TE Challenge Phase I Capstone Webinar

September 20, 2016
1:00-4:00 p.m. ET
Webinar Logistics

- PLEASE Mute yourself
  - If background noise, you may be muted by organizer.

- Chat window: Please use for comments and questions.
  - We will pause periodically to address questions. The organizers may either address questions as written, or may ask you to verbally repeat and possibly clarify your question.

- Webinar slides will be made available on the NIST TE Challenge website: https://pages.nist.gov/TEChallenge/
Agenda

• Welcome
  – David Wollman, NIST

• Phase I team reports
  – David Holmberg introduction, NIST
  – John Caldwell, Edison Electric Institute
  – Jennifer Worrall, Iteros
  – William Miller, MaCT-USA
  – Rolf Bienert, OpenADR Alliance
  – William Cox, Energy Mashup Labs

• Co-simulation Framework
  Marty Burns (NIST), Chad Corbin (PNNL), Himanshu Neema (Vanderbilt)

• DOE TE program (Chris Irwin, DOE)

• NIST TE Challenge Phase II
  (Avi Gopstein, NIST)

• Q & A (David Holmberg, NIST)
TE Challenge Goals

1. Simulation tools and platforms
   1. Demonstrate how different TE approaches can improve reliability and efficiency of the electric grid to address today’s grid challenges
   2. Make use of Phase I-developed co-simulation platform, reference grid, scenarios and metrics to allow comparable results.
   3. Develop a repository of co-simulation platform components.

2. Collaboration—promote collaboration among industry stakeholders.

3. Progress—work toward implementation of TE applications.

4. Communication—provide a stage for teams to present the exciting work they’ve accomplished.

→ Deliver value to utilities, regulators, policy makers and other stakeholders in understanding, testing, and applying TE to meet today’s grid challenges.
Timeline

- September 2015: Launch of Phase I and formation of 7 teams
- Summer 2016: Completion of Phase I team efforts, development of Co-simulation platform architecture
- September 20: Phase I Capstone meeting
- Fall 2016: Implementation of basic components of a co-simulation platform tool set. Outreach meetings in CA and NY.
- Early 2017 TE Simulation Challenge Phase II Launch.
  - Focus on TE simulation based on co-simulation platform tools, in addition to
  - Collaboration, demonstration, understanding and communication
- Collaboration site: https://pages.nist.gov/TEChallenge/ gives access to the latest documents
  - JOIN US!
What is the TE Challenge?

Transactive Energy (TE) refers to techniques for managing the generation, consumption, or flow of electric power within the electric power system through the use of economic or market-based constructs while considering grid reliability constraints. As the electric grid transforms to integrate more wind and solar energy and to give customers more choice and control in their use of energy, the concept of transactive energy is likely to play a key role. Members of NIST’s Smart Grid Team have been working closely with the Department of Energy to understand TE’s potential and to support utilities, technology developers, and policy makers. The TE Challenge will bring researchers and companies with simulation tools together with utilities, product developers, and other grid stakeholders to create and demonstrate modeling and simulation platforms while applying transactive energy approaches to real grid problems.

- Utilities are concerned about the impact of dynamic pricing and markets on grid stability
- Researchers are interested in the development of economic and grid models for the new complex grid
- Vendors are looking for how to use developing modeling tools to guide technology design and implementations

Learn
- TE Challenge Introduction
- Timeline and Benefits for Participation

Tool Chest
- Co-sim Platforms, Simulation Tools, Data Sets, Baseline Scenarios

Community
- Teams Involved in the TE Challenge

Join
- Register for the TE Challenge

Library
- Videos, Presentations, and Documents
TE Challenge Phase I
Team Reports

Dr. John Caldwell
Edison Electric Institute
Business and Regulatory Models team

Jennifer Worrall
Iteros
Microgrids Demonstration team

Rolf Bienert
OpenADR Alliance
Transactive ADR team

William Cox
Energy Mashup Lab
Common Transactive Services team

Khaled Masri, NEMA
Reference Grid and Scenarios team

William Miller
MaCT-USA
PowerMatcher/IoT team

Himanshu Neema and Marija Ilic
Co-simulation Platform team

David Holmberg
TE Challenge Coordinator
NIST
TE Challenge Team Briefs

TE Business and Regulatory Models

Dr. John Caldwell
Edison Electric Institute

September draft of team’s
“Models for Transactive Energy” Report
Membership

- John Caldwell, EEI (team lead)
- Ed Cazalet
- Larisa Dobriansky
- Anand Kandaswamy
- Jeffrey Price
- Farrokh Rahimi
- Paul De Martini
- Eric Woychik

