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ISO/IEC 15067-3

Title: Information technology — Interconnection of information technology equipment — Home Electronic System — Application models — Part 3: Model of an energy management system for HES

Project: 1.25.01.04.02-03-01

Introductory note: **This CD is distributed for approval as FCD.**

ISO/IEC TR 15067-3 was published as the technical report type 3 in 2000. Since this was more than five years ago the TR shall be replaced with an international standard. To this effect SC 25/WG 1 has revised the text. In accordance SC 25 resolutions 20/16 and 16.4 of ISO/IEC JTC 1 Directives to transform a TR to an international standard, the revised text is distributed as CD 15067-3 with this document.

REQUESTED: ACTION **National Member Bodies of ISO/IEC JTC 1/SC 25 are requested to vote on this document.**

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights (not listed in the draft) of which they are aware and to provide supporting documentation.

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Date 2010-05-03~~2009-10-29~~

FCD 15067-3

Information technology –
Home Electronic System (HES)

Application models — Part 3: Model of an energy management system for HES

CONTENTS

LIST OF FIGURES

FOREWORD

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

INTRODUCTION

This part of ISO/IEC 15067-3 was prepared by Joint Technical Committee ISO/IEC JTC 1, Information technology, Subcommittee SC 25, Interconnection of Information Technology Equipment.

ISO/IEC TR 15067 currently consists of four parts. All parts were previously published as Technical Reports. Part 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 1: Application services and protocol

Part 2: Lighting model for HES

Part 3: Model of an energy management system for HES (this document)

Part 4: Model of a security system for HES

WG 1 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 document defines a standard 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. Product 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 a method 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 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 ~~Demand response~~ is one element in the concept of the “smart grid.” The smart grid for electricity integrates subsystems for generation, transmission and 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 — Interconnection of information technology equipment — Home Electronic System — Application models — Part 3: Model of an energy management system for HES

1 Scope

This standard focuses on products and services that can manage energy consumption dynamically in response to electricity supply and prices that . Dynamic adaptation is important because the supply and cost of electricity may vary over time. The model presented specified here for energy management is intended to be generic and representative of a wide range of situations. This standard applies to the customer interface 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 (5.2.2), local control (5.2.3.2), and distributed control (5.2.3.3). These methods offer a mix of control and data. Customer and customer equipment may use these data to exercise control the energy consumption of based on premises equipmentdevices such as appliances. The taxonomy and lexicon of an energy management model that supports these methods of demand response are presented in 7.3 and 7.4. The choice of demand response 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 links between a utility communications network and a home area network facilitate effective distributed control, as specified.

2 Normative references

ISO/IEC 14543-2: Information technology – Home Electronic System (HES) Architecture

ISO/IEC 15045-1, Information technology — Home Electronic System (HES) — Gateway — Part 1: Introduction

ISO/IEC 15045-2, Information technology — Home Electronic System (HES) — Gateway — Part 2: Modularity and protocol (under consideration)

ISO/IEC 18012-2, Information technology — Home Electronic System (HES) — Guidelines for product interoperability — Part 2: Taxonomy and Lexicon (under consideration)

ISO/IEC 24752-1, Information technology — User interfaces — Universal remote console — Part 1: Framework

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

3.1.1
demand charge
charge for electricity based on the total power consumed during a specified interval of time

3.1.2
demand response
method for matching the demand for energy to the available supply of energy

3.1.3
direct load control
demand response via remote control of one or more appliances

3.1.4
disaggregated bill
utility bill that shows energy consumption by major appliances

3.1.5
distributed load control
demand response based on dynamic price data, event notices, or other information sent from the utility to smart appliances or to an energy management agent

3.1.6
electricity grid
electricity supply network

3.1.7
energy management agent (EMA)
set of control functions that manage energy consumption as an agent for the customer

3.1.8
energy management gateway
residential gateway facilitating direct or distributed load control or demand response for electrical energy usage

~~3.1.8~~3.1.9
HAN device
device located in the home that can communicate via ~~be connected to~~ a home area network (HAN) wirelessly or via wires.

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

~~3.1.9~~3.1.10
HES gateway
residential gateway standardised as part of the Home Electronic System (HES) in ISO/IEC 15045 (multiple parts)

~~3.1.10~~3.1.11
local load control
demand response via publication of time-of-use electric rates

NOTE: With local load control the utility typically informs customers of the electric rates by a notice sent with the electric bill or via a user interface such as various coloured lamps at the customer premises, not via a communications network connected to appliances. The customer may use these rate data to select which appliances to operate.

~~3.1.11~~3.1.12
major appliance
large kitchen appliance

NOTE: See also "white goods."

~~3.1.12~~3.1.13
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

~~NOTE: A residential gateway architecture is standardised as the HES gateway (ISO/IEC 15045, multiple parts).~~

~~3.1.13~~3.1.14
smart appliance
home appliance that exchanges command and control data with other devices on a home area network

~~3.1.14~~3.1.15
smart grid
intelligent, supply/demand self-balancing and self-monitoring electricity grid that accepts electricity from any source of fuel (coal, sun, wind) and transforms it into a consumer's end use (heat, light, warm water, appliance operation) with minimal human intervention

~~3.1.15~~
~~utility gateway~~
~~residential gateway facilitating direct or distributed load control or demand response~~

3.1.16
value-added services
optional services offered by a utility that may or may not be related to energy and may generate additional revenue

3.1.17
white goods
large kitchen appliances

NOTE: This term is used in the appliance industry for large kitchen appliances, also called “major appliances” Examples are a refrigerator, range, oven, and dish washer.

3.2 Abbreviations

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

CFL	Compact Fluorescent Lamp
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
HAN	Home Area Network
HES	Home Electronic System
HVAC	Heating, Ventilation, and Air-Conditioning
LED	Light ~~Emitted~~ Emitting Diode
PV	Photo-Voltaic
RTP	Real-Time Pricing
TOU	Time-of-Use
UPS	Uninterruptible Power Supply

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 profiles in Clause 5 must be implemented.

Utilities may offer value-added services in conjunction with demand response, as listed in 5.2.3.4, which are optional.

For those utilities choosing distributed load control for demand response, Clause 6 is also required.

7.3 and 7.4 define the taxonomy and lexicon corresponding to the options for demand response according to the HES energy management model. These include a combination of control signals, pricing data, and event notices. An implementation of a demand response use case shall conform to the taxonomy and lexicon specified in these sections for that use case.

NOTE: In some countries approvals from government regulators are required for the implementation of demand response.

5 Energy management using demand response

5.1 Demand response overview

Demand response (DR) is a form of demand-side management (DSM). DSM is described in informative Annex B.~~Electricity consumption patterns have peaks daily and seasonally. During weather extremes of heat and cold the demand for electricity rises sharply. To meet these occasional peak demands, some utilities need to keep relatively expensive generators running or must build new plants.~~

~~Some laws mandate that utilities maintain the supply of electricity sufficient to meet any demand. However, this is becoming less practical because of the cost of new electricity plants, public resistance to new plants and transmission lines, and government environmental regulations controlling pollution. The pressure for plants to meet peak demands could be reduced if customers evened out their power consumption so the peaks are flattened.~~

~~Utilities have developed specific programs to influence the customer demand for power in order to align with the available supply. Such utility programs are called demand-side management (DSM).~~

~~DSM programs and associated tools enable utilities to modify the cumulative demand for energy, known as the load shape when plotted over a one-day interval. Utilities have developed a variety of DSM programs to manipulate the load shape. Different programs have different load shape goals, with the majority intended for peak clipping, as explained in informative Annex B.~~

~~Utilities have developed more deterministic methods for influencing the demand through DSM. Since DSM programs may not involve explicit management by the utility, the term demand response (DR) is being widely used in the industry.~~ DR uses incentive-based and indirect methods for controlling how much electricity is consumed during a specified time interval by water heaters, air-conditioners, and industrial equipment. 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 wholesale and delivery costs, with limited or no advanced notice to customers.

