CLEAN ENERGY ADVISORY #4

Transactive Energy

What is "Transactive Energy" or "TE"?

TE is a method of managing or controlling the flow of energy in an electricity grid—of balancing supply and demand. This is important because the supply of electricity must exactly match the demand on a second-by-second basis. Each time a light is switched on, somewhere on the same grid additional power must be added to supply it, and the opposite when the light is switched off.

The basic concept of TE is simple. It can be defined as:

> *Transactive electricity control–a method for balancing electricity supply and demand employing a mutual or reciprocal exchange of value or benefit.*
>
> *NOTE: This stands in contrast to* command *electricity control.*

In other words, TE can be seen as a form of "demand response" (or supply response) that employs a market mechanism, rather than a direct command mechanism, to control the flow of electricity. This is analogous to the difference between a market economy and a command economy. It essentially uses a price signal mechanism to allow each customer (user and/or supplier) to decide for themselves whether to buy or sell power to the grid over some interval.

In a broader sense,

> *TE is a mechanism for community sharing of energy resources and benefits.*

What is demand response?

"Demand response" (DR) is a conventional method of reducing the electricity demand at certain times of peak load on the grid as an alternative to bringing on more power generation. DR is accomplished by sending a pre-arranged signal from a utility to a customer asking or telling them to turn off some non-essential load (*e.g.,* air conditioning, pool pump, pool heater, etc.) for some brief period. "Dispach" is the opposite—using a pre-arranged utility signal to turn on some customer's generation or storage equipment for a brief period to help meet a peak load or demand.

What is wrong with demand response?

Demand response helps preserve the long-standing practice of *baseload generation*[1] to burn more coal. It simply helps shave off the peaks, making the coal baseload more acceptable from a supply economic viewpoint (but not from an environmental viewpoint). In doing so, it impedes and limits the incorporation of renewables because it perpetuates dependency on baseload generation. Baseload is incompatible with renewables. Dependency on baseload generation must be eliminated to fully take advantage of renewable generation.

[1] Baseload generation" is electricity primarily produced by large, fixed-output generators (usually coal or nuclear plants) that can (and must) run at full capacity most of the time to be efficient. Baseload plants offer significant economies of scale and require large investments (and thus yield large returns on that investment through rate-of-return regulation).

What form would TE take?

TE could take the form of a brief recurring electronic transaction by each customer using the Internet. A transaction is a purchase and sale—an exchange agreement to buy and sell. This transaction would be accomplished by an automated electronic double-auction bidding system based on an offer and acceptance. The transaction could include *spot* pricing/sale and/or *forward* pricing/sale.

Such a local grid bidding system would be operated by a neutral party and defined by regulator-approved tariffs. A model retail transactive tariff system has been described by the Smart Grid Interoperability Panel (SGIP), an offshoot of the National Institute of Standards and Technology (NIST).[2]

Where has TE been tested?

A TE method was applied in the Pacific Northwest National Laboratories (PNNL) *Olympic Peninsula* trial begun in 2007 in which 109 homes were equipped with smart appliances, smart thermostats, simulated generation devices, and a gateway platform that allowed each home to bid in an automated double auction process to either buy or sell electricity into the local grid at a rate that was re-priced on a five-minute interval.[3] The results of the trial were very promising.

Subsequent trials have been conducted by certain utilities and as part of the Pacific Northwest Smart Grid Demonstration Project by the DoE. However, since the Olympic Peninsula Trial, progress has been slow and the DoE has had a difficult time raising interest in TE within the electricity industry.

The origins of TE were at PNNL in research projects related to control strategies for optimizing energy use by HVAC systems entirely within a large building (Katimpamula, *et al*, 2006).[4]

Why is TE better than conventional command demand response or dispatch?

TE could replace conventional demand response or dispatch because it would standardize and fully automate the process of controlling the flow of electricity by using a price or exchange mechanism. It would be voluntary, less intrusive, and more adaptable—providing a clearer benefit to the customer, and would be more flexible. It would not be dependent on the utility company (*i.e.*, an independent automated broker).

