Tipping Point for Transactive Energy: A Discussion of the Evolving Electric Industry's Policy and Technical Challenges[1]

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Introduction

Transactive Energy refers to a set of techniques that manage the flow of electric power within an electric power system through the use of economic or market-based constructs while considering grid reliability constraints. You have probably already heard references to transactive energy, but as more people use the term, it is important to develop a common understanding about what transactive energy really means and how it will impact electric grid reliability, utility operations, customer options, and the regulatory process. At the same time, it is important to understand why transactive energy is so important and how it has so much potential to enhance the flexibility and reliability of the electric grid and marketplace. Transactive energy systems have a lot to offer, but in order to realize the benefits we have to have policies that recognize the potential, guides its implementation, provides ways to measure its success, and incentivizes its use.

What is Transactive Energy?

For many people transactive energy delineates a communications and business model through which electric customers interact with their utility to buy and sell electricity based on economic and reliability signals. In a transactive energy system each participant chooses to take action (or not) based upon the monetary, philosophical, or other value to them of that action. The transactive energy model captures the evolutionary transition from the traditional model where utilities provide electricity and ancillary services to customers with minimal communications outside the monthly bill for service, to today's transitional situation where some customers self-generate and buy and sell power to the utility at fixed rates.

Why do we say transition? The industry is undergoing a fundamental shift from a load following paradigm to a supply following paradigm and we can't afford to design purely for either extreme during the transition. That means we need an electric system that is flexible. Transactive energy is a model that provides that flexibility. More importantly, it captures the future utility-customer interactions in which

[1] The perspectives guiding the writing of this article reflect the Transactive Energy Framework developed by the GridWise Architecture Council.

an increasing number of customers will self-generate and independently decide when to buy and sell power. Customers will also likely buy and sell power between themselves, independent of the utility and regulatory communities and even without selling power, organizations with campus facilities or large buildings may want to utilize these techniques to focus on the elements that are of most value to them whether that be cost, power quality, or other measurable criteria. In a strip mall where the anchor tenant has PV and ground source heat pumps they might choose to provide power and demand-side management services to other tenants in the mall. Businesses within a building that might be able to shed load in support of another tenant (e.g. one with more computer processing needs) in response to a utility company directive to shed load. In this instance there could be monetary benefits for the party that could shed "more" than its share of the load and the utility would neither know nor care so long as the overall load was reduced.

How would these transactions work and would there be broker? There might or might not be a broker. If we talk about an industrial park or high rise office building, there might be an aggregator/broker; if we talk about a strip mall, it might be the energy manager for the anchor tenant or mall owner.

Accordingly, when defining transactive energy and transactive energy systems, it is helpful to think of transactive energy not as some software or hardware that can be purchased and installed, but as a model in which generation, storage, and loads enabled by intelligent communications capabilities create the ability for customers and utilities to buy and sell commodities (including energy) and services between themselves based on mutual economic benefits.

Historically, the electricity industry has focused very narrowly on capturing value along the traditional electricity production-to-consumption value chain. Today, opportunities are available to capture additional value by “growing the pie” along other related dimensions. In fact, opportunities are already being monetized in the electricity industry in two of these dimensions. Including the conventional value chain, three degrees (dimensions) of value[2] may be stated as follows:

1. Value from the primary energy channel; i.e., the traditional “core business” of the utility, including unregulated energy trading activities and support services such as energy efficiency and demand response programs.
2. Value from service/product sales through fees and revenue sharing from co-marketing, co-branding, or referrals that are related to the core business (e.g., appliance sales, energy equipment maintenance and financing).
3. Value from service/product sales that are not directly related to the core business, but are made possible by capitalizing on information/intelligence derived from the first two streams (e.g., non-energy related financial services, security, water-related services).

These three degrees of value can and are being combined to create more compelling business strategies for new and existing ventures. Transactive mechanisms will allow utilities to extend revenue streams beyond their core business via greater customer engagement for provision of grid services in return for

[2] GWAC Transactive Energy Framework

monetary incentives; this will result in an alignment of the value streams of all interested parties. The values from the secondary and tertiary sources may be by-products of greater customer engagement fostering an eco-system of third-party providers of specialized services.

And if this sounds like a vision of the future, the recent NYREV Order states that DSPs will provide or sell a set of products and services to customers and service providers. Those might include transaction or usage fees, platform access, analytic services, interconnection services, pricing and billing, metering information services and data sharing and DER maintenance, operation, and financing.

Why is there so much interest in this?

