Transactive Energy Systems Tutorial Part 1

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Presented at TESC 2018
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INTRODUCTIONS
Your Instructors

- Dr. Ron Melton – Pacific Northwest National Laboratory
- Mr. Ron Bernstein – RBCG Consulting
- Ms. Tanya Barham - PECI
Dr. Ron Melton

Ron Melton is the Team Lead for Electricity Infrastructure Integration at PNNL. He is the Principal Investigator leading development of GridAPPS-D, an open platform for developing advanced distribution system planning, operations, control and management applications. He is a member of the DOE Grid Architecture core team and the DOE GMLC Interoperability project. He was the Project Director for the Pacific Northwest Smart Grid Demonstration one of the largest transactive energy system field projects in the world. He is the former administrator of the GridWise Architecture Council.
Mr. Ron Bernstein (ME, MS-PSY, MS-PHI, LCP)

- CEO – RBCG, LLC
- CEO/Executive Director – LonMark International
- GWAC Council Member - Elected
- Leadership/Member/Advisor/Instructor: ASHRAE, CTA, UPnP, IES, MSSLC, LMI, ANSI/CTA R7, CABA IBC, HPBCCC, CMU, APPA, SBI, GMLC, GWAC, IAS

Mr. Bernstein is CEO of RBCG, an engineering and business consulting company. He has over 30 years’ experience with control automation design, specification development, educational program development, and facility master planning. His is a co-author of the latest ASHRAE BMS Guidespec, training developer/instructor, co-author of texts on Control Networking and Building Automation, author/advisor of control standards for the US DOD, healthcare, retail giants, and the oil/gas industry. He is an elected member of the US DOE Gridwise Architecture Council and a partner of the Grid Modernization Laboratory Consortium. He is the Executive Director of LonMark International a non-profit standards development association. He holds a BS in Mechanical Engineering from CMU, a Masters in Psychology, and a Masters in Philosophy.
Ms. Tanya Barham
Participant Introductions

• Name
• Organization
• What do you hope to learn from this tutorial?
GridWise® Transactive Energy Framework

- **Purpose**
  - Build a community of transactive energy practitioners
  - Common definitions of terms
  - Promote discussion at the conceptual level

- **Audience expected to be familiar with**
  - GWAC Interoperability Context Setting Framework
  - Energy markets and related business models
  - Electric power systems and end uses

What is a framework?

- Material at a high, organizational or conceptual level
- Neutral presentation providing common ground for stakeholder discussions of issues and concerns related to a large, complex system
- Broad and overarching
- **Independent of specific models, designs, and implementations**
What's old is new again – Homeostatic Control

Our response to the problems of today's utilities is called Homeostatic Control. Homeostastic Control is founded on two major principles:

- Feedback Between Customer and Utility
- Customer Independence

Schweppe, et, al, MIT – late 70's early 80's
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 Principles

<table>
<thead>
<tr>
<th>Highly automated, coordinated self-optimization</th>
<th>Provide non-discriminatory participation by qualified participants</th>
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<tbody>
<tr>
<td>Transacting parties are accountable for standards of performance</td>
<td>Observable and auditable at interfaces</td>
</tr>
<tr>
<td>Maintain system reliability and control while enabling optimal integration of distributed energy resources</td>
<td>Scalable, adaptable, and extensible across a number of devices, participants, and geographic extents</td>
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Principles: High-level requirements for TE systems that provide an additional point of reference for communicating with stakeholders and identifying common ground within the transactive energy community.

From GridWise Architecture Council’s Transactive Energy Framework
http://www.gridwiseac.org/about/transactive_energy.aspx
Transactive Energy Systems
Outline

• Examples of TE systems – TE System Definition
• Architectural Consideration
• TE System Deployment Considerations
• Transactive Control and Coordination – “A day in the life of a transactive grid”
Examples of TE systems
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

• TE Mix
  – TEMix\(^{TM}\)\(^2\)

\(^1\) See http://flexiblepower.github.io/
\(^2\) See 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>Consensus</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>Bilateral Trades</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>
Spectrum of Fundamental Transactive System Mechanisms

Foundation in Economics
- Consensus
- Double Auctions
- Bilateral Trades

Foundation in Physics

For more details Don Hammerstrom will present Comparing Fundamental Transactive Energy System Mechanisms during the conference.
Double Auction Market Example from AEP

gridSmart™

Transactive Cooling Thermostat

More Comfort

More Savings

$/kWh

Price

Bid

Indoor Temperature

T_{air}  T_{set}

Real-time Market Clears Customer Bids

Price ($/MWh)

Demand Curve (customer bids)

Node Supply Curve

Rated Node Capacity

Load (MW)

P_{clear}  P_{whole-sale}

Q_{clear}
Transactive Control and Coordination – PNW Smart Grid Demo Approach

- Functions, e.g., battery storage
- External Interfaces: Utility systems, e.g., SCADA, DMS, etc
- Neighboring Nodes
- Transactive Feedback Signal
- Transactive Incentive Signal

Operational Objectives

Status and Opportunities
Transactive Control and Coordination – PNW Smart Grid Demo Approach

Toolkit Functions, e.g., battery storage

External Interfaces

Local Interfaces

Asset System, e.g. Battery
Utility systems e.g. SCADA, DMS, etc

Transactive Feedback Signal
Transactive Incentive Signal

Neighboring Nodes
TeMix™ – structure and approach

Consumers, Prosumers, and DERs

Device  Device  Device  Device
Service Interface

Tenders and Transactions

Retail Transaction Platforms

Distribution Transport  Energy

Tenders and Transactions

Existing Distribution Operators

Existing Wholesale Platforms

Wholesale Parties  Forwards and Futures  Balancing Operators

Interoperaible Transactive Retail Tariffs

One year  One month  One hour  Five minute

One year  One month  One hour  Five minute
Transactive Energy System Interaction Model

Transactive Agent
- Optimize local business objective
- Register & qualify capabilities to participate in other’s programs
- Assess terms & qualifications of others
- “Bid” for services needed, evaluate & accept “offers” from supplier(s)
- Value offers for services rendered, evaluate & accept bids from buyers
- Control local assets according to agreement
- Deliver & receive ”products” required by transaction
- Deliver & receive data, measurements, & verification required by transaction
- Financial settlement & reconciliation

Registration/Qualification
- Registration Process
- Operations Process
- Measurement & Verification
- Settlement & Reconciliation

One or more other Transactive Agents

Remote Data
- Local Data
- Local Control

Local Devices/Systems
- Local Intelligence
- Transactive Interaction
Workshop Question #1:

• What is your view of how Transactive Energy can be applied to a real world project/situation/opportunity?
  – How do you see TE providing value?
  – Who are the relevant parties?
  – What are the barriers?