NORTHEAST POWER COORDINATING COUNCIL, INC.
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NPCC REGIONAL STANDARDS COMMITTEE

AGENDA FOR MEETING #21-2

May 12, 2021 12:00 p.m. – 4:00 p.m. EDT **WebEx Meeting**
DER VER Forum May 13, 2021 8:30 a.m. – 2:00 p.m. EDT **WebEx Meeting**

Dial-In: 415-655-0003 (USA) / 416-915-6530 (Canada)

Day 1 - RSC Business:
Guest Code: 1851217290
Password: 6TmsPEtm*64 (68677386 from phone)
WebEx Link

Day 2 - DER VER Forum:
Guest Code: 1856003526
Password: FWjfb2m2F$5 (39532262 from phone)
WebEx Link

For Reference:
Glossary of Terms Used in NERC Reliability Standards, dated January 4, 2021
NPCC Glossary of Terms, dated October 2, 2019

Introductions and Chair's Remarks- COVID-19, NERC and FERC

NPCC Antitrust Compliance Guidelines

Agenda Items:

1.0 Review of Agenda

2.0 RSC Meeting Minutes (Approval Item)

3.0 Items Requiring RSC Discussion

3.1 NPCC DER Guidance Revision
3.2 FERC Activities
3.3 NPCC Directory Prioritization Whitepaper

4.0 NERC Reliability Standards
http://www.nerc.com/pa/Stand/Pages/Standards-Under-Development.aspx

4.1 Currently Posted Projects

Project	Comment Period End Date	Ballot Period End Date
Project 2016-02 Modifications to CIP Standards Norm Dang from IESO @ 12:15 PM	3/22/21 (F)	3/22/21 (I)
Project 2017-01 Modifications to BAL-003-1.1 David Lemmons from Cooper Compliance @ 12:30 PM	4/27/21 (I)	10/24/19 (F)
Project 2019-02 BES Cyber System Information Access Management William Vesely from Con Edison @ 12:45 PM	9/21/20 (F)	5/10/21 (A)

Project 2019-04 Modifications to PRC-005-6 Giannuzzi Giuseppe from HQ @ 1:00 PM	2/26/21 (F)	
Project 2019-06 Cold Weather Matthew Harward @ 1:15 PM	4/26/21 (F)	4/26/21 (A)
Project 2020-02 Transmission-connected Dynamic Reactive Resources Latrice Harkness @ 1:45 PM	3/20/20 (I)	
Project 2020-03 Supply Chain Low Impact Revisions SAR Tony Hall @ 1:30 PM	6/3/20 (I)	
Project 2020-04 Modifications to CIP-012	6/11/20 (I)	
Project 2020-05 Modifications to FAC-001-3 and FAC-002-2 SAR	12/11/20 (I)	
Project 2021-01 Modifications to MOD-025 and PRC-019	4/2/21 (I)	
Project 2021-03 CIP-002 Transmission Owner Control Centers		
Comments: (I) – Informal; (F) – Formal; (N) – Nomination Period **Ballots:** (I) – Initial; (A) – Additional; (F) – Final		

4.2 Ballot History (Since last RSC Meeting)
4.3 Comment Form History (Since last RSC Meeting)

5.0 NPCC Non-Standards

https://www.npcc.org/Standards/SitePages/NonStandardsList.aspx

5.1 Items for Discussion

5.1.1 NPCC Goal --- Prioritization of Directory Reviews
5.1.2 Directory#1 Design and Operation of the BPS --- Scope of Work
5.1.3 Directory#12 UFLS --- Retirement
5.1.4 Directory#11 Disturbance Monitoring --- TFSP Review
5.1.5 Executive Tracking Summary

6.0 RSC Member Items of Interest

6.1 RSC Roster

7.0 Standards Activity Post NERC BOT Approval

(Since last RSC Meeting)

7.1 NERC Filings to FERC
http://www.nerc.com/FilingsOrders/Pages/default.aspx
7.2 FERC Orders / Rules
http://www.nerc.com/FilingsOrders/Pages/default.aspx
7.3 Federal Register
https://www.federalregister.gov/
7.4 FERC Sunshine Act Meeting Notice
7.5 FERC Open Meeting Summaries

8.0 NERC Meetings

8.1 Standards Committee (SC)
http://www.nerc.com/comm/SC/Pages/default.aspx

January 20th – Call	February 17th – Call	March 17th – Call
April 21st – Call	May 19th – Call	June 16th – Denver, CO (Xcel Energy)
July 21st – Call	August 18th – Call	September 23rd – Salt Lake City, UT (WECC)
October 20th – Call	November 17th – Call	December 15th – Atlanta, GA (NERC)

8.2 Board of Trustees (BOT) Meeting
http://www.nerc.com/gov/bot/Pages/Agenda-Highlights-and-Minutes-.aspx

February 5-6 - Meeting	May 13-14 - Meeting	August 19-20 – Conference Call
November 4-5 – Conference Call		

9.0 NERC Items of Interest (Since last RSC Meeting)

9.1 Lessons Learned
http://www.nerc.com/pa/rrm/ea/Pages/Lessons-Learned.aspx

9.1.1 There have been seven new Lesson Learned issued since the last RSC meeting.

9.2 Alerts
http://www.nerc.com/pa/rrm/bpsa/Pages/Alerts.aspx
There has been one new NERC Alerts released since the last RSC meeting.

9.3 NERC Reliability and Security Guidelines
https://www.nerc.com/comm/Pages/Reliability-and-Security-Guidelines.aspx

9.4 NERC Rules of Procedure
https://www.nerc.com/AboutNERC/Pages/Rules-of-Procedure.aspx

10.0 Other Items of Interest

10.1 NPCC Board of Directors Meeting (BOD) 2021

January 27th – SGR Law Offices, Jacksonville, FL	March 17th - Call	May 5th – NPCC Office
June 2nd – Call	June 23rd – NPCC Office	August 4th – Call
September 1st and 2nd – Pierce Atwood	October 27th – Call	December 1st – Halifax, NS

11.0 Future RSC Meetings and Conference Calls

11.1 RSC 2021 Meeting Dates

February 10th-11th, WebEx
May 12th-13th, WebEx
August 11th-12th Toronto/Montreal or WebEx
October 13th-14th Toronto/Montreal or WebEx
December 2nd General Meeting or WebEx

Day Two RSC Meeting – DER VER Forum:

May 13, 2021 8:30 a.m. – 2:00 p.m. (all times in EDT)

12.0 Distributed Energy Resources (DER) Variable Energy Resources (VER) Forum Topics

12.1 Chair Opening Remarks, Antitrust Guidelines, Disclaimer, Public Notice, and Meeting Protocols - Guy V. Zito, NPCC Chair of the RSC and DER Forum (8:30 am - 8:40 am)
12.2 FERC Order 2222 Overview – Guy Zito (8:40 am – 8:50 am)
12.3 FERC Order 2222 NAESB Standards development – Dick Brooks, Reliable Energy Analytics (8:50 am – 9:00 am)
12.4 ISO-NE (9:00 am - 10:15 am)
  12.4.1 Addressing How Increasing DER Impacts System Operations – Dean LaForest
  12.4.2 FERC Order 2222 – Stephen George
12.5 FERC Order 2222 and DER integration R&D needs – Erik Ela and Deepak Ramasubramanian, EPRI (10:15 am - 11:00 am)
12.6 DER Aggregation Registration – John Romano, Con Edison (11:00 am – 11:30 am)

15 Minute Break (11:30 am - 11:45 am)

12.7 Hilo – Maude Lemieux, Hydro Quebec (11:45 am - 12:30 pm)
12.8 Advanced Inverters and Phased Deployment Plan – David Lovelady, National Grid, on behalf of the Joint Utilities of New York (12:30 pm - 1:15 pm)
12.9 Blockchain and Energy - Claudio Lima, Enterprise Blockchain, Chair of IEEE Blockchain Working Group (1:15 pm - 1:45 pm)
12.10 Discussion, Future Topics and Forums, and Other Matters – Guy Zito, NPCC (1:45 pm - 2:00 pm)

Northeast Power Coordinating Council, Inc. (NPCC)

Antitrust Compliance Guidelines

It is NPCC's policy and practice to obey the antitrust laws and to avoid all conduct that unreasonably restrains competition. The antitrust laws make it important that meeting participants avoid discussion of topics that could result in charges of anti-competitive behavior, including: restraint of trade and conspiracies to monopolize, unfair or deceptive business acts or practices, price discrimination, division of markets, allocation of production, imposition of boycotts, exclusive dealing arrangements, and any other activity that unreasonably restrains competition.

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- Industry-related topics considered sensitive or market intelligence in nature that are outside of their committee's scope or assignment, or the published agenda for the meeting;
- Their company's prices for products or services, or prices charged by their competitors;
- Costs, discounts, terms of sale, profit margins or anything else that might affect prices;
- The resale prices their customers should charge for products they sell them;
- Allocating markets, customers, territories or products with their competitors;
- Limiting production;
- Whether or not to deal with any company; and
- Any competitively sensitive information concerning their company or a competitor.

Any decisions or actions by NPCC as a result of such meetings will only be taken in the interest of promoting and maintaining the reliability and adequacy of the bulk power system.

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Distributed Energy Resources Forum Disclaimer Statement

1. General

Any information presented [at NPCC forums] is for informational purposes only. NPCC accepts no responsibility for the accuracy of such presentations, or for your reliance on any information contained within the content available through such forums. Discussions represent a wide range of views and interests of the participating individuals and organizations. Statements made during discussions do not necessarily reflect those of NPCC.

2. Vendors

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Public Announcement

RSC and DER Forum Meetings, WebEx, and Conference calls:
Participants are reminded that this meeting, WebEx, and conference call are public. The access number was posted on the NPCC website and widely distributed. Speakers on the call should keep in mind that the listening audience may include members of the press and representatives of various governmental authorities, in addition to the expected participation by industry stakeholders.

FERC Order 2222, "Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators"

NPCC DER/VER Forum
Guy V. Zito
NPCC Asst. Vice President - Standards

Highlights of the Order, Issued 9/17/2020

- What does it say?

"..remove barriers to the participation of DER aggregations in the capacity, energy, and ancillary service markets operated by Regional Transmission Organizations and Independent System Operators (RTO/ISO)."

- ISO/RTOs to file Tariff changes by end of July 2021 (or request an extension)

Highlights of the Order, Cont.

What's required?

- ISO/RTOs to file Tariff changes by end of July 2021 (or request an extension)-each RTO/ISO to establish DER aggregators as a type of market participant and to allow DER aggregators to register aggregations under one or more participation models in the RTO's/ISO's tariff that accommodate the physical and operational characteristics of the DER aggregation
- DER aggregations would be required to meet the 100 kW minimum size requirement that the Commission required for that participation model.

Highlights of the Order, Cont.

Definitions

- DER defined in the Order- “any resource located on the distribution system, any subsystem thereof or behind a customer meter.”
- DER aggregator makes sales of electric energy into RTO/ISO markets, it will be considered a public utility subject to the Commission’s jurisdiction. Such distributed energy resource aggregators must fulfill certain responsibilities set forth in the FPA and the Commission’s rules and regulations.
- If a DER aggregator (1) aggregates only demand resources; or (2) aggregates only customers in a net metering program that are not net sellers, that distributed energy resource aggregator would not become a public utility.

Highlights of the Order, Cont.

The ISO/RTO tariffs also must address technical considerations such as:

- locational requirements for DER aggregations;
- distribution factors and bidding parameters;
- information and data requirements;
- metering and telemetry requirements; and
- coordination among the regional grid operator, the DER aggregator, the distribution utility and the relevant retail regulatory authority.

Highlights of the Order, Cont.

The ISO/RTO tariffs also must also address other considerations such as:

- allow distributed energy resources that participate in one or more retail programs to participate in its wholesale markets;
- allow distributed energy resources to provide multiple wholesale services; and
- include any appropriate restrictions on the DER's participation in RTO/ISO markets through distributed energy resource aggregations, to avoid double counting

Potential Challenges in Implementing

- wholesale on the distribution system and 7-factor test;
- situational awareness for reliability and also settlement;
- big data;
- sufficient distribution platforms; and
- injection point- node or across ISO footprint
- effect on essential grid reliability services as energy producing resources compete or are replaced with DER
- effect on planning processes
- no NERC standards requirements for DER Aggregators
- settlement, accounting, and market enforcement

"Intelligence is the ability to adapt to change."- Stephen Hawking

Stephen Hawking (Jan 1942-March 2018)

Questions?

gzito@npcc.org

B. NAESB's Process

- NAESB used its consensus procedures to develop and approve the Version 3.1 Standards. **As the Commission found in Order No. 587, the adoption of consensus standards is appropriate, because the consensus process helps ensure the reasonableness of the standards by requiring that the standards draw support from a broad spectrum of industry participants representing all segments of the industry. Moreover, since the industry itself must conduct business under these standards, the Commission's regulations should reflect those standards that have the widest possible support. In section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTT&AA),13 Congress affirmatively requires federal agencies to use technical standards developed by voluntary consensus standards organizations, like NAESB, as means to carry out policy objectives or activities determined by the agencies** unless an agency determines that the use of such standards would be inconsistent with applicable law or otherwise impractical.

REF: 18 CFR Part 284 [Docket No. RM96-1-041; Order No. 587-Y]

NAESB Energy Storage/Distributed Energy Resource Standards Development Effort

- Recommendation of NAESB Advisory Council and received strong industry support for NAESB to consider standards activities in this area
- Intended to support wholesale electric market efforts to integrate energy storage and, more broadly, distributed energy resources in response to FERC Order Nos. 841 and 2222
- NAESB WEQ Business Practices Subcommittee developing business practices to:
    1. Define an index/registry for energy storage resources and distributed energy resources participating in the wholesale markets
    2. Create information and reporting requirements for these resource types
    3. Establish performance metrics for these resource types

Addressing How Increasing DER Impacts System Operations

NPCC DER Forum Presentation

Dean LaForest

ISO NEW ENGLAND

Highlights

Introduction

Generation Queue, Energy Supply and Reliability Services with Increasing DER Mix

Conditions When DER Impacts System Performance

Weather Impacts, Transient Impacts and Light Loads

Issues and Mitigation Measures

Evaluation of Individual Issues and Methods to Mitigate

Off-Shore Wind

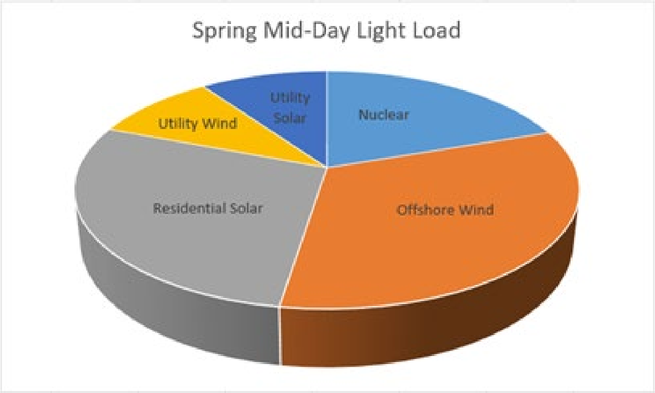
Integration Concepts

Conclusions

Meeting the Need to Integrate DER

Introduction

- New England is transitioning to a resource mix with large numbers of renewable energy facilities
- Looking forward, within 10 years, expect low load levels to be supplied only with renewable resources and remaining nuclear facilities
- New risks are being identified and new mitigation methods will be utilized

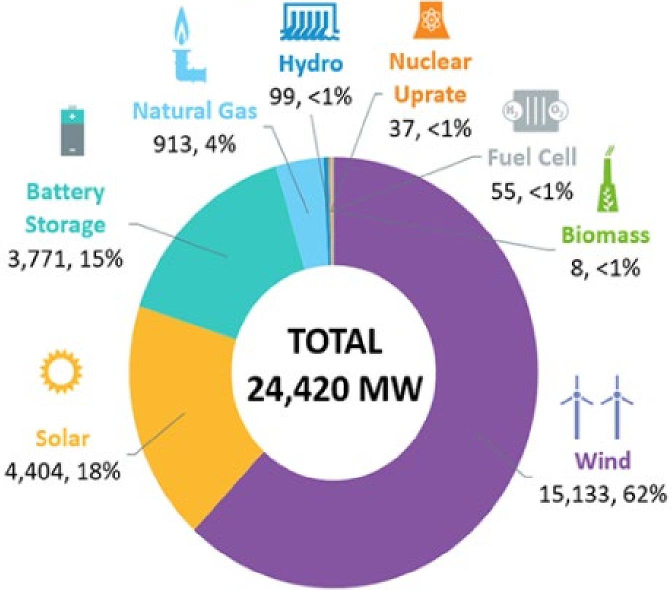


Future Spring Mid-Day Resource Mix

Nuclear units have limited ability to respond to frequency variations due to NRC regulations, but can provide area voltage support. Remaining mix made up of various inverter-based resources with varying capabilities and characteristics

Generation Queue – Shifting to Renewable Resources and Battery Storage

All Proposed Resources



Source: ISO Generator Interconnection Queue (February 2021)
FERC and Non-FERC Jurisdictional Proposals; Nameplate Capacity Ratings
Note: Some natural gas proposals include dual-fuel units (with oil backup).
Some natural gas, wind, and solar proposals include battery storage.

Proposals by State

(all proposed resources)

State	Megawatts (MW)
Massachusetts	12,540
Connecticut	7,653
Maine	2,260
Rhode Island	1,331
New Hampshire	531
Vermont	105
Total	**24,420**

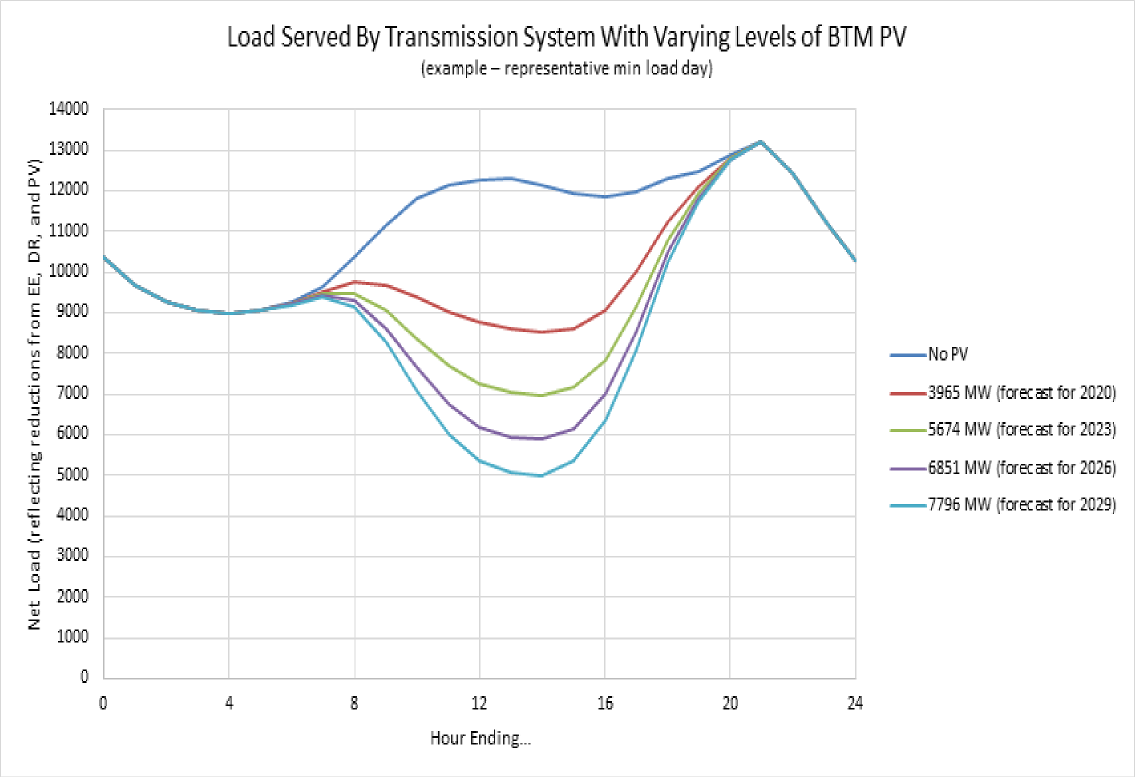
Source: ISO Generator Interconnection Queue (February 2021)
FERC and Non-FERC Jurisdictional Proposals

Inverter Based Renewable Resources

- Most of the focus of this part of the presentation is on distribution connected DERs with limited ISO Tariff applicability
  - Inverter-Based Resources (IBR)
  - Majority is comprised of rooftop solar
  - Installed per older IEEE 1547 standard which did not have stringent requirements for "utility grade" performance
  - Many variables and difficult to forecast

Projected Net Load Over Time

- More than 3,500 MW at end of 2020
- Largest concentration of photovoltaics (PV) is in eastern MA
- Most PV is behind the meter and not visible to ISO in real time
- PV reduces load served by the bulk electric system, but the ISO still needs to manage *reactive* load



Conditions When DER Impacts System Performance

- DER can impact system performance in various conditions
  - Light loads — as described when DER is the predominate resource
  - Peak loads — when weather significantly impacts DER output with limited time to react
  - Transient conditions — when DER would be expected to provide reliability service such as frequency or voltage response

Emerging Issues and Approaches to Address Them

- Approximate time when need must be mitigated: near / mid / long term
- Identify and catalog risks associated with DER integration
- Describe current and future mitigation methods
- Determine whether mitigation methods have a “lagging” or “leading” effect
- Capital budget look-ahead order of magnitude

Leading / Lagging Mitigation Concepts

Catalog risks associated with DER and determine mitigation and "indicator effects"

- Does the mitigation effort have a "leading" effect?
  - Provides insight and additional accuracy for future projections
  - Can be used to assess and successfully mitigate future impacts
  - Consider the degree of confidence in the mitigation measure
- Is the mitigation measure lagging?
  - Provide insight into DER performance after it has been installed
  - Consider degree of confidence in accuracy

Issue – Inherent DER Equipment Characteristics

- Inherent DER Characteristics
  - DER output changes and frequency of change
  - Ramping and flexibility to address demand forecast inaccuracy with DER output
  - Operating reserve necessary to manage steep hour-to-hour variations
- Mitigation considerations – lagging impact
  - Running conventional generation out of merit
  - Potentially adjusting imports (AC or HVDC)
  - Limiting DER output (with compensation mechanism)
  - Battery energy storage alternatives
- Approximate time to address issue: mid range

Limitations of the Earlier IEEE 1547-2003 *

- IEEE 1547-2003
  - Distributed energy resources (DERs) were still relatively rare and sparsely deployed
  - Represented only a tiny fraction of the power generation capacity of the system then, so the effects of DERs were almost entirely local
  - The 2003 standard's philosophy centered largely around ensuring that DERs did not interfere with the normal operation of the distribution system's regulation and protection systems
  - Although ride-through was not required, some utilities did implement it
- Typically, cease to energize was the most effective way to implement limited DER installations contemplated with IEEE-1547-2003

Focus on Significant Amounts of DER with the New IEEE Standard 1547-2018 and beyond

- IEEE 1547-2018 and as amended by 1547a-2020
  - IEEE 1547-2018 was developed with very different DER deployment
  - Many areas are now seeing sufficient levels of DER that the impacts on their systems are significant
  - Pronounced shift toward supporting Bulk Power System (BPS) dynamic and transient stability
- Ride-through is required with the new version
- ISO is working with New England regulators and utilities to implement the revision and amendment

Issue – DER Impact on Load Factor

- Load Factor Assumptions for real-time, day-ahead and outage coordination studies / Net load readings don't capture maximum load
- Mitigation considerations – lagging impact
  - Already observed with light spring loading during pandemic. Generation reductions where possible with existing Transmission Operator actions
  - Historical load coupled with weather data – may need more metering that doesn't presently exist
- Approximate time to address issue: near term

Issue – Impact on Load Forecasts

- While DER may be distributed geographically, their commonality can cause coordinated responses to weather events, which may create significant generation contingency risk / loss of load
- Mitigation considerations – lagging impact
  - For weather events that would cause energy and/or capacity deficiencies, replacement energy would be brought on-line with sufficient time to react. Collect additional information to fully understand the impact of these events and the resiliency of the power system.
- Approximate time to address issue: mid range

Issue – Impact on Load Forecasts (Continued)

- Net load reduction with DER can be erratic thereby limiting the use of "similar-day" based load forecasts
- Mitigation considerations – lagging impact
  - Implemented an explicit Behind The Meter (BTM) PV forecast process that is used as an input to the regional load forecast. This modeling technique differentiates between seemingly "similar days"
  - Ongoing R&D efforts for accuracy and fidelity for regional and zonal forecasts are continuously underway
- Approximate time to address issue: mid range

Adjustment to Operations Forecast for PV

Similar Day Adjustment Load Summary, *continued*

ISO NE Load Forecast - Similar Day Adjustment Details

Adjustment for solar power

Similar Days Adjustment Details for 06/21/2019

Select Similar Day 6/17/2016

Select Data Type BTM PV

Print Return

Previous Day Hour 24

Actual: 13073 Forecasted: 12230 % Diff: -6.7%

Copy All Hours to Adj

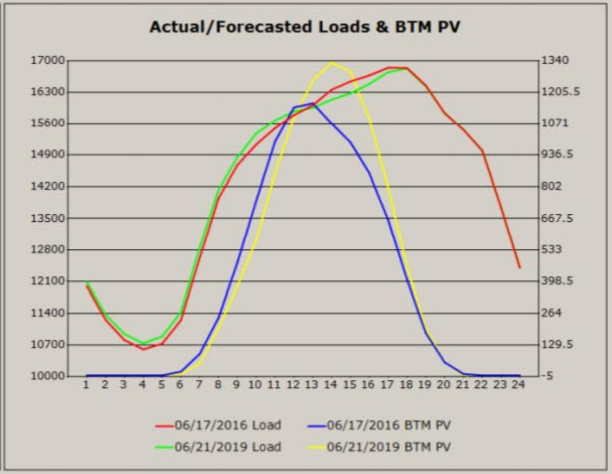
Clear All Hours

Load Adjustments

Hour	Actual Loads	Temp Adj	CC Adj	DP Adj	BTM PV Adj	Year Adj	Misc Adj	Forecasted Load
1	11995	0			0			12085
2	11257	1			0			11370
3	10808	1			0			10943
4	10603	1			0			10736
5	10729	1.5			0			10890
6	11249	1.5			10			11428
7	12626	1.5			41			12856
8	13956	1			42			14138
9	14678	0.5			102			14853
10	15138	0.5			169			15383
11	15502	0			135			15676
12	15796	0			43			15878
13	16015	0			-97			15958
14	16359	0			-261			16139
15	16543	0			-303			16281
16	16677	0			-233			16486
17	16848	0			-138			16752
18	16843	0			-55			16830
19	16455	0			-20			16435
20	15842	0			0			15842
21	15463	0			6			15469
22	15000	0			0			15000
23	13747	0			0			13747
24	12394	0			0			12394

Weather Adjustments

Hour	06/17/2016 Actual	06/21/2019 Forecast	Difference	Adjustment
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	16	6	10	10
7	92	51	41	41
8	246	204	42	42
9	479	377	102	102
10	745	576	169	169
11	995	860	135	135
12	1141	1098	43	43
13	1159	1256	-97	-97
14	1072	1333	-261	-261
15	991	1294	-303	-303
16	860	1093	-233	-233
17	663	801	-138	-138
18	407	462	-55	-55
19	181	201	-20	-20
20	56	56	0	0
21	6	0	6	6
22	0	0	0	0
23	0	0	0	0
24	0	0	0	0



Issue – Inaccurate DER Modeling

- Insufficient and/or inaccurate modelling of DER characteristics
- Mitigation considerations – lagging impact
  - OP-14 requires models for certain generation above 1 MW and all generation 5 MW and above participating in ISO markets including EMS, PSS/e power flow and dynamics modeling along with PSCAD for utility scale inverter based generation. Exploring other options (could be large budgetary expense for large number of EMS inputs)
- Approximate time to begin to address issue: mid range

Issue – Difficulty Detecting Faults with DER

- Protective Relay Sensitivity - Difficulty detecting and clearing system faults with widespread DER and off-shore wind installations
- Mitigation considerations – leading impact
  - Communication and coordination with large TO/TP protection managers to describe generation queue / New England Protection Working Group
- Approximate time to begin to address issue: mid range

Issue – DER Limited Reactive Support

- Reactive Support (Operations) – DER steady state reactive support to control local voltage during abnormal system conditions may not be enabled
- Mitigation considerations – leading impact
  - Local / regional mitigation strategies are being reviewed
  - Continue to work with state regulators and utilities to implement IEEE-1547-2018
- Approximate time to address issue: mid range

Issue – Restoration Coordination and Participation

- Transmission Operators coordinate transmission connected black start generation to energize the grid and add load in defined steps
  - Impact of DER on load needed in restoration unknown
- Entry of DER into black start program with uncertain performance characteristics
- Mitigation considerations – leading impact
  - Continue to work with state regulators and utilities to implement IEEE-1547-2018
  - Participation in restoration program with ISO New England approval consistent with other generation
- Approximate time to begin to address issue: mid range

Issue – DER Performance During Voltage Reduction

- Response to Voltage Reductions - Inverter based DERs embedded in distribution systems that provide energy management through conservation voltage reductions and Volt/VAR optimization can limit the response to the ISO 5% voltage reductions. Older installations may trip resulting in an increase in load.
- Mitigation considerations – leading impact
  - Continue to work with state regulators and utilities to implement IEEE-1547-2018
- Approximate time to address issue: mid range

Off-Shore Wind Installations

- New England has the nation's first off-shore wind farm off Block Island, Rhode Island (30 MW), and several thousand megawatts of off-shore wind are proposed
- Coupled with distribution DER, ISO New England has large off-shore wind installations in the generation queue

More Off-Shore Wind Is Being Proposed

Represents almost two thirds of proposed generation in the Queue

- Over **15,000 MW** of wind projects have been proposed in New England, representing **63%** of the ISO Generator Interconnection Queue

- Majority of wind proposals in Maine and off the coast of Connecticut, Massachusetts and Rhode Island

Source: ISO Generator Interconnection Queue (February 2021)
FERC and Non-FERC Jurisdictional Proposals
Nameplate Capacity Ratings

Conclusions – DER Risks to Operations

- ISO is considering conditions when DER impacts operations that include
  - Light loads
  - Peak loads
  - Transient conditions
- Internal process for evaluating issues and mitigation methods
- Identifying the issues and working with stakeholders to support the transition to the region's renewable energy future

MAY 13, 2021

FERC Order No. 2222

NPCC DER Forum Presentation

Stephen George

ISO NEW ENGLAND

Participation of Distributed Energy Resource Aggregations in Wholesale Markets

- Order No. 2222, issued on September 17, 2020, requires that ISOs/RTOs allow distributed energy resources (DERs) to provide all wholesale services that they are technically capable of providing through an aggregation of resources
- To comply, ISO/RTOs either need to:
  - Revise their tariffs consistent with specific requirements from the Order, or
  - Demonstrate how current tariff provisions satisfy the intent and objectives of the Order
- Compliance filings are due on **July 19, 2021**
  - ISO has filed a request with the FERC to extend its filing deadline to **February 2, 2022**
- The following slides present portions of the ISO's high-level design approach to comply with Order No. 2222
  - The ISO is continuing to receive and reflect on feedback from stakeholders, which may result in design modifications and updates that will be shared with stakeholders

