Transactive Energy Systems Tutorial Part 1

June 12, 2018

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.

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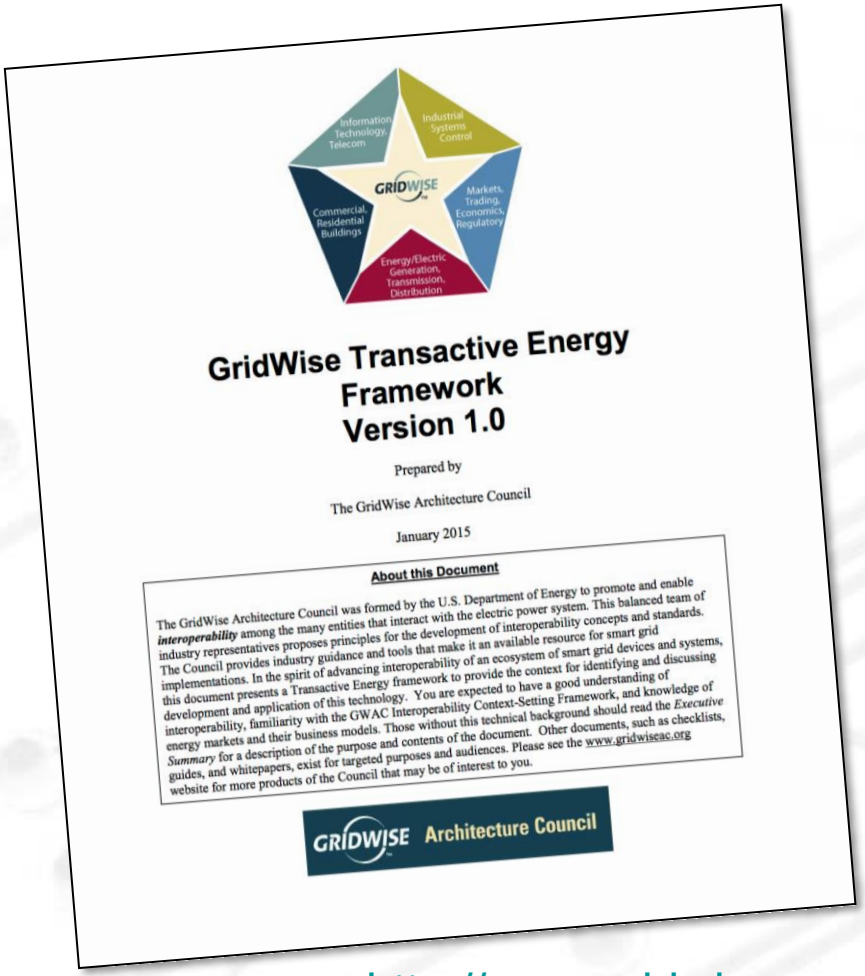
Ms. Tanya Barham

Participant Introductions

- Name
- Organization
- What do you hope to learn from this tutorial?

GridWise® Transactive Energy Framework



Information Technology, Telecom
Industrial Systems Control
Markets, Trading, Economics, Regulatory
Energy/Electric Generation, Transmission, Distribution
Commercial, Residential Buildings

GridWise Transactive Energy Framework Version 1.0

Prepared by

The GridWise Architecture Council

January 2015

About this Document

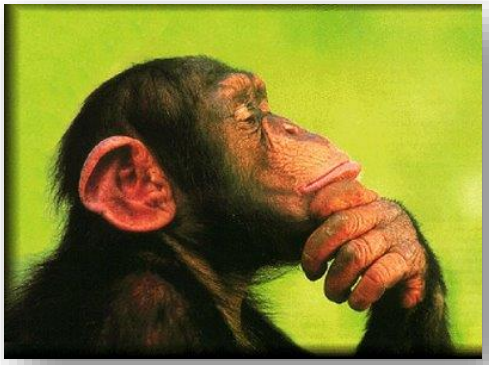
The GridWise Architecture Council was formed by the U.S. Department of Energy to promote and enable ***interoperability*** among the many entities that interact with the electric power system. This balanced team of industry representatives proposes principles for the development of interoperability concepts and standards. The Council provides industry guidance and tools that make it an available resource for smart grid implementations. In the spirit of advancing interoperability of an ecosystem of smart grid devices and systems, this document presents a Transactive Energy framework to provide the context for identifying and discussing development and application of this technology. You are expected to have a good understanding of interoperability, familiarity with the GWAC Interoperability Context-Setting Framework, and knowledge of energy markets and their business models. Those without this technical background should read the *Executive Summary* for a description of the purpose and contents of the document. Other documents, such as checklists, guides, and whitepapers, exist for targeted purposes and audiences. Please see the www.gridwiseac.org website for more products of the Council that may be of interest to you.

