LEVERAGING DISTRIBUTED ENERGY RESOURCE CAPABILITIES THROUGH TRANSACTIVE ENERGY

NARUC CENTER FOR PARTNERSHIPS & INNOVATION WEBINAR SERIES

APRIL 21, 2022

ABOUT NARUC

- The National Association of Regulatory Utility Commissioners (NARUC) is a non-profit organization founded in 1889.
- Our Members are the state utility regulatory Commissioners in all 50 states & the territories. FERC & FCC Commissioners are also members. NARUC has Associate Members in over 20 other countries.
- NARUC member agencies regulate electricity, natural gas, telecommunications, and water utilities.

NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS
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ABOUT NARUC'S CENTER FOR PARTNERSHIPS & INNOVATION

- Grant-funded team dedicated to providing technical assistance to members.
- CPI identifies emerging challenges and connects state commissions with expertise and strategies to inform their decision making.
- CPI builds relationships, develops resources, and delivers trainings.

Regularly updated CPI fact sheet with recent publications & upcoming events under Quick Links at:

https://www.naruc.org/cpi-1/

NARUC Center for Partnerships & Innovation

Current Activities

Recently Released Publications

- Public Utility Commission Stakeholder Engagement: A Decision-Making Framework (Jan. 2021)
- Private, State, and Federal Funding and Financing Options to Enable Resilient, Affordable, and Clean Microgrids (Jan. 2021)
- User Objectives and Design Options for Microgrids to Deliver Reliability and Resilience, Clean Energy, Energy Savings, and Other Priorities (Jan. 2021)
- Understanding Cybersecurity for the Smart Grid: Questions for Utilities (Dec. 2020)
- Artificial Intelligence for Natural Gas Utilities: A Primer (Oct. 2020)
- Cybersecurity Tabletop Exercise Guide (Oct. 2020)

Forthcoming Resources

- NARUC-NASEO Task Force on Comprehensive Electricity Planning Blueprint for State Action and related resources
- A Guide for Public Utility Commissions: Recruiting and Retaining a Cybersecurity Workforce
- Cybersecurity Partnerships and Information Sharing
- Approaches to Economic Development in Decision-Making for Public Utility Commissions
- Regulators' Financial Toolbox on Advanced Metering Infrastructure

Recent Events

- Integrated Distribution Systems Planning: NARUC partnered with DOE national laboratories to deliver a virtual training in Oct. 2020 on forecasting, control and automation, metrics, resilience, PUC practices, and more. The next session will be held for Western state officials beginning Feb. 26, 2021. *Contact Dominic*
- NARUC-NASEO Task Force on Comprehensive Electricity Planning. Resources developed by the Task Force will be shared in a virtual workshop on Feb. 11, 2021. Read the Task Force fact sheet. *Contact Danielle*
- National Council on Electricity Policy (NCEP). Presentations from NCEP's December 2020 Annual Meeting are available as well as an updated Transmission and Distribution Resource Catalog. *Contact Kerry*
- Carbon Capture, Utilization and Storage Workshop Webinar Series. Recordings are available from a Western Interstate Energy Board- and NARUC-hosted six-part webinar series in Sept. and Oct. 2020. *Contact Kiera*

Available Virtual Learning Opportunities

- Cybersecurity Training for State Regulatory Commissions: NARUC is hosting a virtual cybersecurity training on Feb. 23-25, 2021. *Contact Ashton*
- National Council on Electricity Policy (NCEP). Register for a special session on Exploring Optimization through Benefit-Cost Analysis on Feb. 25, 2021. Learn More about NCEP. *Contact Kerry*
- Emergency Preparedness, Recovery and Resilience Task Force: The EPRR Task Force will meet Feb. 5, 2021 to discuss BRIC funding with FEMA. *Contact Will*
- Commission Staff Surge Calls. NARUC hosts quarterly calls on which commission staff discuss how different states approach emerging issues in electricity policy. The next call will be held in early **Mar., 2021**. Summaries from past calls are available. *Contact Kiera*
- Innovation Webinar Series. NARUC hosts monthly webinars for members and the public. ***Mar. 11:*** Data for the Public Interest: Empowering Energy Equity. ***Apr. 15:*** Initiative on Cybersecurity in Solar Projects. ***May. 13:*** Staffing the Evolving PUC Workforce. Register and find recordings of past events. *Contact Dominic*

Join us! NARUC hosts four working groups for members:

- Performance-Based Regulation. *Contact Kerry*
- Electric Vehicles. *Contact Jasmine*
- Microgrids. *Contact Kiera*
- Grid-Interactive Efficient Buildings. *Contact Danielle*

www.naruc.org/cpi

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MARIA KRETZING, BIDGELY INC.

JOSEPH VELLONE, EV.ENERGY

Pacific Northwest
NATIONAL LABORATORY

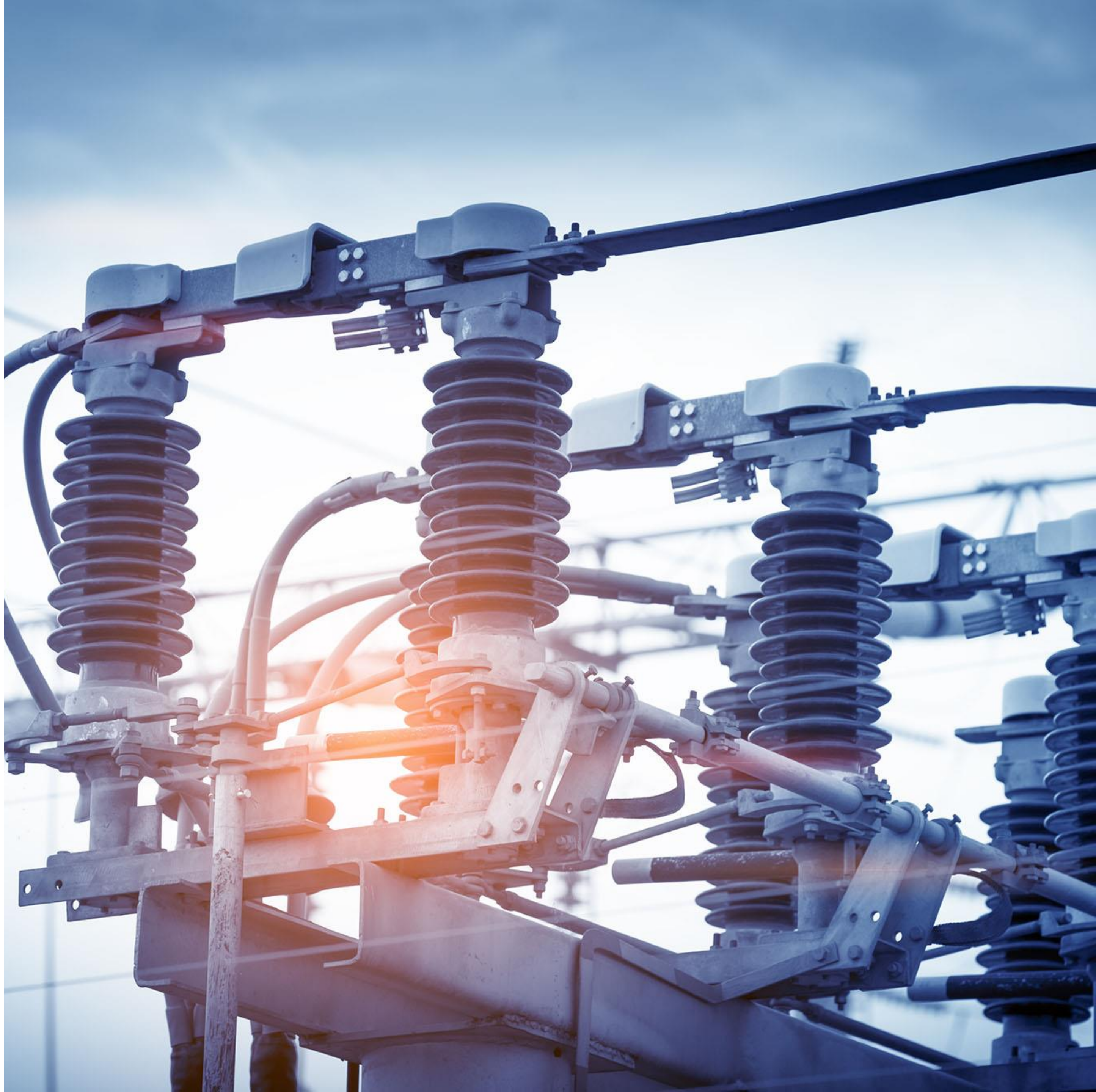
Transactive Overview: The DSO+T Study

April 21, 2022

Hayden Reeve
Senior Technical Advisor

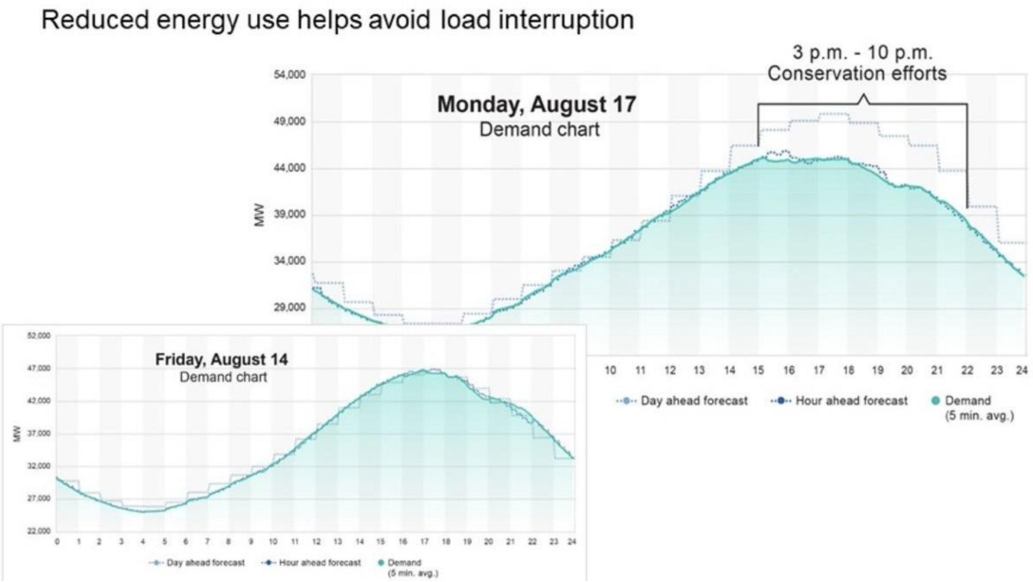
PNNL-SA-172084

U.S. DEPARTMENT OF ENERGY BATTELLE



Why Coordinate Distributed Energy Resources?

- Extreme events, electrification, and intermittent generation are challenging the centralized, 'supply-side' focused operation of the grid
- Coordination of flexible distribution assets can avoid systems hitting generation and delivery constraints that result in excessive prices or, worst still, blackouts.
- Need to integrate demand flexibility into everyday grid operation, ensure it is automated, put the customer in control of their participation, and fairly compensate them.

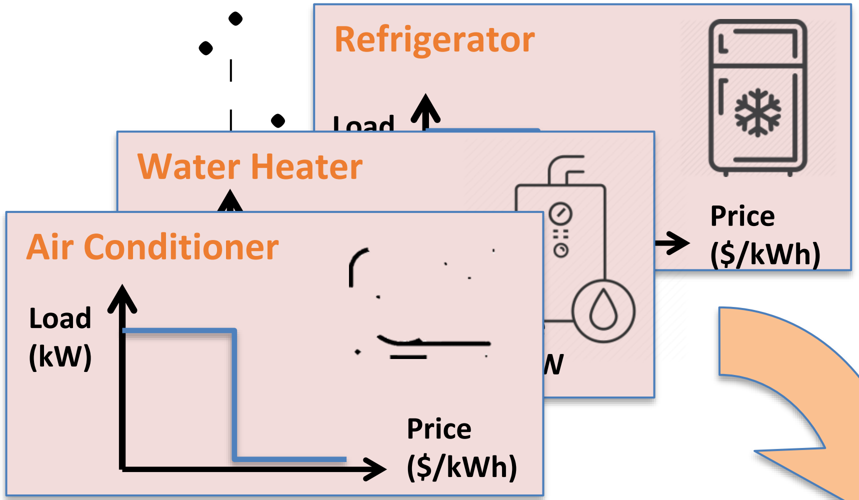


Demand flexibility helped avoid additional California blackouts

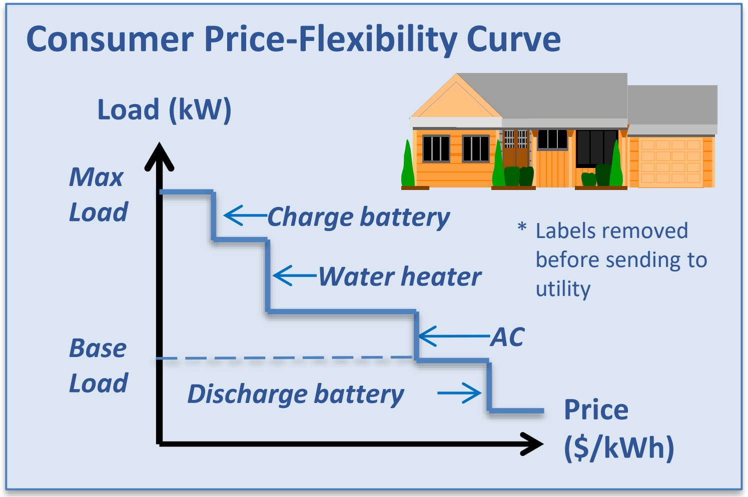
Pacific Northwest NATIONAL LABORATORY

Transactive Energy Interaction Overview

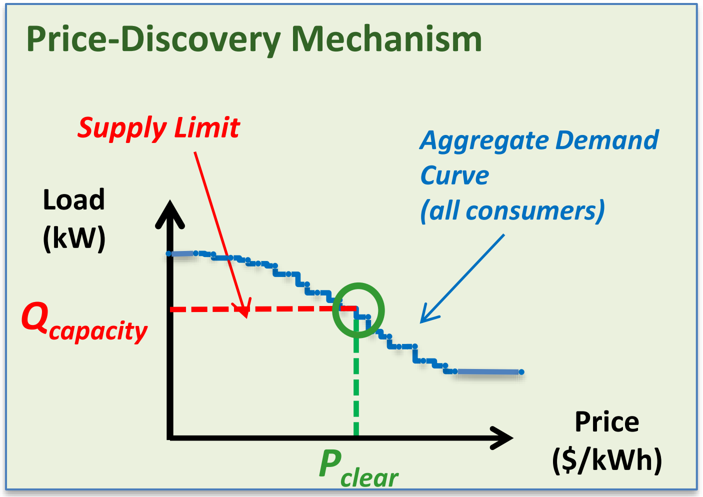
1. Automated, price-responsive device controls express consumer's flexibility (based on current needs)



