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TE Background

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

RON MELTON

Team Lead, Electricity Inftastructure Integration and Administrator, GridWise® Architecture Council

TE Challenge Kickoff Meeting, NIST, Setpember 10 – 11, 2015

U.S. DEPARTMENT OF ENERGY

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"

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

A means of characterizing and comparing: TE System Attributes

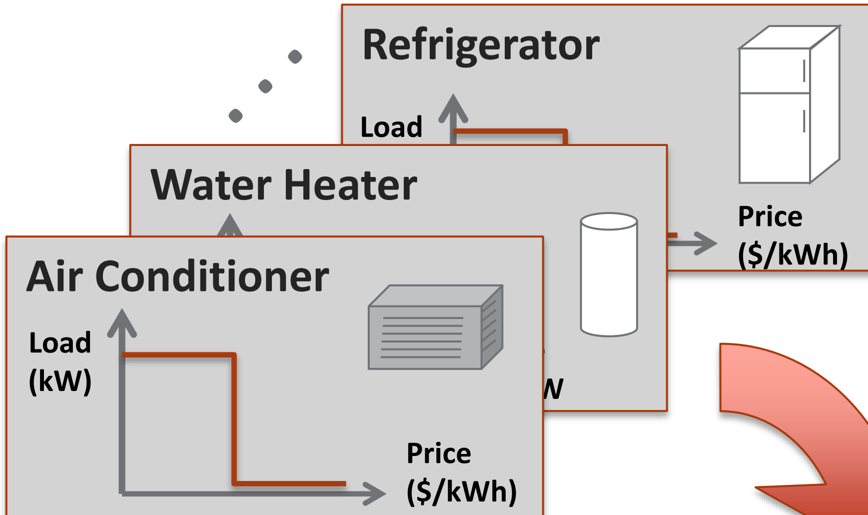
- Architecture
- Extent
- Transaction
- Transacting parties
- Transacted Commodities
- Assignment of value
- Value discovery mechanism
- Temporal variability
- Interoperability
- Alignment of objectives
- Assuring stability

General Design Requirements: TE System Principles

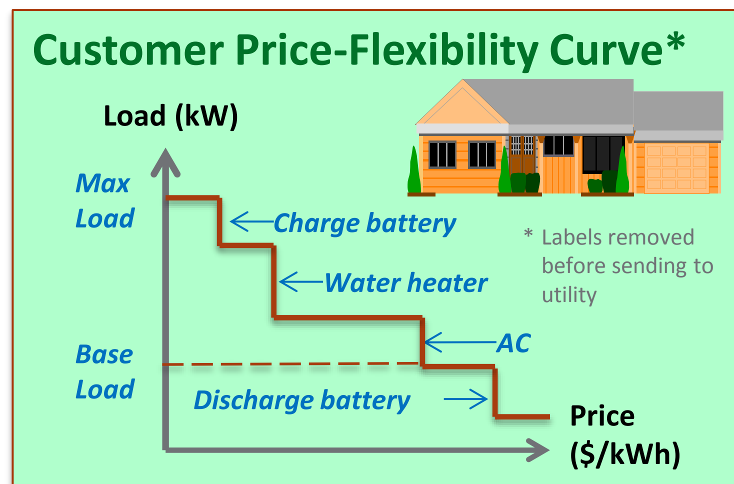
- Transactive energy systems implement some form of highly coordinated self-optimization.
- Transactive energy systems should maintain system reliability and control while enabling optimal integration of renewable and DERs.
- Transactive energy systems should provide for non-discriminatory participation 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