GRIDWISE Architecture Council

- 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

http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf

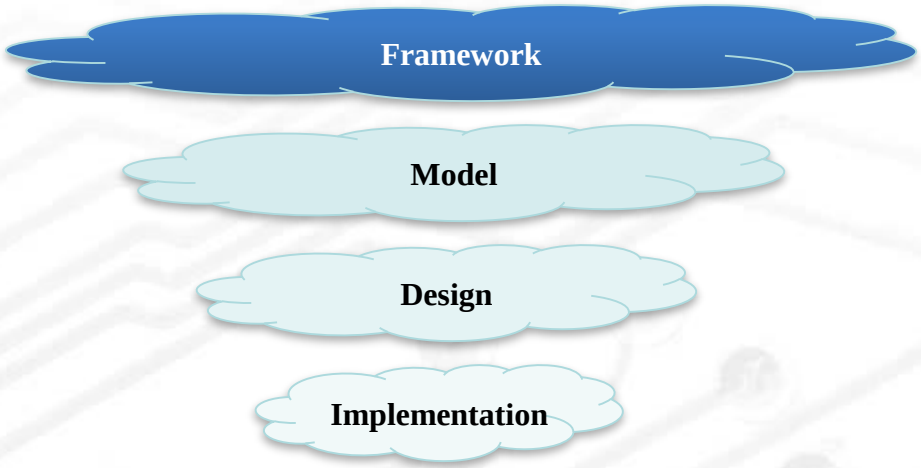
GWAC 5-Point Framework



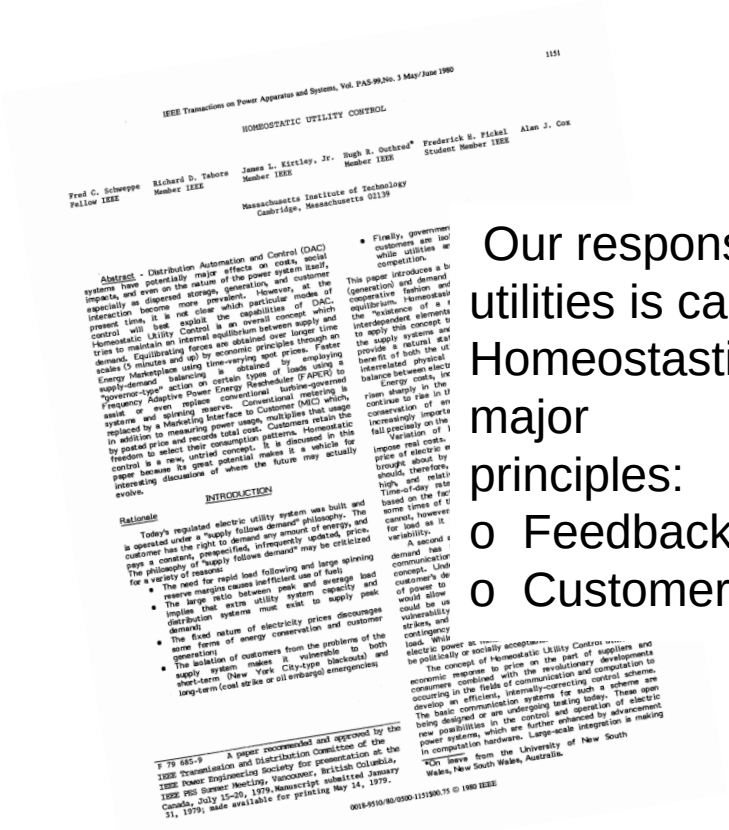
http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf

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**



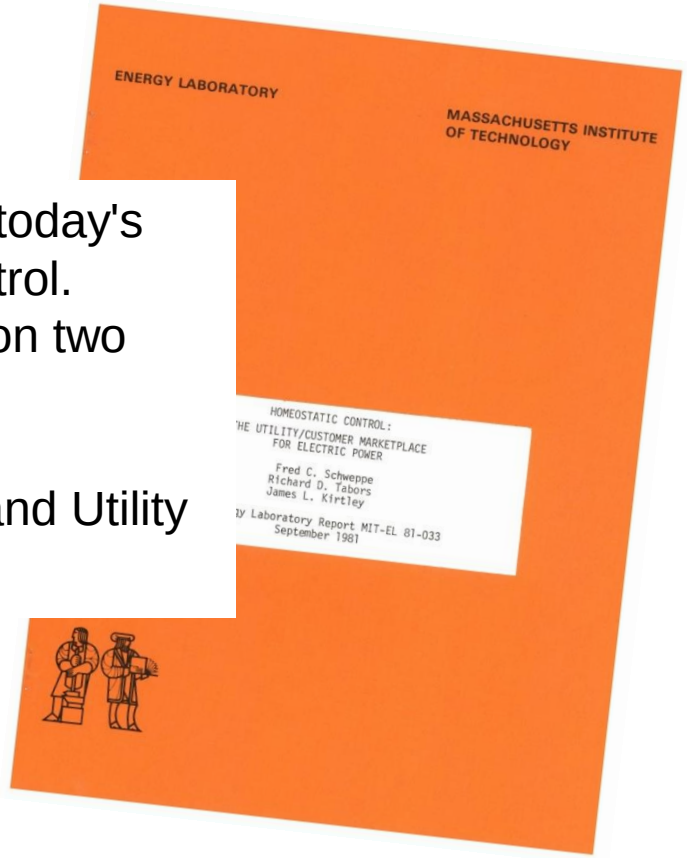
What’s old is new again – Homeostatic Control


IEEE Transactions on Power Apparatus and Systems, Vol. PAS-99,No. 3 May/June 1980

HOMEOSTATIC UTILITY CONTROL

Fred C. Schweppe, Fellow IEEE; Richard D. Tabors, Member IEEE; James L. Kirtley, Jr., Member IEEE; Hugh R. Outhred*, Member IEEE; Frederick H. Pickel, Student Member IEEE; Alan J. Cox

Massachusetts Institute of Technology, Cambridge, Massachusetts 02139


ENERGY LABORATORY

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

HOMEOSTATIC CONTROL:
THE UTILITY/CUSTOMER MARKETPLACE FOR ELECTRIC POWER

Fred C. Schweppe
Richard D. Tabors
James L. Kirtley

Laboratory Report MIT-EL 81-033
September 1981

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

- o Feedback Between Customer and Utility
- o 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*"

* http://www.gridwiseac.org/pdfs/te_framework_report_pnnl-22946.pdf

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

Highly automated, coordinated self-optimization	Provide non-discriminatory participation by qualified participants
Transacting parties are accountable for standards of performance	Observable and auditable at interfaces
Maintain system reliability and control while enabling optimal integration of distributed energy resources	Scalable, adaptable, and extensible across a number of devices, participants, and geographic extents

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™[2]

[1] See http://flexiblepower.github.io/
[2] See http://www.temix.net/

TE Systems Compared

TE System	Architecture	Transaction	Time	Decision Inputs
Double Auction	Distributed agent based	Bids with market closing	Next time interval (e.g. 5 minutes)	Info for Market price and bid amount
Consensus	Distributed network	Iterative exchange of price forecast and load forecast	72 hour forecast horizon – variable granularity	Price and load forecasts – using local info and TC signals
Bilateral Trades	Decentralized	P2P, bilateral, retail tariff or exchange agreements between buyers and sellers	Forward positions taken through tenders and transactions	Local and other info needed to establish tenders and transactions