2. Consumer system aggregates responses to form overall price flexibility curve



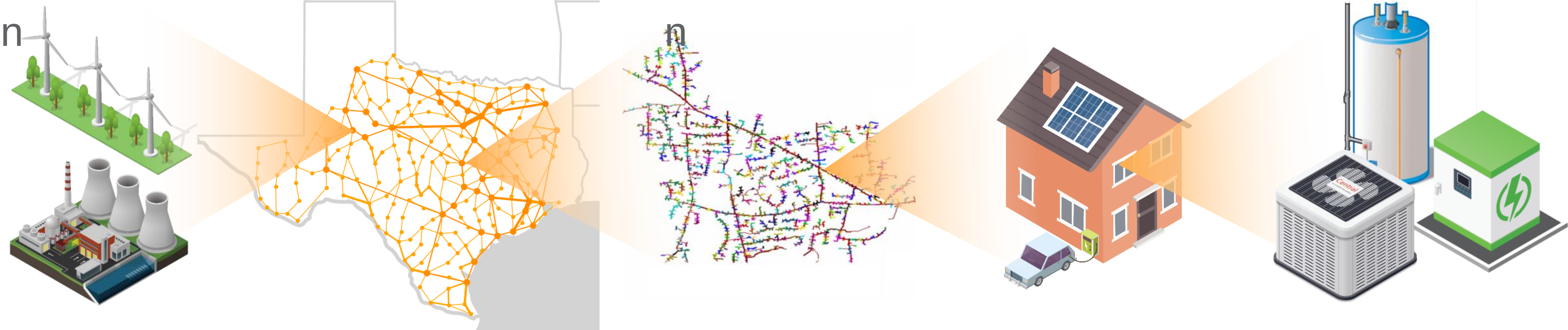
3. Service provider aggregates curves from all consumers



