



Introduction to IEEE 2030.5 and CA Rule 21 /CSIP

Webinar Overview

- Speaker: Steve Kang, Sr. VP of Engineering
 - Actively involved in 2030.5 since 2010
 - Contributor to IEEE 2030.5, SunSpec CSIP Test Procedures, CSIP and other specs
 - Training companies in 2030.5 since 2013
- Agenda
 - IEEE 2030.5 Background
 - IEEE 2030.5 Introduction
 - Road to CSIP Certification
 - Q&A
- All participants in the webinar will be muted
- Please post your questions to the Q&A dialogue
- The slides and recording will be made available to all attendees after the webinar



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 and OpenADR
- Active in standards development
 - IEEE 2030.5, CSIP, 1547/1547.1, SAE, OpenADR

IEEE 2030.5 Background

Smart Energy; History of IEEE 2030.5

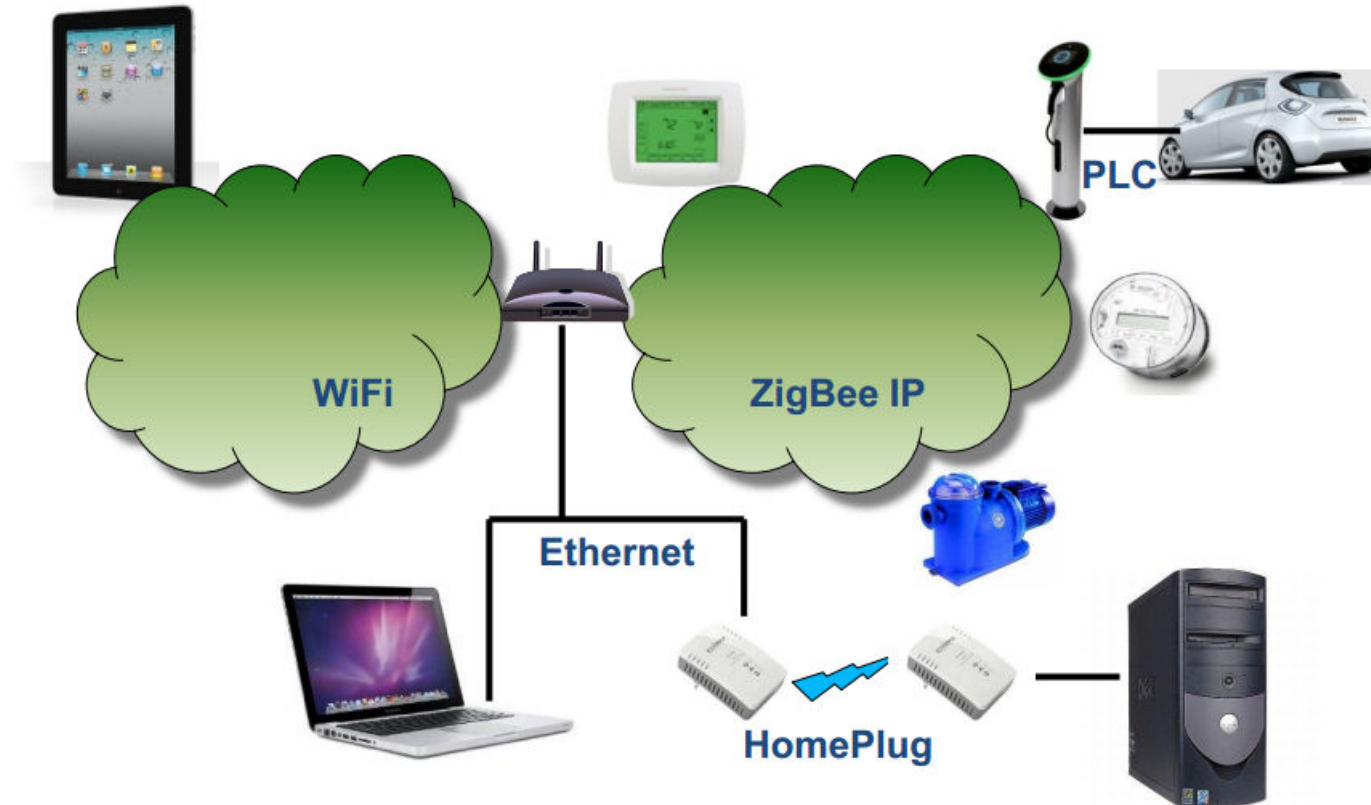
IEEE 2030.5 (SEP 2.0)

