QualityLogic

Introduction to IEEE 2030.5 and CA Rule 21/CSIP

QualityLogic

Webinar Overview

- Speaker: James Mater, GM of Smart Grid & Steve Kang, Sr. VP of Engineering
  - Actively involved in 2030.5 since 2010
  - Contributor to IEEE 2030.5, SunSpec CSIP Test Procedures, CSIP, OpenADR, 1547, etc.
  - Training companies in 2030.5 since 2013

- Agenda
  - North America DER Standards Landscape (James Mater)
  - IEEE 2030.5 Background (Steve Kang)
  - IEEE 2030.5 Introduction (Steve Kang)
  - Q&A (All)

- All participants in the webinar will be muted
- Please post your questions to the Chat dialogue
- The slides and recording will be made available to all attendees after the webinar

QualityLogic

QualityLogic's role in Smart Energy industry

- QualityLogic focused on Smart Energy Testing
  - IEEE 2030.5 and OpenADR (Approved Test Harnesses)
  - Standards Training & Consulting
- QualityLogic has been involved with 2030.5 since 2010
  - Only SunSpec approved test harness for 2030.5/CSIP
  - Used by NRTLs and End Users to perform 2030.5 Testing/Certification
  - Active in 2030.5, CSIP and SunSpec Test Plan development
  - Trained thousands of people in 2030.5, OpenADR and other technologies
- Active in standards and test specification development
  - IEEE 2030.5, CSIP, 1547/1547.1, SAE J3072, OpenADR, UL 3001