Spectrum of Fundamental Transactive System Mechanisms

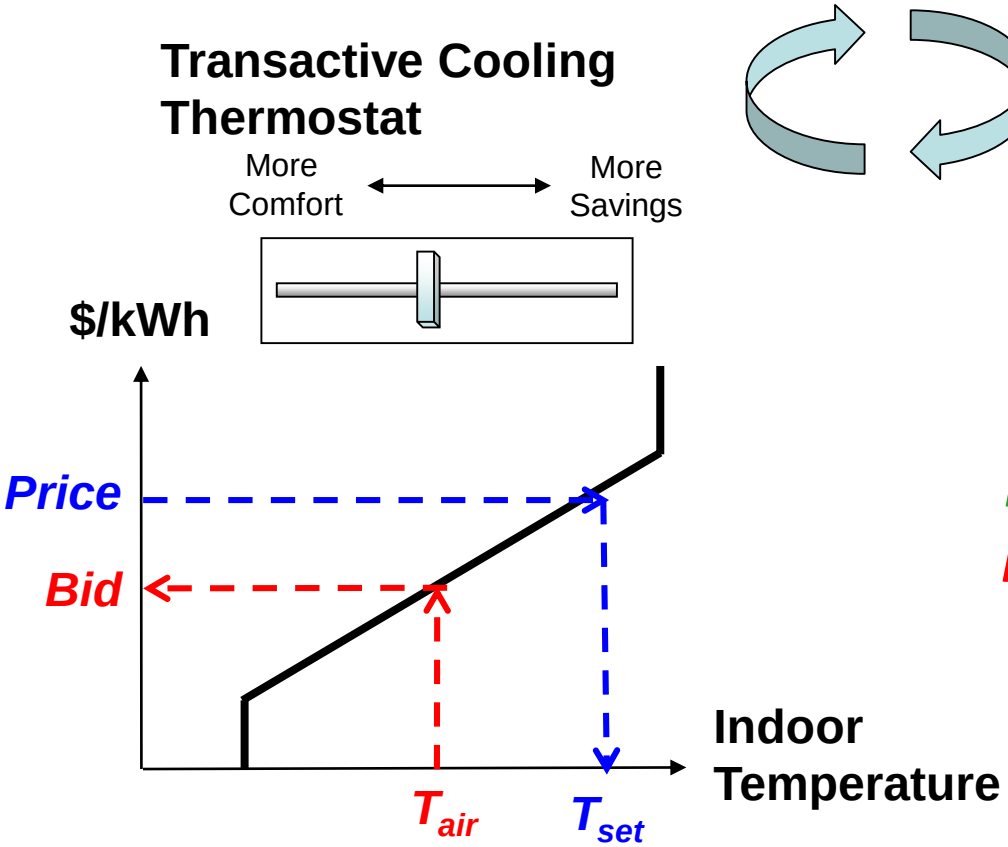
Foundation in Economics

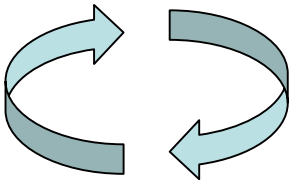
Consensus | Double Auctions | Bilateral Trades

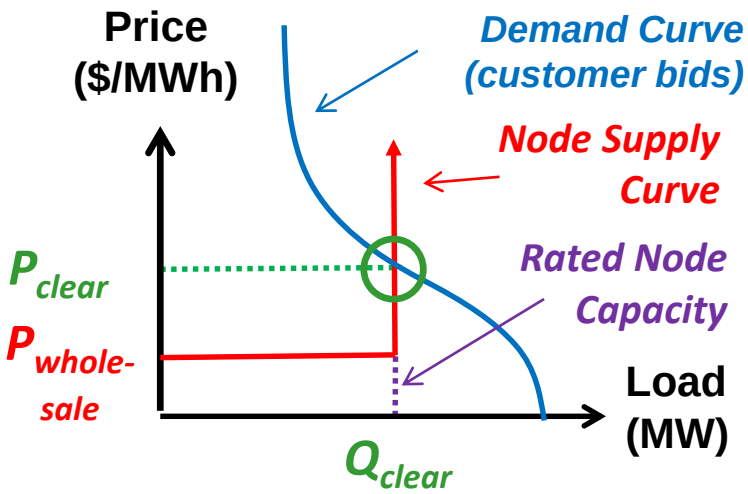
Foundation in Physics

For more details Don Hammerstrom will present Comparing Fundamental Transactive Energy System Mechanisms during the conference.

