ISO/IEC 15067-3

Edition 1.0 2012-07

INTERNATIONAL STANDARD

colour inside

Information technology – Home electronic system (HES) application model – Part 3: Model of a demand-response energy management system for HES

ISO/IEC 15067-3:2012(E)

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,…).
It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

ISO/IEC 15067-3

Edition 1.0 2012-07

INTERNATIONAL STANDARD

colour inside

Information technology – Home electronic system (HES) application model – Part 3: Model of a demand-response energy management system for HES

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRICE CODE Q

ICS 35.200

ISBN 978-2-83220-191-6

CONTENTS

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

Part 3: Model of a demand-response energy management system for HES

FOREWORD

1) ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards. Their preparation is entrusted to technical committees; any ISO and IEC member body interested in the subject dealt with may participate in this preparatory work. International governmental and non-governmental organizations liaising with ISO and IEC also participate in this preparation.

2) In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

3) The formal decisions or agreements of IEC and ISO on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC and ISO member bodies.

4) IEC, ISO and ISO/IEC publications have the form of recommendations for international use and are accepted by IEC and ISO member bodies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC, ISO and ISO/IEC publications is accurate, IEC or ISO cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

5) In order to promote international uniformity, IEC and ISO member bodies undertake to apply IEC, ISO and ISO/IEC publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any ISO/IEC publication and the corresponding national or regional publication should be clearly indicated in the latter.

6) ISO and IEC provide no marking procedure to indicate their approval and cannot be rendered responsible for any equipment declared to be in conformity with an ISO/IEC publication.

7) All users should ensure that they have the latest edition of this publication.

8) No liability shall attach to IEC or ISO or its directors, employees, servants or agents including individual experts and members of their technical committees and IEC or ISO member bodies for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication of, use of, or reliance upon, this ISO/IEC publication or any other IEC, ISO or ISO/IEC publications.

9) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

10) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 15067-3 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

This International Standard replaces ISO/IEC TR 15067-3, first edition, published in 2000, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– the demand response options have been expanded;
– distributed energy resources such as local generation and storage have been included;
– the terminology for demand response has been aligned with smart grid.

The list of all currently available parts of the ISO/IEC 15067 series, under the general title *Information technology – Home electronic system (HES) application model*, can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

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

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

ISO/IEC 15067 currently consists of three parts. All parts were previously published as Technical Reports. ISO/IEC 15067-3, energy management, is being upgraded to a standard at the request of the IEC Standards Management Board study group on energy efficiency (SG1 SMB-SG 1/0027/INF, July 2008, Recommendation 16). Energy management is becoming an essential part of the worldwide development of smart grids for electricity.

Part 2: Lighting model for HES

Part 3: Model of a demand-response energy management system for HES (this document)

Part 4: Model of a security system for HES

SC 25/WG 1, the Home Electronic System (HES) working group, has developed these models to foster interoperability among products from competing or complementary manufacturers. Product interoperability is essential when using home control standards, such as HES. This International Standard defines a standard framework for a generic energy management system and describes the communications services needed. A high-level model for an energy management system using HES is presented.

Homebuilders, suppliers of building materials and consumer product manufacturers all affect energy consumption in buildings. Products and services intended for energy management can be provided by

- programs developed for consumers by electricity suppliers, typically a public utility,
- products purchased by consumers independent of electricity supplier programs.

Various methods for managing the electricity supply network, called the “electricity grid,” have been developed. The goal of these methods is to match the customer demand for power with the available supply. The need for such methods results from

- electric supply limitations,
- public resistance to building large generating plants,
- public concern for environmental pollution, including greenhouse gases,
- public opposition to siting of new transmission lines,
- an anticipated demand for and availability of electricity for charging electric vehicles,
- public interest and support for renewable sources of energy,
- the introduction of distributed energy resources (DER) with local generators such as wind turbines and solar photo-voltaic (PV) panels,
- the variable and unpredictable nature of wind and solar distributed generation with output that may fluctuate with time and weather,
- the development of batteries and other advanced premises storage technologies plus power conditioning and management equipment,
- the introduction of alternative electricity pricing methods or tariffs that encourage efficiency.

The model presented in this standard focuses primarily on methods known as “demand response” (DR). Because demand response systems extend beyond the meter into customer premises, those impacted by demand response technology choices include utilities, third-party suppliers of demand response services, home network developers, appliance and DER manufacturers and consumers. An example of a third-party provider of demand response services is an aggregator serving a large building or neighbourhood.

Three types of DR are specified in this standard: direct control, local control and distributed control. The choice of DR method will vary by utility to achieve the load shape that aligns with supply limitations, transmission and distribution capabilities, regulatory constraints and business considerations. However, distributed control offers consumers the most flexibility in adapting appliance operation to constraints imposed by the utility. The various standards developed by JTC 1/SC 25 for the *Home Electronic System* are important for effective distributed control, as specified.

DR is one element in the concept of the "smart grid". The smart grid for electricity integrates subsystems for generation, transmission, distribution and customer services to improve the reliability and efficiency of electricity systems. The smart grid also extends these subsystems to accommodate distributed energy resources and demand response. A goal of the smart grid is to enable all these subsystems to interoperate using information technology. Therefore, this standard is an important contribution to the smart grid.

As the market develops for energy management products, consumer electronics companies, appliance manufacturers and other residential suppliers may offer products that combine load management using demand response with energy conservation. Energy conservation may offer methods for consumers to reduce energy consumption overall, in addition to reducing consumption at times of peak demand. These methods include products and systems for electricity generation, storage and management. Such products and systems are located on premises and can communicate with other on-premises products and systems in order to interoperate as a larger system. Examples are included in Annex A. Standards for these products are anticipated to expand this energy management model in future updates.

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

Part 3: Model of a demand-response energy management system for HES

1 Scope

This part of ISO/IEC 15067 focuses on products and services that can manage energy consumption and generation of devices dynamically in response to electricity supply and prices that may vary over time. The model specified here for energy management is intended to be generic and representative of a wide range of situations. This part of ISO/IEC 15067 applies to the customer services portion of the electricity smart grid.

This standard specifies an energy management model for programs that manage the consumer demand for electricity using a method known as “demand response”. Three types of demand response are specified in this standard: direct control (5.3.1), local control (5.3.2.2) and distributed control (5.3.2.3).

NOTE Customers and customer equipment may use these methods to control the energy consumption and generation of devices such as appliances and distributed energy resources (for example, photo-voltaic [PV], wind, fuel cell [FC], combined heat and power [CHP], electric vehicle [EV], and stationary battery [SB]).). The taxonomy and lexicon of an energy management model that supports these demand response methods are presented in 7.3 and 7.4.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 14543-2-1, *Information technology – Home electronic system (HES) architecture – Part 2-1: Introduction and device modularity*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
application domain
logically related group of components that provides the functions of an application in a home or building

3.1.2
demand charge
charge for electricity based on the peak power consumed during a specified interval of time, subject to a time-smoothing algorithm

3.1.3
demand response
method for matching the demand for energy to the available supply of energy

3.1.4
direct load control
demand response via remote control of one or more appliances by a utility or third-party service provider

Note 1 to entry: With direct control the utility uses a communications network or other signalling method (e.g. a control frequency signal) to control appliance operation remotely.

3.1.5
disaggregated bill
utility bill that shows energy consumption by major appliances

3.1.6
distributed load control
demand response based on dynamic price for electricity, event notices, or other information sent from the utility to smart appliances or to an energy management agent

3.1.7
DR supplier
utility or third-party supplier of demand response energy management services

3.1.8
electricity grid
electricity supply network

3.1.9
energy
electric energy

3.1.10
energy management agent
set of control functions that manage energy consumption as an agent for the customer

3.1.11
energy management gateway
residential gateway facilitating direct load control, distributed load control or demand response for electrical energy usage

Note 1 to entry: A residential gateway may provide gateway functions for energy management. If the residential gateway provides no other services, such as TV or Internet access, it is equivalent to an energy management gateway, which is a gateway limited to energy management. Some electric utilities use the term energy services interface for an energy management gateway.

3.1.12
energy reliability
enhanced availability of energy enabled for example by business and technical procedures

3.1.13
HAN device
device located in the home that can communicate via a home area network (HAN) wirelessly or via wires

Note 1 to entry: HAN is defined in ISO/IEC 15045-1. A wired HAN may use cabling specified in ISO/IEC 15018.

3.1.14
HES gateway
residential gateway that conforms to ISO/IEC 15045-1

Note 1 to entry: ISO/IEC 15045-1 is published. ISO/IEC 15045-2 is to be published.

3.1.15
local load control
demand response via publication of time-of-use electric rates

Note 1 to entry: With local load control the utility typically informs customers of the electric rates by a notice sent with the electric bill or via simple electrical signalling to a user interface such as various coloured lamps at the customer premises, and does not directly control appliances. The customer may use these rate data to select the times for an appliance to operate.

Note 2 to entry: In some implementations the utility sends a signal across the grid to a receiver at the premises that switches device operation between at least two different states according to the electricity tariff.

3.1.16
major appliance
household device using large amounts of energy compared to other appliances

Note 1 to entry: Examples include oven, microwave, refrigerator, cooking range, washing machine and dryer. Also called “white goods”. Most of the appliances listed use large amounts on power when operating in some modes. However, the appliances that are appropriate for energy management are those that consume large amounts of energy.

3.1.17
residential gateway
communications function that interconnects two or more networks using different communications protocols, with at least one network outside the premises and one or more networks inside the premises

3.1.18
smart appliance
home appliance that exchanges command and control data with other units on a home area network

Note 1 to entry: Depending on the application, smart appliances can communicate via the HAN with other appliances, with an application controller or with a utility for energy management. Smart appliance specifications are under development by appliance manufacturers and trade associations.

3.1.19
smart grid
electric energy distribution system using information and communications technology with automation for improving the stability and availability of electricity

Note 1 to entry: Some smart grids integrate into the electric grid excess power generated locally from sun and wind-driven devices.