ORDER NO. 2222

Definition of DER, DERA, and DER Aggregator

DERs and the delivery point of wholesale market services

- DERs include a wide array of devices that produce or consume energy; for example:
  - A generator and/or an electric storage device behind the same Point-of-Interconnection (POI) with the distribution network
  - A generator, electric storage, load management, energy efficiency and/or electric vehicles located behind a Retail Delivery Point (RDP) of an end-use customer facility, i.e., behind-the-meter (BTM) devices
- The delivery point of wholesale market services produced by or provided to one or more DERs at a facility is the POI/RDP of the facility to which the DER(s) belongs
  - For example, an end-use customer facility with 3 MWs of BTM generation and 3 MWs of load delivers no services to the wholesale market
  - If the same facility increases BTM generation to 4 MWs and decreases its load to 2 MWs, it injects 2 MWs to the grid and delivers 2 MWs of service to the wholesale market

ORDER NO. 2222

DERA Participation Models

DERs can participate under existing models or the proposed new models

- DERs can participate using any of the ISO's existing participation models for which they qualify
  - The ISO administers five markets and offers eleven participation models
  - Five ISO-administered markets: Forward Capacity Market, Forward Reserve Market, Day-Ahead Energy Market, Real-Time Energy Market, and Regulation Market
  - Eleven participation models including: Desired Dispatch Point Dispatchable Generator, Do-Not-Exceed (DNE) Dispatchable Generator, Settlement Only Resource (SOR), Continuous Storage Facility (CSF), Demand Response Resource (DRR), Dispatchable Asset Related Demand (DARD), and several others
- ISO does not plan to change the existing participation models with the Order No. 2222 compliance proposal
  - DERs that are currently participating under the existing models will be unaffected by the proposal
- ISO proposes two new models to facilitate heterogeneous aggregations to participate in the markets

DERA and Settlement Rules

- A Distributed Energy Resource Aggregation (DERA) can:
  - Be an aggregation of one or more DERs, depending on the size and location of the DERs
  - Include one technology type or multiple technology types
  - Be generation only, or load only, or generation and load
  - Be settlement-only or dispatchable
  - Participate in wholesale markets and retail programs
- It is the DERA, not the constituent DERs, that is offered into the markets and dispatched and settled by the ISO
- Meter readers report to the ISO a single meter value for the DERA, which is the sum of the meter values of the DERs comprising the DERA
  - If the DERA meter value shows energy production, the production amount will be credited at LMP
  - If the DERA meter value shows energy consumption, the consumption amount will be charged at LMP
  - ISO is considering approaches that allow DRRs to participate as part of a DERA
    - The load reduction performance of DRRs would be added to the DERA meter value

Settlement Only DERA Participation Model

- Settlement Only DERA (SODERA) model is an extension of Directly Metered Load Asset and Settlement Only Generator (SOG) models with aggregation

- If a DER Aggregator registers a SODERA, it participates as:
  1. **DERA SOG** represents the generation portion of the resource
  2. **DERA Load Asset** represents the load portion of the resource
  3. **Or both**

- A SODERA
  – Is not dispatchable by the ISO
  – Must meet proposed revenue quality metering requirements
  – May inject and/or withdraw
  – May participate in the Forward Capacity Market
  – May buy and sell energy in the Energy Market
  – Cannot provide reserves or regulation
    - It is not dispatchable and does not provide telemetry to the ISO

Dispatchable DERA Participation Models

- Dispatchable DERA (DDERA) model is an extension of Continuous Storage Facility (CSF) model with aggregation

- If a DER Aggregator registers a DDERA, it participates as:
  1. **DERA Generator** represents the generation portion of the resource
  2. **DERA DARD** represents the load portion of the resource
  3. **DERA ATRR** represents the regulation capability of the resource
  4. **As mentioned previously**, ISO is considering adding DRRs to this list
  5. **Or any combination** of the above

- A DDERA
  – Must meet the Dispatchable Resource definition (*see footnote*)
  – Must meet proposed telemetry and revenue quality metering requirements
  – Must have Designated Entity to perform dispatch service
  – Must submit and manage bids and/or offers
  – May inject, withdraw, and regulate
  – May participate in the Forward Capacity Market
  – May buy and sell energy in the Energy Market
  – May provide reserves and regulation

"…is capable of receiving and responding to electronic Dispatch Instructions in accordance with the parameters contained in the Resource's Supply Offer, Demand Bid, Demand Reduction Offer or Regulation Service Offer…"

SIZE AND LOCATIONAL REQUIREMENTS

- *100 kW minimum size for DERA*
- *Aggregation across a wide geographic footprint*

Size Requirements

For a DERA:

- Minimum size is 100 kW
- No maximum size limit

For a DER:

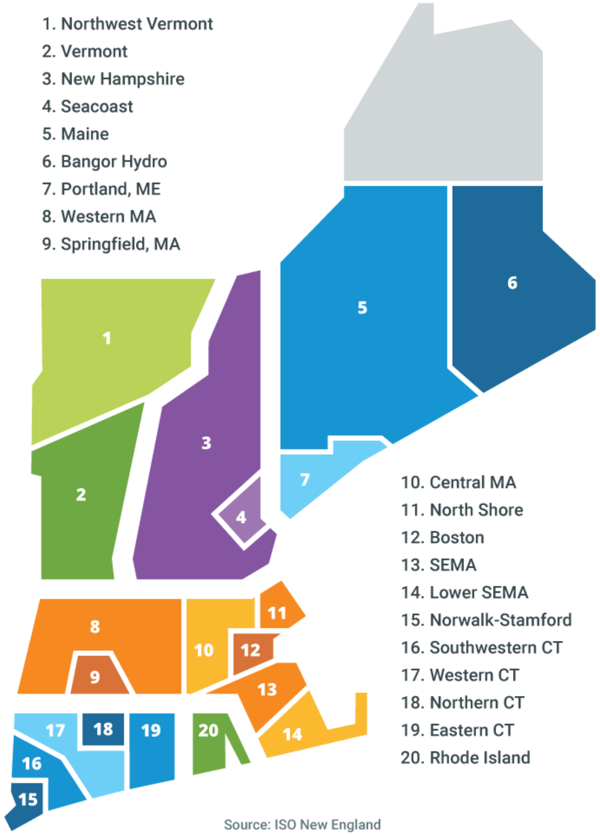
- No minimum size requirement
- No maximum size limit for a DER, provided an individual resource with generation injection capability greater than or equal to 5 MW:
  - Cannot be a SODERA
  - Can participate as its own DDERA if it meets the definition of Distributed Generation
  - Can participate as a Generator Asset (but not as a DDERA) if it does not meet the definition of Distributed Generation
  - This rule is consistent with the existing maximum size limit for a Settlement Only Resource and a Demand Response Asset
- Any DER greater than or equal to 100 kW, that is otherwise qualified to be a part of a DERA, may be its own DERA

Locational Requirements

- For a DDERA or a SODERA, all constituent DERs are required to be located within the same metering domain
  - Metering domain generally follows a distribution utility's service territory within a single Load Zone
- For a DDERA, all constituent DERs must also be located within the same DRR Aggregation Zone
  - Currently there are 20 DRR Aggregation Zones (map on next slide)
- In ISO's market software, a DERA will be mapped to a single pricing node (Pnode) from the following:
  - DRR Aggregation Zone Pnode, Load Zone Pnode, substation Pnode
- Since a DERA is a single-node aggregation, DER Aggregators are not required to provide distribution factors per the Order

New England Aggregation Zones

1. Northwest Vermont
2. Vermont
3. New Hampshire
4. Seacoast
5. Maine
6. Bangor Hydro
7. Portland, ME
8. Western MA
9. Springfield, MA



10. Central MA
11. North Shore
12. Boston
13. SEMA
14. Lower SEMA
15. Norwalk-Stamford
16. Southwestern CT
17. Western CT
18. Northern CT
19. Eastern CT
20. Rhode Island

Source: ISO New England

ORDER NO. 2222

Telemetry Requirements

Telemetry requirements – Settlement Only DERA (SODERA)

- Telemetry is not required for a DERA that is registered to be settlement only (SODERA)
- Only the RQM data for energy injection and withdrawal is required for settlement

Telemetry requirements – Dispatchable DERA (DDERA)

- Telemetry data provided to the ISO representing the DDERA is the sum of telemetry from each component DER
- Telemetry for each component DER is required to be located at or compensated to the RDP or POI, or, if DERA is metered at the device level, telemetry must totaled for each device
- OP-18 requirements for DARDS, ATRRs, and Generators would apply to DDERAs
- Telemetry latency for DDERA depend on market participation choices
  - Energy, Capacity, and thirty-minute reserves only
  - Energy, Capacity, thirty-minute reserves, ten-minute reserves, and/or regulation

Telemetry requirements – DDERA (Cont.)

- If DDERA is providing only capacity, energy, and TMOR:
  - Telemetry can either meet the requirements below for DDERAs providing ten minute reserves and/or regulation or:
    - Telemetry data is the average energy injection and withdrawal for the DERA in each 5 minute interval
    - Telemetry data must be received by the ISO within 5 minutes of the end of each interval
    - Telemetry data will include at a minimum MW and MVAR
- If DDERA is providing ten minute reserves and/or regulation in addition to capacity, energy, and TMOR:
  - Telemetry data is instantaneous rate of injection or withdrawal
  - Telemetry data must be updated every 10 seconds (4 seconds if providing regulation)
    - If DRRs are added to a DDERA, the current one-minute telemetry requirement for DRRs providing ten minute reserves will need further consideration
  - Telemetry data will include at a minimum MW and MVAR

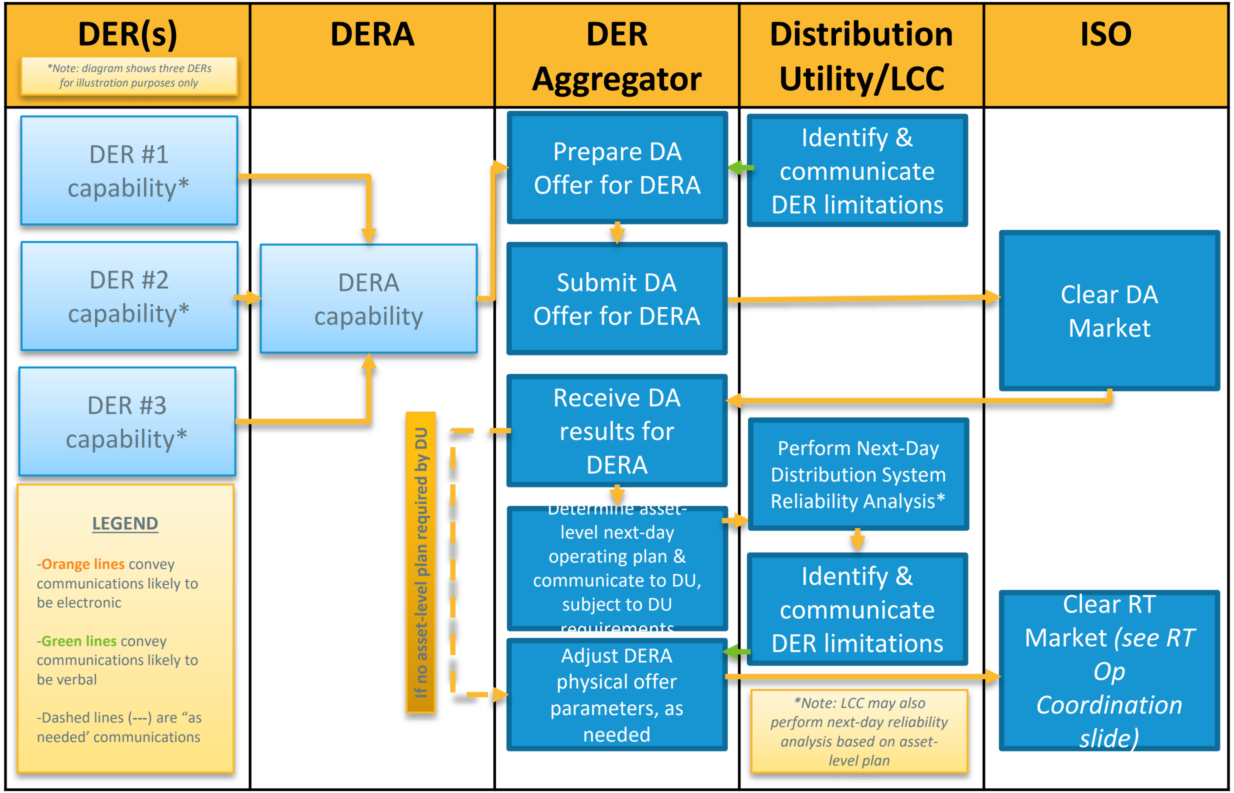
Operational Coordination Framework

- With respect to ongoing operational coordination, Order No. 2222 requires that we:
  - Address data flows and communication between RTO/ISO, DER Aggregators, and the distribution utilities
  - Require DER Aggregators to report any changes to offered quantity and related distribution factors that result from distribution line faults or outages
  - Include coordination protocols and processes for the operating day that allow distribution utilities to override RTO/ISO dispatch of a DERA to maintain the reliable and safe operation of the distribution system

Day-Ahead Operational Coordination Description

- DER Aggregators submit aggregation level Day-Ahead offers to the ISO, inclusive of restrictions due to distribution constraints as previously communicated by the DU to the DER Aggregator
- ISO clears Day-Ahead Market and provides aggregation level Day-Ahead awards to DER Aggregators
- DER Aggregators determine an asset-level operation plan to be provided to the DU for analysis, subject to the specific requirements of the DU
- Following receipt of the asset-level operation plan, the DU performs next-day distribution reliability analysis, if necessary
- DU informs the DER Aggregator of any operating constraints impacting either the asset or the aggregation
- DER Aggregators modify their physical operating parameters or financial offers in order to reflect any constraints identified by the DU

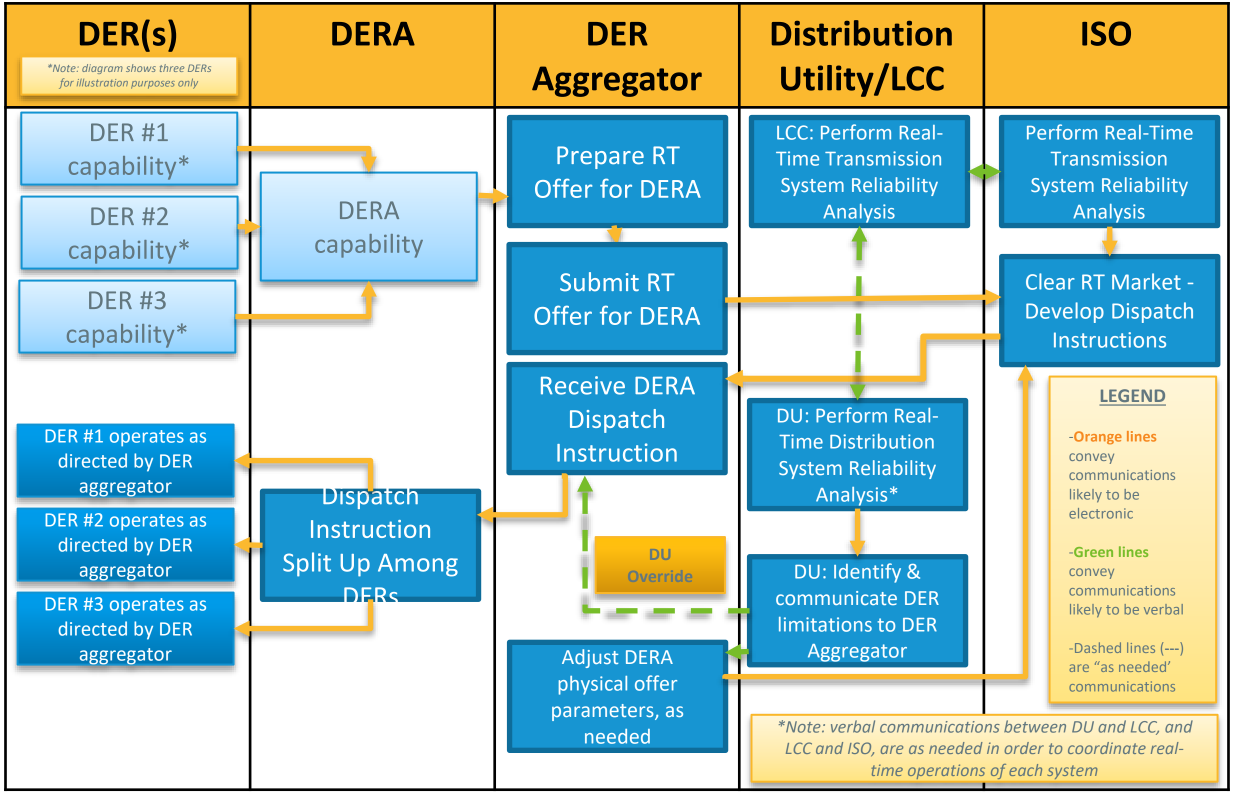
Day-Ahead Operational Coordination



Real-Time Operational Coordination Description

- As necessary, DER Aggregators update aggregation level physical operating parameters or financial offers inclusive of restrictions due to distribution constraints as previously communicated by the DU to the DER Aggregator
- ISO clears the Real-Time Market and transmits aggregation level desired dispatch points (DDP) to the DERA
- The DERA Aggregator ensures the DERA follows ISO's DDPs
- In the event that the DU detects actual or anticipated reliability issues in the distribution system during real-time operation, the DU informs the DER Aggregator of any operating constraints at either the asset or aggregation level
- The DERA immediately complies by adjusting the dispatch of the DERA as necessary
  - The DER Aggregator declares (to the ISO) any change of physical parameters accordingly

Real-Time Operational Coordination



Q&A and Discussion

DER R&D Activities

Challenges of integrating DERs into bulk power systems: Markets and planning

Erik Ela and Deepak Ramasubramanian
May 13, 2021
NPCC DER Forum

Today's Agenda

- FERC Order 2222
  - History and Overview
  - Existing and ongoing O2222 and DER activities
  - Research gaps and questions
- Integrating DERs into planning
  - The modeling challenge
  - The parameterization challenge

FERC Order 2222: Overview and R&D Gaps

FERC O2222 Timeline

June 2016:FERC accepts CAISO DERP design

Feb. 2018: FERC defers DER proposal in Order 841, issuing a technical workshop instead

September 2019: FERC requests information from ISOs on DERs

Jan. 2020: FERC accepts NYISO DER proposal

September 2020: FERC issues Order 2222 on DERA market participation w/ July 2021 compliance date

Electric Storage Resources and DER Aggregations treated together

DER Aggregations: FERC seeks more information before O2222

Electric Storage Resources: RTOs file changes to meet O841

Nov. 2016: FERC issues NOPR on electric storage resources and DERAs

Feb. 2018: FERC issues Order 841 on electric storage market participation

May 2019: FERC issues Order 841-A

Jan 2021: FERC requests information on hybrid resources

FERC ORDER 2222

A High Level Overview

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What is a DER? What is a DER Aggregator?

***DER**: any resource located on the distribution system, any subsystem thereof or behind a customer meter*

***DERA**: Entity that aggregates one or more DER for purposes of participation in RTO and ISO markets*

What are the Key Implementation Challenges?

Operational Coordination → Aggregator Management → Metering and Telemetry → Market Design

How Does 2222 Enable DER to Participate in ISO/RTO Markets?

Key Eligibility Requirements

- ➢ All DER technologies can **heterogeneously** aggregate to meet RTO/ISO requirements, if aggregation is at least **100 kW** in size
- ➢ Existing and/or new **participation models**
- ➢ Aggregation as ***geographically broad as technically feasible***
- ➢ Data, bidding, metering, and telemetry for *DERAs* **balanced** with existing requirements, but reduce burden on *DERs*
- ➢ Limit compensation for the **same service** in other programs

ORDER 2222 enables DER participation in ISO/RTO Markets

Who does this impact?

Customers
DER
Aggregators
Distribution Utilities
RTOs/ISOs
Regulators

How Will Market Participation Be Coordinated?

- **Main market interface:** RTO/ISO ↔ AGGREGATOR
- **Key Elements of Coordination**
  - ➢ Distribution utility **preclears** DER to join an aggregator
  - ➢ Distribution utility may **override** DERA schedule to ensure distribution system safety and reliability
  - ➢ **Data sharing** practices between all parties
  - ➢ **Retail rate authorities** involved in coordination
  - ➢ Allow regional **flexibility,** no explicit **coordination framework**

What is the Timeline?

ISO tariff modifications due within 270 days. (7/19/21)
Implementation date part of each RTO/ISO proposal.

Relevant EPRI Research Areas

Grid Operations & Planning	DER & DER Integration	Information & Communications	Energy Utilization

Existing DERA Market Designs

	CAISO (DERP)	NYISO
Filed Tariff Revisions / FERC Acceptance	March 2016 / June 2016	June 2019 / January 2020
Market Participation Eligibility	Energy and Ancillary Services (not eligible to provide resource adequacy)	Energy, Ancillary Services, Capacity Market
Min Aggregation Size	500 kW for DERs; 100 kW for ESRs	100 kW
DERs Not Allowed to Participate	Individual DERs 1 MW or greater Demand Response (DR) participating through reliability or proxy demand response Resources participating in retail net metering program	Individual generators 20 MW or larger Prohibits Single DER participation Except for DR Other limitations apply
DERA and locational requirements	Multiple pricing nodes (Must be in a single sub-LAP) Maximum aggregation size of 20 MW for multi-node aggregations only Dispatch instructions according to distribution factors Paid weighted-Average LMPs across multiple nodes	Single transmission pricing nodes List of nodes updated annually
Dual Participation	Disallows resources participating in net metering program Currently working with stakeholders to further evaluate dual participation	Tariff revisions in May 2020 allowed DERs to provide services to a local distribution utility and participate in NYISO at the same time
Metering and Telemetry	DER Aggregators must follow the same metering and telemetry standards as other suppliers Real-time 4-second telemetry if more than 10 MW or providing ancillary services	Each DER required to have adequate metering Real-Time 6-second telemetry for DERA
Potential Changes for Compliance with Order No. 2222	Reduce minimum aggregation size to 100 kW Resource adequacy eligibility Operational Coordination?	Allow for single DER participation Demonstration of geographical scope limit to one node Operational Coordination?

O2222 original proposal primarily based on CAISO DERP

Stakeholder Discussions Across the Continent

RTO/ISO	Working Group Latest Update	Filings due
PJM	DER and Inverter-based Resources Subcommittee (DIRS): Recently presented an initial proposal to comply with O2222 requirements	February 1, 2022
MISO	Distributed Energy Resources Task Force (DERTF): Presented initial thoughts on participation models and locational requirements	April 18, 2022
SPP	O2222 Task Force: Created draft tariff language to comply with several aspects of the order	April 28, 2022
ISONE	Markets Committee: Proposed two new participation models; Engaged in discussions with stakeholders to refine the proposal	February 2, 2022*
NYISO	Working with stakeholders on what changes required for compliance	July 19, 2021
CAISO	Not much action yet, DERP mostly already compliant	July 19, 2021
ERCOT	Has worked on DER participation for number of years	N/A
IESO	Recently held first local distribution auction in York region	N/A
AESO	DER Roadmap published in 2020	N/A

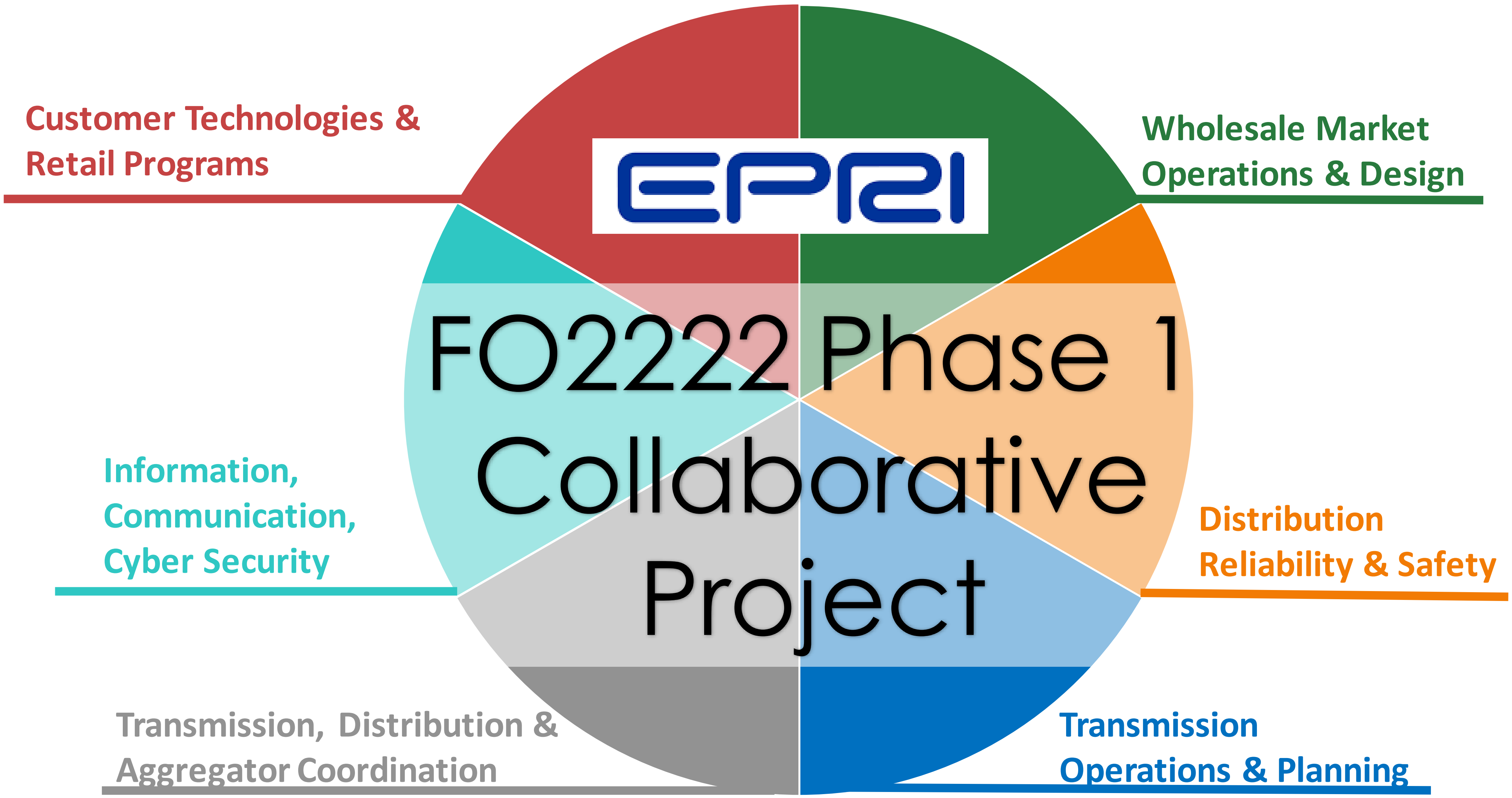
*FERC has not approved extension yet.

All ISOs and RTOs are engaged in stakeholder discussions to address O2222 and DERA market participation

Research Gaps

Participation Models	Heterogenous participation model consequences Computational issues with market clearing Guiding principles to understand double counting Can distribution system losses impact dispatch decisions
Locational Requirements	Proven engineering methods to determine geographical limits on aggregation Price formation impacts of multi-node aggregations Forecast error impact on distribution factors
Metering and Telemetry	What cyber security risks and opportunities present Privacy concerns of multiple parties sharing information New cost-effective methods beyond direct metering
Coordination	Explore practicality of emerging coordination frameworks Tools to determine when and how much override needed What communication procedures enable coordination

https://www.epri.com/research/products/000000003002020586


Customer Technologies & Retail Programs
EPRI
Wholesale Market Operations & Design
FO2222 Phase 1 Collaborative Project
Information, Communication, Cyber Security
Distribution Reliability & Safety
Transmission, Distribution & Aggregator Coordination
Transmission Operations & Planning

Market Design

Participation Model Modification

- Requirement: Allow DER Aggregators to register under one or more participation models in the RTO tariff that accommodate the **physical and operational characteristics** of the DERA
  - ISO may modify its **existing** participation models to facilitate participation of DERA, establish **one or more new** participation models for DERA, or both.
- ***Comments***: New participation models may be unnecessary or **too costly**
- ***Comments***: Existing participation models may have **limitations**
- Participation Model: What does it mean?
  - NOPR: We define a participation model as a set of **tariff provisions** that accommodate the participation of resources with particular **physical and operational characteristics** in the organized wholesale electric markets of the RTOs and ISOs.
  - Order 841: Tariff revisions that consist of **market rules** that, recognizing the **physical and operational characteristics** of the resource, **facilitates** their participation in RTO/ISO markets
  - Comments from ISO NOPR: “Focus on participation models rather than on services is **inconsistent** with its core market design objective of **technology neutrality**”
  - Comments from EPRI NOPR: “definition of a participation model also includes the set of **market clearing software provisions** required to represent the physical and operational characteristics of the resource.”

Market Design

Locational Requirements

- Requirement: Each ISO allow DER aggregations as **geographically broad as technically feasible**
- Requirement: Aggregators must give **distribution factors** during registration and whenever they change

- **Multi-node aggregations?**
  - **For:** Provides efficient market entry and competitive benefits, including economies of scale to meet size requirements
  - **For:** Already done for demand response
  - **Against**: Aggregations on both sides of a transmission constraint can impact reliability and price formation, congestion patterns change
  - **Against**: allocation will change, distribution factors cannot be predicted with perfect accuracy

Market Design

Research Gaps

Are existing participation models sufficient? What warrants creation of new models?

What are the key changes for heterogenous participation models? Demand response, energy storage, renewables?

What bidding parameters may be required from DERAs not required from other resource types?

What ancillary services are DERAs eligible or not eligible to provide? Does it depend on the underlying DER technology?

Are there market clearing software computational challenges to massive amounts of small DERAs added to the market? Is unit commitment needed for DERAs?

Should multi-node DER aggregations be allowed? How broad can they cover? How do you set LMP?

What retail programs would lead to unfair double counting of the same service? Are there broad principles to apply?

Distribution Utility Operations

Registration and Review

» Requirement: Allow non-discriminatory process for **timely review by utility of individual DERs** in an aggregation

» Determine criteria that utilities would use to determine whether

- Each DER is eligible to participate
- If the participation of the DER in an aggregation would pose **significant risks** to the reliable and safe operation of the distribution system

» What about aggregations that the utility itself establishes?

» How to settle disputes

Distribution Utility Operations

Distribution override and curtailment

» Requirement: Create procedures for the distribution utility to override RTO dispatch of a DERA when needed to maintain distribution system reliability

» Determine criteria that utilities would use to determine whether

- Each DER is eligible to participate
- If the participation of the DER in an aggregation would pose **significant risks** to the reliable and safe operation of the distribution system

Distribution Utility Operations

Research Gaps

What is a distribution system operator, or DSO, and do what do they do?

What tools and metrics can the distribution utility use to study operating day reliability needs in a timely fashion?

What technology solutions (software and hardware) for near-real time situational awareness are needed to enable market participation and override process ?

How will distribution system interconnection procedures and planning studies need to change?

Coordination

Requirements

» **Requirement**: Coordination for registration and ongoing operational coordination (discussed earlier)

» **Requirement:** Create a process for ongoing coordination addressing data flow and communication among RTO, aggregator, distribution utility and relevant retail regulatory authority (RERRA)

» **Requirement**: Each RTO/ISO must specify in its tariff how it will accommodate and incorporate the voluntary involvement of RERRA in coordinating the participation of DER Aggregations in RTO/ISO Markets

» **Requirement**: Encourage but not require coordination frameworks

- But wait, did everything else that FERC say require it?

