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TE Approaches and Experience

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U.S. DEPARTMENT OF ENERGY

Outline

- Background and definitions
- Examples of TE systems
- Modeling and simulation considerations

Definition of Transactive Energy

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- 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 charactizing and comparing: TE System Attributes

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- 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

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- 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

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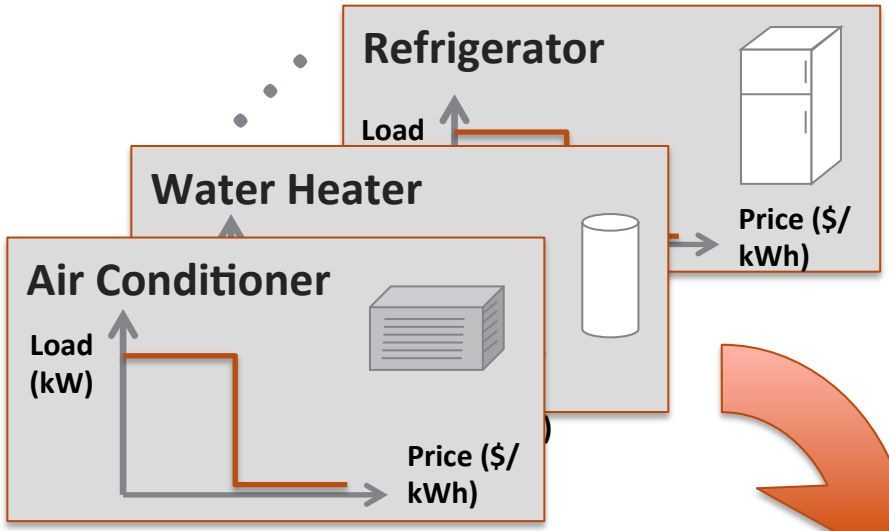
PACIFIC NORTHWEST 50 Years 1965–2015

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

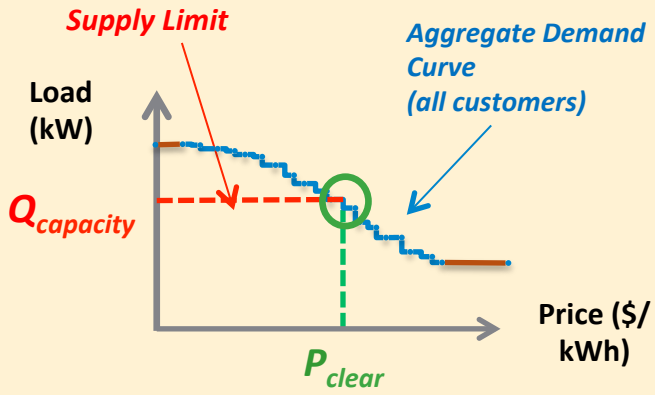


2. Customer system aggregates responses to form overall price flexibility curve

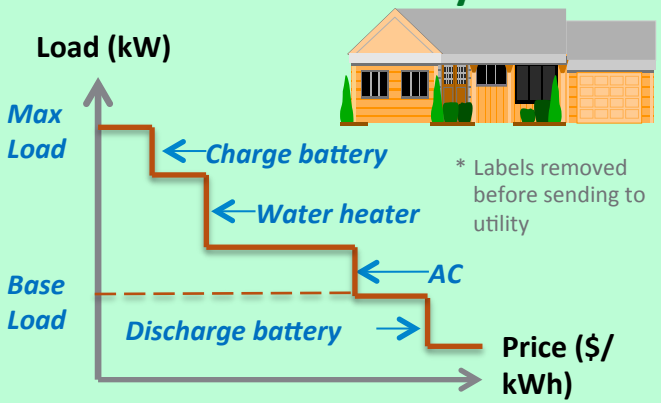
3. Utility aggregates curves from all customers

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

Price-Discovery Mechanism



Customer Price-Flexibility Curve*



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

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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

