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Applying Retail Markets and Transactive Resources for Grid Flexibility

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Abstract

The electric grid faces strain driven by rapidly growing loads (e.g., data centers, onshoring of industry), retiring dispatchable generation, and increasing intermittent alternative energy sources. Traditional utility mechanisms for managing customer resources, such as demand response (DR), do not provide 24/7 localized balancing. Large flexible loads such as data centers cannot allow direct outside dispatch control, which leaves utilities without an effective way to use edge flexibility. Local markets enable continuous and efficient integration of flexibility.

Common Transactive Services (CTS) specifies an open messaging protocol for local energy markets at the feeder, neighborhood, campus, and building levels. Based on standard financial market semantics, CTS enables interoperable participation of edge devices, microgrids, and facility systems.

Local markets solve distribution grid problems through local resource coordination while keeping customer information private. CTS markets can help to address: (1) distribution grid infrastructure, voltage, and reliability challenges, (2) dynamic trading of data centers' own energy generation and storage, (3) siting for storage and generation using local market history for improved investment decisions, and (4) adding market capability to a device, microgrid, or facility using CTS standard interactions and data structures.

This technical note discusses grid challenges, the value of local markets, and the role of CTS. It then reviews next steps for deployment, regulator support, and technical work. It also provides examples of how CTS can be applied and reviews key CTS semantics.

Keywords

Common Transactive Services; Flexibility; Local Markets; Market Agent; Transactive Energy; Transactive Resources.

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1. Introduction

1.1. Current Challenges for Integration of Customer Flexibility

The electric grid is facing a narrowing margin of control. It was built for yesterday's load peaks, and yet we are adding large loads (data centers, industry) while retiring dispatchable generation and adding intermittent energy sources. Adverse weather or localized failures stress the grid. Distributed energy resources (DER)—solar photovoltaics (PV), electric vehicles (EV), and batteries—offer flexibility that could stabilize the grid if it could be used effectively.

Utilities, governments, and edge users are adding storage, expanding demand response (DR) flexibility, adding generation, revising interconnection rules, and deploying microgrids. These tools help, but distribution problems remain: voltage fluctuations, overloaded transformers, and the difficulty of coordinating behind-the-meter (BTM) loads and generation. Utilities lack practical mechanisms to manage these problems while maintaining grid stability; on the other hand, large facilities lack effective ways to offer their flexibility to others.

Utilities commonly use DER management systems (DERMS) [1]. A DERMS system interacts both indirectly with DER via DR programs and directly controls some equipment to maintain grid stability. DR enables use of customer device flexibility as a bulk capacity resource. Additionally, a utility may use dynamic prices to access DER flexibility [2]. However, system-wide DR events (or prices) cannot mitigate distribution-level voltage and transformer overload problems. Local electricity markets not only reduce peak flows but enable local resource sharing for improved voltage stability and reduced transformer loading while improving local resilience.

Data centers and industrial facilities that require gigawatts of power may install on-site generation to guarantee their own resilience and to skip long interconnection queues [3]. Internal business processes determine their willingness to export or consume across the day. Utilities want visibility and direct control access to that behind-the-meter (BTM) plant, but these large facilities will not allow outside dispatch. To the utility, the site remains a black box. But in a local market context, the need for local energy supply is communicated via tendered prices. If local prices reward a change the facility can accept, the customer can buy or sell without opening the box to outside control.

Wholesale markets prefer large generators that can deliver power when needed. Effective Load Carrying Capability (ELCC) [1] accredits capacity on that model. A data center or factory that serves its own work first scores poorly on ELCC because the metric cannot see availability that moves with internal processes. ELCC describes the black box from outside. It does not describe what the facility will do if a local market pays for a specific interval. A market allows the facility to enter on its own terms, not via centralized dispatch of the plant.

Grid operators have tried to achieve load flexibility through demand response, paying customers to reduce load at peak times. Virtual Power Plants (VPPs) have grown as a popular

[1] A measurement of a resource's ability to produce energy when the grid most likely faces electricity shortfalls. In PJM, this applies to the capacity market, not to the day-ahead or real-time energy markets.

approach to manage customer resources to meet wholesale or utility capacity shortfalls. That model takes customer flexibility and fits it into a bulk capacity resource. The Federal Energy Regulatory Commission (FERC) Order No. 2222 follows this same wholesale-aggregation path. On the positive side, DR, VPP, and dynamic tariffs achieve some flexibility. They fit the present grid framework and build some DER integration skills. However, they do not provide 24/7 balancing down in the distribution system or maximize DER resource flexibility.