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[2] SGIP (2015). *A Model Interoperable Transactive Retail Tariff*. Smart Grid Interoperability Panel. January 23. <http://www.sgip.org/Publication-Retail-Tariff>

[3] Ambrosio, Ronald (2008). "The GridWise Olympic Peninsula Project: real-time price controls of distributed energy resources dramatically reduced stress on local distribution systems," *Case Studies, Customers and Markets*, IBM Research, 2008. <www.UtilitiesProject.com/documents.asp?d_4610#>

[4] Katimpamula, S, *et al* (2006). *Transactive Controls: Market-Based GridWise™ Controls for Building Systems.* U. S. Department of Energy, Pacific Northwest National Laboratory. (PNNL-15921) July

As described in the Katimpamula paper, "The premise of transaction-based control is that interactions between various components in a complex energy system can be controlled by negotiating immediate and contingent contracts on a regular basis in lieu of or in addition to the conventional command and control. Each device is given the ability to negotiate deals with its peers, suppliers and customers to maximize revenues while minimizing costs."

Can TE replace time-of-use (ToU) tariffs?

TE could completely replace ToU or demand rates/tariffs. ToU rates are a blunt instrument. They are based on general fixed assumptions about what the value of electricity is in a given system, divided into rough time-based categories and not easily adaptable to situational circumstances.

Why can't ToU rates be implemented simply with smart meters?

Smart meters cannot do the job because they are not smart enough—and not fast enough. To be effective, ToU rates would require premises-based gateway/energy management system (EMS) equipment to control loads, generation, or storage, in order to respond to the changing rates. This is because if ToU rates depend on manual user-intervention they will likely have a very limited effect. However, if such equipment is in place, why not then jump directly to TE rates instead of implementing ToU? ToU rates are likely too little and too late. Their time may have already come and gone.

Would TE rates requiring premises EMS be unfair to low income customers?

TE tariffs could accommodate "lifeline" rates, subsidies, or other mechanisms to compensate for any disadvantage for customers that cannot or choose not to install such gateway/EMS equipment.

What is the status of TE today?

The results of the Olympic Peninsula trial in 2008 were very promising. Additional trials have been conducted since, including some trials run by PNNL as part of the *Pacific Northwest Smart Grid Demonstration Project* begun in 2013 by The Bonneville Power Administration (BPA) and also in a trial by American Electric Power (AEP) in Ohio. TE has also been applied by PNNL in trials in large transmission grid applications.

However, to date the Olympic Peninsula trial remains the clearest application of TE at the local distribution grid scale. Although a number of trials have been conducted since, they seem to have become more and more complicated, applied at larger scales, and their results have become less definitive. The emphasis seems to have shifted to higher levels of application (i.e., toward centralized generation and transmission concerns) and away from building controls, low level distribution, and microgrids).

In 2013, the DoE-sponsored *GridWise Architecture Counil* (GWAC) in an industry-wide committee effort, began a project to write the definitive work on the topic of TE, the *GridWise Transactive Energy Framework*, and Version 1.0 (65 pages) was published in January 2015 (GWAC, 2015).[5] Unfortunately, the *Framework* document, a large highly technical report, does not well serve the purpose of clarifying the essence of TE and its value and importance, to the public, to industry, or to regulators. Although it is a valuable piece of work and filled with important technical and historical information, it is also mired in arcane industry jargon, with many unstated assumptions and missing or unclear antecedent concepts, and a parochial focus on the U.S. grid operational context which differs significantly from other world utility practices.

[5] GWAC (2015). *GridWise Transactive Energy Framework*. GridWise Architecture Council. U. S. Department of Energy, Pacific Northwest National Laboratory. (PNNL-22946) January

It was observed that that after two years of GWAC focus on TE, there was still no clear, concise message/concept. One definition of TE was however agreed on: *TE is a mechanism for community sharing of energy resources and their value/benefits*.

What is the future of TE?

The importance of TE is primarily within the local distribution grid, as was demonstrated in the Olympic Peninsula Trial. It offers a method for localized balancing and trading of electricity at the community level for enabling higher levels of solar PV penetration. It may be an ideal dynamic control mechanism for microgrids and solar-plus-storage.

Why is TE important to us?

TE in some form will likely be the primary mechanism for balancing supply and demand among users in distribution grids or in microgrids of the future. It is possible that TE can and may serve to replace demand response, net metering, feed-in, and all other tariffs and forms of variable rate pricing and utility control schemes.