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TECHNICAL REPORT

Information technology – Home electronic system (HES) application model – Part 3-7: GridWise transactive energy systems research, development and deployment roadmap

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colour inside

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FOREWORD

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ISO/IEC TR 15067-3-7, 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-SC25/2900/DTR	JTC1-SC25/2966/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.

In this document, the following print type is used:

- ***Bolded italics*** represent condensed encapsulations of the transactive energy (TE) principles described in ISO/IEC TR 15067-3-8:2020, 6.4.

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

It has been said that if Thomas Edison could see the electricity 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. New distributed devices, both consumer and utility-owned, affect the grid directly and also interact with each other. Preparations are already underway to integrate these new resources and technologies by considering operational and policy changes based on measured and effective choices. For example, the industry is undergoing a fundamental shift from a "load following" paradigm, where central generation adjusts to varying demand, to a "supply following" paradigm, where responsive demand absorbs variable generation such as solar and wind. During the transition to a more distributed system, the industry cannot afford to design purely for either extreme. A key to success is to use technologies that support flexible coordination of both centralized and distributed elements. One such approach is provided by transactive energy (TE) systems.

Transactive energy systems are systems of economic and control mechanisms that allow the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter. This definition is from ISO/IEC 15067-3-8:2020, 3.28 [1][1].

This broad definition allows us to recognize the existing use of transactive techniques in bulk energy markets and to consider how to enable new techniques for possible use in distribution systems, at the interface between transmission and distribution, and perhaps even more broadly.

The need for transactive energy systems is being driven by economic, technological, and customer preference opportunities that were just beginning to exist five years ago. Better performance and declining costs for many renewable energy sources and storage technologies now being deployed suggest use of distributed energy resources will continue growing. Distribution systems were not designed for large-scale deployment of distributed energy resources with potential power flows in multiple directions. Ad hoc arrangements have worked so far, but as the combined effects of changes that are often outside of regulatory and utility observation and control become significant, a more robust response to maintaining and enhancing safety, reliability, and resilience of distribution energy systems and markets is required.

ISO/IEC TR 15067-3-7 is adapted from the GridWise®[2] Architecture Council document, *Transactive Energy Systems Research, Development and Deployment Roadmap* [2], which provides a broad perspective of how transactive energy systems and their use will evolve over time. It has been edited to align with the format of IEC documents.

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1 Numbers in square brackets refer to the Bibliography.

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.

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

Part 3-7: GridWise transactive energy systems research, development and deployment roadmap

1 Scope

This part of ISO/IEC 15067, which is a Technical Report, explains the organization and structure of the transactive energy systems research, development, and deployment roadmap.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, and abbreviated terms

3.1 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

3.1.1
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

3.1.2
cyber-physical system
smart system that includes engineered interacting networks of physical and computational components

3.1.3
deterministic
<model> always producing the same output when given a particular input (no randomness)

3.1.4
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.

3.1.5
prosumer
person or entity who both consumes and produces

3.1.6
stochastic optimization
minimization or maximization of a function in the presence of randomness in the optimization process

3.2 Abbreviated terms

NOTE This list also includes some terms not used in this document, but which relate to other terms and so could be useful for the user.

ADMS	advanced distribution management system
AMI	advanced metering infrastructure
BEM(S)	building energy management (system)
CVR	conservation voltage reduction
DER	distributed energy resource
DERMS	distributed energy resource management system
DMS	distribution management system
DOE	U.S. Department of Energy
DR	demand response
DSO	distribution system operator
FERC	U.S. Federal Energy Regulatory Commission
GWAC	GridWise® Architecture Council
IOU	investor-owned utility
LMP	locational marginal price
MDM	meter data management (system)
PSC	public service commission
PUC	public utility commission
PV	photovoltaic
RTO	regional transmission operator
T&D	transmission and distribution
TE(S)	transactive energy (system)
TSO	transmission system operator
VVO	volt-var optimization
X2G	anything to grid