One or more demand response (DR) profiles shall be implemented when an electric utility determines that DR would address a mismatch between the supply and demand for power.

5.2 Demand response profiles

5.2.1 Choice of profile

An electric utility or other provider (also called “third-party supplier”) of energy management services shall choose one or more of the profiles described in this section for designing a demand response system to influence customer use of power. The profiles include:

- Direct load control (5.2.2)
- Local load control (5.2.3.2)

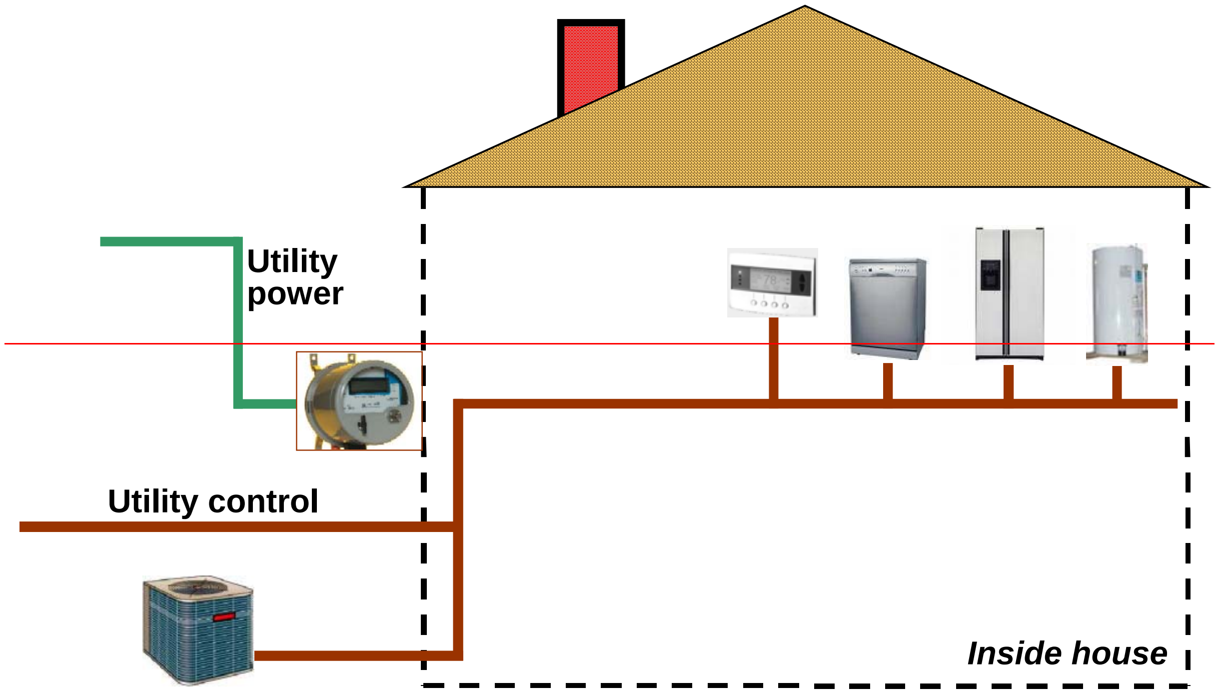
- Distributed load control (5.2.3.3 and Clause 6)

5.2.2 Direct load control

~~Some large industrial customers volunteer for lower electric rates in exchange for deliberate service interruptions. When utilities are facing a supply limitation, perhaps on a hot summer day, they order these volunteers to reduce or to curtail some energy consuming equipment. The analogous program for residential customers is "direct load control." This program may be offered by utilities or by third-party suppliers.~~

To implement direct load control (described in B.4), utilities or third-party suppliers of energy management services shall send control signals to interrupt the operation of selected devices such as air-conditioners and water heaters remotely from outside the house. 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 1~~Figure 1~~Figure 1~~Figure 1~~ illustrates the architecture of direct load control. Not all appliances are equipped for participation in demand response, such as the television shown in Figure 1~~Figure 1~~.



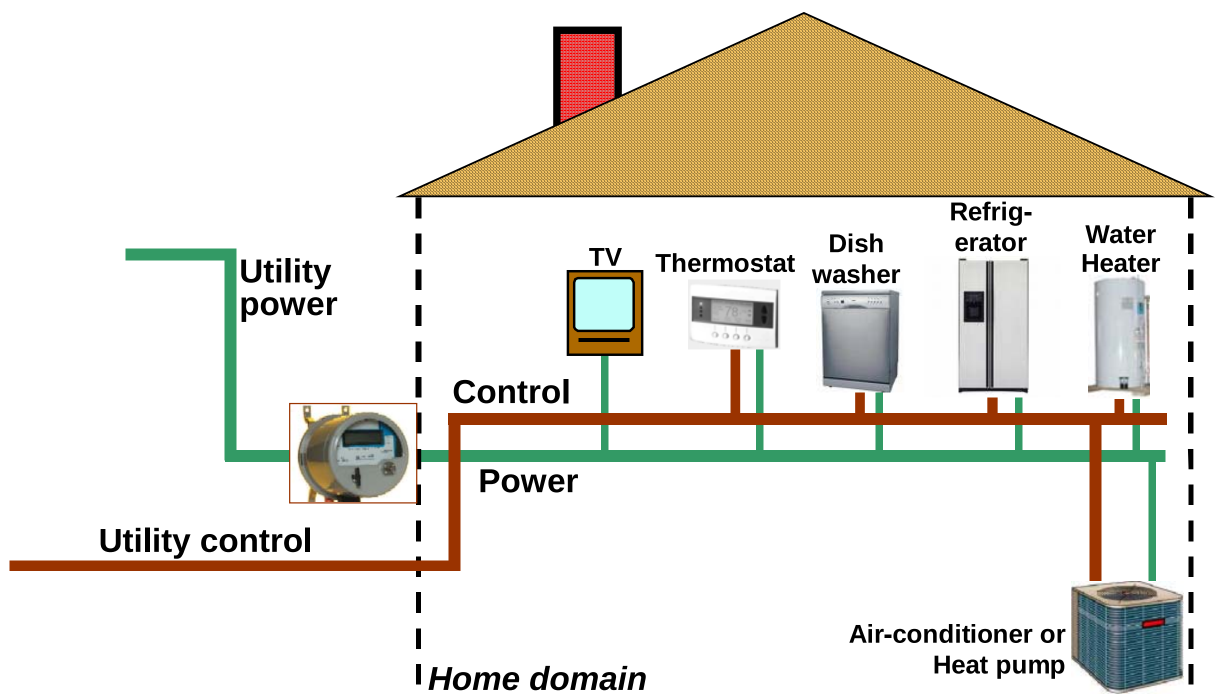


Figure 1 – Direct load control

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 1Figure 1Figure 1Figure 1 illustrates a uniform path to deliver the utility control signal to the selected appliances. The utility may interpose a communications gateway between the utility network and the network within the home if different communications protocols are implemented outside and inside the home. If a gateway is involved, it shall conform to ISO/IEC 15045 (multiple parts).