"A broader, holistic approach to coordination [i.e., a coordination framework] could help ensure different elements of DERAs do not work at cross-purposes"

Coordination

Frameworks

- » Taft, PNNL: A way to exchange information and control signals between the three levels of the U.S. electric system (BPS, Dist., customer)
- » R Street: Way to create incentives for innovation and deployment of advanced active network management practices
- » Many argue toward decentralized frameworks; some toward hierarchical frameworks
- » Potential frameworks
  - Transactive markets (PNNL)
  - Platform markets (TCR/NYSERDA)
  - Total ISO, Total DSO, Hybrid DSO (De Martini & Kristov)

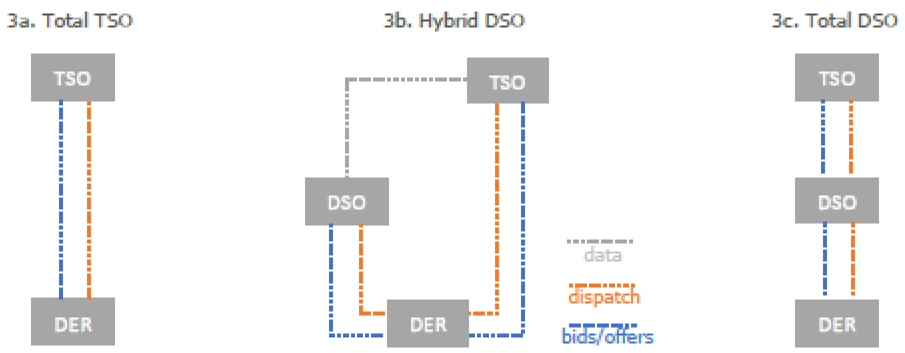
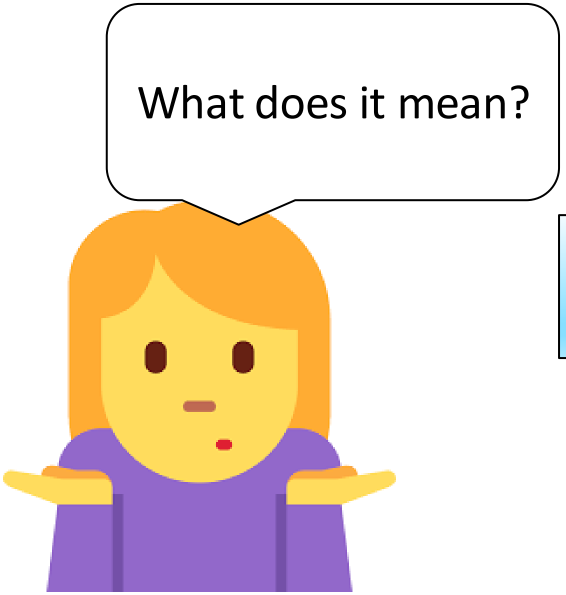
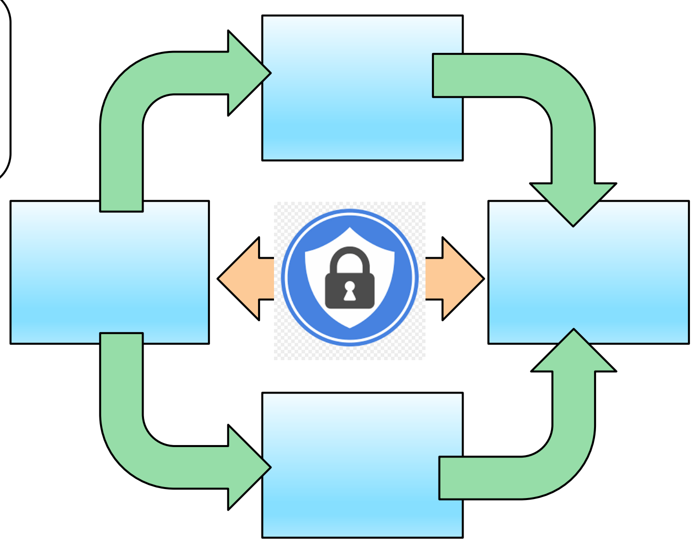


Figure 3: TSO-DSO coordination models[9]



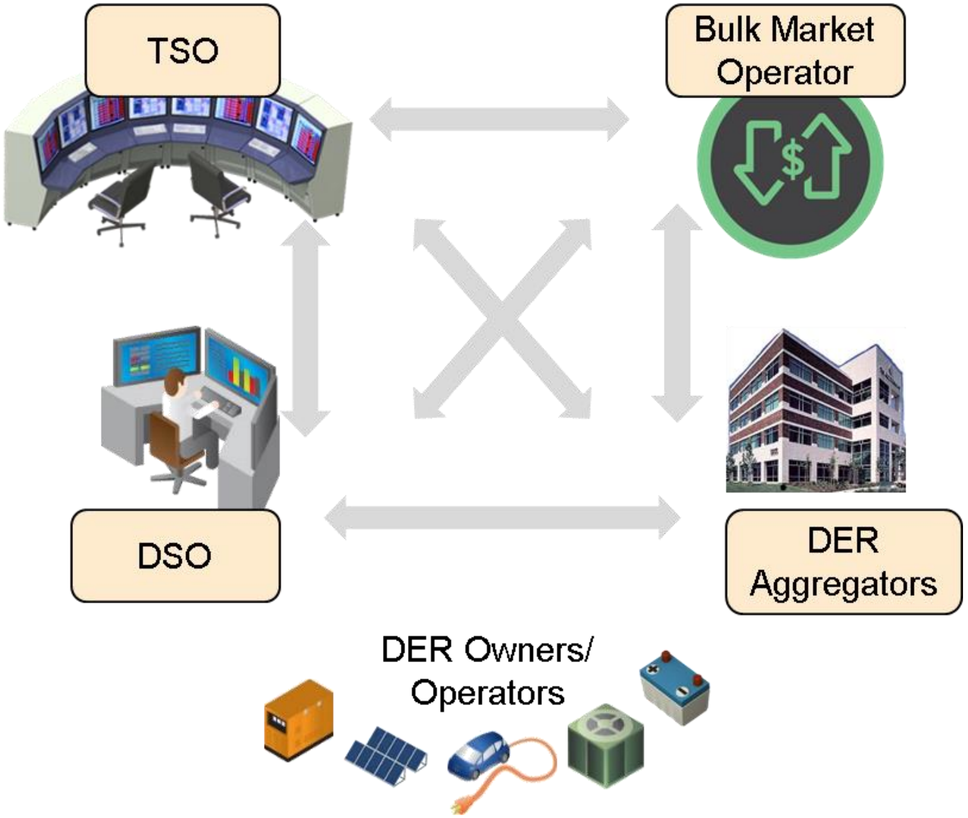


Coordination

EPRI approach to coordination frameworks

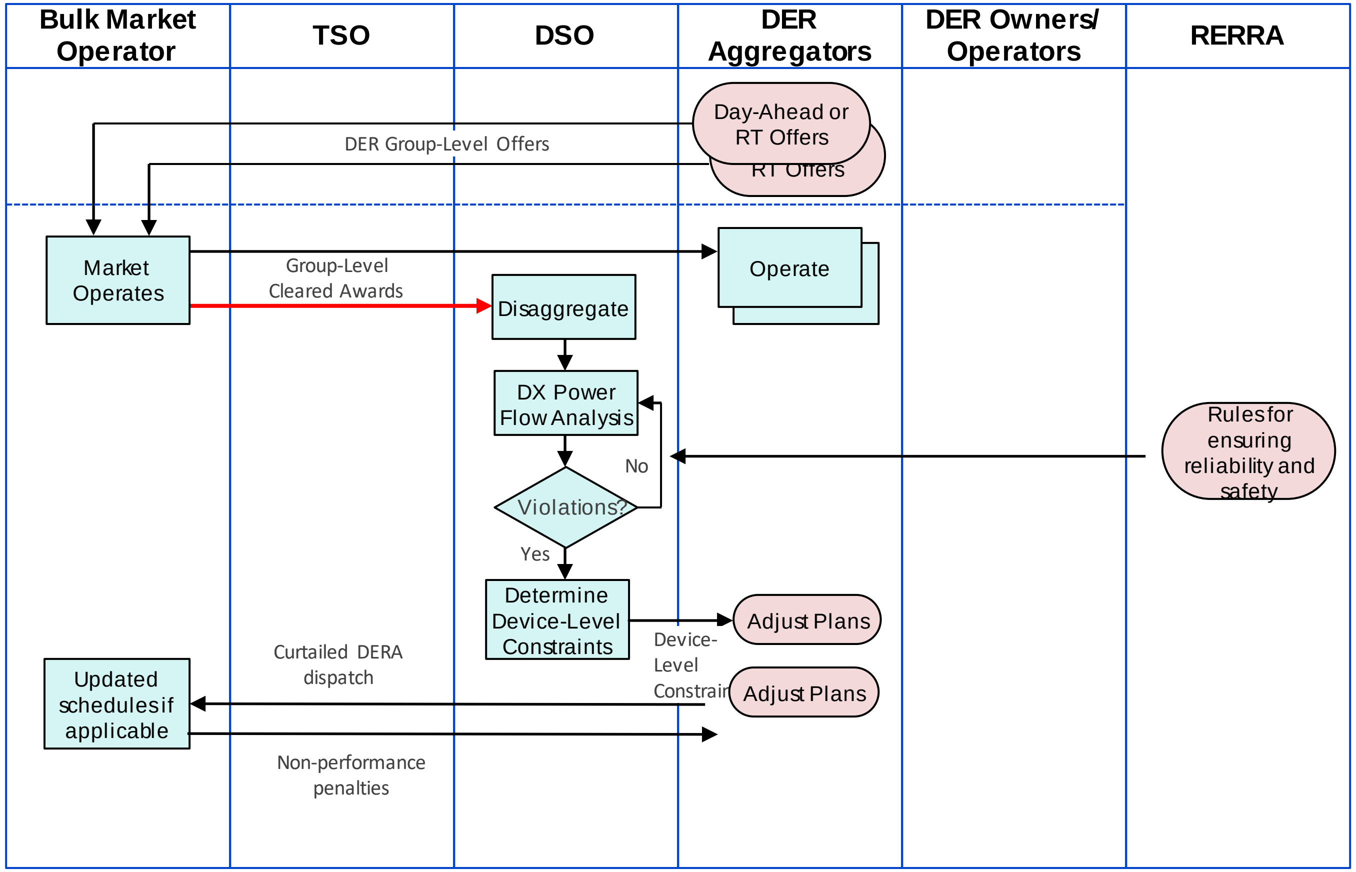
» A way to share information between actors when DER are providing grid services to,

- Reduce the cost and complexity of providing grid services from DER/DER aggregations
- Ensuring reliable system operation
  - Bulk system
  - Distribution system
- Addressing double payment of DER services
- Improve utilization/access of DER for grid services
- Simplify the process of integrating DER with the grid.



Coordination

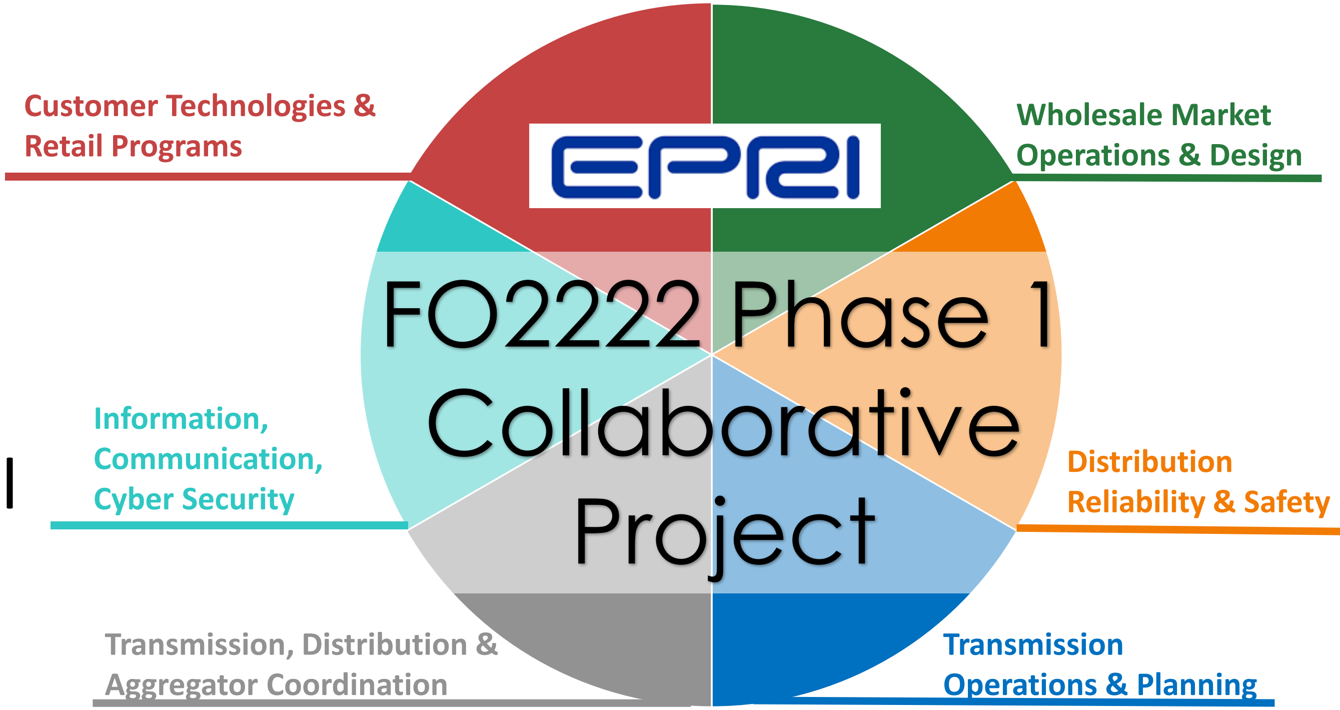
Aggregation Dispatch and Potential Override Curtailment



Example Timing: 10:00 D-1 | 13:00 D-1 | 17:00 D-1 | D, t

EPRI FO2222 Project Outcomes

- 35 companies including all RTOs/ISOs in North America participating
- Bi-monthly topical webcasts, educational sessions, inclusion of all impacted stakeholders
- Workstream *Challenge Guides* published throughout May and June
- Roadmap report for implementation planned for September
- Updated *Challenge Guides* in the Fall

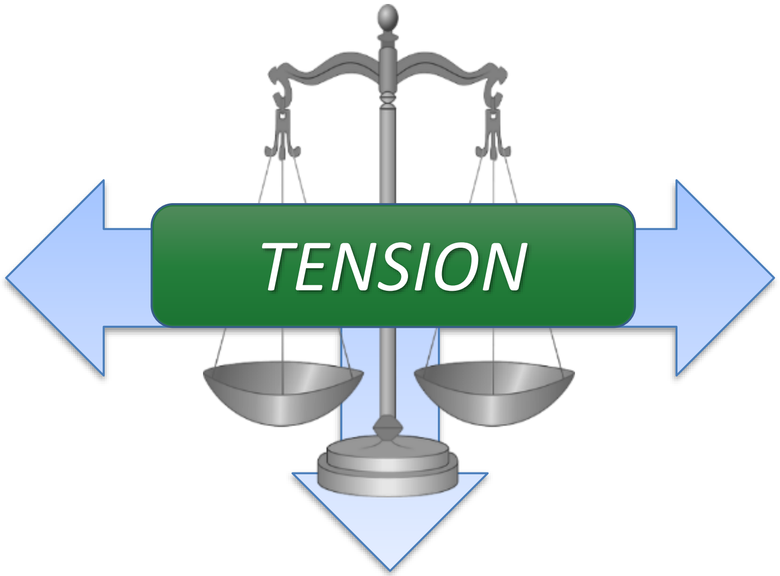


DER Modelling Challenge for Transmission System

Outlook: Balancing Bulk & Distribution Grid Needs

Distribution Grid Side

- Short trip times
- Ride-through *with momentary cessation*
- Voltage rise concerns
- Islanding concerns
- Protection coordination
- Safety of line workers



Bulk System Side

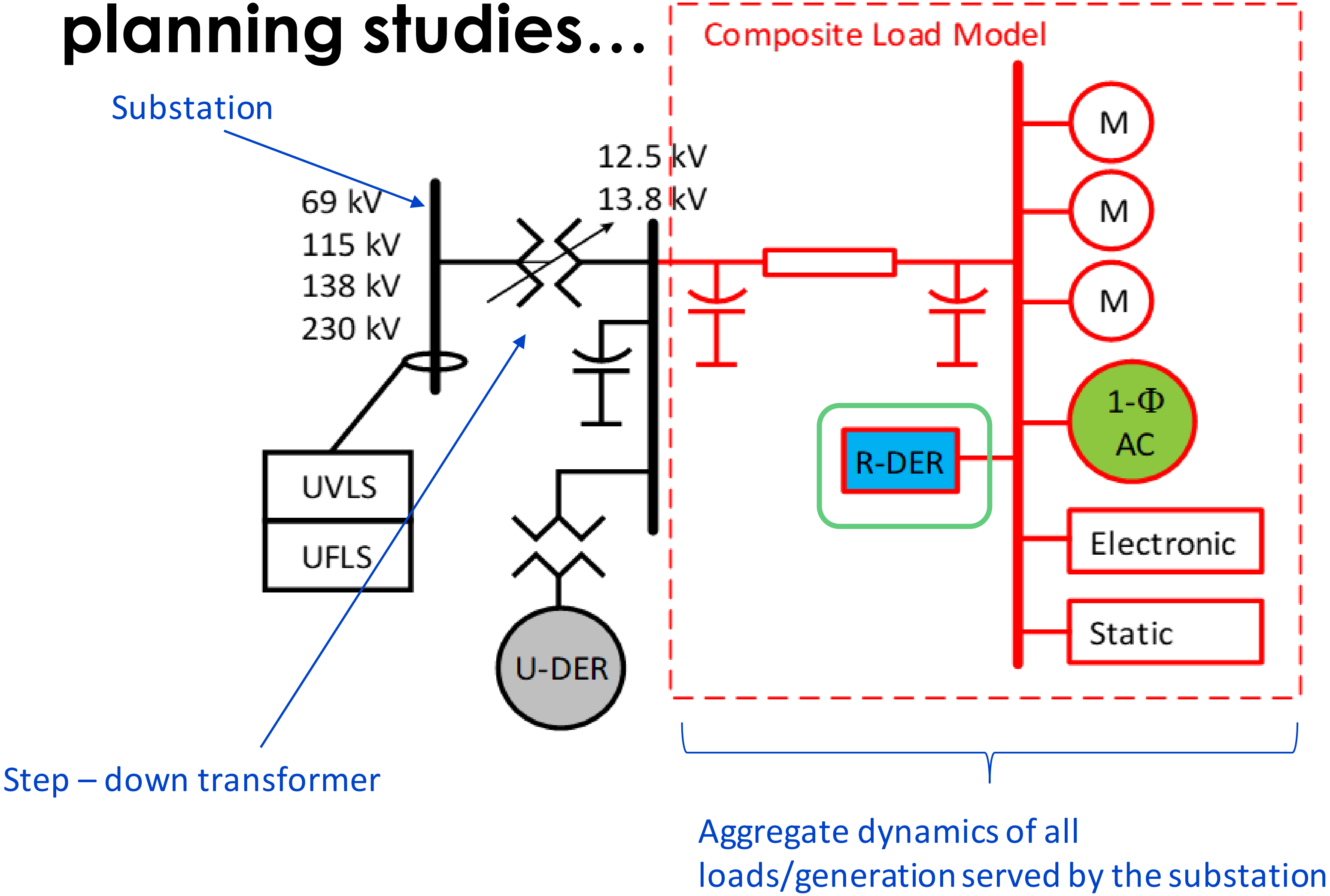
- Long trip times
- Ride-through *with constrained* momentary cessation
- Reactive power demands
- Dynamic voltage support
- Frequency support

Increasing need for T&D Coordination

The Modeling Challenge

- With growing population of distribution connected DER there is an increasing concern that their trip for unbalanced transmission events would go unnoticed while conducting bulk power system analysis using positive sequence simulation tools
  - Three phase DER trip when voltage magnitude on any of its phases is lower than the threshold
  - A fault on one phase in the transmission system has potential to affect multiple phases on the distribution system, resulting in increased single phase DER trip.

A solution for DER to be modeled for bulk power system planning studies…

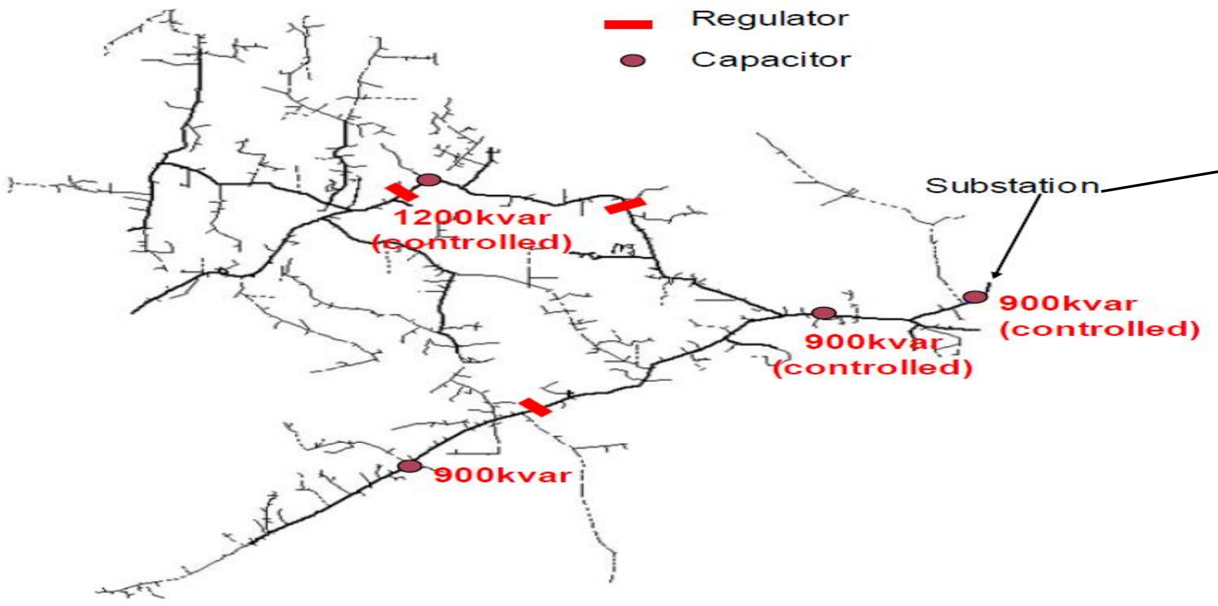


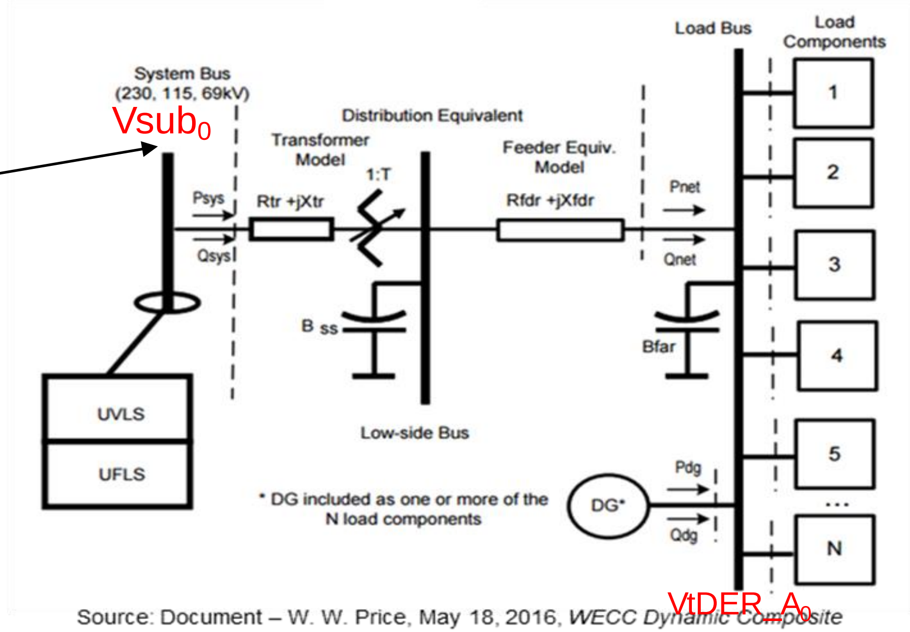
- Represents pumps, fans, lighting, HVAC systems, residential AC.
- Recently updated to represent behind the meter DER (R-DER)
- Also represents dedicated load serving DER resources not netted with load

- Is this representation perfectly accurate?
  - No. It is only reasonably accurate
- Does it need to be perfectly accurate?
  - No.

If the decision to be made from studies does not change whether one uses detailed models or aggregated models, then aggregate models are sufficient

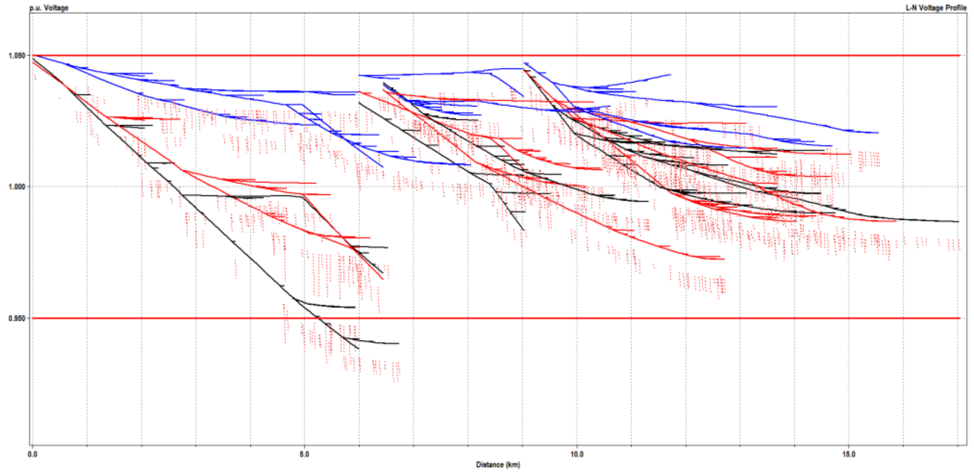
The Modeling Challenge (cont'd)



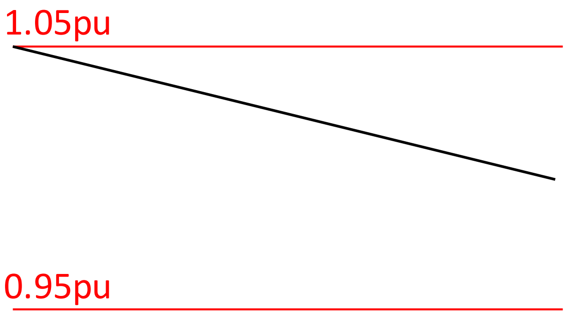


Source: Document – W. W. Price, May 18, 2016, *WECC Dynamic Composite Load Model (2nd Generation) Proposed Structure*

Entire load on a substation modeled as a single equivalent



Complete three phase voltage profile represented by single RMS profile



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The Parameterization Challenge …

» Factors that affect the ride through of DER on a feeder:

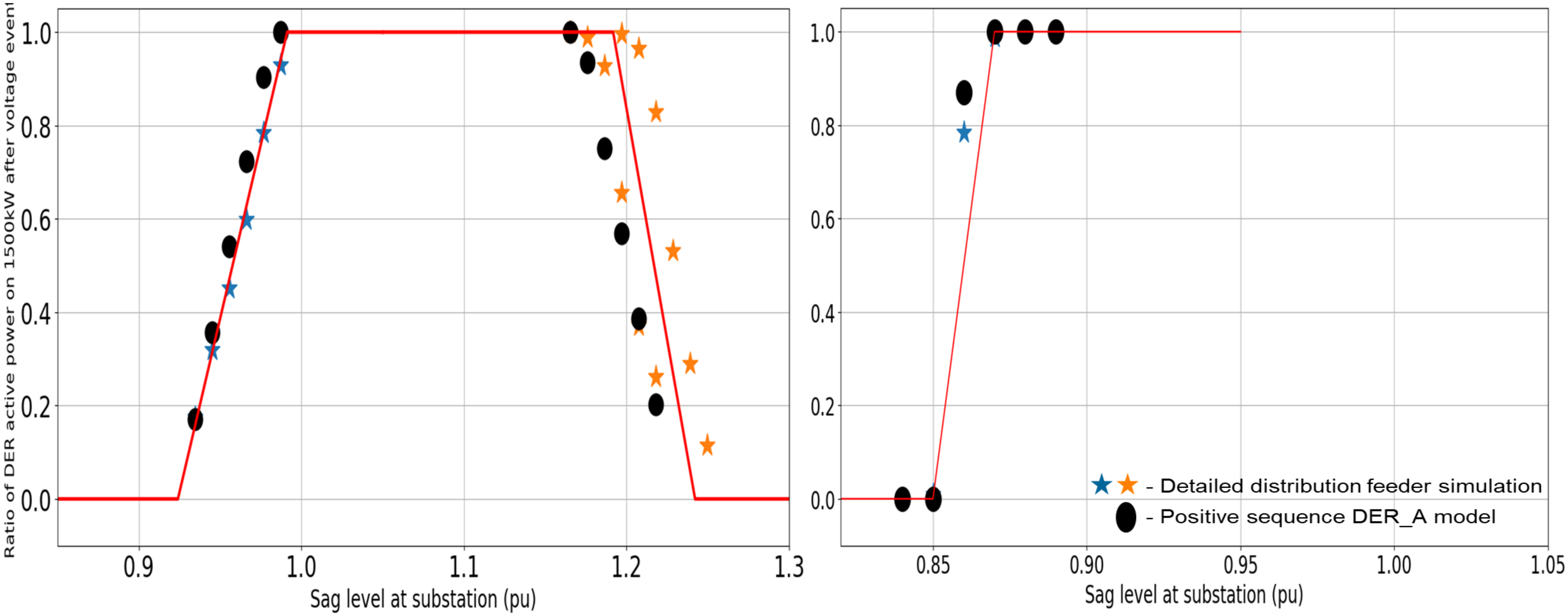
- Type of DER (3-phase or 1-phase)
- Location of individual DER on the feeder
- Balance of load across three phases
- Presence of capacitor banks or voltage regulators
- Voltage magnitude threshold of DER trip
- Type of voltage event
  - Sag or swell, along with balanced or unbalanced

Transmission planner has minimal to zero information

Transmission planner has information

This behavior is essentially within a black box, and development of generic parameters for a wide variety of feeders and geographical areas is of interest

Potential method to parameterize aggregated models…



References:

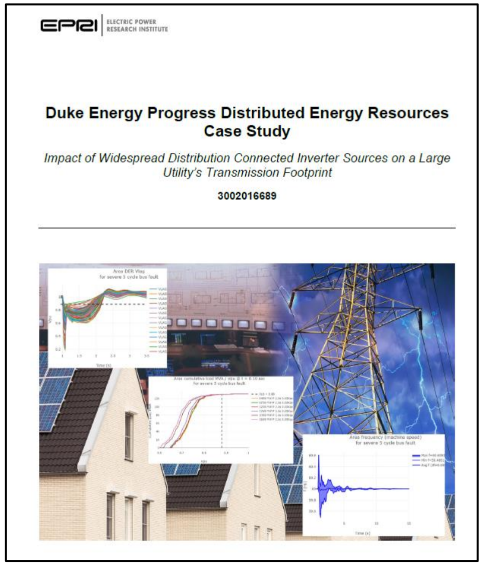
Deepak Ramasubramanian, Inalvis Alvarez-Fernandez, Parag Mitra, Anish Gaikwad and Jens C. Boemer, "Ability of Positive Sequence Aggregated Distributed Energy Resource Model to Represent Unbalanced Tripping of Distribution Inverters," *2019 IEEE Power & Energy Society General Meeting (PES)*, Atlanta, GA, USA, 2019 (Online)

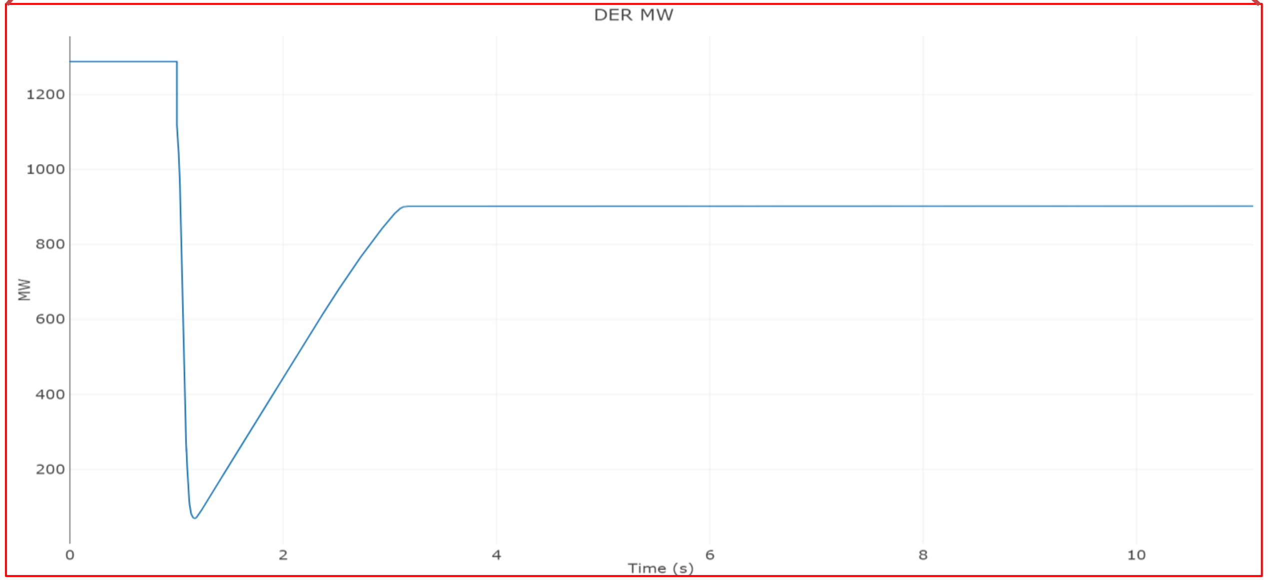
Inalvis Alvarez-Fernandez, Deepak Ramasubramanian, Wei Sun, Anish Gaikwad, Jens C. Boemer, Stephen Kerr, and Daniel Haughton, *"Impact Analysis of DERs on Bulk Power System Stability through the Parameterization of Aggregated DER_A Model for Real Feeders," Electric Power Systems Research, vol. 189, Dec 2020* (Online)

Recreation of DER Tripping Event with DER_A Model

» Comparing DER modeling performance to measured event
- ~ 300 MW DER tripping in SCADA measurement
- ~ 350 MW DER tripping in simulation

» Report publicly available at epri.com (Product ID: 3002016689)





Summary of load shed and generation shed

	P7 Contingency - 1			3-Φ Delayed Clearing Bus Contingency		
Scenario	MW / Mvar Load Shed	MW / Mvar Non - DER Generation Shed	MW Mvar DER Generation Shed	MW / Mvar Load Shed	MW / Mvar Non – DER Generation Shed	MW Mvar DER Generation Shed
Base Case	1858 / 513	0.0 / 0.0	N/A	1273 / 325	1858 / 485	N/A
1	2984 / 785	8672 / 1412	6600 / 183	N/A	N/A	N/A
1a	2000 / 557	0.0 / 0.0	2074 / 74	N/A	N/A	N/A
2	1992 / 555	0.0 / 0.0	0.0 / 0.0	N/A	N/A	N/A
3	1553 / 433	0.0 / 0.0	0.0 / 0.0	941 / 233	2182 / 605	1746 / 38
4	1983 / 553	0.0 / 0.0	0.0 / 0.0	N/A	N/A	N/A
5	1553 / 433	0.0 / 0.0	0.0 / 0.0	941 / 233	2182 / 605	1746 / 38
6	1553 / 433	0.0 / 0.0	0.0 / 0.0	941 / 233	2182 / 605	1746 / 38
6a	1441 / 389	0.0 / 0.0	0.0 / 0.0	928 / 228	2182 / 605	1746 / 38
7	1553 / 433	0.0 / 0.0	0.0 / 0.0	941 / 233	421 / 560	0.0 / 0.0

Impact of mom. cess.