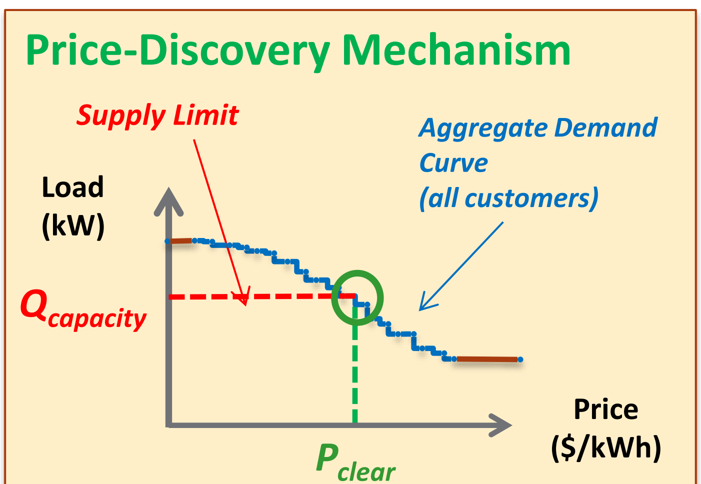
1. Automated, price-responsive device controls express customer's flexibility



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

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Why does it matter?

Motivation for Transactive Energy Systems

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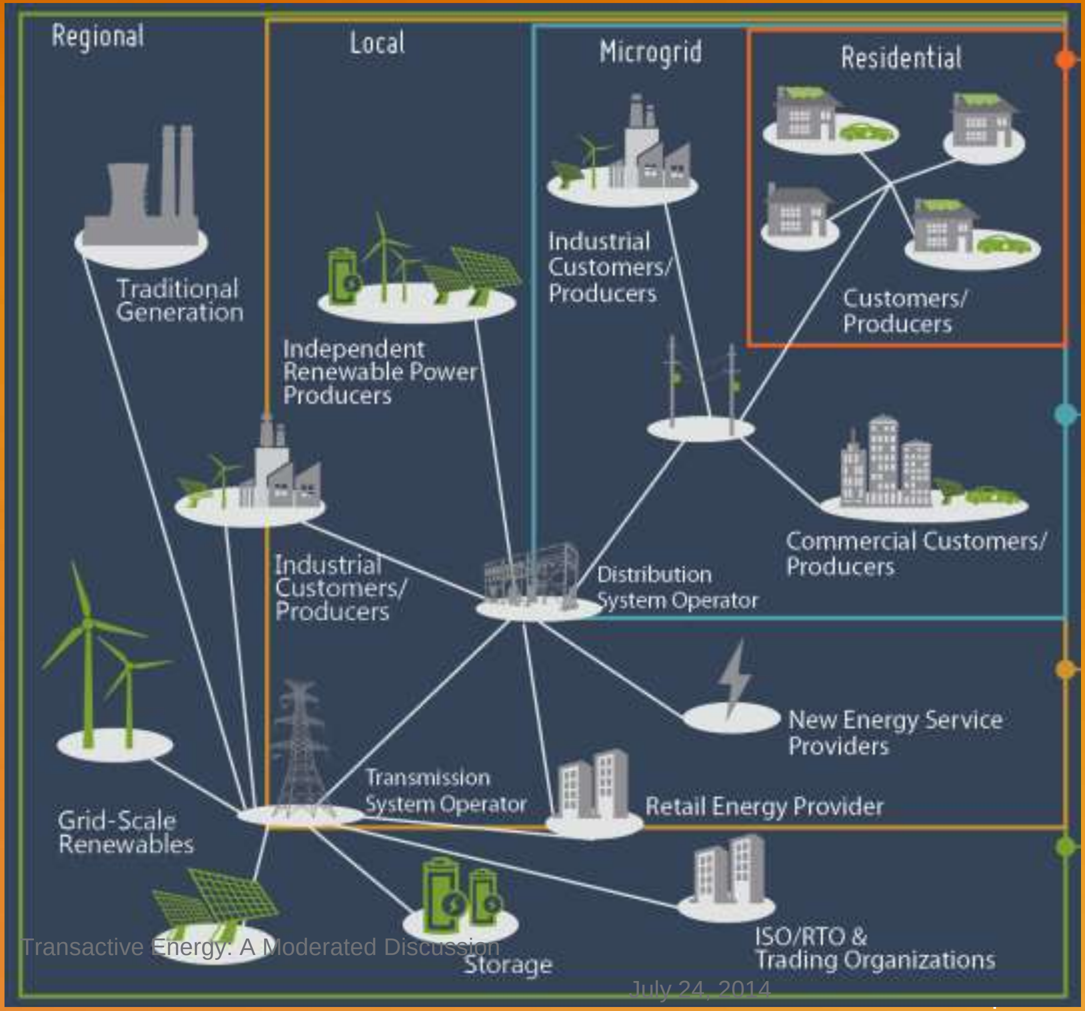
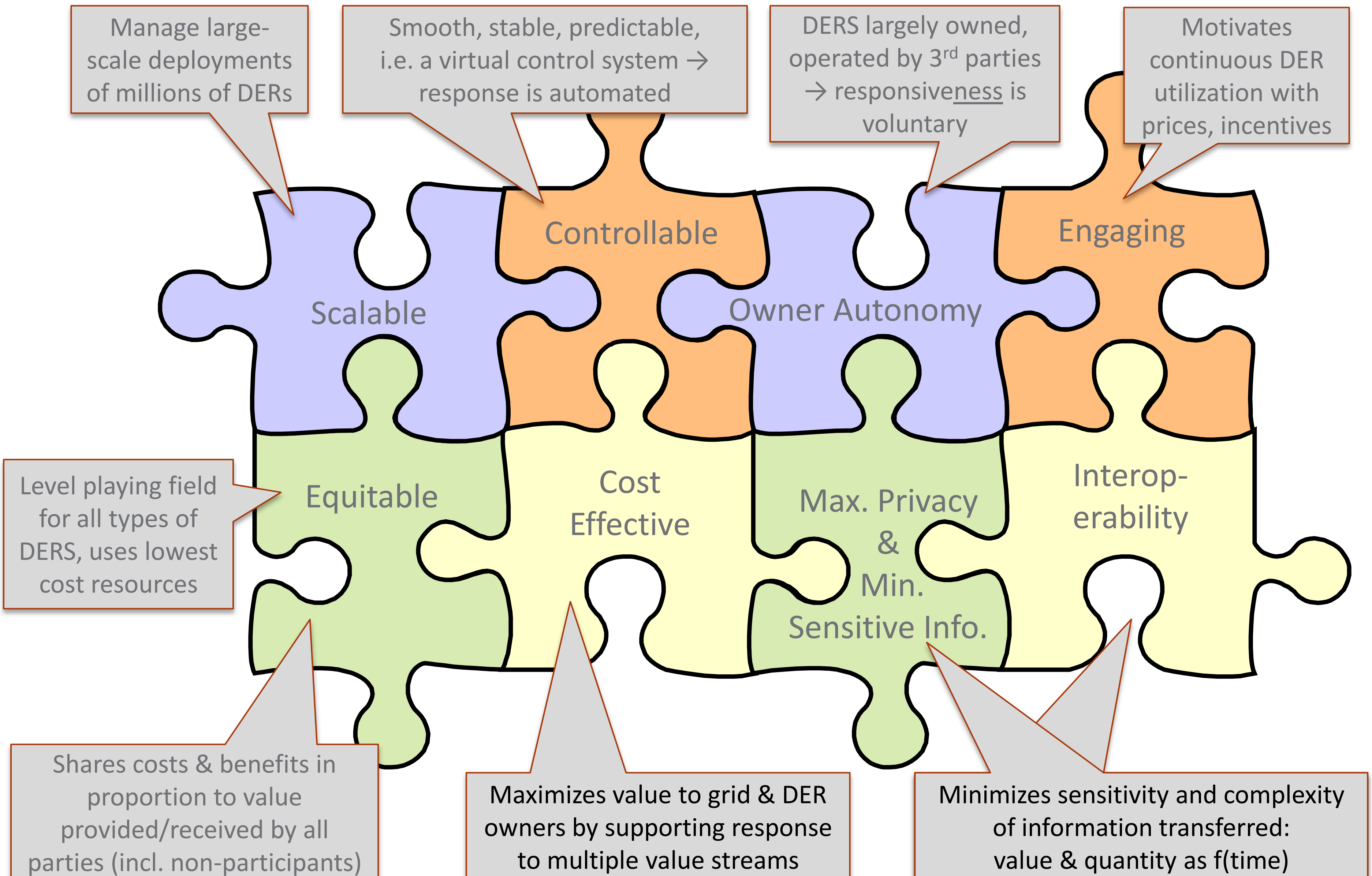
The changing nature of the electric power system:

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

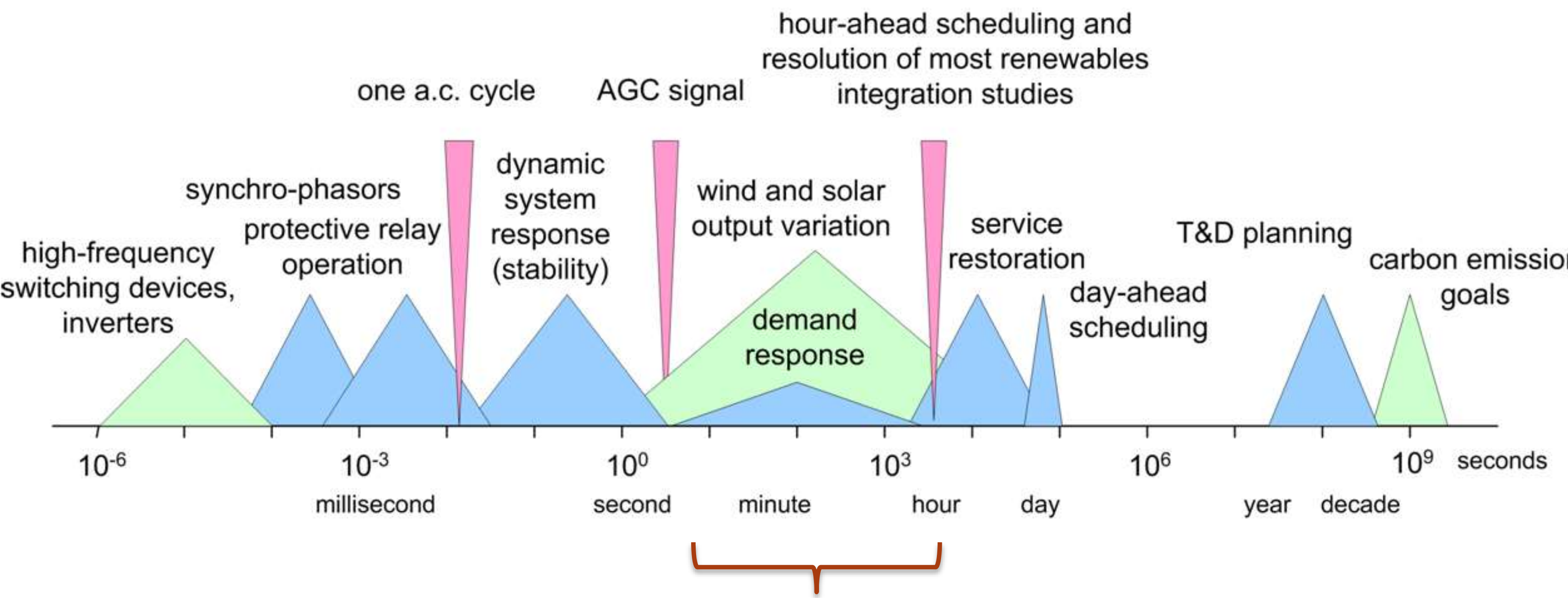
TE responds to the need to coordinate variability and flexibility



Good Transactive System Designs Address Key Barriers to Deploying & Utilizing DERS