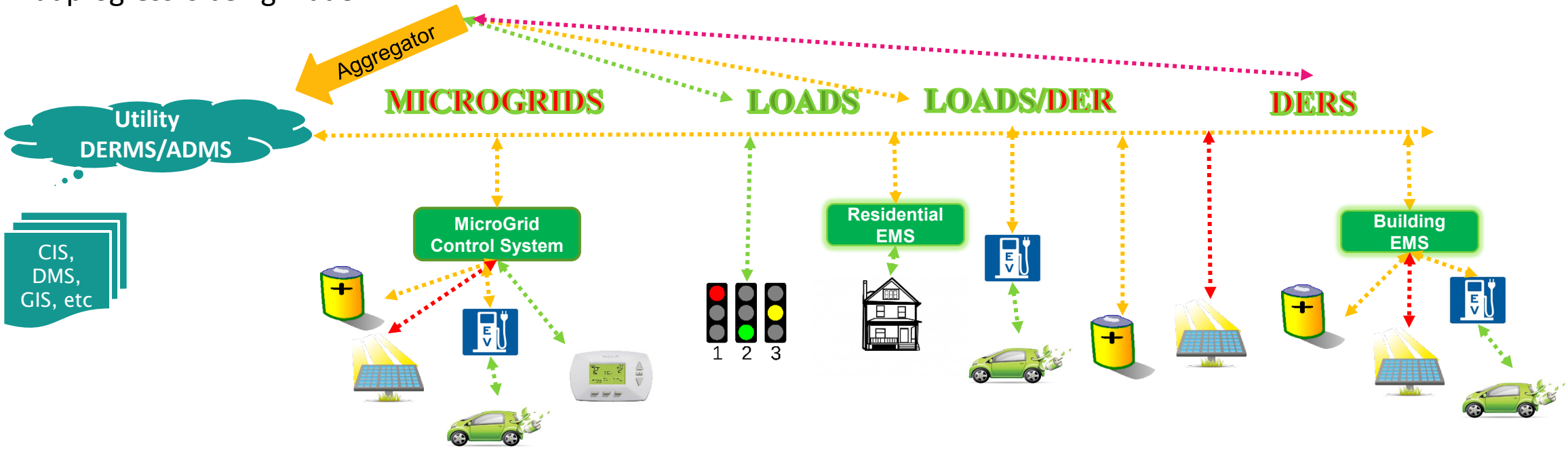
The North American DER Standards

An Evolving Landscape

QualityLogic

The DER Landscape in North America

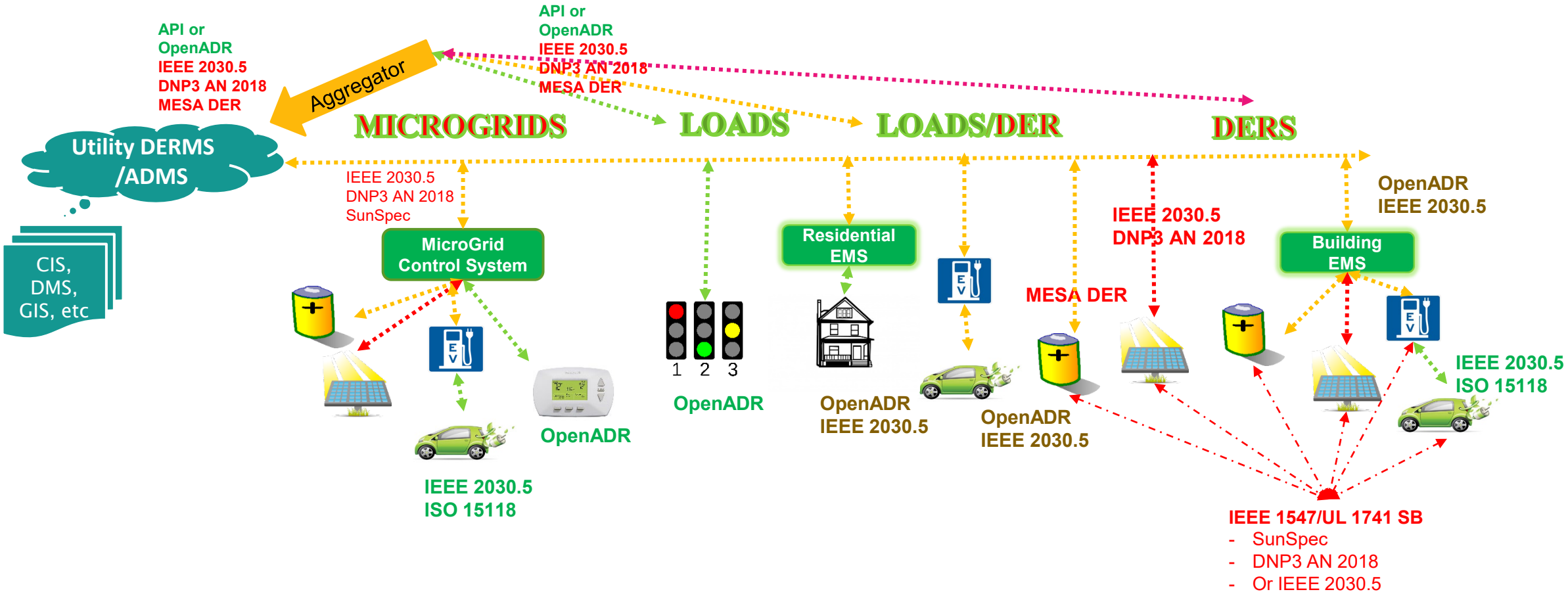
- Electric Utility Industry is integrating a portfolio of DER including MicroGrids and Loads. Protocol standardization is a hot topic with a range of activities
- The urgency and schedule for protocol adoption depends on specific circumstances: DER adoption incentives and rates, state policies, etc.
- But progress is being made.



QualityLogic

The Emerging NA Protocol Landscape for DER

- An evolving standards-based protocol landscape



QualityLogic

IEEE 2030.5 Background

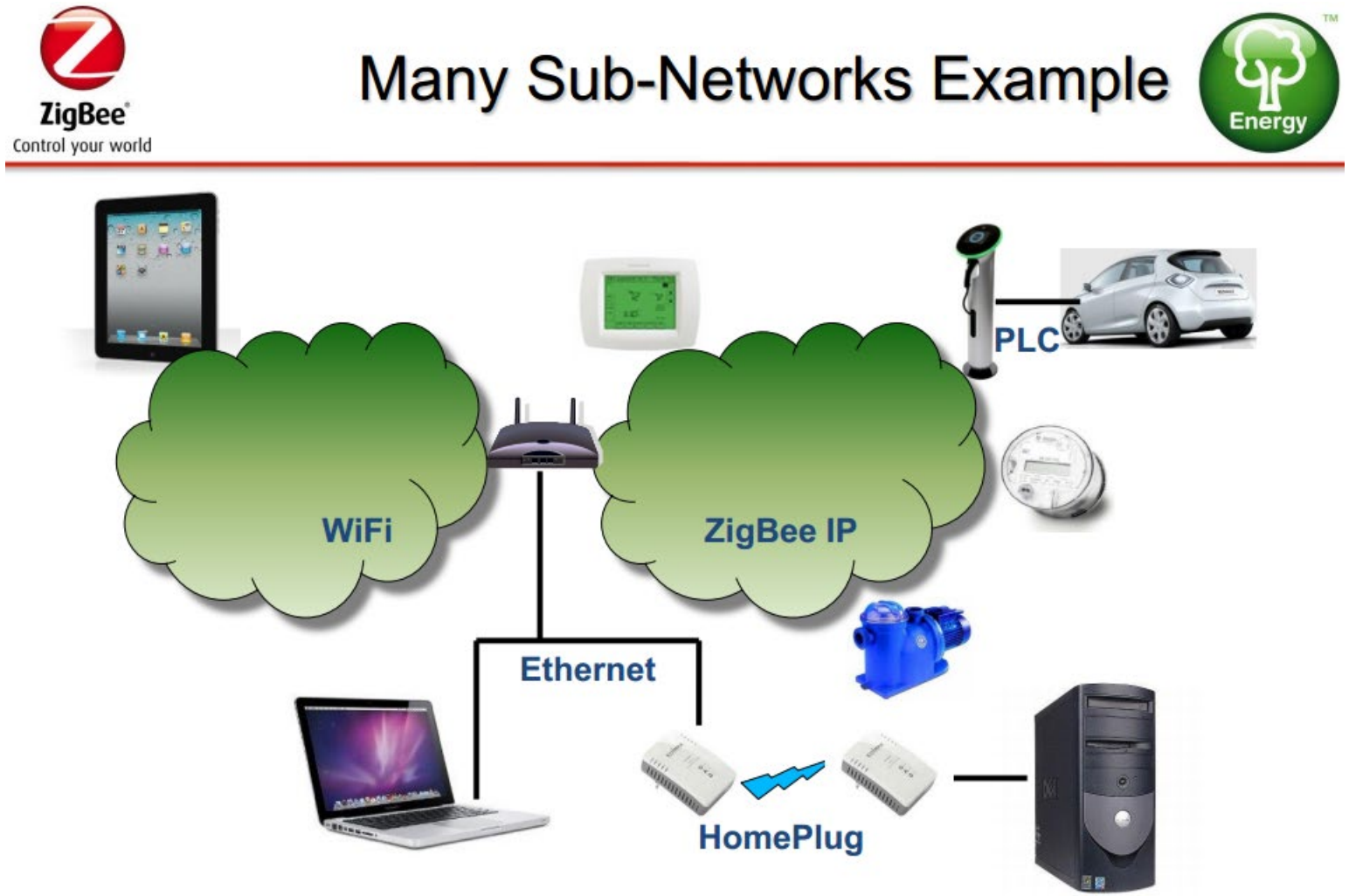
Smart Energy; History of IEEE 2030.5

QualityLogic

IEEE 2030.5 (SEP 2.0)