- Scott Andersen
- Gary Radloff
- Yogesh Bichpurya
- Ted Johnson
- Ron Melton
- Robert Hershey
- Paul Heitman
- Bill Cox
History

- Team formed in September 2015 to explore business/regulatory models for transactive energy
- Paper & Presentation on TE models given at TE Conference in Portland in May 2016
- Phase 1 paper on business and operational models completed in September 2016
- Phase 2 paper will focus on legislative/regulatory drivers and models
Phase I Paper

• Principal authors
  – Ed Cazelet - Paul De Martini
  – Jeffrey Price - Eric Woychik
  – John Caldwell

• Editors/Reviewers
  – Larisa Dobriansky - Bill Cox
  – Farrokh Rahimi
Growth of Distributed Solar Energy

U.S. electric generation capacity additions, 2015 vs. 2014
megawatts (MWAC)

- **wind**
  - 2015: 8,112
  - 2014: 4,844

- **natural gas**
  - 2015: 7,521 combined cycle
  - 2014: 398,382 other

- **solar**
  - 2015: 2,158 distributed PV
  - 2014: 375 utility-scale PV

- **other**
  - 2015: 509
  - 2014: 536
Drivers of Distributed Energy Resource Penetration

- Reliability/Resiliency Issues
- State/Federal Policies Promoting Clean Energy
- State Net Energy Metering Policies
- Federal and State Policies Promoting Grid Modernization
- Falling Solar PV Costs
Many States Have DER Goals
Residential Solar PV Costs Have Plummeted
Drivers of Transactive Energy

- Growing presence of distributed energy resources
- “Grid modernization”
  - Evolving Grid Operations (e.g., AMR/AMI, microgrids, advanced communication and control technologies)
  - Increasing Customer Engagement (through dynamic pricing tariffs, retail customer choice, and other programs)
  - State (and Federal) Support
Two Alternative Retail Market Structures for TE

- TeMix
- Distribution Marginal Pricing
Structure for TeMix Two-Way Subscription Retail Tariff & Platform
Example of how a two-way subscription TE tariff works for a typical retail consumer.

- Based on my typical usage or production, I automatically transact for subscriptions for prescribed quantities of energy and transport in each hour of the year(s) for a fixed monthly payment (subscription.)

- If I use less than I subscribed for in each hour then I am paid for the difference at spot prices.

- If I use more than I subscribed for then I pay for the difference at spot prices.

- As my needs change I can automatically buy or sell to modify my subscriptions at the current tendered prices from a Transactive Energy Platform.

This means stable bills for customers and stable revenues for distribution operators and energy suppliers.

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Pricing, Programs and Procurements

Current approach in CA and NY grid services that is analogous to that used for DER under non-wires alternatives under FERC 1000

Current Distribution Operational Services Market:

- Utility purchases distribution grid services from 3rd parties to defer grid capital investments & avoid operating expenses
- Services sourced either through customer response to time-varying rates and/or services provided under standard offer tariffs, targeted DSM programs or competitive procurements

Future Distributed Energy Market:

- Bilateral energy transactions among DER providers, retail energy services providers, load serving entities and prosumers emerging now
- But, spot market for residual energy may only emerge when sufficient need & liquidity exists (likely >15 yrs)
- Unlikely that dynamic constraint management on distribution grid will be needed before 2030 even in CA or elsewhere due to need & cost-effectiveness
Four Main Components in Distribution Marginal Costs
DMP Roadmap

**Step 1:**
- Long-run Marginal Pricing based on avoided incremental distribution costs

**Step 2:**
- Integrated resource, transmission & distribution long-run marginal pricing

**Step 3:**
- Integrated Long-run & short-run locational marginal pricing
- Distribution Access Tariff – 2 part with demand & fixed charges
- Post-NEM DMP based DER retail tariffs

**DER Value Pricing**

**Distribution Service Pricing**
Consumers: The Source of Value

Business models explain how organizations create and capture some of that value.

- Who are the customers?
- What is the value proposition?
- How will the organization deliver value?
- What is the value chain?
- What share of value will it capture as margin?

What business models would be viable for TE?
Increasingly Diverse Business Models

Current business models will evolve.