4. Aggregator determines price at which grid objective achieved, broadcasts to consumers

DSO+T Study Overview

Generation Transmission Distribution Customers Assets



Integrated System Model

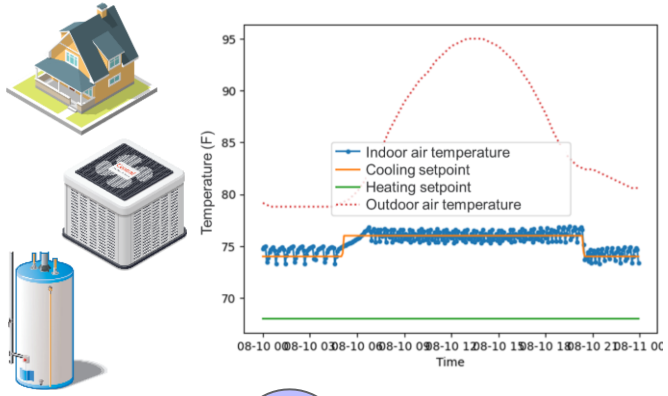
Transactive Coordination Framework

Valuation Methodology and Economic Performance

Pacific Northwest
NATIONAL LABORATORY

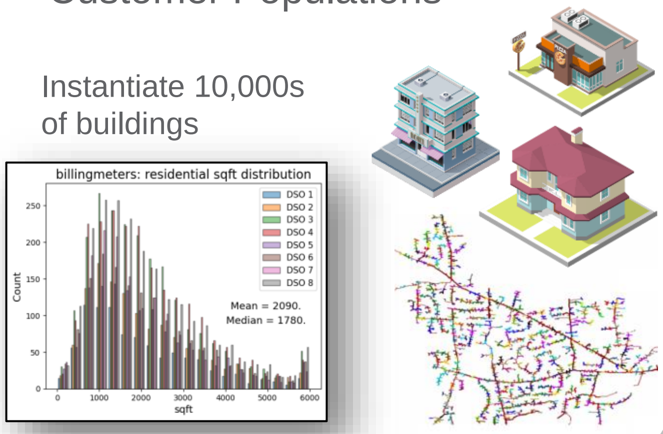
Summary of the Integrated Model

Individual Building Models

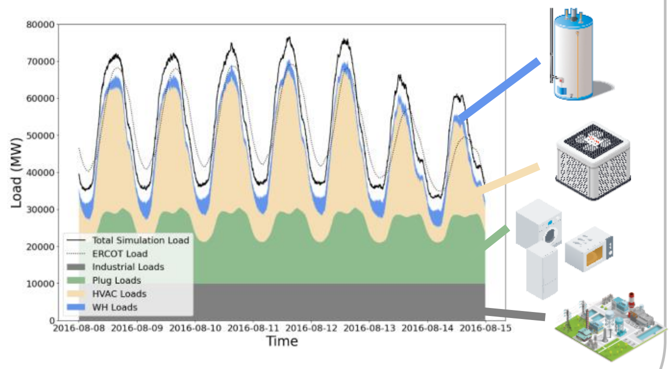


Customer Populations

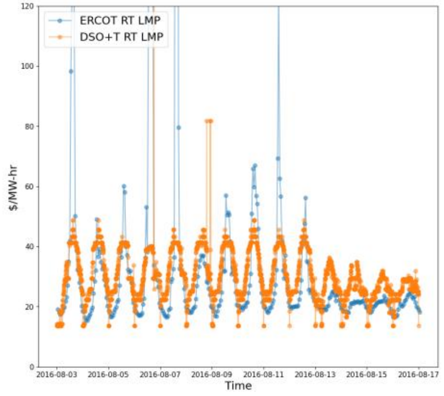
Instantiate 10,000s of buildings

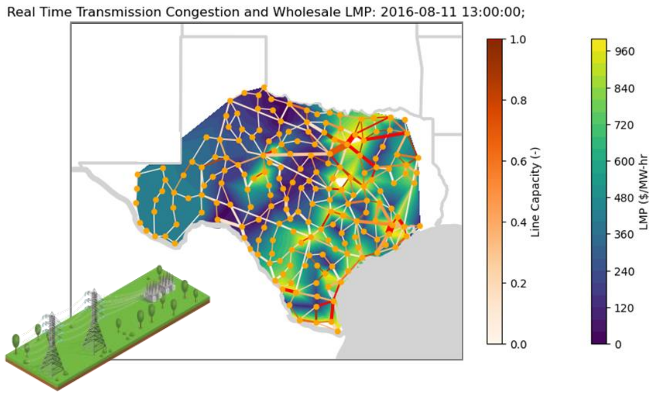


System Demand

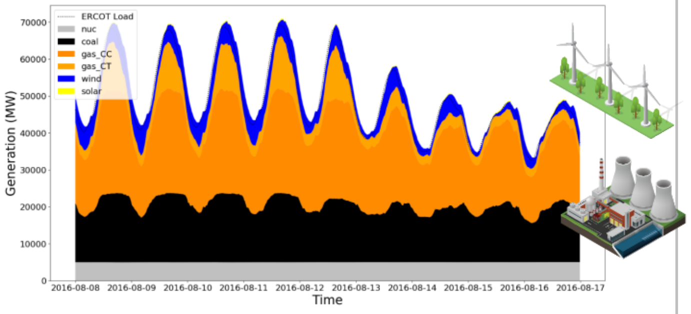


Wholesale Prices

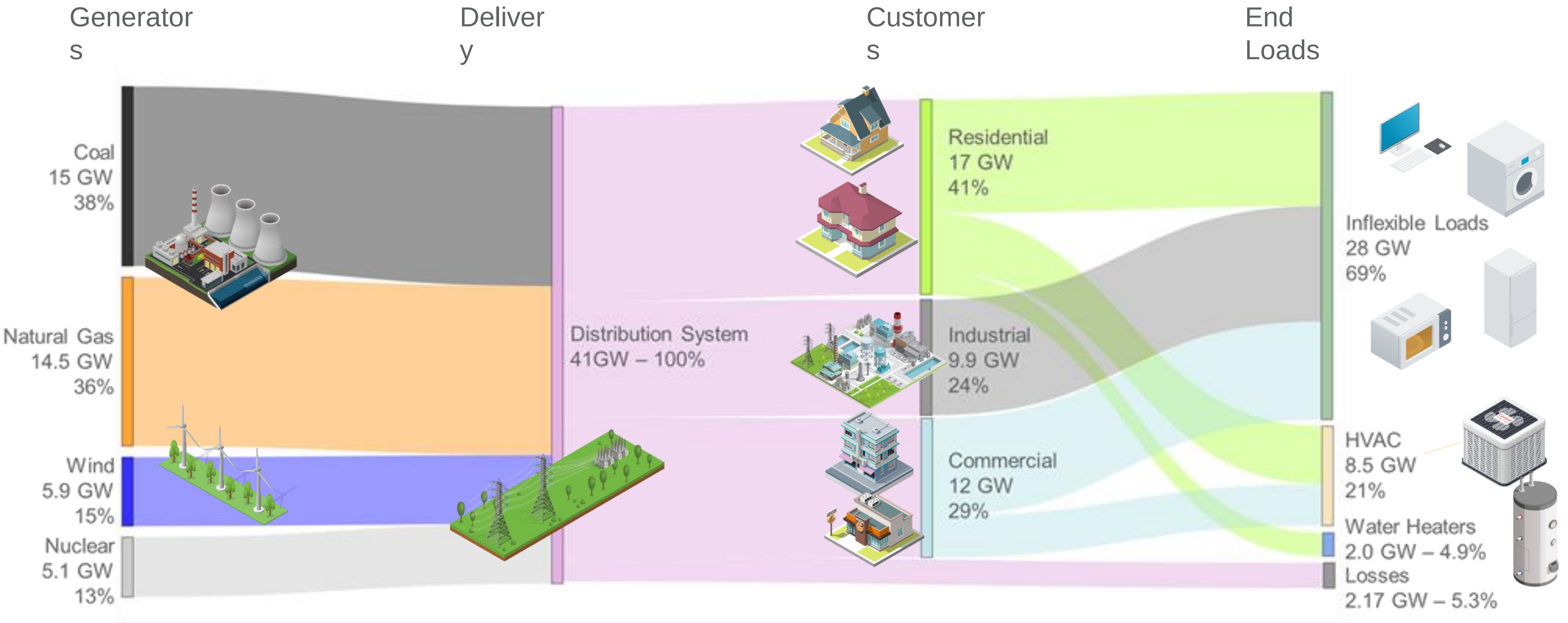




Generation Dispatch

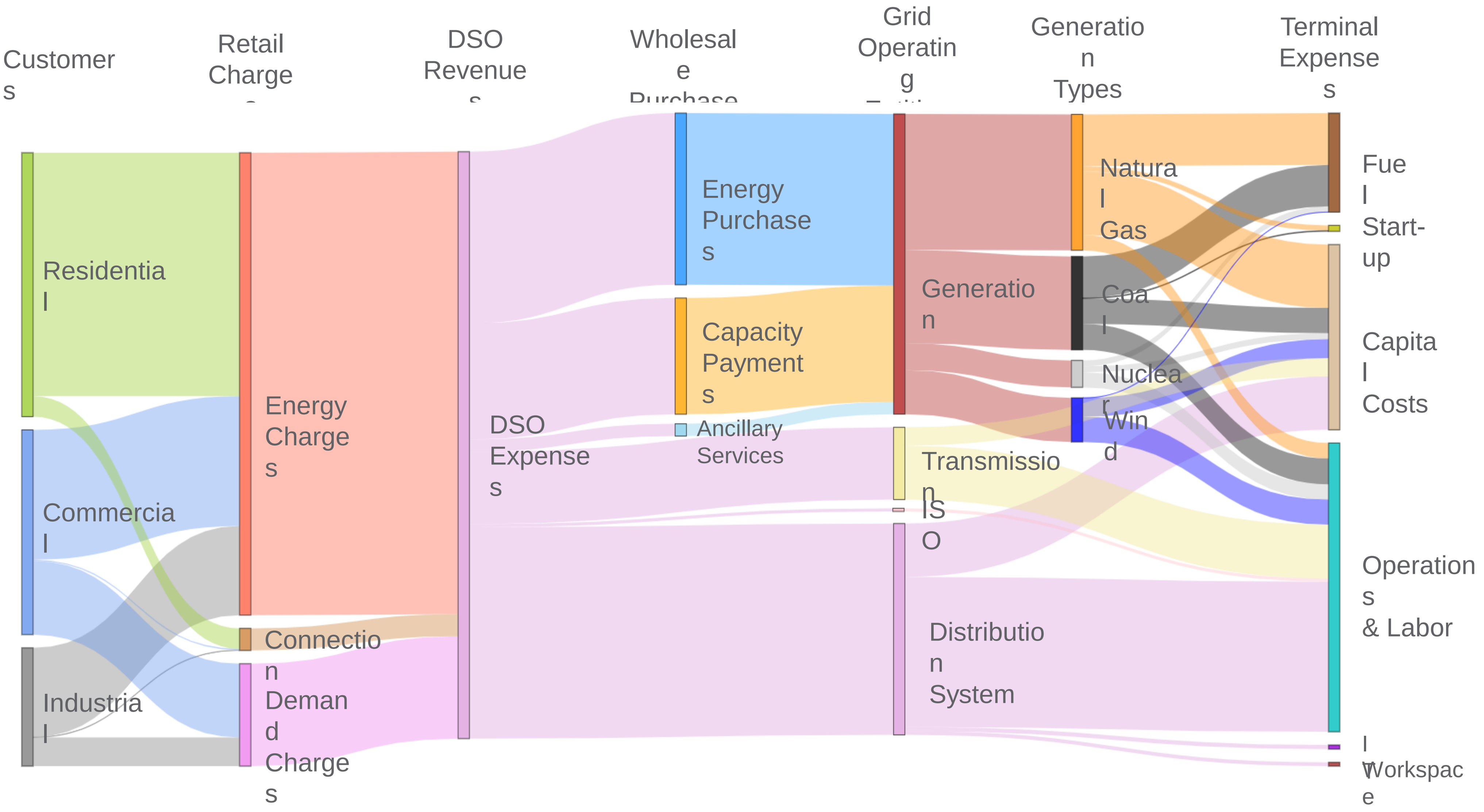


Integrated Model – Moderate Renewable Scenario

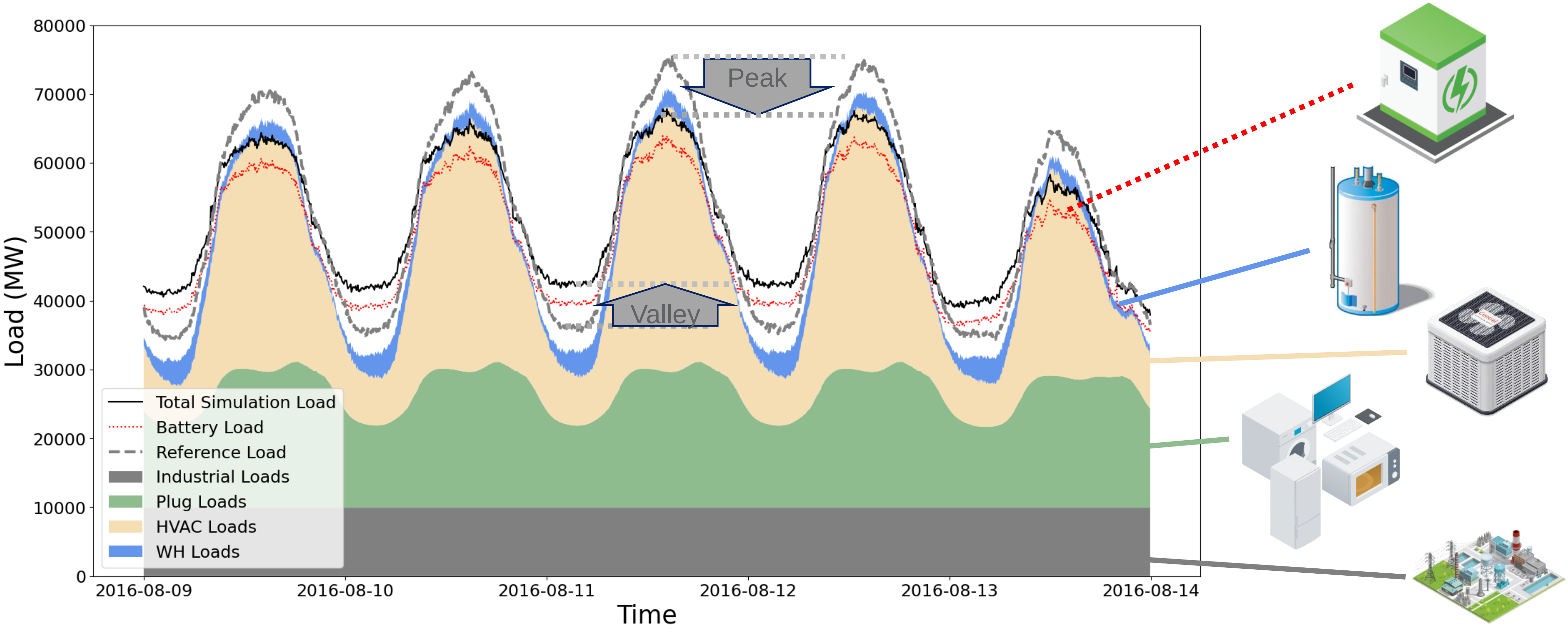


Parametric, high-fidelity integrated grid model captures system wide loads

Mapping of Cash Flow through Grid Ecosystem



Engineering Performance and Peak Reduction



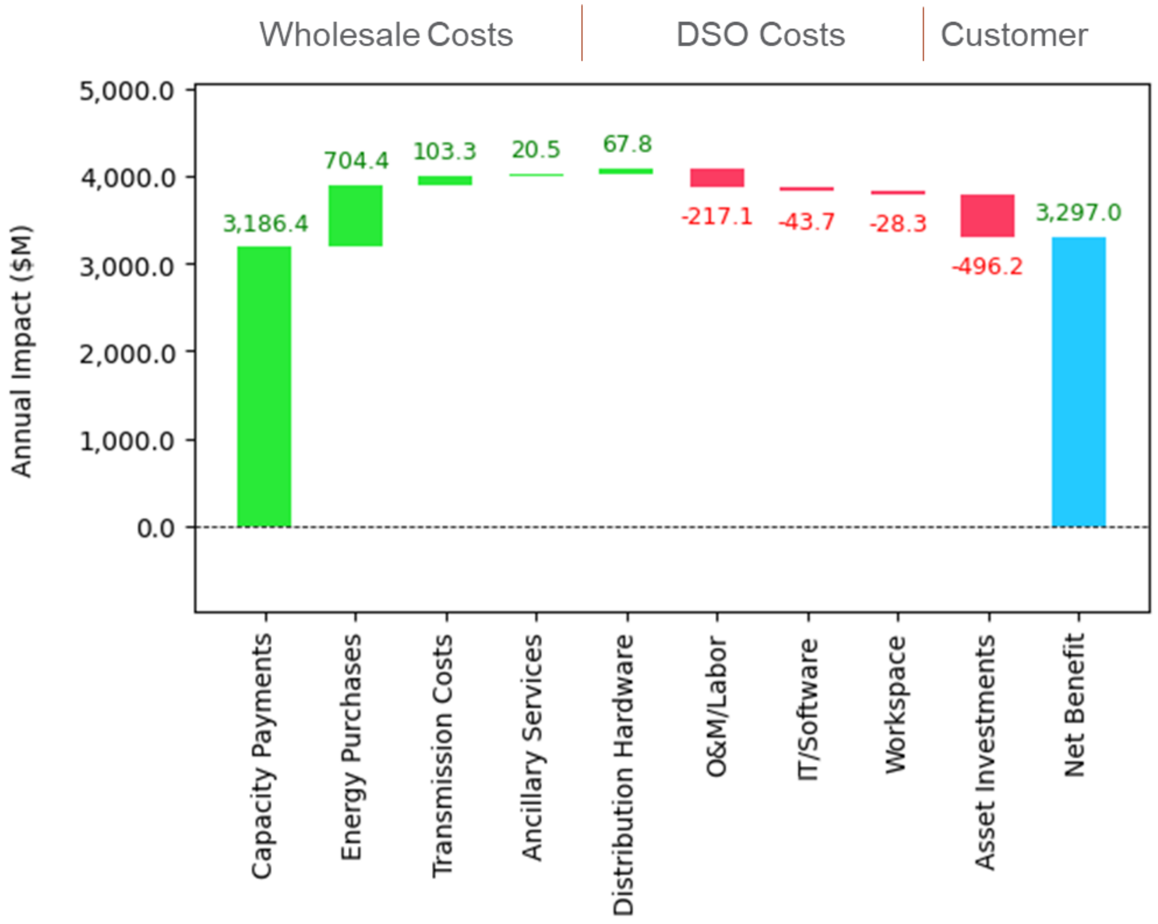
Example battery DER scenario illustrating ~10% reduction in peak load

Overall Economic Performance

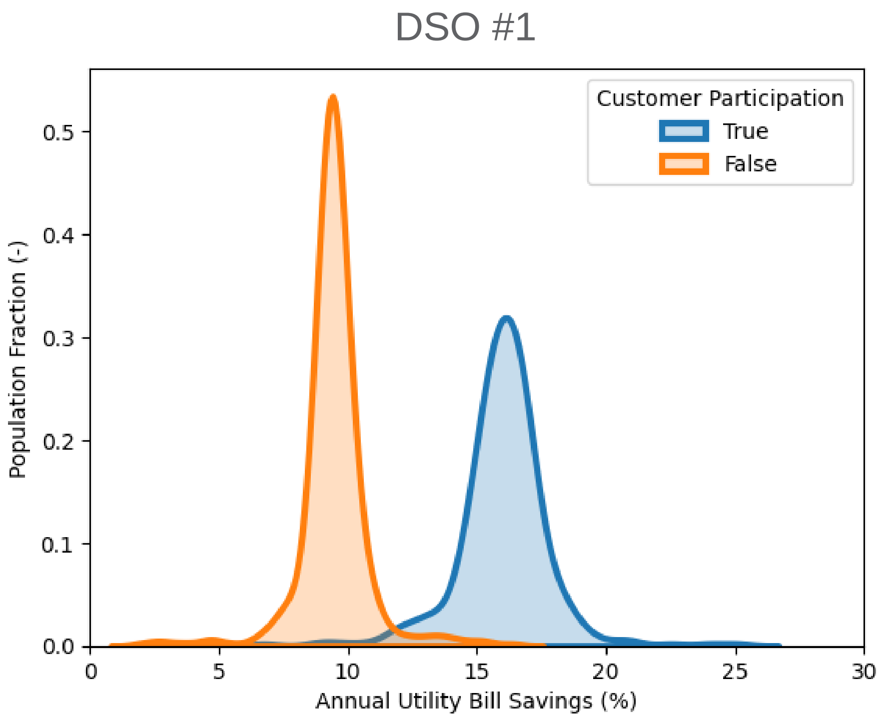
- Allows benefits and costs of implementation to be broken out by stakeholder

- Overall value proposition is highly sensitive to volatile capacity market

- Likely under-estimating value of energy market savings due to under-prediction of extreme pricing



Customer savings Participation: MR Batt Case



Participants save more than non-participants
Non-participants still benefit from the lower cost basis of the DSO

Summary

- Physics-based load and market models enable freedom to do parametric investigations and have been shown to be representative of ERCOT system
- Tight integration with economic cost models ensures impacts on stakeholder finances and customer rates is understood
- Reinforces the engineering feasibility and broad economic benefits of transactive energy
- Study website: https://www.pnnl.gov/projects/transactive-systems-program/dsot-study

BLOCKCHAIN ENGINEERING COUNCIL

Claudio Lima, Ph.D.
Chair IEEE Blockchain Transactive Energy Initiative

NARUC INNOVATION WEBINAR

Transactive Energy

with Blockchain DLT

IEEE BLOCKCHAIN

IEEE FUTURE DIRECTIONS

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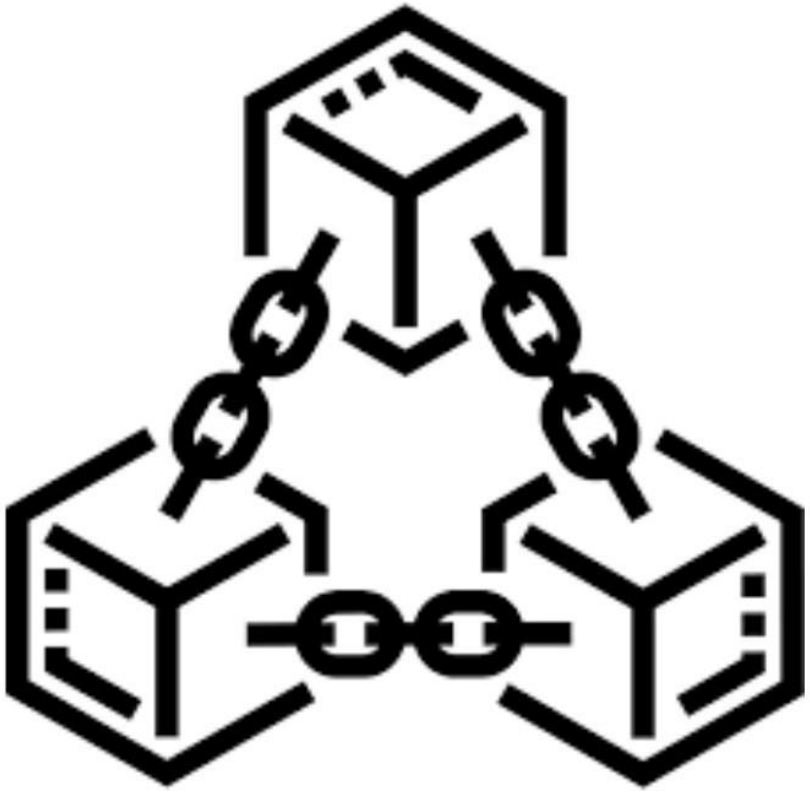
April 21st, 2022

What is Blockchain?