1.2. The Value of Local Energy Markets

Markets are the proven mechanism to balance supply and demand over time. Wholesale electricity markets have demonstrated this at regional scale for decades. Local markets operating continuously at the feeder, neighborhood, campus, or building level, can perform the same function with finer geographic and temporal granularity.

Local markets can fill troughs, reduce peaks, coordinate flexible load and storage, and reduce the need for additional supply and distribution infrastructure [4]. In doing so, they create clear investment signals for distributed storage and generation exactly where it is most valuable.

Coordinating equipment owned by many actors, each with private information and priorities, poses a knowledge problem, identified by Hayek [5]. A customer’s DER serves that customer first. A central controller cannot know the customer’s changing schedule and priorities. Even feeder-level VPP depends on centralized management and pre-negotiated dispatch availability. While feeder-level focus helps to defer infrastructure upgrades [6], it still depends on central observation and control. Markets coordinate dispersed knowledge through prices, solving the knowledge problem and unlocking additional flexibility.

Just as distributed energy resources are local, markets must become local. Local markets enable fine-grained balancing of supply and demand, maximizing the use of localized PV generation and battery storage precisely where the energy is needed. This localized approach provides 24/7 balancing, rather than emergency peak shedding, and creates stronger incentives for intelligent controls compared to DR or VPP aggregations. Simulation experiments using a CTS [7] market federate [8] demonstrate how a local market at the service transformer level can coordinate energy use on a constrained transformer with multiple large electrical loads, including EVs. The utility does not need to sign DR agreements, dispatch resources, or need to know anything about their availability. Additionally, the cost of reliability for each participant falls as the direct need for redundant resources in each participant is replaced by resilience based on market access to the resources of peers. Each participant keeps local decision rights and internal systems stay private and autonomous.

CTS provides standard semantics and interaction protocols to enable local energy markets.

2. Common Transactive Services (CTS)

CTS enables autonomous decision making at the edge.

2.1. CTS and Transactive Energy

CTS connects devices to markets with the same interaction patterns and semantics financial markets use. CTS extends those semantics to Transactive Energy (TE), where the value of a resource depends on the time of delivery. A kilowatt hour at 6:00 p.m. generally commands a higher price than one at 1:00 p.m.

CTS makes markets accessible. It supports the sale of multiple products on the same wires, for example locally sourced energy versus energy from the utility grid. CTS provides auto-discovery so that a device can find a local market and learn how to interact; a vendor does not need to custom-build a device for each locale. And implementers can use existing open-source code and UML models [9] to connect intelligent devices to markets.

The OASIS Common Transactive Services protocol [7] provides the semantics and messaging required for local power markets. Developed from the service orientation of OASIS Energy Interoperation [10], CTS functions as a market protocol for transactive resources. Participants can use standard messages without adapting messages in one utility territory versus another. CTS governs the interface to the market only, not the energy-management software or protocols inside a customer facility. Local concerns and local interests drive decision-making. New technology can appear at each level under the common framework of markets.

Standard messages include Quotes (with price and time interval) and Tenders for buying or selling some product. A Tender can result in a Transaction. The different CTS market roles, standard messages, market types and other terms are provided in Appendix A.