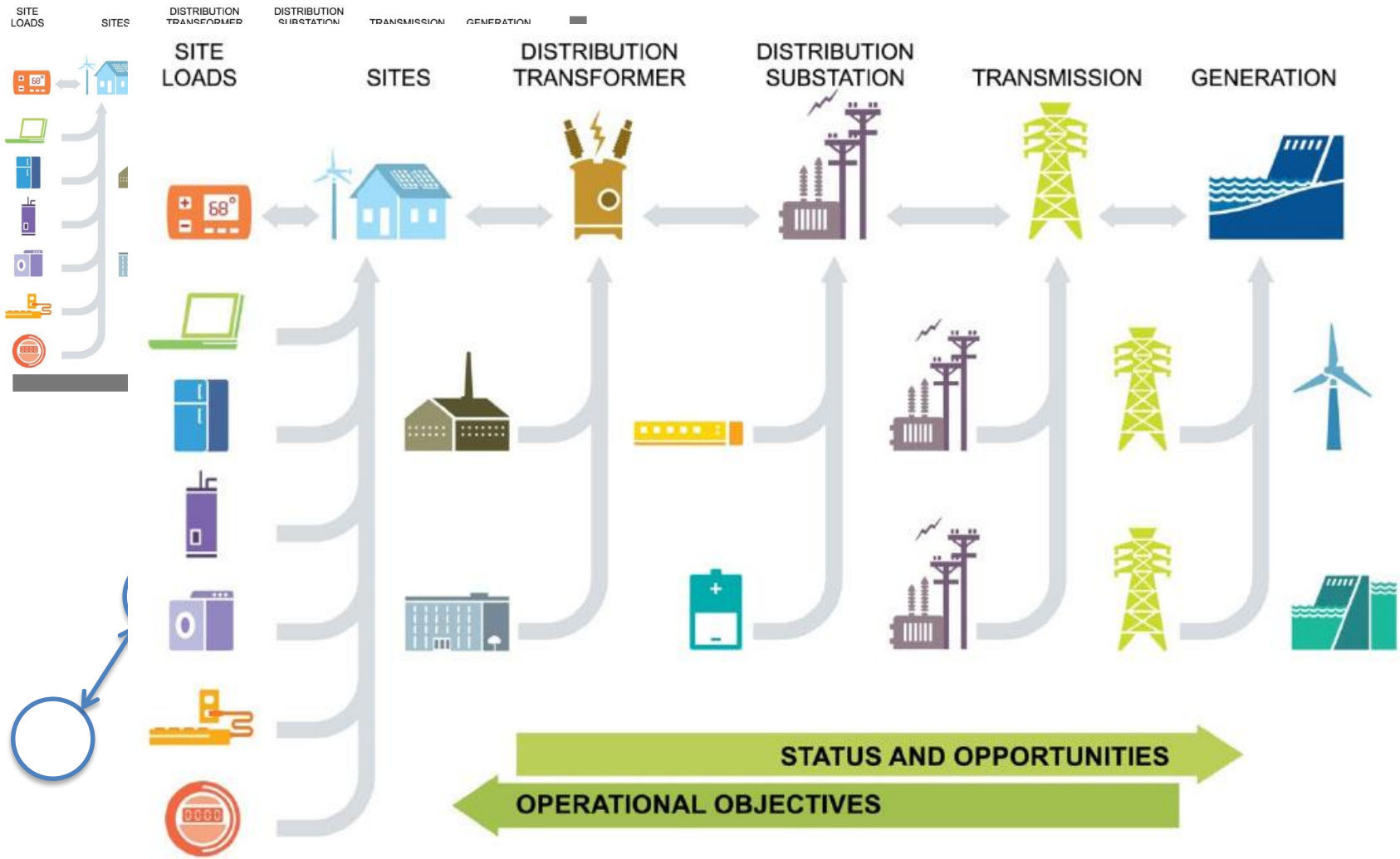
Double Auction Market Example from AEP gridSmart™