Transactive energy is creating interest because it addresses the rapid changes that are occurring in the electricity industry. New devices, both personal and utility-owned will be able to impact the grid directly and also interact with each other. Preparation to integrate these technological and policy changes and to make measured and effective choices has already started. The State Of New York Public Service Commission epitomized the start of the transition to a transactive energy-capable system with its Order adopting a new regulatory policy framework and implementation plan on February 26, 2015. In that Order the NYPSC states that the electric industry is in a period of momentous change and that the challenges that stimulate action also reveal tremendous opportunities to improve the century-old regulatory system. The NY Reforming the Energy Vision (REV), aims to reorient both the electric industry and the ratemaking paradigm toward a consumer-centered approach that harnesses technology and markets. This construct is ripe for the application of transactive energy.

In today’s market, utilities must purchase surplus customer generated electricity when it is available (e.g., net metering requirements) and sell power to those customers on the customer’s demand. Utilities have less than perfect predictions of when customer generated energy will be available or when the customer demands will arise; and as more and more customers adopt behind the meter generation, the system as a whole will become less predictable thus it needs to become more flexible, able to respond rapidly to changing conditions and circumstances.

In a transactive energy system, utilities and customers can (continuously) negotiate to buy/sell energy and provide ancillary services based on the value to each party to provide and receive those products and services. Whereas today utilities may have rates for interruptible service, power quality, time of use and other factors, “tomorrow’s” customers will be able to respond to price and/or reliability signals to increase or reduce their generation/consumption and offer products and services to other customers in direct competition with the utility or other energy suppliers and/or customers.

Customers and Transactive Energy

There is a significant body of research and opinion that many consumers are not interested in anything more than having the lights come on when a switch is thrown. For policy-makers, utility executives, and regulators, the difference between “early adopters” and other customer types raises questions about what types of intellectual and financial investments will be necessary by utilities and customers to make things work? If we expect most residential customers in the near term to invest a lot of time and effort into making these consumer systems work, we have very little chance for success. For most consumers it will have, at least initially, to be plug and play. Yet it is the residential customer class that represents the most untapped potential for demand response (DR) and, based on the experience of telecommunications providers, the vast majority of customers will adopt interactive capabilities within five years of availability.   While residential customers provide roughly 17 percent of today's demand response potential they provide a huge potential for transactive energy systems and demand response. In Europe the DR market is estimated to grow from 2014 to 2019 at a compound annual growth rate of 36.3%[3]. A primary focus now and for the next decade involves creating differentiated services, resolving market access issues and creating successful customer value propositions[4]. A customer can participate in responding to operational and market signals without knowing that they are part of a transactive energy system.

Customer Choices, Utility Options, Technological Change

So as more and more customers decide to self-generate and interact with each other how would this work? And how would small prosumers and the larger entities be integrated into a reliable grid operation?

Customers have always had the opportunity to self-generate and many large customers regularly do so (e.g., co-generation, back-up generation to offset utility load shedding requests). The increasing popularity and political acceptance of small scale self-generation (e.g., roof top solar, small wind turbines) by residential customers is enabled by political acceptance, technological advances, environmental activism, and decreasing purchase, installation and maintenance costs. Customers do not however always act in their financial best interests, as early adopters of solar units experienced high prices and low reliability. Consumers are also far from the purely rational decision-makers assumed by traditional economic models, and there is often a wide gap between peoples' values and material interests, and their actual behavior[5]. Some early adopters of solar units may have been driven by environmental and political factors, but their investments resulted in an improvement in product quality and performance, lower costs to acquire and operate, and much broader acceptance/installation of self-generation devices.

Large customers are equally driven by a multitude of factors to self-generate, reduce their carbon footprint, and be more environmentally responsible. Military installations are under Presidential and Congressional directives and also acting out of security concertns; major corporations face stockholder and customer pressures, and smaller businesses are seeking to emulate their customers' values. For both large and small customers, the ability to self-generate and better manage demand-side options

[3] Europe Demand Response Management System (DRMS) Market, MicroMarket Monitor, 17 Feb 2015
[4] DR 2.0: Future of Customer Response, Paul De Martini, Newport Consulting, July 2013
[5] Household energy use: Applying behavioural economics to understand
consumer decision-making and behavior, Elisha R. Frederiks, Karen Stenner, Elizabeth V. Hobman, CSIRO Adaptive Social and Economic Systems, September 2014

combined with technological advances in communications (e.g., smart phones and interactive apps between the phone and appliances), results in increased demands on utilities, regulators, and policy-makers to enable customers to better monetize their generation, load shifting, and inter-customer/customer-utility communications capabilities.