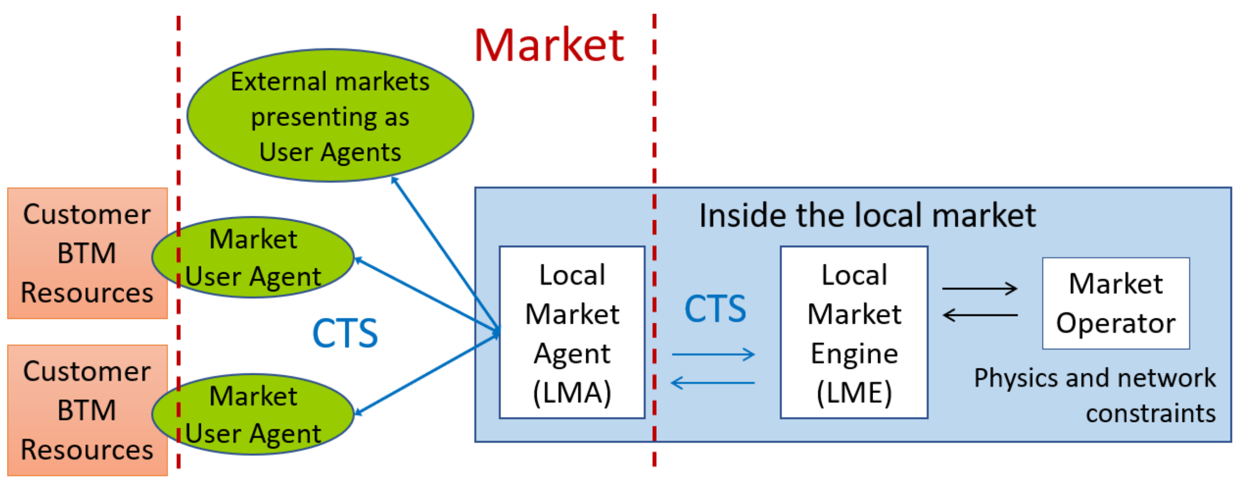

Fig. 1. CTS market architecture. BTM = behind-the-meter.

CTS markets (the “Market” between the dashed lines in Fig. 1) are operated by a Local Market Agent (LMA). Market User Agents connect to that market. Each User Agent speaks for behind-the-meter resources, and carries the owner’s policy for grid interaction. CTS markets can sit inside a microgrid and also between microgrids at campus, city, or regional scale. CTS names this pattern “fractal markets.” Each tier adds a privacy boundary and removes a single point of failure.

The Market Engine matches Tenders (A5.2) and records Transactions and Positions (A2.1). The Market Operator may refuse a Transaction that would harm the system. The LMA is the Operator’s market-facing agent. Market User Agents represent flexible resources, inflexible load, and inflexible generation such as PV. A User Agent can stand for a data center, a microgrid, a battery, an aggregated load, or an EV charger. A regional market or a utility can enter the same local market through its own User Agent. The LMA may be operated by the distribution utility, an independent operator working with the utility and the bulk markets, or by an isolated microgrid acting alone.

A Market participant has three logical layers, Table 1.

Table 1. Market participant conceptual model.

Layer	What lives there	Who decides	What the market sees
1. Device	Loads, PV, batteries, HVAC, EVSE, industrial lines	Physics and local control	Nothing. These act only as energy drivers.
2. Policy	Owner or tenant intent: comfort, process schedule, reserve, shed order	The customer	Nothing. Policy stays inside the fence.
3. Market	Buy and sell over time to meet policy	Market User Agent (the CTS Party)	Tenders, Quotes, Transactions, Position

Layer 1, Device. Devices, systems, and processes must report energy use: present use, use under another operating posture, and run time. Telemetry can come from a meter, from computation, or from prior results. The device layer reports energy use via the function of an “energy driver”. By analogy with a printer driver, an energy driver knows operating limits (long-running processes, freezer temperature, and other factors that cap response). It does not speak CTS. It stays behind the meter and reports present use, feasible future use, and the change it can make if asked.

Layer 2, Policy Agent. This layer defines and defends owner or tenant intent. A homeowner sets comfort goals. A factory schedules a long process. A kitchen plans service around meals. Priorities decide what to shed when shared power runs short. Storage can put emergency reserves ahead of present load. These choices stay local. CTS specifies the market interface, not this policy.

Layer 3, Market User Agent. This agent acts as the economic Party. It presents resources to the market, manages budgets, and buys or sells power over time to meet policy goals. It reports market results back to the policy agent, especially any failure to acquire enough power. It submits Tenders and holds a Position.

One policy agent may interact with many energy drivers. One Market User Agent may interact with many policy agents or treat a whole facility or microgrid as one Party. CTS addresses market communications only and does not require any particular implementation of these three layers.

Many energy driver models already exist: EcoPort (CTA-2045) on many consumer devices; OpenADR 3.0 for load and DER shaping, usable inside the facility to feed a User Agent; MIL-STD-3071 (Tactical Microgrid Standard) for battlefield microgrid taxonomy and control; Open Platform Communications (OPC) and similar industrial protocols, which can present a production line as one process. Firms that manage solar or other DER often keep proprietary driver libraries. This note does not discourage their use.