- Smart Energy Profile 2.0 (SEP 2.0) was developed by ZigBee to address utility specific concerns with SEP 1.x – e.g., security, ZigBee specific network, etc.
- In 2013, IEEE adopted the ZigBee SEP 2.0 Smart Energy Profile as IEEE 2030.5
- IEEE 2030.5 is an application layer protocol that supports modern IP networks
  - SEP 1.x is integrated and requires ZigBee communications
  - IEEE 2030.5 is communication layer independent – supports WiFi, HomePlug, ZigBee or others that support http/IP.
- Transitioned from ZigBee Cluster definitions to Function Sets – supports many different Smart Energy functions, ex. DER, DRLC, Pricing, Metering, etc.
- Leverages industry standard technologies like XML, HTTP, REST, XSD, CIM, TLS, etc. – enables quick adoption through commonly available toolkits
- By using industry standard protocols, IEEE 2030.5 promotes easier interoperability

IEEE 2030.5 Design Goals



QualityLogic

Rule 21 Investor Owned Utilities (IOUs)

- Pacific Gas and Electric (PG&E)
  - Rule 21 Website: https://www.pge.com/en_US/for-our-business-partners/interconnection-renewables/interconnections-renewables.page?ctx=business
  - Rule 21 Tariff: https://www.pge.com/tariffs/tm2/pdf/ELEC_RULES_21.pdf
- Southern California Edison (SCE)
  - Rule 21 Website: https://www.sce.com/wps/portal/home/business/generating-your-own-power/Grid-Interconnections/Interconnecting-Generation-under-Rule-21
  - Rule 21 Tariff: https://www.sce.com/NR/sc3/tm2/pdf/Rule21_1.pdf
- San Diego Gas & Electric (SDG&E)
  - Rule 21 Website: https://www.sdge.com/more-information/customer-generation/electric-rule-21
  - Rule 21 Tariff: http://regarchive.sdge.com/tm2/pdf/ELEC_ELEC-RULES_ERULE21.pdf

QualityLogic

Rule 21 Phase 1 Autonomous Functions

- **Anti-Islanding Protection** – use of Low/High Frequency/Voltage Ride Through to handle unintentional islanding
- **Low and High Voltage Ride-Through** – requiring inverters to stay connected during Low/High voltage fluctuations
- **Low and High Frequency Ride-Through** - requiring inverters to stay connected during Low/High frequency fluctuations
- **Dynamic Volt-Var Operation** – requiring inverters to counteract voltage deviations from nominal voltage levels by consuming or producing reactive power.
- **Ramp Rates** – ramp rate of increasing/decreasing their output power to smoother the transitions from one output level to another.
- **Fixed Power Factor** – setting of power factor of inverters (inject or absorb)
- **Soft Start Reconnection** – ability to disperse when inverters reconnect after disconnection to reduce effect on the grid

QualityLogic

Rule 21 Phase 2

- Requires communication between the grid operator and distributed resource
- Enables IOUs to remotely manage and control DERs
- Default protocol is IEEE 2030.5 unless another protocol is mutually agreed
- Common Smart Inverter Profile (CSIP) details out implementation guide using IEEE 2030.5
- Certification underway by various NRTLs and Test Labs