Regulated Retail Electric Service
- Investor Owned Utility
- Distribution Cooperative
- Public Power Utilities

Competitive Market Businesses
- Retail Power Marketer
- Demand Response Aggregator
- Combined Heat and Power (CHP)
- Community Choice Aggregation
- Community Solar

New business models may also arise.

Emerging Business Models
- Prosumers
- Distributed Storage
- Virtual Power Plants
- Microgrids

Proposed Facilitation Models
- Transaction Platform Provider
- Market Maker
- Distribution System Operator
- Distribution System Owner

Determined by technology penetration, policy and economics.
The Foreign TE Experience

- Denmark
- Canada
- Japan
- Germany
- Australia
Conclusions / Next Steps

• The Future of TE Will Continue to be Shaped by Growth of DER Resources
• Other Factors
  – Legislative/Regulatory Support
  – Technological Development
  – Clean Energy Goals
  – Grass Roots” Projects
  – Actual Implementation in State or Foreign Country
• Phase II: Legislative/Regulatory Models
Transactive Energy for Energy Management in Microgrid Systems

September 2016 Update

Jennifer Worrall
Iteros
Project Overview

• Focused on use of transactive energy in a microgrid setting
  – No regulatory compliance necessary
  – Balancing energy can be challenging due to local renewable assets as primary generation source
  – Transactive Energy mechanism can reduce custom programming necessary

• Focused on a TeMIX-style implementation
  – Need for forward-looking operations to optimize power usage
  – Excellent scalability for transferring to a larger scale implementation
  – Adheres to Energy Interop standard
  – Complies with the Common Transactive Services specification
Approach

Formal software engineering approach used:
• Use Cases
• Requirements
• High Level Design

Future:
• Implementation
• Test Procedures
• Requirements traceability

Documents available at https://github.com/TransactiveEnergy/microgrids
Current Status

- Finish reference implementation for ESI and Facilitator
- Build simulations
- Implement within a microgrid
- Implement in a grid-connected setting

MARKET

ENERGY SERVICES INTERFACE
- Device Agent
- Market Maker
- Scheduling
- Forecasting
- Price Determination

MARKET FACILITATOR(S)
- Enrollment
- Ledger
- Rules Framework
- Reporting
- Settlement

TESTING
- Build Sim Environment
- Development
- Execution
- Experimentation

PHASE COMPLETED PHASE I SCHEDULED PHASE II
Flexible Honeycombed Microgrids using Dynamic Microgrid Configurator

Load, DER Schedules Contingency Scenarios from historical data
Real Time Network Events
Network Constraints Private Microgrid Boundaries

Configuration Repository For Scenarios

Dynamic Microgrid Configurator

Interfaces to TE Framework Event and Report Interfaces

Distribution Network Model

Honeycombed Microgrids Configuration

Implementation is in progress. A demonstrator of DMC with Event & Report Interfaces has been developed.
Phase II Plans

• Build and release open-source (Apache 2.0) Java code for TeMix implementation for Market Participant

• Iteros to develop TeMix-based Market Facilitator implementation and host on AWS for testing

• Participate in larger co-simulation platform with microgrid and VPP scenarios

• Live implementation if suitable location found
TE Challenge Team Briefs

PowerMatcher / IoT Team

William Miller
MaCT-USA

Link to latest material on the Collab Site
IoT/PowerMatcher TE Test Bed

William J. Miller
ISO/IEC/IEEE
P21451-1-4, Chairman
http://www.sensei-iot.org
NIST TE Challenge Test Bed
Team Leader

09/20/2016
Goals and Description

• **Protocol:**
  – IoT XMPP Interface to PowerMatcher & Energy Flexibility Interface (EFI)

• **Goals**
  – The TE Test Bed will provide secure high performance energy transactions initially in a simulated energy micro market to demonstrate the benefits of decentralized energy balancing using PowerMatcher without exposing sensor devices and protecting privacy of end-users
  – Provide bi-directional data exchange to multiple PowerMatcher nodes secured using IoT XEPs in ISO/IEC/IEEE P21451-1-4 (Sensei-IoT*)
  – “The IoT/PowerMatchingCity” clients will be in the US and Canada.
  – Smart Cities to offer similar conditions to the pilots in the Netherlands, with exception of secure session initiation for transactions.
  – PowerMatcher clients will communicate to an aggregator node to perform actions with a simulated transactive energy market under real world conditions.
Type of Devices

• The devices participating in this energy grid will include:
  1. **Time-shifters** – appliances or equipment that can be operated on a discretionary basis to take advantage of lowest energy prices.
  2. **Buffers** – devices that can store energy.
  3. **Uncontrolled loads or producers**, such as wind and solar generation.
  4. **Energy storage** in the form of batteries or electric vehicles (EVs).
  5. **Projected benefits** include giving consumers maximum choice in device decisions; preventing vendor “lock-ins”; and creating an eBay-like energy market.