In every case, only the Market User Agent interacts with the market.

2.2. Financial Information Exchange (FIX) and the FIX Trading Community

CTS aligns OASIS Energy Interoperation[2] [10] with FIX Trading Community[3] standards used in financial markets worldwide. CTS uses that semantic richness and defines a smaller set of services for energy markets. CTS includes pre-market, market, and post-market services.
By using FIX protocol semantics extended for transactive resources, implementers do not have to learn a different API or vocabulary for each resource market. Developers can build new solutions without new tooling for each environment. The same messages serve any market. Only the products traded, instruments[4], market structure, and business models may differ.

Developers do not have to invent market types. Standard types (Order Book, Auction, and Quote-Driven, see A.4) already exist. CTS-based markets describe themselves, so a participant can discover product, instrument, and market structure in machine-readable form (see A.1 and A.5). Regulators and market designers can use markets that meet local needs without requiring new code and new devices to buy and sell power.

CTS uses a small message set compared with full FIX financial instruments. CTS services still cover many market contexts: wholesale auctions, next-day firm price communications, industrial load-curve acquisition, or real-time markets.

[2] The OASIS Energy Interoperation Technical Committee originally developed the Energy Interoperation (EI) specification. Common Transactive Services profiles EI for markets.
[3] https://www.fixtrading.org/
[4] An *Instrument* names what Parties buy and sell. The *product* names the nature of what they sell, e.g., energy. An instrument would name energy at 1 p.m. tomorrow, which differs from energy at 5 p.m. today.

3. Advancing Local Energy Markets

Research, utility trials, and the CTS specification already support local markets. Remaining barriers sit in structure and regulation, not in the protocol.

3.1. CTS and the Regulatory Compact

Most U.S. distribution utilities still work under a regulatory compact: obligation to serve, recovery of used-and-useful plant, commission oversight of rates and reliability. The compact leaves open who may own the wires, who may take a return on them, and who remains supplier of last resort. It does not ban a local market.

FERC Order No. 2222 requires wholesale energy market operators to admit DER aggregations to regional energy, ancillary-service, and capacity markets. It does not design a distribution market. Retail rates, distribution interconnection, and most double-counting questions stay with the retail regulator and the distribution utility. The bulk system operator, the utility, and the aggregator must coordinate. The utility keeps a reliability override.

CTS does not replace that wholesale path. CTS specifies the market interface at the feeder, campus, or microgrid. The Local Market Agent may belong to the utility, to a commission-authorized operator, or to a microgrid that already carries its own reliability risk. If a Transaction would overload a circuit or violate a utility override, the Market Operator refuses it. That refusal performs the distribution reliability function FERC 2222 presumes.

CTS deployments can begin wherever existing rules already let Parties buy and sell at the edge.

- **Isolated or islanded utilities** already carry local reliability risk. Many fall under the FERC 2222 small-utility opt-out or sit outside of a regional transmission operator. They can stand up an LMA without a regional aggregation tariff.
- **Military expeditionary and installation microgrids** fall outside civilian retail regulation. An operational deadline (e.g., a fleet charged by a fixed hour) gives the policy agent a clear job and lets one Market User Agent speak for the site.
- **Communities that face recurring outages**, such as Public Safety Power Shutoffs, already live with a broken reliability promise. Microgrids and backup resources can buy and sell locally. If those resources also join a FERC 2222 aggregation, the local market and the aggregator must split intervals so the same delivery does not clear twice.
- **Voluntary peer arrangements** need no new franchise if neighbors or campus parties register Over-the-Counter (OTC) or quote-driven trades and the Market Engine only records Positions. The utility can still reject a trade that would harm the circuit.
- **Large commercial or multi-tenant facilities** can virtualize internal operations and systems into virtual microgrids to reduce peaks and to respond as a group to ongoing grid signals. A facility then acts as a microgrid, managing its own energy resilience.

Each case can keep the split in 2.1: devices behind the meter, policy with the owner, and only the Market User Agent in the market. Wider retail use inside regulated territories comes later (3.5) beside FERC 2222 aggregation.

3.2. CTS Markets Solve the Large Load Capacity problem

CTS markets can support more effective large-load management while the facility stays a black box. Data centers and industrial sites can determine their energy needs while responding to grid prices, communicating their energy profile via Tenders (A5.2) and Quotes (A5.4) to the market. The work still required is to profile existing EMIX [11] operating-state terms inside CTS, confirm what already suffices, and identify gaps. A large load might participate in a city-level local market, boosting energy resilience, or may use a CTS interface to an existing wholesale market.