- 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



Many Sub-Networks Example



DER Specific Complementary Standards



Owner of IEEE 2030.5 and IEEE 1547



Owner of CA Rule 21 Certification Program



Mandated CA Rule 21 CSIP



Funding IEEE 2030.5 Certification and Demonstration Projects



DER Information Model used by IEEE 2030.5



Developer of open source IEEE 2030.5 Client

California Rule 21 Interconnection

- California state mandate requiring DERs with Rule 21 technical requirements
- From the California Public Utility Commission (CPUC) website:
 - Electric Rule 21 is a tariff that describes the interconnection, operating and metering requirements for generation facilities to be connected to a utility's distribution system. The tariff provides customers wishing to install generating or storage facilities on their premises with access to the electric grid while protecting the safety and reliability of the distribution and transmission systems at the local and system levels.
 - Each investor-owned utility (IOU) is responsible for administration of Rule 21 in its service territory and maintains its own version of the rule.
 - The investor-owned utilities in California are Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDGE).
 - See <http://www.cpuc.ca.gov/Rule21/> for general Rule 21 information

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

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 smoothen 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

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

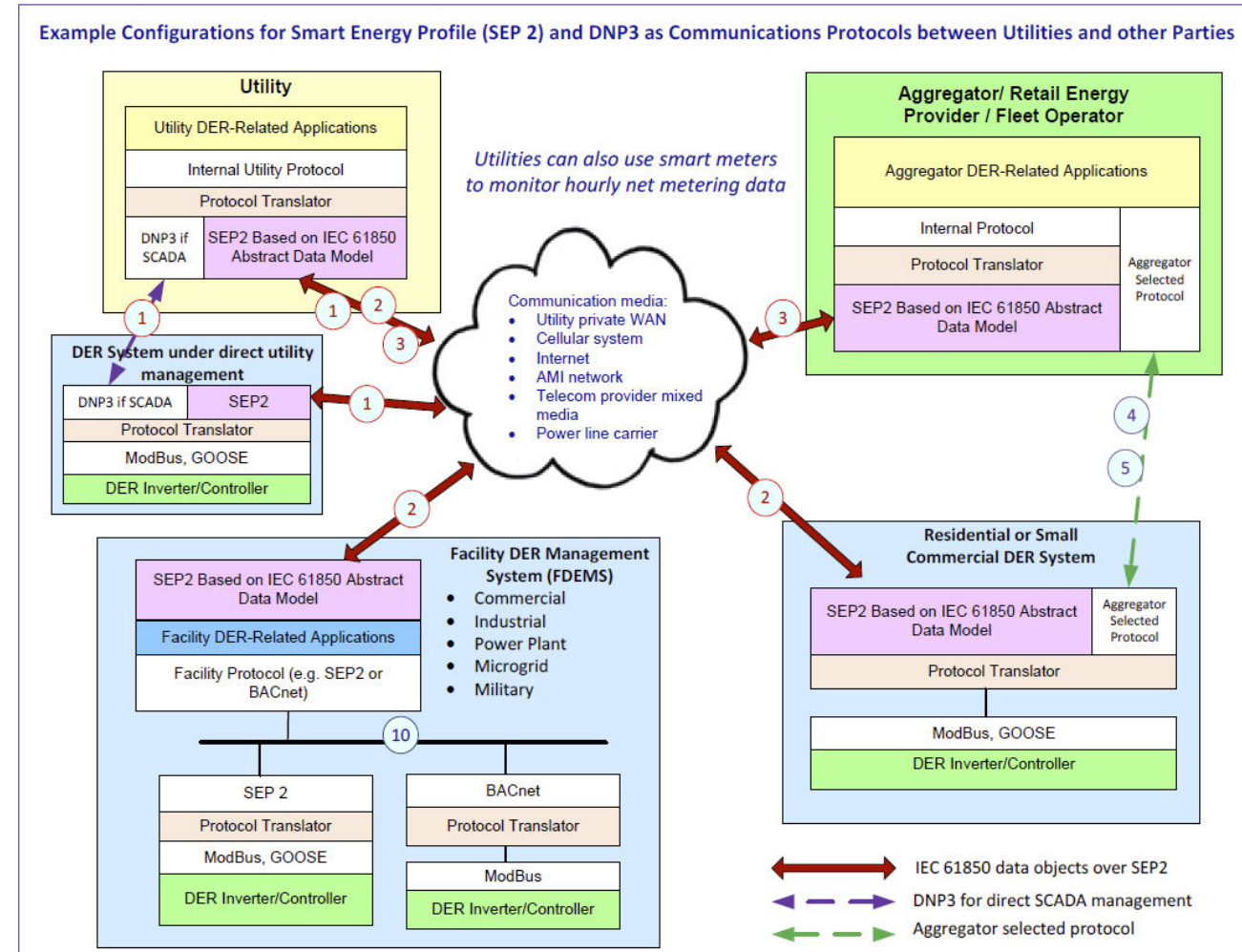
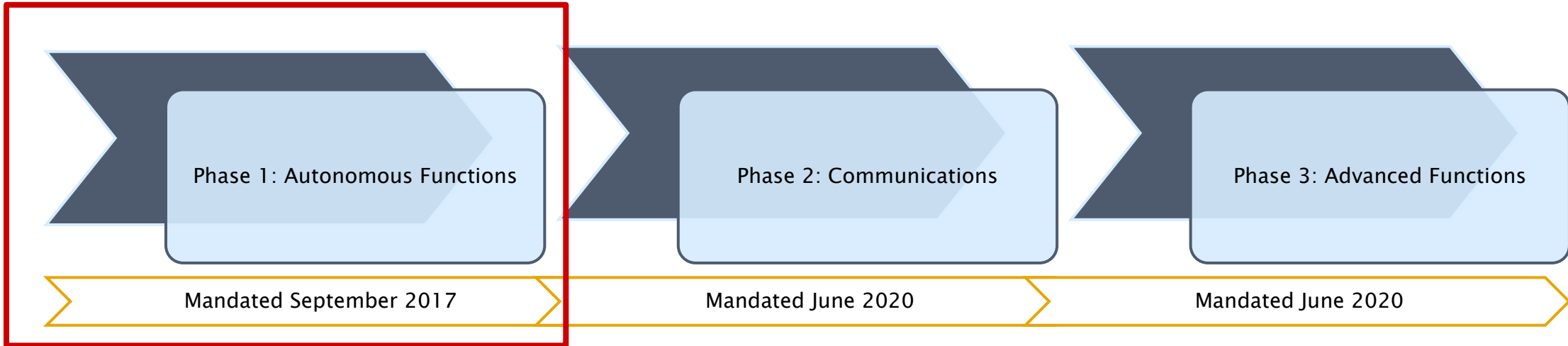