Note 2 to entry: Technically, a grid is a network. However, in common usage the term “smart grid” refers to the entire energy system, which include generation, transmission, distribution, and customer systems.

3.1.20
supply indication
static or dynamic signal or message related to electricity supply

3.1.21
value-added services
optional services offered by a utility that may or may not be related to energy and may generate additional revenue

3.1.22
white goods
large sized household appliances using larger amounts of energy

Note 1 to entry: Examples include: oven, microwave, refrigerator, cooking range, washing machine, dryer. Also called “major appliances”.

3.2 Abbreviations

The following acronyms and abbreviations, commonly used in other industry publications, are used in this document.

CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power
DER	Distributed Energy Resources
DR	Demand Response
DRAM	Demand Response and Advanced Metering Coalition
DSM	Demand-Side Management
EMA	Energy Management Agent
EPRI	Electric Power Research Institute
EV	Electric Vehicle
FC	Fuel Cell
HAN	Home Area Network
HES	Home Electronic System
HVAC	Heating, Ventilation and Air-Conditioning
LED	Light Emitting Diode
PV	Photo-Voltaic
RTP	Real-Time Pricing
SB	Stationary Battery
TOU	Time-of-Use
UPS	Uninterruptible Power Supply
WAN	Wide Area Network

4 Conformance

This standard specifies methods for demand response that may be implemented by an electric utility or by a third-party supplier of energy management services. For compliance with this standard one or more of the demand response methods in Clause 5 shall be implemented.

NOTE 1 Which method of demand response is chosen may be subject to local regulations and/or market conditions.

Utilities may offer value-added services in conjunction with demand response, as listed in 5.3.2.4, which are optional.

For those utilities choosing distributed load control for demand response, Clause 6 shall be implemented.

Any framework for the demand response options in Clause 5 shall use the taxonomy and lexicon of Clause 7. 7.3 and 7.4 define the taxonomy and lexicon corresponding to the options for demand response according to the HES demand-response energy management model. These include a combination of control signals, pricing data and event notices. An implementation claims conformance with this standard shall meet the requirements of at least one of the use cases specified in 7.3.2 to 7.3.8.

NOTE 2 Note that in some countries approvals from government regulators are required for the implementation of demand response.

5 Energy management using demand response

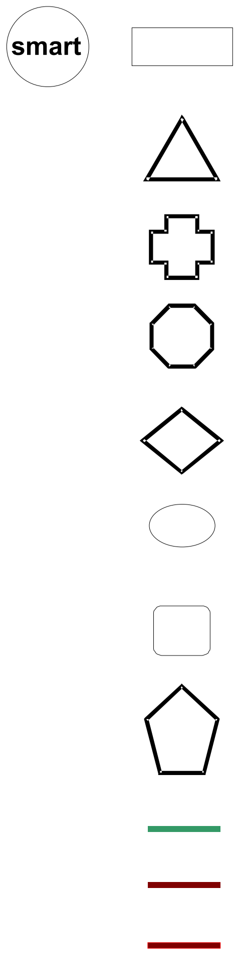
5.1 Model for energy management

Efficient interaction of energy management in premises (homes and buildings) with the electrical power grid and distributed energy resources (DER) requires a common understanding of

- the elements of an electrical power system,
- measures to manage the energy usage in premises,
- the necessary interfaces between premises control systems, power grid systems and DER.

A common understanding requires a common model. The abstract model for energy management that fulfils the framework for demand response and that is the basis for this standard is presented in this subclause. Figure 1 lists the elements used in the model. Each element is identified by one the following unique graphical shapes.

- Oval shape represents the gateway.
- Circles represent power-using appliances that can communicate via a HAN.
- Rectangular shapes represent energy-using loads (e.g., appliances) that are not able to communicate. These elements are also called power sinks. Any control of these loads (e.g. switching on/off, dimming, changing a closed-loop control variable such as a temperature set point, or restricting usage via a schedule or maximum power level) shall be done directly by the power circuits supplying these loads.
- Octagonal shape represents a power conversion device, such as a device that transforms electrical power from a given voltage and frequency to another voltage and frequency, or a power conditioner that may include functions of an inverter, charger and/or circuit controller.
- Cross shapes represent power storage devices such as a battery, a flywheel or pumped hydro storage.
- Triangular shapes represent DER power-generating devices.
- Rectangle with curved corners represents utility elements such as a meter, WAN, service entrance, etc. These functions are sometimes called the power exchange. The point of interface between two entities or organisations (in this case the utility and customer). Typically, the electrical energy flowing between the entities is measured at this point with a power meter. With DER installed, power may be measured when flowing in either direction, according to the utility tariff.
- Diamond shape represents a sensor or controller element (e.g., DR switch).
- Pentagon shape represents grid elements such as generators, transmission, and distribution.



- **Power using elements**
  – Appliances or other loads (either smart or non-communicating)
- **Power generating elements**
  – Solar PV, wind turbines, generators, fuel cells, other DER elements
- **Power storage elements**
  – Batteries, flywheels, electric vehicles, other DER elements, etc.
- **Power conversion/conditioning elements**
  – Inverters, chargers, power factor compensators, etc.
- **Power controlling elements**
  – Sensors, switching devices, energy management agents, etc.
- **Communication network elements**
  – Gateways, WANs, HANs, etc.
- **Utility elements (power exchange)**
  – Utility meters, utility WANs, service entrance, etc.
- **Grid elements**
  – Generators (fossil fuel, nuclear, wind turbines, hydro-electric, solar power), transmission, and distribution
- **Power**
- **WAN Data**
- **HAN Data**

Figure 1 – Elements of the HES energy management model

Figure 2 depicts a generalised HES energy management model. It shows the system architecture and interrelationship among the elements. The green arrows represent electrical power paths, and the red and brown arrows represent communication paths. These paths may be two-way or one-way. The demarcation line is the boundary between the HES domain and the external domain. The WAN (wide area network) is any external access network (e.g., cable, DSL, wireless, power-line carrier, etc.). The meter is the grid connection and premises service entrance, and may also support additional utility WAN communications (e.g., in the case of a "smart meter" network). Grid power sources may include fossil fuel power generation plant, a nuclear plant, wind turbines, a hydro-electric power plant or a solar power plant. The grid communications network and home network do not usually use the same communications protocol. In the case where they do, the gateway protocol translation function is null. Similarly, if the devices within the home use the same communications protocol, the gateway protocol translation function is null.

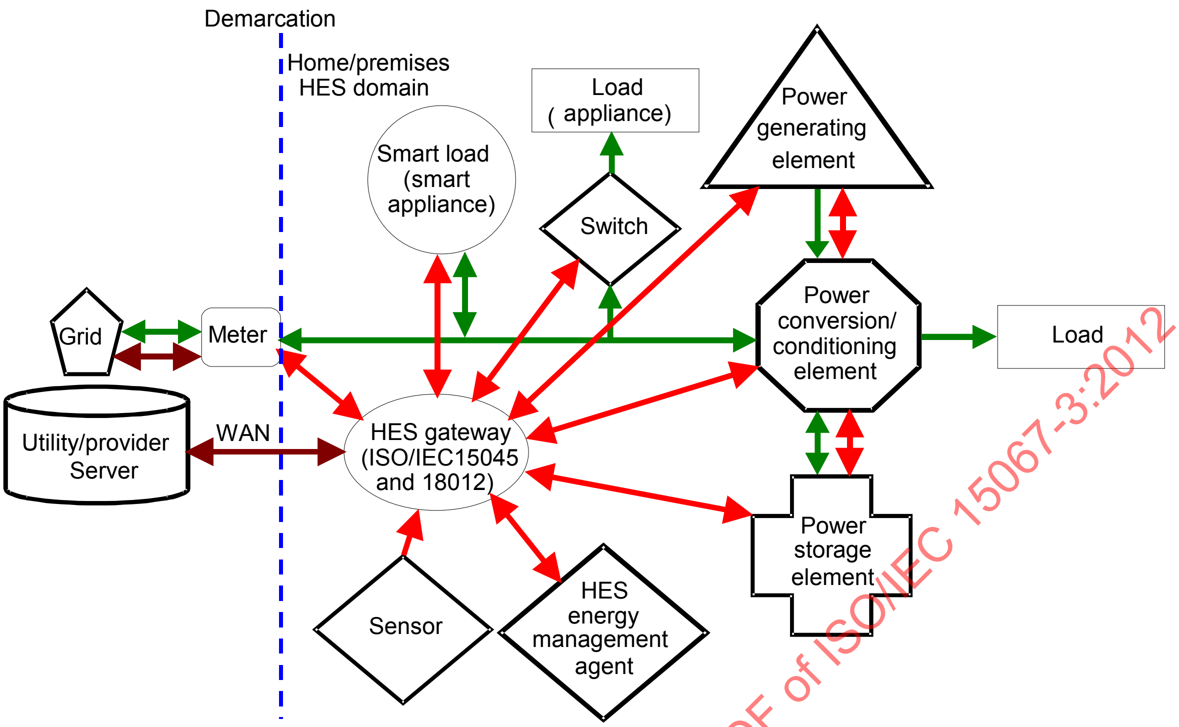


Figure 2 – HES energy management model

To facilitate the comprehension of the HES energy management model, Figure 3 shows an example of a building energy management system. The functions are very similar to the HES model using typical equipment icons. The grid communications network and building network do not usually use the same communications protocol. In the case where they do, the gateway protocol translation function is null. The building control system manages the power source and power sink entities in the building according to rules set by the building operator. The operator considers information provided by the utility via the data associated with the power exchange entity. HES does not assume the presence of a building operator. In the HES environment, one or a combination of the following entities participates in performing energy management, which are:

- the utility (or service provider);
- devices in the home such as the energy management agent;
- smart appliances;
- the user.