• Expected benefits for utilities include reduced complexity and consumer engagement in better control of their energy usage resulting in cost savings while maintaining grid loads and support of renewable generation.
Examples

• HVAC
• Solar Inverters
• Electric Rechargers
• Ventilation Systems
• Lighting Systems
• Building Management Systems (BMS)
Team Participants and Roles

- Erie County – Buffalo, NY USA
  - to supply test sites and coordinate local actions
- City of Glassboro, NJ USA
- City of Oshawa, ON CANADA
- City of Richmond, VA USA
- Dubai UAE
- Esensors – Buffalo, NY USA
  - to supply wireless power meters for test bed include development of device drivers
- TNO/Alliander – Netherlands
  - to help integrate IoT XEPs SDK into PowerMatcher
- Clayster – Sweden
  - to supply Provisioning Server
- MaCT USA – Washington, DC USA
  - To provide project management including IPDX.NET data sharing
- Universities – to provide link to IPDX.NET for data federation
  - SUNY/Buffalo State (Buffalo, NY) 2016
  - Rowan University (Glassboro, NJ) 2016
  - University of Ontario Institute of Technology (Oshawa, ON) PENDING
Milestones

• Smart City: Erie County (Buffalo, NY)
  – Determine device locations – May 2016
  – Data Analytics – June 2016
  – Provisioning Server – May 2016
  – PowerMatcher IoT XEPs – June/July 2016
  – Integration Testing – November 2016
  – Field Testing – 2017
Network Architecture for Transactive Energy (TE)
IPDX.NET
IP Data Exchange Sensor Sharing Network

• ISO/IEC/IEEE P21451-1-4 provides session initiation and protocol transport for sensors, actuators, and devices. The standard addresses issues of security, scalability, and interoperability. This standard can provide significant cost savings and reduce complexity for the Internet of Things (IoT).

http://www.ipdx.net
http://iot.telesonera.com
TE Challenge Team Briefs

Transactive ADR Team

Rolf Bienert
OpenADR Alliance

Link to latest material on the Collab Site
Enabling Standards for Demand Side Management

Transactive ADR Update

Rolf Bienert
Technical Director OpenADR Alliance
Recap - Transactive ADR Team

- Goal: advance TE in OpenADR Alliance, with goals of leveraging established DR member alliance (OpenADR Alliance) to create an industry solution for TE
- Extending the OpenADR standard to include TE, pointing the way to a practical future for TE
- Engaging both new and existing OpenADR members in the creation of Transactive Automated DR (TADR)
- Integrating IoT transactive framework with DR
- Synchronize with California Energy Commission efforts
What’s happening

• We have been following the TE Challenge teams
• Identified the necessary services
  – Quote, Tender, Transaction, Delivery
  – To be implemented in the OpenADR specification series: EiTender (offer/bid),
    EiTransaction (acceptance/contract)
  – Estimated completion: **End of 2016**

• Formed a new working group in the OpenADR Alliance
  – Group is looking beyond the TE services to see how EVSE, battery storage, and
    other Distributed Energy Resources (DER) can benefit and be integrated
  – Starting to gather use cases and implementation scenarios
Thank you!
Common Transactive Services [CTS]

Report Authors:
- William Cox
- William Miller
- Edward Cazalet
- Wilco Wijbrandi
- Alexander Krstulovic

William Cox
Energy Mashup Lab
Purpose

- Transactive systems need to work together at system boundaries
- Simplify interoperation and integration between systems
- Allow mix and match combining of systems
  - For example, put a PowerMatcher node in a TEMIX microgrid inside a CIM Markets system
- Simplify simulation design
- Generalize simulation results through demonstrated interoperability
Common Transactive Services—Requirements