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

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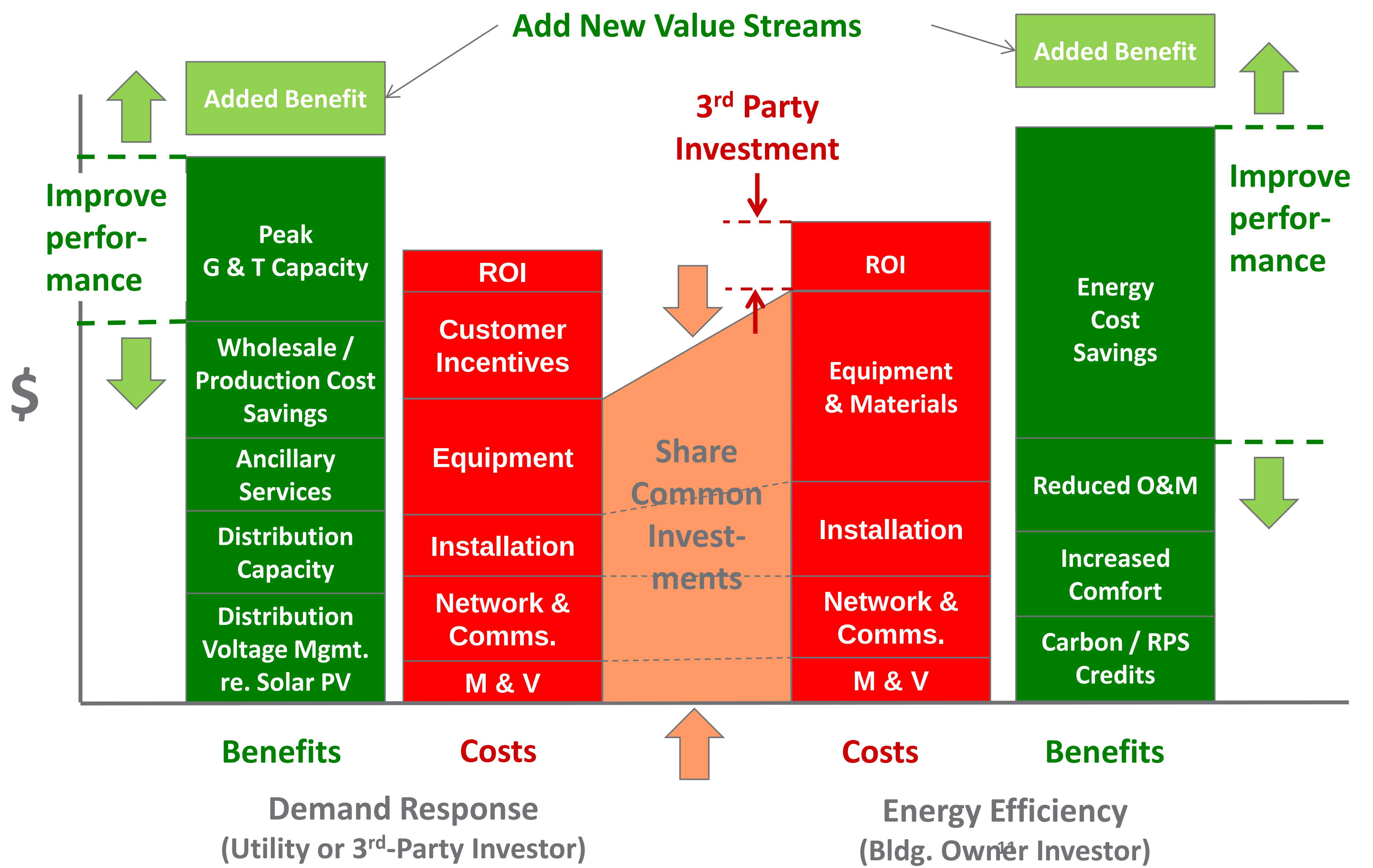

Where have we been on this journey?