Regulators and technical experts should decide together whether dedicated on-site generation should receive front-of-the-meter treatment (a bulk-dispatchable resource, which utilities and FERC tend to favor) or behind-the-meter treatment (facility-controlled, exporting only secondarily). BTM treatment keeps ownership and load priority with the facility. Resource-adequacy planning then cannot see that capacity and cannot impose an emergency-dispatch obligation.

3.3. Local Markets Stakeholder Organization

A local energy market stakeholder organization would bring together microgrid developers, utilities, regulators interested in local market implementations, and vendors of market-based systems and customer resource-management systems. The organization would:

- Provide coordination and collaboration across stakeholders in order to identify, implement and promulgate best practices.
- Provide resources for regulation and policy, pilot case studies, and a shared catalog of driver-layer standards (OpenADR 3, EcoPort, MIL-STD-3071/TMS, C4SB, LF Energy);
- A technical lab to support reference code development and product testing and certification.

3.4. Next Steps for Technology Development

There are key technical work activities that remain. The 3.3 proposed local energy markets stakeholder organization(s) can host and/or guide this work.

- Develop a conformance test suite for independent third-party validation to support product development. This effort would also extend and validate the open-source Energy Mashup Lab reference implementation [9].
- Document pilot case studies per priority deployment category (i.e., 3.1 isolated communities and data centers) and pursue targeted outreach to those communities. Pilot implementations should pursue an energy-driver model: OpenADR 3.0, as a device-

facing interface, lets a transactive agent negotiate building capacity (HVAC, storage, EV charging) without penetrating internal systems or requiring a third-party energy services company, which preserves privacy while exposing needed flexibility. MIL-STD-3071 (Tactical Microgrid Standard, TMS) should be recognized as a second driver-layer standard. It defines device control and object models, not dispatch decisions.

- Migrate existing product vendors' flexibility market software to be CTS standards compliant. Additionally, CTS interfaces to existing energy markets should be developed.

3.5. Regulatory Opportunities

Independent of the resources a stakeholder organization may provide (3.3), regulators have an ongoing set of tasks to shape retail market design so jurisdictions can adopt TE incrementally, including territories that still operate under the compact.

- Develop market mechanism types (MMT) for local retail power markets, then write the matching market rules, following the FIX Trading Community MMT framework. Apply financial-market best practices to local power markets, drawing on FIX Trading Community recommended practices as a starting reference.
- Consider whether policy requires separate Segments on the same physical wire in some areas, so differently structured markets can coexist without forcing a single design on all participants. Consider cross-segment settlements and avoid double counting against DR aggregations.
- As these regulatory issues are addressed by different utility commissions and piloted in different areas, consider how to bring lessons learned up to the National Association of Regulatory Utility Commissions (NARUC) to publish best practices and recommended local energy market guidelines.
- Adopt regulations that allow access to local markets for both industrial and residential generation.

3.6. Building on Existing Resources

Implementers at the edge (device integrators, microgrid operators, and building owners) benefit from the shared conceptual architecture in 2.1. They also have a body of existing work and standards. Existing open-source and standards resources already map to these layers and should go into an implementer catalog, not a rebuild.

- **OpenADR 3.0** specifies automated demand response: a device or system's capability to use more or less power on request (see Section 2.3).

- **EcoPort interfaces (ANSI/CTA-2045)** provide OpenADR 3.0 interfaces for many device types and a practical source of device drivers for individual systems.
- **LF Energy** (the Linux Foundation Energy project) hosts device- and system-operation projects, generally from the grid-operator perspective but often usable at the edge.
- **The Coalition for Smarter Buildings (C4SB.org)** develops open-source device drivers for building systems, including specifications for in-building clouds to host systems of systems locally.
- **The Energy Mashup Lab** [9] has developed free, open-source code for market interactions and market agents, originally built to support NIST TE market modeling.
- **MIL-STD-3071 (TMS)** builds on the Object Management Group's Data Distribution Service (DDS) for its data-modeling, data-bus, and security layer. TMS covers device coordination that keeps a microgrid stable. TE assumes multiple independent Parties. In the context of a TMS microgrid, sets of devices support a single mission or business function and each such set can have a shared changing policy. One set or multiple sets can be represented by a single Market User Agent. These Market User Agents then interact in the TMS-connected local market. CTS over TMS keeps device control inside the fence.