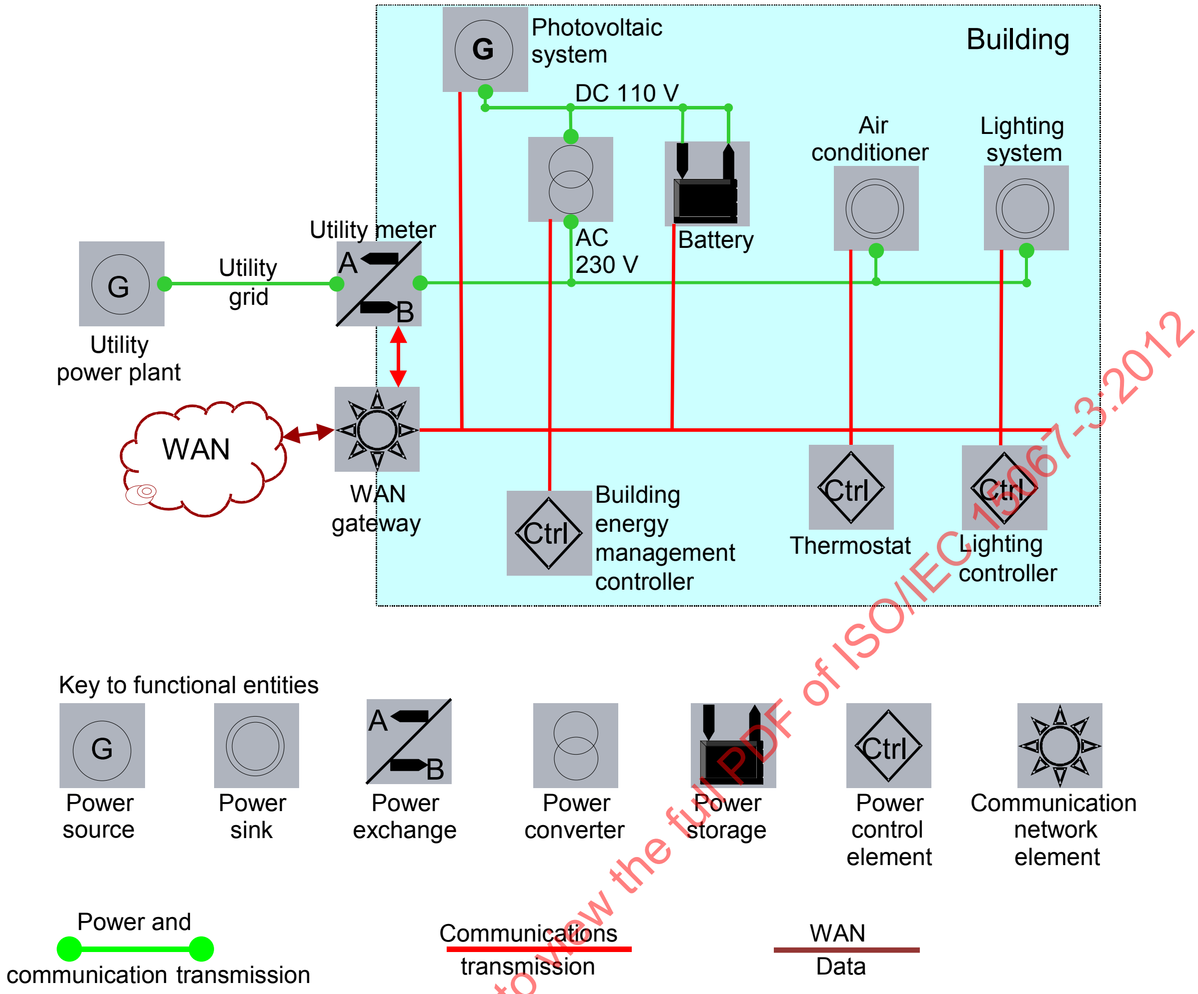


Figure 3 – Example of building energy management

5.2 Demand response overview

Demand response (DR) is a form of demand-side management (DSM). DSM is described in Annex B. DR uses incentive-based and indirect methods for controlling how much electricity is consumed during a specified time interval by end-devices such as water heaters, air-conditioners and appliances. The more innovative methods of load control depend on market forces for exerting control by varying the price of electricity at the retail level according to market conditions with limited or no advanced notice to customers.

One or more demand response (DR) methods shall be implemented when an electric utility determines that DR would address a mismatch between the supply and demand for power. An electric utility or other provider (also called "third-party supplier") of energy management services shall choose one or more of the methods described in the following list to design a demand response system in order to influence the customer's use of power. The methods include

- direct load control (5.3.1),
- local load control (5.3.2.2),
- distributed load control (5.3.2.3 and Clause 6).

Customers may implement multiple demand response systems in parallel depending on the capabilities of the appliances, the communications networks and the availability of auxiliary equipment such as an energy management agent. Separate communications channels (logical connections) may be needed for each demand response program.

NOTE All demand response methods described could co-exist. All methods described have been independently implemented or are being planned by utilities or service providers. The ability to adapt to changes in demand response programs depends on the capabilities of home appliances and the availability of auxiliary equipment such as an energy management agent.

5.3 Demand response methods

5.3.1 Direct load control

To implement direct load control (described in Clause B.4), the utility or third-party supplier of demand-response energy management services (collectively called the DR supplier) shall send control signals to interrupt the operation of selected devices such as air-conditioners and water heaters remotely from outside the house.

NOTE In a typical version of direct load control the utility sends a signal via the power line, radio, telephone line, Internet or cable television channel to a switch that limits the run time of air-conditioners to (0 to 15) min each half-hour for up to six hours each day. Water heaters are generally turned off entirely for (2 to 6) h.

Appliances and devices such as thermostats that participate in direct load control shall include internal or external communications interfaces to receive and execute electronic commands sent by the utility. Figure 4 illustrates the architecture of direct load control. Not all appliances participate in demand response, such as the television shown in Figure 4.

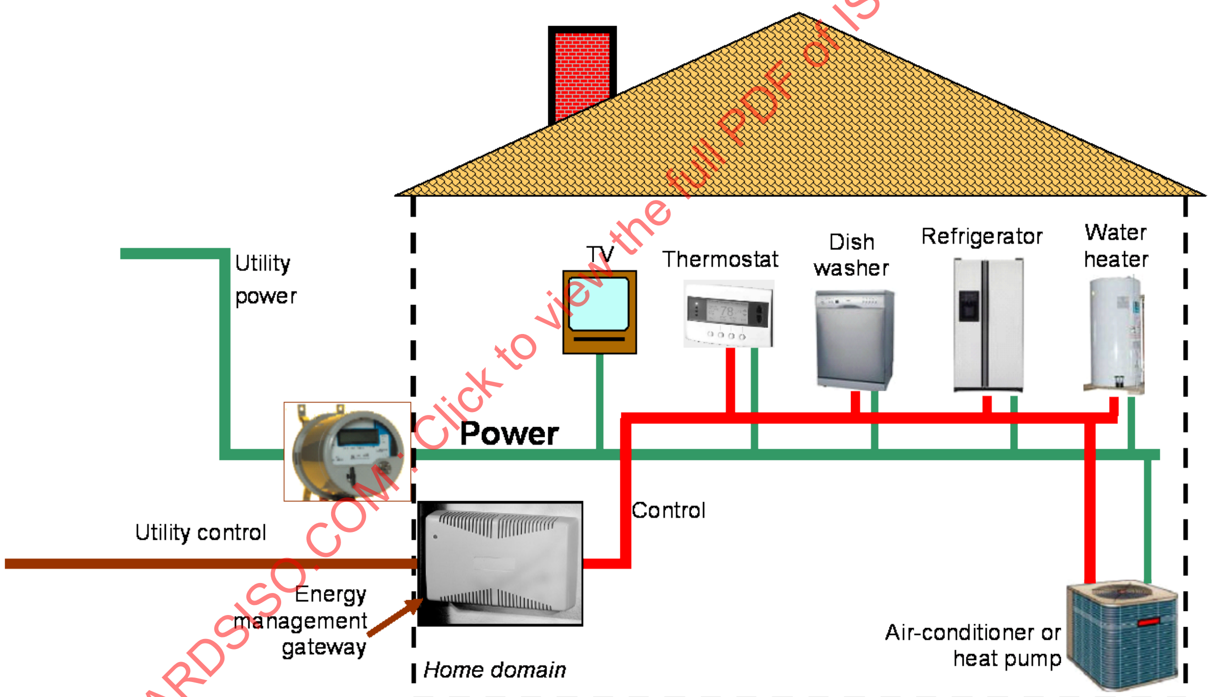


Figure 4 – Direct load control

Direct load control requires prior arrangements with customers for permission and equipment installation. The signalling method, choice of communications channel and appliance interfaces are outside the scope of this standard. Figure 4 illustrates a uniform path to deliver the utility control signal to the selected appliances. The appliance interfaces are outside the scope of this standard. If the same communications protocols are implemented outside and inside the home, the translation functions of the communications gateway are null. The HES gateway is recommended. If the customer denies permission for direct load control, the customer may opt out of a direct load control program or configure the gateway to block direct load control signals.

NOTE Direct load control is subject to agreements or contracts between utilities or service providers and customers.

The elements to generate, encode, transmit, decode and execute demand-response data for the purpose of demand-response energy management are communications interfaces and a communications network. These elements are outside the scope of the framework in this standard.

5.3.2 Demand response via pricing and event notification

5.3.2.1 Indirect control of customer demand

With indirect control methods utility suppliers do not operate any customer appliances or devices remotely. Instead, they issue a static or dynamic signal or message related to electricity supply (called the "supply indication") in order to influence customers to make choices about appliances and device operations. Customers may use local controllers to help in these choices. Such supply indications may include the following.

a) Price signals: A multi-level signal that indicates at least two different states corresponding to the electricity price.

b) Time-of-use pricing: A static rate structure (called a tariff) with specified rates that change at specified times in a repeating pattern.

c) Real-time pricing: Prices that change dynamically, as explained in 6.3.1. The specific price, time duration of this price and amount of prior notification before this price level is in effect vary by utility practice.

d) Event notices sent by the utility to customers about pending supply limitations that are usually temporary.

e) Event notices sent by the utility to customers about temporary rate changes.