Note: Customers may be offered a financial incentive to participate in direct load control.Many customers in the U.S. are offered rebates of up to $10 a month for participating in direct load control. Of the 8 % of U.S. customers under load control, most are participating in direct control.

5.2.3 Demand response via pricing and event notification

5.2.3.1 Indirect control of customer demand

Indirect methods for controlling customer demand for electricity include:

- Time-of-use rates that vary according to the time of day.
- Event notices sent by the utility to customers about pending supply limitations that are usually temporary.

~~An indirect method of load control is based on electric rates that vary over time or a notice to customers of a pending event, such as a partial supply interruption, requiring consumption reductions.~~

~~Time-of-use rates vary the price according to the time of day. Typically, on-peak and off-peak rates are announced. The hours for each rate are fixed for each day, or at least for work days, similar to telephone rates. Rates that change dynamically with one-day or even no advanced notice constitute real-time pricing. Time-of-use rates are usually static compared to real-time pricing.~~

~~Note: In many countries electricity traditionally was sold at a flat rate or a volume-sensitive rate. New pricing schemes are adding time as a factor.~~

5.2.3.2 Local load control

Utilities choosing local load control shall publish time-of-use (TOU) pricing for electricity. The published rates shall be provided to customers prior to implementation and prior to any changes of the TOU rates. The method for publishing TOU may vary by utility. ~~Utilities shall deliver TOU pricing data via a mailed letter or electronically to a user interface display via a communications network and optionally via a residential gateway to the customers. If a gateway is involved, it shall conform to ISO/IEC 15045 (multiple parts). Utilities should educate customers to help them select which appliances to operate when in order to avoid peak power charges.~~

Note: Utilities typically deliver TOU pricing data via a mailed letter or electronically to a user interface display via a communications network and optionally via a residential gateway to the customers. Customers may need guidance to help them select which appliances to operate when in order to avoid peak power charges.

~~TOU pricing typically involves pricing electricity higher during specified hours, such as 4 PM to 6 PM when the wholesale cost of power is higher. Some utilities set the ratio of on-to-off peak pricing high enough to motivate customers to defer heavy power-consuming appliance usage to the off-peak times.~~

~~In some countries, TOU pricing also includes a demand charge. The consumer pays a special charge called a "demand charge" if the total electricity consumed during a short interval (typically 15 min or 30 min) exceeds a pre-set limit. The penalty may be higher charges or even interruption of power flow.~~

~~As with telephone tariffs, customers are notified of the TOU rates and are expected to adjust consumption accordingly. For this technique, called *local control*, to be effective the customer must:~~

- ~~Remember the time period for off-peak pricing of power.~~
- ~~Know which appliances consume relatively large amounts of energy.~~
- ~~Know which combination of appliances may result in a demand charge if imposed by the utility.~~
- ~~Not be significantly inconvenienced by deferring appliance operation to off-peak times.~~

5.2.3.3 Distributed load control

Utilities can better match electricity supply with customer demand by dynamically varying the price of electricity as market conditions change, a method known as real-time pricing (RTP). Eventually, utility policy makers would like to adjust prices according to the wholesale market price of electricity to reflect actual utility costs. The utility has the opportunity to change prices when a peak demand is expected.

Note: In some countries regulations do not presently permit residential users to be offered fully flexible real-time pricing. Utilities may be permitted tariffs with two or more price tiers to reflect their costs of energy generation and distribution. In countries with a competitive market, third-party suppliers may set the retail rates.

Some utilities are capable of accurately forecasting the cost of energy in the near future, typically 24 h in advance, and supplying this information to the residential consumer. The prediction of such forecast pricing enables peaks in demand to be smoothed both forward and backward in time, thereby reducing the impact of such measures on consumer comfort and convenience. As these innovative pricing schemes lower the peak demand, utility costs are reduced.

Distributed control enables users to respond effectively to utility price variations and event notices with minimal involvement or inconvenience by using computer-based agents and smart appliances, as described in 6.3. Forecasted pricing enables the consumer, or an intelligent energy management system, to “draw forward” on consumption in anticipation of peak pricing. This may involve comparatively simple measures such as ensuring that heat storage devices, water heaters, and similar appliances are fully charged when the peak-price period starts.

Distributed load control combines local and direct load control with much increased flexibility and customer control. Utilities choosing distributed load control shall publish time-varying electricity prices and optionally notices of critical events regarding the supply of electricity. Utilities shall make these data available via a communications pathway to each customer with connections to a home area network (HAN). The connection to a HAN may be via a residential gateway that shall conform to ISO/IEC 15045 (multiple parts). The architectural choices for distributed control are specified in Clause 6.

5.2.3.4 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. This pathway enables the supplier to offer additional services to benefit consumers, as described in Annex C. Utilities and other providers of energy management services that implement demand response in compliance with this standard may offer one or more of the value-added services listed in Annex C. In a competitive market for energy, utilities are considering such additional services in order to retain customers and to generate additional revenue from offerings ancillary to power. Collectively, these are known as value-added services. Some governments have mandated that utilities, which traditionally were granted monopolies, start planning for competition. Therefore, utilities are seeking value-added services to make their products more attractive to customers. Utilities and third-party suppliers that implement demand response in compliance with this standard may implement one or more of these value-added services.

Potential value-added services for electric utilities beyond load control are listed. The services preceded by a check mark (✓) may be sold for additional revenue beyond the usual energy charges.

- Automatic meter reading
- Remote connect/disconnect
- ✓ Offer disaggregated bills with details about consumption by major appliances
- Monitor power delivery
- ✓ Monitor power quality

- ~~✓Offer load profiles~~
- ~~Control customer access when customers move or don't pay bills~~
- ~~Stagger power restoration in a neighbourhood after a power failure~~
- ~~Detect tampering~~
- ~~✓Diagnose appliances problems and notify the customer~~
- ~~✓Offer information and telemetry services~~
- ~~Compute the environmental impact of customer energy consumption~~

6 Distributed control architecture and strategies

6.1 Smart appliances

~~There are two important problems for effective use of the changing cost of power. First, the price data must be delivered to the customer in a timely fashion. Second, the customer must interpret the data and apply it to appliance operation. Since most customers do not understand electricity measurements, such as kilowatt-hours, they are not likely to use these data correctly. Here is where home control technology can benefit the consumer and the utility by insulating the customer from the complexity of dynamic energy management and enabling distributed load control.~~

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

Appliances that function as HAN devices are sometimes called “smart appliances.” Smart appliances can communicate via the HAN with other appliances, with an ~~HAN~~ application controller, or with the utility, depending on the application. For distributed control, the HAN ~~is~~ shall be linked to a utility network, possibly via a residential gateway.

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. Utility pricing or event data are sent directly to smart appliances with prices-to-devices. In this case the smart appliance may modify operation upon receiving a price signal according to algorithms designed into the appliance. The demand response effectiveness of prices-to-devices is limited by the capabilities of smart appliances. An energy management agent, specified in 6.3, enables a more effective appliance response. The agent for energy management is a specialised controller that co-ordinates energy consumption among multiple smart appliances.