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]

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

TE Systems Compared

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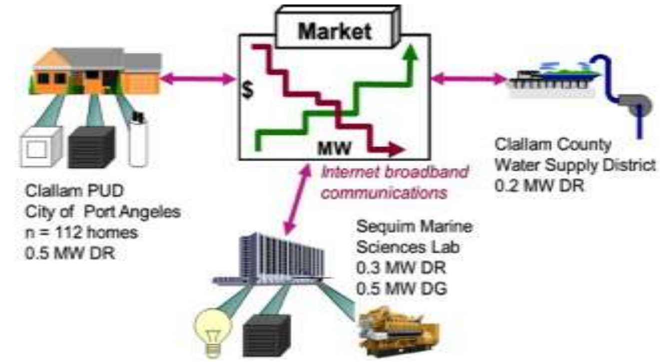
TE System	Architecture	Transaction	Time	Decision Inputs
Double Auction	Distributed agent based	Bids with market closing	Next time interval (e.g. 5 minutes)	Info for Market price and bid amount
Transactive Control and Coordination	Distributed network	Iterative exchange of price forecast and load forecast	72 hour forecast horizon – variable granularity	Price and load forecasts – using local info and TC signals
TE Mix	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

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

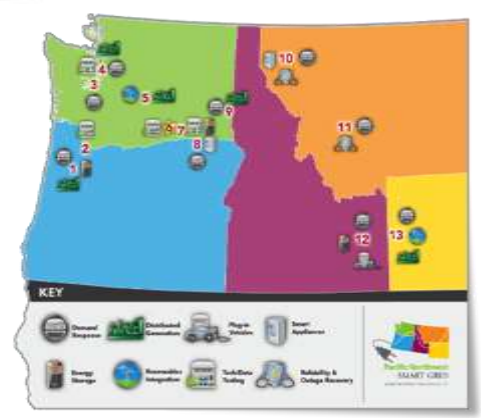


AEP gridSMART® demo, ca. 2010-2014

- 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

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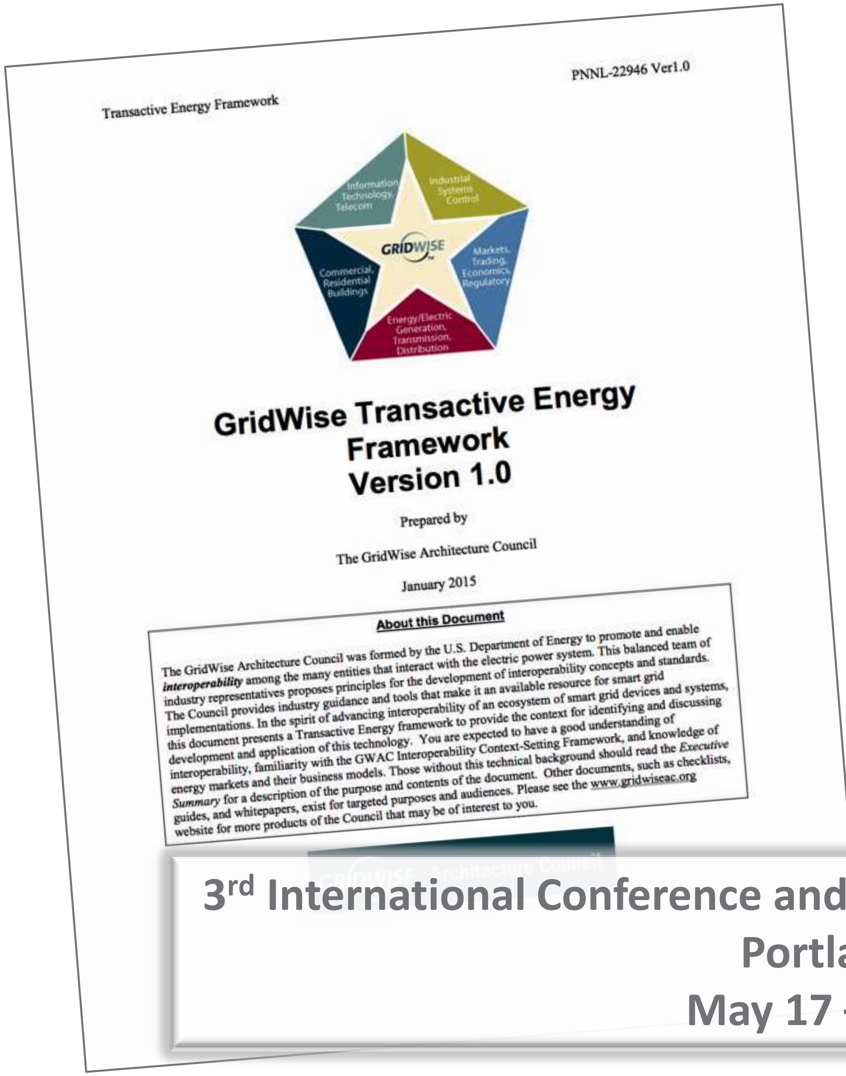