NOTE 1 A typical time-of-use tariff may include a high rate during peak usage times (e.g., (7 to 10) AM and (4 to 7) PM), a medium rate during the day (10 AM to 4 PM) and a low rate for evenings and weekends. Time-of-use pricing may also include a top tier called "critical peak pricing." Time-varying retail prices may respond to market forces as wholesale power prices fluctuate.

NOTE 2 The utility supplier specifies the format and encoding of real-time price and event messages. International standards are being written. Manufacturers are advised to check.

Methods for customers to exercise control that affect electricity demand in response to these supply indications are specified in 5.3.2.2 and 5.3.2.3 (with details in Clause 6).

5.3.2.2 Local load control

Utility suppliers choosing local load control shall issue supply indications using price signals (option a) in 5.3.2.1) or time-of-use pricing (option b) in 5.3.2.1).

NOTE 1 For price signal indication the utility sends a signal across the grid to a receiver at the premises. The user decides how to direct this signal to end-devices that may switch device operation between at least two different states according to the electricity tariff indicated by the price signal. This signal may be delivered via an interface in an electric meter.

NOTE 2 For time-of-use (TOU) pricing it is recommended that the TOU tariff rates be published for customers prior to implementation of the TOU rates and prior to any changes of the TOU rates. The method for publishing TOU may vary by utility. Utilities typically deliver TOU pricing data to the customers via a mailed letter or electronically to a user interface for display or to a residential gateway. The purpose of publishing such pricing is to motivate customers to alter or shift the demand for electricity. Customers may need guidance to help them select which appliances to operate and when, in order to avoid peak power charges, or have such functions done automatically.

5.3.2.3 Distributed load control

Utility suppliers choosing distributed load control shall issue supply indications using "real-time" pricing (option c) in 5.3.2.1) and may issue event notices (options d) and e) in 5.3.2.1). Utility suppliers shall make these data available via a communications pathway to each customer with connections to a home area network (HAN). The HAN shall be linked to a utility network, possibly via a residential gateway. If a gateway is involved, the HES gateway is recommended. The architectural choices for distributed control are specified in Clause 6.

NOTE Distributed load control combines the features local and direct load control with much increased flexibility and customer control to accommodate time-varying prices that change dynamically. Time-of-use (TOU) prices change at pre-determined times. Time-varying price levels or times of change may not be pre-determined. This is why the actual price data are communicated to customer devices as specified in Clause 6.

5.3.2.4 Value-added services

Demand response and automated meter reading require two-way communications between customers and the utility or a third-party energy-management service provider. The utility or third-party service provider of distributed load control may use the same communications pathway to offer optional additional services to benefit consumers. Services not essential for power delivery are called value-added services.

NOTE The choice of value-added service and revenue arrangements depends on the utility, the market and local regulations. For examples, see Annex C.

6 Distributed control architecture and strategies

6.1 Smart appliances

Demand response via distributed load control shall link a utility communications network to a home area network (HAN) in accordance with the architecture specified in ISO/IEC 14543-2-1. Devices on a HAN (smart appliances, where available) may be home appliances, consumer electronics, sensors, actuators, user interfaces or controllers. The HAN may be wired or wireless or a mixture.

NOTE 1 Examples of such devices typically involved with energy management include thermostats, HVAC (heating, ventilation and air-conditioning) equipment, displays and major appliances (called “white goods” by the appliance industry).

Distributed load control shall be implemented by using the prices-to-devices method of 6.2 or by using the agent for energy management method of 6.3.

NOTE 2 Various standards for specific pricing and control data are under development by other standards bodies.

6.2 Prices-to-devices

In the prices-to-devices method of distributed load control utility prices and any event notifications shall be communicated directly from the utility to smart appliances. A gateway may be interposed if needed for protocol translation between the utility wide area network and the HAN. If a gateway is used, the HES gateway is recommended. If the customer denies permission for prices-to-devices, the customer may opt out of the program or configure connected appliances or the gateway to ignore pricing data.

Such smart appliances shall be programmed to understand the price or event messages and to respond accordingly with reduced consumption where appropriate. Smart appliances may respond to price or event messages from the utility in one of the following ways or in other ways to be developed by appliance manufacturers in consultation with utilities such as:

– Load reduction in a limited number of levels.

NOTE 1 The utility supplier specifies the format and encoding of such price and event messages. International standards are being written. Manufacturers are advised to check.

NOTE 2 For example, four or five possible power consumption levels may be specified.

NOTE 3 The number of energy reduction levels is determined by the appliance manufacturer after considering the functionality of the appliance and design / usability / market condition.

– Adjusting the operating temperature of an appliance or the set point of a temperature-controlling appliance.

NOTE 4 For example, a thermostat controlling a heater or air-conditioner during a period of higher priced electricity.

The customer shall always have the option to override these actions and to resort to full power usage or different energy consumption modes.

Figure 5 illustrates the architecture of distributed load control using prices-to-devices. In this figure, the utility data contain the price of electricity and / or utility event notices.

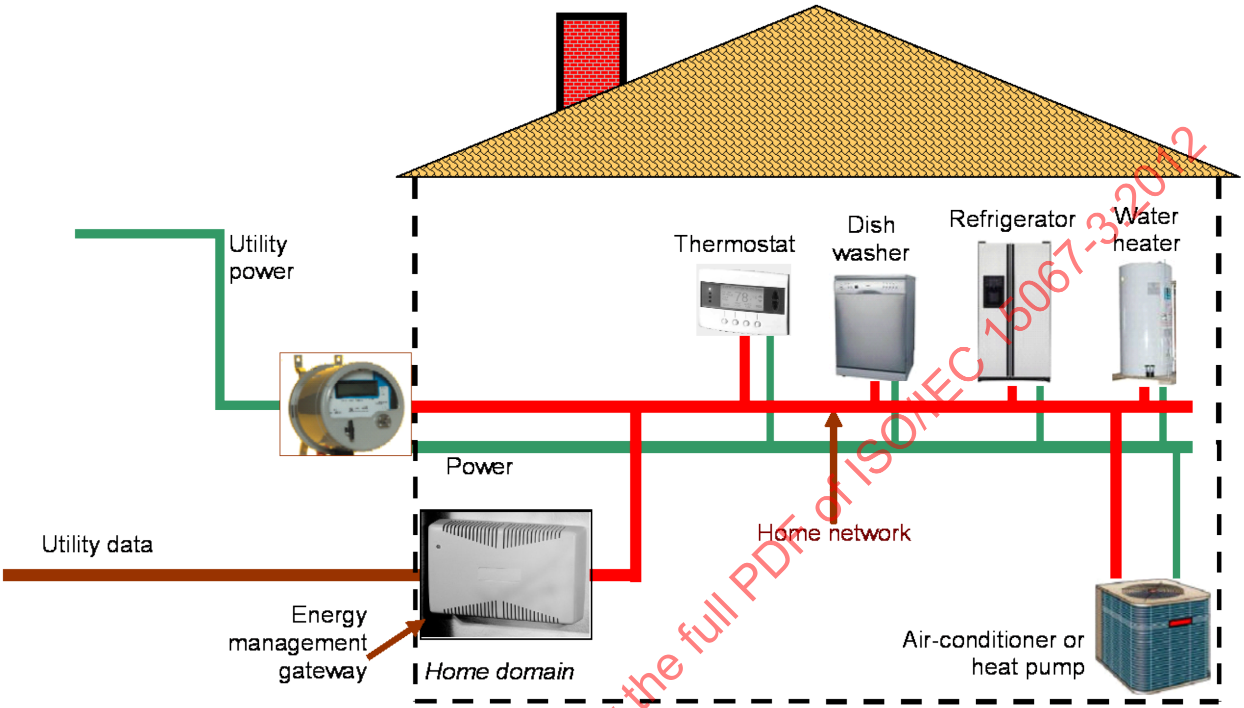


Figure 5 – Price-to-devices

6.3 Energy management agent (EMA)

6.3.1 EMA overview

The introduction of an energy management agent, acting as an agent for the consumer, adds functionality to distributed load control and DER control. The EMA enables the allocation of limited energy (or a limited budget for energy) among appliances or by switching energy sources from grid to local generation or battery according to consumer preferences. Figure 6 shows a feasible distributed load control residential implementation. In this figure, the utility data contain the price of electricity and / or utility event notices. The utility shall send pricing data electronically in real-time. Real-time is determined by the utility or third-party provider of the dynamic pricing program. Real-time may include advanced notification of price changes, such as one or more hours up to one day ahead pricing. These are all called real-time in common usage by utilities.

Smart meters may provide a wide area network pathway for messages to reach home devices including a home gateway. Other wide area network pathways may be used such as optical fibre, telephone, wireless, and cable services. The utility specifies the time window for real-time data. The agent for energy management included in Figure 6 is a specialised controller that co-ordinates and allocates energy consumption and generation among multiple smart appliances and DERs.

NOTE 1 This allocation of limited energy is not possible among the smart appliances involved in prices-to-devices (6.2), where each appliance responds independently to utility price data. Therefore, the demand response effectiveness of prices-to-devices is limited by the capabilities of algorithms designed into smart appliances.

This pricing signal shall enter the house through an energy management gateway that is recommended to be the HES gateway.

NOTE 2 This gateway interconnects a public network using optical fibre, telephone, cable TV, power lines or radio with a home network. The HES gateway (ISO/IEC 15045-1:2004, 5.1.4. and 5.6.1) defines a modular architecture and a class of modules known as service modules that may accommodate the functions of an EMA. The gateway may be a separate device, as shown in Figure 6, or could be integrated with other gateways, controllers or even inside an electric meter. The EMA may also be a separate device that is already part of the home automation system.