Double Auction Market Example from AEP gridSmart™

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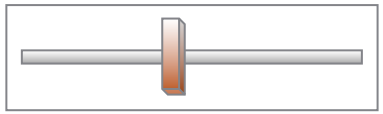
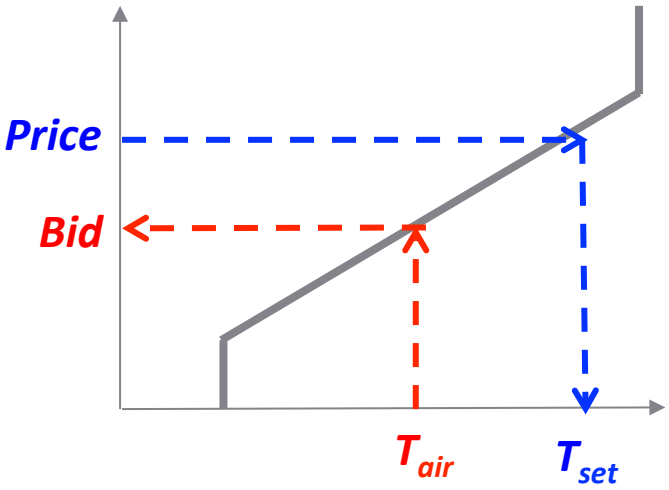
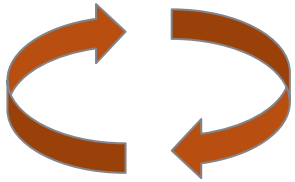
Transactive Cooling Thermostat