• The Common Transactive Services should be
  – Standard, providing service requests and responses that are clearly defined and standardized
  – Extensible and adaptable with standard models for price (in any currency) and product definition
  – Open Free to read and use
  – Supportable in open source implementations
  – As simple and minimal as possible
  – Implement Transactive Energy and
    • Support highly automated coordinated self-optimization
    • Bridge to and from each system
# Common Transactive Services—Definition

<table>
<thead>
<tr>
<th>Common Transactive Service</th>
<th>Description</th>
<th>Other Names Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quote</td>
<td>Provide or request a price quotation on a product</td>
<td>Price quote, quote</td>
</tr>
<tr>
<td>Tender</td>
<td>Make a tender to buy or sell a product. Tenders may be binding or non-binding.</td>
<td>Offer, bid</td>
</tr>
<tr>
<td>Transaction</td>
<td>Accept a Tender, agreeing to and creating a Transaction binding on the parties.</td>
<td>Acceptance, contract, clearing</td>
</tr>
<tr>
<td>Delivery</td>
<td>Meter the actual delivery quantity</td>
<td>Verify, certify, meter, read meter</td>
</tr>
</tbody>
</table>
Transactive Systems Addressed

- Systems examined in this team effort were
  - CIM Markets (62325 family)
  - Pacific Northwest Smart Grid Demo Project (PNW)
  - PowerMatcher
  - TeMIX
  - OASIS Energy Interoperation/IEC 62939-3 in progress

- Outside reviewers included
  - Rob Pratt, PNW Project
  - members of the MIT Transactive Control System Team
  - Rolf Bienert, OpenADR Alliance
  - Toby Considine, TC9 and The Energy Mashup Lab
  - David Cohen, Evolution 7 and The Energy Mashup Lab.

- See the full report for a brief discussion of
  - MIT Transactive Control System
  - Transactive OpenADR
Conclusions

• We’ve shown how to apply a small set of standardized Common Transactive Services to
  – Guide interoperability
  – Focus product definition

• The CTS
  – Are easily automatable
  – Keep standards of performance with the transacting parties (GWAC TE Principles)
  – Support the GWAC and TEA definitions of Transactive Energy

• Recommendation:
  – Simulators, implementers, architects, and integrators of Transactive Energy Systems take advantage of the CTS to accelerate their work
Reports and Papers

• Report, presentations, and papers available at
  – https://github.com/EnergyMashupLab/TransactiveEnergyChallenge/tree/master/CommonTransactiveServices

  – Authors email addresses
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    • Edward Cazalet ed@TEMIX.com
    • Alexander Krstulovic alexander.krstulovic@alliander.com
    • William Miller mact-usa@att.net
    • Wilco Wijbrandi wilco.wijbrandi@tno.nl
TE Co-simulation Framework
-with reference grids, scenarios, metrics

• Marty Burns, NIST

• Chad Corbin, PNNL

• Himanshu Neema, Vanderbilt
TE Challenge Co-Simulation Framework

• Reason for Tiger Team Effort
• The Participants:
  – PNNL
  – Vanderbilt
  – CMU/MIT
• The Results
  – Draft Technical Framework
  – Extensible Component Model
  – Canonical Experiment/Simulation
  – Core Analytics
TE Challenge Common Platform Specification

• A detailed technical specification that can be faithfully implemented on one or more simulation platforms comprising:
  – A set of model components with specific minimum interfaces
    • Any interface can be extended as needed for any TE Challenge Case
    • Core components can be combined and hide internal interfaces
  – A canonical simulation that allows the set of components to be orchestrated in a simulation
    • Minimal or extended models can be substituted for any component(s) and can simulated by the same experiment controller
  – A reference grid and scenario
    • A defined set of grid nodes, resources, controllers, and transactive agents and market simulation to provide a baseline for comparison
  – A minimum core set of analytics based on the data provided through the canonical simulation
Federation of Transactive Energy Experiments

Federated experiments allow components of experiments to be distributed locally, in clouds, and/or geographically dispersed.

