Evaluating Transactive Energy for Rural America

A DOE "Connected Community" Project

May 2023

Overview

Distributed energy resources (DERs) – such as heat-pumps, battery storage units, electric vehicles, and solar panels – have the potential to significantly increase the electric grid's flexibility. This enhanced flexibility provides a pathway to lower energy costs, accelerate decarbonization and electrification, reduce CO_2 and other pollutant emissions, and increase the grid's resilience and reliability. The degree to which these benefits can be realized, however, depends on whether the DERs are effectively coordinated across grid-interactive and energy efficient buildings. This project will evaluate a particular coordination technology, called "Prices-from-Devices Transactive Energy," that can help energy consumers, utilities, state-regulators, and other policy makers meet these energy, financial and environmental goals.

Funded by the US Department of Energy (DOE), the project team – Post Road Foundation, SLAC, Knowledge Problem, New Hampshire Electric Coop and Efficiency Maine Trust – will evaluate a new Prices-from-Devices Transactive Energy architecture, called TESS, which provides significant advantages over conventional command-and-control and other types of DER coordination. To test these advantages, the team will deploy TESS in three communities in rural New Hampshire and Maine, including low-income areas. If the project demonstrates net benefits for energy consumers and utilities, TESS may be extended widely in both states.

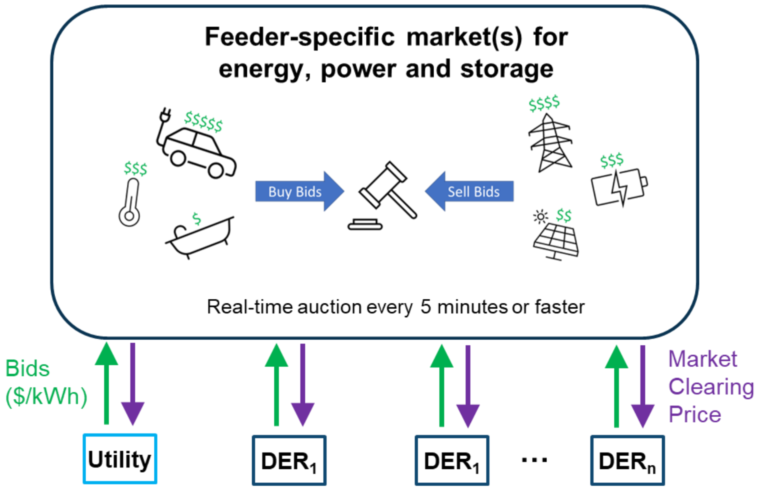
Project Background

This project is part of Post Road's mission to develop synergistic broadband and energy infrastructure nationwide. Over the past five years, Post Road has studied electric utility synergies that robust and reliable advanced communication networks can facilitate. This project puts this prior work into practice by demonstrating how Transactive Energy can use communication networks to advance electric grid modernization. Post Road's long-term vision is that TESS will support the full panoply of DER grid service capabilities expected of an economically sustainable, reliable, and customer-focused electricity system.

TESS is enabled by modern broadband infrastructure and was developed through prior DOE-funded work at Stanford University and Pacific Northwest National Laboratory. By design, TESS improves occupant comfort, building load flexibility and efficient and resilient integration of DERs in an increasingly decarbonized grid. Although this will be the first project that demonstrates the benefits of Transactive Energy at the multi-hundred-building scale with a complete mix of DER technologies, individual elements of the approach have been demonstrated before. Prior efforts include the GridWise Olympic Peninsula Demonstration, the AEP gridSMART Demonstration, and, most recently, a small scale pilot with Holy Cross Energy, an electric cooperative in Colorado.

Advantages of TESS

TESS coordinates DER operation through local, feeder-based electricity markets. Each market calculates a clearing price, on five-minute or faster intervals, using individual DER and utility bids for buying or selling electricity during the market interval. DER bids are calculated automatically based on the preferences of DER users, expressed through a mobile app or in-building console. In combination, the DER bids and clearing price determine which DERs consume energy from the grid and which DERs put energy onto the grid during the market interval. Real-time human participation is not required, but building occupants always have the option to override participation or change their previously expressed preference.



Although TESS requires more robust and reliable communications infrastructure than other DER coordination technologies, it is expected to have five significant advantages:

- ***Building Occupants are in Control.*** TESS gives building occupants granular control over how their DERs participate in grid-wide coordination by setting bid prices. Unlike command-and-control alternatives, in which a utility sends a dispatch signal to individual DERs, building occupants participating in TESS decide how to participate, not just whether to participate. The project team expects that this granular control will increase long-term participation rates.