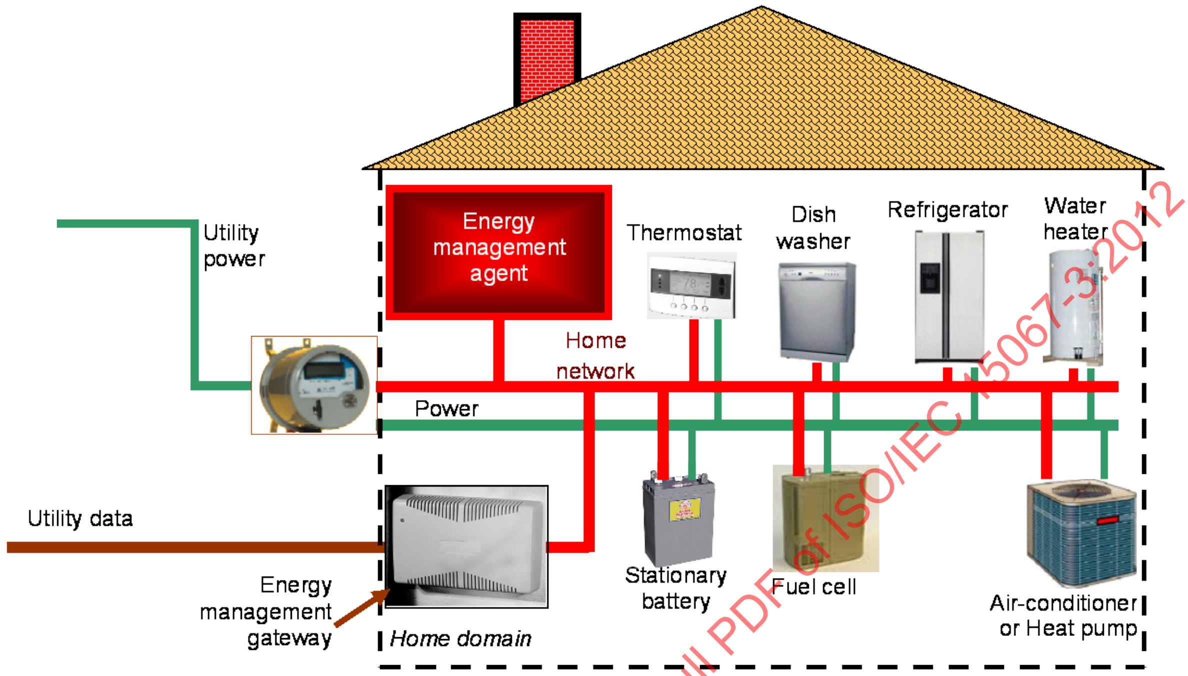


Figure 6 – Distributed load control system

The EMA allocates energy consumption and generation among those appliances and DERs that it manages.

NOTE 3 The implementation of an EMA is not specified since it depends on the market development of home controllers and smart appliances. Some possible embodiments of an EMA include a discrete physical unit, embedding the EMA functions in a smart appliance, a cable set top box and a residential gateway.

The EMA performs specialised computing functions by receiving the electricity rate data from the residential gateway and applying sophisticated software algorithms to determine which appliances and DERs to operate and when. The functions of the EMA are illustrated in Figure 7.

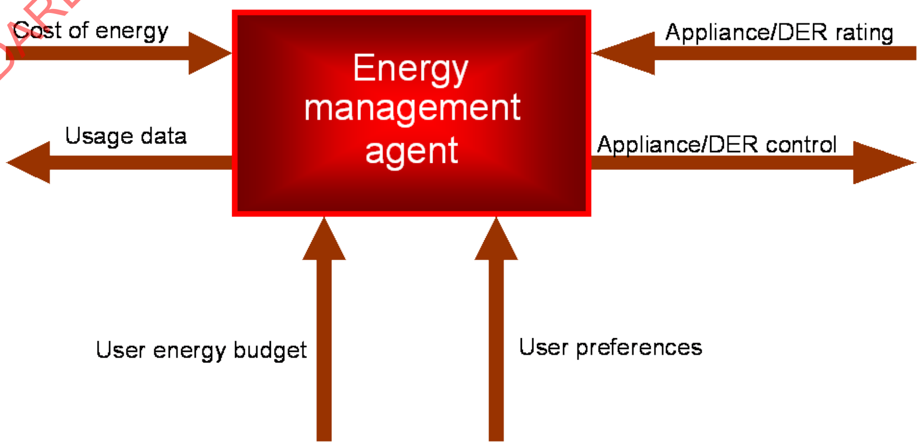


Figure 7 – Energy management agent

NOTE 4 Effective communications with appliances in this model depend on the standardisation of a common language for appliance messages, under development by appliance manufacturers and various appliance trade organisations. For non-smart appliances, a proxy may be inserted that understands messages and provides control that is limited to the appliance capabilities.

6.3.2 EMA grid-to-home functionality

Unless overridden by the customer, the EMA shall provide automated demand response by determining how and when to operate appliances and DERs based on the cost of energy, the energy requirements of the appliances and DERs and user inputs among others. The user inputs should be primarily entering preferences for home activities that involve energy-consuming devices.

NOTE 1 The user might specify a monthly energy budget and preferences (shower at 8 AM, air conditioning at 6 PM, pool at 8 PM, etc.).

The customer shall always be able to override decisions of the EMA. Unless overridden by the customer, the controller shall issue signals that are distributed over a home network to the relevant appliances and DERs. A smart appliance that can operate in energy conserving modes shall react to such signals by altering the operating mode according to the signal and to the capabilities of the appliance.

NOTE 2 The specifications of the user interface for configuring the EMA are outside the scope of this standard. The user interface may comply with ISO/IEC 24752-1, which specifies a framework of components for a user interface that is simple, non-intrusive and adaptable by language and physical impairment. The user interface may be an education tool to explain the relative energy consumption levels of various appliances and could display the actual consumption by major appliances.

Communications between the utility and the energy management agent shall include the cost of energy data and may include the electricity usage data shown on the left side of Figure 7. The cost of energy data shall be sent by the utility or a demand response service provider using a secure link that ensures the data originated from the utility or the service provider. This level of security entails authentication to confirm that the data are from the real source and have not been altered during transmission. It is not necessary to encrypt such data since the data are public. However, the customer usage data shall be encrypted if sent to the utility or provider of energy management services so that the data cannot be intercepted by anyone for whom the data is not intended, such as a burglar or unauthorised commercial entity. (A potential burglar might use such data to determine a customer's daily activities and occupancy. A commercial entity might use such data to market alternative products.)

NOTE 3 Thus, if allowed by regulations and utility practice, the customer and the utility should agree if and how frequently usage data in aggregate and usage by selected appliances are collected.

NOTE 4 The secure link security methods vary by utility.

NOTE 5 The potential impact on customer privacy from the collection of usage data is discussed in B.4.5.

NOTE 6 Appliance companies are debating the types of secure links between the appliance and the gateway. Encryption of consumption data may be performed in the gateway rather than in the appliance.

6.3.3 Home-to-grid functionality

The EMA functions may be extended to manage on-premises distributed energy resources and power conditioning/conversion subsystems. Such systems work in conjunction with distributed energy resources to feed power from the home into the grid as described in informative Annex A.

7 HES energy management taxonomy and lexicon

7.1 Introduction to energy management taxonomy and lexicon

The methods for energy management using demand response have been described in previous clauses of this standard. The taxonomy and lexicon in 7.3 and 7.4 specify the HES model for energy management using demand response. 7.2 specifies generic logical and physical models for HES energy management. The taxonomy for specific use cases of the HES energy management model is specified in 7.3. The lexicon of the messages for demand response is presented in 7.4. The materials presented here constitute a framework for energy management and are not specific to a particular HAN communications protocol. The generic energy management model is presented in 5.1.

7.2 Examples of logical and physical models

The typical components for demand response are shown in Figure 8. The logical relationship among the components for demand response systems is illustrated in Figure 9. To accommodate prevalent practices of direct control, a logical model with minimal functionality is presented in Figure 10. In this case, the energy management agent has been eliminated because the utility controls appliances (including appliance actuators, such as thermostats) by a direct signal. A user interface is included because some implementations allow the user to over-ride a direct load control signal. A cost penalty is usually assessed for over-rides. Furthermore, when the utility installs and manages the link to the appliances, the gateway may be eliminated if the utility uses the same signalling inside and outside the house, possibly via a virtual private network.

NOTE 1 The logical models in this standard are intended to show the logical relationship among energy management components. They are not intended to portray an abstract model.

NOTE 2 The utility gateway is the logical boundary between the utility wide area network outside the home and the home area network inside.