• **A Federate is a component of an experiment.** It could be a piece of equipment, a simulation model, or a permutation of multiples of both. . . .
• **Federates can be located anywhere** and are identified by their description and network address.
• **A Federation is a collection of Federates** that can be part of an experiment.
• **An Experiment is the description of the orchestration** of a Federation to exercise the Federates and exchange of information among them.
• **The Federation Manager is a specialized Federate** that operates on the Experiment definition and the Federation to perform the actual experiment.
Notional Topology of A TE Simulation

Key

- Grid + Controls
- Manages
- Transactive

Microgrid PCC
Grid Node
Resources
- Resource: Load
- Resource: DER
- Local Controller
- Weather
- Supervisory Controller
- Transactive Agent
Core Modeling Components of Common Platform

class Model
    BaseModelComponent
    Grid
        + Nodes: Link [1..*]
    WeatherData
    BaseModelComponent
    SupervisoryController
        + resources: Resource [0..*]
        + TA
        + WeatherData
    BaseModelComponent
    TransactiveAgent
        + TA
        + WeatherData
    BaseModelComponent
    Weather
    BaseModelComponent
    Resource
        + gridNodeId: GridNodeId
        + current: Current
        + power: Power
        + impedance: Impedance
        + phases: Phases
        + voltage: Voltage
        + status: boolean
    BaseModelComponent
    LocalController
        + actualDemand: float [0..1]
        + demandLimits: PowerRatings [0..1]
        + downRamp: PowerRampSegmentType [0..*] [ordered]
        + upRamp: PowerRampSegmentType [0..*] [ordered]
        + locked: Boolean [0..1]
        + status: LoadStatusType [0..1]
    BaseModelComponent
    LocalControl
    ResourcePhysicalStatus
    1..*
    1
    1
    1..*
Why we need a “Common Platform” for TE Simulations?

• The goal of the simulation platform is to be able to understand, evaluate, and validate transactive energy approaches, grid operations and controls.

• We realize that TE simulations are a highly complex System of Systems (SoS) simulations and may require a diverse set of modeling and simulation tools for evaluating these transactive approaches that involve not just the grid operations and controls, but also cyber components for control and communication, humans components for consumer and aggregate behavioral modeling, and economics components for transactions and market modeling.

• The goal is to design a common platform that has well-defined interfaces and semantics such that stakeholders can use to evaluate in their own contexts and may even plug-in their own [proprietary/confidential] models and components.

• As part of the platform we envision a set of library of tools & models that will be available for users to leverage the great work from the open-source domain.

• Toward this goal, we defined a set of “core components” and their interactions that everything else can build upon for complex scenarios and behaviors.
Physical simulation of load/generator attached grid. The message lines in this case may be messaged or actual physical simulation.

Logical simulation of controller action on its managed loads and generators. Messages in this case may be directly messaged or may be messaged in conjunction with a communications simulation such as NS3 or Omnet.

Transactive time step. Note that self-links for TransactiveAgent imply sharing among the various Transactive Agents in the scenario.
How Simulation Components Get Realized in Simulators

Simulation Interaction Bus (HLA, FNCS, SGRS)
Baseline Reference Scenario

30 houses divided among three phases on one distribution transformer.

The distribution system has one uncontrollable load (Resource) and one source of bulk power (Resource).

There is a weather feed of TMY3 Data for a single locale (Weather).

Each house has:
- A solar panel (Resource)
- A controllable load – HVAC (Resource)
- A non-controllable load (Resource)
- A home automation system (SupervisoryController)
- A thermostat (LocalController)
- A transactive agent (TransactiveAgent)

Resources
- PV Panel (+inverter)
- Bulk Power
- Dummy Grid Load
- Controllable Load (HVAC)
- Uncontrollable Load

Nodes
- Meter (triplex)
- Node (triplex)
- Node (three-phase)

Links
- Transformer
- Power Flow
- Triplex cable
- Data

Logical Connectors
- SupervisoryController
- Bidding Controller

LocalController
- Thermostat

Transactive Agents
- Auction

X10 for each phase

{Quote: Cleared Price, Marginal Quantity}

{Tender: Bid Price, Bid Quantity, State}

{Setpoint}

(Desired Setpoint, State)

(Setpoint)

(TM3 Data)
Metrics that can be Extracted by Analytics Component

Through the course of the experiment/simulation the following data can be extracted from the message exchange:

- Grid power flow and voltage states
- Load profile as consumed by all loads
- Generation profiles as produced by all solar panels
- Aggregated loads by household
- Price negotiations and exchanges
- Realized pricing coordinated by loads and generators
Next Steps

• Gather Feedback on Tiger Team result
• Add object instance diagram to UML model for beta scenario
• Model TMY details of weather component
• Trace transactive components to OpenADR/EI/CIM
• Define sets of initial conditions
• Implement specification on several platforms
DOE Transactive Energy Program