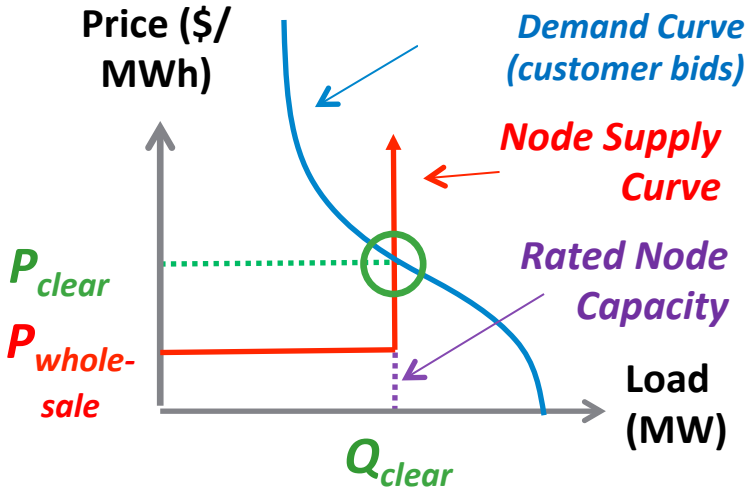
More Comfort ⟷ More Savings







Real-time Market Clears Customer Bids



Transactive Control and Coordination – PNW Smart Grid Demo Approach

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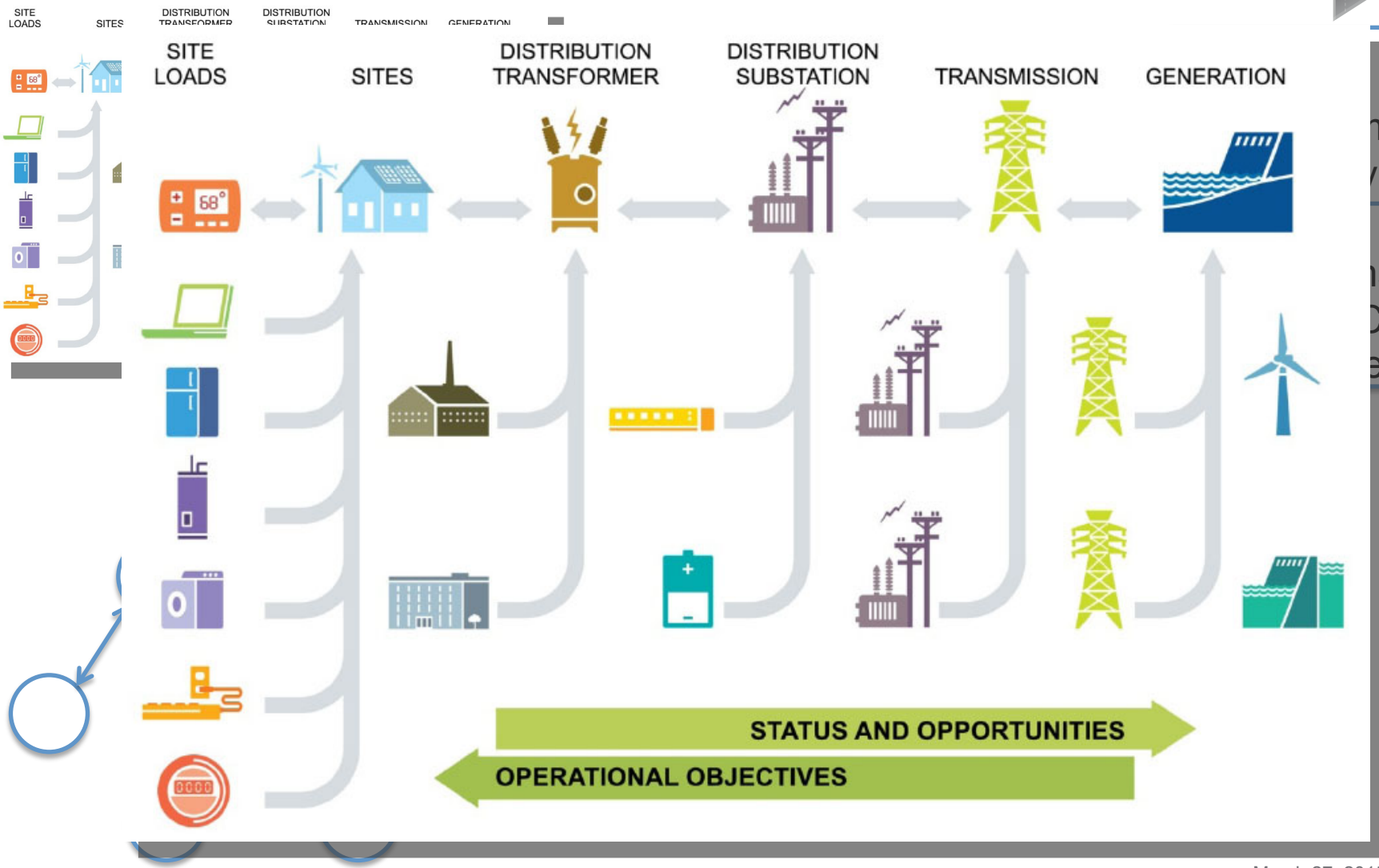
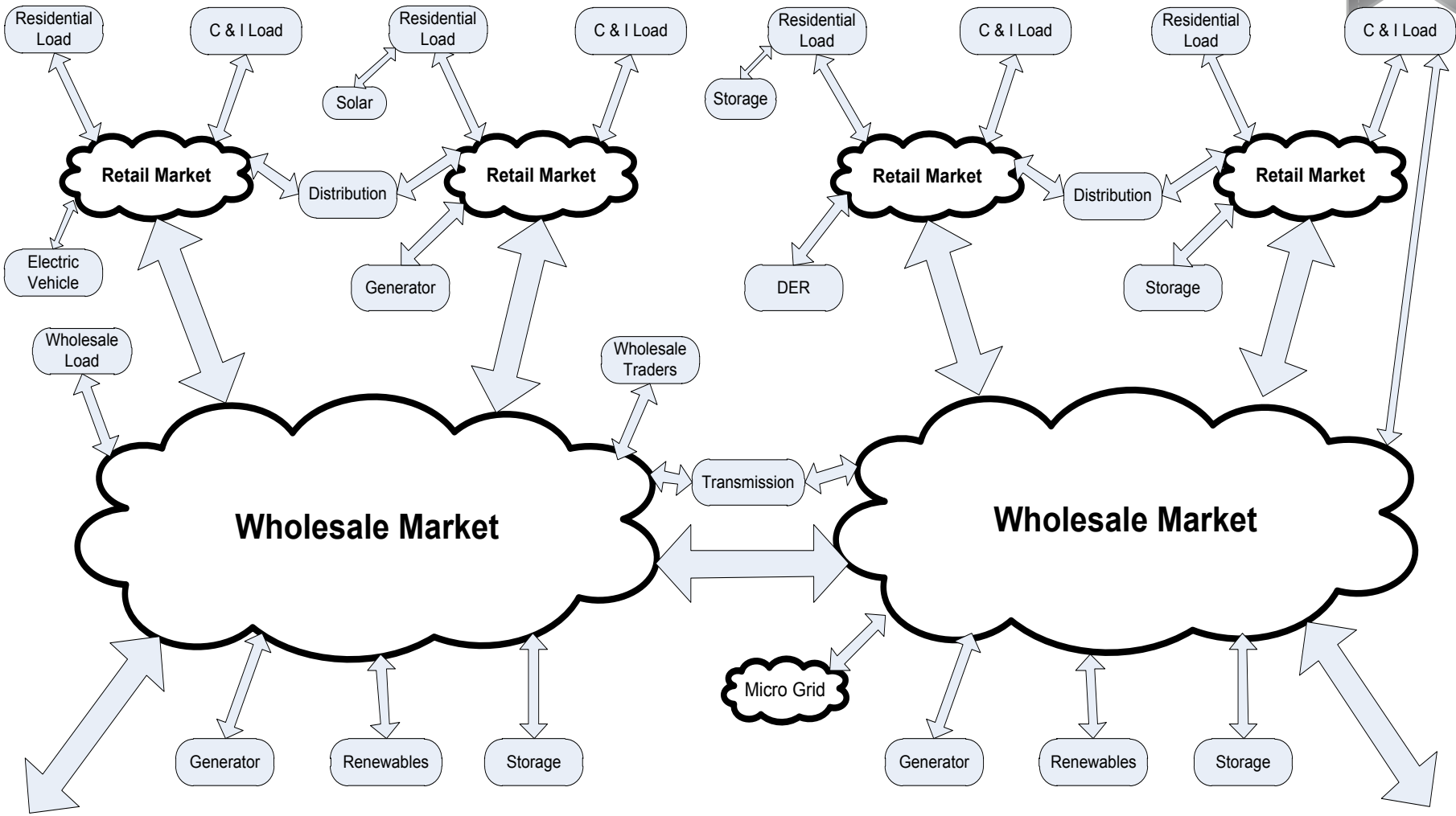