Note: Various standards for specific pricing and control data are under development by other standards bodies.

6.2 Prices-to-devices

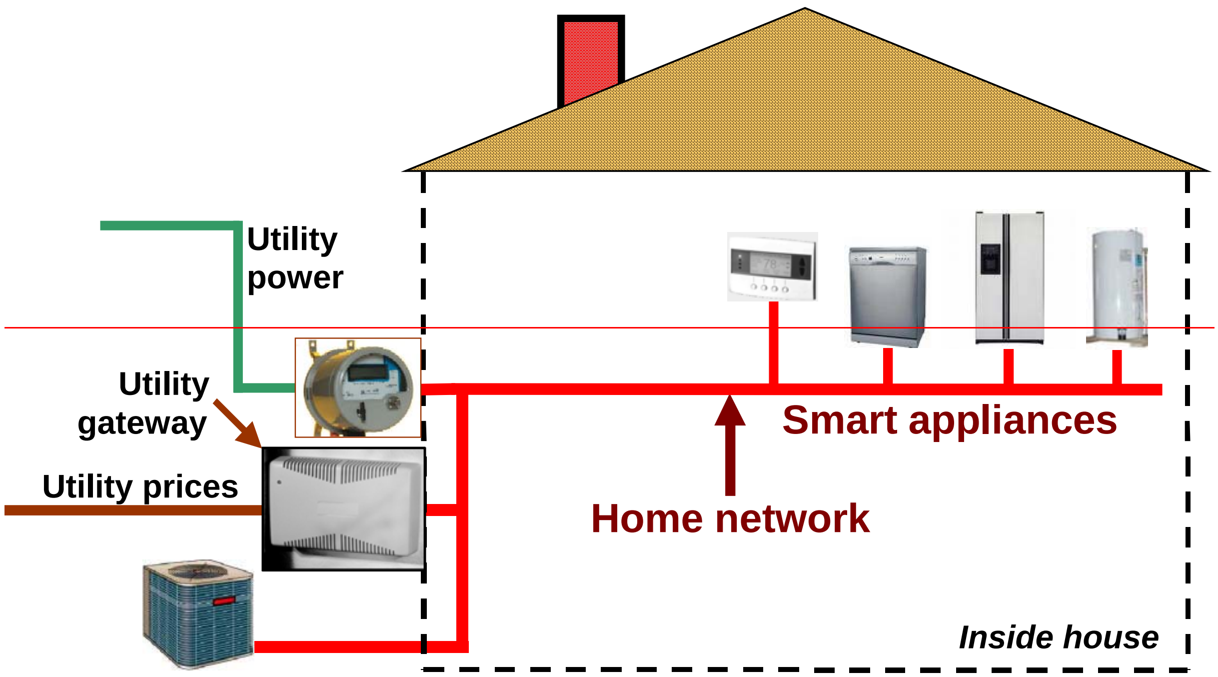
In the prices-to-devices method of distributed load control utility prices and any event notifications shall be communicated directly from the utility to smart appliances. A gateway may be interposed if needed for protocol translation between the utility wide area network and the HAN. If a gateway is used, it shall conform to ISO/IEC 15045 (multiple parts).

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:

- Shedding load in a limited number of levels (for example, four or five possible power consumption levels).
- Adjusting the temperature setting of 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 resort to full power usage or different energy consumption modes.

Figure 2Figure 2Figure 2Figure 2 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.



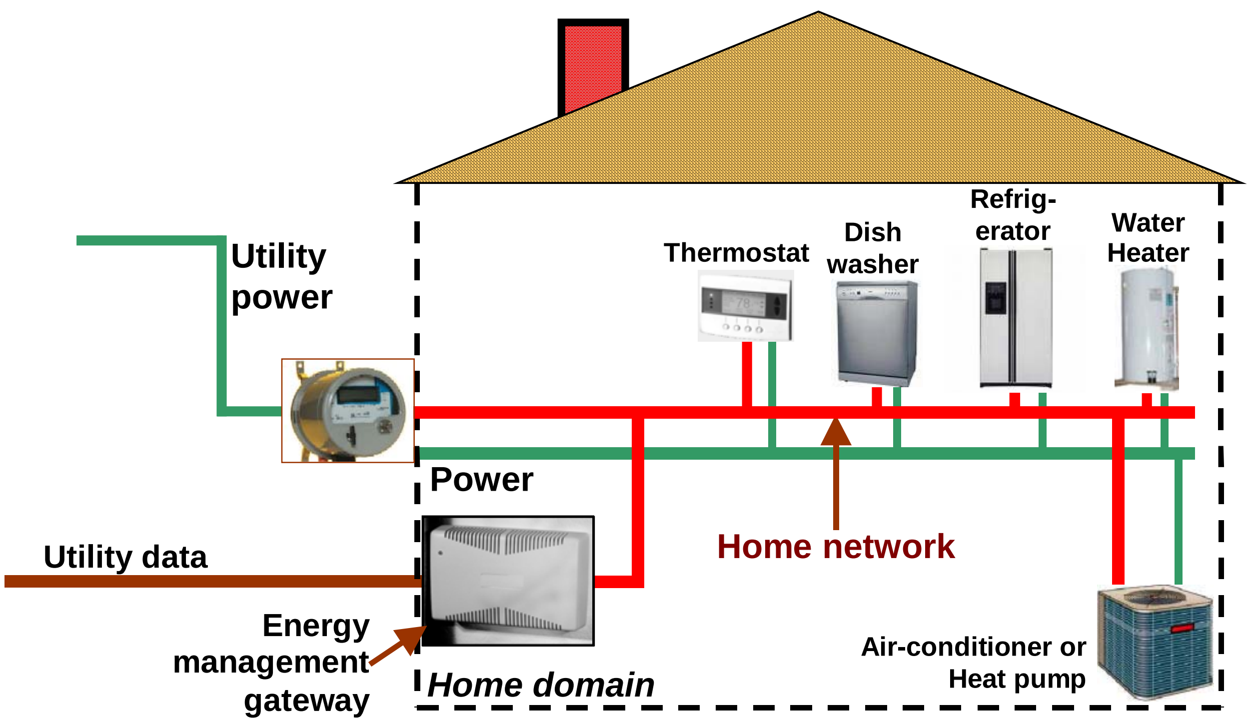
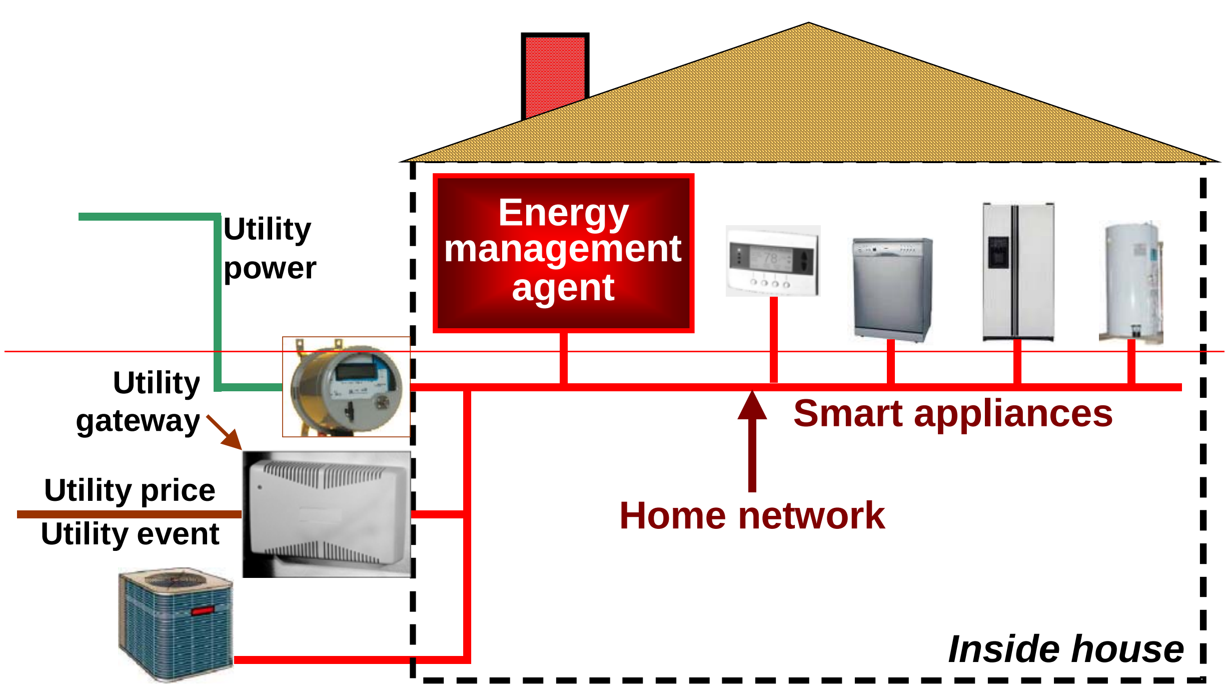


