TE Background

What is it, why does it matter, and where is it headed?

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TE Challenge Kickoff Meeting, NIST, September 10 – 11, 2015
Outline

- What is TE? – Background and definitions
- Why does it matter?
- Where have we been on this journey?
- Where are we headed?
Definition of Transactive Energy

From GridWise® Architecture Council’s Transactive Energy Framework*

“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”

Paraphrased to fit a tweet:

“a set of techniques that encompass both economic and control mechanisms together to balance an electric power system using distributed agent based collaboration”

A means of characterizing and comparing: TE System Attributes

- Architecture
- Extent
- Transaction
- Transacting parties
- Transacted Commodities
- Assignment of value

- Value discovery mechanism
- Temporal variability
- Interoperability
- Alignment of objectives
- Assuring stability
Transactive energy systems implement some form of highly coordinated self-optimization.

Transactive energy systems should maintain system reliability and control while enabling optimal integration of renewable and DERs.

Transactive energy systems should provide for non-discriminatory participation by qualified participants.

Transactive energy systems should be observable and auditable at interfaces.

Transactive energy systems should be scalable, adaptable, and extensible across a number of devices, participants, and geographic extents.

Transacting parties are accountable for standards of performance.
How Transactive Control & Coordination Works: An Illustrated Example

1. Automated, price-responsive device controls express customer’s flexibility

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

3. Utility aggregates curves from all customers

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

Price-Discovery Mechanism

Customer Price-Flexibility Curve*

* Labels removed before sending to utility
Why does it matter?
Motivation for Transactive Energy Systems

The changing nature of the electric power system:

- Increased penetration of distributed energy resources – Increased variability
- Intelligent devices / internet of things becoming our reality – increased flexibility

TE responds to the need to coordinate variability and flexibility
Good Transactive System Designs Address Key Barriers to Deploying & Utilizing DERS

- Manage large-scale deployments of millions of DERs
- Smooth, stable, predictable, i.e. a virtual control system → response is automated
- DERS largely owned, operated by 3rd parties → responsiveness is voluntary
- Motivates continuous DER utilization with prices, incentives

- Scalable
- Controllable
- Owner Autonomy
- Max. Privacy & Min. Sensitive Info.
- Interoperability
- Cost Effective
- Engaging
- Equitable

- Level playing field for all types of DERS, uses lowest cost resources
- Shares costs & benefits in proportion to value provided/received by all parties (incl. non-participants)
- Maximizes value to grid & DER owners by supporting response to multiple value streams
- Minimizes sensitivity and complexity of information transferred: value & quantity as f(time)
Time Scales

Current range for Transactive Systems

Adapted from Alexandra von Meier, CIEE
Used with permission
Synergies Between Transactive Systems for Grid Integration and Building Energy Services and Energy Efficiency in Buildings

- Add New Value Streams
- Improved performance
- Added Benefit

**Benefits**
- Demand Response (Utility or 3rd-Party Investor)

**Costs**
- ROI
- Customer Incentives
- Equipment
- Installation
- Network & Comms.
- M & V

**Costs**
- Equipment & Materials
- Installation
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**Benefits**
- Improved performance
- Added Benefit
- Energy Cost Savings
- Reduced O&M
- Increased Comfort
- Carbon / RPS Credits

- Wholesale / Production Cost Savings
- Ancillary Services
- Distribution Capacity
- Distribution Voltage Mgmt. re. Solar PV

- $ Reduced O&M
- Increased Comfort
- Carbon / RPS Credits

- 3rd Party Investment
- Share Common Investments

- Improved performance
- Added Benefit
Where have we been on this journey?
Some Existing TE Systems

- Double auction market
  - PNNL – GridWise Olympic Peninsula Demonstration
  - TNO PowerMatcher\(^1\)
  - PNNL / Battelle – AEP GridSmart Demonstration Project

- Transactive Control (and Coordination)
  - Battelle / PNNL Pacific Northwest Smart Grid Demonstration\(^2\)

- TE Mix
  - TEMix\(^3\)

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\(^1\) See [http://flexiblepower.github.io/](http://flexiblepower.github.io/)

\(^2\) See [http://www.pnwsmartgrid.org](http://www.pnwsmartgrid.org)