Figure 3: Conceptual Implementation of IEEE 2030.5 (SEP2) Communications with DER.

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



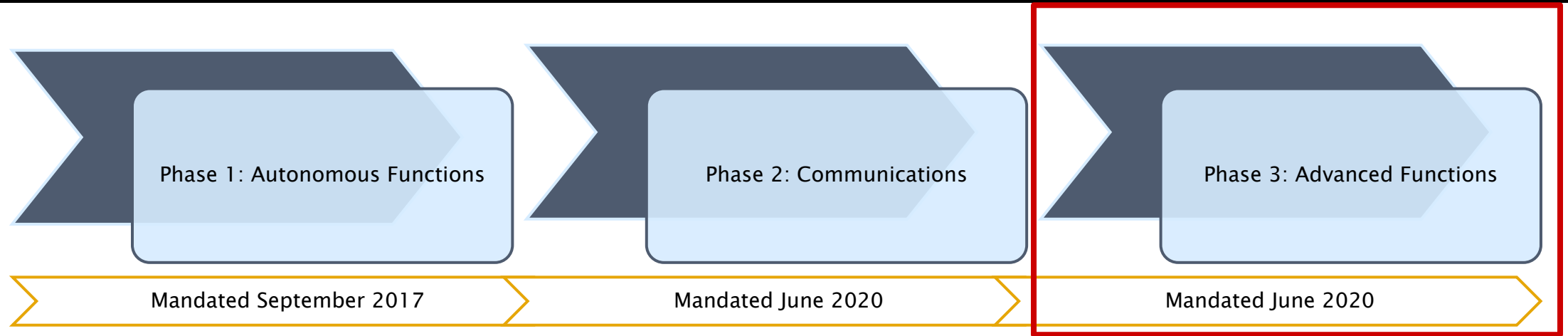
- Required functions: anti-islanding, Voltage ride-through, Frequency ride-through, Dynamic Volt-Var, Ramp Rates, Fixed Power Factor and Soft Start Reconnect
- Certifications
 - Inverters tested using UL 1741 SA (electrical functions) by NRTLs
 - No communication
- Inverter manufacturers already meet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