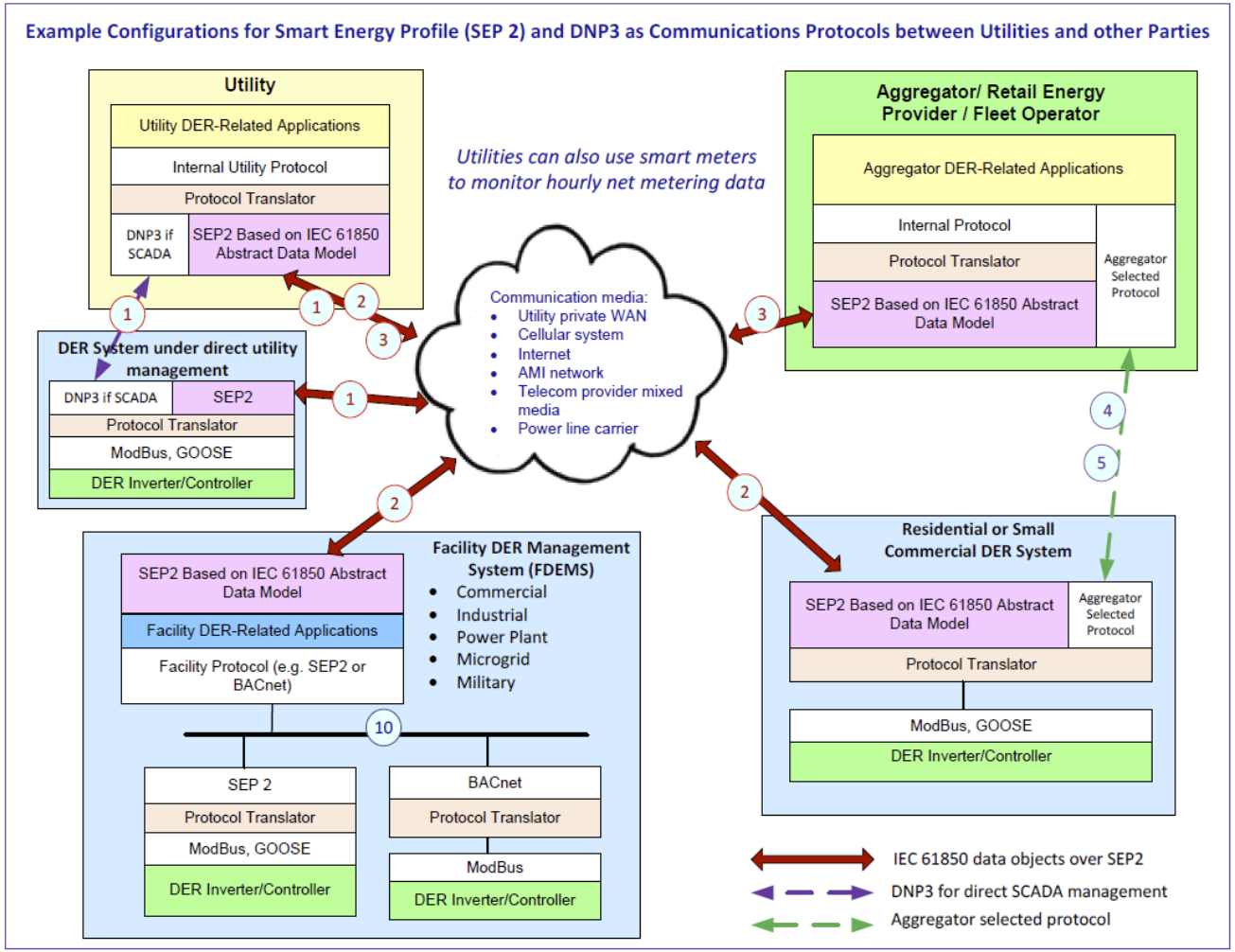


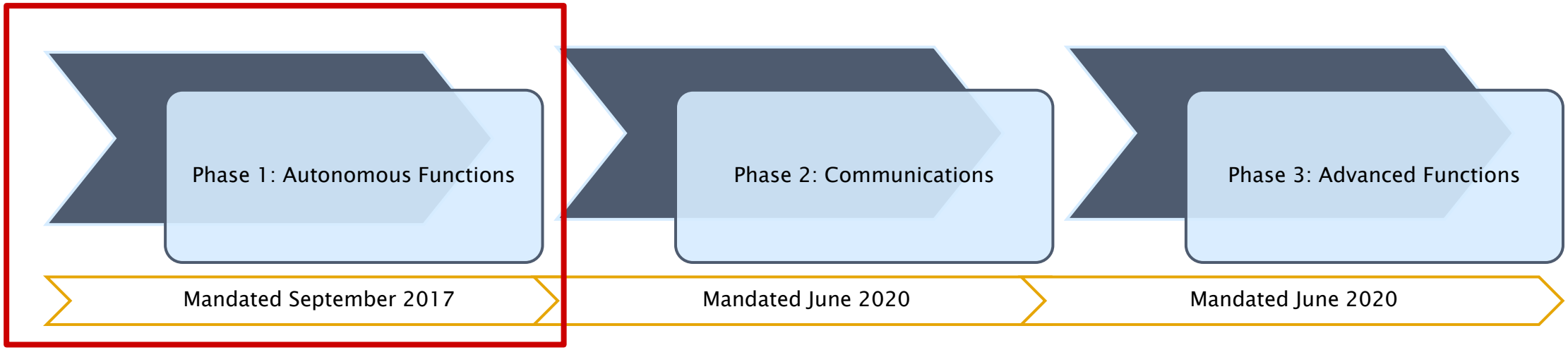
Figure 3: Conceptual Implementation of IEEE 2030.5 (SEP2) Communications with DER.

QualityLogic

Rule 21 Phase 3 Advanced Functions

- **Monitor Key Data -** Obtain current readings for specified measurements and status, ex. Active power, Reactive power, Voltage, Frequency, Operational state, Connection status, Alarm status, Operational state of charge
- **Disconnect/Reconnect -** Cease to energize/reenergize at the grid interface.
- **Limit Maximum Active Power Mode -** Limit maximum active power output to specified level.
- **Set Active Power Mode -** Maintain active power at specified level.
- **Frequency Watt Mode -** Modifies active power based on frequency.
- **Volt Watt Mode -** Modifies active power based on voltage.
- **Dynamic Reactive Power Support -** Modifies reactive power based on rate of voltage change.
- **Scheduling Power Values and Modes -** Schedule control settings.