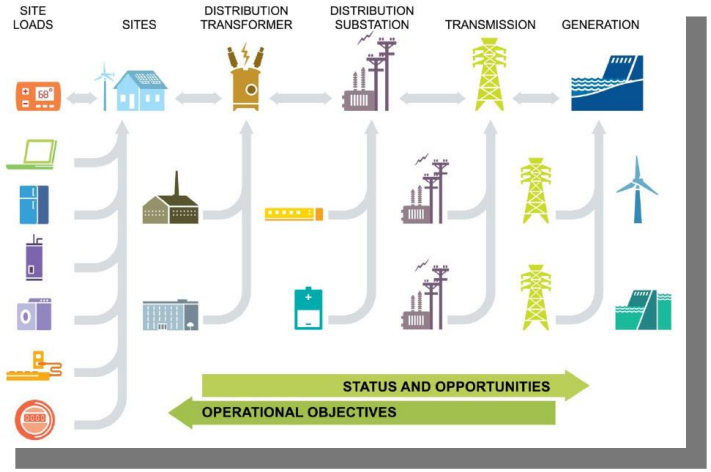
Transactive Control and Coordination – PNW Smart Grid Demo Approach

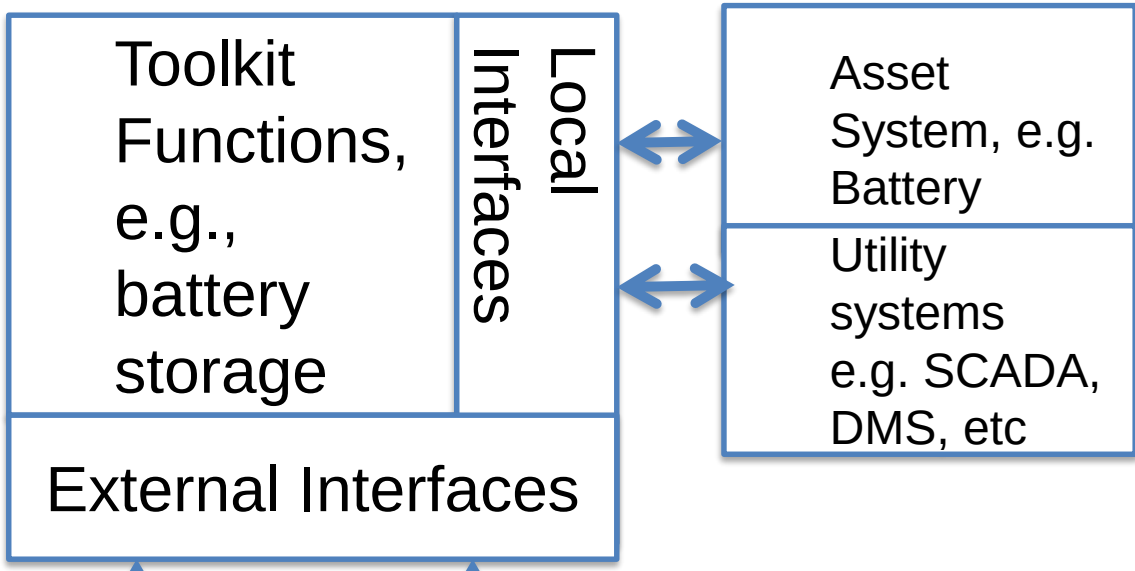


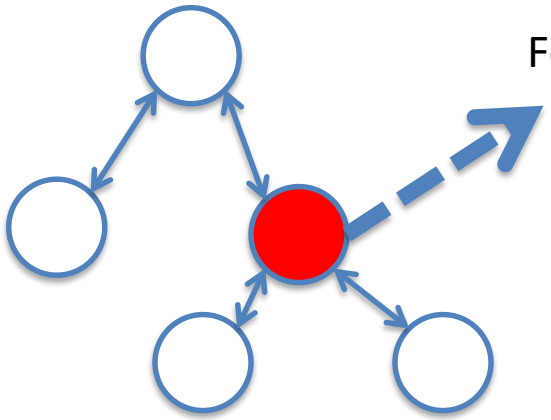
n, e.g.