Figure 2~~2~~2 – Price-to-devices

6.3 Energy management agent

The introduction of an energy management agent (EMA), acting as an agent for the consumer, adds functionality to distributed load control by enabling the allocation of limited energy (or a limited budget for energy) among appliances according to consumer preferences. 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. Figure 3~~Figure 3~~Figure 3~~Figure 3~~ 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 to all houses in real-time over a network such as the Internet. This pricing signal shall enter the house through ~~a utility~~ an energy management gateway, a version of a residential gateway (HES Gateway) conforming to ISO/IEC 15045 (multiple parts). This gateway interconnects a public network using telephone, cable TV, power lines, or radio with a home network. The HES gateway (ISO/IEC 15045-1, 5.1.4. and 5.6.1 (multiple parts)) 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 3Figure 3Figure 3Figure 3, or could be integrated with other gateways, controllers, or even inside an electric meter.



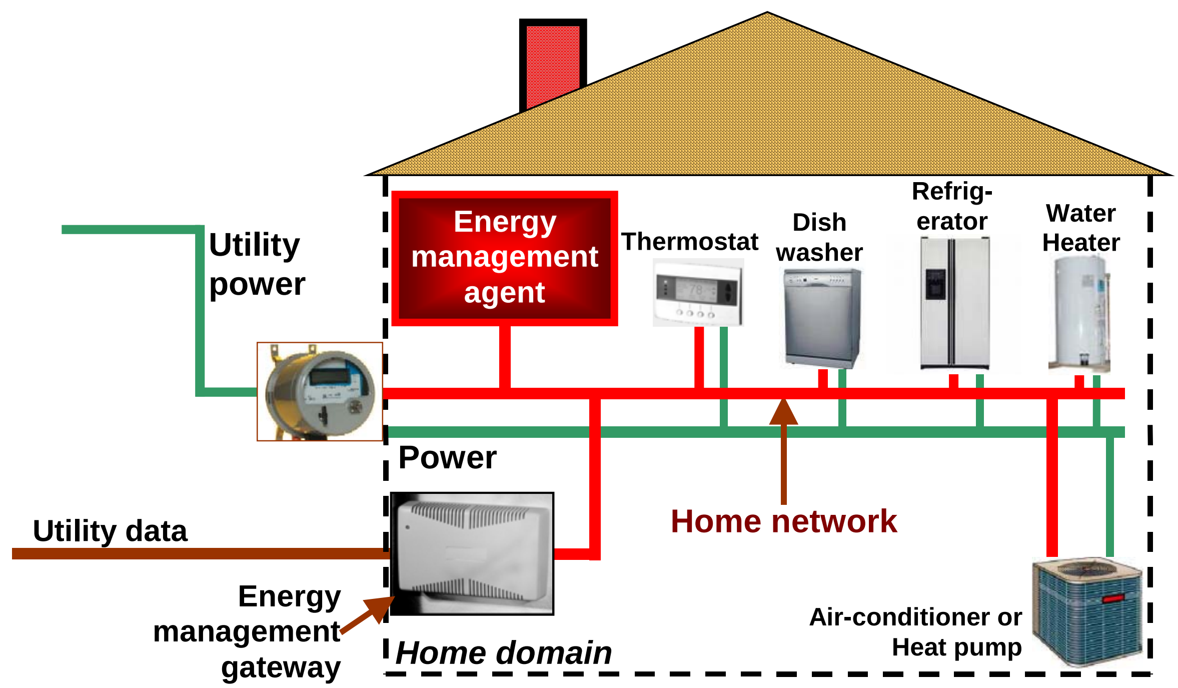


Figure 333 – Distributed load control system

The EMA shall is responsible for regulating regulate energy consumption. Options for the implementation of an EMA depend 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, a residential gateway, etc.

The EMA shall perform ~~performs~~ specialised computing functions by receiving the electricity rate data from the residential gateway and applying sophisticated software algorithms to determine which appliances to operate and when. The functions of the EMA are illustrated in Figure 4~~Figure 4Figure 4~~.

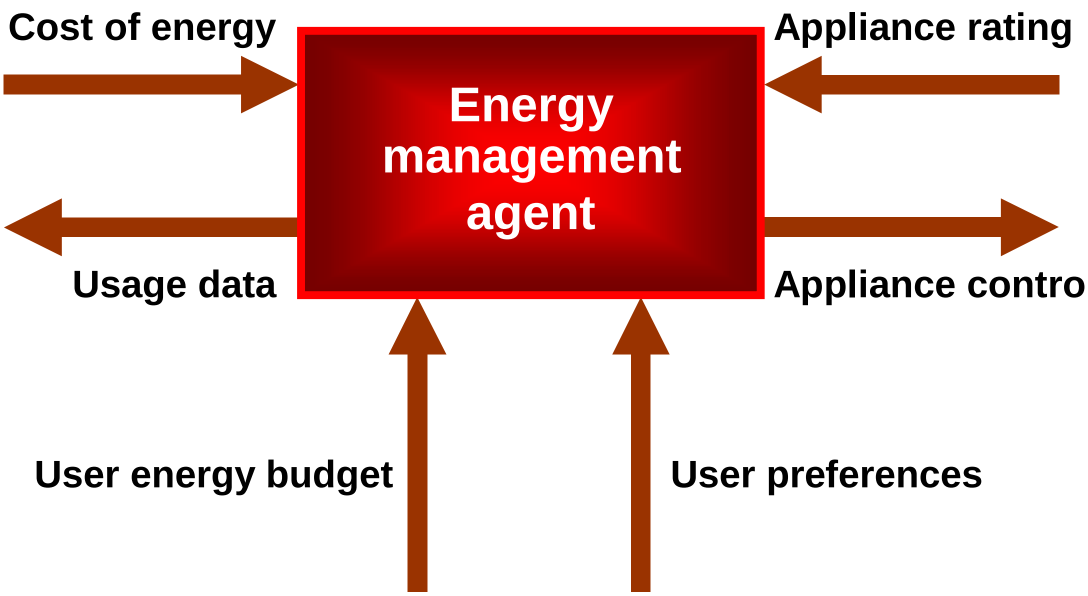


Figure 4~~44~~ – Energy management agent

6.3.1 EMA grid-to-home functionality

The EMA shall be programmed to determine how and when to operate appliances based on the cost of energy, the energy requirements of the appliances, and user inputs. 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. After processing these data, the controller shall issue signals that are distributed over a home network to the relevant appliances. Smart appliances that can operate in energy conserving modes can improve the effectiveness of a distributed load control system.