**DLT- Distributed Ledger Technology*

The simple definition of Blockchain:

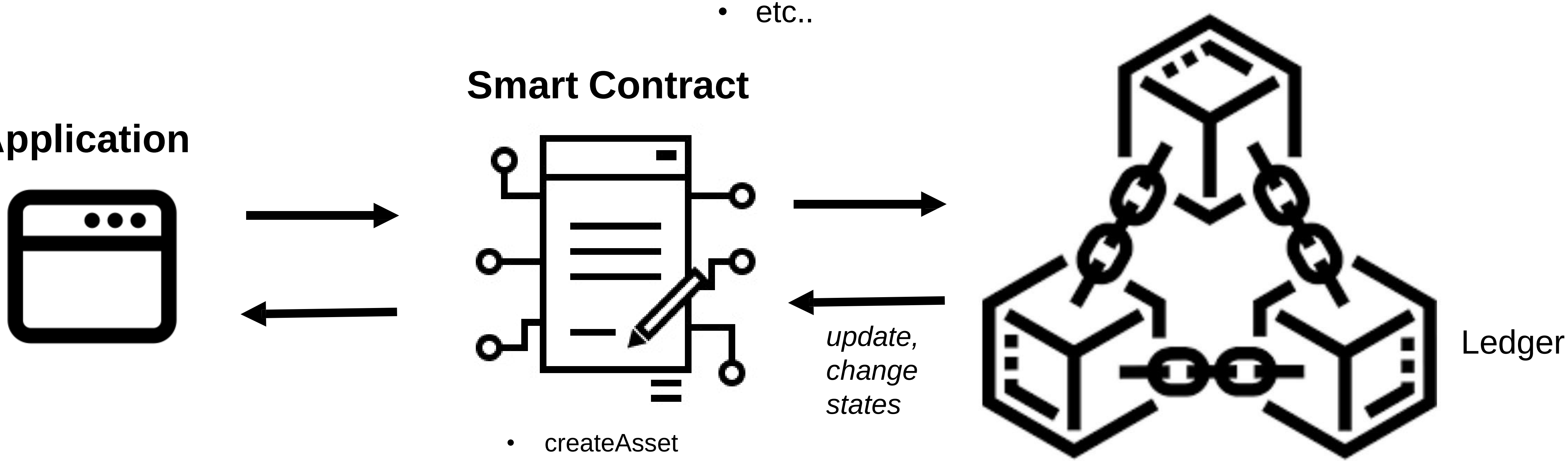
- "A time-stamped series of cryptographic data records (ledgers) that is managed by distributed computers."
- Blockchain ledgers are immutable, transparent, and traceable.
- Each blocks of data is secured and bound to each other in a chain using cryptography hashes.

Smart Contract Definition

Smart Contract is a computer logics that automates and executes ”what..if” conditions.

- update transactions
- order transaction proposal
- notify ledge update
- run query
- return query results
- etc..

Blockchain



- createAsset
- querryAsset
- querryAssetProperties
- updateAsset

Why Smart Contract is Important for the Energy Industry?

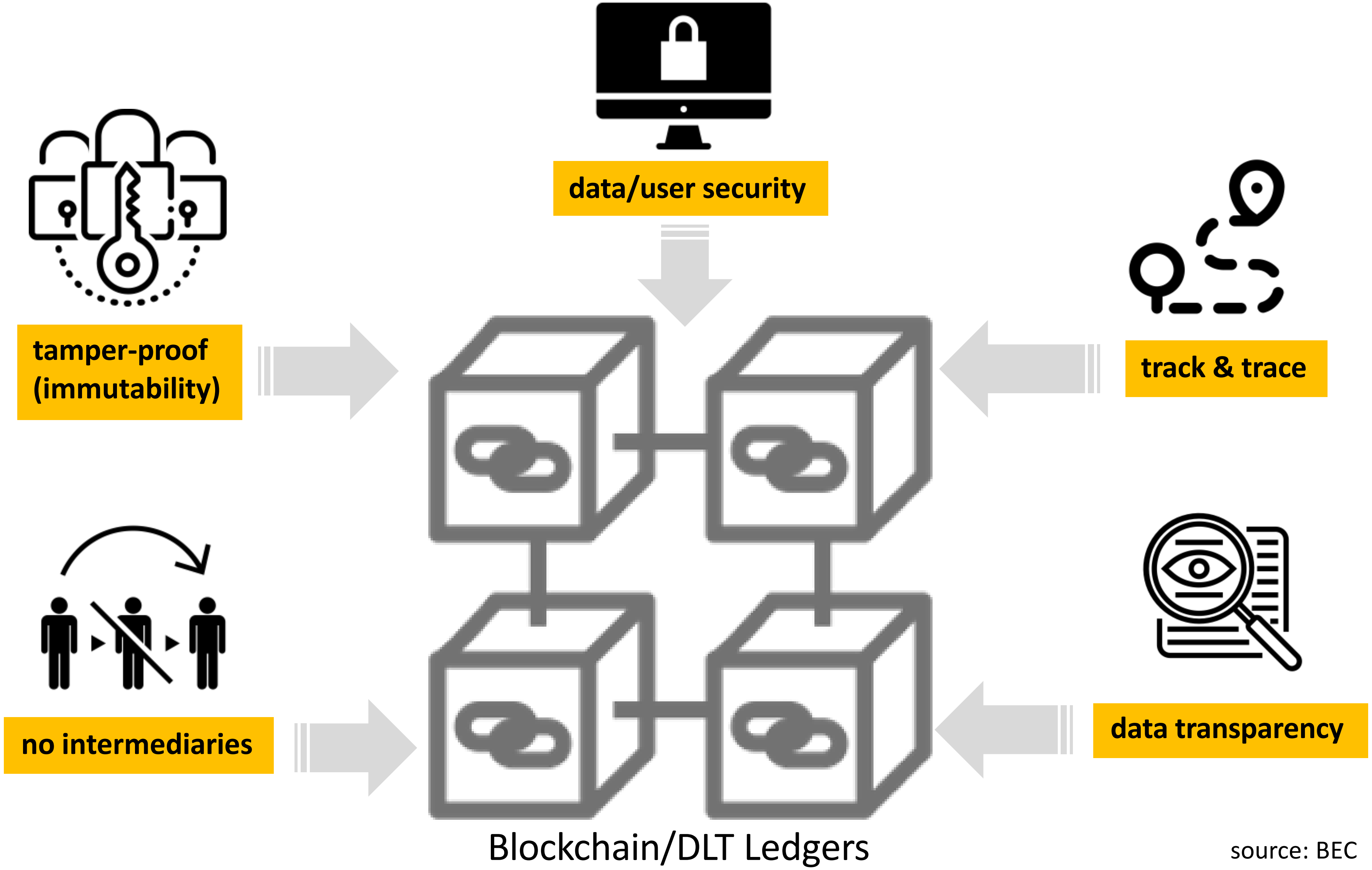
Energy trading and transactions – reconciliation, settlements, etc.

Automate grid processes and operations workflows

Track and trace grid assets, processes and personnel

Blockchain Distributed Ledger Technology (DLT)

Data Properties & Benefits



source: BEC

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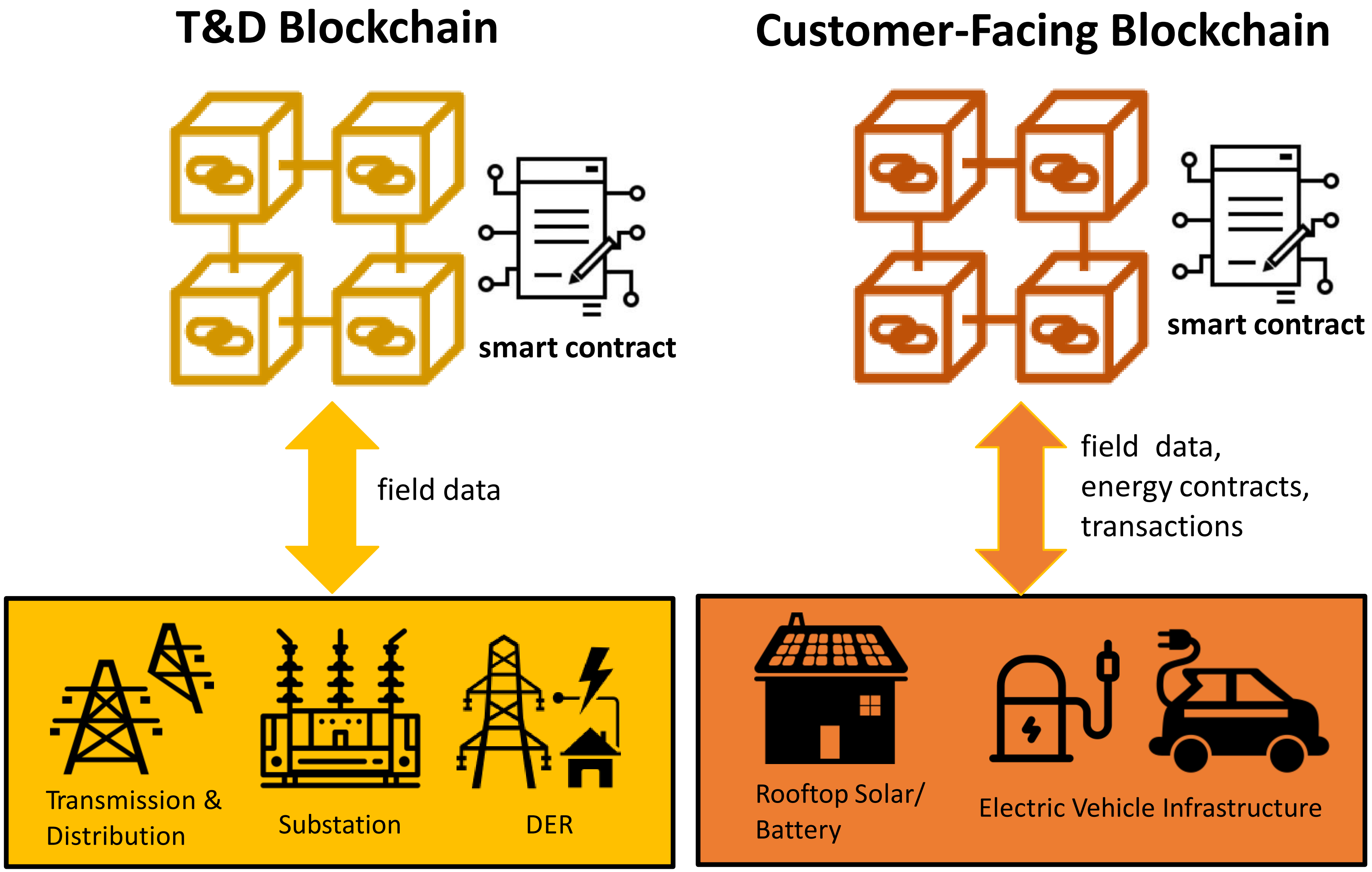
Blockchain in Energy

Grid Applications



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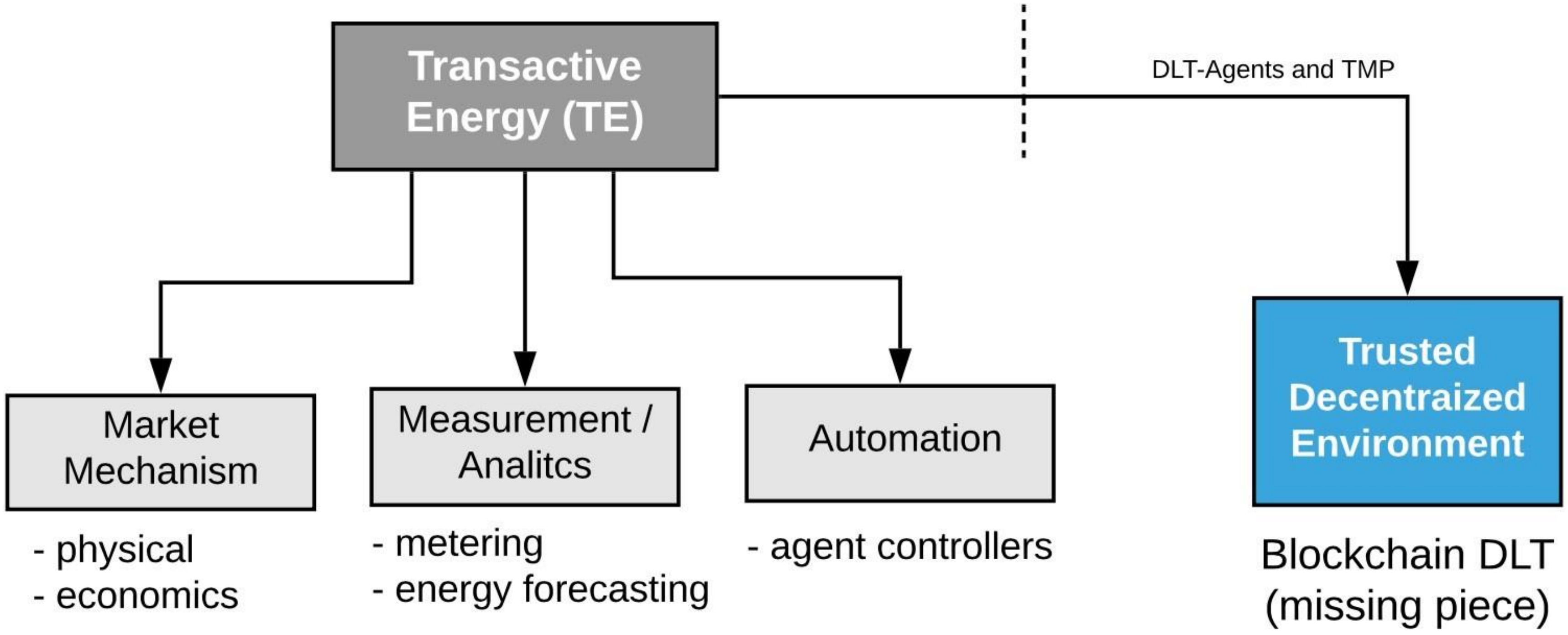
Blockchain in Transactive Energy