CA Rule 21: Standardizing DER functionality and communications



- Required functions: anti-islanding, Voltage ride-through, Frequency ride-through, Dynamic Volt-Var, Ramp Rates, Fixed Power Factor and Soft Start Reconnect
- Certifications
  - Inverters tested using UL 1741 SA (electrical functions) by NRTLs
  - No communication
- Inverter manufacturers already meet these certification requirements
- NRTLs are performing certification testing using UL 1741SA

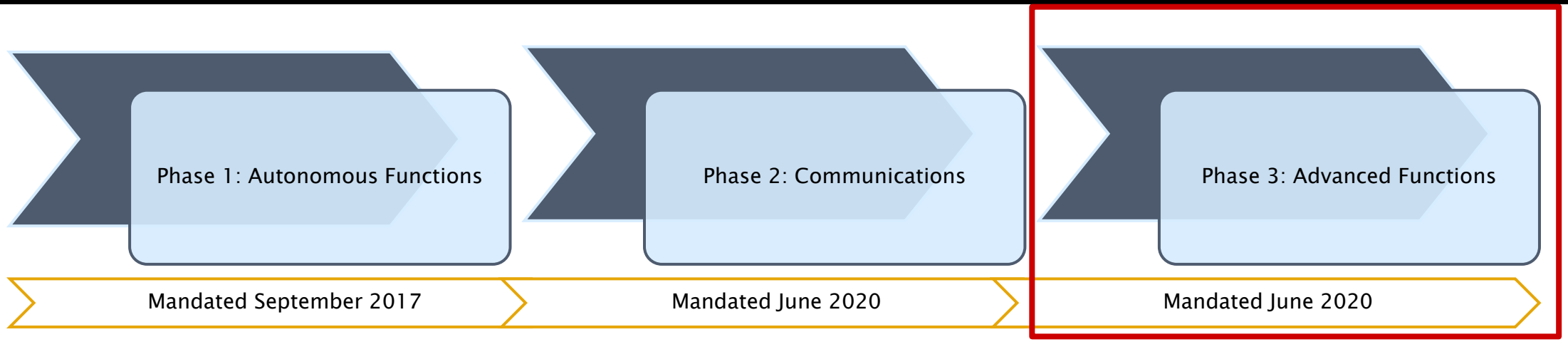
QualityLogic

CA Rule 21: Standardizing DER functionality and communications

- DER must be capable of communicating all required information
  - Default protocol is IEEE 2030.5
  - Common Smart Inverter Profile (CSIP) – implementation guide of CA Rule 21 using 2030.5 protocol
- Certifications
  - Based on SunSpec CSIP Conformance Test Procedures – QualityLogic contributed over 50% of test cases
  - Protocol testing performed by ATLs
  - No electrical verification

QualityLogic

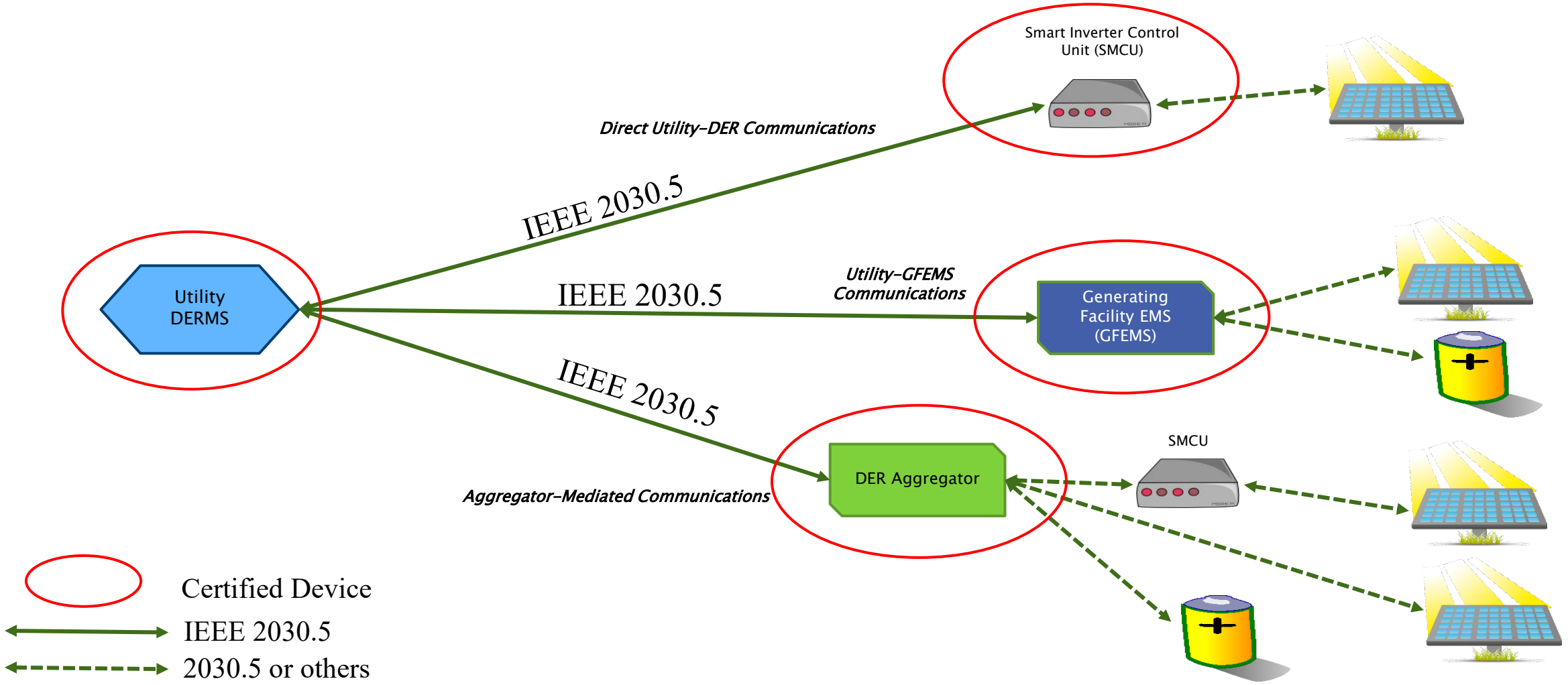
CA Rule 21: Standardizing DER functionality and communications