Chris Irwin
Program Manager for Transactive Energy, Communications and Interoperability in Smart Grid, DOE Office of Electricity Delivery and Energy Reliability
NIST TE Strategy and the TE Challenge Phase II

Avi Gopstein
NIST Smart Grid Program Manager
Modeling Use Cases – Migrating from Possible to Optimal

- TE core use case scenarios provided by Challenge participants
- Assessed on issues of
  - Simplicity/quantifiability
  - Impact
  - Ability to advance TE frontier
  - Co-simulation potential
- Early modeling strategy focused on:
  - Regular operations
  - Ongoing value propositions
  - Localized effects
- Future modeling activity to address:
  - Regionalization
  - Mesoscale effects
  - Market integrations/overlap
Beta Use Case: High-penetration PV & Voltage Control

TE Challenge Team guidance
- 120% of e− load produced by solar PV
- Reverse flow and overvoltage may occur
- Utilize TE to respond to voltage fluctuations, minimize curtailment.
- Focus on distribution grid regulation & services

Cloudless day

Residential customers only HVAC + MELS

4 nodes
30 customers

Autumn double-peak load curve

Electric load curve: New England, 10/22/2019
Beta Use Case vs Reality

TE Challenge Team guidance
- 120% of e-load produced by solar PV
- Reverse flow and overvoltage may occur
- Utilize TE to respond to voltage fluctuations, minimize curtailment.
- Focus on distribution grid regulation & services
Building modeling capability: From $\beta$ to $\text{GRID}$, $\text{NATURAL RESOURCE}$, $\text{CUSTOMER (RESOURCE)}$, $\text{REGIONALIZATION}$
Research questions abound, input needed

- What is the effect of TE on reliability?
- What is the effect of TE on resiliency?
- What is the effect of TE on infrastructure investment?
- What is the effect of TE on grid operations?
- What is the effect of TE on the price of electricity?
- How much flexibility is enough?
- What is the supporting business case for TE to facilitate RE integration?
- How do we validate business models?
- How do business models change across geographic areas?
- What are the full range of TE programs?
- What percentage of the customer base needs to participate to make TE successful?
- What are the demographics of the active TE participants, and is that sufficient?
- Is it necessary to allow prices in a single neighborhood to vary differently from neighbor to neighbor according to their physical connection? If so, is that fair?
- How is TE best marketed to the end customer?
- How do we know when enough customers have signed on to be successful?
- What is the customer fatigue time from enrollment to dropping out?
- How do we minimize customer drop-out?
- How can we maximize a persistent DR resource?
- How does TE differ if implemented for continual optimization versus extreme reliability events?
- What do TE pilots need to examine in detail?
- Where is modeling and simulation most useful to advance TE? In the regions already deploying TE-style solutions (e.g., CA + NY), or where the community is slower to adopt such ideas?
- Can TE provide meaningful value across multiple markets and scales simultaneously?
- How to best represent regional interactions beyond feeder?
- Do we know the mechanisms to settle TE markets, and how quickly that can happen?
- What are the response times of TE solutions?
- How does TE compare to conventional grid services?
Stakeholder engagement workshops

- Two workshops: CA + NY
- Engage industry deploying TE solutions today
- Gain perspective:
  - Business case for TE
  - Verification needs for DER grid services (incl. multiple-market scenarios)
  - Analytical areas of greatest impact

*Details forthcoming*
Q&A discussion
Questions to consider

- For which use cases are you planning simulations or would benefit from simulations? What outputs do you need from those simulations?
- What teams do you suggest to form to work on which simulation scenarios? Who should be on the team?
- Are you interested in using and/or developing the co-simulation framework components? Please let us know how you are considering to apply the framework and which components you might use or develop.
- What work items are critical to develop the TE Challenge Phase II and prepare for 2017 launch?
- How can we most effectively use upcoming face to face outreach meetings? Who should be there and how to connect with them?
- What barriers do you see that we need to address and how?
- What changes in business models, regulations, electric grid changes will impact our efforts as we go forward? How should we structure the Challenge to adapt?
- How can you or would you like to be involved?
- How does/should Transactive Energy consider localization and regional conditions?

Submit feedback on chat or by email (techallenge-info@nist.gov)
Connect with the TE Challenge

• Send us your feedback and suggestions at techallenge-info@nist.gov

• Go to the TE Challenge collaboration website to get more information on the team efforts and participants, and to get access to work products

• Consider joining/forming a team to participate in our TE Challenge Phase II
Thank you.