective Relaying base logical node: for PUVR, POVR, PTOC, PDPR, PFRQ
PBTC{n}	DER Protective Relaying timing logical node: for PUVR, POVR, PTOC
RREC{n}	Reclosing relay for circuit breakers
PRCF{n}	*DER Rate of Change of Frequency Relaying*
Pxxx {n}	*Other protection functions (TBD)*
	Automatic Transfer Switch
ATSC{n}	DER Automatic Transfer Switch Characteristics
SWIT{n}	DER Automatic Transfer Switch (ATS) status
SDRV{n}	DER ATS Control
AUTO{n}	DER ATS Automatic Control Logic
FIND{n}	DER ATS Fault Indicator
	Administrative Function
DMIB{n}	SNMP Management Information Base for DER Installations

DER Logical Nodes Imposed on Power System Diagram

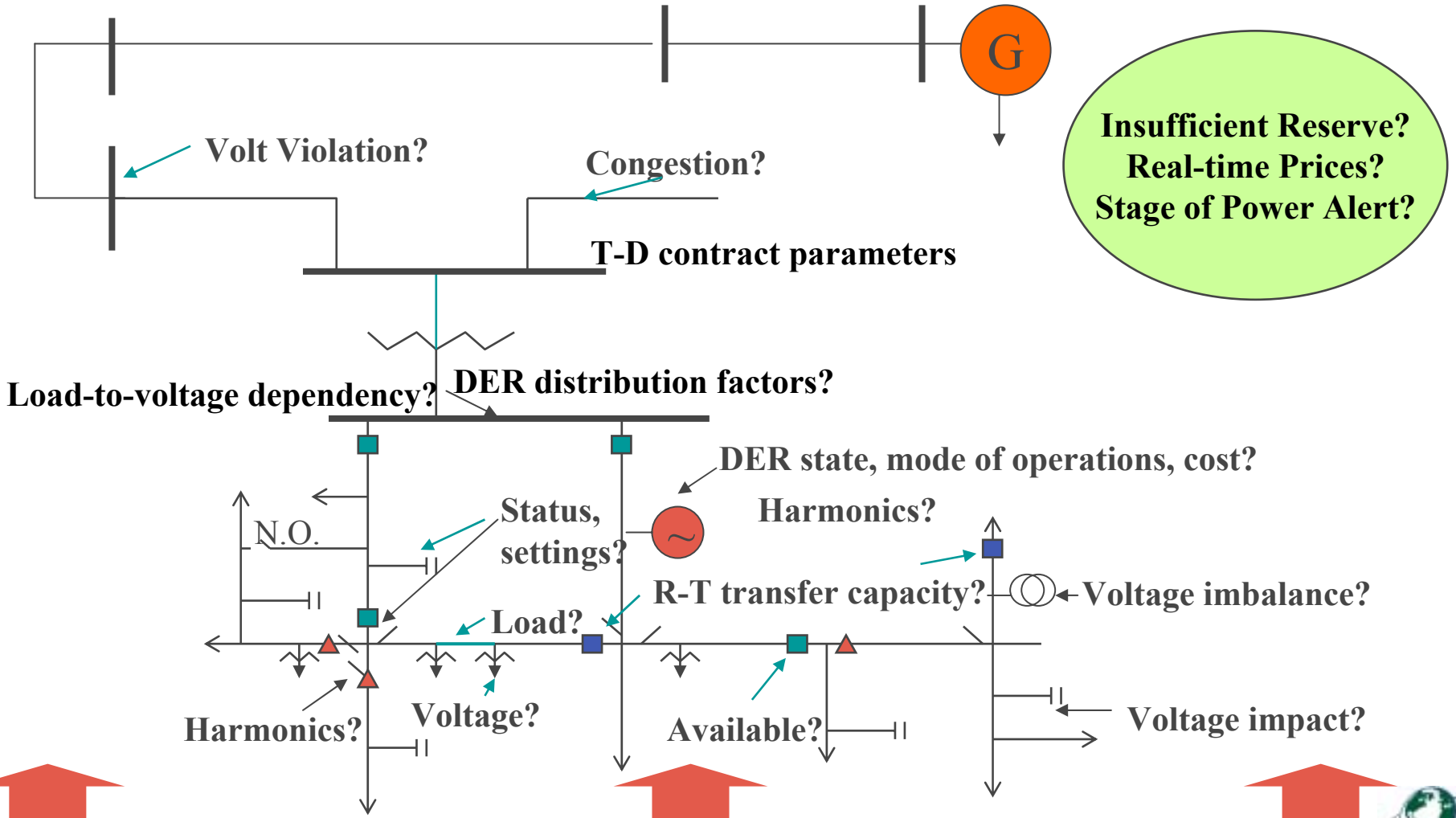


Prime Mover = Microturbines, Fuel Cells, Photovoltaic Systems, Wind Turbines, Reciprocating Engines, Combustion Turbines

Storage Device = Superconducting Magnetic Energy Storage, Battery, Pumped Hydro, Flywheels, Micro-flywheels

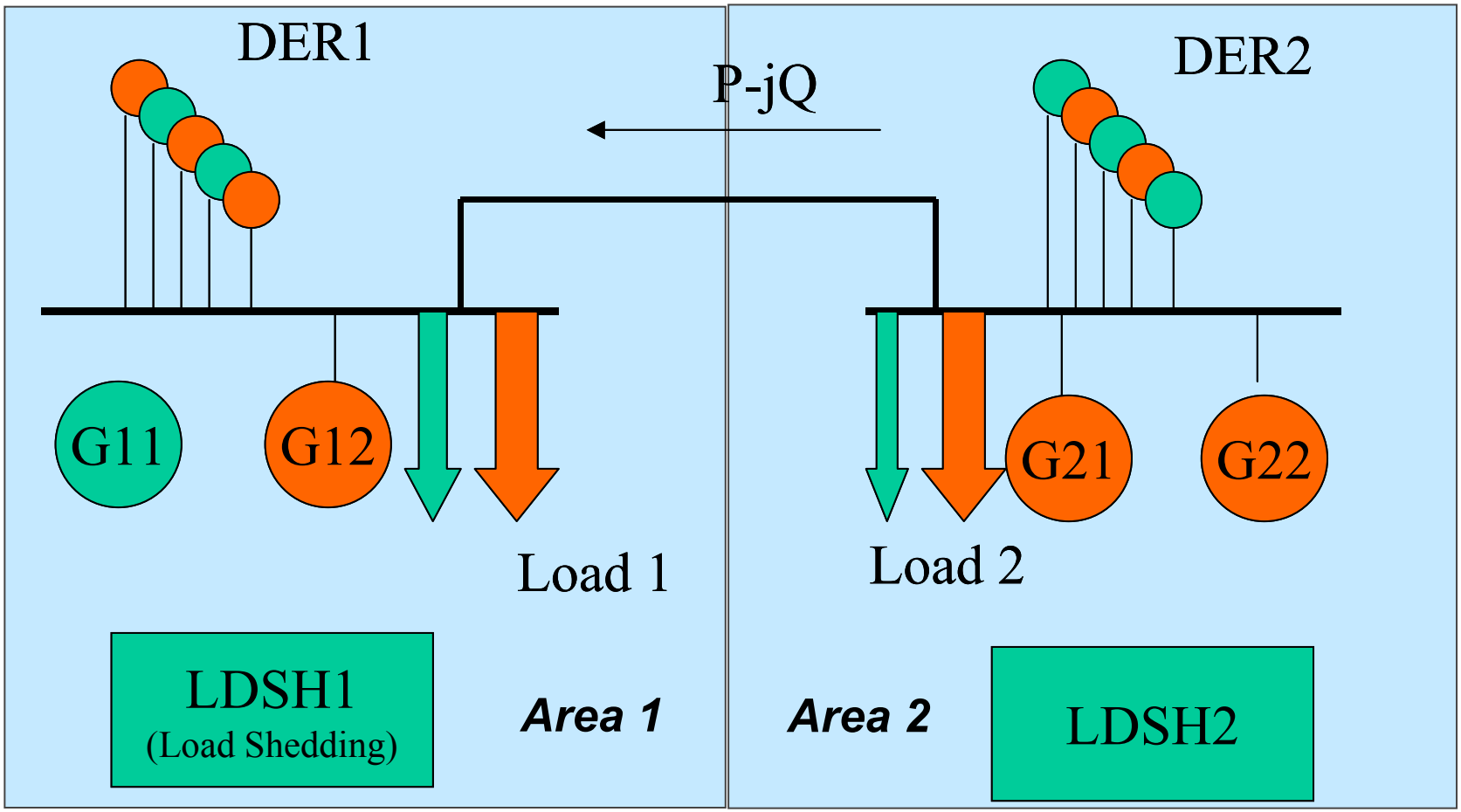
Converter = DC to AC, frequency conversion, voltage level conversion