4 Overview of the roadmap

4.1 General

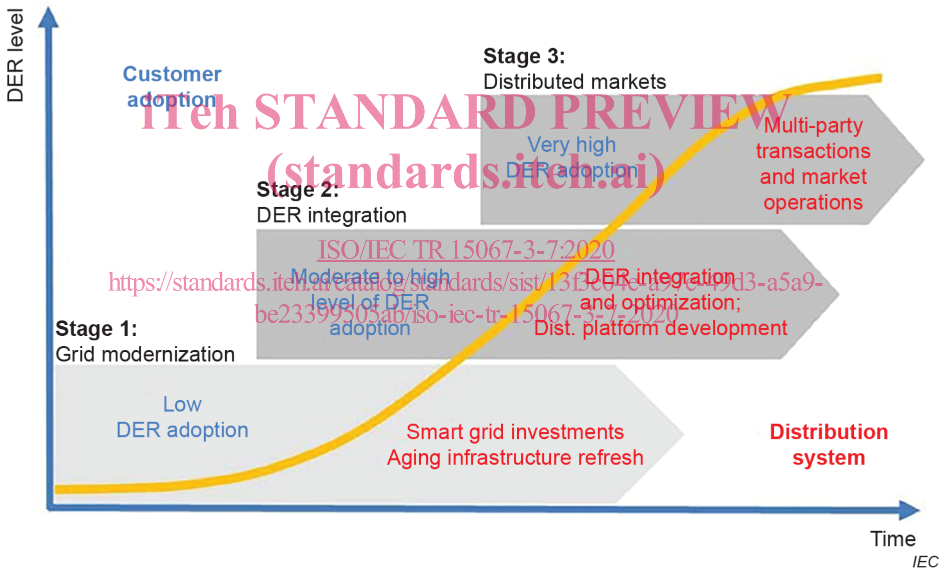
The GridWise® Architecture Council (GWAC) transactive energy roadmap outlines a vision and path forward to achieve deployment of transactive energy systems at scale as an operational element of the electric power system to facilitate the integration of DERs and dynamic end uses, such as connected buildings. It also considers the application of transactive energy systems (TESs) for the coordination and control of end uses – for example, in managing energy in buildings and campuses.

The roadmap considers drivers of change, triggers for transactive energy system deployment, and required infrastructure for deployment at scale. Gaps in technology and infrastructure that could require investment are identified.

The roadmap captures potential changes over time (stages) and organizes them by business and technical tracks. Within each track, it also groups potential changes into "swim lanes" that identify what we hope to see, what it takes for this to occur, what we see as a result, and what these features do to add value.

4.2 Stages

The roadmap is based on considering what is required to support increasing levels of DER penetration in electricity distribution systems. The roadmap considers the overall vision in three stages, depicted in Figure 1, primarily characterized by the level of market development around DER penetration. These stage definitions help the user determine what stage a given distribution system is in, based on how its characteristics align with these definitions. Note that there are implications for the relationship between the distribution utilities and the bulk power system, and given the regional nature of the bulk power system, all distribution utilities within a given region will not usually find themselves at the same stage.



SOURCE: LBNL-1003797 [3].

Figure 1 – Distribution system evolution

– Stage 1

In stage 1, DER penetration is limited. DER value is administratively set (such as in net-metering tariffs). DER has minimal but perceivable effects on distribution system operations. In the following clauses, this stage is characterized as "persistently demonstrated".

– Stage 2

Levels of DER penetration grow as device prices continue to drop. Net-metering tariffs begin to be replaced with market interactions that establish the value of the DER assets. Aggregated DER or large DER assets interact with bulk power markets based on a limited number of value streams. Effects of DER penetration on distribution system operations are manageable. In the following clauses, this stage is characterized as "broadly applied".

– Stage 3

DER penetration grows, affecting distribution system operations and requiring new means for asset owners to realize return on investment. Combinations (stacks) of value streams are realized through DER participation in local, distribution-level markets. The stacked value streams have spatial and temporal variability that reflects operational needs in the distribution and bulk power systems. In the following clauses, this stage is characterized as "at scale".

4.3 Roadmap tracks

4.3.1 General

The roadmap tracks generally follow the ISO/IEC TR 15067-3-8 [1] breakdown of considerations for TE systems into the four tracks outlined in 4.3.2 to 4.3.5.