CA Rule 21: Standardizing DER functionality and communications



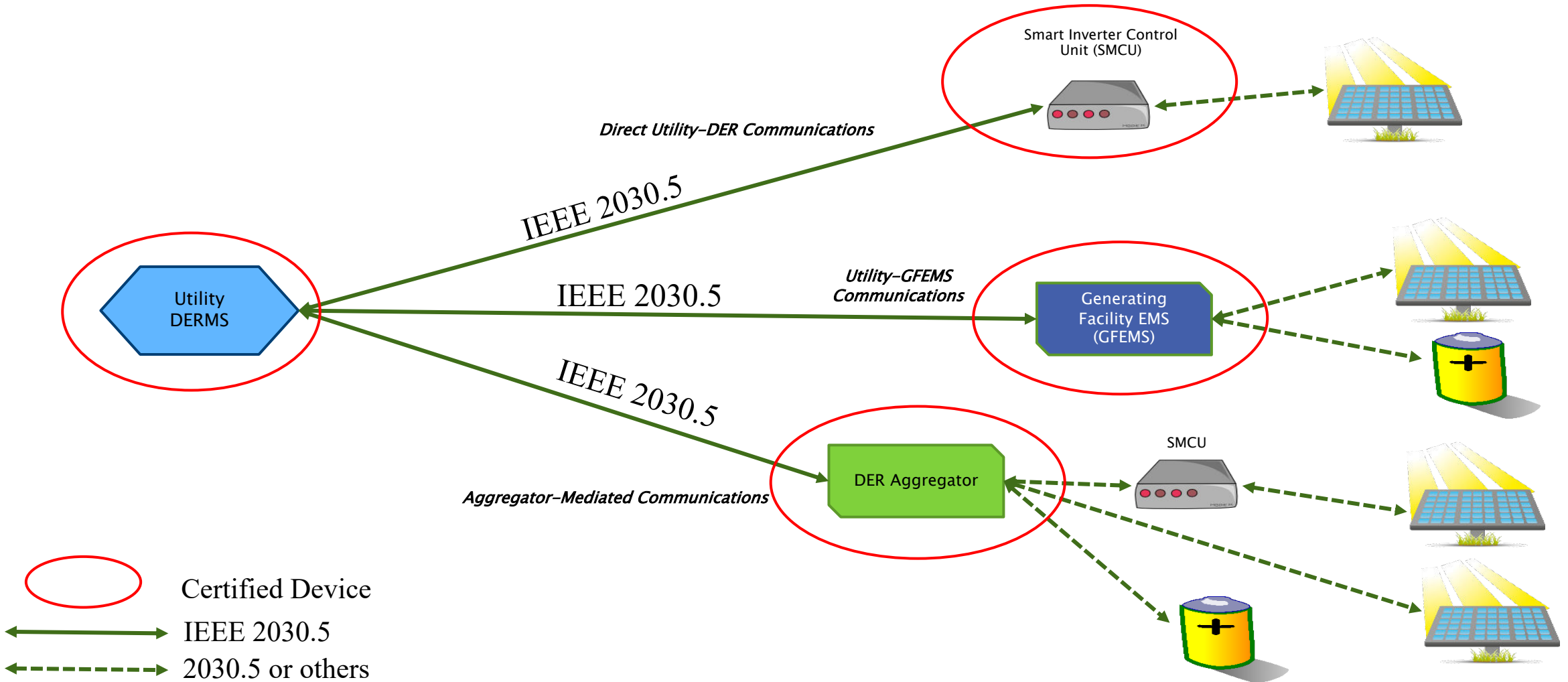
- DER must be capable of communicating all required information
 - Default protocol is IEEE 2030.5
 - Common Smart Inverter Profile (CSIP) – implementation guide of CA Rule 21 using 2030.5 protocol
- Certifications
 - Based on SunSpec CSIP Conformance Test Procedures – QualityLogic contributed over 50%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