, e.g.

ns
CADA,
etc

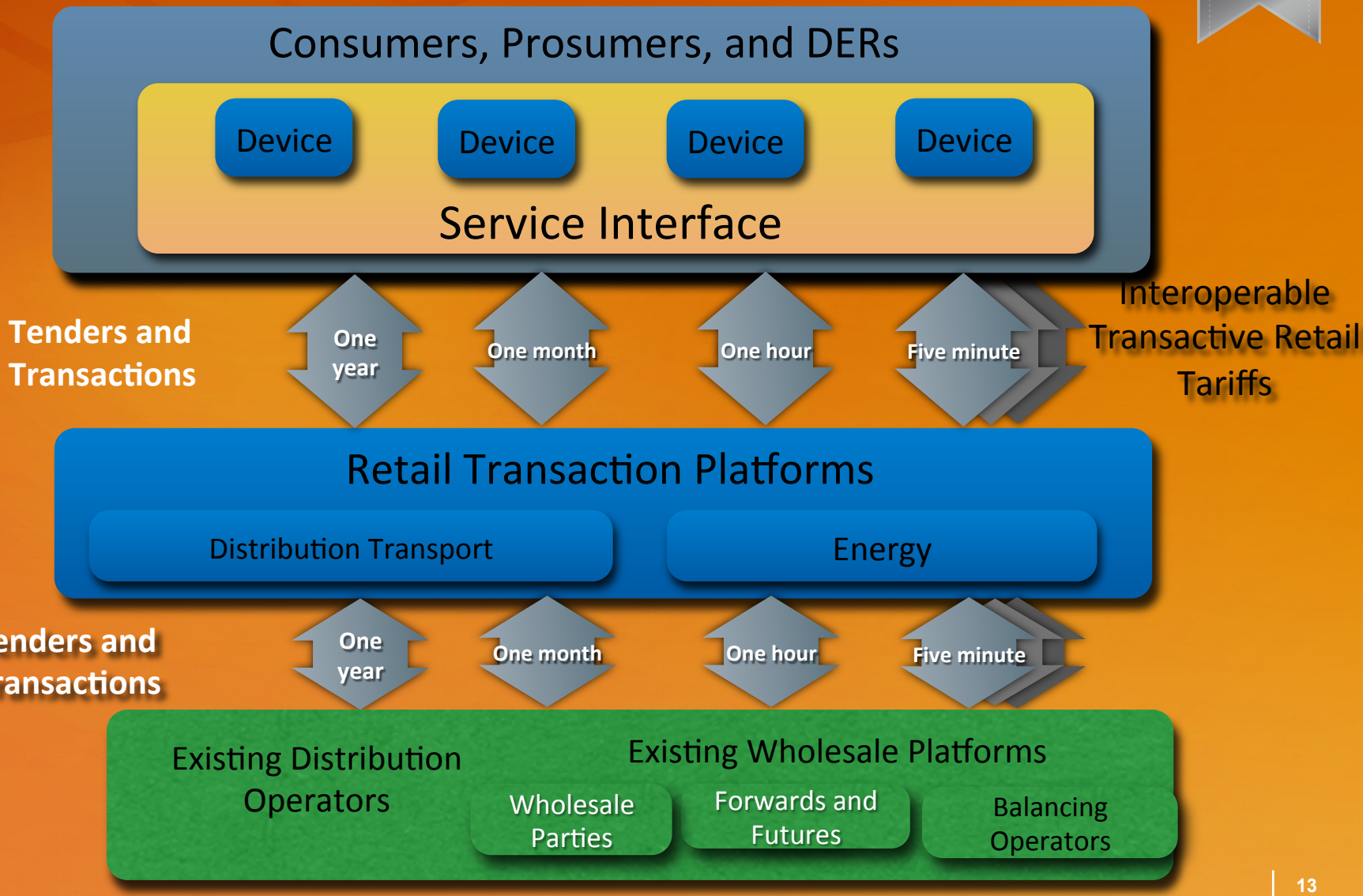
TE Mix



From TEC 2013 proceedings

Figure © TeMix Inc.

TeMix – structure and approach



Considerations for Modeling and Simulation

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- 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