4.3.2 Regulatory and policy

This track describes the actions needed by regulators and other policy makers to enable TE systems as envisioned in each of the three stages. The objective of the actions in this track is to establish an environment that enables transacting parties to understand rules of engagement and compensation in addition to performance requirements (and penalties for non-performance). The actions also focus on achieving a consistency of approach across jurisdictions, as much as possible, to promote interoperability. The actions described could be carried out by different policy-making bodies depending on the individual jurisdictions and types of utilities.

Many of the actions described in this track support development and implementation actions described in the "business models and value realization" track (4.3.3), and to a limited extent, the actions included in the "system design and architecture" (4.3.4) and "physical and cyber technologies and infrastructure" (4.3.5) tracks.

4.3.3 Business models and value realization

This track focuses on the various stakeholders, their roles in TE, and how their business models need to evolve for them to provide and realize value in each of the three stages. While the "regulatory and policy" track describes the actions policy makers need to take to establish the needed TE environment, this track focuses on the actions to assess and implement needed business model changes by various categories of stakeholders, recognizing that business model changes include value propositions on both supply and demand sides.

4.3.4 System design and architecture

This track focuses on system design and architecture actions necessary to support each stage, specifically dealing with information interoperability to support TE valuation, and operation and control aspects to understand and manage the effects on the electricity grid. This track depends on the business model to describe the content and timing of required information exchange between TE parties. This is where each stakeholder needs to develop or understand their existing architecture and their planned architecture, then develop a set of transitional states to get them there and transition between stages.

4.3.5 Physical and cyber technologies and infrastructure

This track focuses on the changing cyber-physical needs and required actions through the progression of the three stages. This track addresses the technical layers of the GWAC Stack and the physical layers of the Control Abstraction Stack as described in ISO/IEC TR 15067-3-8. It includes the activities aimed at the electrically connected network and the communications networks that are necessary to monitor and control the electricity grid. This track depends on the information exchange requirements considered in the "system design and architecture" track to ensure the ability to exchange information in support of transactions without impairing the reliability of the electrical network.

Each of these areas is informed by the drivers for change, such as increased penetration of rooftop solar, energy storage, electrification of transportation, etc.

4.4 Swim lane definitions

For each of the roadmap tracks, there is a separate table that describes the features of that track in each of the three stages. Also, for each stage, there are four swim lanes that provide a more detailed breakdown of the features not only by stage but also by the following different perspectives.

- Vision – what we hope to see at each stage.
- Enablers – elements required for the vision to be realized.
- Results – outcomes made possible by new patterns of use.
- Benefits – how these outcomes add value (compared to the status quo).

4.5 Organization of material

In order to show the effects of changes based on the use of tracks, stages, and swim lanes, this document is organized into clauses based on tracks. In addition to the tracks mentioned above, Clause 4 gives an overview that captures some of the key concepts from the other tracks. It provides an executive summary for the roadmap.

At the start of each subclause in Clauses 5 to 8 is a list of three to five main concepts that were considered important to represent in that clause. These core concepts state the fundamental concept in as timeless (stage-free) a manner as possible so that one can then apply the concept by stating how it manifests through the stages. These manifestations are arranged in tables. Also included in the core concepts are condensed encapsulations of the TE principles described in ISO/IEC TR 15067-3-8:2020, 6.4 [1].

Within each clause there are four tables, one for each swim lane. Each row in a table captures something that represents a change or evolution occurring over time, with three columns to describe what is seen in stages 1, 2, and 3, as the examples in Table 1 to Table 4 show.

Table 1 – Example vision table

Vision **What we hope to see at each stage**	**Stage 1** **Persistently demonstrated**	**Stage 2** **Broadly applied**	**Stage 3** **At scale**
	Early scenario 1	Mid scenario 1	Late scenario 1
	Early scenario 2	Mid scenario 2	Late scenario 2
	Early scenario 3	Mid scenario 3	Late scenario 3

Table 2 – Example enablers table

Enablers **Elements required if the vision is to be realized**	**Stage 1** **Persistently demonstrated**	**Stage 2** **Broadly applied**	**Stage 3** **At scale**
	Early scenario 1	Mid scenario 1	Late scenario 1
	Early scenario 2	Mid scenario 2	Late scenario 2
	Early scenario 3	Mid scenario 3	Late scenario 3