Impact of DVS

Impact of Q priority

Impact of aggressive DVS

Impact of Cat III

N/A signifies either No – DER or the case had a convergence error

Category III voltage ride-through capability beneficial for delayed-cleared faults.
Dynamic voltage support has limited impact.

NPCC Specific Discussion

- Value Add of NPCC Guideline over NERC Reliability Guideline *Bulk Power System Reliability Perspectives on the Adoption of IEEE 1547-2018*?
  - *Abnormal performance category assignment*
  - *Functional settings impacting BPS (trip, frequency droop, etc.)*

- Work with distribution utilities regarding feeder & substation protection DER to coordinate with ride-through?

- Other Topics
  - Value of DER steady-state voltage/reactive power control?
  - Potential benefits & challenges of DER fault-related dynamic voltage support?

NPCC Reliability Guideline Could Provide Guidance to ISOs/RTOs and Distribution Providers

Summary…

» DERs with dynamic voltage support can prevent stalling of 1 – Φ induction motors
  - Requires quite a large amount of reactive current injection

» Aggressively tuned fast DER controllers can fight with themselves
  - In this study, the controller interactions did not transfer up to the 230kV system
  - It could transfer to the sub – transmission system

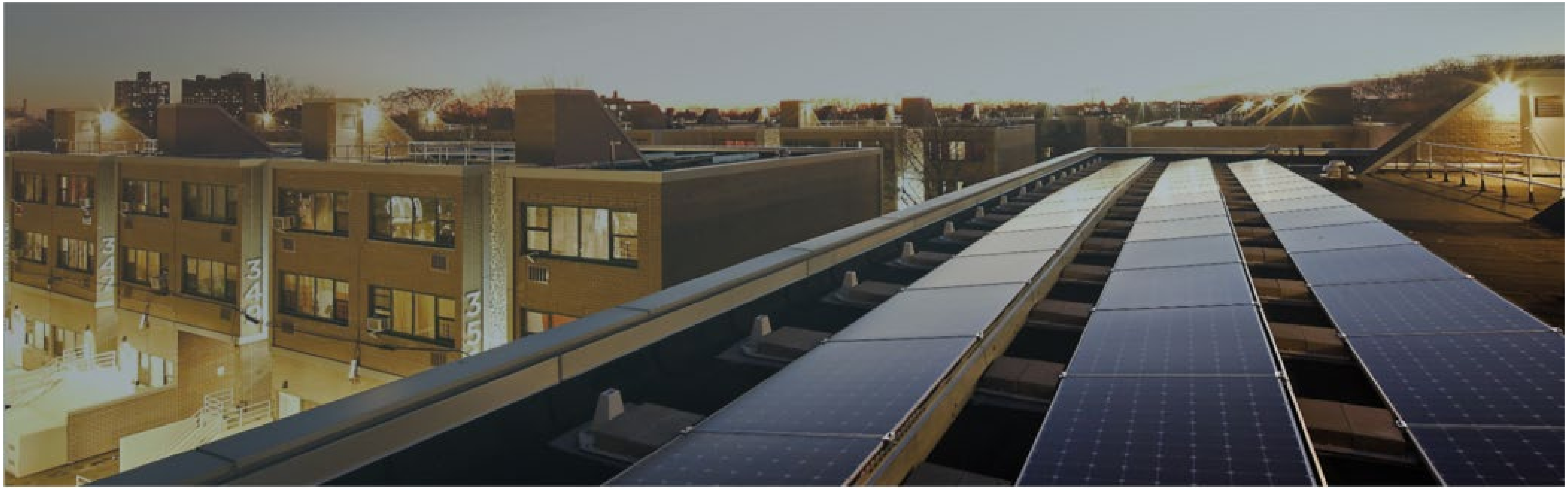
Summary…

- There is both a modeling and parameterization challenge to represent aggregate impact of distributed energy resources
  - Transmission planner has visibility only of one ride-through impacting factor out of six factors
  - Parameterization of an essential black box model
    - DER_A has shown promising preliminary results
    - Should however go hand-in-hand with load modeling

- DER_A default parameters on a large system have shown the model to be numerically robust.

- It is possible that unexpected results might arise due to block tripping of DER represented by model
  - However, it is not uncommon for DER to trip in blocks as the tripping is based upon pure logic embedded in the controllers.

DER Aggregation Registration



John Romano

Utility of the Future

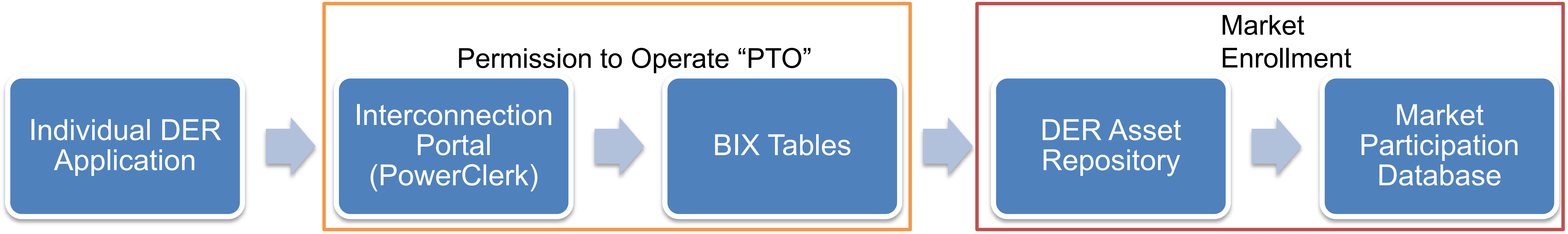
May 13, 2021

Agenda

Three processes will have to be enhanced to enable DER Aggregation registration and enrollment

1. DER Interconnection Process
   - SIR 5MW<
   - Non-SIR
2. Aggregator Registration
   - Allow Aggregators to form aggregations
3. Aggregation Enrollment
   - 3 Step utility engineering review

Interconnection



Enhanced

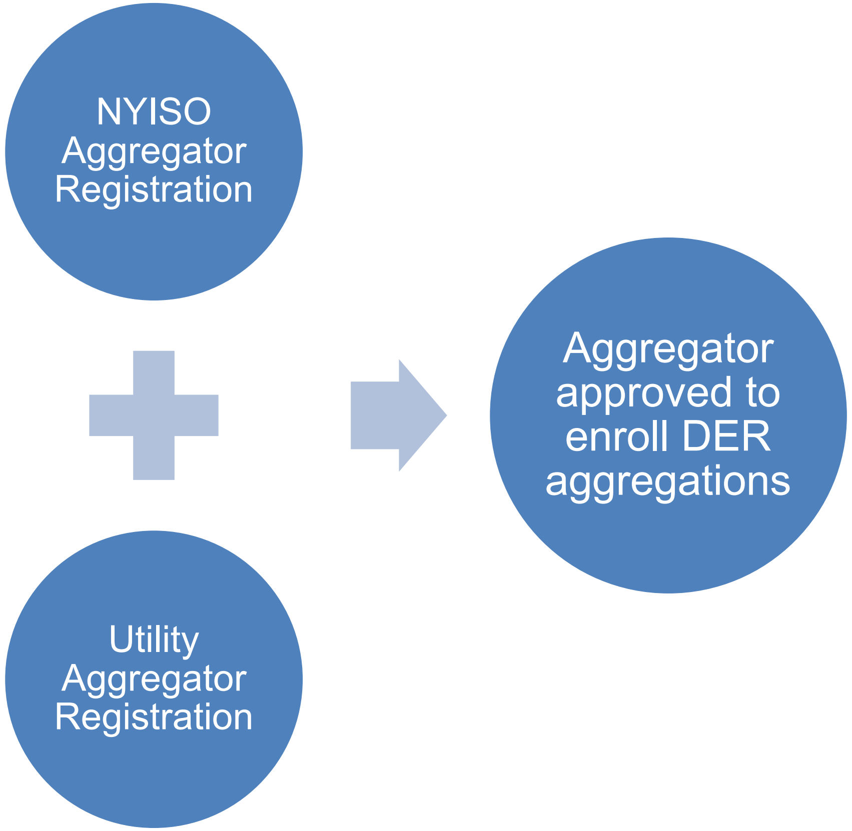
New Systems/Process

New EPRI Supplemental: "DER Systems of Record to Support Enterprise-wide Applications"

- PowerClerk Enhancements
  - Assign DER Unique ID
  - Capture new and existing data in operational formats
- DER Asset Repository
  - Source of truth for DER information
  - Dynamically updated from system models and external data sources
    - Informs connectivity models, forecasting, and system impact tools
- Market Participation Database
  - Tracks market participation across wholesale and distribution
  - Needed for duplicative compensation checks
    - There may be a need to capture metering configurations to inform participation models

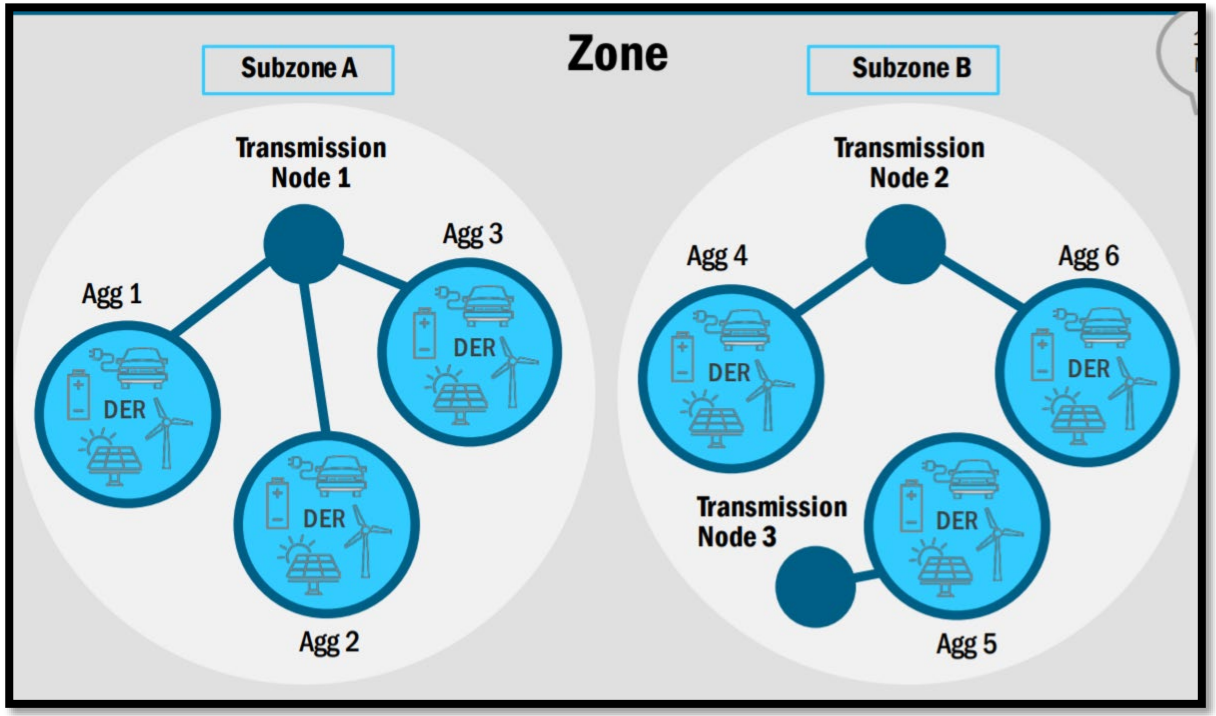
Aggregator Registration

- NYISO Registration Process
  - Market Participant registration process
    - similar to existing generator process (~60 days)
- Individual Utility registration
  - Replicate existing Demand Response Process
    - NY Data Security Agreement
  - Approved aggregators will obtain access to limited customer information
    - Customer Data privacy
    - New considerations for compliance with NY IEDR and Data Access Framework Orders
- Approved aggregators from both the NYISO and Utility will be allowed to enroll resources in an aggregation to initiate utility review



Aggregation Enrollment

- Completed NYISO Aggregator Registration
  - Approved Market Participant (MP)
  - Aggregators assigned PTID unique to T-node
- Completed Utility Aggregator Registration
  - Access to customer data
  - Access to enrollment portal
- DER Transmission Node (NYISO Sub-zonal pricing)
  - Publicly posted map
  - Proposal to add to existing Hosting Capacity Maps
- DER Unique ID
  - Available through utility portal, assigned during DER interconnection



Source: NYISO MIWG 2019

Utility Review – Interconnection Validation

- Can the interconnection case be validated?
  - Some legacy DER may have incomplete operational information
- Are the enrollment details the same as interconnection?
  - Nameplate ratings
  - Inverter Settings
  - Interconnection Location
  - Has the system configuration changed substantially to warrant a new interconnection study?
    - “Material Modifications”
- Verify Transmission Node mapping
- Duplicative compensation check
  - Check against utility tariff and distribution services based on which NYISO and Distribution services an individual DER is participating in.
  - Metering configuration may be required

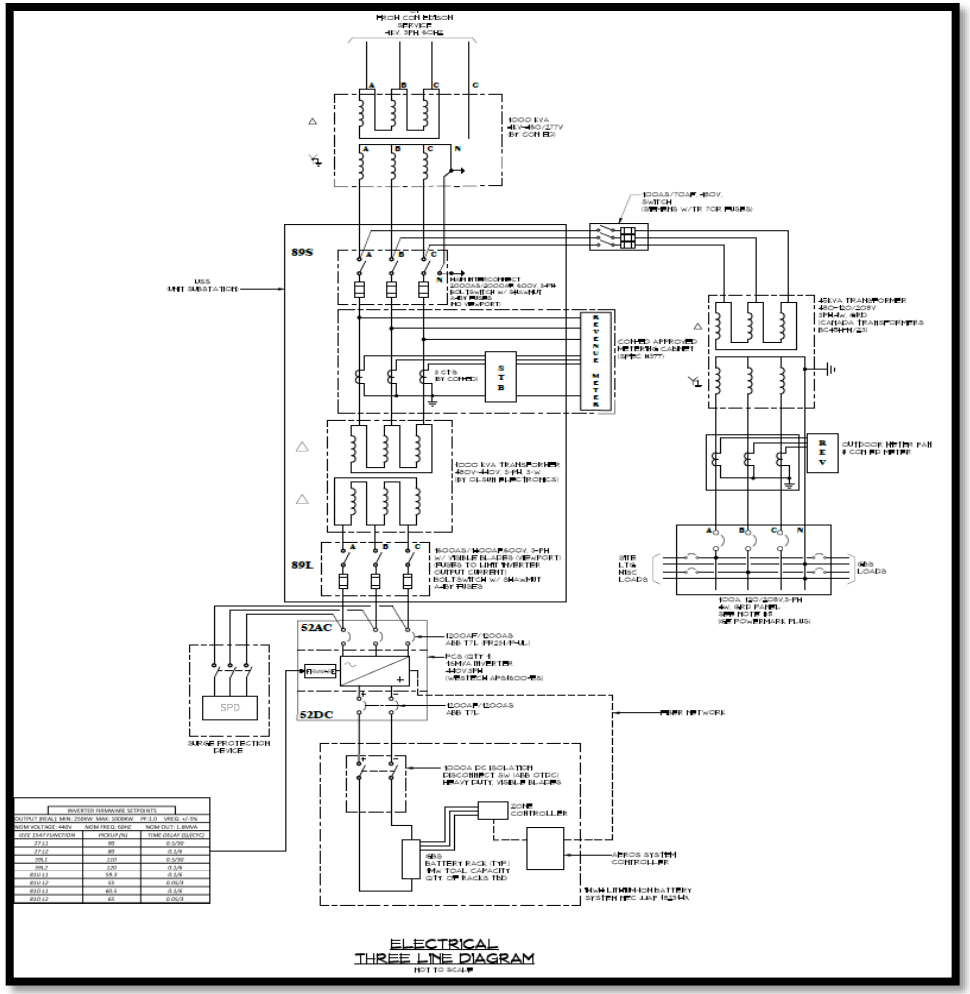
Example compatibility Matrix

		ISO and DSO Programs/Services				
		DSO_P1	DSO_P2	DSO_PX	ISO_P1	ISO_P2
ISO and DSO Programs/ Services	DSO_P1					
	DSO_P2	Compatible				
	DSO_PX	Compatible	Incompatible			
	ISO_P1	Partial	Compatible	Incompatible		
	ISO_P2	Compatible	Partial	Incompatible	Compatible	
	ISO_PX	Compatible	Incompatible	Incompatible	Compatible	Incompatible
	…	…	…	…	…	…

Source: EPRI TO/DSO WG

Utility Review – Individual DER Review

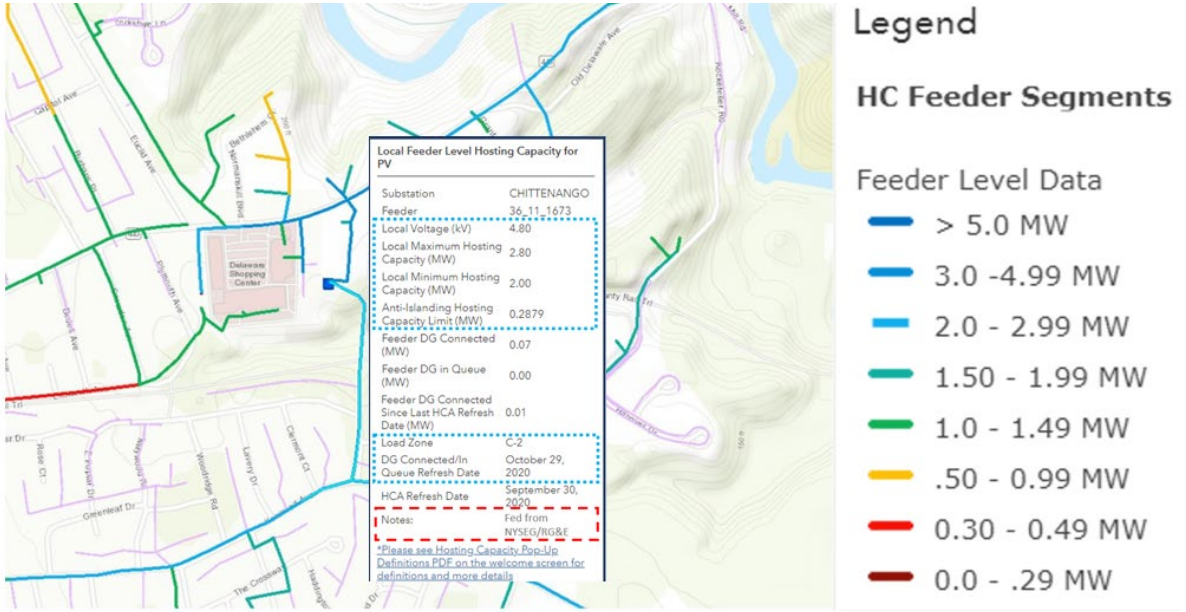
- Has the DER use case changed since interconnection?
  - Applicable for Dispatchable Storage
  - Current interconnection practices study specific storage use cases
- Do any operating parameters need to be changed or restudied?
  - Time of day import/export limits
    - Networks where system peak is not coincident with NYISO peak
  - Seasonal import/export limits
  - Maximum export, ramping limitations
  - Inverter settings



Utility Review – Aggregation Level Review

10,000-foot view of potential concerns with coordinated activity of DER

- Circuit Hosting Capacity Limitations
  - Voltage violations from large swings in net load
  - Impacts to substation or circuit loading
- Flicker concerns
  - Rapid response of DER injection
- There may be a need for an aggregation “queue” similar to interconnection if aggregation level system impacts become restrictive



Thank You

Hilo – A complete smart energy service for your home and business

DER/VER Forum | May 13, 2021

Hilo
par Hydro-Québec

A mission in sync
with its parent company

Hilo is a second-tier wholly owned Hydro-Quebec subsidiary.

Its mission is to develop innovative, value-added products and services in the energy sector and related areas, thereby helping Hydro-Quebec to position itself as a key player in new energy services.

Hilo

Create value on the other side of the meter

in alignment with Hydro-Quebec '20-'24 Strategic plan

Maintain the relationship with customers & control of the electron

Ensure Hydro-Quebec has visibility on the entire energy value chain

Reduce power demand and strengthen power grid reliability through smart energy solutions

Aim high and far ahead through key projects

targeting new ways to consume, produce & manage our energy

Hilo subsidiary creation

Completed
February 2019

Test phase for our smart home service

Completed
Winter 2019-2020

Commercial launch of our smart home service

Completed
Winter 2020-2021

Commercial launch of our smart building service

Coming soon
Winter 2021-2022

Electric mobility offering

In progress

Solar energy self-production solutions

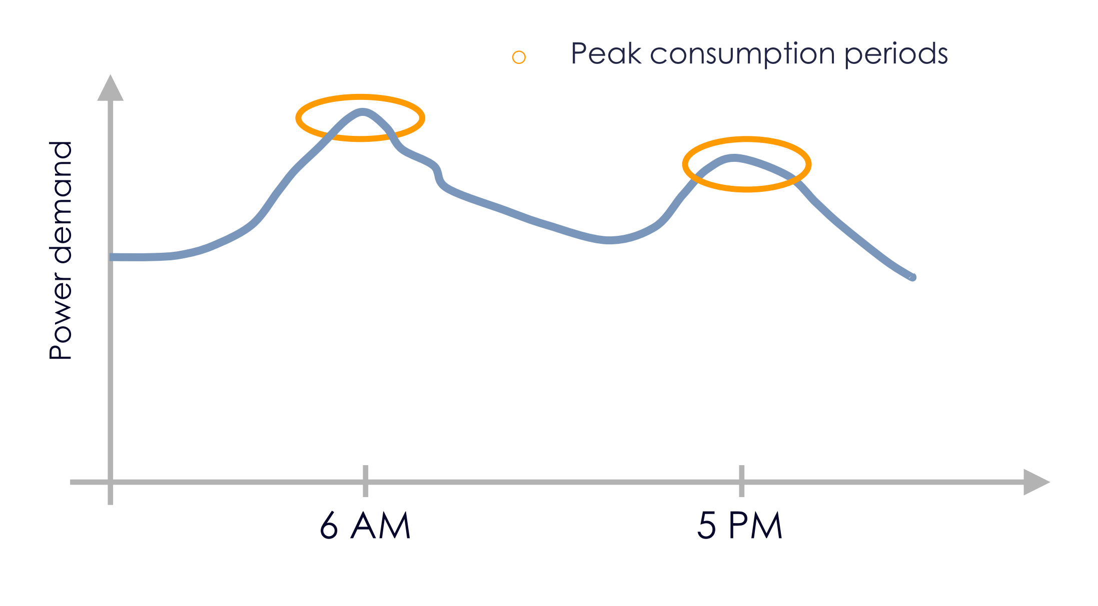
In progress

The customer: A solution to the power grid challenges

The customer: A solution to the power grid challenges

Hilo Smart home solution

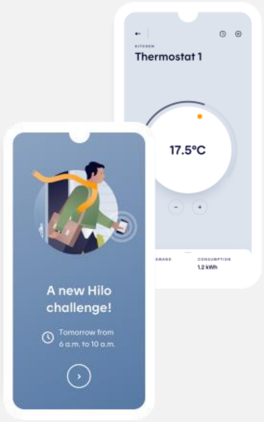
A solution that meets Hydro-Quebec's needs



Main considerations while designing the Hilo solution

- Preserve Customer' comfort
- Allow customer customization
- Minimize collateral impact on the power grid

Energy features have been integrated into the Hilo devices



Demand-side management (DSM)

- Reduce power demand during winter peak hours

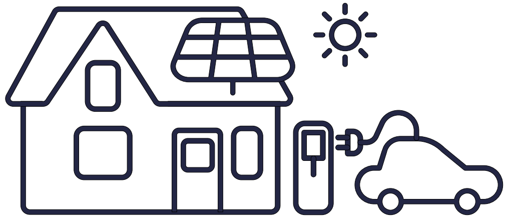
Recovery after power failure

- Ensure a controlled and progressive recovery after a power failure

Hilo

Hilo is gradually rolling out
its products & services for homes and businesses

Residential offers



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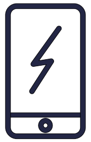
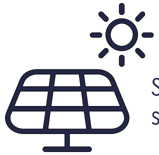


Smart home

2

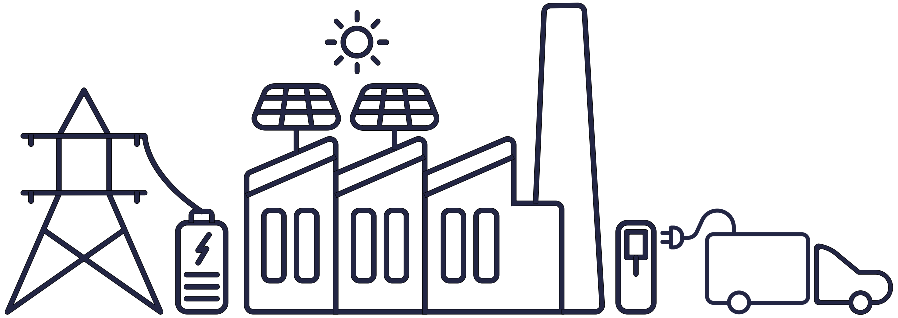
Electric mobility

3



Solar self-generation

Commercial, industrial and institutional offers



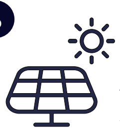
4

Enhanced energy services

5

Electric mobility

6



Solar self-generation

7

Smart energy storage

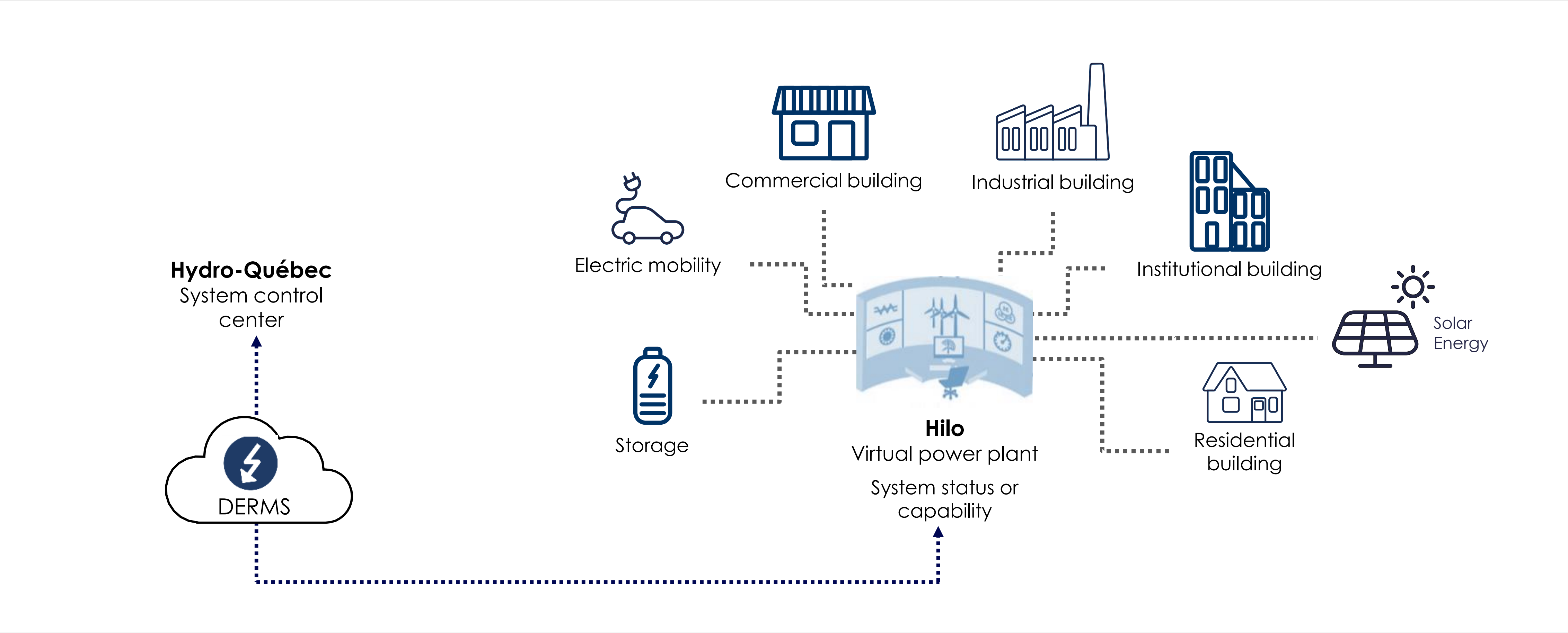
8

Demand response

Hilo

A solution developed by Hilo

The Distributed Energy Resource Management System (DERMS)



Hilo

In-market Smart home offer

3 bundles to fit the size of the customer's home

Small Home

Pay only

$199.99*

What's included

- 3 to 5 smart thermostats
- Up to 4 connected products as a bonus
- 1 Hilo hub and the mobile application
- 3-year commitment to Hilo challenges
- Installation by a certified electrician

Medium Home

Pay only

$339.99*

What's included

- 6 to 10 smart thermostats
- Up to 6 connected products as a bonus
- 1 Hilo hub and the mobile application
- 3-year commitment to Hilo challenges
- Installation by a certified electrician

Large Home

Pay only

$479.99*

What's included

- 11 to 20 smart thermostats
- Up to 8 connected products as a bonus
- 1 Hilo hub and the mobile application
- 3-year commitment to Hilo challenge
- Installation by a certified electrician

Hilo

The Hilo challenges

Challenges that make customers save while helping the planet

What's a Hilo challenge?