Results from Operations Studies: What Do We Need to Know to Optimally Control Distribution Operations with DER?

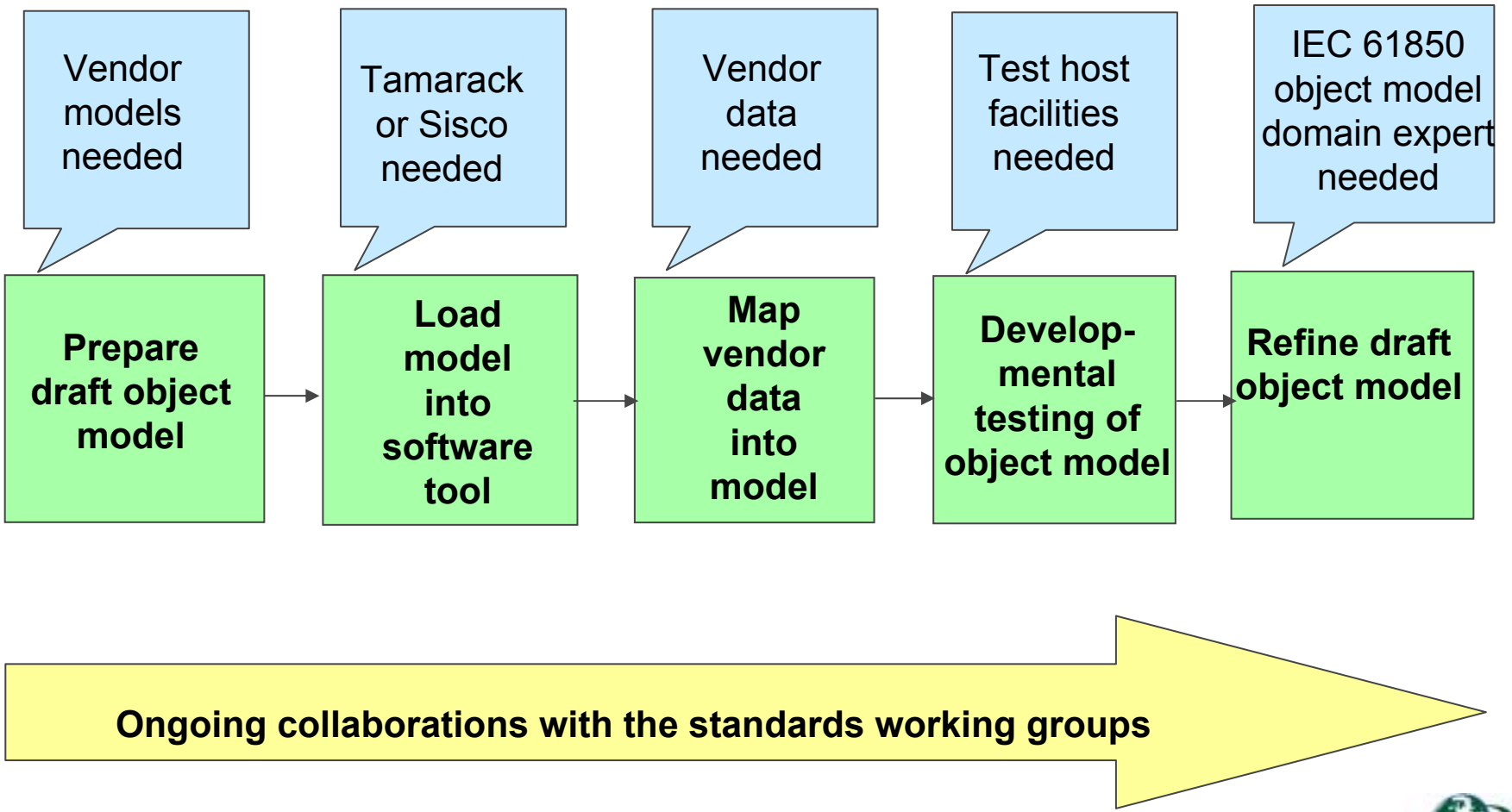


Distribution and Transmission Facility Parameters and Customer Data

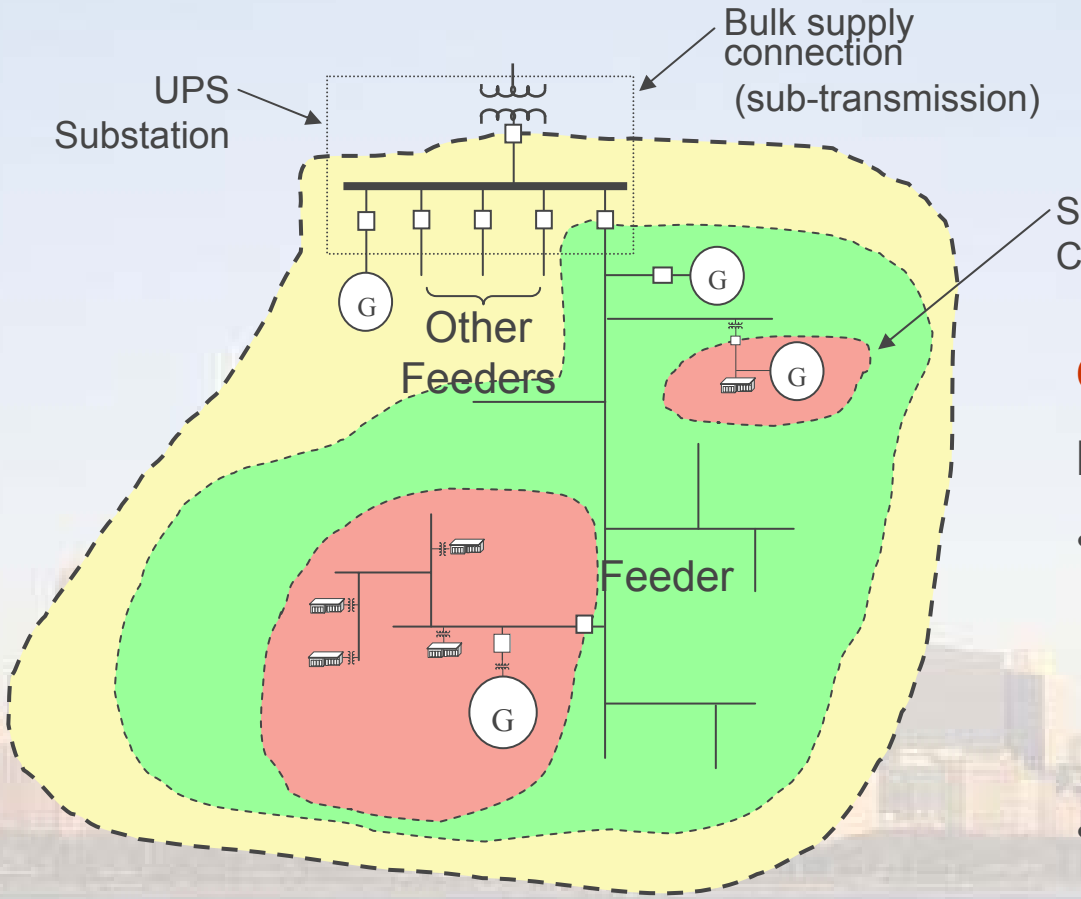
Two-Area Load-Rich Transmission-Generation Island With DER in Distribution System



Preparing an object model for developmental testing with actual vendor data



Questions/Discussion



ADA Enables True Integration of DER into Electric Power Systems

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