4. CTS Applications and Examples

This section presents examples, each using CTS messages as specified.

4.1. One-Way Price Distribution

A Load Serving Entity (LSE, the utility and possible market operator) provides future prices to its customers so that they can plan power use. The LSE provides CTS Indicative Quotes, which are distributed to the market by a Quote Ticker. This regularizes the non-standard methods many ISOs and RTOs use today to send prices. Target loads could include industrial sites, microgrids, commercial buildings, or homes. Nonetheless, as flexible load participation grows, a two-way approach with feedback into the bulk markets will be advantageous (see 4.2 and A.4.3).

4.2. Day-ahead local markets for better balance

The LSE acquires power in the wholesale market to meet expected customer needs. Using local retail markets, the LSE makes firm offers to customers with power quantity and price for each hour of tomorrow using a Quote-driven Market (A.4.3). Customer agents make firm commitments to acquire power at these prices based on expected needs, responding to Quotes with Quote Response messages, and the market operator (LMA) announcing Transactions.

The LSE can take the local market transactions as feedback into wholesale intraday markets. Local and wholesale markets together serve to balance loads across the day, use flexibility, incentivize storage, share resources, reduce capacity shortfalls, and lower prices.

4.3. Load Shaping and the Real-Time Market

The LSE may use real-time pricing to shape load. A customer who has already purchased power in the day-ahead hourly market (DAM) owns that power and may resell it in a five-minute real-time market (RTM). The RTM operator issues CTS Quotes every 5 minutes for the next 5-minute interval. Consider a thunderstorm that will reduce solar PV generation and the energy that the PV owner already sold to market (in the DAM). The PV owner (or the PV User Agent) must then buy that power back in the local real-time market. That demand may raise the price for the storm interval. If the price rises enough, a battery agent may sell power, or a heat-pump agent may raise house temperature under the customer's comfort programming.

4.4. Co-located Power Generation

Large power consumers (data centers, industrial plants, microgrids) show growing interest in co-located BTM generation. These sources support internal business activities. These businesses do not commit to full-time participation in bulk power markets. The facilities may also hold significant internal storage.

An LSE facing a short-duration brown-out wishes to acquire large blocks of power from these large loads, perhaps along a single transmission line. The market Segment permits participation from all facilities connected to that circuit. In this example, these facilities provide power or load shedding in the manner of peaking generators.

The LSE sends short-duration Quotes to facilities along the circuit. Any facility may lift the Quote to execute a Transaction and then begin supplying power, or dropping previously purchased power, for the contracted duration.

4.5. Negotiation with Facilities with Co-located Power

This example is similar to the one above in 4.4, but the power deficit lasts longer, perhaps after a failed transmission asset. The LSE could send a Request for Quotes (RFQ) for a specific time and amount, or send Indications of Interest to invite more flexible proposals. The RFQ can mark All-or-None if the LSE wants a single source to fulfill the requirement.

Facilities may submit Quotes with response times and quantities tied to workloads and orderly operations. A facility may support only part of the requested interval, given current operations, energy storage, or fuel storage. A facility may rely on additional generation that takes time to call in or warm up. The proposed start time may lag the request.

The LSE may lift some submitted Quotes and may start a follow-on negotiation for additional power.

4.6. Black-Start of Circuit or Microgrid

A distribution operator may use a black-start market to coordinate a restart [12]. Different microgrids may have storage and generation not visible to the operator. This example presents one possible market scenario.

The operator announces an auction to all market participants, who submit Tenders to buy and to sell. The auction includes an indicative (non-transactable) opening price. The operator may determine that the circuit remains unstable based on the puts and calls of the just-completed auction. The market could then cancel all Tenders, and the operator could announce a new auction, perhaps at a higher opening price. Steps repeat until the operator computes a stable startup configuration and notifies the market to close the auction. The market creates Transactions and notifies the startup participants.

4.7. Negotiation for Substation with Constrained Transmission

A transmission line feeds a distant substation that supports several industrial users. The line already runs at capacity. Excessive consumption by any one industrial user would cause voltage sags and could raise maintenance costs in all the facilities.