A single event during which the Customer is invited to **reduce the setpoint temperature of its thermostats** and get **cash reward for each kilowatt-hour (kWh) that he does not use.**

Hilo challenges take place **during peak consumption periods**, between 6 to 10 AM and/or 5 to 9 PM. There is up to **30 challenges per winter**.

A 3-phase challenge

Preheating (2-3 hours): Before the set challenge time, the temperature will go up to ensure an optimal level of comfort in the home. The preheat phase is optional.

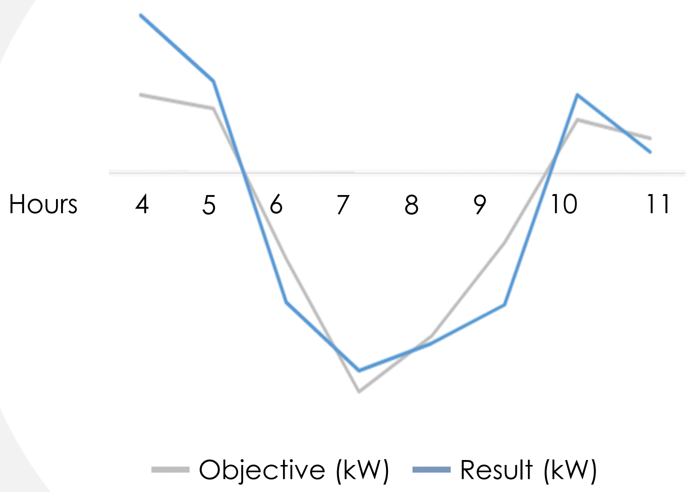
Reduction (4 hours): The temperature in the home will go down during the challenge.

Recovery (2 hours): The temperature in the home will gradually return to its normal level all on its own.

Hilo

The Hilo challenges

Key results from the 2020-2021 winter season



30
Hilo challenges during winter

96%
participation rate to Hilo challenges

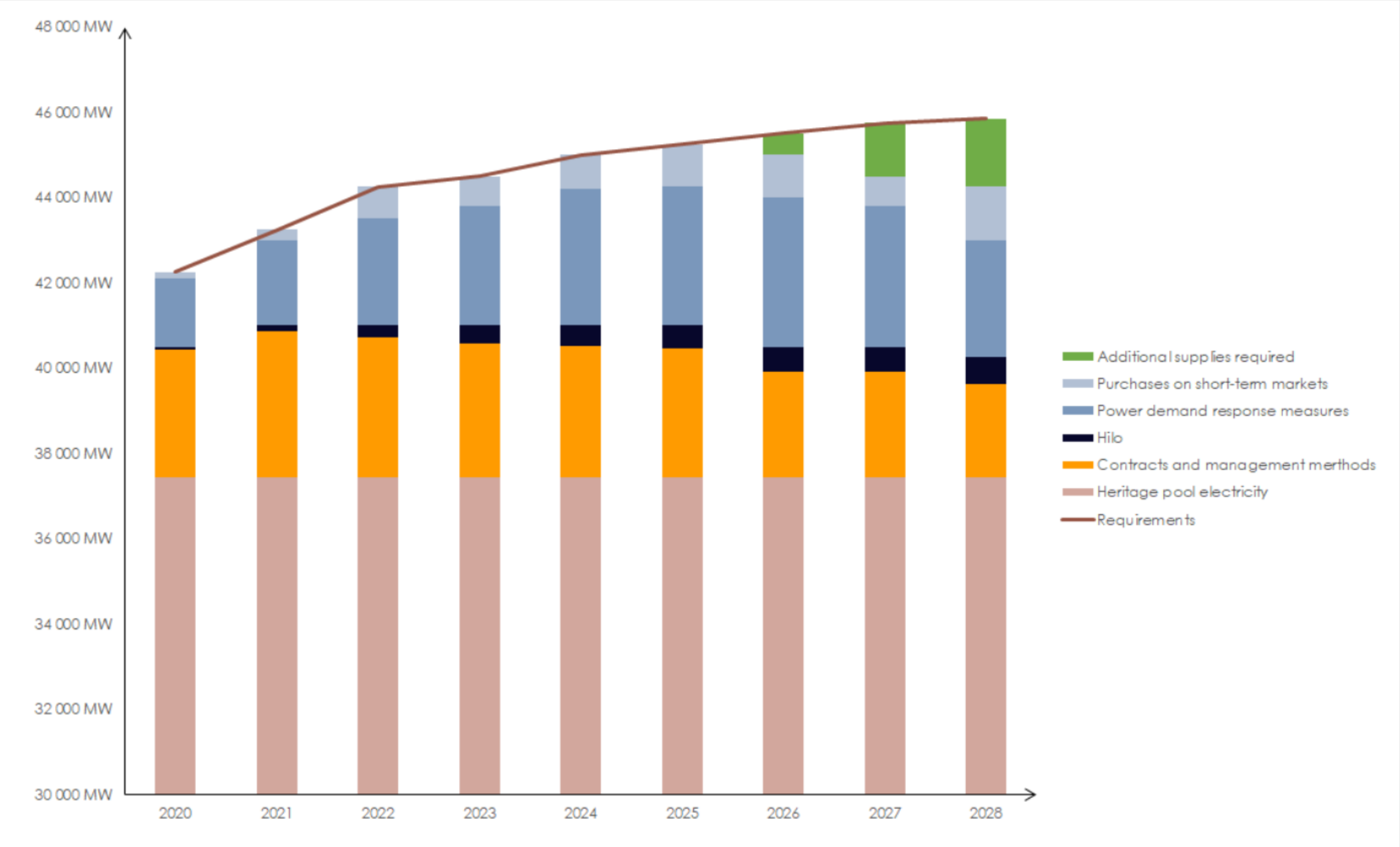
4,87$
in cash rewards per customer per challenge

2,1 kW
curtailed per customer per challenge

92%
customers' success rate to Hilo challenges

Hilo

Hilo contribution
to Hydro-Quebec's Capacity Balance



By winter 2028-2029
Hilo should contribute to a decrease in capacity needs of over **600 megawatts (MW)**.

This is equivalent to the demand of over 114,000 households or the power generated by Romaine-2 generating station.

Hilo

What's next
for Hilo?

- Add new connected devices to our Smart home offer: water heater, smart electrical load controller, heating floor, low-voltage thermostat
- Launch our Smart building service for commercial customers
- Develop new energy functions in collaboration with Hydro-Quebec and other utilities
- Launch Electric mobility, Smart energy storage & Solar energy self-production solutions for homes and businesses

Together, let's build the Quebec of tomorrow.

Hilo

With Hilo, energy just got smarter

DRAFT v.2

JOINT UTILITIES

OF NEW YORK

NPCC DER Forum

Current Joint Utilities DER-Related Major Activities

May 13, 2021

nationalgrid Orange & Rockland NYSEG RG&E Central Hudson conEdison

Agenda

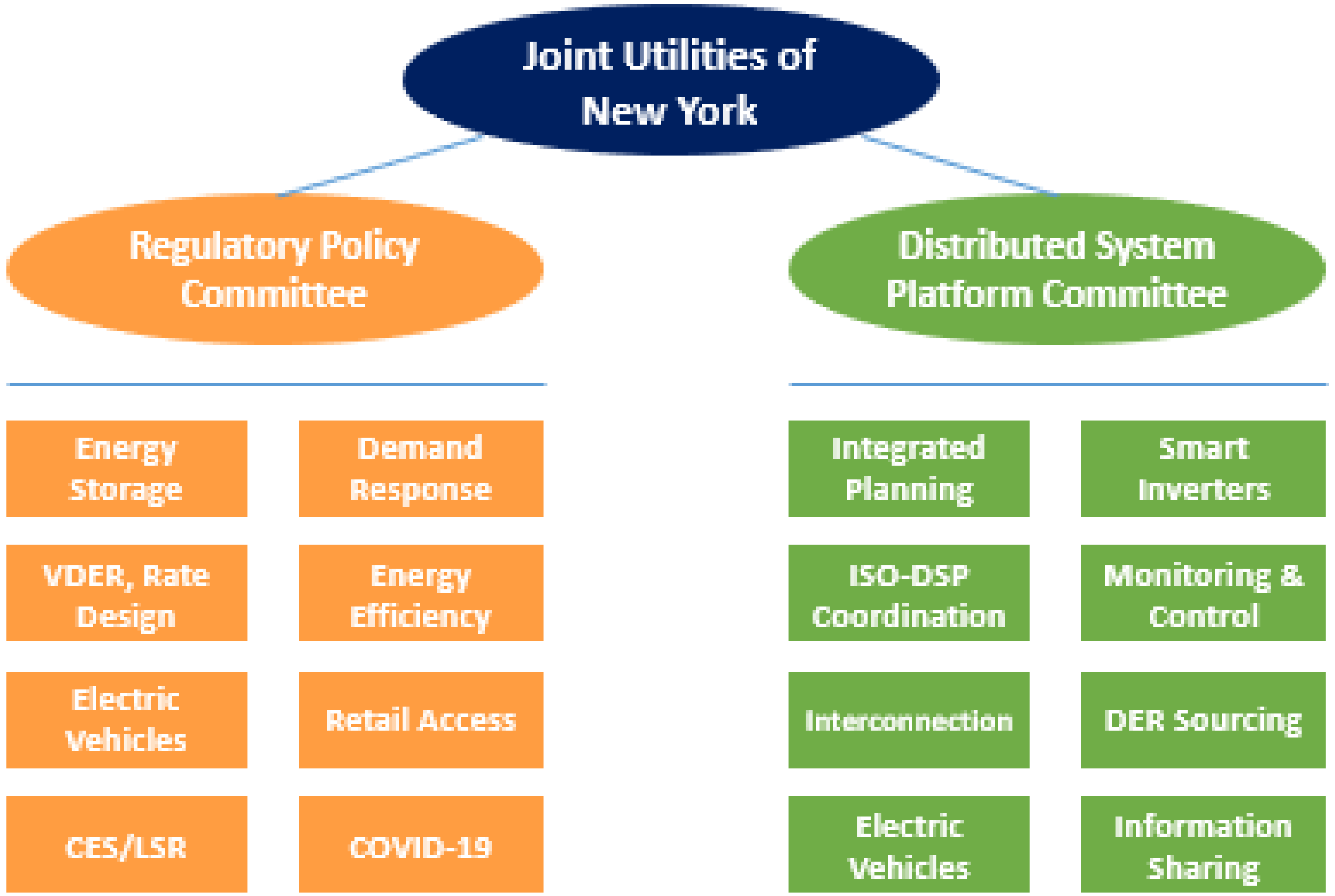
1. Who are the Joint Utilities?
2. Joint Utilities Smart Inverter Working Group
3. Joint Utilities, New York Independent System Operator (NYISO), and FERC Order 2222
4. Hosting Capacity Maps
5. Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act (Transmission Planning Order)

Who are the Joint Utilities?

Together, the Joint Utilities provide electric and gas service to over 13 million households, businesses, and government facilities across New York State. The Joint Utilities are comprised of:

- Niagara Mohawk Power Corporation d/b/a National Grid (National Grid)
- Central Hudson Gas and Electric Corporation (Central Hudson)
- Consolidated Edison Company of New York, Inc. (Con Edison)
- New York State Electric & Gas Corporation (NYSEG)
- Orange and Rockland Utilities, Inc. (O&R)
- Rochester Gas and Electric Corporation (RG&E)

JOINT UTILITIES OF NEW YORK



The Evolving DSP Vision

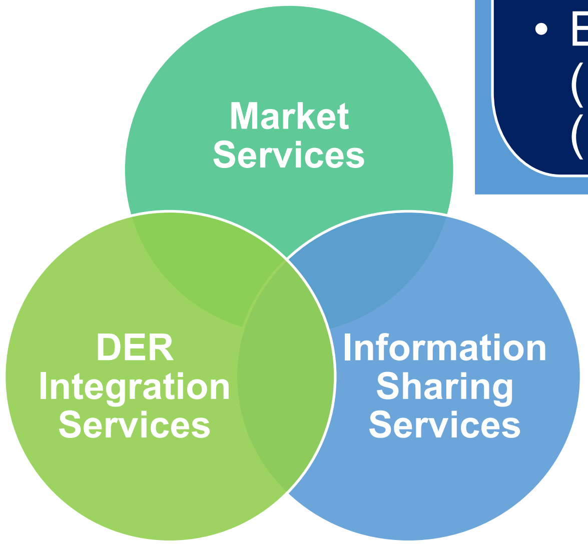
The CLCPA builds on a foundation established in the New York Public Service Commission's (PSC) Reforming the Energy Vision (REV) Proceeding

REV: Multiple Reforms

- Utility incentives, resilience, affordability, engaged and informed consumers, sustainability, greenhouse gas (GHG) emission reductions
- Emphasis on both large-scale resources (LSR) and distributed energy resources (DER)

CLCPA: Focused on GHG Emission Reductions and Equity Framework

- Economy-wide goals and targets Increased targets for LSR and DER
- Electrification of transportation and buildings
- Serving disadvantaged communities



The Distributed System Platform (DSP) offered by the utilities

Utilities Actively Driving the Energy Future

Goals of the CLCPA

- 40 percent emissions reductions in absolute terms from 1990 levels by 2030, 85 percent emissions reductions by 2050
- 70% renewable energy by 2030, 100% clean energy by 2040
- 9,000 MW of offshore wind by 2035
- 6,000 MW of solar energy by 2025
- 3,000 MW of energy storage capacity by 2030
- Reduce energy consumption by 185 trillion British thermal units (BTUs) from the State's 2025 forecast
- 850,000 zero emission vehicles (ZEVs) by 2025

Transmission and distribution system investments

Close collaboration with NYISO

Novel interconnections & hosting capacity maps

Storage Implementation & Contracts

EV Make-Ready Program

Major Joint Utilities Accomplishments

Submitted multiple joint filings, including the flagship **Supplemental DSIP** in November 2016

Developed a common methodology for advanced **hosting capacity** maps which add sub-feeder level granularity and existing distributed energy resources

Collaborated with stakeholders to refine and streamline the **interconnection process** for DG and energy storage

Created **non-wires suitability criteria** to determine opportunities for DER to address identified electric system needs

Established common **monitoring and control** standards for solar PV and identified potential low-cost solutions

Developed a **smart inverter roadmap** to inform future implementation efforts and stakeholder discussions

Defined **operational requirements** for coordination among the DSP, NYISO, and DER aggregators

Enabled **dual participation** for DER and energy storage resources to access value for both distribution-level services and wholesale markets

Collaborated with stakeholders in the development and implementation of the Value of Distributed Energy Resources **VDER Value Stack**

Established the Electric Vehicle Make-Ready Program to facilitate wider adoption of **electric vehicles** and charging infrastructure deployment

Produced statewide **privacy standards** for sharing of customer data

Completed a **T&D study** and filing focused on how future capital investment plans help achieve State energy goals

JOINT UTILITIES OF NEW YORK

nationalgrid Orange & Rockland NYSEG RG&E Central Hudson conEdison

Sharing Up-to-Date Information

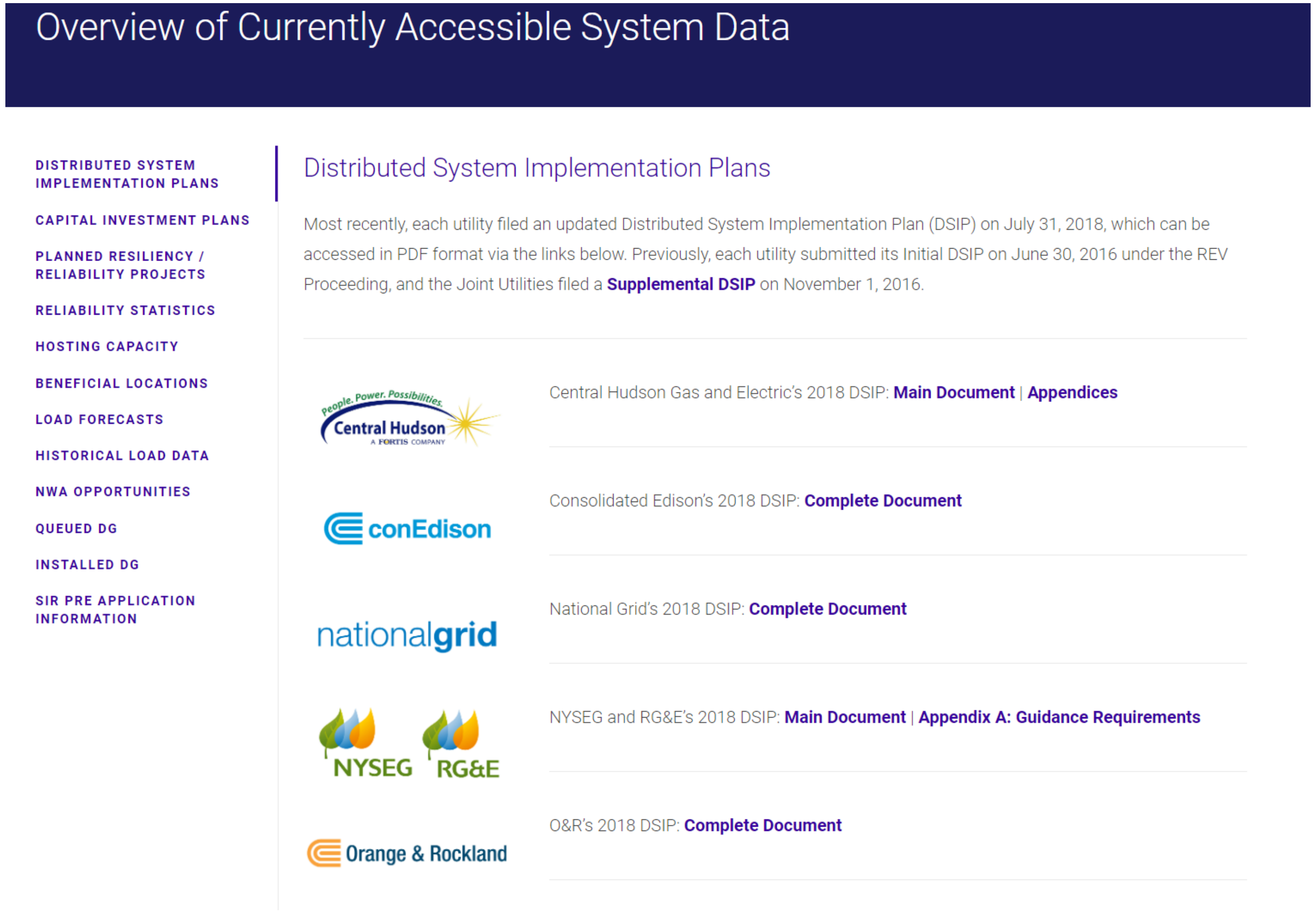
Please visit our website: www.jointutilitiesofny.org

Links to utility-specific information:

- NWA (Non-Wire Alternatives) Opportunities
- System Data
- Hosting Capacity
- Electric Vehicles

Stakeholder engagement opportunities

Quarterly newsletters with detailed utility updates



JOINT UTILITIES OF NEW YORK

Joint Utilities Smart Inverter Working Group

Smart Inverter Working Group Background and Objectives

- The Joint Utilities (JU) chartered an additional working group focused on smart inverters starting in May 2019.

- A few of the main objectives were to:
  - **Establish a common understanding** of smart inverter (SI) developments in other jurisdictions.
  - **Take a proactive approach** and develop a common JU roadmap for future discussions on implementation with stakeholders.
  - **Establish alignment and consistency** across JU members on SI configuration and deployment.
  - **Develop a clear message** on how the JU are currently thinking through future use of smart inverters for industry and developers in New York.
  - **Drive implementation** of IEEE 1547:2018 standard in alignment with NPCCs May 14 2020 DER Guidance Document

Major Activities to Inform the Roadmap

Conducted internal education regarding SI functions and ongoing SI demo projects in NY

Conducted interviews with utilities external to NY

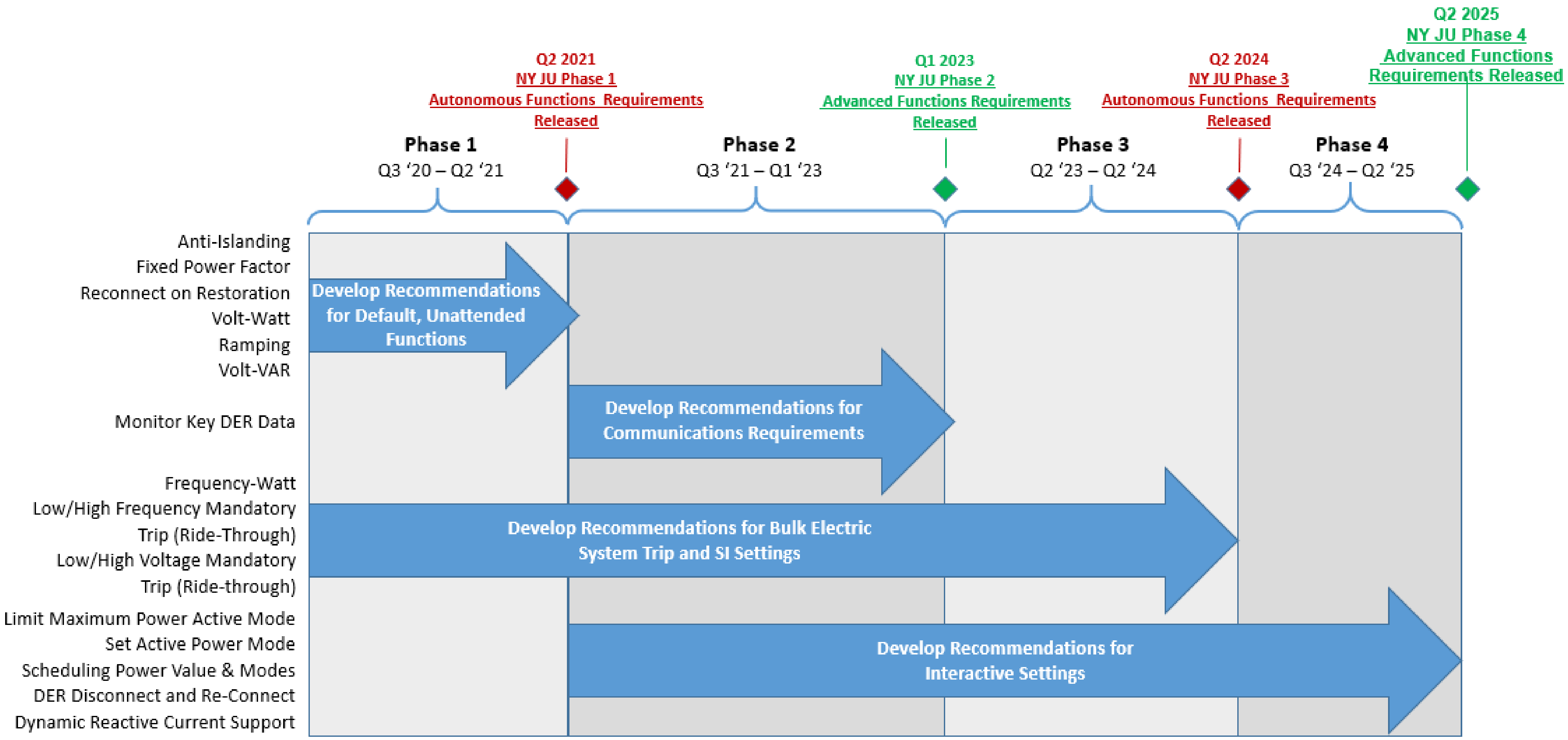
Conducted an internal JU self-assessment of priority, readiness to implement, and perceived complexity

Surveyed different SI settings deployed throughout the U.S. by leading utilities

Held a workshop with EPRI to hold an open discussion and solicit feedback

Held a workshop with the NYISO to discuss SI settings and timetable for finalizing harmonized settings

Smart Inverter Working Group Draft Roadmap



Individual utility release of phases may deviate from this timeline depending upon rate case approvals of supporting systems etc. However, the JU will strive to follow this common timeline.

* Dates are subject to change

JOINT UTILITIES OF NEW YORK

Ongoing Coordination with NYISO

- **SI implementation needs to balance distribution and BPS (Bulk Power System) needs.**
- **Have begun to meet monthly with NYISO to establish a proposed timeline and begin making progress on the details of JU-NYISO coordination.**
- **Targeting to have joint recommendations on smart inverter BPS support function settings by May/June 2021**

Distribution System Priorities

- Protection coordination and reclosing schemes
- Line worker safety
- Islanding concerns

BPS Priorities

- Long trip times
- Reactive power demands
- Dynamic voltage support
- Frequency support

Points of Coordination
Category Selection
Voltage Disturbance Trip Settings
Frequency Disturbance Trip Settings
Frequency-Droop
Enter Service Criteria
Enter Service Performance

Next Steps

- Finalize the next draft of the proposed timeline with key stakeholders to capture when all new DER applications require inverters certified to UL 1741SB.

- Continue discussing the details of implementing distribution support functions and voltage support functions such as volt-var and volt-watt.

- Continued collaboration between the Joint Utilities and NYISO to determine settings for SI BPS related functions.

FERC Order 2222

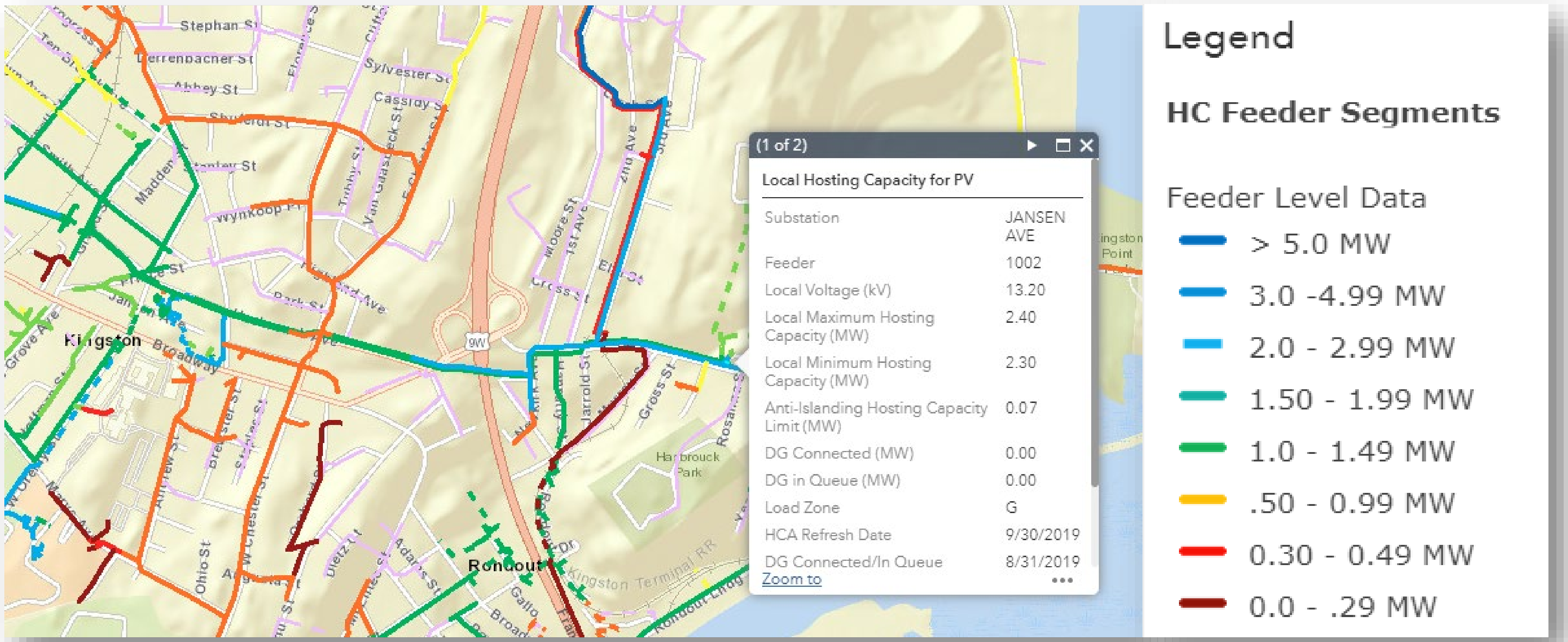
Ongoing JU-NYISO Coordination on DER Aggregations

- Dating back to 2017, the JU and NYISO have maintained ongoing coordination on topics directly related to FERC Order 2222
- FERC approved NYISO's DER aggregation participation model in January 2020
- Key topics the JU and NYISO continue to coordinate on:
  - Aggregation enrollment requirements
  - DSP-Aggregator-NYISO operational coordination
  - DER metering configurations
  - Processes to prevent double counting
- These coordination efforts will support NYISO's market go-live for DER aggregations in Q4 2022

Hosting Capacity Maps

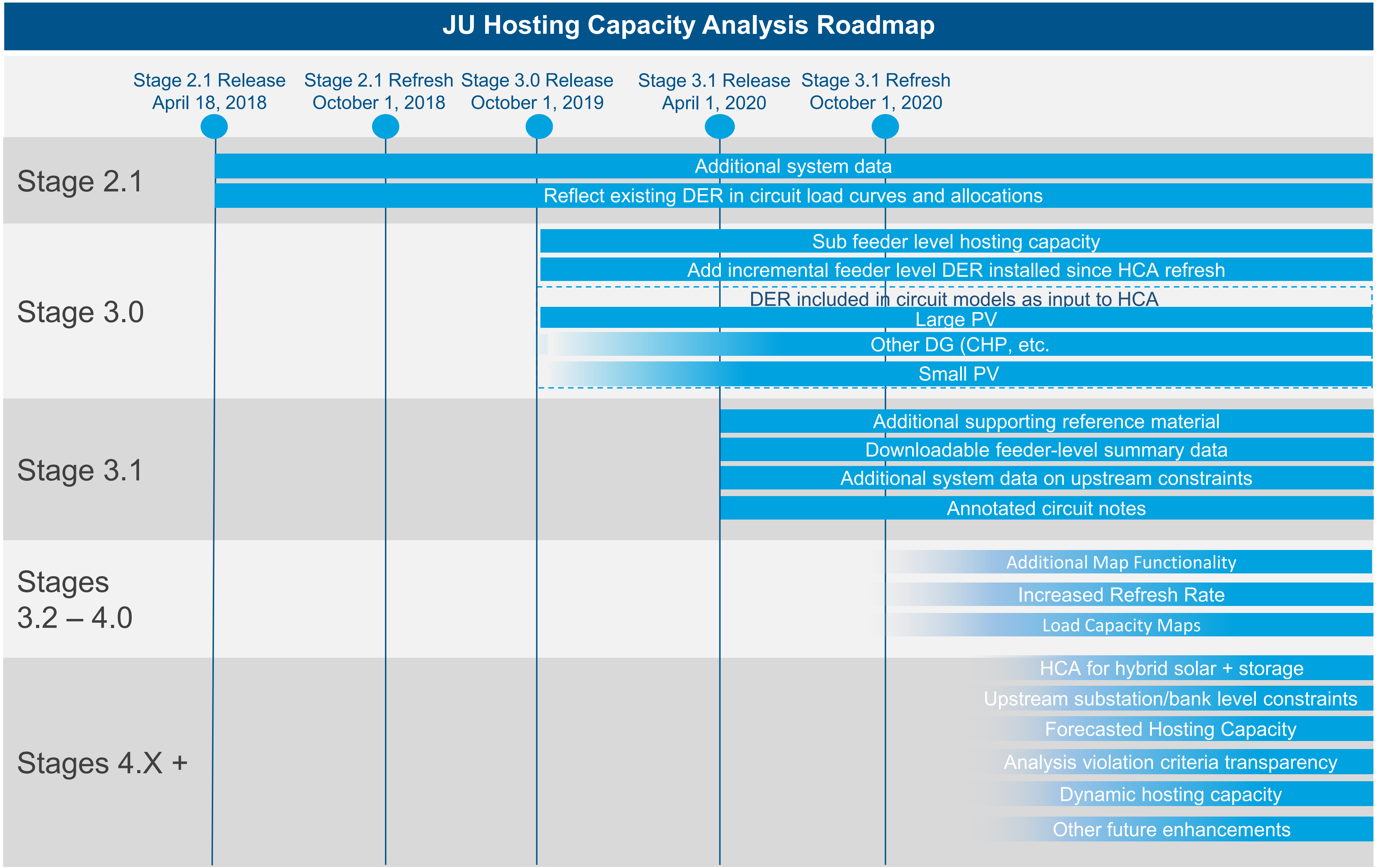
Hosting Capacity Maps for Solar PV Greater than 500 kW

- The JU maps show the gross hosting capacity (HC) in MW at all feeders for all JU. Stage 3.0 introduced more location-specific sub-feeder level information by displaying the local hosting capacity across a feeder.