The details of the user interface for configuring the EMA are left to market development. Recommended guidelines for such a user interface are simple, non-intrusive, and adaptable by language and physical impairment, as specified in ISO/IEC 24752-1. 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. However, the EMA system shall provide automated demand response so customers should not need interaction with the EMA multiple times per day.

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 4~~Figure 4Figure 4~~. 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, if intercepted, a potential burglar could not determine customer daily activities and occupancy. The customer and the utility shall agree if and how frequently usage data in aggregate and usage by selected appliances are collected.

NOTE: The secure link security methods vary by utility.

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

The customer and the utility shall agree if and how frequently usage data are collected. The more frequently the usage data are sent, the more detailed a record of household activities and preferences can be accumulated, thereby impacting customer privacy. Aggregated energy consumption data, weighted by the price when consumed, are the only required data to be sent to the utility for billing. The customer shall decide how often the total consumption data and any detailed data are sent to the utility based on the tariffs offered by the utility. Detailed usage data by appliance (such as HVAC, refrigerator, water heater, etc.) are called “disaggregated data.” Consumers may choose to share such data with utilities or service providers for enhanced energy management or ancillary services such as appliance diagnostics.

NOTE: Privacy requirements extend beyond technical issues. Such requirements reflect a combination of agreements between consumers and service providers as allowed or mandated by government policies.

6.3.2 Home-to-grid functionality

The EMA functions may be extended to manage on-premises energy management devices. Descriptions are provided in informative Annex A.

7 The HES energy management model

7.1 Energy management taxonomy and lexicon

The architecture of the energy management model and options for demand response have been described in the previous sections of this standard. 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 are presented in 7.4. The materials presented here are not specific to a particular HAN communications protocol.

7.2 Logical and physical models

The typical components for demand response are shown in Figure 5Figure 5Figure 5Figure 5. The logical relationship among the components for demand response systems is illustrated in Figure 6Figure 6Figure 6Figure 6. To accommodate prevalent practices of direct control, a logical model with minimal functionality is presented in Figure 7Figure 7Figure 7Figure 7. 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: The logical models in this standard are intended the show the logical relationship among energy management components. They are not intended to portray an abstract model.

