White Paper on

TRANSACTIVE ENERGY RETAIL APPLICATIONS

Prepared by the B2G/I2G Joint DEWG of SGIP 2.0

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INTRODUCTION

THE BIG PICTURE

Smart grids are advancing to enhance energy security and sustainability, as mandated by the U.S. Energy Independence and Security Act of 2007. The constituents of smart grids include smart meters, grid sensors, distributed generation, microgrids, storage, and customer equipment.

Renewable energy resources such as wind and solar produce power that varies with the weather and time-of-day. When more power is produced than can be used locally, some utilities buy the excess power and allow it to be fed onto the electric grid. This creates two-way power flows that vary significantly by time-of-day and weather. A passing cloud might reduce the output quickly in a neighborhood that has lots of solar power.

Presently, the levels of renewable production in most countries are so low that this insertion of power has minimal impact on grid operations. However, as renewable production reaches about 30% of the total power needed in a region, renewable sources could impact the business of utility power production and the technology of power distribution via an electricity grid. As renewable energy installations expand, utilities and ISOs (Independent System Operators) need to:

- Adjust supplies to accommodate renewable energy resources.
- Expand operational tools for achieving grid balance.
- Include customer equipment as active participants in achieving grid balance.

Balance in a traditional grid is achieved on a very short time scale of seconds by governors on electric generators. On a time scale of approximately 15 to 30 minutes, engineers at the electric plant can bring additional generators on line, take generators off line, or adjust generator outputs through a dispatch process as demand changes (these supplies are characterized as *dispatchable*). Utility operators and independent system operators (ISOs) can anticipate loads a day ahead with more than 90% accuracy based on historical data, weather predictions, time-of-day, and weekday versus weekend. This continual procedure of adjusting supplies is called *load following*.

Some customers facilitate grid balance by participating in demand response (DR) programs, which traditionally operate on longer time scales than load following. Demand response (DR) methods have been evolving for about 20 years to alleviate demand fluctuations in conventional grids. About 10% of customers are active participants in programs that achieve grid balance through demand response (DR).

As renewables proliferate, new tools are needed because a larger percentage of the supply is not dispatchable. These tools should encourage the development of customer equipment that automatically adjusts demand as supply fluctuates. Also, these tools should encourage the development of effective energy and thermal storage systems.

Our goal is to address increasing amounts of variable generation, loads, and storage while maintaining grid reliability. Therefore, we seek an efficient and cost-effective solution for empowering maximum customer participation and for encouraging the deployment of storage systems. This paper describes a Transactive Energy approach for addressing some of the challenges around integration of renewable generation.

TRANSACTIVE ENERGY AND THE TRANSACTIVE RETAIL TARIFF

Transactive Energy (TE) combines market forces and control techniques to achieve grid balance[1]. In a retail TE environment, customers (typically using automation tools) purchase power for future delivery (called a *forward market*) according to anticipated loads and pay for the power when delivered to complete the *forward transaction*. If a customer has excess generation or storage resources, these may be sold to the market. Power is bought and sold at a specified level and time, which could be a few minutes or hours later. *Forward transactions* enhance grid stability because supplies (generation and storage) can be prepared for delivering power to a load at an assured price. In addition to power, the markets also trade transmission capacity, since power must flow from source to load over wires that have capacity limits. Thus, TE is not a purely financial market like a stock market. Furthermore, customers expect lights and appliances to operate. Therefore, a TE market needs constraints to protect small-volume consumers from excessive price volatility and from being squeezed out of the market for power.

The U.S. Department of Energy asked the GridWise® Architecture Committee to create a conceptual framework that can be used for developing architectures and designing solutions related to Transactive Energy. The goal of this effort is to encourage and to facilitate collaboration among the many stakeholders involved in the transformation of the power system and, thereby, to advance the practical implementation of Transactive Energy. A draft of the Transactive Energy Framework document is available at http://www.gridwiseac.org/about/transactive_energy.aspx.

This white paper introduces a type of retail transactive tariff that can best accommodate two-way transactions between customers and energy commodity and distribution services providers. Such tariff designs communicate prices that reflect costs and support public policy and intelligent energy use. This paper does not address the political, business, and technical implementation of Transactive Energy.

For purposes of this white paper we define a "transactive tariff" as an agreement or contract that enables specific transactions at specific prices between two parties. The transactive tariff does not specify the prices of transactions; such prices are determined by the business processes of the parties that may be subject to regulatory oversight.

SCOPE OF RETAIL TRANSACTIVE ENERGY (TE)

TE and associated tariffs apply to conventional retail energy providers (REPs), distribution operators and all retail sectors. These retail sectors include residential, commercial, industrial, government, military,

[1] Wacks, Kenneth, "Transactive Energy for Balancing Smart Grids," *iHomes and Buildings*, summer 2013, pp 15-18. http://docs.caba.org/documents/ihomesandbuildings/CABA_iHomes_summer_2013_web.pdf

agricultural, and electric vehicle. Power production will be shared among traditional utility plants, renewable resources from large wind and solar farms, and distributed energy resources operated by customers. Eventually, the electricity grid may evolve from a tree structure to a mesh of local power grids called *microgrids*. Retail distributed generation and storage includes rooftop and community photo-voltaic (PV) equipment, co-generation, battery and thermal storage, and other devices and business applications that may present two-way flows to the distribution grid.

Interoperable transactive tariffs for commodity energy and distribution services may be provided by investor owned, public power, municipal, community choice aggregators, cooperative, competitive, and microgrid REPs. TE at the retail level can also support peer-to-peer transactions and retail exchange markets. However, the focus of this paper is on tariffs for conventional REPs and distribution operators providing service in both cost-based and competitive jurisdictions.