ID	Function	Phase 3 Pt 1	Phase 3 Pt 2
1	Monitor Key Data	Attestation until Nat Std.	
2	Disconnect/Reconnect	Mandatory (comm+electrical)	
3	Limit Maximum Active Power Mode	Mandatory (comm+electrical)	
4	Set Active Power Mode		12 mos after national test std.
5	Frequency Watt Mode	Mandatory (Part of UL 1741 SA)	
6	Volt Watt Mode	Mandatory (Part of UL 1741 SA)	
7	Dynamic Reactive Power Support		12 mos after national test std.
8	Scheduling Power Values and Modes	Attestation until Nat Std.	

QualityLogic

CA Rule 21 CSIP IEEE 2030.5 Usage Models



QualityLogic

IEEE 2030.5 DER Certification

- Certification Requirements
  - SunSpec CSIP/Rule 21 specific – Test Spec released (May 2018)
- SunSpec CSIP Certification for DER client and server devices
- Test Harness and Test Labs
  - SunSpec approved QualityLogic Test Harness for CA Rule 21/CSIP Certification
  - Authorized 8 test labs: UL, Intertek, CSA, TUV, PCTest, SGS, Kyrio, Cere
  - Kyrio as SunSpec's PKI
- QualityLogic IEEE 2030.5 Test Tool meets all of the above certification testing requirements

QualityLogic

IEEE 1547-2018

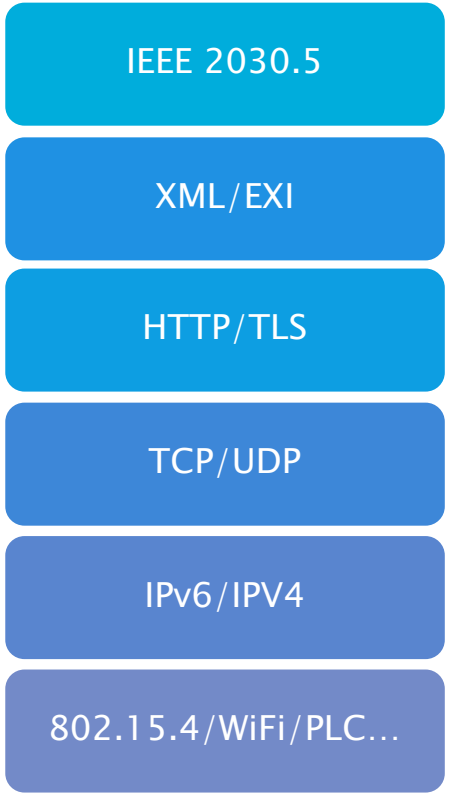
- International Interconnection standard mandated in the US and some other countries
- Specifies standard inverter functions
  - Based on IEC 61850-7-420 Information Model for DER (CA Rule 21 and IEEE 2030.5 uses same information model)
  - Mandated certification by December 2019 or earlier
- Specifies communications interoperability using at least one of:
  - IEEE 2030.5 – designed for behind-the-meter DER management
  - DNP3 – designed for SCADA direct control of larger DERs
  - SunSpec Modbus – designed for controller/inverter interface
- Interoperability certification planned to be required by 2H 2021
  - Validate each 1547 function can be correctly managed via standard communications
  - CA Rule 21 being updated to reflect 1547 requirements by SIWG

IEEE 2030.5 Introduction

Structure of IEEE 2030.5

IEEE 2030.5 Introduction

- Communication Model – IEEE 2030.5 is communication layer independent – assumes support for http



QualityLogic

Birds Eye View of 2030.5

- Supports wide variety of smart energy functions within a premise
- Built upon building blocks (function sets and resources)
- Implementing DER requires other functions from 2030.5
- New version approved in March 2018

Common	Support	Smart Energy	Core Functionality
• Time • Device Information • Power Status • Network Status • Log Event • Configuration • File Download • Configuration	• Device capabilities • Self Device • End Device • Function Set Assignments • Subscription/notification • Response	• DRLC • Metering • Mirrored Metering • DER Program/DERInfo • Messaging • Billing • Prepayment • Flow Reservation • Pricing	• Design Pattern (WADL/Schema/List) • Application Support (HTTP/URI/XML/EXI) • Security (TLS, Certs, ACL) • Discovery (xmdns, dns-sd)

Key 2030.5 Principles

- All communication is done through HTTP
- Data payload is packaged in XML (or EXI)
- Security is provided through TLS 1.2 and 2030.5 specific cipher suite (TLS_ECDHE_ECDSA_WITH_AES_128_CCM_8)
- Client devices discover “resources” that are hosted by a server
  - Ex. DER Program that includes a Voltage ride through setting is specified as a resource on the server
- Server devices create, own and manage resources and client population retrieves such resources
- Various levels of authentication/access is granted by server to client(s)
- Underlying technologies widely available – internet technologies