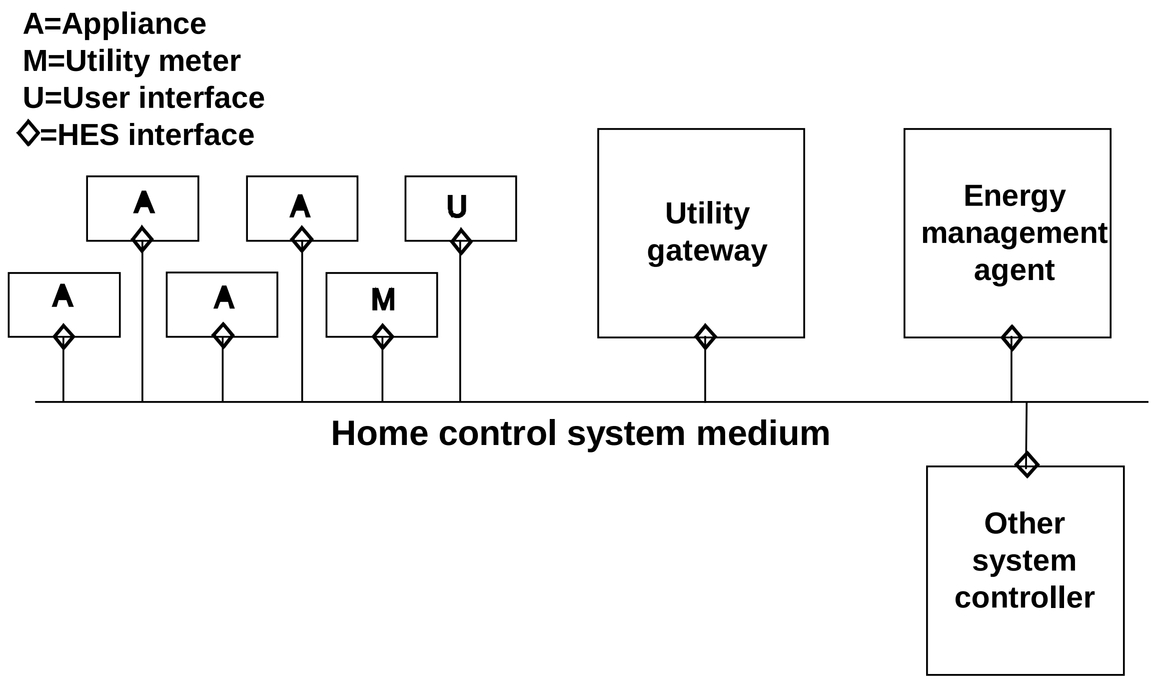


Figure 555 – Typical HES energy management model component

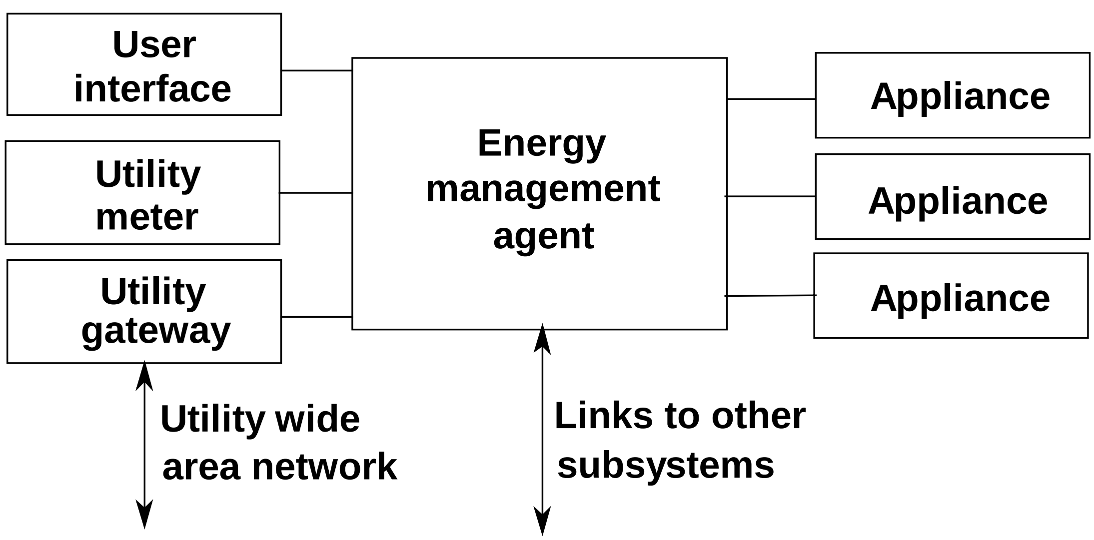


Figure 666 – Logical model for HES energy management

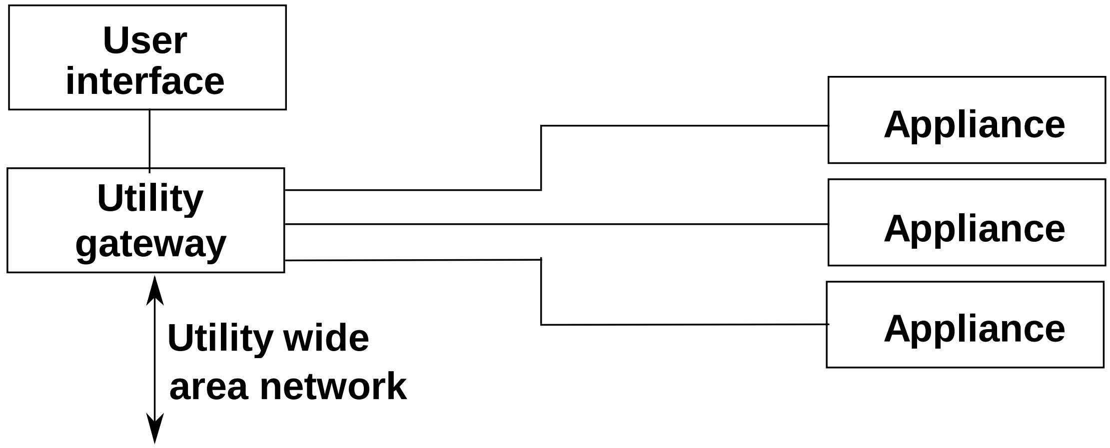


Figure 777 – Logical model of minimal HES energy management

Energy management is one of many subsystems possible in a home control network. As shown in Figure 6Figure 6Figure 6Figure 6 the energy management agent may be linked to other home control systems or to a home control co-ordinator. The 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 section presents examples of energy management 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 kW. 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

(Illustrated in Figure 8Figure 8Figure 8Figure 8 and Figure 9Figure 9Figure 9Figure 9.)

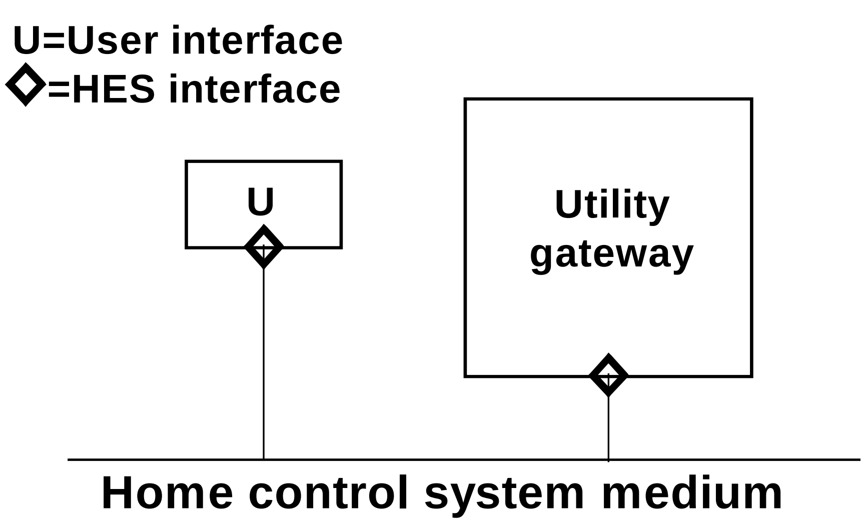


Figure 888 – Case 1: local control, physical model

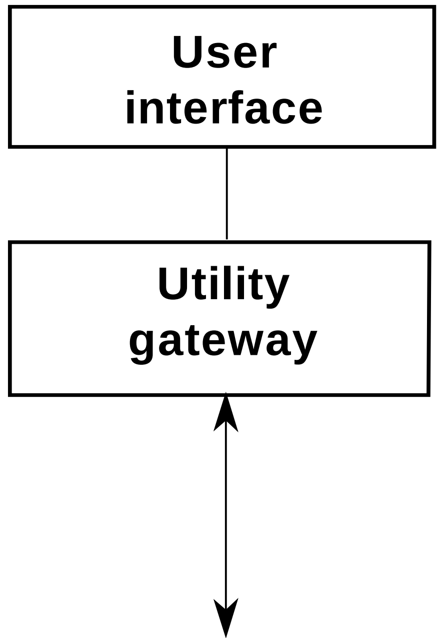


Figure 99~~9~~ – Case 1: local control, logical model

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

(Illustrated in Figure 10~~Figure 10~~Figure 10~~Figure 10~~ and Figure 11~~Figure 11~~Figure 11~~Figure 11~~.)

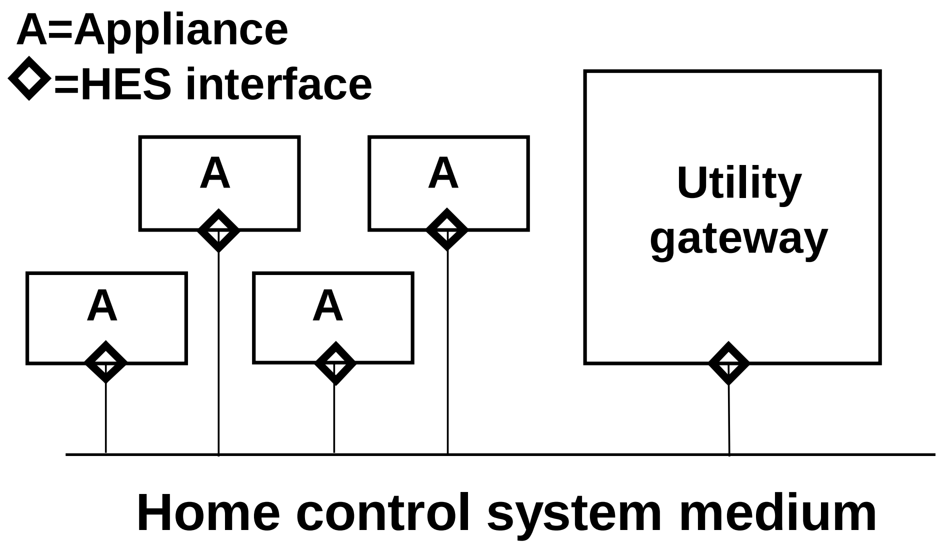


Figure 10~~10~~~~10~~ – Case 2: direct control, physical model

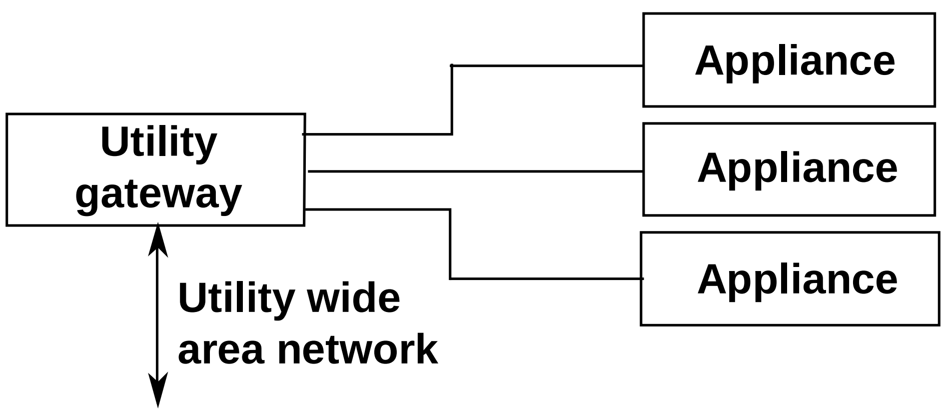


Figure 11~~11~~~~11~~ – Case 2: direct control, logical model

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 ~~Newer~~ 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

(Illustrated in Figure 12~~Figure 12~~Figure 12~~Figure 12~~ and Figure 13~~Figure 13~~Figure 13~~Figure 13~~.)