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. | |

CA Rule 21 CSIP IEEE 2030.5 Usage Models



CA Rule 21/CSIP Usage Models

- Direct DER – small scale DER directly communicating with Utility DER Management System (DERMS)
- Generating Facility EMS – facility/VPP that has multiple inverters connected through single electrical coupling point
- Aggregator – 3rd party aggregator manages multiple inverters located anywhere on the utility's grid
- Utility DERMS manages, groups and targets all of these inverters
 - Ability to schedule and assign all of the Phase 1 and 3 grid functions
 - Ability to group inverters based on their connection to the grid assets
- Managed inverters (via Generating facility or Aggregator) may or not use 2030.5

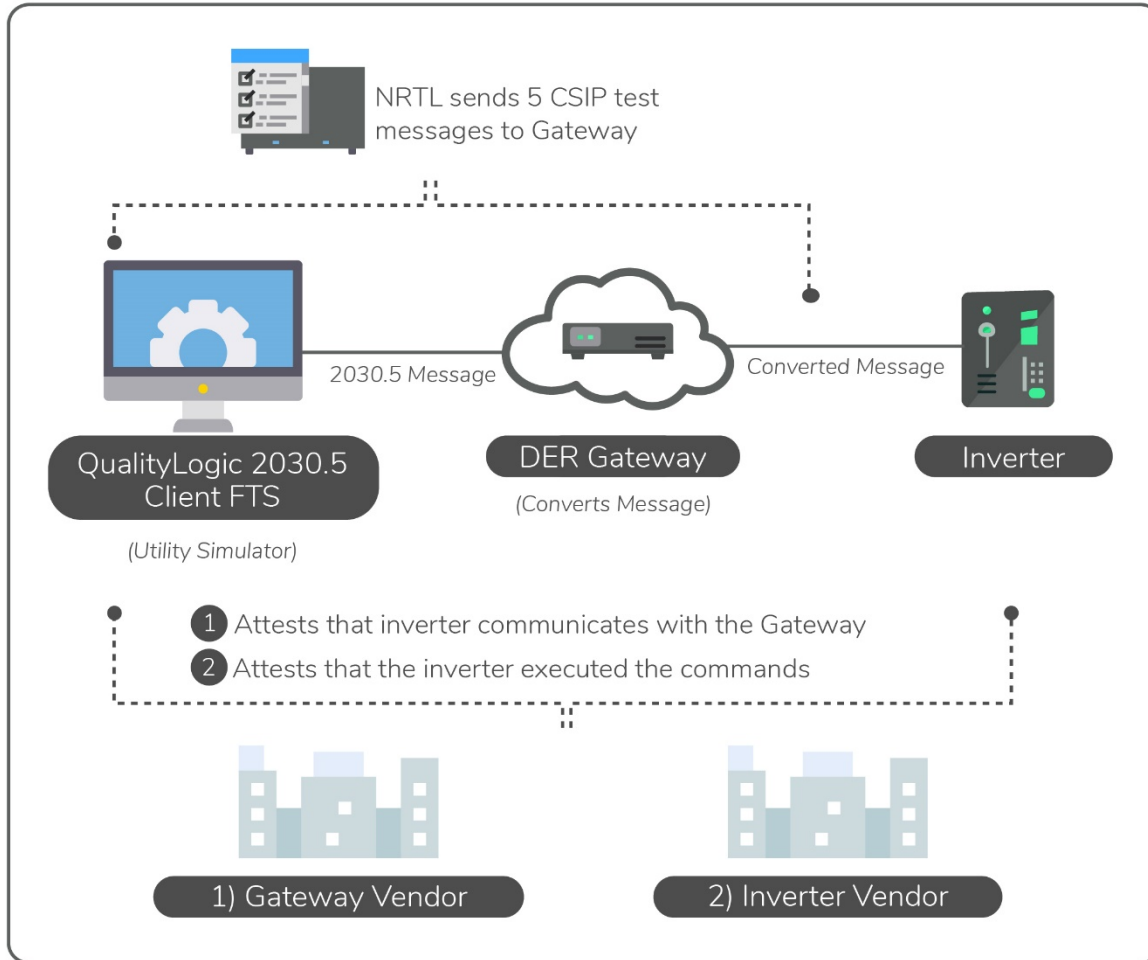
IEEE 2030.5 DER Certification

- 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
- CALSSA Testing Pathway to accommodate non 2030.5 capable inverters

CALSSA Testing Pathway

- California Solar & Storage Association (CALSSA) proposed that non 2030.5 based inverters can be tested for CA Rule 21 compliance through the use of a gateway device.
- Testing pathway requires:
 - Gateway must be capable of communications in conformance with IEEE 2030.5
 - Inverter must be capable of receiving and responding to communications from a gateway
 - Inverter must be capable of performing functions 1 (monitor data) and 8 (scheduling) from Phase III recommendations from SIWG
- Because the inverter communications can be other protocols besides 2030.5 and there is no test procedures for such connection, CALSSA proposed that utilities accept “manufacturer (inverter) attestations” for the inverter specific capabilities.
- QualityLogic’s test tool support the testing of the functions 1 & 8 as well as other Phase 1/3 functions.