The Missing Component



DLT-TES is built upon existing TE system, adding another layer of trustability, traceability and transparency

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

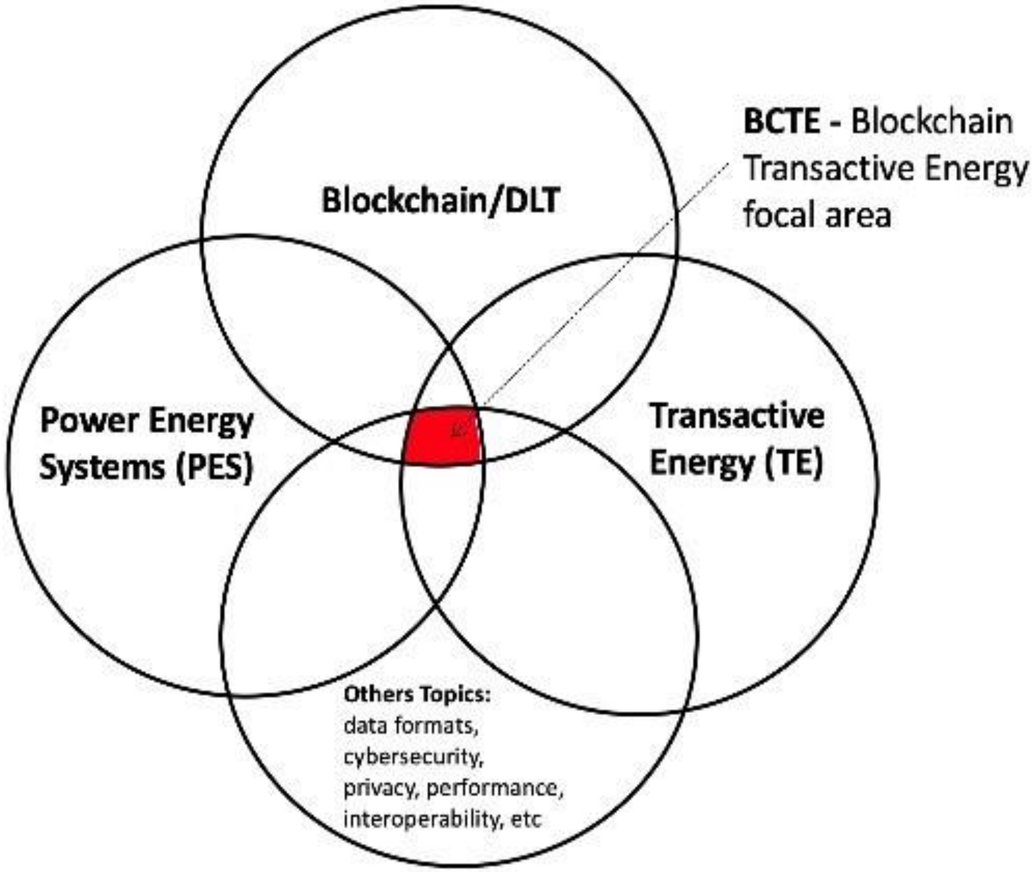
Blockchain Transactive Energy Definition

BCTE is an IEEE framework used for the design, and implementation of **Distributed Ledger Technology (DLT)/Blockchain in Transactive Energy systems**.

It is composed of a modular architecture that interfaces with existing distribution energy systems and intersects with other existing technologies components.

Areas of standardization

- Data formats
- Consensus algorithms
- Governance models
- Cybersecurity
- Smart contracts framework
- Interoperability



IEEE BCTE Blockchain Transactive Energy

BLOCKCHAIN ENGINEERING COUNCIL

IEEE Blockchain Transactive Energy (BCTE) Initiative

IEEE BCTE
Blockchain Transactive Energy

IEEE-CIGRE 2020, 2021, 2022
IEEE PES 2019, 2020,2021
IEEE ISGT 2019, 2020, 2022
IEEE-Ethereum Hackathon
IEEE Blockchain Energy Workshop, 2022

2020
IEEE BCTE Position Paper

2021-2022
BCTE Architecture Framework

2022
BCTE Events, Standards, etc.

IEEE P2418.5 standards

BCTE Field Demonstration

13x U$10K Global Awards for BCTE demonstration in 2022

utilities, ISOs, service-providers, start-ups, etc.

participating partners

IEEE FUTURE DIRECTIONS

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IEEE Blockchain in Energy Standards, P2418.5

IEEE SA
STANDARDS ASSOCIATION

IEEE BLOCKCHAIN IN ENERGY WG STANDARDS P2418.5

Claudio Lima, Ph.D.

IEEE P2418.5 Blockchain Energy WG Standards, Chair

Blockchain Engineering Council, BEC, Co-Founder

IEEE

IEEE P2418.5, D 1.9, AUG19th, 2020
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Approved <Date Approved>

IEEE-SA Standards Board

IEEE SA
STANDARDS ASSOCIATION

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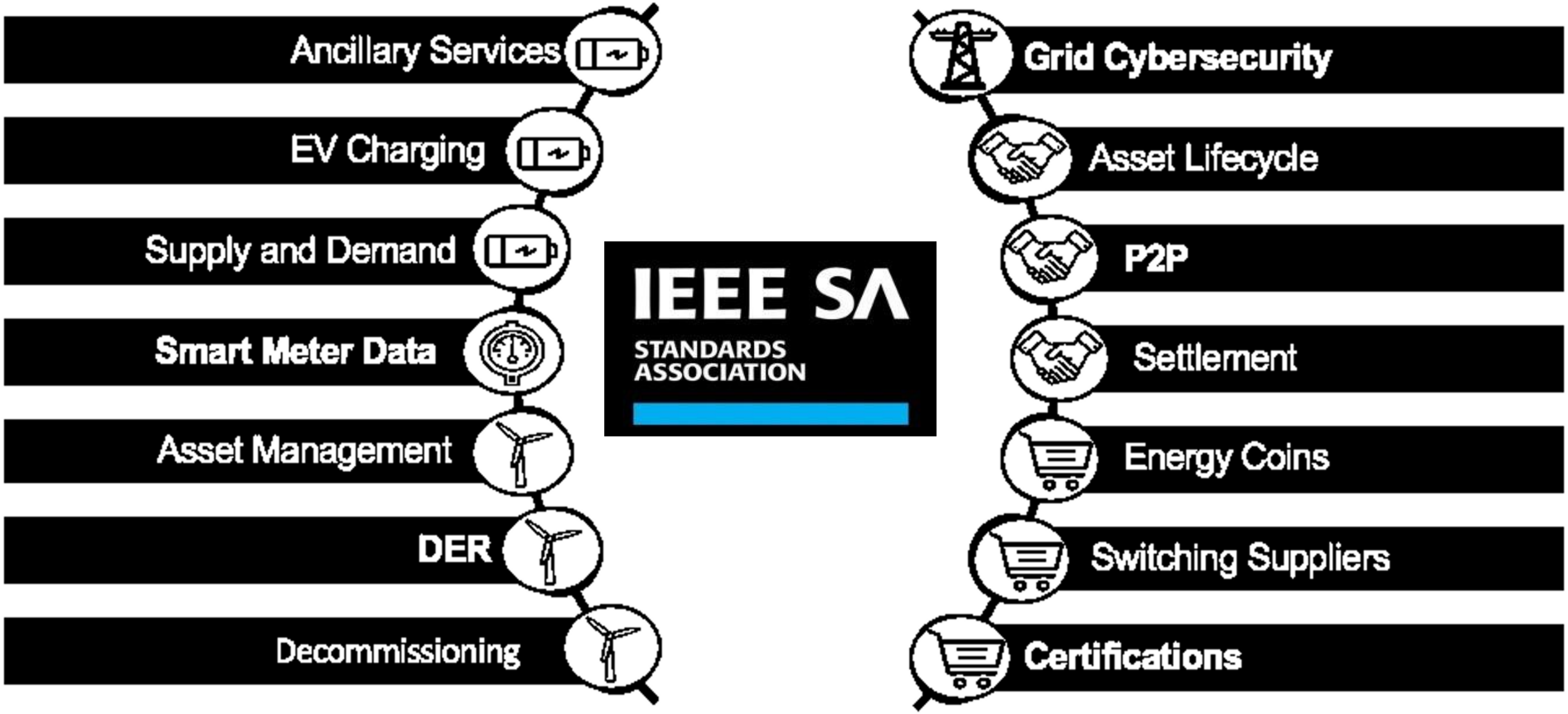
IEEE P2418.5 DLT for Energy Use Cases



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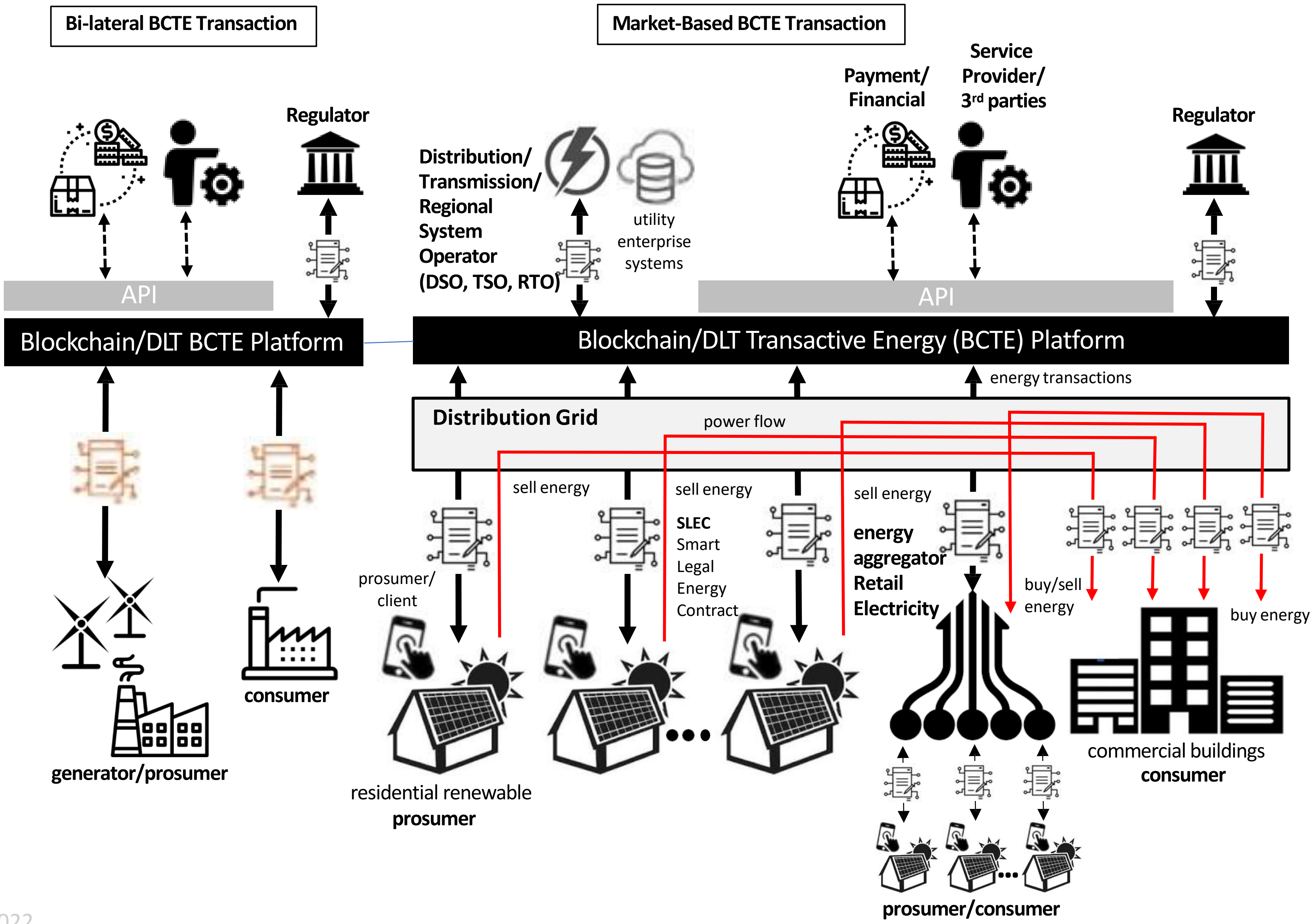
High Level Blockchain Transactive Energy Framework