Hosting Capacity Analysis Roadmap

- Stages 1.0 and 2.0 focused on distribution indicators and feeder-level hosting capacity.
- The Hosting Capacity Roadmap builds in additional functionality, granularity, and data over time.



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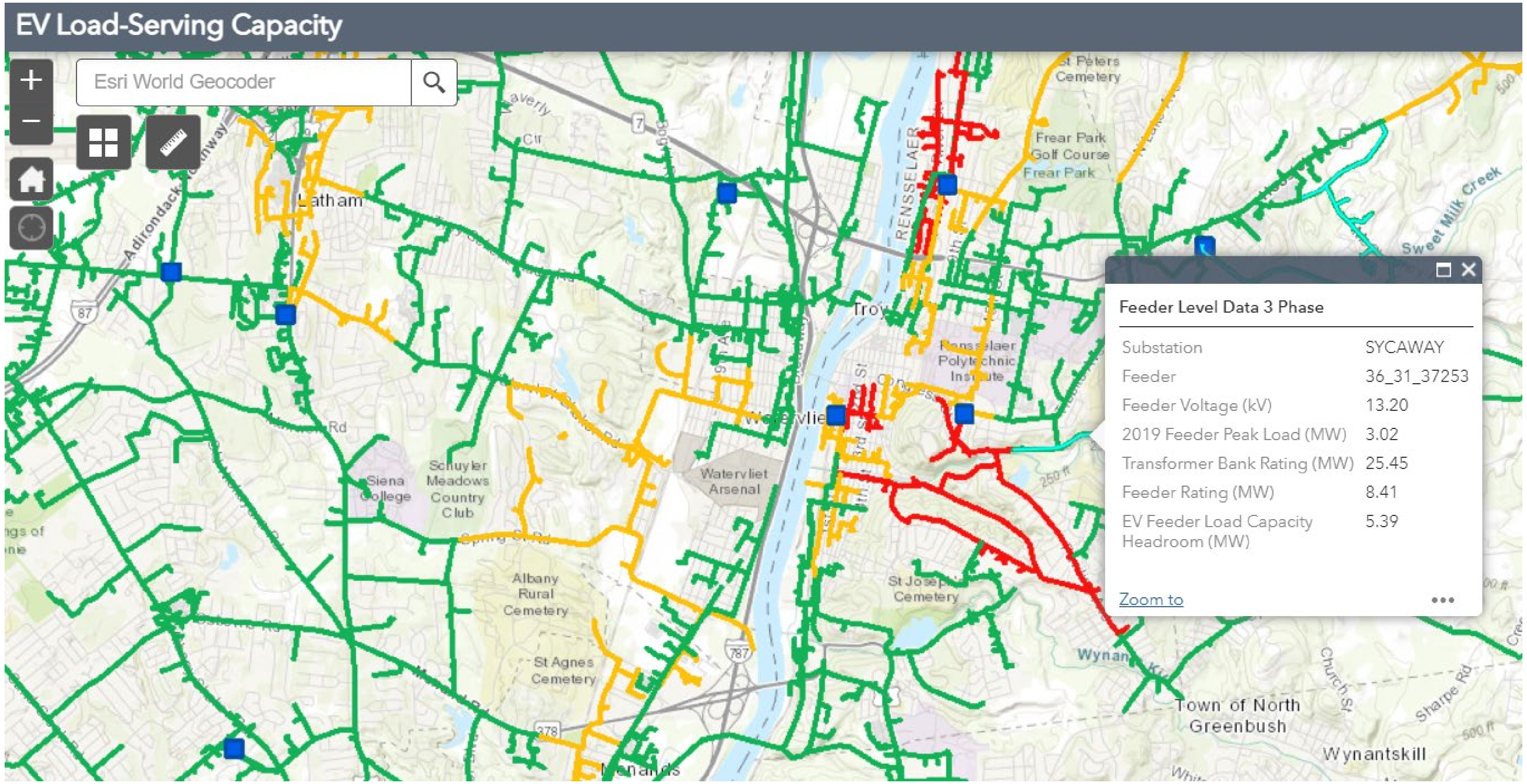
Electric Vehicle (EV)-Load Hosting Capacity Maps

- The EV load capacity maps were prioritized for development per the PSC's July 2020 Order Establishing EV Infrastructure Make-Ready Program.
- The maps are an estimate of the remaining circuit and substation load capacity.
- The use case is to help indicate areas with potentially higher interconnection costs for direct current fast charging (DCFC) development.



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Next Steps: Developing Hosting Capacity Maps for Energy Storage

- The EV load capacity maps helped provide a starting point for further refinement and development per the hosting capacity roadmap.

EV Load Capacity Maps December 2021

- Focused on thermal violation criteria
- Tailored to electric vehicle supply equipment (EVSE) development use case

Initial Energy Storage Hosting Capacity Release ~ April 2022

- Feeder-level analysis (Min / Max)
- Focused on large, centralized systems (> 300 kW)
- All applicable system data already provided
- Representational State Transfer (REST) URL access

Future Releases 2023 +

- Sub-feeder-level analysis
- Increased temporal granularity
- Long-term priorities to be defined

Increasing effectiveness, complexity, and data requirements

Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act (Transmission Planning Order)

CLCPA objectives and Resulting PSC Transmission Planning Order

- In May 2020, the PSC issued the Order on Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act (Transmission Planning Order).

- Among other directives, the Tranmission Planning Order called on utilities to complete a "power grid study" and sought to establish "a distribution and local transmission capital plan" for each utility.

The **Climate Leadership and Community Protection Act (CLCPA)** establishes aggressive targets for the reduction in GHG emissions, renewable and emissions-free electric generation, and development of off-shore wind.

The **Accelerated Renewable Energy Growth and Community Benefit Act (AREGCB Act)** directs the PSC to take specific actions to ensure that New York's electric grid will support the State's climate mandates.

Transmission Policy Working Group Report

The Utility T&D Report is split into three parts:

- **Part 1** the utilities present project investment criteria and prioritization recommendations

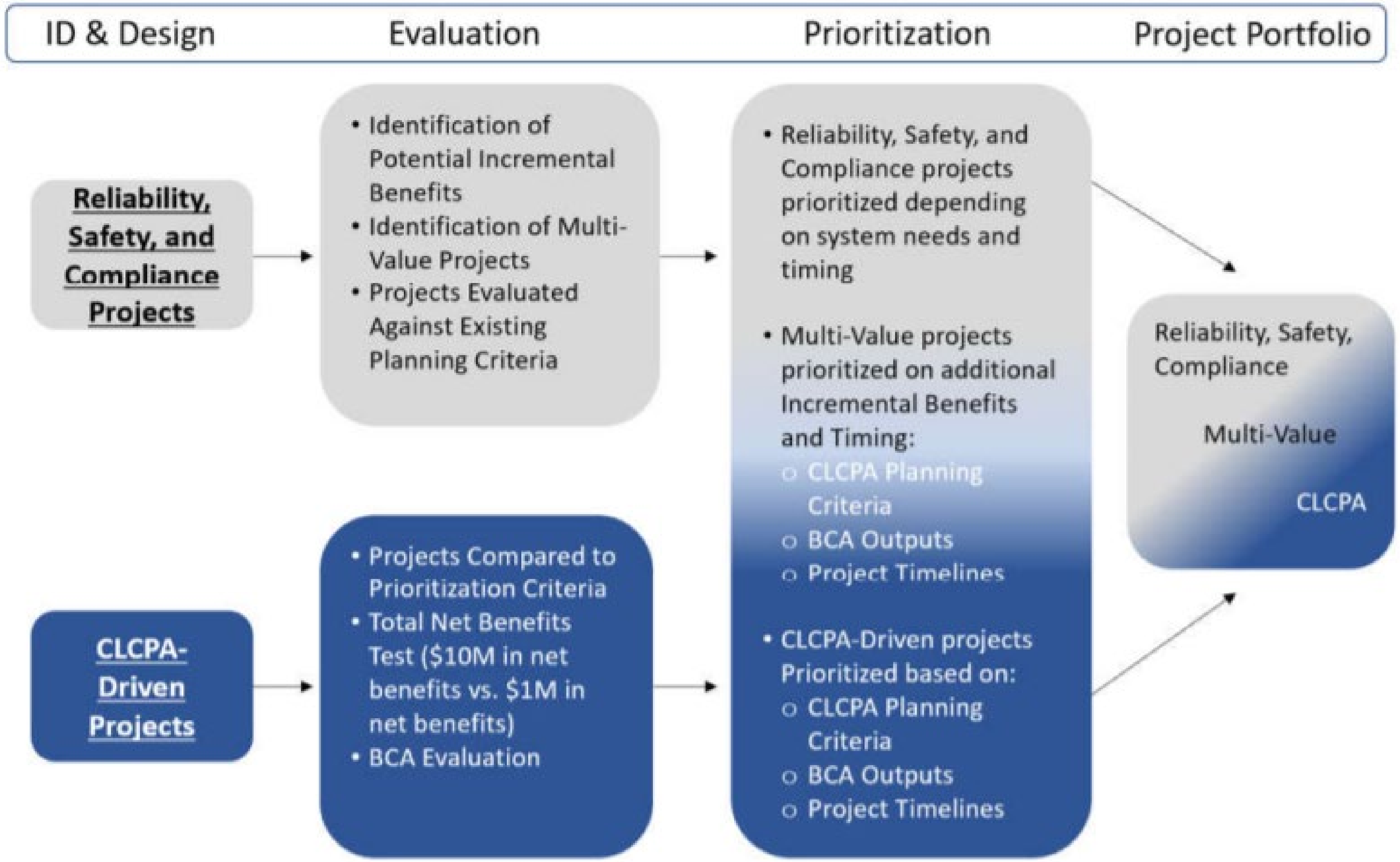
- **Part 2** identifies the range of potential local T&D (LT&D) upgrades each utility recommends as being necessary to accelerate achievement of CLCPA objectives.

- **Part 3** provides an overview the utilities' progress in developing plan to study, evaluate, pilot, demonstrate, and deploy new and/or underutilized technologies and innovations that can provide a range of electric grid benefits.

Prioritization and Approval of Local T&D Projects

Four basic inputs to the evaluation process:

- Existing planning criteria (e.g., reliability)
- Incremental CLCPA investment criteria
- Expected incremental clean energy value
- Expected investment costs



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Phase 1 LT&D Proposed Project Estimates

- **Phase 1** projects are immediately actionable projects that satisfy Reliability, Safety, and Compliance purposes but that can also address bottlenecks or constraints that limit renewable energy delivery within a utility's system.

- Order on Phase 1 Local Transmission And Distribution Project Proposals directed the JU to proceed with the development of the Phase 1 LT&D projects

Project Name	Projects (No.)	Estimated Project Cost	Estimated Project Benefit (MW)[102]
Central Hudson			
Transmission	6	$152.1M	433
Distribution	12	$137.0M	132
CECONY			
Transmission	3	$860M	900
Distribution	8	$1,130M*	418
LIPA			
Transmission	8	$402M	615
Distribution	19	$351M	520
National Grid			
Transmission	13	$773M	1,130
Distribution	5	$649M	428
NYSEG/RG&E			
Transmission	16	$1,560M	3,041
Distribution	8	$229M	165.8
O&R			
Transmission	6	$417M	500
Distribution	9	$156M	308
Total	**113**	**$6,800M**	**8,162**
Transmission Total	**52**	**$4,164M**	**6,619**
Distribution Total	**61**	**$2,636M**	**1,543**

* $789 million of investment (reflecting 5 of 8 projects) have already received funding approval. Incremental Phase 1 distribution costs for CECONY are $341 million.

Phase 2 LT&D Proposed Project Estimates (Conceptual)

- **Phase 2** projects may increase capacity on the local transmission and distribution system to allow for interconnection and delivery of new renewable generation resources within the utility's system.
- These projects are not currently in the utility's capital plans.

Project Name	Projects (No.)	Estimated Project Cost*	Estimated Project Benefit (MW)
Central Hudson			
Transmission	6	$138M	766
Distribution	7	$55M	222
CECONY			
Transmission	6	$4,050M	7,686
Distribution	2	$1,300M	360
LIPA			
Transmission	6	$1,281M+	1,830
Distribution	8	$167.2M	937
National Grid			
Transmission	13	$1,371M	1,500
Distribution	7	$584M-$1,292M	1,152-2,700
NYSEG/RG&E			
Transmission	11	$780M	943MW
Distribution	5	$125M	88.3MW
Total	71	$9,7777-$10,428M	15,494-16,473
Transmission Total	42	$7,620	12,725
Distribution Total	29	$2,157-$2,853M	2,769-3,748

* In general, the Phase 2 projects included by the Utilities are in early stage development, without completed, detailed designs and/or engineering. Therefore, costs provided in this figure should be considered conceptual estimates.

Advanced Technologies Working Group

- An Advanced Technologies WG was created to discuss potential R&D level projects for consideration in helping to meet the CLCPA goals
- The JU has prioritized several issues and potential technology solutions as being key to achieving CLCPA goals.
- The JU believes there is an opportunity to create a New York State focused R&D consortium to expedite the assessment and adoption of state-of-the-art and advanced technologies.
- Technology solutions include:
  - Dynamic line ratings and improved transmission utilization
  - Power flow control devices – distributed and centralized
  - Energy storage for T&D services
  - Improved operator situational awareness
  - Transformer monitoring
  - Advanced high temperature, low sag (HTLS)
  - Compact tower designs
  - SF6 monitoring/SF6 alternatives
- The Phase 1 Order stated Transmission projects should consider the use Advanced Technology Alternatives

Next Steps

- Move forward with implementation of Phase 1 projects
- Provide 6 monthly updates to the Commission and public on progress of Phase 1 projects
- Awaiting Order from Commission on phase 2 projects

Thank you!

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IEEE Blockchain in Energy Standards & Initiatives

IEEE P2418.5 and IEEE BCTE

Claudio Lima, Ph.D.
Chair

Presented to NPCC DER/VER Forum
NPCC, Inc.
NORTHEAST POWER COORDINATING COUNCIL, INC.

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May 13rth 2021

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Disclaimer

This presentation and the information it contains is a brief overview and shall not be construed as legal advise or exhaustive engineering recommendation as some are working in progress, Blockchain Reference Models and Frameworks are contributions from the Blockchain Engineering Council (BEC).

This presentation is technology or vendor implementation agnostic and neither recommends nor endorses any specific technology. The generic frameworks, models and examples presented here serves only for the purpose of introducing and defining new topics and explaining generic concepts and are currently "working in progress" and "contribution to standards" only.

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Agenda

- Blockchain in Energy Concepts and Use Cases
- Overview of IEEE P2418.5 Blockchain in Energy Standards
- Blockchain Power Energy System Reference Model
- DLT-CIM Blockchain Power Energy Interoperability Model
- Smart Legal Contract for Energy/Power Systems
- IEEE Blockchain Transactive Energy (BCTE) Initiative

DLT – Distributed Ledger Technology

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Why Do We Need Blockchain DLT Standards in Energy?

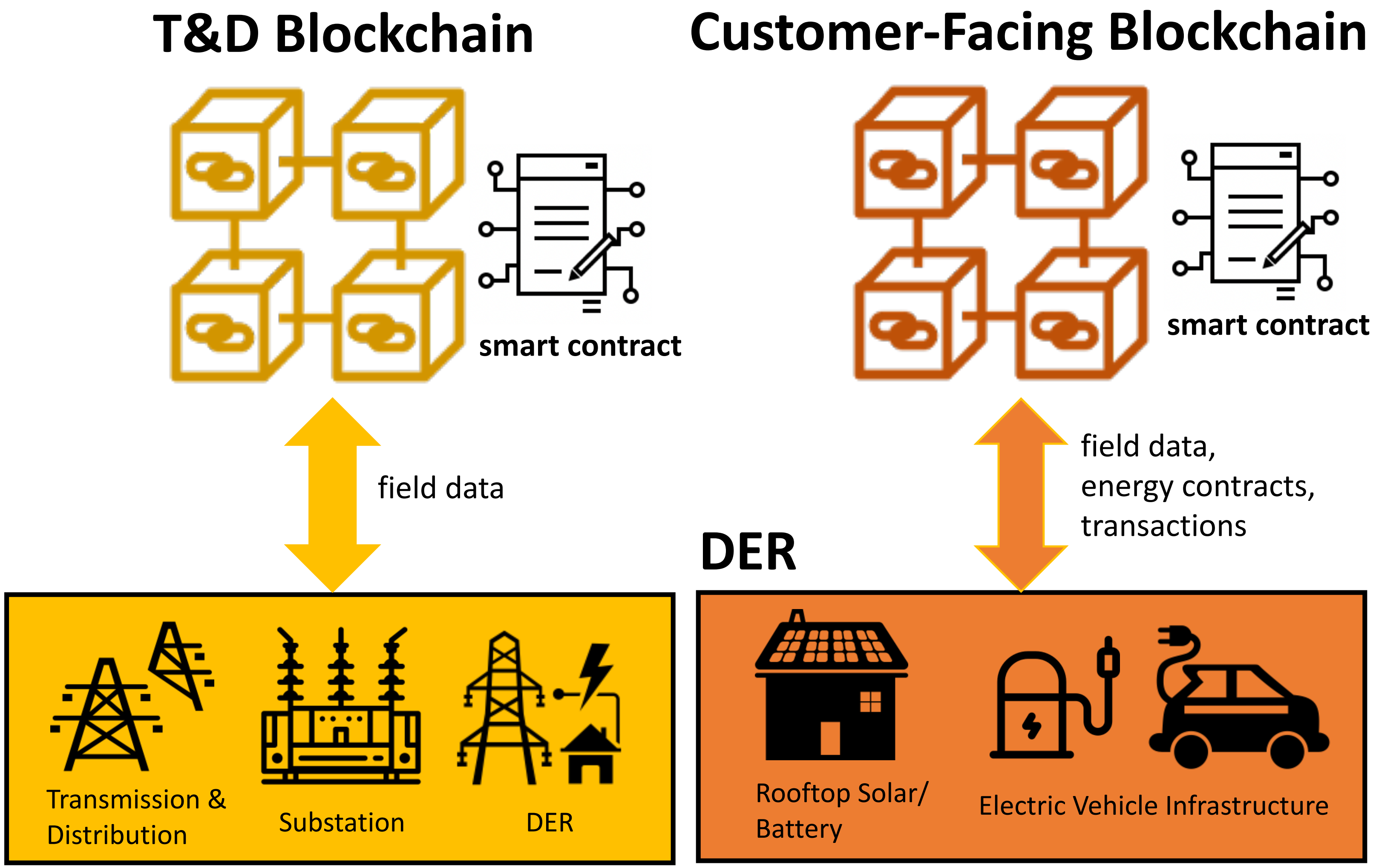
- Accelerate the industry adoption
- Demystify the technology and applications
- Define terminologies, specifications and reference frameworks
- Create interoperability models
- Address cybersecurity, privacy and performance
- Communicate with the industry and other standards organizations

Blockchain Data Properties & Benefits

Blockchain is digital ledger of transaction data recording system, distributed across many computing systems, that makes it difficult or impossible to change, hack, or fraud the system

source: BEC

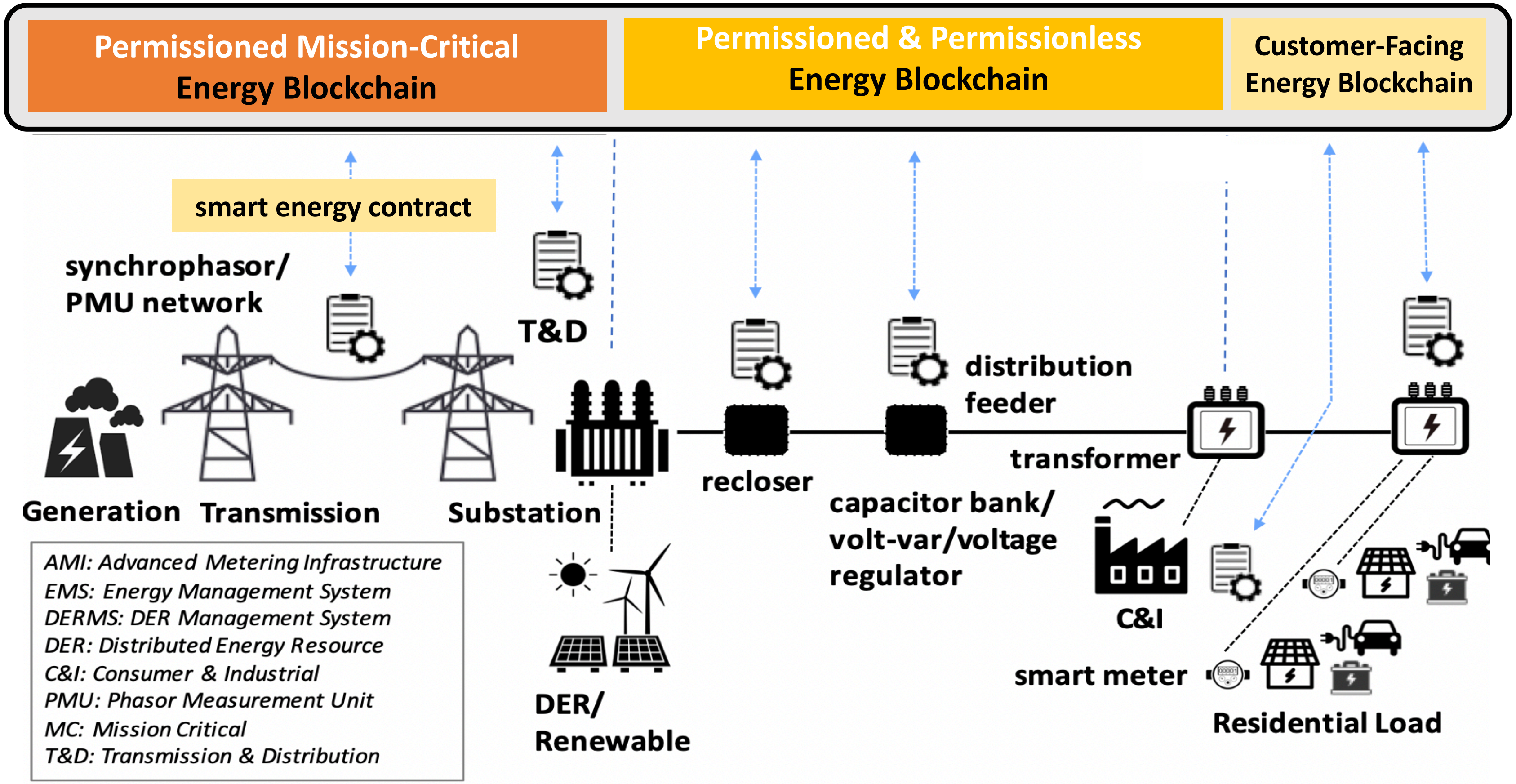
Blockchain in Energy Grid Applications



source: BEC

IEEE P2418.5 Blockchain-DLT Energy Standards

Grid Segmentation



Shall comply with 2P2S design principles (Performance, Privacy, Security & Scalabiluty

source: BEC, IEEE

IEEE SA STANDARDS ASSOCIATION

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IEEE

source: BEC

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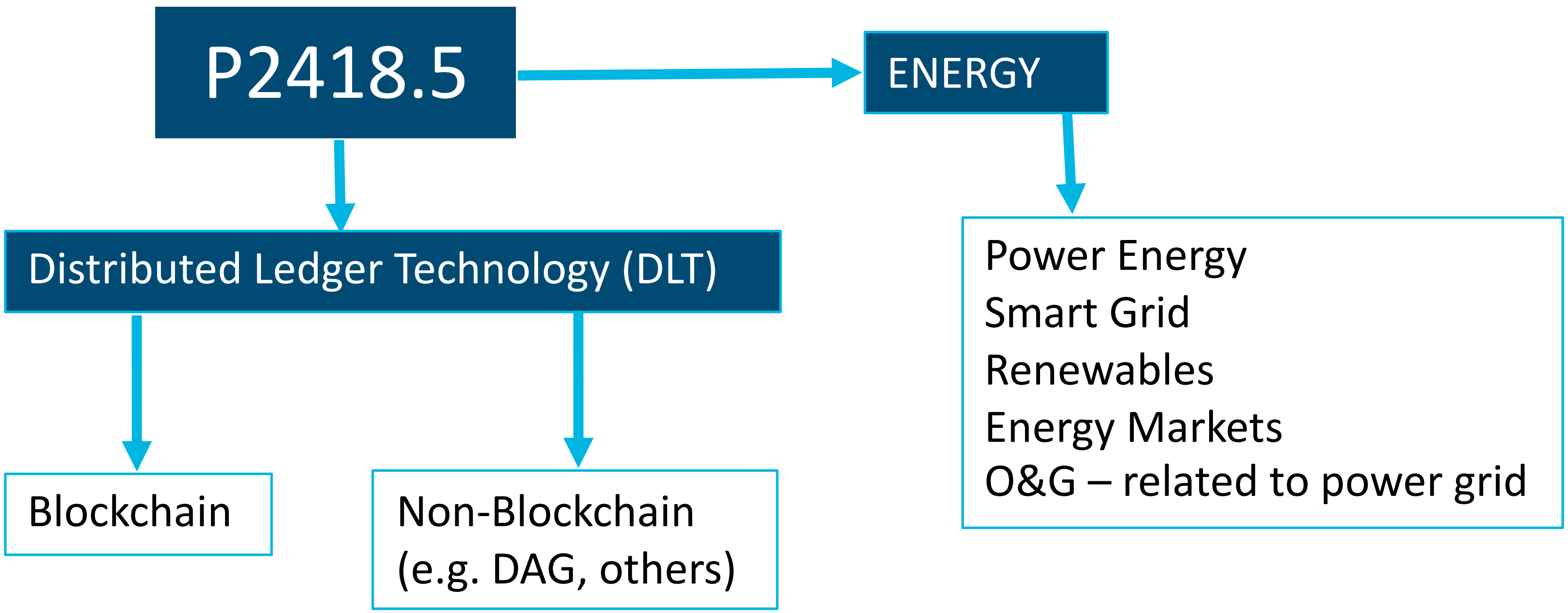
IEEE Blockchain DLT Standards

- ✓ **P2418.5 is primarily a DLT standard**. Blockchain is used because is the most popular use of DLT, but other DLTs shall be considered.

- ✓ **P2418.5 is an Energy standard** and shall cover all related power and energy grid definitions.



IEEE P2418.5 Blockchain-DLT Case Studies

some initial cases

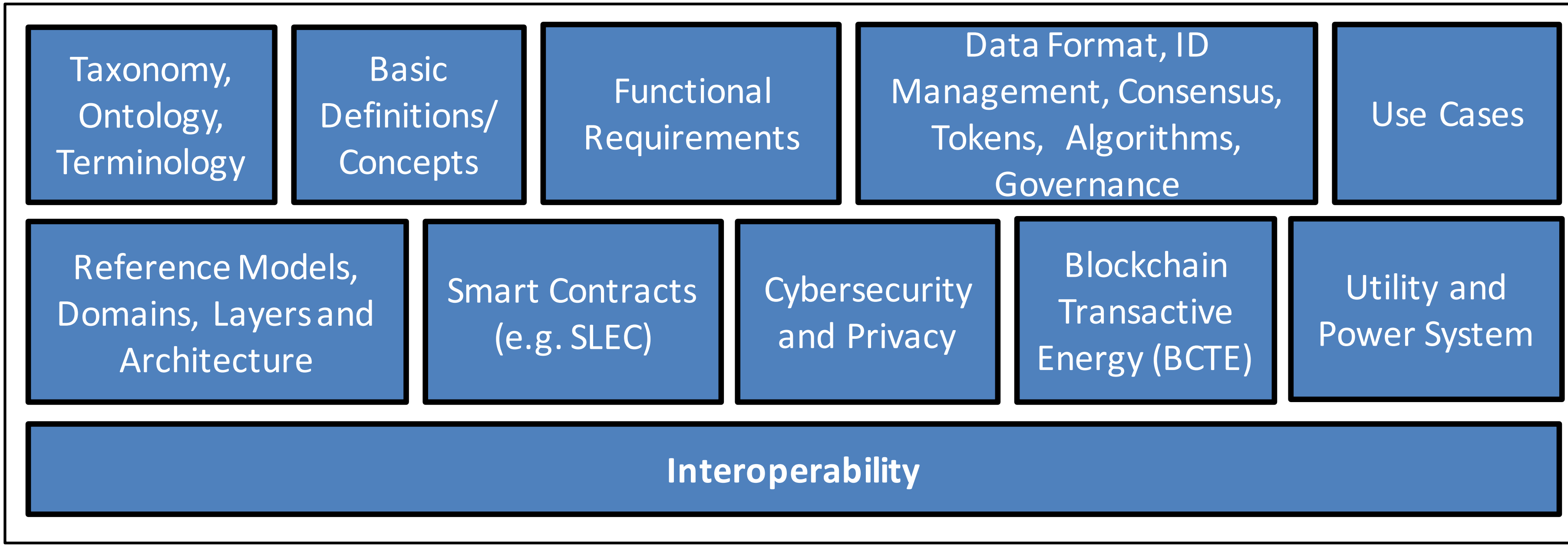
- DER Aggregation with Blockchain DLT Platform
- EV Charging Station Integration with DLT
- Renewable Energy Certificate (REC) – Blockchain RECs
- Blockchain in Energy Cybersecurity
- Wholesale Energy Markets Blockchain Transactions
  - Capacity and energy markets

IEEE P2418.5 Charter Goals

- Create **domains** and **building blocks**
- **Define/create sub-systems**, key actors and interfaces
- Define **terminology**, ontology and acronyms
- Create **grid segmentation**
- Classify, validate **use cases**
- Create **functional requirements**
- Create **reference frameworks and architecture**
- Create **interoperability** frameworks
- **Harmonize** with existing and future IEEE and other international blockchain **DLT grid standards**

IEEE P2418.5 Blockchain in Energy Stds.