ns
CADA,
etc

Transactive Control and Coordination – PNW Smart Grid Demo Approach





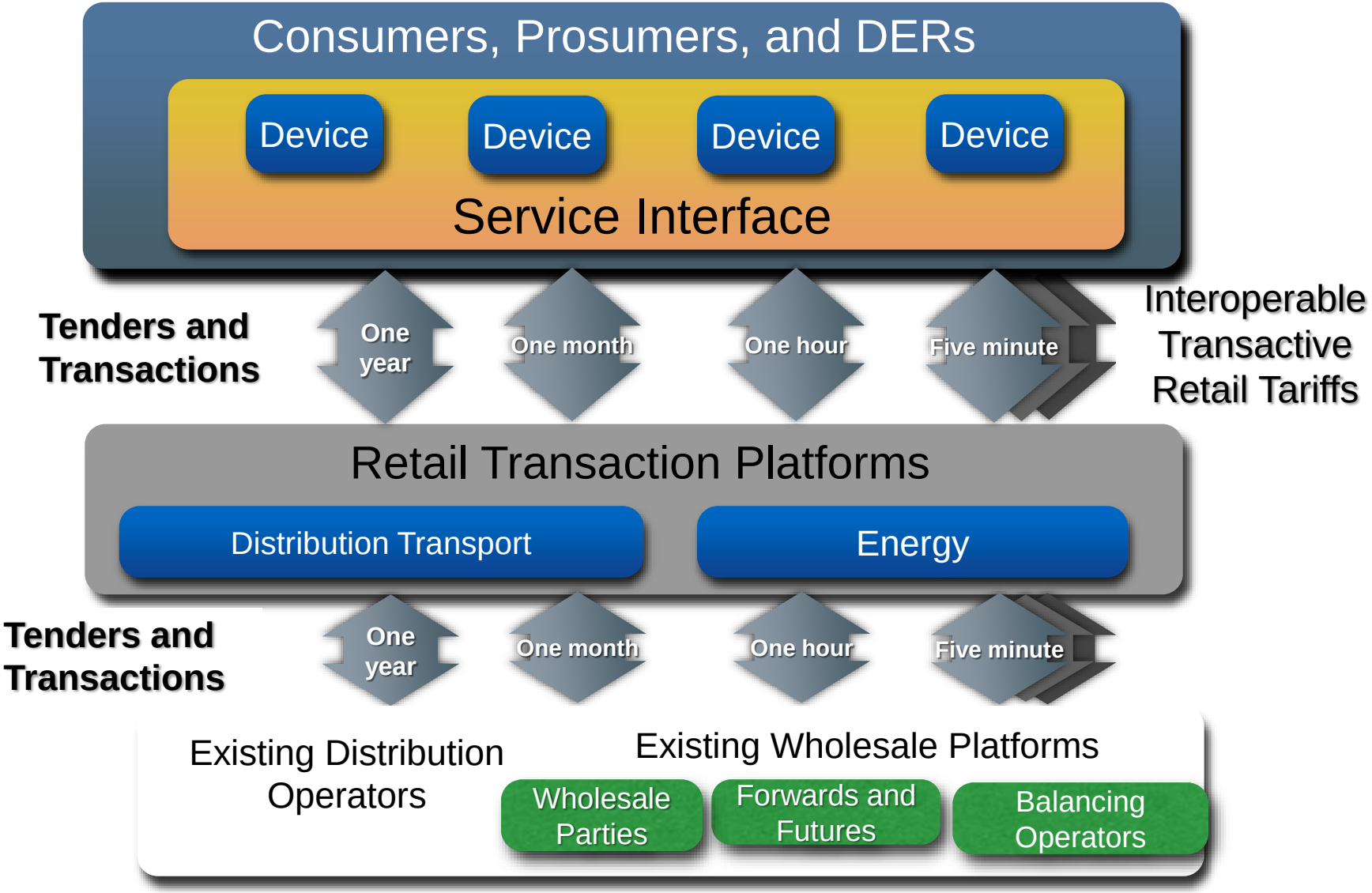


Transactive Feedback Signal

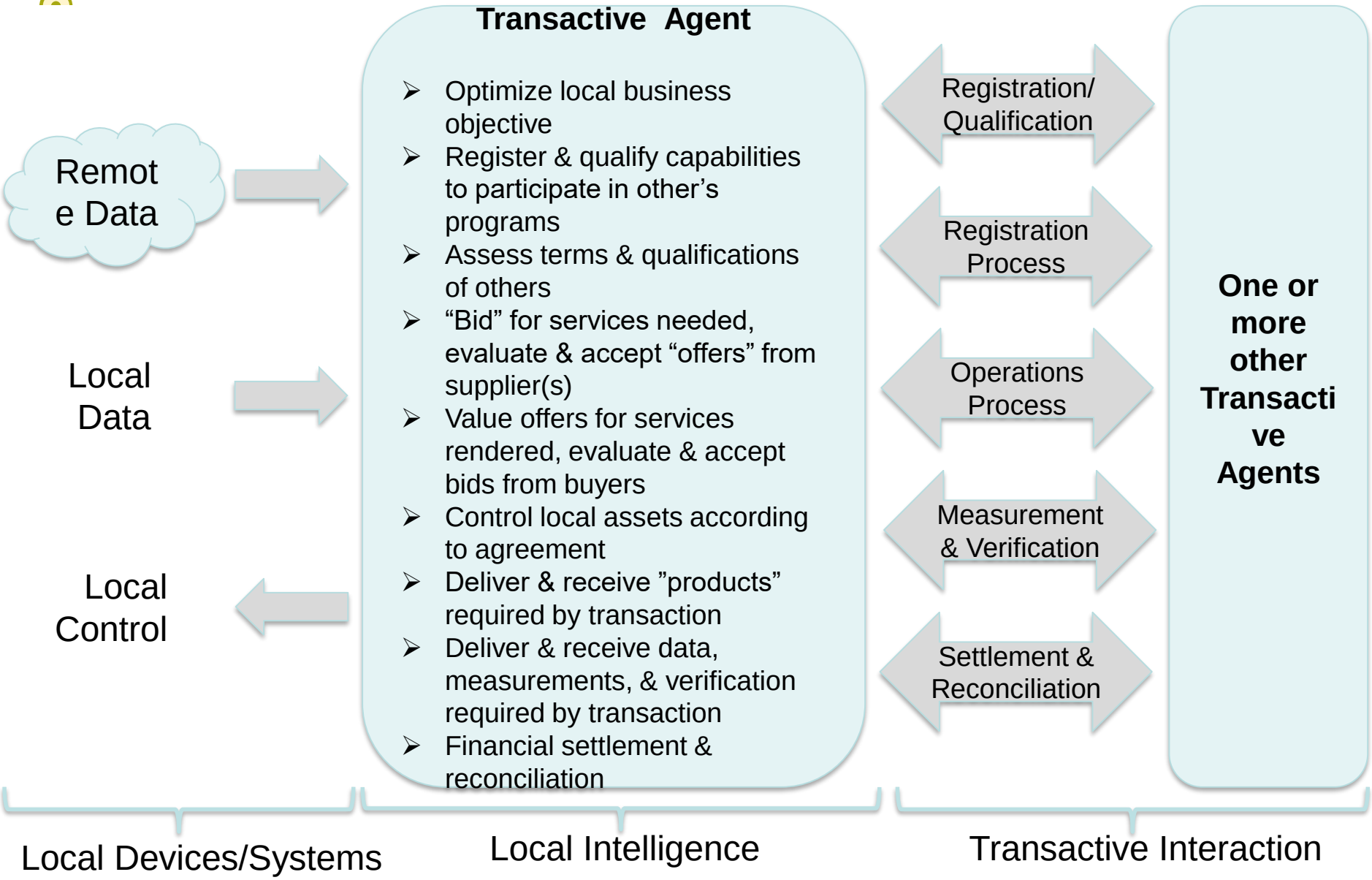
Transactive Incentive Signal

Neighboring Nodes

TeMix™ – structure and approach



Transactive Energy System Interaction Model



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?