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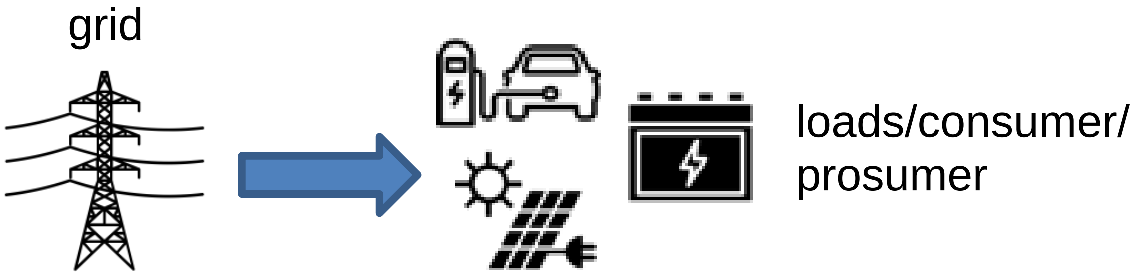
Tiers of Transactive Energy Blockchain/DLT Governance

+

market regulation

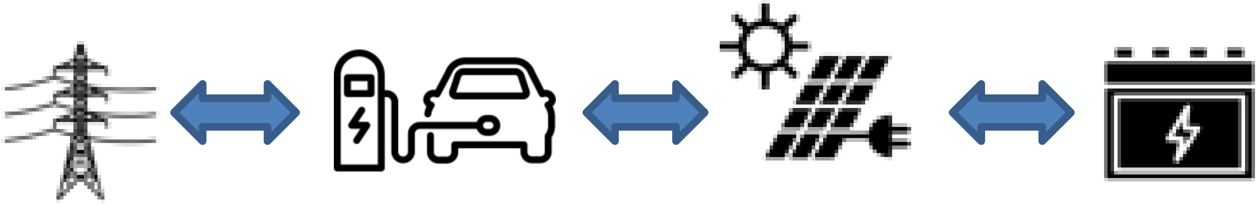
-

Tier 1: utility governs/owns



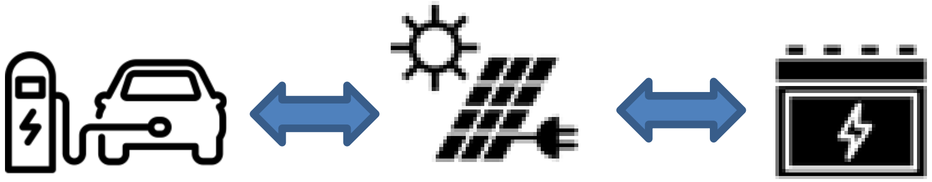
utility grid **governs and owns** the blockchain DLT platform/consortium

Tier 2: utility is a participant



utility grid **participates** in the blockchain DLT platform/ consortium

Tier 3: peer-driven



peers **govern & participate** in the blockchain DLT platform/ consortium

Utilities can benefit from implementing Blockchain/DLT in tiers 1 and 2

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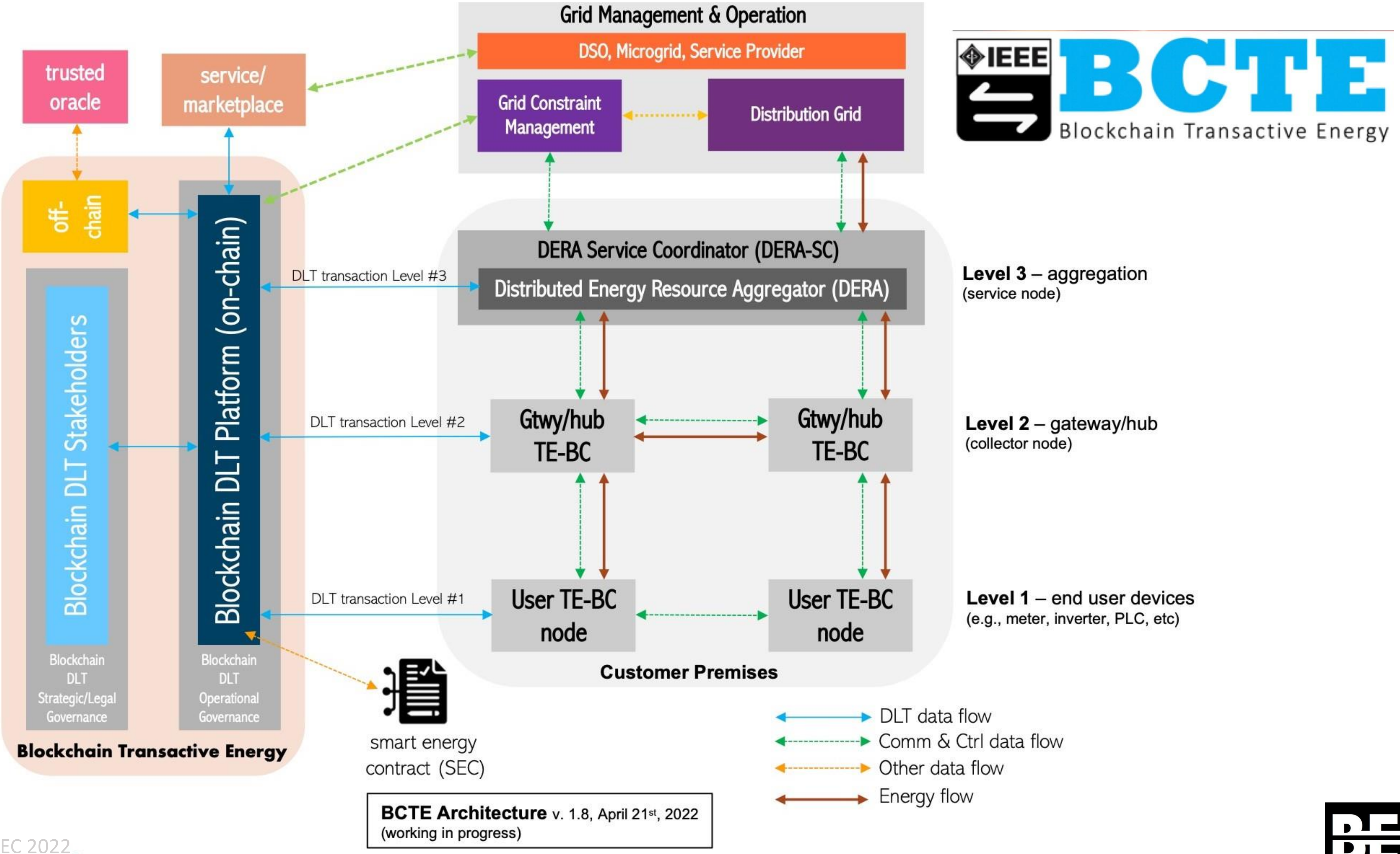
IEEE Blockchain Transactive Energy Framework



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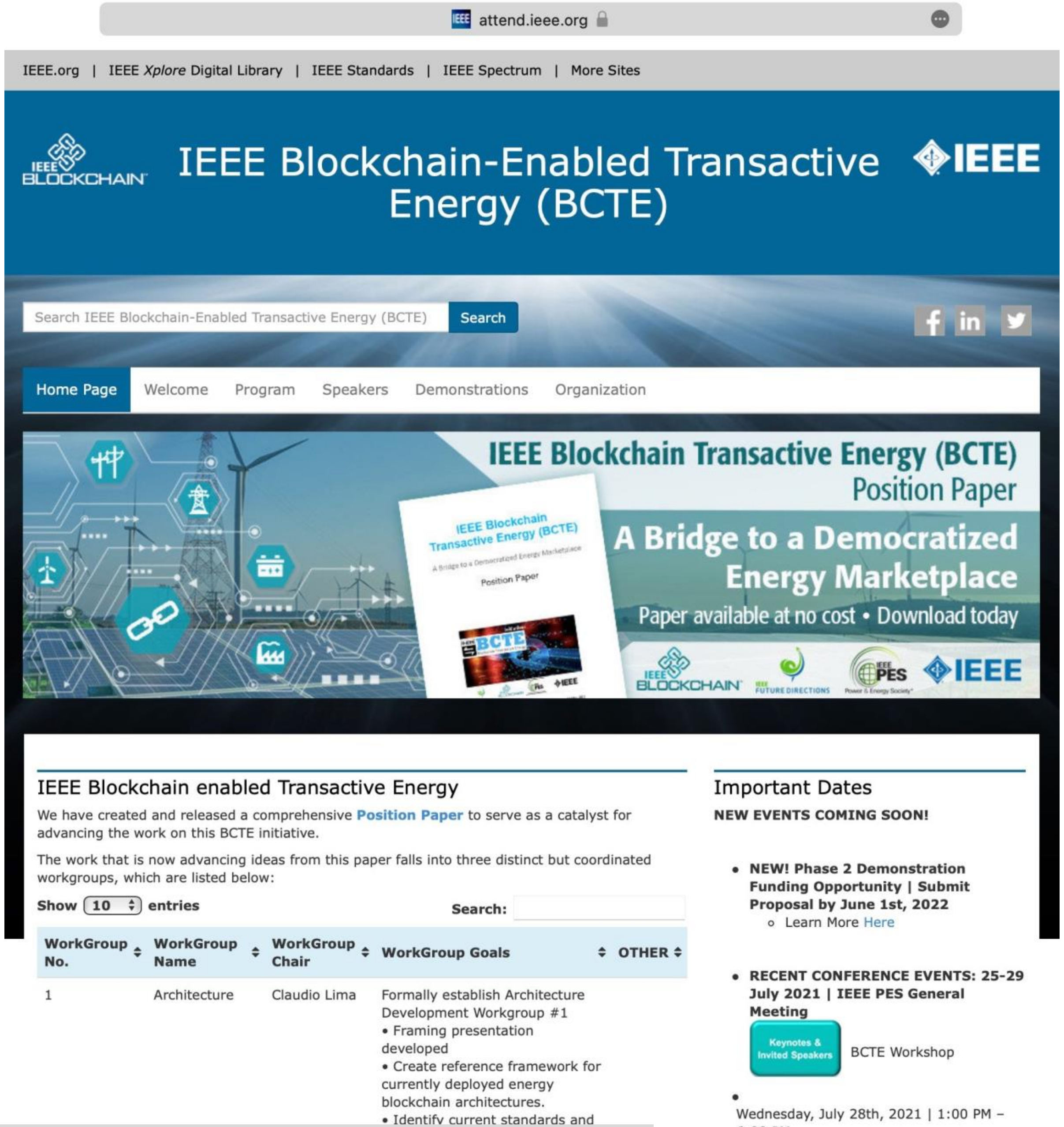
Thank You!

Claudio Lima

clima@blockchain-eng.org

SCAN ME



https://attend.ieee.org/bcte/

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About the Speaker

Claudio Lima, Ph.D.

- *Executive and thought leader in advanced blockchain, IoT, and AI technologies*
- *Expertise in energy (utilities, oil, and gas), smart city, and telecom/IT digital transformation*
- *Distinguished Member of Technical Staff at Sprint Advanced Technology Labs in Silicon Valley, California.*
- *Co-founder of the Blockchain Engineering Council (BEC)*
- *Chair of 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).*

clima@blockchain-eng.org

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TRANSACTIVE ENERGY:
Moving to a new Market, Customer and Data Driven Regulatory Paradigm

NARUC/NCEP Innovation Webinar Series
“Leveraging Distributed Energy Resource Capabilities Through Transactive Energy”

April 21, 2022

Larisa Dobriansky
General MicroGrids
Chief Business & Regulatory Innovations Officer;
Lead, SEPA Transactive Energy Working Group’s Regulatory Project Activity
Larisa.Dobriansky@gmail.com

TE PRESENTATION QUESTIONS

- **What is the scope/definition of Transactive Energy ("TE")?**
- **What are drivers of TE and what problems can TE address?**
- **How can TE benefit the Grid, Customers, the Market and Communities?**
- **What Regulatory and Business Models are needed to implement TE?**
- **What are important Considerations for Regulators and How would TE affect the Roles and Responsibilities of Regulators?**
- **Why should Regulators support TE Pilots and should Guidance be developed to inform the Design, Implementation and Evaluation of such Pilots?**
- **Are TE Solutions matters for Long-Term Consideration by Regulators or should Regulators be considering TE Solutions now in connection with meeting cost-effectively Policy Goals and Mandates?**

SCOPE OF TRANSACTIVE ENERGY

- **Gridwise Architecture Council:** "A system of **economic and control mechanisms** that allows the **dynamic balance of supply and demand** across the entire electrical infrastructure using **value** as a key operational parameter."

- **NARUC: :** "TE is both **technical architecture** and an **economic dispatch** system highly reliant upon **price signals, robust development of technology** on both the grid side and the customer side, and **rules** allowing for markets to develop to enable a wide variety of participants to provide services directly to each other" ("peer to peer"). (NARUC Manual on Distributed Energy Resources Compensation)

- **TE** involves using market mechanisms to identify and enable the provision of efficient, reliable and environmentally sound electricity services sought by utilities, third parties or customers, including "value streams" available from "customer-sited" resources (DR, ES, solar PV, EV, Microgrids, etc.) that are interconnected and interactive with the grid.