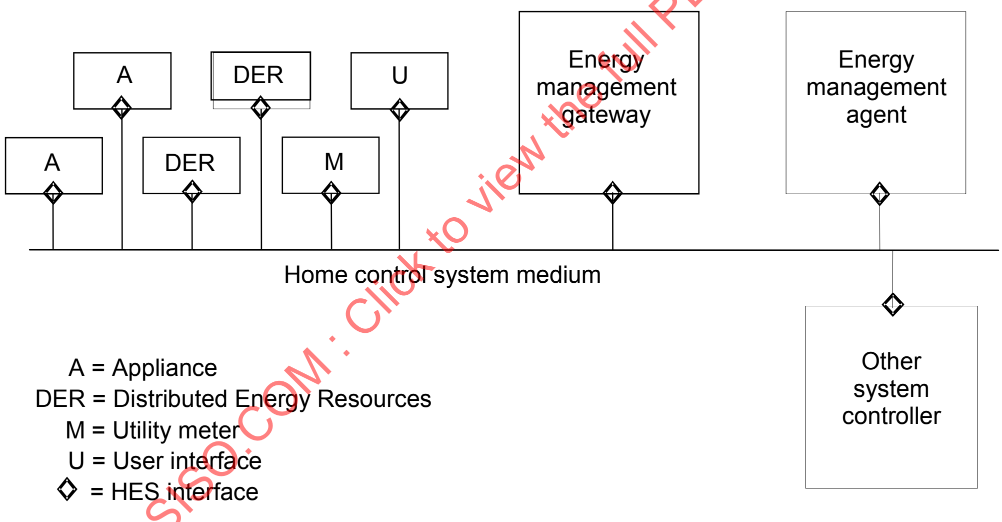


Figure 8 – Typical HES energy management model components

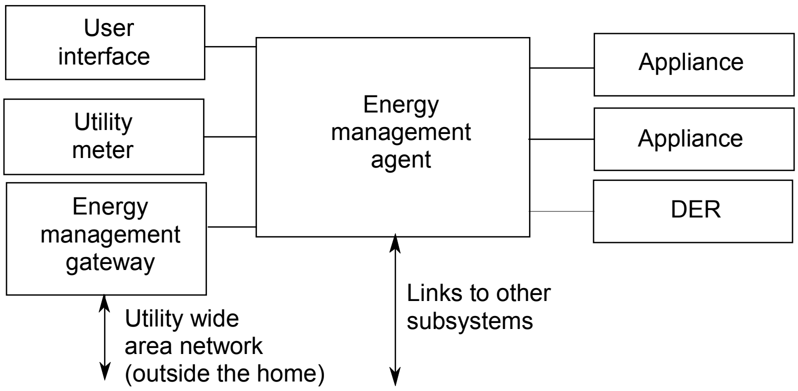


Figure 9 – Logical model for HES energy management

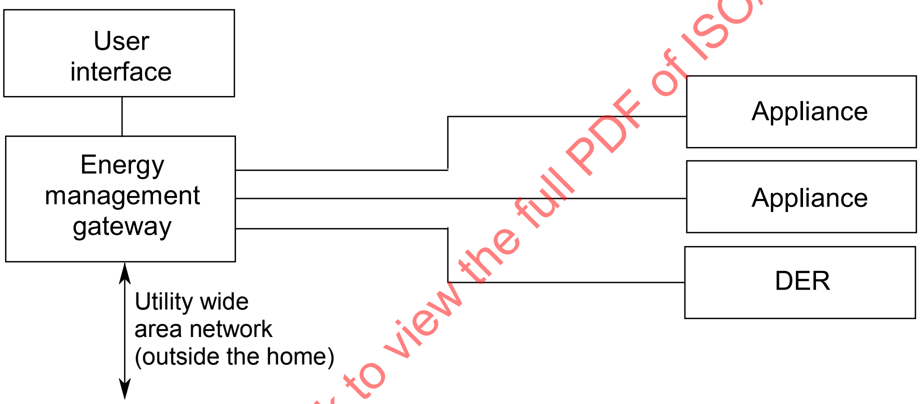


Figure 10 – Logical model of minimal HES energy management

Energy management is one of many subsystems possible in a home control network. As shown in Figure 9 the energy management agent may be linked to other home control systems or to a home control co-ordinator.

NOTE 3 A home control co-ordinator might be responsible for providing common scheduling and subsystem interaction. This co-ordination function may be distributed among the system controllers through sophisticated software, thereby eliminating the co-ordinating controller.

7.3 Taxonomy of HES energy management use cases

7.3.1 Structure of use cases

This subclause specifies demand response applications. Each application is explained in words and illustrated with physical and logical models. These models are based on the components of the HES energy management model. In the following cases, reference is made to power and kilowatts. With a change of terminology, these cases can apply to other utilities, such as gas, water, fuel oil, or heat flow (for district or central heating).

7.3.2 Case 1: local control

Local control is illustrated in Figure 11 and Figure 12.

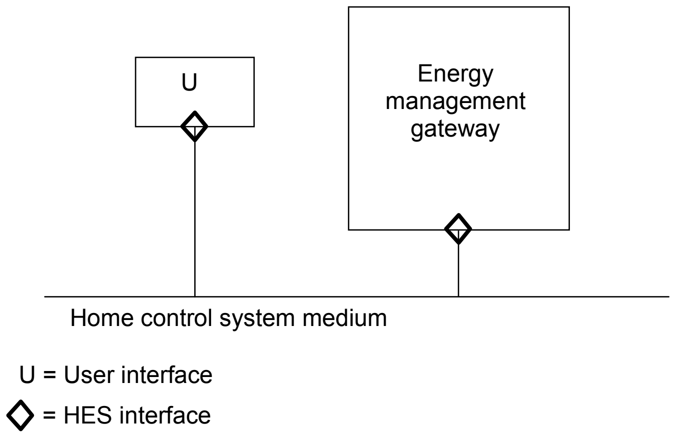


Figure 11 – Case 1: local control, physical model

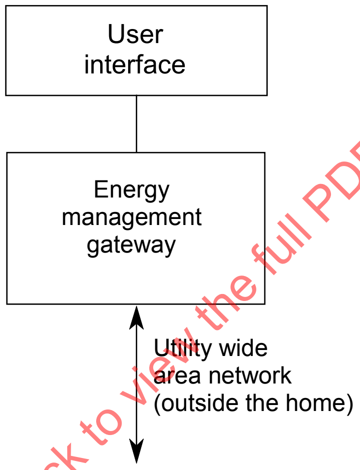


Figure 12 – Case 1: local control, logical model

Most local control schemes currently involve no communications to the customer, in which case the models in these figures do not apply. Typically, a static two-tier rate is announced by the utility to customers. In more sophisticated local control the utility may establish:

- peak and off-peak rates that change with appropriate notice;
- the times for peak and off-peak rates;
- multiple-rate levels, such as time periods for low rates, medium rates, high rates and emergency rates. The latter rate may be unusually high to indicate an emergency condition.

NOTE As the number of pricing tiers grows and the time of transition becomes variable, local control pricing becomes similar to the "real-time" pricing associated with distributed control.

In all of these variations of local control, the possible communications messages, if there are any, between the utility and the customer consists of an indication of which price level is in effect. Therefore, signals flow from the utility via the gateway to a user interface, as illustrated in the physical and logical models. The user interface may consist of indicator lamps on a special unit with markings to indicate whether peak or off-peak or any intermediate rates are in effect.

7.3.3 Case 2: direct control without supervision

Direct control without supervision is illustrated in Figure 13 and Figure 14.

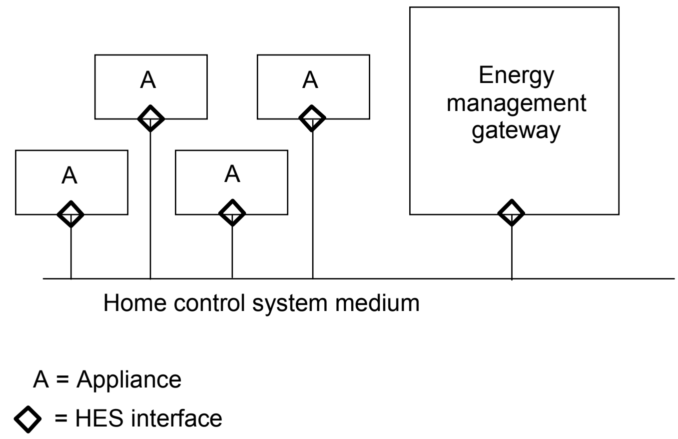


Figure 13 – Case 2: direct control, physical model

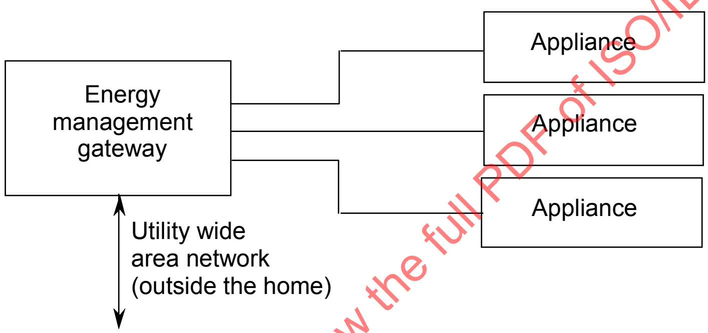


Figure 14 – Case 2: direct control, logical model

The utility enables or disables the operation of specific appliances. This case is representative of direct load control. Most present direct control consists of one-way communications from the utility to the customer appliances. The utility does not know if the control signal actually reached the appliance or if the appliance was operating. An improved option for direct load control schemes includes acknowledgement that the control signal was received.

The utility messages are usually limited to specifying which appliance is to be turned-off or to be restored to operating status. When the utility installs and manages the link to the appliances, the gateway may be eliminated if the utility uses the same signalling inside and outside the house, possibly via a virtual private network.

7.3.4 Case 3: direct control with supervision

7.3.4.1 Case 3: physical and logical models

Direct control with supervision is illustrated in Figure 15 and Figure 16.

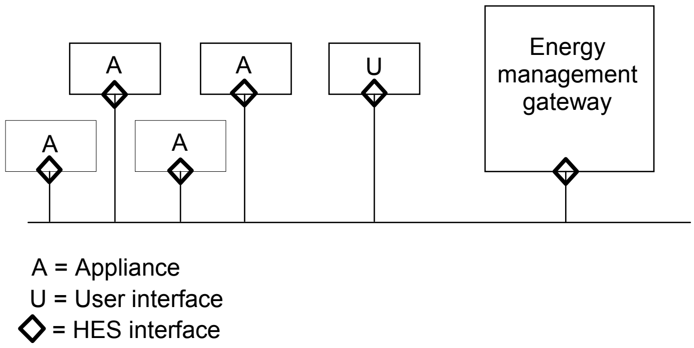


Figure 15 – Case 3: direct control with supervision, physical model

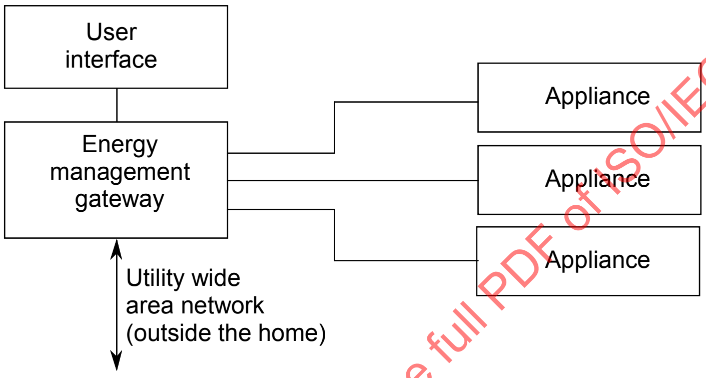


Figure 16 – Case 3: direct control with supervision, logical model

Case 3 accommodates more advanced direct control with two-way communications. This case allows the utility to verify that specific appliances are responding to control. Also, the utility can determine the effectiveness of load shedding and, therefore, can detect "free-riders". These are customers where the controlled load never attempts to use energy during the controlled time period. Typically, these customers are not home and the appliances are not operating during the controlled period.