Transactive Energy Framework

PNNL-22946 Ver1.0

Information Technology, Telecom

Industrial Systems Control

Markets, Trading, Economics, Regulatory

Energy/Electric Generation, Transmission, Distribution

Commercial, Residential Buildings

GRIDWISE

GridWise Transactive Energy Framework Version 1.0

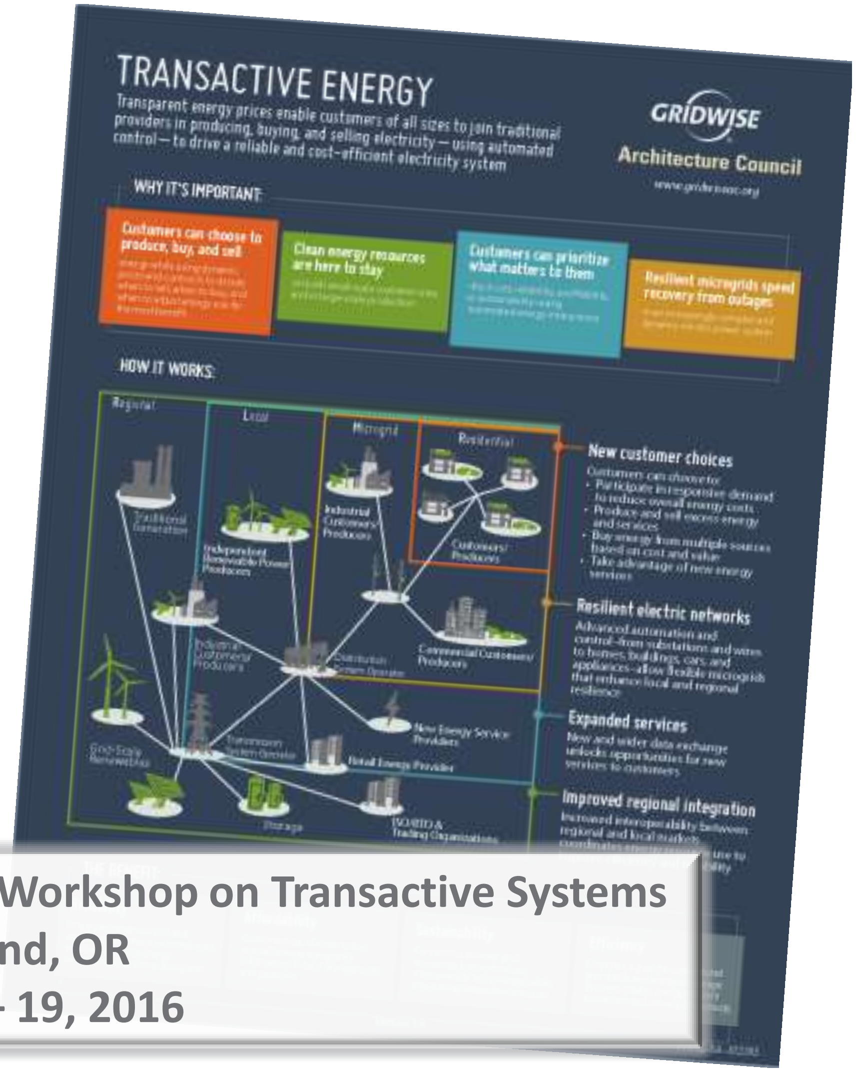
Prepared by

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.