QualityLogic

Discovery Process

- How does client device find servers on the HAN, ex. which IEEE 2030.5 server can I connect to?
- Primary Methods are “In band” and “Out of band” discovery
- In Band Discovery
  - Uses multicast or DNS-SD to find 2030.5 servers
  - Multicast DNS (xmdns in 2030.5) does not require dedicated DNS servers
- Out of band Discovery
  - XMDNS may not be feasible due to network constraints
  - Server reveals network information directly to clients, ex. ip address=x.x.x.x, tls port=443, etc.
- CSIP Recommended Methods is either Out of Band or DNS-SD
  - Depends on Utility’s deployment plans

QualityLogic

Function Sets and Resources

- Fundamental backbone of 2030.5 – they work together (not silos!)
- Building blocks to implement product functionality – 30 function sets/resources
- IEEE 2030.5 organized into 3 major function set groups
  - **Smart Energy Function Sets** – main business application oriented features of the IEEE 2030.5 devices, ex. DER
  - **Support Resources** – features that provide operational support to the Smart Energy functions like device capability, function set assignments, end device
  - **Common Resources** – general purpose features like time, network, file download
- DER function set builds on Support and Common Resources
  - Ex. DER Program is discovered through Device Capabilities-> End Device -> FSA
  - Ex. DER Control is an event that has a time period: uses Time function set

Security

- Built upon HTTP/TLS technologies for encrypted communication
- Specific cipher suite for 2030.5 required
  - Supported by commercial and open source SSL libraries
- In addition to HTTPS cyber security measures, 2030.5 supports:
  - Access Control List where specific authorizations are granted based on:
    - Is the client registered?
    - Is the client authenticated?
    - Is the client using a valid device certificate?
  - PIN number (like a debit card PIN) can be preregistered to provide another measure of authenticity

QualityLogic

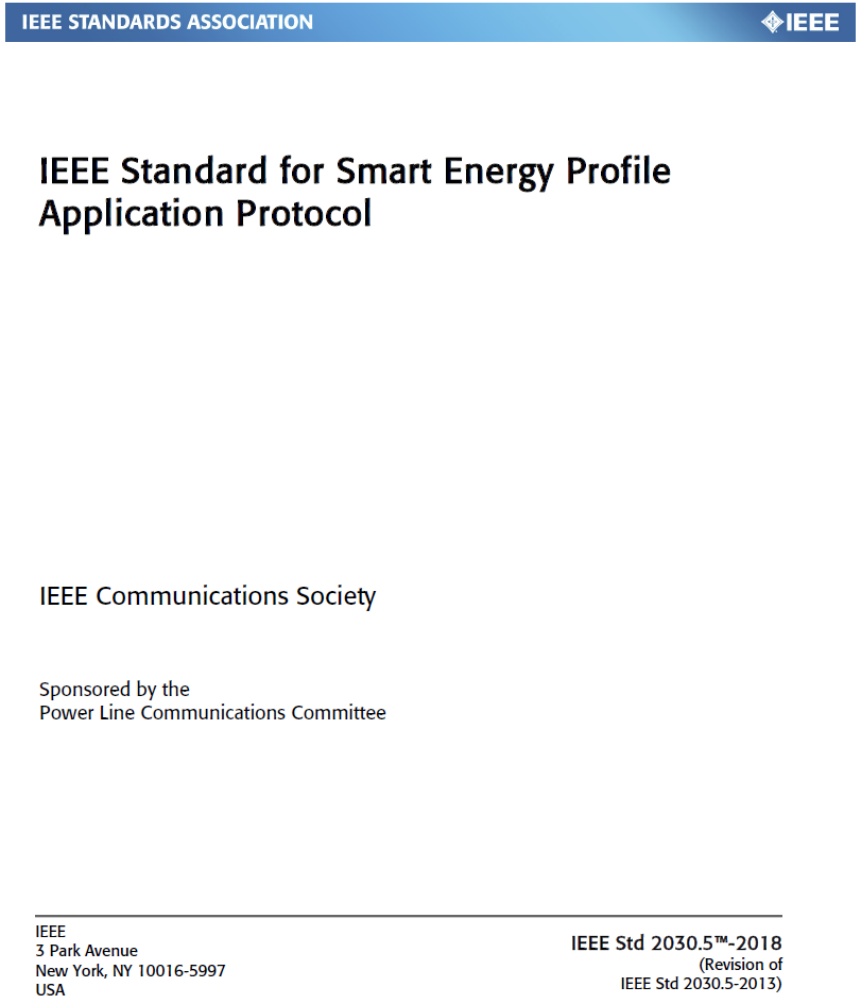
Building Products using 2030.5

- Core set of function sets and technologies are mandatory for client & servers
  - Examples: TLS, Discovery, Security, HTTP, IPV4/6, DeviceCapability, Time, XML, WADL
- IEEE 2030.5 devices build upon the core set and implement Smart Energy function sets
  - DER functionality to implement CA Common Smart Inverter Profile implementation guide
  - Utility Server (DER Head End System) is considered a “server” that schedule and manage DER Programs and Events
  - Aggregator and inverters are considered “clients” that consume these DER Programs and Events
- Development decisions observed
  - Develop their own 2030.5 stack (different platforms observed such as .net, embedded C/C++, Java)
  - License commercial 2030.5 stacks
  - Leverage EPRI open source client (major updates required by vendors)