Case 3 also allows the utility to institute control over the demand for power by setting a limit on power during a specified interval. The following expanded set of messages supports Case 3.

7.3.4.2 Utility messages

The following messages are sent from the utility.

- Which appliance will be controlled (turned-off) and for how long.
- For appliances that have multiple levels of power consumption, such as a heater, the utility may indicate the maximum level of operation allowed instead of sending a turn-off signal. This may consists of a specified reduction in the power demand of the appliance.
- When a specific appliance will be controlled, and for how long.
- How often an appliance is likely to be controlled. Alternatively, the customer may be told when the next control time is likely after the present one is being announced.
- The priority level of the control. The customer should always have the option of over-riding the control.
- The approximate cost consequence if the customer over-rides the control. The customer is not expected to have an energy management agent. Appliance interaction is conducted by

the utility via a sophisticated gateway. This gateway also controls any display device involved in direct load control.

7.3.4.3 Customer messages

The following messages are sent from the customer or from customer equipment.

- Static information about the controlled device: name and type of device, location of device, name of customer, typical power consumption, maximum power demand in an interval (typically 15 min, or should be specified), amount of power that can be shed by load control, maximum duty cycle (to indicate how often the device can be safely controlled).

NOTE The typical power consumption may change with time. The amount of power that can be shed by load control is an average value. This set of values depends on the appliance design and demand response program.

- Historical information about the controlled device: date and time the last control command was received and whether it was accepted (whether the customer allowed the device to be controlled), number of control commands and acceptances during a specified period, amount of load shed during the most recently accepted control command, average load shed during a specified period, reduction in power demand during a specified period.
- Device operating status: on, off, operating level (if appropriate), out-of-service, under direct load control. An unpowered (off) device may or may not respond with this message.
- Customer acceptance or rejection of utility plans to control a specific appliance. A reason for rejecting direct load control may be provided: customer choice, life-safety device, device out of service, etc.

7.3.5 Case 4: distributed control

The logical and physical arrangements contain all the elements in the generalised diagrams; see Figure 8 and Figure 9. An energy management agent accesses “real-time” pricing data. This controller enables / disables selected appliances or causes them to increase / reduce power consumption, turn-on / turn-off or power-up / power-down selected DERs or charge / discharge SB to meet the user's programmed goals of budget versus convenience. Figure 7 illustrates the signal flows into and out of the energy management agent. The utility pricing data may be provided in “real-time” indicating an immediate rate change. In a more realistic scenario, the utility broadcasts the rates one-day in advance. These rates may change hour-by-hour.

The energy management agent receives the electricity rate information from the energy management gateway via a home automation communications network. The controller combines this information with stored data about appliance power requirements, DER rating and customer information. The customer can enter preferences for appliance operation and budget limitations for electricity expenditures. For example, the customer may indicate a preference for hot water in the morning (for bathing) and heat in the early evening. Also, the customer might attempt to set a limit of monthly expenditures for energy. The energy management agent uses these inputs to allow or disallow appliance operation.

The software in the energy management agent determines which appliances and DERs to operate and when. Such software may be complex to balance economy with the user's desires for comfort and convenience. Elements of artificial intelligence are frequently required for effective operation.

The consumer benefits by attaining maximum convenience for appliance operation while controlling electricity costs. The consumer does not need to know details about time-of-use or demand-based electric rates. The customer can over-ride the energy management agent and be informed of the cost impact. Thus, the consumer is insulated from technical issues while making simple economic decisions.

7.3.6 Case 5: advanced distributed control

The logical and physical arrangements contain all the elements in the generalised diagrams; see Figure 8 and Figure 9. Case 5 extends Case 4 with the additional ability of the energy management agent to monitor appliance and DER operation and restrict the operating modes of selected appliances. Thus, the control signals to appliances are extended from on and off to operating mode or demand level (as appropriate for the appliance). Also, messages may flow from the appliance to the energy management agent.

The signals between the energy management agent and the appliance are similar to those defined for Case 3, direct control with supervision. The fundamental difference is that all decisions about appliance control are made locally based on “real-time” price data. The energy management agent can calculate the cost consequences of appliance and DER operation.

Appliances may include indicators and controls for energy management. For example, the energy management agent may determine that an appliance should not be operated. If the user attempts to run that appliance, a lamp on the appliance may indicate that the operation is deferred by the energy management agent. Furthermore, the user may be allowed to over-ride this decision by pressing a special key on the appliance. A display on the appliance or on a nearby home automation control panel may tell the user the cost consequences of over-riding the energy management agent. The user is now making an informed decision on spending money for energy.

The same set of messages between the energy management agent and appliances is required as defined in Case 3. The following additional messages are needed.

– From the energy management agent:
  - data about the cost of operating the appliance in the operating mode requested by the user;
  - data suggesting operating modes and costs that will save money;
  - a request to reduce average power consumption by a stated percentage. Note that this command is intended for appliances with intelligent controls. Most appliances will not be able to respond to such a request. Most will be able either to operate normally or to stop operating completely. Others may be able to operate in specified modes, as directed by the energy management agent;
  - which DER will be controlled (turned-on, charge/discharge), when and how long/how much;
  - for DERs that have multiple levels of power generation, such as FC, the EMA may indicate power-up/power-down.
– From appliances connected to the energy management agent:
  - confirmation of the mode of operation set by the user;
  - manual operation of the appliance or the DER by the user;
  - user request to over-ride control of the energy management agent;
  - power being consumed by the appliance, being stored by the battery, being generated by the DER or power being provided by the battery. This information may be compiled for bill desegregation: a bill that shows how much power each major load is consuming. Also, the utility may request these data to be uploaded for a load survey.

7.3.7 Case 6: distributed control for intelligent appliances

The logical and physical arrangements contain all the elements in the generalised diagrams, see Figure 8 and Figure 9. Additional energy services are possible with intelligent appliances, as listed in the examples below.

– Automatic adaptation to real-time pricing

- Some appliances might eventually be able to adapt energy consumption according to the price of electricity directly. This means that part of the algorithm planned for the energy management agent might be built into future appliances.
- The messages between the energy management agent and the appliance convey the current price and the anticipated duration of this price level.

– Emergency load control

- The utility issues an emergency notice that supplies are limited and a specific level of power consumption should not be exceeded. The energy management agent could calculate the demands of all operating appliances to achieve this limitation. Some networked appliances have been marketed that interleave operating cycles among major appliances to limit the demand peak.
- An intelligent appliance might be able to control demand to a desired level automatically. The command sent to such an appliance would simply indicate the maximum energy consumption for a specified period of time.
- The utility commands to the energy management agent specify the maximum power availability and the time allowed to shed loads. The energy management agent should confirm acceptance of the power reduction within the specified time or the customer may be disconnected from the grid.

– Power consumption

- Some utilities gather power consumption statistics from major appliances for load planning purposes. Others offer these data to customers in a scheme called “bill disaggregation”. This shows the customer consumption by major appliance to explain the bill and encourage conservation. Such appliances should be out-fitted with power meters. Current meters may be adequate if the appliances are primarily resistive loads.
- Commands to support power consumption consist of polling the appliances by the energy management agent. Each appliance returns the energy consumed since the last poll. Ancillary commands to initialise or reset power measurement in the appliance may be provided. The energy management agent may also communicate with the electric meter to gather whole-house consumption data.
- The utility may communicate with the energy management agent to request power recording and to upload data accumulated by the energy management agent. The controller would be responsible for gathering and averaging the data and producing a summary report.

7.3.8 Case 7: utility telemetry services

Utility telemetry services are illustrated in Figure 17 and Figure 18.

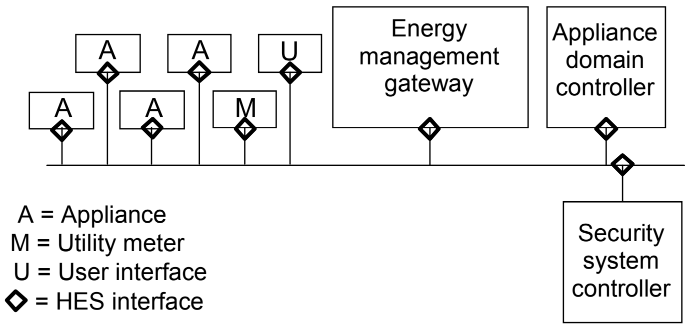


Figure 17 – Case 7: utility telemetry services, physical model

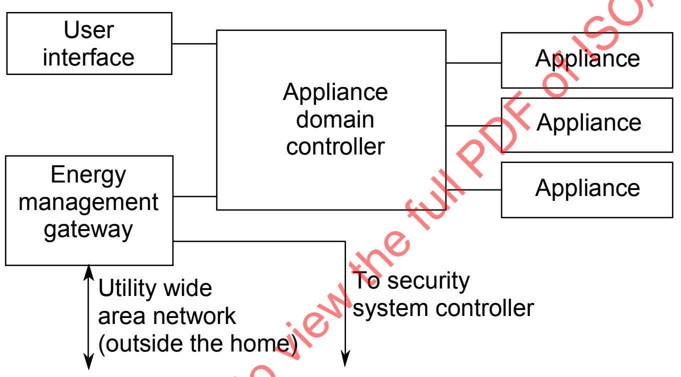


Figure 18 – Case 7: utility telemetry services, logical model

This case accommodates a variety of new value-added services being considered by some utilities. It is not possible to anticipate all messages necessary to support services to be defined. Nevertheless, the pathways for such messages will likely be between an energy management gateway and one or more local application domain controllers (see NOTE 1), similar to the energy management agent. The local controllers, shown in Figure 17 and Figure 18 as an appliance domain controller and a security controller, exchange messages with specific appliances or subsystems to be controlled. Please note that an explicit controller may not be present. In this case, control functions are distributed among the network components comprising a fully distributed system (see NOTE 2.)