Transactive energy systems are being driven by economic, technological and customer preference opportunities that were just beginning to exist five years ago. Utilities, regulators, and policy-makers must decide whether to embrace the evolving electric generation and marketplace developments or resist them. Regardless, the evolution will continue, just as the wireless communications devices (cell phones) transformed the telecommunications industry, so too technological innovations and expanded capabilities are transforming the electric industry. With today's enhanced performance and declining costs for many renewable energy sources entering the system today, these resources are here to stay. Facilitating their reliable integration into the grid using ad hoc arrangements has worked so far but as their combined effects become significant, a more robust response is required. The response should be to create an increasingly flexible network – at all levels of the electricity deliverability system – and this is the challenge we face and the direction in which we are headed.

What are the challenges that we will need to overcome?

Residential consumers, remain reluctant to participate in grid activities in part because they do not see adequate value in terms of the effort required or the perceived risks or because they have a more passive relationship to the electricity delivery system. Many of the benefits for today's residential customers are non-financial though the financial case is still positive but with the increase in smart apps to control electricity use, respond to price signals, and interact with other customers, the number and percentage of residential customers who engage with transactive energy systems will rapidly increase.

While customers may end up being a large proportion of the transactions in many transactive energy systems, the question arises "if the market is open to tens of thousands of participants, all responding to the same price signals, who's the traffic cop?"

In its Transactive Energy Framework, the GridWise Architecture Council (GWAC) defines transactive energy as "*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*." It also goes on to address the question of operating markets by saying that ideally policy makers will have a toolkit available to them that includes a catalog of policy guidance and mechanisms such that regulators could compose transactive energy policies specific to the needs of their regulated jurisdictions. However, any policy would require flexibility to compensate for deficiencies in market design (such as undue market power or gaming) that are discovered in the course of market operations.

In addition, regulators may take a conservative, phased approach to introducing transactive energy mechanisms in their jurisdictions by using familiar tariff constructs and testing the effectiveness of certain pricing and market designs in limited pilots to ensure participants are properly incentivized and aligned through these mechanisms. GWAC members, in consultation with utility, regulatory, legislative and consumer interests, are developing a Transactive Energy Decision-Makers' Check List to help frame discussions and decision-making in regulatory and legislative arenas.

In its Order Adopting Regulatory Policy Framework And Implementation Plan (CASE 14-M-0101 – Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision) NY REV describes its expectations (page 31) that a Distributed System Platform Provider (DSP) should foster broad market activity that monetize system and social values, by enabling active customer and third party engagement that is aligned with the wholesale market and bulk power system. In its Order the NYPSC also states that the Commission's chief concerns with respect to DSP regulation will be to enable markets, ensure fair market practices, fair and transparent information, data and services to all providers and their customers, impose standards for business practices and other protections necessary to protect consumer interests, and ensure the continued reliability of the system.

Control and Markets

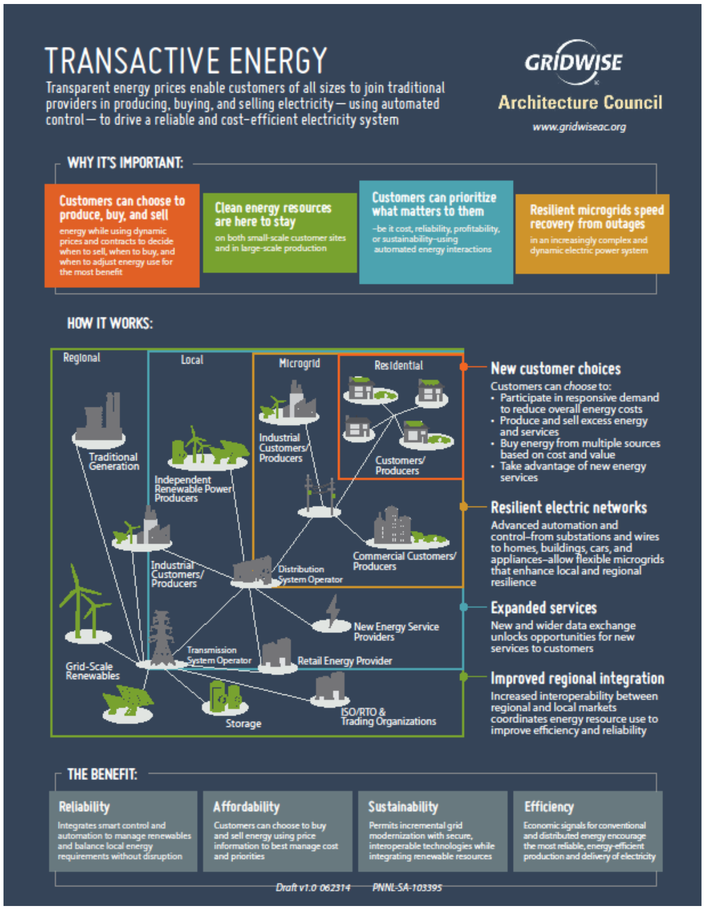
Over the past 50 years, telecommunications advances have enabled electric utilities to more efficiently manage and control grid operations because they have more information about system operations (e.g., generation efficiency, transmission line losses) in a more timely fashion. The evolving communications-electric capabilities enables customers to interact on the generation, demand-side, distribution, ancillary services dimensions as near equals with the utility. It has been said that if Thomas Edison could see the industry today he would recognize it as being much the same as 100 years ago but that may not be the case for much longer. The century old paradigm of large scale generation and distribution is starting to change as renewable resources make more of an impact.