Framework and Charter Goals for IEEE P2418.5 Blockchain Energy Standards



https://sagroups.ieee.org/2418-5/
https://standards.ieee.org/project/2418_5.html

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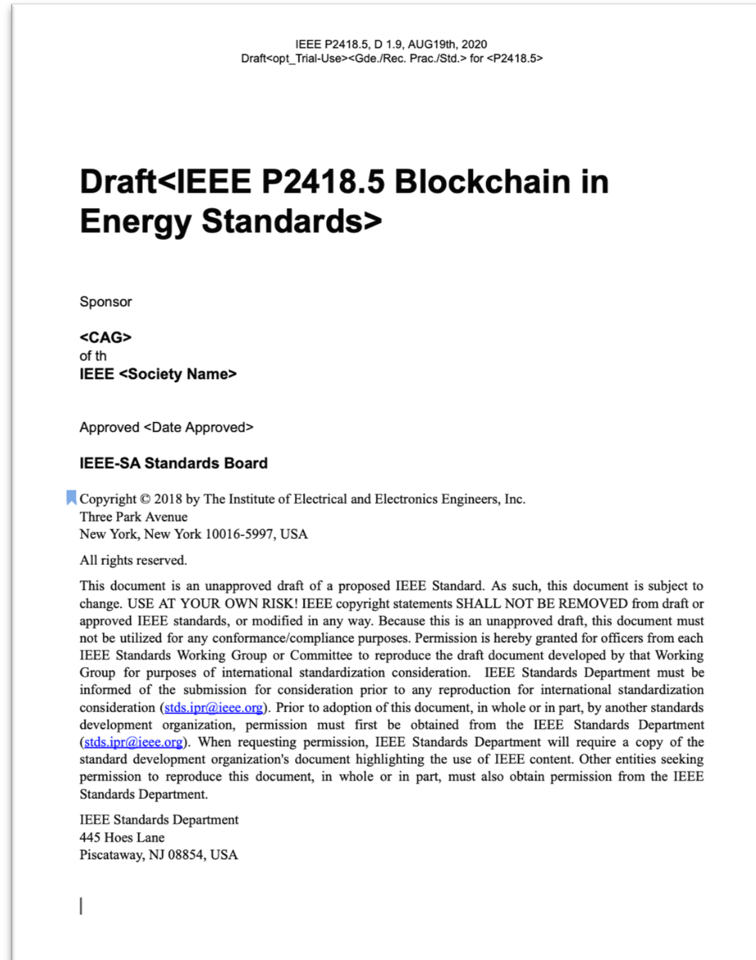
Call for Contribution to IEEE Standards

Contribute with the creation of a new standards: **IEEE P2418.5 Blockchain in Energy Std** (2021)



IEEE P2418.5, D 1.9, AUG19th, 2020
Draft<opt_Trial-Use><Gde./Rec. Prac./Std.> for <P2418.5>

Draft<IEEE P2418.5 Blockchain in Energy Standards>

Sponsor

<CAG>
of th
IEEE <Society Name>

Approved <Date Approved>

IEEE-SA Standards Board

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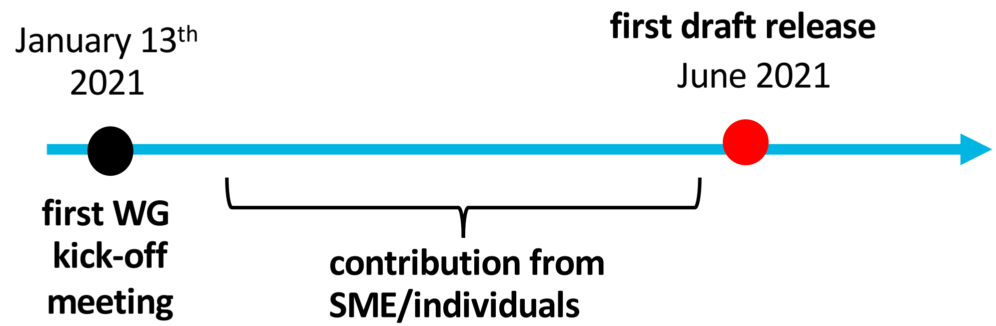
Call for Contribution to IEEE Standards


Draft<IEEE P2418.5 Blockchain in Energy Standards>

Alignment/Liaison:

- IEEE 2030-20, P825, 1547, 2030.x, etc
- CIGRE, ISO/TC307, GWAC, IEEE BCTE, etc.

2021 Timeline



- Establish task forces (for sub-topics)
- Bi-weekly draft review/write-up meetings (informal)

IEEE P2418.5 Task Forces

Task Forces

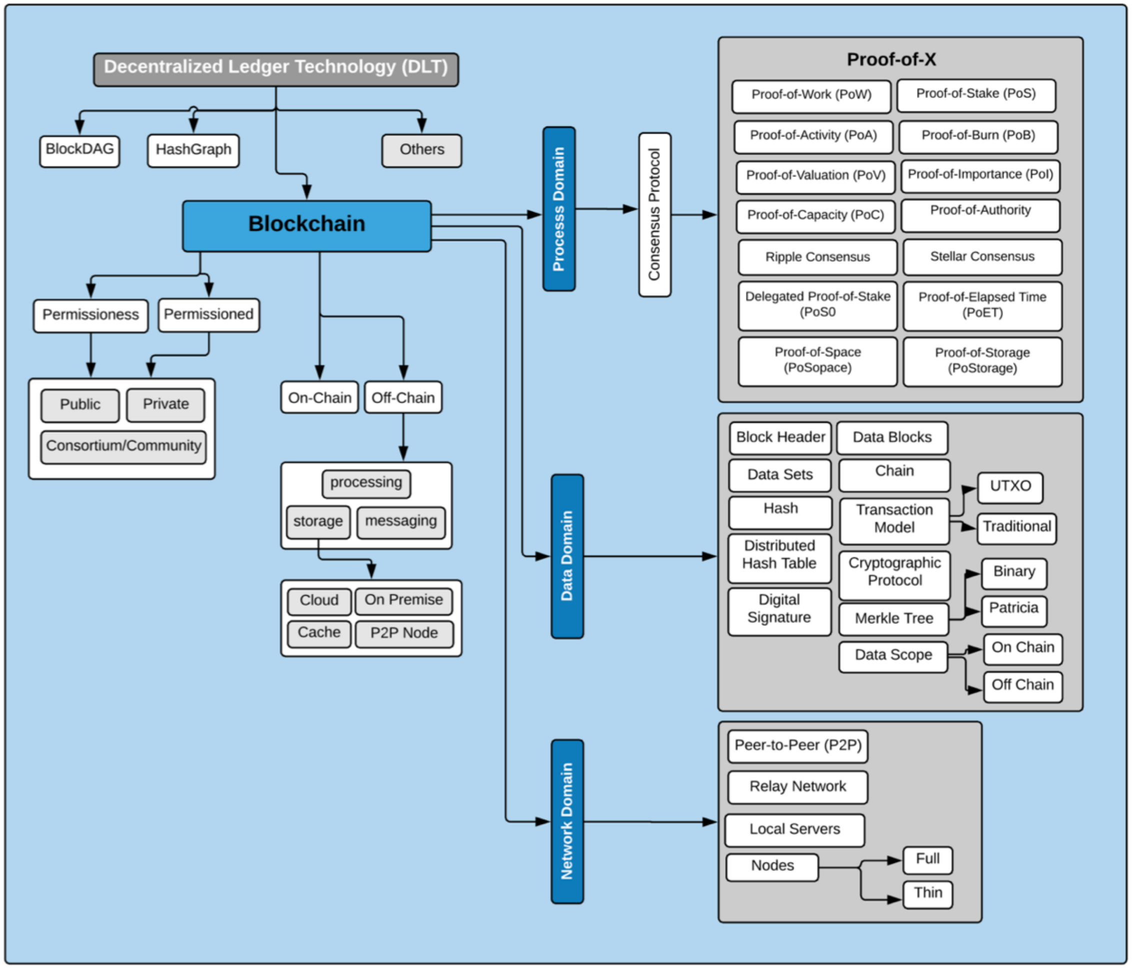
- TF 1 Cybersecurity and Privacy
- TF2 Utilities
- TF3 Blockchain Transactive Energy
- TF4 Smart Contract
- TF5 Interoperability
- TF6 Power Network Communications

Others…

Blockchain DLT (IEEE 42010) Model

An All inclusive Framework

DLT/Blockchain System of Interest



- ✓ Blockchain-IoT Reference Architecture, based on IEEE 42010 framework (undergoing)
- ✓ All alternatives included - considers more than Blockchain as technology enabler
- ✓ Addresses key domain/layer levels
- ✓ Includes (most) Blockchain/DLT technologies elements

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P2418.5 Blockchain-DLT Layers

The building layers of Blockchain DLT systems need to be defined to categorize its key elements, independent of the DLT technology adopted

physical and cybersecurity layer

DLT Layers

TRANSACTIVE	marketplace, monetization layer
APPLICATIONS	decentralized apps (Dapps)
SERVICES	transactions/contract, tokens
PROCESSES	consensus algorithms
DATA MODELS	block, chain structure, cryptography,hashing
NETWORK (connectivity, runtime, cloud infrastructure and/or P2P)	node, OS, VM/kubernetes, P2P messaging/discovery
Things, Things, Things, Things, Things	IoT, OS, UID

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P2418.5 Blockchain-DLT Key Principles

Key Principles

10 Best Principles & Recommendations

- Open Standards
- Secure
- Technology Agnostic
- Future Proof
- Interoperable
- Scalable
- Modular
- Manageable
- Reliable
- Inclusive

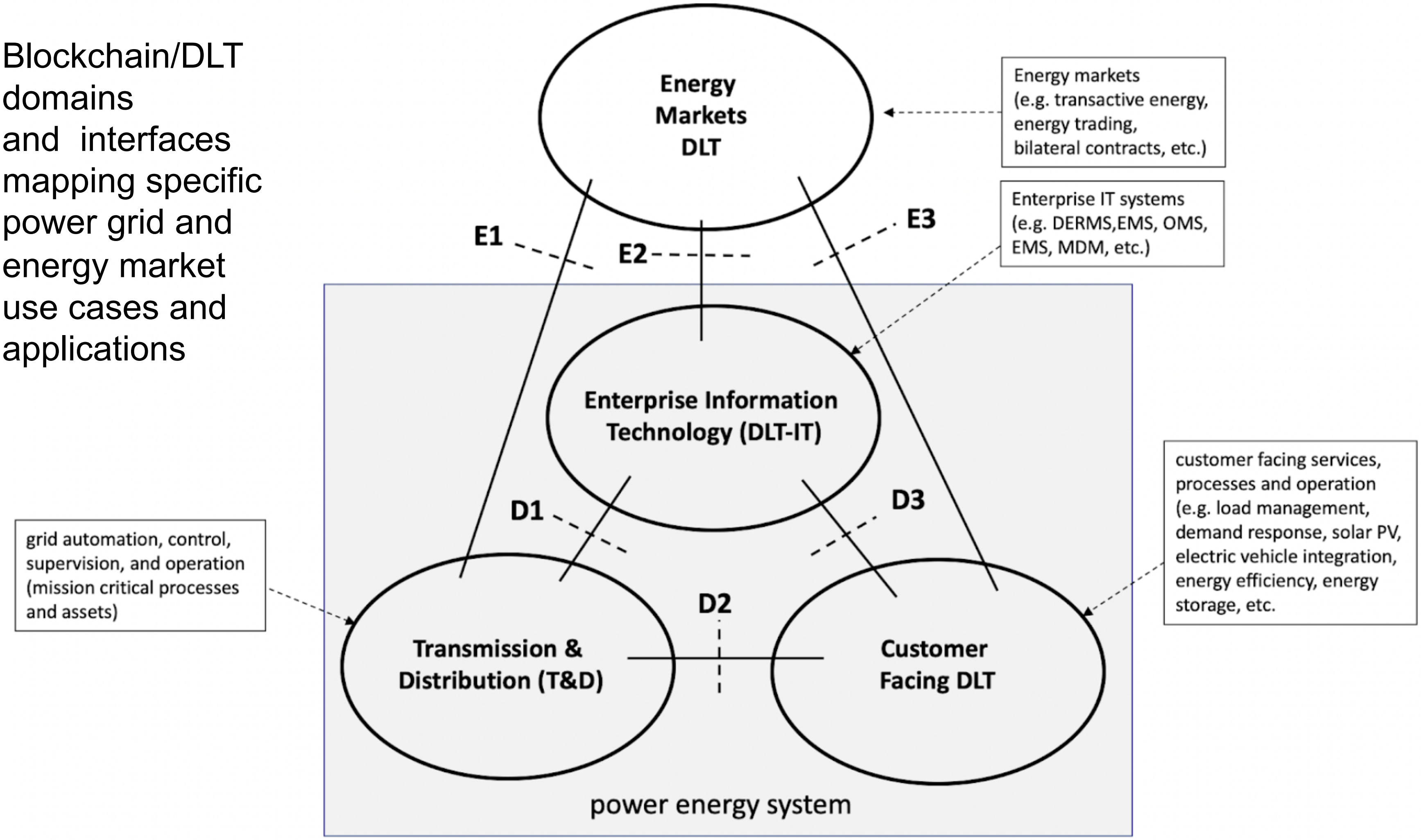
Recommended Approach →

P2418.5

"Open" and Interoperable DLT/Blockchain Standards-Based

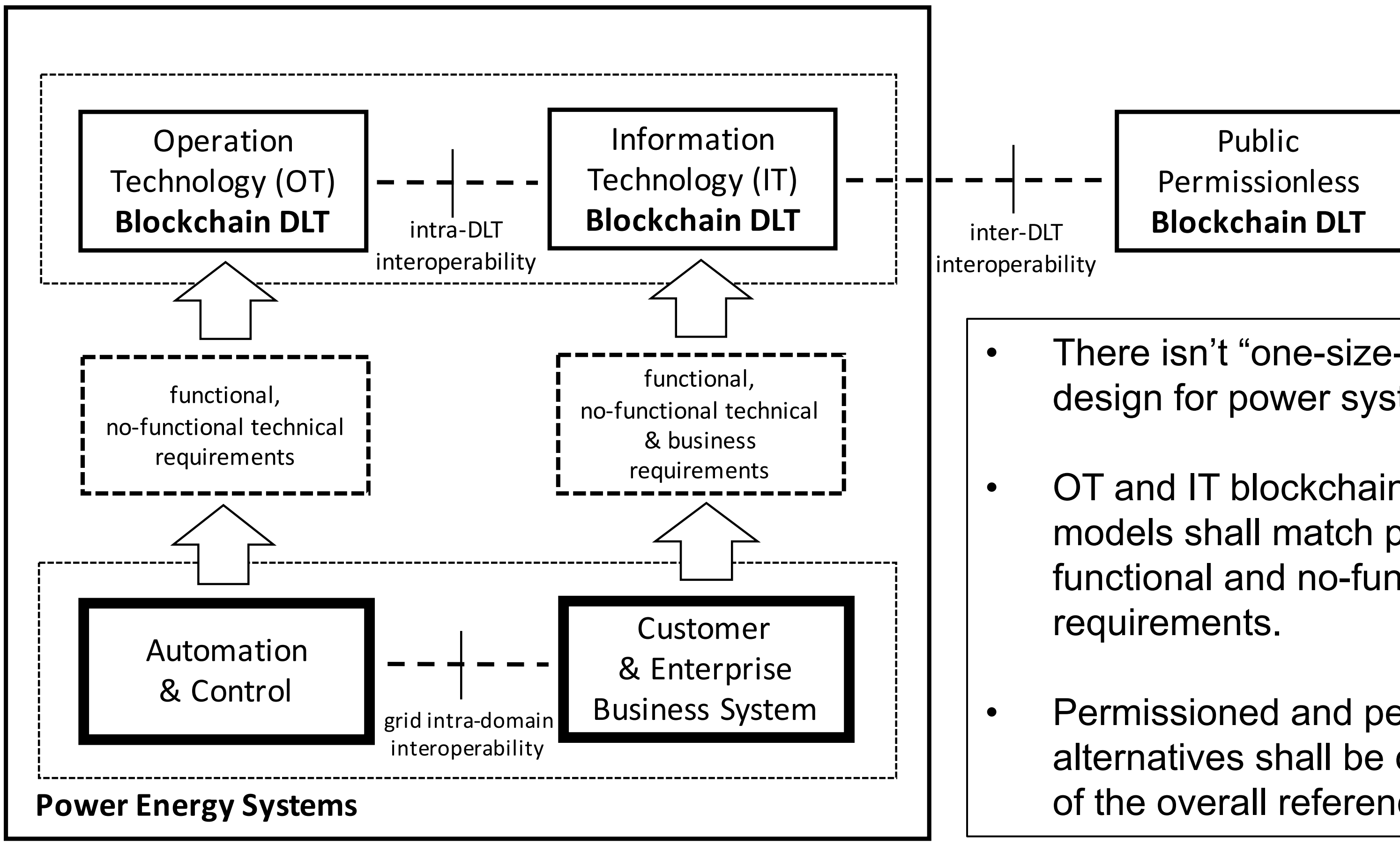
P2418.5 DLT Energy Domains

Blockchain/DLT domains and interfaces mapping specific power grid and energy market use cases and applications



Blockchain DLT Power Energy System

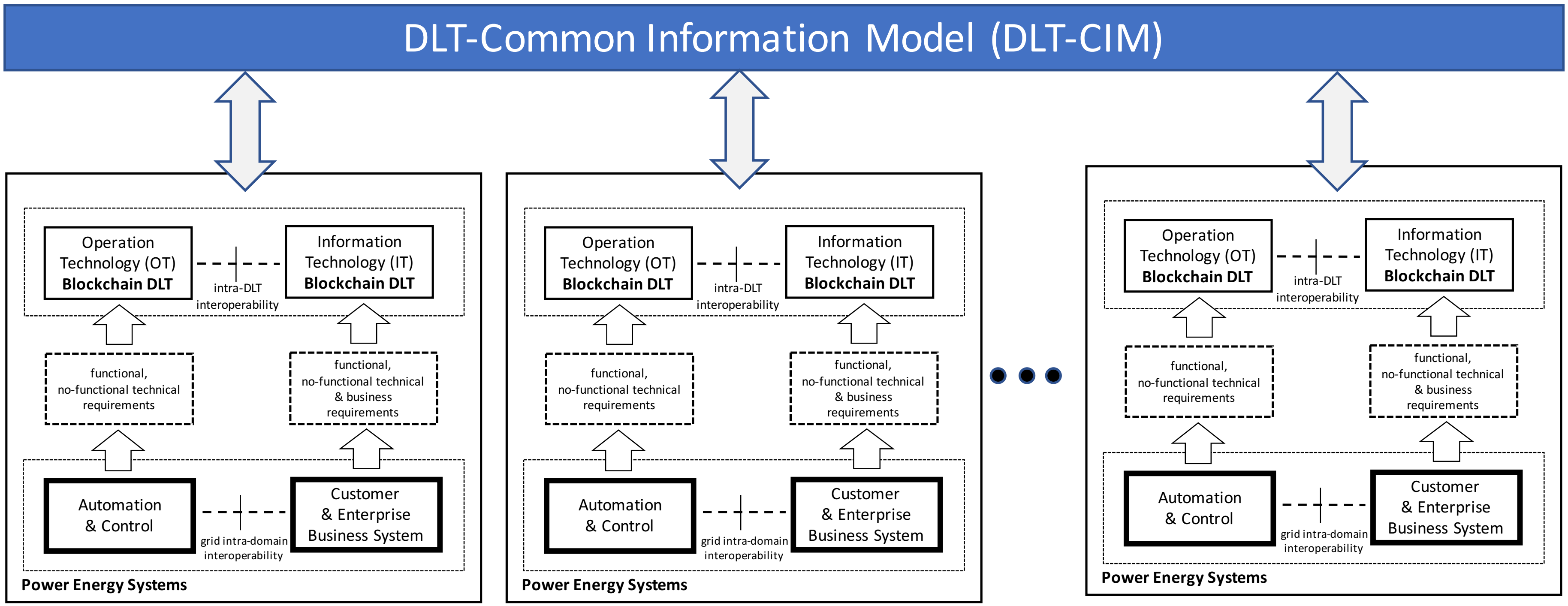
Interoperability Framework



- There isn't "one-size-fits-all" blockchain design for power system.
- OT and IT blockchain DLT reference models shall match power grid functional and no-functional requirements.
- Permissioned and permissionless DLT alternatives shall be considered as part of the overall reference model.

Blockchain DLT Power Energy System

Interoperability Model (DLT-CIM)



Defining the intra- and interoperability DLT/Blockchain reference model for the Power and Energy Industry, based on a **new DLT-CIM framework**.

Blockchain DLT Power Energy System

Interoperability Model

There are different levels and types of Blockchain DLT interoperability

Semantic Interoperability

dApps, Smart Contract Interoperability

Multi-Ledger Interoperability

Middleware Layer Interoperability

Multi-Cloud/P2P Network Interoperability

source: BEC

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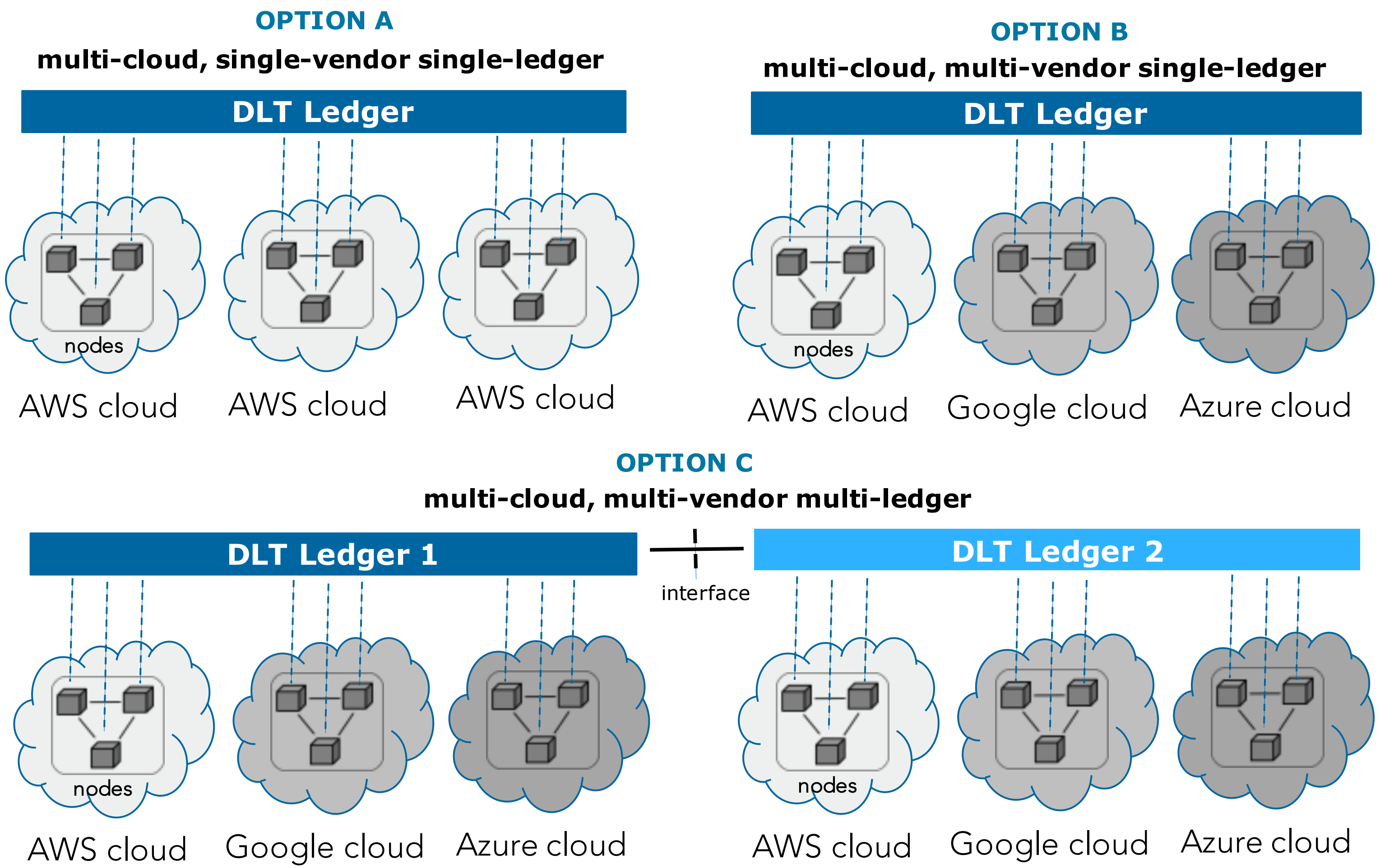
Blockchain DLT Power Energy System

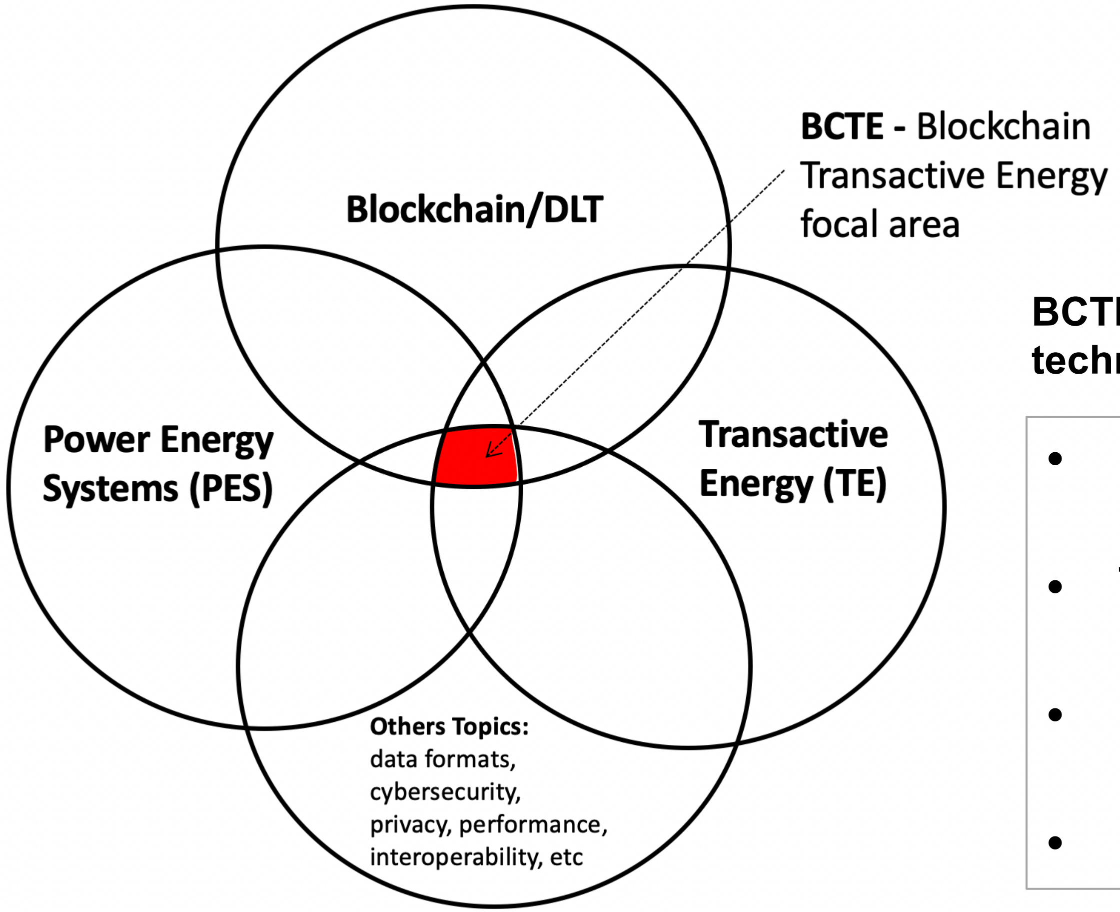
Interoperability Model



IEEE Blockchain Transactive Energy (BCTE)

coming soon…May 2021

Defining the Blockchain Transactive Energy (BCTE) Intersections



BCTE is the intersection of multiple technology segments:

- Blockchain/DLT
- Transactive Energy (TE)
- Power Energy System
- Other technology topics

