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TECHNICAL REPORT

colour inside

Information technology – Home electronic system (HES) application model – Part 3-8: GridWise transactive energy framework

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INFORMATION TECHNOLOGY –
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FOREWORD

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ISO/IEC TR 15067-3-8, which is a Technical Report, has been prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
JTC1-SC25/2944/DTR	JTC1-SC25/2965/RVDTR

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the ISO/IEC 15067 series, published under the general title *Information technology – Home electronic system (HES) application model*, can be found on the IEC and ISO websites.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Over the past two decades, the use of demand response and other flexible distributed resources for electricity market efficiency and grid reliability has grown dramatically. Customers' loads, generation, and storage will impact the management of an increasingly unpredictable power system. Because of this growth in flexible distributed energy resources deployment, attention is being devoted to addressing not only the economics of the electricity grid, but also the control system implications for grid reliability. This has led to a focus on an area of activity called "transactive energy". Transactive energy (TE) refers to the use of a combination of economic and control techniques to improve grid reliability and efficiency. These techniques can also be used to optimize operations within a customer's facility.

The motivations for employing TE systems come from the increasing diversity of resources and components in the electric power system and the inability of existing practices to accommodate these changes. Expanded deployment of variable generation on the bulk power side, distributed energy resources throughout the system, and new intelligent load devices and appliances on the consumption side necessitate new approaches to how electric power is managed and delivered, and the associated economic and business models. Conventional wisdom is that once variable generation resources reach 30 %, the current control systems for the grid will be simply inadequate [1][1].

Transactive energy systems provide a way to maintain the reliability and security of the power system while increasing efficiency by coordinating the activity of the growing number of distributed energy resources. These multiple goals pose a multi-objective control and optimization challenge. This is one reason why TE embraces both the economics and the engineering of the power system. The same considerations outlined for the electricity grid apply to building energy systems and other local energy systems such as microgrids [2].

In the past, these systems could be considered simply end nodes on the physical power grid that act as simple "dumb" loads. But they are becoming increasingly more interactive with the grid, providing intelligent load, storage, and generation sources. They now need to be considered integral and active components of the grid as a whole. Building energy systems account for a majority of the electric power consumed in the United States. For example, the U.S. Energy Information Administration (EIA) estimated that buildings (residential and commercial) would account for around 70 % of electricity consumption in the United States in 2014 [3]. Recent EIA data shows that this projection was correct and electricity use in buildings is currently just over 70 % each year [4]. From the grid perspective, buildings are examples of loads that will be integral, active components of the end-to-end electric power system. Within buildings, the same need exists to achieve similar economic and reliably optimized solutions to manage energy and potentially to realize new revenue streams through participation in markets related to electric power systems. The growing adoption of electric vehicles presents a new class of controllable loads, and possibly even generating loads, that can interact with the grid.

Asset owners, system operators, and other economic entities involved in the generation, transmission, and use of electric power all have a stake in a reliably efficient power system envisioned with the use of TE. There is a clear need to align value streams for all of these parties by using incentives for participation in an actively managed system. This document describes the considerations and basic elements for all stakeholders. This provides an opportunity for discussing how various approaches can enable alignment of value streams and the creation of sustainable business models.

[1] Numbers in square brackets refer to the Bibliography.

Regulatory, policy, and business issues frame the discussion about the functional characteristics of TE systems. From these characteristics, this document also presents a conceptual or reference architecture illustrating the principal functional entities and relationships. The intent of this material is not to define a specific solution, but to describe the TE environment and to enable comparisons among various approaches.

This document further examines the practical dimensions of implementing TE systems by considering the cyber-physical system aspects. Here, too, this document avoids prescribing specific solutions, but rather identifies gaps and technology challenges that need to be addressed.

There have also been several new TE pilots proposed and implemented, and panels on TE can be found at most conferences, including technology-focused conferences such as Institute of Electrical and Electronics Engineers (IEEE) Innovative Smart Grid Technologies and industry conferences such as DistribuTECH, showing considerable interest in this topic. TE is also a frequent topic in technical journals, magazines, and blogs. These varied platforms for discussing TE indicate a broad acceptance of the possibilities offered and interest in ways to apply TE by service providers, utilities, and regulators.

The intent of the TE framework is to promote discussion at the conceptual level of common features or elements of specific models, designs, or implementations of TE systems. At this conceptual level, the framework is intended to be broad and overarching.

In promoting broader discussion, multiple diverse stakeholders need to be considered. Consequently, TE involves contributions from multiple disciplines spanning both economics and engineering. The implications of the potential new approaches for managing and controlling electric power systems call for a broad involvement of economists, regulators, policy makers, vendors, integrators, utilities, researchers, end-consumers such as building owner-operators, and other stakeholders. The diversity of thought provided by multiple viewpoints is important to achieving a framework that addresses the variety of perspectives and needs these stakeholders bring to the table.