\(^3\) See [http://www.temix.net/](http://www.temix.net/)
## TE Systems Compared

<table>
<thead>
<tr>
<th>TE System</th>
<th>Architecture</th>
<th>Transaction</th>
<th>Time</th>
<th>Decision Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double Auction</td>
<td>Distributed agent based</td>
<td>Bids with market closing</td>
<td>Next time interval (e.g. 5 minutes)</td>
<td>Info for Market price and bid amount</td>
</tr>
<tr>
<td>Transactive Control and Coordination</td>
<td>Distributed network</td>
<td>Iterative exchange of price forecast and load forecast</td>
<td>72 hour forecast horizon – variable granularity</td>
<td>Price and load forecasts – using local info and TC signals</td>
</tr>
<tr>
<td>TE Mix</td>
<td>Decentralized</td>
<td>P2P,bilateral, retail tariff or exchange agreements between buyers and sellers</td>
<td>Forward positions taken through tenders and transactions</td>
<td>Local and other info needed to establish tenders and transactions</td>
</tr>
</tbody>
</table>
Journey on Transactive Concepts – US field projects

Olympic Peninsula demo, ca. 2006-07
- Established viability of transactive, decision-making to coordinate to achieve multiple objectives
  - Peak load, distribution constraints, wholesale prices
  - Residential, commercial, & municipal water pumping loads, distributed generation

AEP gridSMART® demo, ca. 2010-2014
- PUC-approved RTP tariff developed
  - Provides dynamic, real-time incentive to respond
  - Reflects real-time prices in PJM energy market
  - Manages AEP T&D constraints and peak load

Pacific NW Smart Grid demo, ca. 2010-2015
- Key advancements made by PNWSGD
  - Wind balancing
  - Developed look ahead signals
  - Formalized standardized definition of transactive node, test rig, etc.
  - Showed how “old school” approaches (e.g. direct load control) can be integrated with a transactive schema
Building the Transactive Systems Community – GridWise® Architecture Council

GridWise Transactive Energy Framework
Version 1.0
Prepared by
The GridWise Architecture Council
January 2015

TRANSACTION ENERGY
Transported energy prices enable customers of all sizes to join traditional providers in producing, storing, and selling electricity—using automated control—to drive a reliable and cost-efﬁcient electricity system

WHY IT’S IMPORTANT?
Customers can choose to produce, buy and sell electricity.
Class energy resources are more reliable.
It’s essential to have a variety of energy resources.
Resilient electric networks
Improve regional integration

3rd International Conference and Workshop on Transactive Systems
Portland, OR
May 17 – 19, 2016

See http://www.gridwiseac.org
Where is it going?
Threads

- Establishing value
- Assuring performance
- Persistent deployments at scale
Developing methodology for assessing value of coordinated integration of Distributed Energy Resources (DER)

Structured approach

Enables

- Assessing potential value (benefit) for different transactive approaches
- Enables one of compare valuation approaches, e.g., why did these different approaches predict different value?

PNNL led project

GWAC convened workshops

- Sept. 29 – 30 at ERCOT in Texas
Assuring performance

➤ Market interfaces and structures
  - Interfaces between distributed, transactive systems and existing bulk power system markets
  - Value at the micro level

➤ Control system theory
  - Time scales involved AND devices and systems involved different than bulk power system
  - Overall complexity in distribution systems higher
  - Must be able to express transactive approaches from control system theory point of view to enable analysis of stability, convergence and optimality

➤ Modeling and simulation
  - Supports all of the above items
  - Provides insight into value and business cases
  - Allows assessment of larger scale deployments – value and performance
Persistent deployment at scale

- Regulators and utilities beginning to consider consumer centric distribution utility operating models
  - NY REV
  - CA – AB327 Distribution IRP
  - WA – Distribution IRP
  - HI – PV integration

- Internationally
  - Australia
  - Europe

- Drivers are strong with increased deployment of wind and solar resources, storage, and growth of electric vehicles
Considerations for Modeling and Simulation

- Time
- Coupling elements of TE system to modeling and simulation of grid and end-uses
- Modeling and simulation of existing markets
- Scale up
- Coupling between TE system and existing markets and/or grid or building controls