An important concept in TE is the establishment of a TE domain. TE is not like a stock market with nation-wide trading, but more like a farmers market, where buyers and sellers strike deals on a local or regional level. Eventually, TE could expand into markets comparable in size to an ISO with adjustments for a retail versus a wholesale environment. It is anticipated that automation will be required to enable retail TE, supporting a greater number of smaller trades while representing an owner's control strategies and energy use preferences.

The perspective of this white paper is that REPs offering transactive retail tariffs will interface with existing wholesale (bilateral and exchange forward) energy and transmission markets and ISO/RTO spot markets, or with their own balancing and transmission services if vertically integrated. Therefore we will not address applications of TE at the wholesale level. TE tariffs could be applied for customers taking wholesale transmission-level service. However, micro grids are outside the wholesale domain, so we are focusing on retail customers taking service on the distribution grid and from micro grids.

WHAT IS A TRANSACTIVE ENERGY (TE) MARKET?

Transactive Energy is an automated strategy for balancing the supply and demand for electricity. Traditional load following adjusts supplies, while Transactive Energy introduces market and technology methods that adjust both supplies and loads to achieve balance more effectively and on a larger scale than DR. Thus, utilities and customers will use elements of Transactive Energy.

TE engages customers and suppliers as participants in decentralized markets for energy transactions that strive towards the three goals of economic efficiency, reliability, and environmental enhancement. Customer-premises equipment participates in TE by communicating with other smart grid devices. For TE to be effective and to proliferate, manufacturers need to adapt products such as appliances, thermostats, HVAC equipment (heating and cooling), lighting, and distributed energy resources. Some low-cost devices may not be able to afford TE interfaces. TE functionality may be offered by systems acting as proxies for groups of these low-cost devices. Proxies might include building automation systems and Energy Management Agents (controllers for an energy management (EM) system), as specified in the ISO/IEC 15067-3 standard[2].

[2] ISO/IEC 15067-3:2012, “Model of a demand-response energy management system.” http://webstore.ansi.org.

The benefits of TE accrue to society at large. The benefits result from efficiency gains in investment, operation and consumption, and innovation through markets. Consumers benefit from potentially lower costs, the application of automation to manage electricity use, and the opportunity to purchase the level of reliability they choose. Producers, wires owners, and intermediaries benefit by transparent, stable long-term revenues, and spot market revenues for their products to support investment recovery and profits. These benefits are assumed to be greater than the cost of TE equipment and the cost to adapt building automation systems to TE.

TE enables smart grids to adapt to new challenges introduced by more variable renewables, more distributed generation and storage, more automated management of usage, and two-way flows on a distribution grid.

TRANSACTION TYPES

TE is based on buy and sell transactions of energy among parties that consume, produce, store, and transport electric energy. Parties can include end users who also own energy consuming devices, storage and generation; central generation owners; and distribution and transmission grid operators. Two types of transactions can be considered: forward and spot transactions.

FORWARD TRANSACTIONS

TE transactions are for energy to be delivered later. This interval between purchase and delivery may span a year, month, day, hour, a few minutes, a few seconds, or as soon as possible (see spot pricing below). Not all customers need to transact on the shorter time interval. Forward transactions among parties are necessary for four basic reasons:

1) Device, system, and grid operation generally must be planned and must reflect the physical limits of devices and systems to consume, to produce or store energy, to turn on or off, to ramp up and down, and to provide the services.

2) Devices, systems and grids must be manufactured, constructed, installed, and maintained, and fuel must be purchased and scheduled for delivery ahead of actual operation.

3) Parties prefer stability in costs and revenues, which can in part be accomplished with forward transactions for energy.

4) Forward transactions reduce the volume of spot market transactions and thereby reduce the leverage of large suppliers over spot market prices.

SPOT TRANSACTIONS

In addition to forward transactions, transactions at the time of delivery (spot or real-time transactions) are necessary to balance energy production and usage instantaneously and to ensure that the grid operation is stable. In reality TE can support a continuum of forward and spot transactions at different times before real-time delivery begins and then after delivery for settling some imbalances.

COORDINATED DECENTRALIZED CONTROL

TE supports real-time coordinated decentralized control of electrical devices by the users and owners of these devices. Such coordination is accomplished using explicitly priced tenders (offers) and transactions among parties to pay for electric energy consumed or produced by devices.

Coordinated decentralized control is an alternative to uncoordinated decentralized control or centralized control of devices. In electric grids with fixed prices for retail customers, for example, there is little coordination of device operation and grid conditions. Centralized control of retail devices may not appeal to many retail customers; it is very complex and expensive because of the amount of data on device physics and customer preferences that needs to be collected, raising privacy concerns. In fact, centralized control is generally not feasible on a wide scale; coordinated decentralized control is the only practical option.

TRANSACTIVE ENERGY IS A BUSINESS PROCESS

TE also is a business process for energy transactions among parties. This business process uses the following definitions:

1) An Energy Transaction is an exchange among parties of an Energy Commodity for a Payment.
2) An Energy Commodity is a Quantity of Energy delivered at a location during an interval of time.
3) A Payment is a transfer of currency from one Party to another.
4) A Price is the Payment per unit of the Commodity.

TE transactions cover a wide range of complex contracts, algorithms, and specific business processes including e-commerce for electricity.

MORE DETAILS

This white paper has focused on introducing retail Transactive Energy and a Transactive Retail Tariff (TRT). A more detailed discussion of TRT is presented in a second white paper, “White Paper on Interoperable Transactive Retail Tariffs” (ITRT) available on the B2G/I2G Joint DEWG SGIP group website. This ITRT white paper on TE tariffs covers challenges faced in smart grids, benefits of the TRT in addressing the challenges for different grid stakeholders, an example interoperable TRT, and the role of the SGIP.