A framework is a method and a set of supporting tools that can be used for developing an architecture. The TE framework is a tool that can be used for developing a broad range of different architectures for implementing transactive techniques. This document discusses approaches for designing a transactive system in terms of a set of building blocks, and for showing how the building blocks fit together.

The United States Department of Energy has supported the GridWise®[2] Architecture Council (GWAC) in specifying a conceptual framework for developing architectures and designing solutions related to TE. The goal of this effort is to encourage and facilitate collaboration among the many stakeholders involved in the transformation of the power system and thereby advance the practical implementation of TE. The GWAC developed this document to provide definitions of terms, architectural principles and guidelines, and other descriptive elements that present a common ground for all interested parties to discuss and advance TE.

In creating the TE framework (this document), the authors presume an audience with a good understanding of interoperability, familiarity with ISO/IEC TR 15067-3-2 [5], and knowledge of energy markets and associated business models. People with this level of background should be reasonably able to understand the proposed ideas, critically review them, and participate in reworking or refining the framework so that it becomes a shared creation with tools that propagate and that serve the diverse smart grid community. This document covers the topic of TE at an abstract, conceptual level without prescribing specific implementations. The audience for this document includes policy makers, regulators, vendors, utilities, researchers, practitioners, and end-use asset owners.

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[2] GridWise is a registered trademark of Gridwise, Inc. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC or ISO.

In addition to this document, the GWAC produced a TE Decision Maker's Checklist [6] and a TE Roadmap (ISO/IEC 15067-3-7) [7]. Each document is designed for a different audience and each provides a different perspective on what transactive systems are, how they will evolve, and necessary policy considerations (see Figure 1). In addition, the Smart Grid Interoperability Panel (now Smart Electric Power Alliance) produced a TE Landscape Scenarios white paper presenting six high-level operational scenarios [8]. Collectively, these explore TE interactions and provide examples where TE systems produce value.

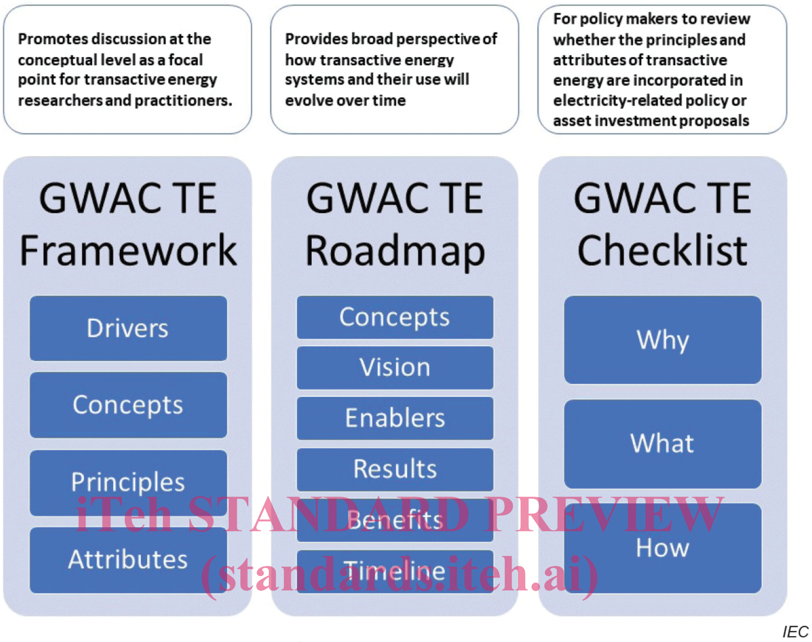

Figure 1 – Overview of GWAC transactive energy reference documents

INFORMATION TECHNOLOGY – HOME ELECTRONIC SYSTEM (HES) APPLICATION MODEL –

Part 3-8: GridWise transactive energy framework

1 Scope

This part of ISO/IEC 15067, which is a Technical Report, provides a conceptual framework for developing architectures and designing solutions related to transactive energy (TE). Transactive energy allows electricity generated locally by consumers using wind, solar, storage, etc., at homes or buildings to be sold into a competitive market. This document provides guidance for enhancing interoperability among distributed energy resources involved in energy management systems at homes and buildings. It addresses gaps identified as problematic for the industry by providing definitions of terms, architectural principles and guidelines, and other descriptive elements that present a common ground for all interested parties to discuss and advance TE.

This document builds upon ISO/IEC 15067-3 [9], with technology to accommodate a market for buying and selling electricity generated centrally or locally by consumers. The energy management agent (EMA) specified in ISO/IEC 15067-3 can represent the customer as a participant in TE. Transactive energy is important for achieving electric grid stability as power from renewable sources such as wind and solar fluctuates with time and weather.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
ancillary services
services necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the transmission service provider's transmission system in accordance with good utility practice

Note 1 to entry: Ancillary services can include synchronized reserves, regulation and operating reserve, energy imbalance (using market-based pricing), and the cost-based services of scheduling, system control and dispatch, voltage control, and black start.