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

See http://www.gridwiseac.org

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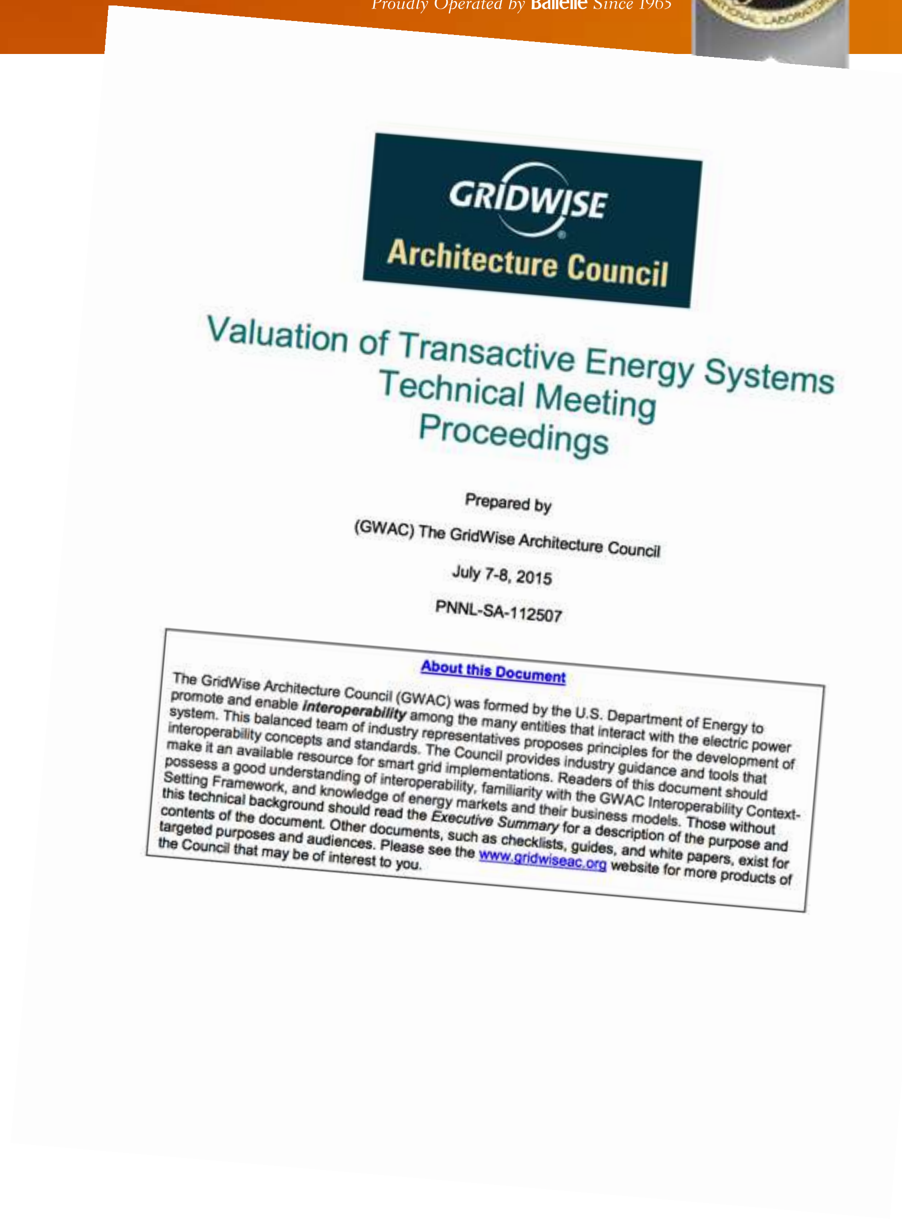
Where is it going?

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



GRIDWISE Architecture Council

Valuation of Transactive Energy Systems
Technical Meeting
Proceedings

Prepared by

(GWAC) The GridWise Architecture Council

July 7-8, 2015

PNNL-SA-112507

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The GridWise Architecture Council (GWAC) 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. Readers of this document should possess 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 white papers, 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.

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