The pace of change and its consequences to those not participating can be partially controlled by the regulatory and policy-maker communities, but customer demands and expectations, combined with the technological ability to self-generate and manage their electricity consumption, will transform the electric industry and marketplaces. Implications for the grid system's reliability due to the increase in distributive generation and customer-customer interaction capabilities outside the regulatory and utility observation and control are significant and it is clear that both GWAC and NYPSC place a high importance of including reliability as an integral component of distribution energy markets and systems so as to maintain the continued reliability of the system. Distribution system operations were not designed for large scale, frequent penetration of inputs from customers with the potential power flows in multiple directions. Nor did yesterday's system operation contemplate the need to rapidly change a utility's generation mix to meet fluctuating demands and the intermittency of some renewable generators.

The load side is changing, too, by becoming more adaptable. With lower costs associated with measuring and communicating with electrical loads (e.g. "smart appliances") the two-way communications capability (between customers and utilities, as well as between customers, appliances, and service providers) reflects and electric system more capable of responding to information and adjusting consumption behavior in ways that benefit both the customer and the greater electrical system. Building these capabilities into household appliances will give consumers the opportunity to participate through set-and-forget devices but these capabilities were not anticipated in the design and operation of the present generation of grid controls, so they introduce new challenges for distribution system operators.

Electric system operations in the future will be driven by the ability and opportunity of each of the principal parties to monetize their contributions. Utilities will continue to provide the backbone of generation and delivery to customers, especially to those who are unable or unwilling to self-generate. Individual customers and customer aggregators will increasingly seek to monetize the value of their generation, load shedding capability, ancillary service provider potential, and contribute to system reliability through micro-grids and other means. Regulators, policy-makers, and utilities must address the technologically driven changes to ensure system reliability and the economic benefits to all stakeholders, including the general welfare of the states.

The GridWise Architecture Council's Transactive Energy infographic below (available at http://www.gridwiseac.org/pdfs/te_infographics_061014_pnnl_sa_103395.pdf) depicts the evolving interactive behavior of customers and utilities. In the center of the diagram (the epicenter of change) is the distribution system operator (DSO). In this document the DSO takes on the responsibility for balancing supply and demand variations at the distribution level and linking the wholesale and retail market agents.



Assuming something like New York's REV platform, would each utility be a Distribution System Operator and orchestrate transactive energy systems and markets? The answer according to the NYPSC is “yes”. The NYREV DSP and DSO are very similar concepts and in its recent Order the NYPSC states that the DSP core functions would be highly integrated with utility planning and system operations, and assigning them to an independent party would be redundant, inefficient and unnecessarily costly.

Regulating/Non-Regulating the Evolving Competitive Marketplace

As the marketplace of generators and inter-customer transactions increases, how does the marketplace and/or government officials ensure transparency, accountability, and fairness to all participants and nonparticipants? Some elements of the evolving marketplace can be effectively regulated (e.g., registration of aggregators), other segments will be impossible (e.g., customer-customer demand-side transactions), and some will marginally be (e.g., signal transparency on prices and ancillary services). Just as generators bid to serve load in competitive markets, so too will self-generators bid into markets (managed by the utility or other entity such as a DSO or DSP) to provide energy, shed load, or provide balancing and other services.

Capability thresholds and performance guarantees may be established, but the number of potential bidders will require transparency and fairness rules be developed by the Public Utility Commissions and policy-makers. This will need to include deliberations on how to treat the increasing amount of storage that is expected to be deployed in the coming years. Does storage require special regulation since it can act either as a load or a generator, or should it simply be required to comply with regulations consistent with its mode of operation? Can a storage device be contracted to be a generator and a load during the same time period? And should that matter if the device can fulfill the requirements of both during the time period for the contacts? How will the increase of electric vehicles affect storage needs and system conditions?