3.2
architecture
fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution

Note 1 to entry: ISO/IEC/IEEE 42010:2011 describes architecture viewpoints, architecture frameworks and architecture description languages for codifying conventions and common practices of architecture description.

3.3
area control error
ACE
instantaneous difference between a balancing authority's net actual and scheduled interchange, taking into account the effects of frequency bias and correction for meter error

3.4
automatic generation control
AGC
equipment that automatically adjusts generation in a balancing authority area from a central location to maintain the balancing authority's interchange schedule plus frequency bias

Note 1 to entry: AGC can also accommodate automatic inadvertent payback and time error correction.

3.5
boundary deference
respect for ownership or system boundaries during interactions

3.6
congestion
characteristic of the transmission system produced by a constraint on the optimum economic operation of the power system, such that the marginal price of energy to serve the next increment of load, exclusive of losses, at different locations on the transmission system is unequal

3.7
customer
anyone taking (using) electric energy

3.8
cyber-physical system
smart system that includes engineered interacting networks of physical and computational components

3.9
demand response
DR
changes in electricity use by end-use customers (including automatic responses) from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized

3.10
distributed energy resource
DER
device that produces electricity and is connected to the electrical system, either "behind the meter" in the customer's premises, or on the utility's primary distribution system

Note 1 to entry: A DER can use a variety of energy inputs including, but not limited to, liquid petroleum fuels, biofuels, natural gas, solar, wind, and geothermal. Electricity storage devices can also be classified as DERs. Some definitions also include DR as a form of DER.

3.11
distributed generation
DG
generation that is located close to the particular load that it is intended to serve

Note 1 to entry: General, but nonexclusive, characteristics of distributed generation include an operating strategy that supports the served load, and interconnection to a distribution or sub-transmission system.

3.12
distribution system operator
DSO
entity responsible for planning and operational functions associated with a distribution system that is modernized for high levels of distributed energy resources (DERs) and handles the interface to the bulk system transmission system operator (TSO) at a locational marginal price (LMP) node or transmission-distribution substation

Note 1 to entry: A range of other DSO models are under consideration in the industry.

3.13
framework
description of a system at a high organizational or conceptual level that provides neutral ground upon which a community of stakeholders can discuss issues and concerns related to a large, complex system

3.14
hedge
protection against financial loss due to price fluctuation by prearranged purchase or sale for future delivery at an agreed-upon price

3.15
home energy management system
HEMS
system that regulates the energy within a household, controlling devices with the goal of achieving optimal energy use and providing consumers with important information about their energy consumption

3.16
interoperability
capability of two or more networks, systems, devices, applications, or components to exchange and readily use information securely, effectively, and without intervention by the user or operator

Note 1 to entry: In the context of the smart grid, systems are interoperable if they can exchange meaningful, actionable information. They share a common meaning of the exchanged information, and that the information can elicit agreed-upon types of responses.

3.17
market
area of economic activity in which buyers and sellers come together and the forces of supply and demand affect prices

3.18
microgrid
electrical system that includes multiple loads and DERs that can be operated in parallel with the broader utility grid or as an electrical island

3.19
photovoltaic power
PV
technology that turns sunlight directly into electricity

3.20
prosumer
person or entity who both consumes and produces

Note 1 to entry: This term was coined by Alvin Toffler. From a smart grid perspective, "prosumer" would apply to DER situations in which the owner of electricity production or storage assets can also have a consumer relationship with a utility, aggregator, or other energy services provider [10].

3.21
regional transmission organization
RTO
entity that is responsible for managing all transmission facilities under its control, maintaining grid stability, and matching electricity demand to supply

Note 1 to entry: RTO can be a regulated independent entity. An RTO performs the same functions as an ISO but has added responsibilities for the transmission network.

3.22
reliability
measure of the ability of the system to continue operation while some lines or generators are out of service

Note 1 to entry: Reliability deals with the performance of the system under stress.

3.23
renewable energy resources
energy resources that are naturally replenished.

Note 1 to entry: Renewable energy resources include biomass, hydroelectric, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

3.24
resilience
ability to resist failure and rapidly recover from a breakdown

Note 1 to entry: See [10].

3.25
supervisory control and data acquisition
SCADA

highly distributed systems used to control geographically dispersed assets, often scattered over thousands of square kilometres, where centralized data acquisition and control are critical to system operation

3.26
smart grid
utility power distribution grid enabled with information technology and two-way digital communications networking

Note 1 to entry: A smart grid enables enhanced and automated monitoring and control of electricity distribution networks for added reliability, efficiency, and cost-effective operations.

3.27
transaction
exchange or transfer of exchangeable products, services, rights, or funds

3.28
transactive energy
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

3.29
transmission system operator
TSO
independent entity that coordinates regional transmission in a manner that is not discriminatory against any transmission owners, operators, or users, and ensures a safe and reliable electric system