TE DRIVERS IN A RAPIDLY CHANGING ELECTRICITY LANDSCAPE

- **Technology Advancements, Policy Directives and Changing Market Conditions** putting pressure on legacy regulatory compact to change; Prompting new **Market Players** to provide electricity-related products, services to commercial and residential customers, increasing market competition; **Moving to a "Prosumer and Distributed Energy Future;"**
- **Increasing levels of Renewable Energy and Distributed Energy Resource market penetration** stressing traditional system capabilities, but also offering potential new Grid, Market and Customer benefits;
- **Growing Digitalization, Decarbonization, Electrification and Distributed Energy/Renewable Resources** calling for fundamental changes in regulatory responses to meet new power system, customer and society needs and rapidly changing market conditions;
- **Traditional Grid Architecture, Distribution System Model, and Utility Regulatory "Administrative" process** unable to keep pace with rate of market changes, technology innovation, and customer expectations, creating "stranded assets," "regulatory lag;"
- **"Smart" technologies** can enable "TES" supportive grid and market design and control engineering (visibility, forecasting, intelligence, flexibility and event control, and integration of new resources; empower consumers; accommodate multi-directional power, information and transactional flows);
- **Proliferation of smart devices**, **applications and systems (nodes of power injection and withdrawal)** increasing the potential for nodes and systems to interact with Grid and each other; need market mechanisms to coordinate and manage efficiently energy usage and investment decision-making.

TE BENEFITS TO GRID, MARKET, CUSTOMERS AND COMMUNITIES

TE can contribute to the following kinds of benefits in transitioning electricity systems to meet 21st century challenges and opportunities:

- **Promoting efficient resource allocation and valuation,** consistent with grid constraints (marginal cost to system attributable to a customer's energy investment/usage); Market structure and processes designed to value system-based investments and operational protocols to drive efficiency, reliability and innovation based on customer market participation;
- **Building a more flexible, interactive and adaptive grid** that affords resource and system flexibility and can address system operational issues in integrating variable renewable and distributed resources, including demand flexibility;
- **Placing Demand-side/load management in parity with supply resources to enhance balancing of supply and demand;**
- **Reducing, shaping and modulating peak demand to alleviate grid stresses;**
- **Harnessing the net locational and temporal benefits of multi-use DER and intelligent devices;**
- **Leveraging new market actor participation to deliver value;**
- **Reducing burdens on the Bulk Power System;** Optimizing local energy to defer costly utility-scale investments, increasing utility system asset utilization, building grid and community resilience;
- **Enabling community-based decarbonization multipliers;** stimulating cost-effective higher value applications and performance; maximize delivery at all time/locational scales.

CHANGING THE ENABLING RULES OF THE ROAD

- **Change Regulatory Compact: Align Utility Financial Interests with Long-Term Customer Value; Reduce Legacy Barriers; Level the Playing Field for all Resources:** DSO Active Network RE/DER Management; Harness net benefits of Distributed Resources to bring “Flexibility” to Generation, Delivery and Use; Maximize Efficiency and Minimize costs of delivering Reliability at all time/locational scales; More efficient Distribution System demands on BPS;
- **Transition to TE/Market-Based Solutions to Provide Efficient and Reliable Electricity Services; Expand the Provision and Consumption of Electricity Services; Capture Value:** (1) Resource and System Flexibility in Integrating DER/VER; (2) New Grid Services arising from New Network Uses and New Resources; (3) Leverage customer, third-party market participation to deliver value; (4) Co-optimize multi-actor, multi-objective, multi-function investment decision-making.
- **“Performance-Based Regulation” to Capture Value:** Shift from focus on historically incurred costs to “forward looking” achievement of Long-term Customer Value; Equalize treatment of capex and opex; Place Load Management in parity with energy supplies in balancing Supply and Demand; Incent continuous improvements in performance/efficiencies and spur innovation;

CHANGING THE RULES OF THE ROAD

- **Consistent Valuation, Verifiable Measurement and Monetization of DER as part of Utility Planning, Procurement/Investment, Operations;**

- **Efficient Pricing and Charges (towards "Dynamic Pricing;" Value-Based" Pricing); Increase Spatial and Temporal Granularity of Pricing; Rates based on Marginal Cost to Power System attributable to Customer's Energy Usage/Investment Decisions;**

BUILDING MARKET CAPACITY AND CUSTOMER ENGAGEMENT

- **Change Utility "Risks/Rewards"** to pursue Cost-Effective Solutions indifferent to sourcing, and **Evolve "value-based" pricing and charges;**
- **Increase Reliance Upon "Cost-Reflective" Economic and Price Signals** to motivate Investment and Operational Decision-making and Price-Responsive Customer behavior;
- **Build capacity for Market engagement using new technologies and analytics;** Modify Consumer Behavior; Increase Competition, consistent with reliability, affordability, safety and equity;
- **Design Rules of the Road/Market Mechanisms to value system-based investments and operational protocols,** to drive utility efficiency, reliability and innovation based on customer demand and expectations**; Administrative to "Customer-Driven Market" Shift**
- **Move from Asset Development to Value Creation; from Commodity to Service Delivery as evolve an "Integrated Grid;"**
- **Establish DSOs/IDSOs to provide proactive network management,** respond to rapidly changing market conditions, taking into account customer/third party resources;
- **Increase Transparency, Reduce Information Asymmetries, Disseminate Material Information with appropriate safeguards.**

BUILDING MARKET CAPACITY AND CUSTOMER ENGAGEMENT

- **Multi-Sided Market Platforms:** Enable transition, innovation, retail market integration and transactive interaction: (1) Embrace diverse party collaboration/participation; (2) Foster mutually beneficial relationships; (3) Promote transparency, material disclosure of information, and robust utility, customer, third party communications; (4) Enable rapid adaptation and response to changing market conditions; (5) Continually integrate new products and services, users, vendors; (6) Use cloud technologies and data analytics to offer "personalized"/heterogeneous services;
- **Market Platform to Generate Service Optionality/Merging Adaptability and Flexibility with Continuity and Stability:** (1) "<u>Operational Platform"/Infrastructure</u> – Transform System Operations fusing power and information (automating, optimizing and interconnecting power system functionality and "smart grid" functions (DA, DR) with customer site-based power systems and load management); (2) "<u>Market Platform"/Connectivity</u> -- Interface or Network with burgeoning distributed energy nodes and prosumers to enable energy services; (3) Unlocking value from technology innovation and new business models;
- **IoT/IT Elements:** Computational and Internet technologies; "Cloud" technology; Mobile devices and apps; Social Networks; Data Management and Analytics;
- **Transitioning**: Commodity Infrastructure Services; Enhanced Commodity Services; New Basic/DER Services; Advanced Platform Services; Customer Maturation Process [John Cooper, Innovation Platform Enables IoT]

TE SHAPING A NEW GRID OPERATING SYSTEM

- **"Integrated Grid":**
  - **New Parameters – DER Integration --** take fully into account and value DER in Utility Planning, Investments, Operations and Trading; Utility indifference to sourcing of cost-effective solutions; **Expanded Electricity Value Chain Parameters –** Changing Grid and Market Boundaries; **"End to End" Interoperability –** Standardize DER use throughout Electricity value chain;
  - **New Market Players –** Prosumers, Third Parties, Microgrid System Operators, DER Aggregators; Energy Service Providers, System Integrators, etc.
  - **New Regulatory Structures –** New Utility Business Model and Market Design to achieve policy objectives, while maintaining reliability, safety and affordability;
- **Cyber Secure-Physically Resilient Grid Architecture:** Highly flexible, configurable, modular and interactive networks of utility, customer and third party applications; Market data, price signals and transactions; multi-directional power, information and transaction flows; and "System of Systems" Layered Infrastructure for DER integration and load-side management; New Grid Operating System vital to realizing the full value of distributed resources and utility-scale renewables, as well to achieve cost-effectively policy objectives;
- **Grid Design to Leverage Local Integrated Energy Development and Use:** Increase independence, flexibility and intelligence for optimizing energy use and management within local energy networks and integrate local energy resources into a Smart Grid and Market [EPRI, Needed: A New Grid Operating System to Facilitate Grid Transformation"];

TE SHAPING A NEW UTILITY DISTRIBUTION SYSTEM MODEL

- **Proactive Distribution Network Management:** Respond to dynamically changing market conditions and manage customer-side resources (**Distribution System Operator);** Transmission System-like functions to manage distribution planning, investments and operations:
  - **Maintain Reliable Operations with two-way, multi—point reversible power flows with increasing volume, diversity of DER;**
  - **Integrate and Balance DER and Load to shape load profile and peak demand;**
  - **Achieve Functional control of DER for real-time balancing and flexibility and grid services;**
  - **Define/Manage Transmission/Distribution Interface;**
  - **Address Changing Characteristics of New Resources and Changing Nature of Customers (Kristov, Erickson, et al., "Distribution Planning")**

- **Smart Technologies Enable TE and Distribution Grid Modernization:** Smart information, communications and control technologies; Distributed Intelligence and Data Management and Analytics; Distribution Automation; Algorithms, Machine Learning and Artificial Intelligence;
- **Advanced Distribution Systems:** AMI, OT/IT Integration; Automated Distribution Management Systems; Distributed Energy Resource Management Systems (sensors, communication and computational ability/modeling, simulation, analytical and diagnostic tools and methods for proactive distribution control model;
- **Leverage Grid-Compatible and Market Participation Protocols to facilitate decentralized dispatchability and "peer to peer" transactions; optimal mix of local and bulk energy.**
- **Customer and Data-Driven, Services-Oriented Model:** Customer choice and decision-making to "value" system-based investments and operation protocols that drive utility efficiency and innovation;

NEW REGULATOR ROLES AND RESPONSIBILITIES

- **Proactive Role –** Address Barriers; Delineate Enabling Frameworks; Create Environments that take into account and balance all relevant stakeholder interests and that are conducive to consensus-building; Promote alternative analyses;
- **Facilitate Managing Risk and Uncertainty;** Forward Planning (past no longer a gauge of the future); Support appropriate new Tools and Methods in Utility planning and decision-making to assess impacts and the costs-benefits of utility and other proposals in responding to system, customer and societal needs; Interrelate System Planning, System Operations and Market Operations;
- **Facilitate Transitioning to a 21st Grid and Markets, supporting --** Active Network Operating Management; Support of Distribution System Level Market Operations; Expansion of Grid and Market Services; Leveraging new Market Actor participation to deliver value; Retail/Wholesale coordination/cooperation; Optimal Distributed and Centralized Resource Mix; Reduction in Information Asymmetries, Data-Driven modernization with data sharing protocols, Increased Transparency with Privacy and Security Safeguards; Protections against Abuse of Market Power and Conflicts of Interest;
- **Enhance Stakeholder Processes –** Using a wide range of regulatory venues alternative to "rate cases" (rulemaking proceedings, workshops, technical conferences, etc.);
- **Access sources of Technical Assistance** (i.e., USDOE, National Laboratories, National and State Energy Offices, Industry, NGOs, Academia, etc.)
- **Support holistic strategies, public-private partnerships; retail/wholesale coordination; electric industry and community cooperation**

REGULATORY SUPPORT FOR SANDBOX DEMONSTRATIONS

- **Apply New Modelling & Simulation Tools, Analytical Methods at Testing Facilities and in "Testbed" Demonstrations:** (1) Validate functions of DER/Microgrids to relate to value streams and quantify/estimate net benefits (economic, reliability/resiliency; power quality, environmental, security and safety); (2) Support open source architecture, standards, protocols and configurations to achieve interoperability, integration, flexibility and spur competitive market opportunities; (3) Shape TE Pilot Planning, Design and Implementation; Perform Scenario Analyses of different TE Market Structures/Business Models and Compare Cost-Effectiveness of TE Scenarios with Traditional Investment Options and with each other; and (4) Assess barriers and challenges.
- **Evolve Uniform, Consistent, Verifiable Valuation Methods and Cost/Benefit Analytical Frameworks** to quantify system, customer and societal net benefits of DER/Microgrids;
- **Apply Relevant Standards to Demonstrations:** Standards issued by such Standards Development Bodies as IEEE (1547; 2030.7, etc.);
- **Design and Implement Demonstrations of Distributed System "Platforms:"** Evaluate distributed systems architecture for optimizing dynamic sets of DER/VER across the diverse infrastructure and built-environment of a community;
- **Interrelate and Leverage Utility Decision Support Tools & Methods with Local Decision-making Tools to** evolve Advanced Energy Communities and Integrated Energy Solutions that support Customer to Grid, Grid to Customer and Peer to Peer interactions;
- **Technical Assistance to Regulators** to help identify; stage/sequence and establish key performance criteria for TE pilots to inform transitioning with respect to decision-making processes.

THANK YOU

Balancing Energy for a smarter, renewable-driven grid

Larisa Dobriansky

General MicroGrids

Larisa.dobriansky@gmail.com

Contact me for information regarding SEPA's Transactive Energy Working Group's Project Activity: "Transactive Energy Regulatory Foundations: Moving to a New Market and Customer-Driven Paradigm.