- ***Confidence in DER response and performance.*** Using "prices-from-devices" coordination technology, TESS can implement and manage load flexibility more reliably than one-way "prices-to-devices" or conventional command-and-control alternatives. TESS' real-time, market-based mechanism operates with a continuous feedback loop, increasing the stability of DER coordination and lessening the impact of unexpected events and forecasting errors (TESS does not require forecasts). As a result, TESS' approach gives utilities confidence that DER coordination will improve their financial performance in a rapidly changing electricity system by reducing energy procurement expenses tied to peak load, increasing electricity sales, and deferring capital investment.

- ***Seamless DER integration.*** By coordinating a heterogenous mixture of DERs through a technology- and vendor-agnostic mechanism, and by reducing the need for detailed engineering studies for DER inter-connection, TESS supports seamless DER integration and dispatch. As a further advantage, TESS reveals the value of adding DERs to particular distribution circuits.

- ***Multiple Options for Value Sharing with Participants.*** TESS' market mechanism provides multiple options for sharing value with participants, including, for example, real-time electricity prices, performance-based rebates, aggregator models that manage devices on behalf of participants, and subscription pricing tied to a participant's willingness to be flexible.

- ***Supporting multiple grid services.*** TESS supports multiple grid services and can naturally incorporate multiple types of prices, including energy, storage and ramping. Utilities can use TESS to reduce peak load and improve the management of (i) procurement of electricity from the bulk system or a utility's own generators; (ii) local feeder-level constraints (and thereby defer capital investment); (iii) DER interconnections; and (iv) decarbonization and electrification policy mandates.

Deployments in New Hampshire and Maine

The project will deploy TESS in one community in rural New Hampshire which aims to include approximately 250 single-family homes and 5-10 small commercial buildings. Each building in New Hampshire will host at least one Li-Ion battery storage unit, heat-pump HAVC system or other DERs. The DERs will also be connected to NHEC's existing "prices-to-devices" transactive system so that a comparison can be made between these two approaches to Transactive Energy.

In Maine, TESS will be deployed in two communities that will each have approximately 100 single-family homes, 50 small commercial buildings, and 5 industrial buildings. Each building in Maine will host a heat-pump-based HVAC or hot water heater and 10-20 buildings will host Li-Ion batteries and other DERs.

Project Goals

1. Enhance TESS to (i) coordinate hundreds of buildings hosting heterogenous DER types; (ii) incorporate cutting-edge cybersecurity and privacy protections; (iii) support multiple market mechanisms, including an order-book and an auction; and (iv) incorporate multiple types of prices, including storage and ramp rate.

2. Measure and validate TESS' ability to meet policy and operational goals, such as achieving demand flexibility and occupant comfort in a cost-effective and equitable manner.

3. Prepare for scale-up and help evaluate TESS' performance by creating a new, open-source Transactive Energy Analysis Tool that utilities and regulators can use to evaluate TESS relative to their own financial and policy goals, including TESS' capability to lower energy costs, accelerate decarbonization and electrification, reduce CO_2 emissions and other pollutant emissions, and increase the electric grid's resiliency and reliability.

Project Team

The team has a history of working together and has the experience, expertise and staff to achieve the project goals. Our collaborative approach is based on the following roles:

Post Road Foundation, led by Dr. Seth Hoedl, is a 501(c)(3) non-profit that studies sustainable infrastructure and helps communities find ways to finance fiber optic networks for both broadband and grid modernization to achieve digital equity and energy justice goals. Post Road has extensive experience managing research projects and subject matter expertise pertaining to energy technologies, electricity law and regulation, and impact finance. Post Road is currently helping develop three fiber-optic networks that will serve 400,000 buildings in persistently unserved areas with an international infrastructure investor and multiple electric utilities. For this Transactive Energy project, Post Road is responsible for project management, reporting, coordination, dissemination of results, and facilitation of scale-up and future investment.

SLAC's GISMo Group at Stanford University, led by Dr. David Chassin, has successfully developed and deployed transactive energy systems and other DER technologies. Dr. Chassin was one of the original inventors of transactive energy and led the Holy Cross Energy pilot project. SLAC also has extensive experience with cybersecurity, privacy, and measurement and evaluation of the performance of DER technologies. SLAC is responsible for further developing TESS to meet the needs of this project.

Knowledge Problem, LLC, led by Dr. Lynne Kiesling, is a thought leader in the underlying economic theory of transactive energy and contributed to the market design of the TESS project with Holy Cross Energy. Knowledge Problem will support the development of electric storage bidding functions and the design of performance and hypothesis testing protocols.

New Hampshire Electric Cooperative is a rural electric utility that serves about 85,000 members. It has a long-standing program for testing, piloting, and scaling new DER technologies and has committed to moving toward a transactive energy business model as part of its strategic plan. It will recruit participants in New Hampshire and manage those deployments.

Efficiency Maine Trust is a quasi-governmental agency charged by the Maine state legislature with implementing multiple energy efficiency-related programs that are central to the state's energy and CO_2 emission reduction goals. It will recruit and retain participants in Maine and manage those deployments.

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