Consider an industrial facility that wants extended uninterrupted power for either Tuesday or Wednesday evening this week. The transmission line feeding the substation cannot supply this load. This Party submits an RFQ to each of the other nodes on the same substation requesting a number of continuous hours of power. A potential counterparty may reply with a Quote that only meets part of the duration, or perhaps a different time period entirely, based on that facility's availability. Negotiation continues to find an acceptable solution, with perhaps multiple facilities selling power to enable the original Party's process to run.

4.8. Direct Power Allocation

If a Segment permits, Parties may register OTC Transactions with the Market Engine. Parties may transfer power off-market (that is, sell outside the market) for any reason they mutually agree to. A gift or other transfer still must appear as a Position change for both Parties. If only one Party records the gift, later settlement can charge the same energy twice.

Consider four residential neighborhood microgrids and a critical medical facility. In an emergency, with high hospital use and no power from outside the market, OTC Transactions transfer power from each neighborhood to the hospital. Each Party then holds a new Position. Markets inside those microgrids adapt to the new Positions. The same pattern fits a campus or a military base with shared ownership.

Other scenarios:

- In a neighborhood, one home may transfer power to another. While the local market may be denominated in 1 kW units, the first homeowner may choose to donate exactly the production of their rooftop PV in odd lots (e.g., 3.2 kWh). This is reported to the LMA.
- In a tactical microgrid, power follows command intent. All power may be redirected to charge a fleet of vehicles. Then local markets are forced to adapt to new positions.
- Inside a microgrid, Parties transfer power to a neighborhood storage system in advance of a storm.

5. Conclusion and Recommendations

The OASIS Common Transactive Services has been completed [7] and an open-source reference implementation is available [9]. The standard itself has been introduced in Section 2 and in Appendix A. Some examples of how CTS can be used to solve grid problems have been shared in Section 4. Section 3 presents recommendations for utilities, microgrid developers, product vendors and regulators that want to see the advantages of local energy markets and potential of CTS to be realized to the benefit of the electric energy industry, the grid, and the customers. These recommendations can be summarized as:

(1) Focus pilots where Parties can already buy and sell at the edge, per 3.1.

(2) Use large loads as the first commercial use case, per 3.2.

(3) Stand up a local markets stakeholder organization, per 3.3, and tackle the technical work items identified (3.4) as part of the work program of this organization.

(4) Regulators work toward developing best practice regulations for local energy markets, per 3.5.

By implementing standardized CTS local energy markets, starting where most suitable, developing best practices, and working in collaboration, we can see grid reliability and local resource optimization realized.

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Appendix A. Market Semantics Glossary for CTS

Terms below follow the OASIS CTS specification. This appendix restates the subset used in this note.[5]

A.1. Products and Instruments

All trading concerns Products: a quantity of power delivered over a duration. An Interval names a Duration anchored by a Starting Time. CTS trades Instruments: Products in specific Intervals.

A.2. Market Participant Roles

CTS participant roles include the Party (Market User Agent, Figure 1), the Market Engine (LME), and the Market Operator. The Engine matches Tenders and records Transactions and Positions. The Operator may refuse a Transaction that would harm the physical system. The Local Market Agent (LMA) is the Operator's market-facing agent.

A.2.1. Parties and Positions

CTS calls every market participant a Party. A Party may buy in one Interval and sell in another. Position equals net purchases and sales for each Interval.

A.2.2. Market Engine

The Market Engine records Transactions and each Party's Position.[6] When Parties submit Tenders, the Engine matches a buy with a sell, creates the Transaction, and notifies both Parties.

A.3. Market Operator

The Market Operator protects the physical system and acts through the LMA. The Operator may change Segment state or refuse a Transaction. Refusal for circuit limits performs the distribution reliability override FERC 2222 assumes. The Engine matches and records; it does not decide reliability overrides. CTS does not specify how the Operator talks to the wires or to the Engine.

A.4. Market Types

CTS messages and terms work for each market type. Markets may run wholesale, retail, or peer-to-peer, and next-day or real-time.

[5] https://docs.oasis-open.org/energyinterop/ei-cts/v1.0/ei-cts-v1.0.html
[6] The CTS open-source implementation including three Market Engines (at https://github.com/EnergyMashupLab/eml-cts) uses Parity Trading, an open-source NASDAQ market-engine implementation.