NOTE 1 Application domain: Typical components include sensors, actuators, user-interface devices, and controllers. Examples of application domains are lighting, security, energy management, and HVAC (heating, ventilating, and air-conditioning).

Application domain controller – A controller responsible for managing the operation of an application domain. An application domain controller may be a physical device, or the application control functions may be distributed in related devices such as a sensors, actuators, and appliances.

NOTE 2 Fully distributed system – A system comprising multiple application domains where the functionality of application domain management is distributed over related devices. In such a system, the presence of application domain controllers as physical devices is optional.

An example of a utility telemetry service is appliance monitoring and diagnosis. A customer would subscribe to this service where the utility periodically tests the operation of a specific appliance. The utility initiates a built-in test sequence in the appliance and reads the result. Any problem requiring customer notification is presented on a local user interface.

Message sets to accommodate remote appliance diagnosis contain the test sequence identification code. The appliance responds with the result code of the test procedure. Future appliances might allow the utility to download special test sequences into the appliance or into the energy management agent. In the latter case, the controller is acting as a test instrument for the appliance.

An important factor to consider as value-added services, including remote testing, is the quantity of data to be communicated between the utility and the customer. The control channel (Class 1) of HES is not intended for large volumes of data. An information channel, defined in the HES architecture, needs to be allocated for this purpose.

7.4 Lexicon for HES energy management

7.4.1 HES message lexicon overview

The following messages are specified for commands, status reports, or data to be exchanged among the logical components in the HES energy management system model. This message set does not imply that all energy management components can or shall support the features of each message. Messages will be chosen according to the needs of a specific implementation. These messages represent a variety of functionality, not necessarily implemented in any one system.

The objective of the lexicon is to provide a bounded set of choices for messages to facilitate interoperability. The standard specifies choices from a bounded set. A developer of an interoperability framework based on ISO/IEC 18012 can write XML schema with a manageable data set.

7.4.2 HES message list

7.4.2.1 General

Each message may be sent to a single device, to all devices (broadcast), or to a predefined group of devices.

7.4.2.2 Gateway ←→ user interface

The user interface may indicate one of a set of predefined price levels for energy. Alternatively, the user interface may display price data, changes in the price tiers and applicable times.

NOTE 1 Predefined price levels may be indicated by multiple lamps, each corresponding to a level. Price data, changes in price tiers and applicable times may be displayed in characters or graphical images sent by the utility via the gateway.

Messages sent to the user interface:

– ON/OFF messages
  - Turn on the addressed indicator lamp in the user interface.
  - Turn off the addressed indicator lamp in the user interface.

Data contained in messages to be displayed on the user interface:

– rate tiers, or unusual conditions;

– cost of over-ride.

NOTE 2 The intent is to inform consumers of the cost of overriding a direct load control signal.

NOTE 3 A string length of about 40 characters is likely to be sufficient. For multiple line displays, multiple messages may be sent. Future displays might support graphical (or icon) display, requiring appropriate coded messages in place of plain text.

7.4.2.3 Gateway ←→ appliances

Messages sent between a gateway and appliances:

– ON/OFF messages
  - Turn off the addressed appliance for a specified duration.
  - Turn on the addressed appliance.

NOTE 1 This message is sent either to the appliance or to a power module that controls the flow of power into the appliance. The specified duration parameter is optional.

– Level of consumption
  - Limit the addressed appliance operation to a specified maximum power for a specific duration.
  - Remove any power restriction from the addressed appliance.

– Time of restriction
  - Notify the addressed appliance of the start time a specified restriction and the anticipated duration.
  - Notify the addressed appliance how often a specified restriction will be instituted.
  - Notify the addressed appliance about the start time of a specified restriction after the present restriction ends.

– Priority of restriction
  - Assign a priority level to the addressed appliance for future on/off or restriction messages.

NOTE 2 It is assumed that there is prior agreement on the number and meaning of priority levels.

– Appliance report
  - Request specified report from addressed appliance.
  - Provide requested report from addressed appliance to the gateway.
  - Specified reports include: static information, historical information, device operating status, customer acceptance or rejection of load control and the reason, if available. The contents of these reports are described in Case 3 above.

NOTE 3 The format of the reports consists of parameters that may be identified by field position or by keyword.

7.4.2.4 Gateway ←→ energy management agent

The following commands involve the exchange of data in character format.

– Rate data update
  - The energy management agent queries the gateway for the availability of new rate data.
  - The gateway responds with the time and date of the last rate update.

– Rate data
  - The energy management agent queries the gateway for a download of rate data.
  - The gateway downloads the rate data.

NOTE The format of the data will be defined. It may follow the format used for wide area communications between the utility and the gateway.

7.4.2.5 Energy management agent ←→ appliances, DERs

The following messages between an EMA and appliances or DER equipment depend on device capabilities.

– Appliance or DER capabilities

- The energy management agent queries an addressed appliance or DER about device information and energy requirements.
- An appliance responds to a query from the energy management agent with static information (see Case 3 above) including data about nominal energy consumption and, if available, data about peak consumption, consumption by operating mode and ability to reduce energy consumption upon request. The latter parameter may indicate that the appliance is in a critical mode that should not be interrupted, or involved with life safety operations.
- A DER responds to a query from the energy management agent with rating information including data about nominal energy generation (W), maximum energy generation (W), minimum energy generation (W), remaining electric power (kWh, %) and momentary charge/discharge electric power (W), current (A), voltage (V).

– Appliance control

- The energy management agent requests the addressed appliance to turn off or to limit operating modes or power consumption to a specified level or percentage of peak usage within a specified time interval and with a specified urgency.
- The energy management agent requests the addressed appliance to resume operating without any mode or power restriction.
- The addressed appliance responds with acceptance and confirmation or rejection of the request from the energy management agent or indicates that it is turned off, out-of-service, or under manual control.
- The energy management agent informs an addressed appliance about the cost of rejecting the previous request for energy consumption reduction.
- The energy management agent informs an addressed appliance about recommended operating modes with various degrees of conservation.

– DER control

- The energy management agent requests the addressed DER to turn-on, discharge and power-up to switch the electricity source of some loads from the grid to the DER.
- The energy management agent requests the addressed DER to turn-off, standby and power-down to switch the electricity source of some loads from the DERs to the grid.
- The energy management agent requests the addressed DER to charge in order to have the DER store electricity.
- The addressed DER responds with acceptance and confirmation or rejection of the request from the energy management agent with a reason (e.g., out-of-service, user override, etc.).
- The energy management agent informs an addressed DER about the cost of rejecting the previous request for energy generation.

– Appliance energy consumption

- The energy management agent requests an addressed appliance report energy consumption for the previous specified time interval.
- The addressed appliance responds with the energy used (kWh) or indicates that it was off or out-of-service.

– DER energy generation

- The energy management agent requests an addressed DER to report energy generation for the previous specified time interval.
- The addressed DER responds to a query from the energy management agent with
  - static information including data about measured cumulative generated power (Wh),
  - measured cumulative exported power (Wh),
  - a history of momentarily measured generated power (W),

- measured momentary exported power (W),
- measured cumulative charge/discharge electric power (Wh), and
- a history of momentarily measured charge/discharge electric power (W), current (A) and voltage (V).

7.4.2.6 Energy management agent ←→ user interface

The following messages specify user interactions with the energy management agent.

– User inputs
  - Numerical data providing a monthly energy budget.
  - Appliance operating preferences by appliance name, mode of operation, times of operation and priority relative to other appliances.

– Displays for user
  - Numerical data about monthly energy consumption with optional bill disaggregation by major appliance.
  - Numerical data about the present and projected energy tariff.
  - Optional displays for energy management system configuration.

NOTE Interactive menus may be needed to configure the energy management system as appliances are added and deleted. A future network management computer may handle automatic configurations.

7.4.2.7 Energy management agent ←→ meter

The following commands apply to electronic meters with communications capabilities.

NOTE It is possible in some installations that the meter functions as the gateway. Therefore, commands defined for the gateway may be appropriate here.

– From energy management agent
  - Energy management agent requests consumption data from the meter for a specified period and peak usage (the demand), if available.
  - Additional parameters may be requested depending on the meter functionality[1].

– To Energy management agent
  - The meter responds with consumption data, demand data and applicable time period.
  - Additional data may be returned depending on meter capabilities and requests from the energy management agent.

7.4.2.8 Energy management agent ←→ other controllers

Controllers may communicate messages for co-ordination or to announce unusual conditions requiring action by other controllers.

NOTE For example, the energy management agent might request an HVAC unit reduce energy consumption. If the home automation network includes an HVAC applications controller, the energy management agent message might be sent to the HVAC controller rather than to the appliance. This routing would be appropriate if the HVAC controller contains algorithms for managing the operating characteristics of the HVAC equipment.

1. In the United States, ANSI standard C12.19 specifies a set of tables with parameters that define meter capabilities. A meter manufacturer will choose a subset of features to incorporate in a particular meter model. The first table in a meter identifies which features are available in that meter and defined in subsequent tables.