QualityLogic

IEEE 2030.5 Technical Standard

- 2030.5 Application Protocol Standard (IEEE 2030.5 Specification)
- XSD Schema – defines the syntax/grammar of 2030.5 data
- WADL – defines the web services methods for each endpoints
- UML Model – defines the UML model of the standard
  - Very useful to understand the entire 2030.5 standard
  - Protocol Standard does not contain all of the normative information
  - XSD implements UML model for XML/EXI format
- Latest version was approved in March 2018
- https://standards.ieee.org/standard/2030_5-2018.html



QualityLogic

2030.5 Functions Required for CSIP

Common	Support	Smart Energy	Core Functionality
• Time	• Device capabilities	• DRLC	• Design Pattern (WADL/Schema/List)
• Device Information	• Self Device	• Metering	• Application Support (HTTP/URI/XML/EXI)
• Power Status	• End Device	• Mirrored Metering	• Security (TLS, Certs, ACL)
• Network Status	• Function Set Assignments	• DER Program/DERInfo	• Discovery (xmdns, dns-sd)
• Log Event	• Subscription/notification	• Messaging	
• Configuration	• Response	• Billing	
• File Download		• Prepayment	
		• Flow Reservation	
		• Pricing	

Red text = Required CSIP functions

Road to CSIP Certification

How QualityLogic Contributes

QualityLogic

Certification Landscape

- Phase 1 & 3 require UL 1741 tests performed by NRTLs
  - Certification performed at the power level to ensure inverters function correctly
- CA Rule 21 requires IEEE 2030.5/CSIP Certification to meet Phase 2
  - SunSpec Alliance manages the CSIP Certification Program
  - Certification Testing performed by 8 approved test labs
  - QualityLogic's IEEE 2030.5 test tool includes CSIP Certification Tests
- Once certified, certified inverters get listed on the California Energy Commission's approved inverter list website
  - https://www.energy.ca.gov/programs-and-topics/topics/renewable-energy/solar-equipment-lists

QualityLogic

QualityLogic's IEEE 2030.5 DER Training

- **Session 1 – Background**
- **Session 2 – IEEE 2030.5 Introduction**
- **Session 3 – Function Sets and Categories**
- **Session 4 – Support and Common Resources**
- **Session 5 – Smart Energy Function Sets**
- **Session 6 – CA Rule 21/CSIP Overview**
- **Session 7 – CSIP Communications**
- **Session 8 – CSIP Basic Functions**
- **Session 9 – CSIP & IEEE 2030.5**
- **Session 10 – CSIP Utility/Aggregator**
- **Session 11 – Aggregator Operations**
- **Session 12 – DER Event Scenarios**
- **Session 13 – Meter Data, Status and Alarms**
- **Session 14 – Introduction to QualityLogic Tools**
- **Session 15 – Conformance and Certification**

- Interactive 3-day Webinar Workshop
  - Companies around the globe have attended including inverters, aggregators, NRTLs, utilities, storage and others
  - Attendees interact directly with a 2030.5/CSIP expert
  - Private classes offer a confidential setting
- Online IEEE 2030.5 DER Training course
  - https://qualitylogic.thinkific.com/courses/ieee-2030-5-DER-training-plus
  - Contains same content as 3-day workshop
  - Can be taken with instructor support or without
- Testimonials
  - "Steve was an excellent instructor. He covered all the relevant material in an engaging manner, while also allowing time for us to have design discussions for 2030.5 implementation"
  - "The flow of the course was quite good. Steve was also very knowledgeable."

QualityLogic

QualityLogic's IEEE 2030.5 Test Tools

- QualityLogic IEEE 2030.5 Test Tools
  - Supports testing using the latest IEEE 2030.5v2018 version
  - Licensed by NRTLs, labs and vendors for SunSpec CSIP certification, CALSSA and Phase 3 Funcs 2 & 3 testing (UL 1741SA17/SA18)
  - Automation APIs provided through REST web interface
  - Detailed analysis of mandatory requirements performed automatically
- Functional Test Suite – Client and Server
  - Engineering level tests to verify conformance to CA Rule 21/CSIP
  - Approved IEEE 2030.5 Certification Test Harness for SunSpec Rule 21 Certification
- IEEE 2030.5 Ad Hoc Testers – Client and Server
  - Includes DER, Demand Response, Pricing, Flow Reservation (EV charging) and others
  - Supports ad-hoc testing of CSIP based servers and clients

QualityLogic

Summary

- IEEE 2030.5 is actively being adopted and real – ecosystem of vendors and certified products growing
- AU could adopt CA Rule 21 model or modify it to meet regional requirements
- IEEE 1547/UL 1741 SB will reinforce the use of IEEE 2030.5 for DER communications
- Vendors can quickly understand 2030.5/CSIP and develop/test products
  - QualityLogic's IEEE 2030.5 Training and Test Tool support the eco system
- For more information about QualityLogic's services and tools:
  - Contact info@qualitylogic.com or visit https://www.qualitylogic.com/industries/smart-energy/
- Bonus: Selecting protocol for Vehicle-Grid Integration co-authored by James Mater
  - https://sepapower.org/guidelines-for-selecting-a-communications-protocol-for-vehicle-grid-integration/
- Q&A (~15 minutes)