A.4.1. Order Book Market

An order-book market keeps buy and sell Tenders in a live ledger. The Engine executes a Transaction as soon as price and quantity match. Parties discover price continuously, without waiting for a batch auction.

A.4.2. Auction

In an auction, Parties submit Tenders before a deadline. The Segment then picks a clearing price at which buy and sell quantities balance. For Tenders to buy above that price, and Tenders to sell below it, the Engine creates Transactions for those Tenders at the clearing price.

Power markets have usually called this a “double auction.” CTS uses the FIX term Auction.

A.4.3. Quote-Driven Market

Parties post Quotes. A counterparty may lift (accept) a Quote, which creates a Transaction on those terms. The market manager checks that the Quote remains active and that the Transaction meets business terms. A lift commits both Parties.

In contrast, one-way price distribution uses Indicative Quotes; Transactions appear later through meter reconciliation.

A.4.4. Spot Market

Spot markets balance short-term gaps between Position and metered energy. They run beside forward Transactions and support self-dispatch and settlement. That activity adds liquidity and eases voltage and capacity stress.

A.5. Market Terms

A.5.1. Market Segments and Warrants

A machine-readable market description tells a Party how to trade. Each Market contains one or more Segments. A Segment names its products and trading window, for example one-hour forward products or five-minute products.

Warrants distinguish Products across Segments. One Segment may trade only solar power; another may carry no warrant. Every Instrument bought in a warranted Segment carries that warrant.

The Party picks the Segment that fits its goals. Each Segment description includes a market model typology (MMT), which names the trading pattern. Parties use Segments they understand.

A.5.2. Tender and Transaction

A Tender offers to buy or sell an Instrument at a price. The Engine matches two Tenders to create a Transaction. After execution, neither Party may change the Transaction. Either Party may cancel a Tender before execution.

A Put offers to sell. A Call offers to buy. CTS uses those words when they read more clearly.

A.5.3. Position, Delivery, and Settlement

Position equals the net of executed Transactions for a Party. The Party may resell from that Position before delivery. A Party may build a Position across products, for example a one-hour day-ahead buy and a five-minute local sale of the unused portion.

The Engine usually derives Delivery from meters. CTS also permits other measurement or inference. Settlement compares Delivery to Position and creates imputed Transactions for the difference.

CTS does not define the settlement business process. Markets may use Indicative Quotes (A.5.4) or the last executed Spot price (Section A.4.4). The price for unplanned consumption may differ from the price for unused Position. CTS defines neither banking nor settlement operations.

A.5.4. Quotes

A Quote functions as a Tender sent to a counterparty rather than to the Engine. The counterparty lifts it to create a Transaction, then notifies the Engine so both Positions update. A Quote may require All-or-None. Otherwise, the receiver may lift only part. The Operator may refuse execution if the circuit cannot take the trade or if another Party already lifted the Quote.

Quotes come in two kinds: Actionable and Indicative. An Indicative Quote carries information only. A counterparty cannot lift it.

A Party that wants a product not on the market may submit a Request for Quotation (RFQ). A counterparty may return a Quote. The original Party lifts that Quote to accept.

A.5.5. Tickers and Subscriptions

Parties may subscribe to Segment activity. CTS calls these feeds Tickers. Tenders, Transactions, and Quotes may appear on a Ticker.

Those messages name the submitting Party. Transactions and some Quotes also name the counterparty. A consumer market may replace IDs with placeholders. A market may still require real IDs for the utility or an upstream microgrid.

Messages carry all fields, which reduces optionality that can introduce errors. Placeholder IDs remain a policy choice, not a protocol choice.

A.5.6. Over-the-Counter Transactions

OTC Transactions originate outside the Market. CTS does not require standards-based machine-to-machine negotiation for that agreement. The Parties arrive at price and quantity by whatever means they choose, then register the Transaction with the Engine, which updates both Positions.

A.5.7. Multi-Leg Orders

If the Segment allows it, a Tender or Quote may package several Instruments as legs. A multi-leg order may include both Puts and Calls.

A.6. Trading Sessions

A trading session names the hours a market accepts Tenders. Financial markets often open and close on a weekday clock and speak of opening and closing prices. Power markets more often run all day. They may still close during failure or repair. See Black-Start of Circuit or Microgrid (Section 4.7).

Session subscriptions announce Segment state.