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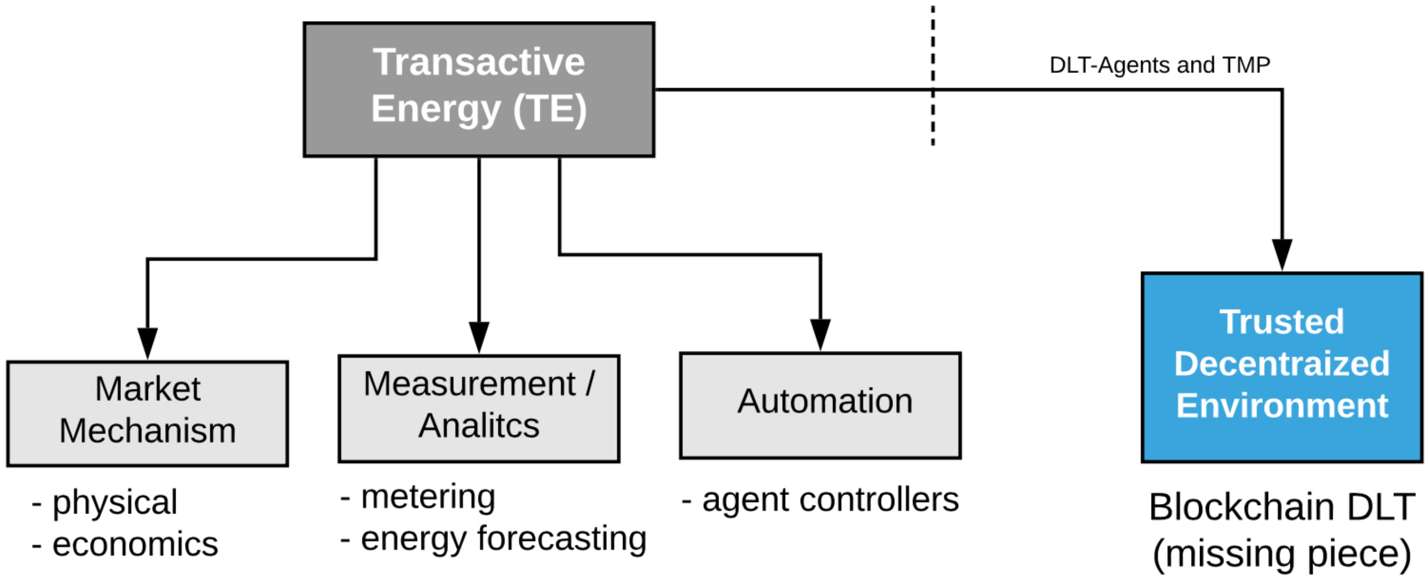
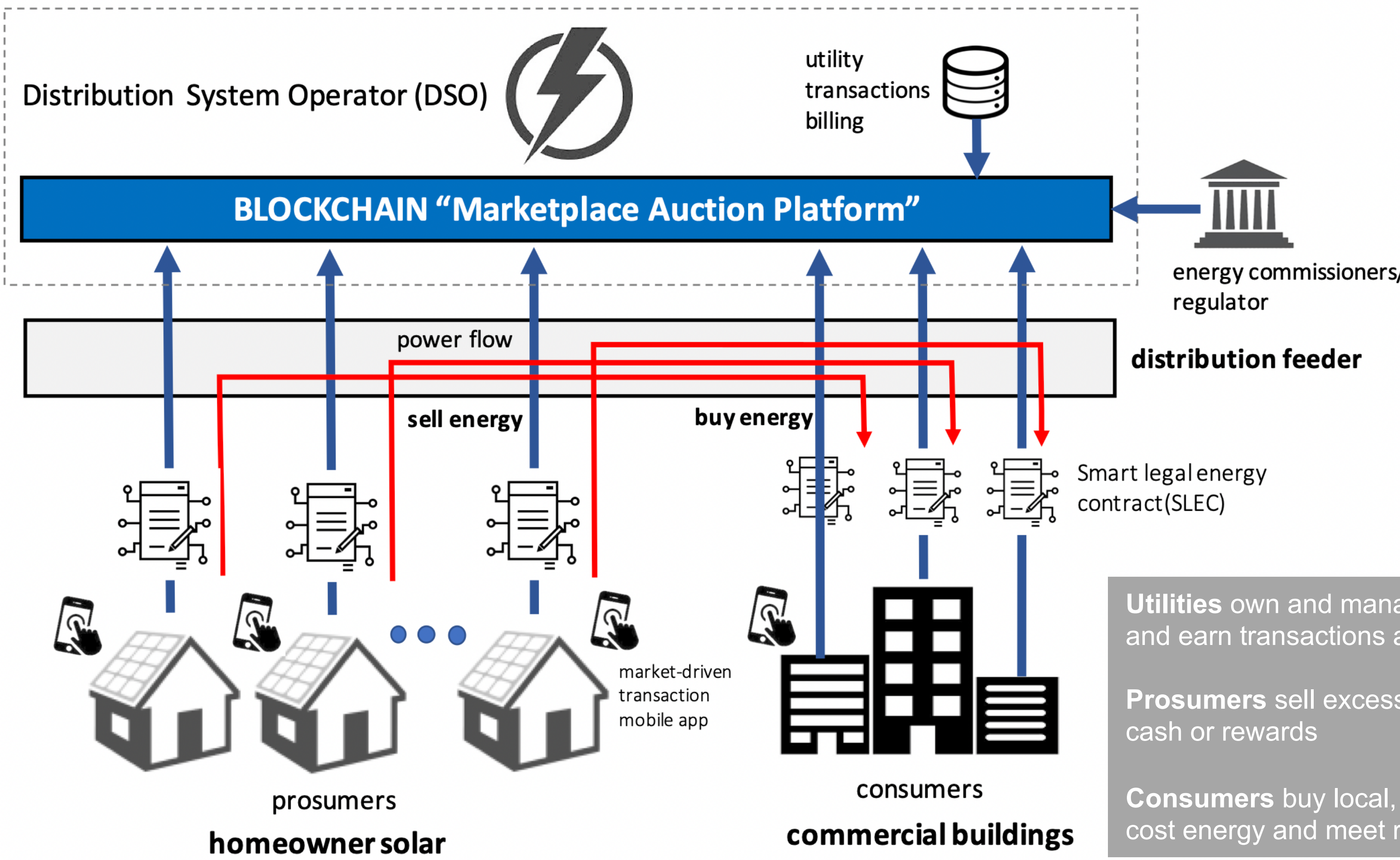
Blockchain Transactive Energy (BCTE) for Trusted Applications



The **Blockchain Transactive Energy (BCTE)** is a new layer that adds trustability, traceability, and transparence to the existing TE layer that were missing

High-Level Blockchain Transactive Energy (BCTE)
Framework



win-win solution

Utilities own and manage the DLT platform and earn transactions and licensing fees

Prosumers sell excess energy or get credits, cash or rewards

Consumers buy local, renewable and low cost energy and meet renewable mandates

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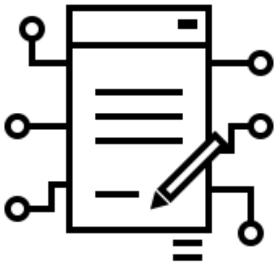
Why a Legal? Energy? Smart Contract?



Smart Contract

Generic
- **Energy** → specific for **ENERGY**
- Healthcare
- Manufacturing
- Supply chain…etc.

Non-Legally Binding
- Just a computer logical (what..if) Code
- No penalties or clauses that establish consequences

→ contains **legally biding** clauses and conditions

Many Languages/ Constructs
- Solidity
- Chaincode, etc.

→ **agnostic to computer languages/** constructs

Smart
Legal
Energy
Contract

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Smart Legal Energy Contract (SLEC) Framework

- Defines the technical parameters, the boundaries and key elements
- Creates *What..if..then* clauses that trigger events, decisions, state changes when conditions are met
- Creates the legally biding contractual clauses linked to the smart contract computer logics

Smart Legal Energy Contract Structure

Technical Energy Parameters Definitions and Algorithms

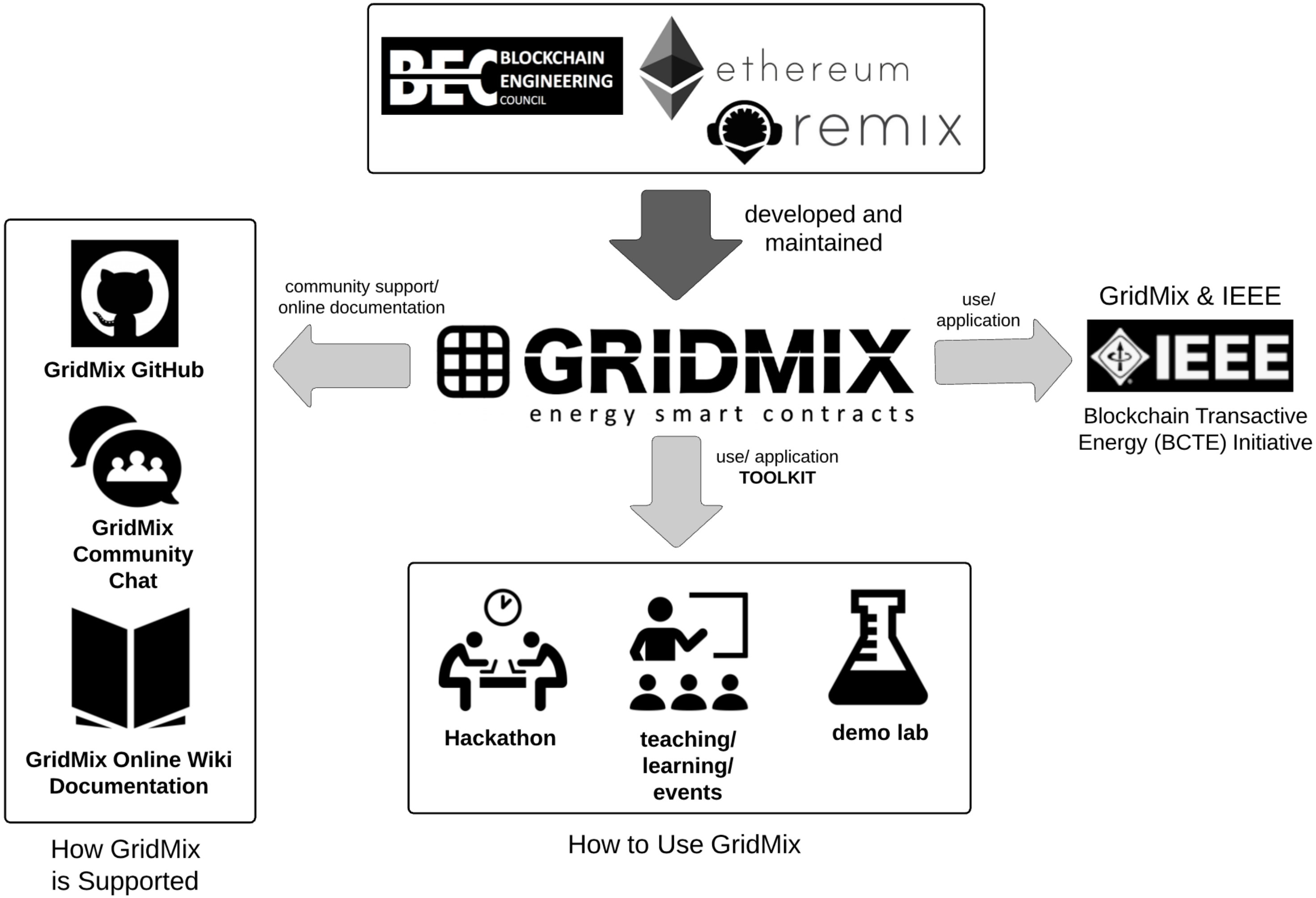
What..if..then Clause

What..if..then Clause

What..if..then Clause

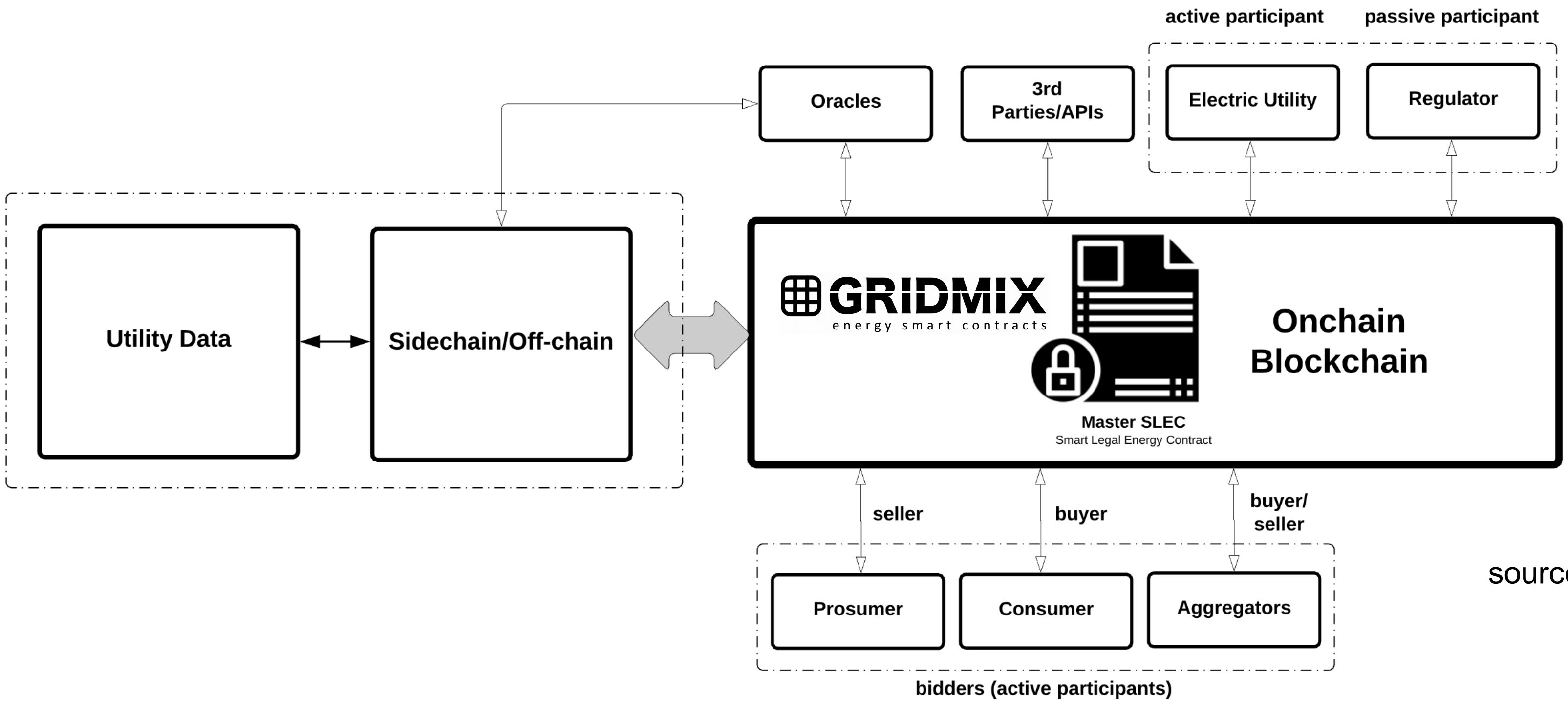
Legally Biding Contractual Clauses

GridMix Ecosystem



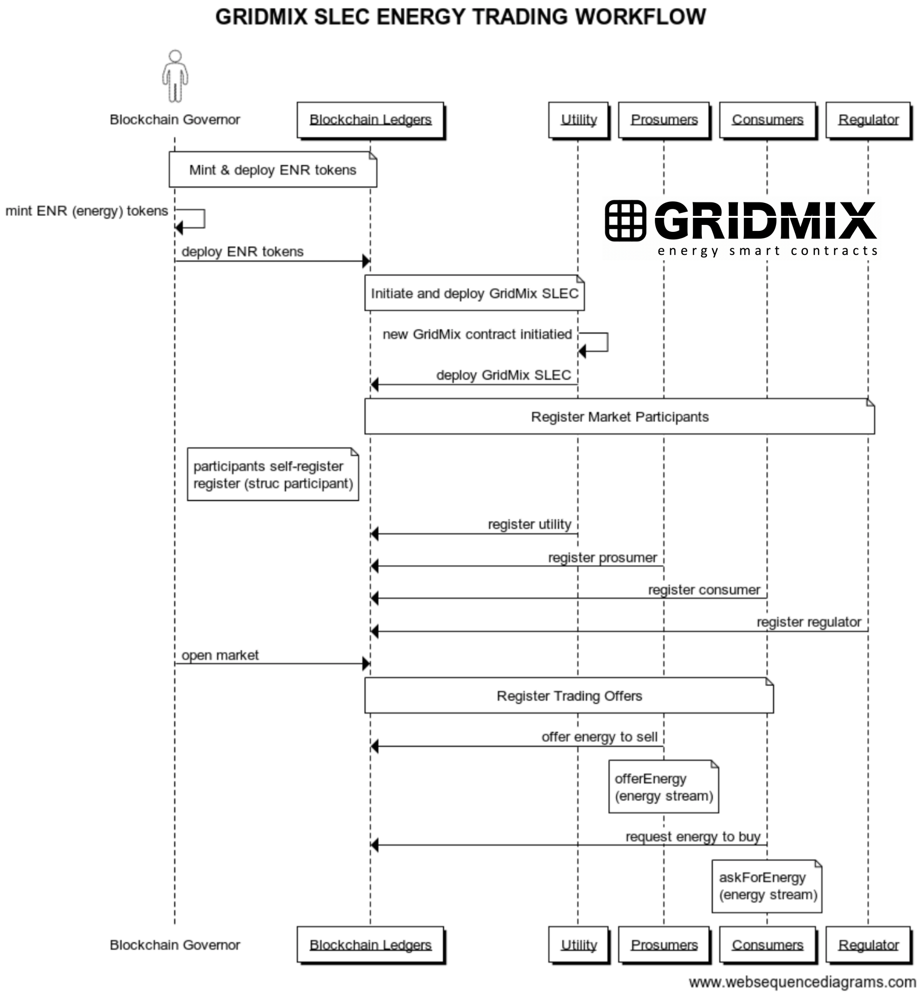
GridMix Smart Contract Reference Model

GridMix is composed of a modular and structured smart contract **<u>generic reference model</u>** that contains logical functions that can be customized for local energy markets



source: BEC

GridMix Smart Contract Transaction Workflow



GridMix SLEC Data Model for Energy Trading Smart Contract

source: BEC

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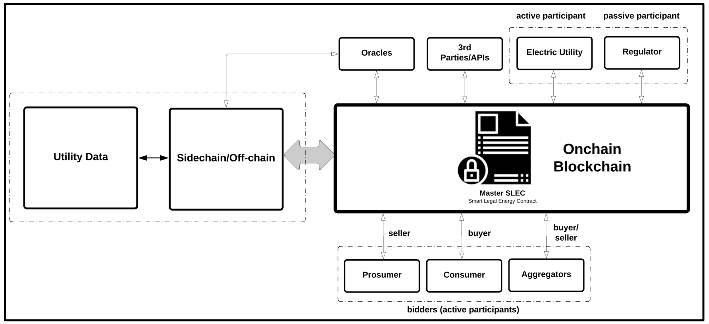
GridMix Smart Contract Ethereum Mapping



GridMix Reference Framework

Mapped on to
Ethereum Solidity coding

400 lines of GridMix Master SLEC code released as a generic framework (version 1.0)

Solidity Smart Contract Code Structure (gridmix.

The GridMix Solidity v. 1.0 smart contract is given below. Howeve please check at the GitHub code repository above. This is the ma "masterSLEC".

An ERC777 **ENR** energy token is minted to start the process to tok

```
pragma experimental ABIEncoderV2;
import "https://github.com/OpenZeppelin/openze
import "https://github.com/OpenZeppelin/openze
import "https://github.com/OpenZeppelin/openze
import "https://github.com/OpenZeppelin/openze

contract masterSLEC is IERC777Recipient {
    using EnumerableMap for EnumerableMap.Uint

    IERC1820Registry private _erc1820 = IERC18
    bytes32 constant private TOKENS_RECIPIENT_

    IERC777 token;

    constructor (address _grid, address _toker
        token = IERC777(_token);
        grid = _grid;
        _erc1820.setInterfaceImplementer(addre
    }

    modifier streamOwner (energyStream memory
        require(_energy.addr == msg.sender, "
        _;
    }

    modifier isParticipant (address _address)
        require(participants[msg.sender].exist
        _;
    }

    modifier marketIsOpen () {
        require(currentMarket.isOpen, "market is closed");
        require(currentMarket.startTimestamp <= block.timestamp &&
        _;
    }

    modifier marketIsClosed () {
        require(!currentMarket.isOpen, "market is open");
        require(currentMarket.startTimestamp > block.timestamp && c
        _;
    }

    modifier deliverytimeIsInRange(energyStream memory _energy) {
        require(_energy.startDeliveryTimestamp >= currentMarket.sta
        require(_energy.endDeliveryTimestamp < currentMarket.endDe
        _;
```

```
    struct participant {
        address prosumerID; // prosumer or consu
        bool canBuy; // has permission to buy
        bool canSell;  // has permission to sell
        buySpecs buyerSpecs; // struct of specs
        sellSpecs sellerSpecs; // struct of spec
        location loc; // longlat
        uint8 zip; // zip code - added in this v
        uint8 exists;
    }

     // energyStream is for requesting and offer
    struct energyStream {
        address addr; // sellerProducer's public
        uint64 timestamp; // timestamp for when
        uint startDeliveryTimestamp;
        uint endDeliveryTimestamp;
        uint price; // sellerProducer price (bid
        uint64 energy;  // sellerProducer energy
    }

    struct streamRef {
        address addr;
        uint id;
    }

    mapping(address => participant) public parti

    mapping(address => energyStream[]) public se
    EnumerableMap.UintToAddressMap private sellE

    mapping(address => energyStream[]) public bu

    mapping(bytes => streamRef[]) bids;
    mapping(bytes => uint) bids_acquired;

    mapping(bytes => bytes) accepted;
    mapping(bytes => bool) done;

    market currentMarket;

    /**
     * @dev Called when the payment has been rec
     * @param operator need more def
     * @param from the buyer
     * @param to the seller
     * @param amount how much was received
     * @param userData need more def
     * @param operatorData need more def
     */
    function tokensReceived (
        address operator,
        address from,
        address to,
        uint256 amount,
        bytes calldata userData,
        bytes calldata operatorData
    ) external override {
        // TODO check if this the right token contract.
        // userData is concatenation of seller , idOffer, idAsk
        bytes memory ref = abi.encodePacked(userData, from);
        bids_acquired[ref] += amount;
    }
```

```
     * @dev Registers a participant into the GridMix
     * currently a participant self registering
     * @param member is a consumer or prosumer joining this system
     */
    function register(participant memory member) public {
        require(participants[msg.sender].exists == 1, "already reg
        participants[msg.sender].prosumerID = msg.sender;
        participants[msg.sender].exists = 1;
        participants[msg.sender] = member;
    }

    /**
     * @dev UnRegisters a participant from the GridMix
     * currently a participant is removing themselves
     */
    function unregister() public {
        delete participants[msg.sender];
    }

    /**
     * @dev A participant registers a desire to SELL an energy str
     * @param _energy The energyStream contains amount of kWh, the
     */
    function offerEnergy(energyStream memory _energy) isParticipant
        require(participants[msg.sender].canSell, "participant can
        require(_energy.startDeliveryTimestamp >= currentMarket.sta
        require(_energy.endDeliveryTimestamp < currentMarket.endDe
        require(_energy.price <= currentMarket.maxPrice, "price to

        sellEnergy_map[msg.sender].push(_energy);
        uint newIndex = EnumerableMap.length(sellEnergy_list);
        EnumerableMap.set(sellEnergy_list, newIndex, msg.sender);

        currentMarket.offerEnergyCounter++;
    }

    /**
     * @dev A participant registers a desire to buy an energy strea
     * @param _energy contains the amount of energy and when it is
     */
    function askForEnergy(energyStream memory _energy) isParticipan
        require(participants[msg.sender].canBuy, "participant can't
        require(_energy.price <= currentMarket.maxPrice, "price to

        buyEnergy_map[msg.sender].push(_energy);
    }

    /**
     * @dev A Consumer bidding to buy energy from a specific seller
     * This happens after the list of appropriate market cohorts (s
     * @param idAsk the ID of this Ask for energy
     * @param seller the address of the seller
     * @param idOffer  the id of the Offer that we are bidding to
     * @param price the price that we are offering
     */
    function bidToOffer (uint idAsk, address seller, uint idOffer,
        require(buyEnergy_map[msg.sender].length > 0, "no ask from
        require(buyEnergy_map[msg.sender][idAsk].addr == msg.sende
        require(sellEnergy_map[seller].length > 0, "no offer from
        require(sellEnergy_map[seller][idOffer].addr == seller, "o
        require(price <= currentMarket.maxPrice, "price to high");
```

GRIDMIX
energy smart contracts

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IEEE Blockchain Transactive Energy (BCTE) Initiative

Activities Roadmap

IEEE FUTURE DIRECTIONS · IEEE BLOCKCHAIN · IEEE SMARTGRID · IEEE PES Power & Energy Society®

2019

August 2019

- **BCTE** kick-off at IEEE PES 2019 General Meeting, Atlanta (IEEE Smart Grid Society)
- 2019 IEEE PES Blockchain in Energy Workshop

September 2019

- 2019 IEEE NIST Blockchain Summit (**BCTE** presentations)

2020

Feb-March 2020

- **BCTE** IEEE MIT meeting, workshop IEEE Future Direction Board Series presentations
- 2020 IEEE Blockchain Transactive Energy (**BCTE**) Workshop, University of Colorado, Boulder
- 2020 IEEE Innovative Smart Grid Technology (ISGT DC) Blockchain in Energy **BCTE** Regulatory & Policy-making Panel

May 2020

- IEEE Blockchain Future Directions/ Blockchain Initiative **BCTE NIC proposal** approved

August 2020

- 2020 IEEE PES Blockchain in Energy Workshop (**BCTE updates**)
- 2020 IEEE **BCTE-Ethereum** Foundation Hackathon
- 2020 **IEEE BCTE - CIGRE**

Sep-Dec 2020

- IEEE BCTE Architecture Framework, Reference Models

Alignment meetings IEEE SA, IEEE PES,IEEE Smart Grid Society, IEEE Future Directions

IEEE BCTE Position Paper

2021

1Q2021

- **BCTE Industry/Utility Sandbox (pilots)**

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IEEE BCTE Initiatives - 2020

IEEE Blockchain Transactive Energy Initiatives

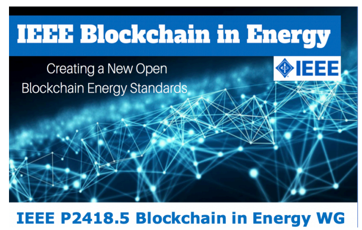
IEEE Future Directions/ Blockchain Initiative

IEEE Blockchain Transactive Energy Project

- Reference Frameworks
- Standards
- P2418.5/TF3
- Use Cases
- Testbeds
- Regulation/Policies Aspects
- Events
- Interoperability Model
- Education
- Terminologies, Definitions, Clarifications
- Interoperability Framework

Launched IEEE PES General Meeting/ EEE Smart Grid (Atlanta, August 2019)

IEEE Standards (SA)



P2418.5/TF3

IEEE Conferences

IEEE PES Blockchain Energy 2019

IEEE NIST Blockchain 2019

IEEE Smart Grid

Webinar

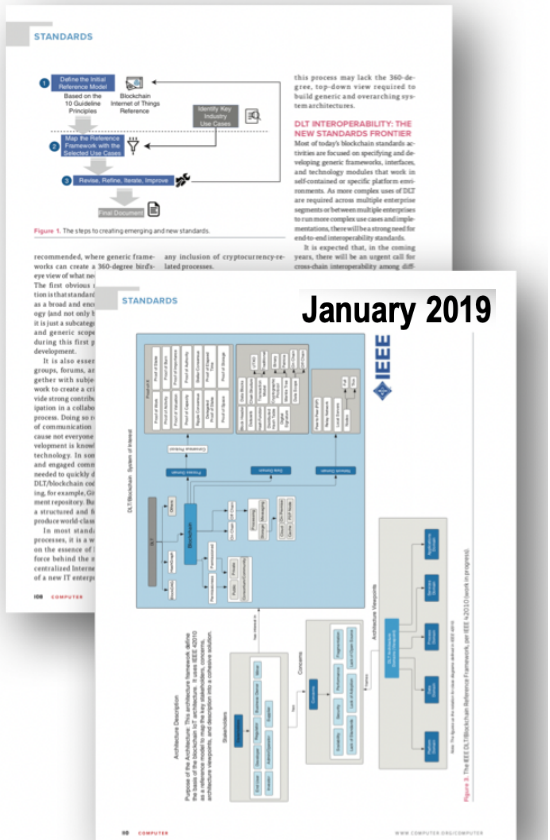
Special Project

Key Takeaways

- ✓ The **IEEE P2418.5 Blockchain in Energy standards** is defining new blockchain in energy concepts, definitions, and frameworks for the energy industry.

- ✓ **The IEEE Blockchain Transactive Energy (BCTE)** is a 3-years new NIC proposal Initiative sponsored by the IEEE Future Directions to develop and promote framework, use cases, applications, standards, regulatory sandbox, education/events in blockchain transactive energy.

References



January 2019

STANDARDS

Developing Open and Interoperable DLT/Blockchain Standards

Claudio Lima, Blockchain Engineering Council; IEEE Blockchain Standards Working Group

How will these standards drive global blockchain adoption and take development of the technology ecosystem to the next level?

FROM THE EDITOR

The field of blockchain or distributed ledger is growing rapidly. The lack of consensus on definitions, implementation, management, and core attributes is driving the need for standardization. Blockchain is often confused with cryptocurrencies like Bitcoin or Ethereum, but the potential applications of this technology in diverse fields, such as smart contracts, buying and selling energy, and so much more, make distributed ledger technologies one of the high-potential technologies for the future. —F.D. Wright

A common set of distributed ledger technology (DLT) or blockchain standards and a focus on interoperability and scalability are among several industry requirements that are essential for the survival and mass adoption of this technology. This column describes standardization efforts in the field.

Recent studies have shown that, by 2025, blockchain applications will represent 10% of global gross domestic product.[1] Blockchain is defined as the new Internet layer of value, adding the so-called trinity of Ts[2]—trustability, transparency, and traceability—to any asset-class web transaction (information/data and physical goods) that can be authenticated, validated, traced, and registered in a distributed, peer-to-peer digital ledger system.

These unique characteristics open new possibilities for services and applications, boosting today's Internet capability. Blockchain is also part of the broader scope of DLT and is

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References

CUTTER Business Technology Journal

Management, Innovation, Transformation

Vol. 32, No. 11 2019 ● REPRINT

"Many use cases can be considered for blockchain in the energy sector, but most still do not have a sufficiently strong business proposition to be considered practical."

Blockchain in Energy and Utilities: Definitions, Use Cases, Standards, and Frameworks

by Claudio Lima

Claudio Lima explains how blockchain technology can be used to digitize and foster growth in the energy sector. Distributed ledger technology (DLT) has the potential to optimize energy management processes and to deal with the growing complexity in the decentralized energy system. Lima introduces the IEEE P2418.5 Standard for Blockchain in Energy, which creates an industry framework that will help with interoperability among different blockchain use cases and technologies. A DLT layer complements existing smart grid architectures, improves grid security and efficiency, and reduces the costs of utility operation.

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IEEE P2418.5 BLOCKCHAIN IN ENERGY PANEL

2021 IEEE PES GENERAL MEETING

IEEE PES Power & Energy Society®

2021 IEEE PES General Meeting | 25-29 July 2021

Managing Energy Business During a Pandemic

IEEE

IEEE PES GM 2021 Blockchain in Energy
Virtual Workshop
Wednesday, July 28, 2021

Description

This workshop will give an overview of the key technologies, use cases, initiatives, recent advances, task forces and standards being developed by the IEEE, industry, academia, and policy makers to advance the emerging field of Blockchain in Energy, focused on electric power and power grid modernization. Workshop topics include, among others, blockchain-based transactive energy systems, utility blockchain applications, interoperability, blockchain for enhanced cybersecurity, field implementations: industrial, markets and policy practices.

The workshop is open to all IEEE PES conference registered attendees.

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About the Speaker

BLOCKCHAIN ENGINEERING COUNCIL
Energy & Smart Grid

Claudio Lima, Ph.D.

- *Executive and thought leader in advanced blockchain, IoT, and a AI technologies*
- *Expertise in energy (utilities, oil & gas), smart city, and telecom/IT digital transformation*
- *Distinguished Member of Technical Staff at Sprint Advanced Technology Labs, Silicon Valley, California.*
- *Co-founder of the Blockchain Engineering Council (BEC)*
- *Vice-Chair IEEE 2030 Comms Architecture*
- *Chair of the IEEE Blockchain Transactive Energy (BCTE) Initiative*
- *Chair of the IEEE Blockchain Standards*
  - *Chair IEEE P2418.5 Blockchain Energy WG*
  - *Vice Chair IEEE P2418.1 Blockchain IoT WG*
- *Member ISO DLT for Power Standards*
- *PhD in Electronic Engineering, University of Kent (UK) (1995).*

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