Transactive Energy: An overview of relevant utility programs and initiatives at National Grid

Eli Shakun

Lead Strategy Analyst
Eli.Shakun@nationalgrid.com

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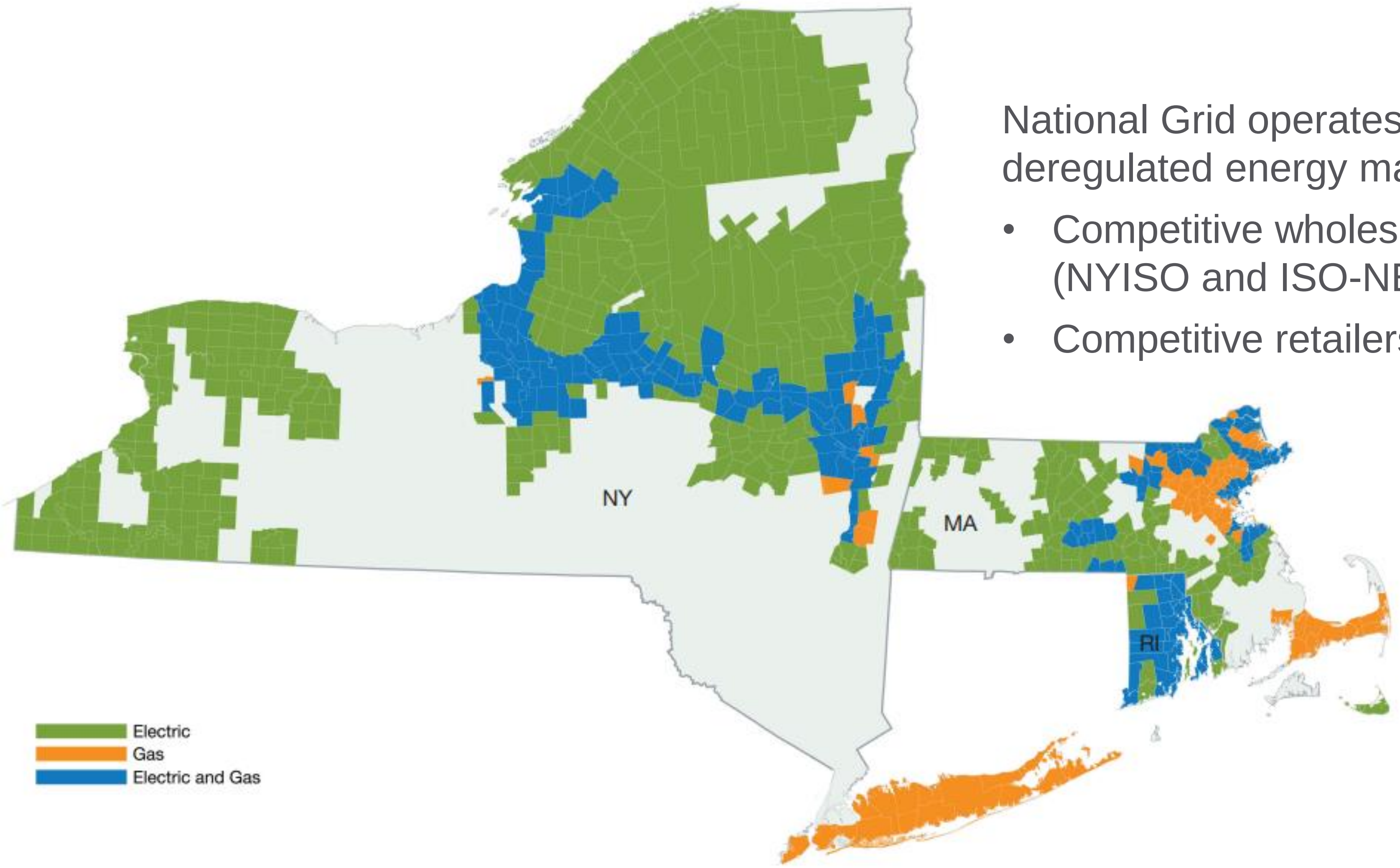
nationalgrid

National Grid is a global energy company whose US electric and gas utility operations serve over 20 million customers in the Northeast US



National Grid operates in states with deregulated energy markets

- Competitive wholesale markets (NYISO and ISO-NE)
- Competitive retailers

National Grid's service territory is among the most densely populated with DER in the US with ambitious targets to accelerate growth into the future

- MA ranks 8th (#2 in US per square mile), and NY ranks 11th in most installed solar MW in the U.S.
- We expect distribution connected solar (MW) to grow up to 3x in MA and 4x in NY over the next 15-years

- NY State energy storage deployment target of 6 GW by 2030
- MA state energy storage deployment target of 1 GWh by 2025
- Storage may go from 10s of MWs on our NG energy network to 1000s of MW in the next 15 years

- NY state electric vehicle target of 2m light duty ZEVs in operation by 2030
- MA state electric vehicle target of 750k ZEVs in operation by 2030

- MA and NY both have ambitious electric heat pump goals, including a MA target for 1 million residential home heat pump installations by 2030

- Well organized wholesale markets with expanding opportunities for DER and DER aggregations
- Lucrative retail incentive programs to increase DER adoption and shape DER operation

National Grid is committed to being at the heart of a clean, fair, and affordable energy future

What is Transactive Energy (TE)?

Pacific Northwest National Laboratory Definition

"Transactive energy is an intelligent, multi-level communications method that coordinates energy generation, consumption, and delivery. Under the transactive energy scenario, electricity suppliers, energy markets, the power grid, homes, commercial buildings, and distributed energy resources (DERs), such as electric vehicles and batteries, would "talk" directly or indirectly with each other to negotiate energy needs and costs. The electronic process would rapidly and automatically harmonize energy availability, consumer needs, cost preferences, and other factors, enhancing overall energy system efficiency."

Source: https://www.pnnl.gov/explainer-articles/transactive-energy

National Grid does not have a company-endorsed definition for "transactive energy," nor can we readily adopt the PNNL definition. For purposes of this discussion, however, we can provide information on National Grid programs and initiatives related to the following:

1. Highly flexible and price responsive DER
2. Bid-based market clearing mechanisms to set prices / quantity for DER grid services
3. Dynamically determined price signals for DER that reflect both wholesale and local grid needs

Disclaimer: Transactive energy is still a nebulous topic without general consensus on definition among the energy industry. National Grid does not have a formal Company definition for transactive energy. These slides are for discussion purposes only.

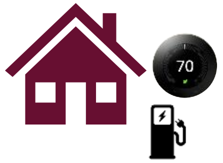
Transactive energy could in theory help solve some of the affordability challenges of the clean energy future

Challenges to distribution utilities that TE could help solve:

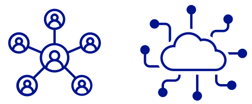
1. Rapid interconnection of distributed generation (DG). Rising hosting capacity costs and challenges
2. Expanded load growth from beneficial electrification (BE). Expanded capacity costs required to keep pace with new load
3. Rates and pricing structures used for billing may not reflect temporal system costs and constraints
4. More variance between transmission level system view and local distribution system needs. Pace and scale of DG growth and BE load adoption impacts will vary by location
5. Limited tools available today for distribution control centers to actively track and manage power flows
6. Limited tools available today for metering, billing, and settlement teams to track and manage more complex $ flows

Emerging opportunities to explore transactive energy as a cost-effective solution for managing power flows:

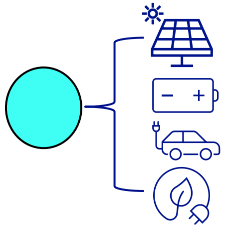
1. Increased adoption of manageable flexible devices on the Dx system capable of responding to dispatch



2. Emergence of new grid technology and software capabilities (DERMs / ADMS / Advanced Metering)



3. New regulatory mandates expand opportunities for DER and third-party vendors / aggregators (i.e., FERC 2222)



How do we utilize transactive energy mechanisms to optimally shape the operation of DER based-on wholesale, distribution, societal, and BTM customer needs?

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Select relevant projects and initiatives at National Grid

1 Buffalo Niagara Mohawk DSP Demo (completed)
NY REV Demo utilizing LMP + D + E pricing model with limited enrollment

2 Connected Solutions (active)
Day-ahead MA and NY Demand Response programs that address system-level peak for residential and C&I customers (traditional curtailment, thermostats, EVs, energy storage)

3 Value for DER (VDER) Value Stack Tariff (active)
NY retail tariff that compensate distributed generation based on an LMP + D + E model

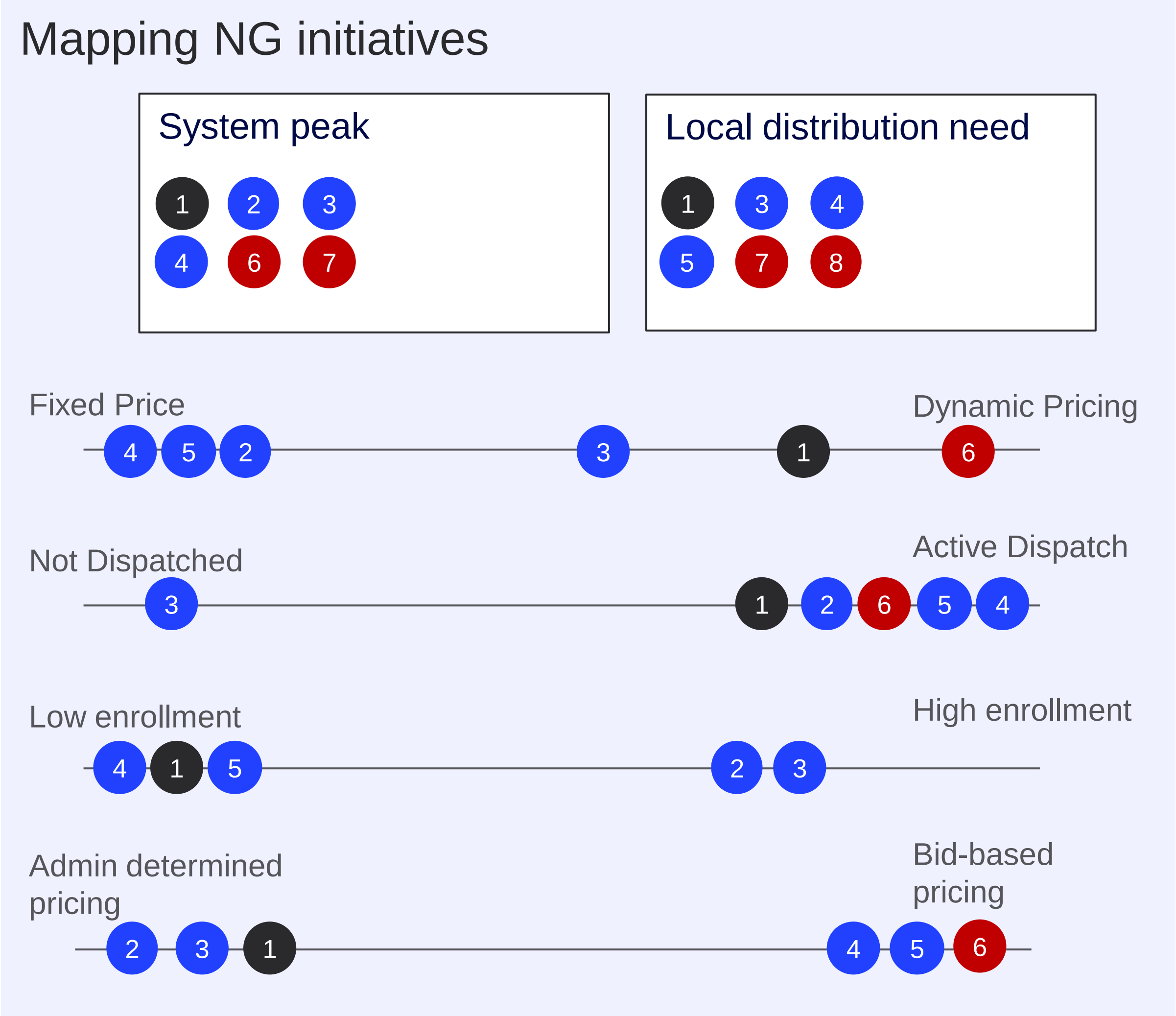
4 Auto-DLM (active)
Pay-as-bid, rapid response (10-minute dispatch) demand load management program in NY to address distribution-level peak and system-level peak

5 Non-wires Alternative Procurements (active)
Procurement, contracting, installation, and operation of DER for the purposes of meeting a specified grid need

6 NYISO DER Aggregation Model Enablement / FERC Order 2222 (in development)
Development of new software tools to enable DER aggregation participation in the wholesale market while maintaining safe, reliable, and equitable network operation

7 Syracuse Building to Grid (in development)
Project to develop Building-to-Grid (B2G) software, communications, and integration between grid management software, Building Management System ("BMS"), and DER to actively manage the expected increased electrical load from net-zero buildings.

8 Flexible Load Study (in development)
NY demo project to determine if enough flexible load exists and, if in a properly designed program, it can address system constraints



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Transactive energy is a journey not a destination

1. We are still in the relatively nascent stages of our transactive energy journey, including how we as a Company define TE, with limited examples of (a) successfully developing and deploying dynamic price signals based on Dx constraints and (b) utilizing highly flexible and price responsive loads

2. To evaluate the relative future importance of TE to distribution utilities requires more rigorous testing of transactive energy concepts and features to understand where and how they can be used as cost-effective and reliable grid and customer solutions

3. Any transactive energy concepts need the right program participants; just because the pricing model may work, we need to be able to take our customers on the journey with us to ensure the programs and markets are well-subscribed enough to be useful for our grid operators and planners

4. Any transactive energy frameworks need proper regulatory approvals, as they involve modifications to the way we charge and compensate customers based on their energy usage. Proposed regulatory changes need to carefully consider both the costs and benefits to our customers

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