Transactive energy systems can exist whether utilities operate in vertically integrated or restructured markets. The difference will be the number of potential participants to provide and consume energy and services, and whether the transactive energy systems exist entirely behind the meter or not. While regulators and policy-makers will establish the broad operating rules (e.g., similar to regulating stock trades on Wall Street), the actual transactions will be “regulated” by the open, transparent marketplace.

Self-generators or customers willing to participate in demand-side management programs, could actively respond to signals initiated by the utility or other market participants (other entities in a transactive energy system), or they could list a sell or buy price or operational parameter that would trigger an offer when the market reached that point (e.g., similar to standing “buy” or “sell” orders for shares of stock). The rules of engagement will necessarily permit both the more active and passive forms of trading. The rules also will need to address competitive fairness so that no party acquires an unwarranted advantage in monetizing their generation or service options.

Large and/or sophisticated energy customers will be able to engage in transactive energy marketplaces on their own; some with less sophisticated energy managers or smaller generation/demand management potential will aggregate their capabilities and participate with other customers through a broker or service provider who engages on their collective behalf. They will also be able to create their own behind-the-meter transactive energy systems to optimize performance of a campus or building.

Challenges and Opportunities for the Electric Utility

No business wants to lose customers or market share, yet markets shift constantly as new products are introduced and new competitors enter. Electric utilities that fail to account for the increasingly cost-effective customer self-generation capabilities and the ability to communicate with each other will suffer decreases in revenues and reduced support among customers, regulators, and public opinion. Utilities that acknowledge the changing technological opportunities available to customers, through both self-generation and smart communications devices/software, will identify new revenue opportunities.

Some utilities have begun seeking higher customer charges to reflect the need for customers to pay their share of stand-by generation and transmission/distribution costs, while others seek to provide customer-generation equipment/services and/or customer generation or demand-side aggregation. The former are attempting to maintain the traditional business model, the latter are recognizing the nature of transactive energy opportunities.

Utilities will thrive if they identify ways to better serve their customers' desires to manage their energy consumption, find niche markets within the larger electricity marketplace, educate their regulatory and policy-maker communities about how the evolving business requires changes in utility and regulatory operations models, and find ways to make their legacy systems more efficient in conjunction with micro-grids anchored by large customers and aggregated neighborhood generation. Utilities that develop partnerships with their large customers to serve as those micro-grid anchors will ultimately have greater system resiliency and operational security.

Transactive energy offers tools to help with a process that will engage customers to develop their own priorities and for utilities to anticipate, react, and operate in new ways. Those customers and utilities who can manage their energy production/consumption needs will thrive in the same manner as the telephone companies that transformed themselves from a wireline-based telephone business to a wireless communications provider. Those utilities that cannot accommodate the evolving technological and "app" revolution will find their markets have shrunk in the same manner as the horse drawn carriage and buggy whip manufacturers

Conclusion

It is important to note that transactive energy and change does not mean the demise of the utility, if the utility demonstrates flexibility. We are facing a transition over a few decades from a load following paradigm to a supply following paradigm and we can't afford to design purely for either extreme during the transition. That means we need an electric system and regulatory policies that are flexible. Transactive energy is a model that provides that flexibility and both organizes and describes the evolving electricity marketplace being driven by: a) customer value, more reliable self-generation capabilities, policies, customer preferences, and government directives; b) improved communications capabilities that permit real time monitoring of electron generation and flow, price and reliability signals, and interactive capabilities to manage consumption and generation by customers; and c) a regulatory environment not able to control customer expectations and capabilities. Successful electric utilities, customers, and third party service providers will create new platforms and services to meet these rising customer expectations.

Islands of customers may decide to go off the grid but we still need the grid to connect the rest of us including centralized generators which will not be going away anytime soon. There will also be customers who will not want or are not able to participate in transactive energy systems. Those customers will continue to receive full services from the traditional utility and will, necessarily, be the focus of many public and government discussions about how best to protect their economic and energy reliability needs.

As we said at the start of this article, we have to have policies in place that recognize the potential benefits of transactive energy to utilities and customers and its inevitability; guides its implementation; provides ways to measure its success; and incentivizes its use. The GridWise Architecture Council's Transactive Energy Framework is one way to visualize the evolving electric system and develop the management and marketing tools necessary to thrive in the new marketplace.