CALSSA Testing Pathway using QualityLogic Test Tool



- Proposed for inverters that do not support 2030.5
- DER Gateway can be local gateway, aggregator or other 2030.5 device that communicates with inverter
- Gateway to inverter communication protocol can be any protocol including proprietary ones
- Attestation provided by gateway manufacturer
 - Confirms inverter communicates correctly with gateway
- Attestation provided by inverter manufacturer
 - Confirms inverter correctly executed the command signaled by 2030.5

IEEE 1547-2018

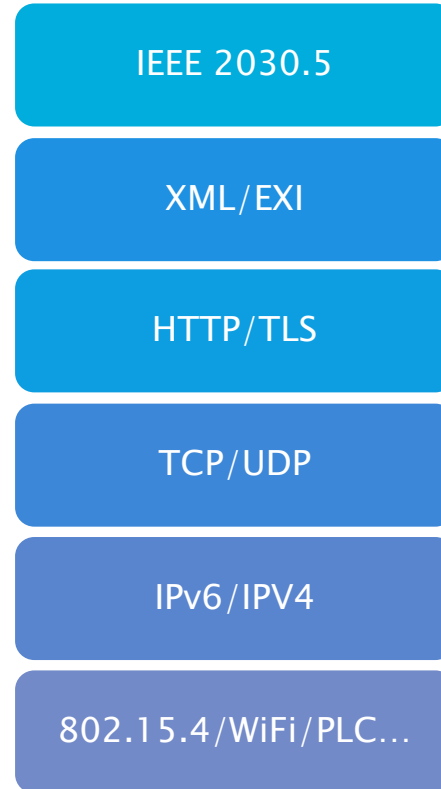
- International Interconnection standard mandated in the US and some other countries
- Specifies standard inverter functions
 - Based on IEC 61850-7-420 Information Model for DER (CA Rule 21 and IEEE 2030.5 uses same information model)
 - Mandated certification by December 2019 or earlier
- Specifies 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 required by end of 2019
 - Validate each 1547 function can be correctly managed via standard communications

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



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 |
|---|--|---|---|
| <ul style="list-style-type: none">• Time• Device Information• Power Status• Network Status• Log Event• Configuration• File Download• Configuration | <ul style="list-style-type: none">• Device capabilities• Self Device• End Device• Function Set Assignments• Subscription/notification• Response | <ul style="list-style-type: none">• DRLC• Metering• Mirrored Metering• DER Program/DERInfo• Messaging• Billing• Prepayment• Flow Reservation• Pricing | <ul style="list-style-type: none">• 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

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

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

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)

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

IEEE STANDARDS ASSOCIATION



IEEE Standard for Smart Energy Profile Application Protocol

IEEE Communications Society

Sponsored by the
Power Line Communications Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 2030.5™-2018
(Revision of
IEEE Std 2030.5-2013)

2030.5 Functions Required for CSIP

Common

- Time
- Device Information
- Power Status
- Network Status
- Log Event
- Configuration
- File Download

Support

- Device capabilities
- Self Device
- End Device
- Function Set Assignments
- Subscription/notification
- Response

Smart Energy

- DRLC
- Metering
- Mirrored Metering
- DER Program/DERInfo
- Messaging
- Billing
- Prepayment
- Flow Reservation
- Pricing

Core Functionality

- Design Pattern (WADL/Schema/List)
- Application Support (HTTP/URI/XML/EXI)
- Security (TLS, Certs, ACL)
- Discovery (xmdns, dns-sd)

Red text = Required CSIP functions

Road to CSIP Certification

How QualityLogic Contributes

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'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'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

Summary

- IEEE 2030.5 is actively being adopted and real
- CA Rule 21 certification for CSIP deadline (June 22, 2020) is coming quickly
 - Contact SunSpec Alliance for certification program details
- 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/>
- Q&A (~20 minutes)