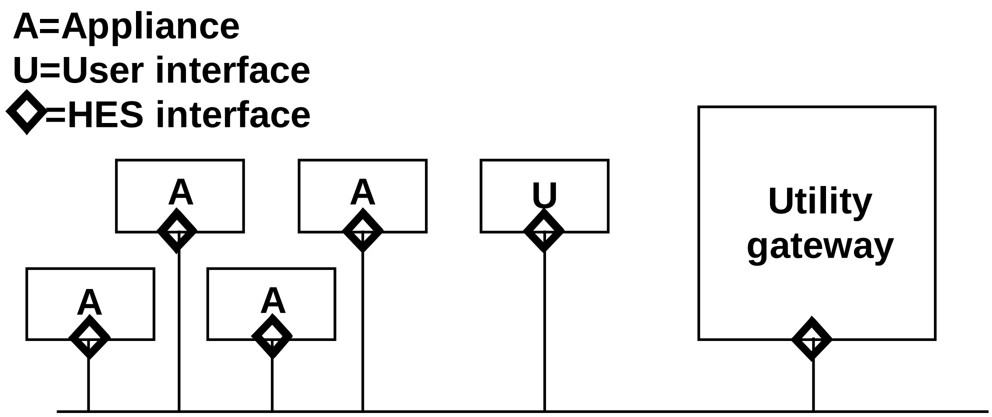


Figure 121212 – Case 3: direct control with supervision, physical model

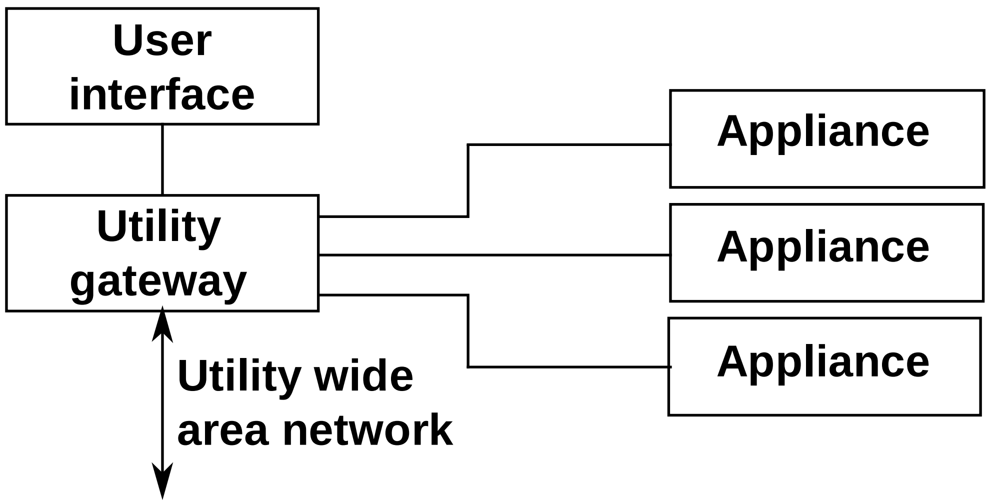


Figure 131313 – Case 3: direct control with supervision, logical model

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 kW during a specified interval. The following expanded set of messages supports Case 3.

7.3.4.1 Utility messages

- 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 kW 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 being announced.
- The priority level of the control. This may indicate whether the customer has 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.

7.3.4.2 Customer messages

- 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 must 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)
- 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.
- 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, Figure 5Figure 5Figure 5Figure 5 and Figure 6Figure 6Figure 6Figure 6. An energy management agent accesses real-time pricing data. This controller disables selected appliances or causes them to reduce power consumption to meet the user's programmed goals of budget versus convenience. Figure 4Figure 4Figure 4Figure 4 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 utility energy management gateway via a home automation communications network. The controller combines this information with stored data about appliance power requirements 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 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, Figure 5Figure 5Figure 5Figure 5 and Figure 6Figure 6Figure 6Figure 6. Case 5 extends Case 4 with the additional ability of the energy management agent to monitor appliance 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 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 kW 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.
- From appliances connected to the energy management agent:
  - Confirmation of the mode of operation set by the user.
  - Manual operation of the appliance by the user.
  - User request to over-ride control of the energy management agent.
  - Power being consumed by the appliance. 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 this data 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, Figure 5Figure 5Figure 5Figure 5 and Figure 6Figure 6Figure 6Figure 6. Additional energy services are possible with intelligent appliances. For example:

- 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 must 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 must 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 must 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

(Illustrated in Figure 14Figure 14Figure 14Figure 14 and Figure 15Figure 15Figure 15Figure 15.)

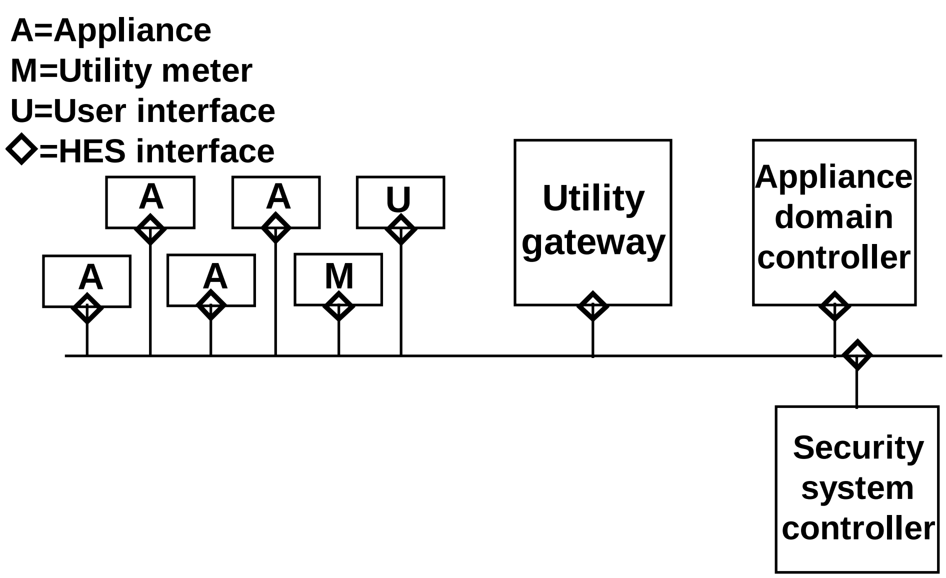


Figure 141414 – Case 7: utility telemetry services, physical model

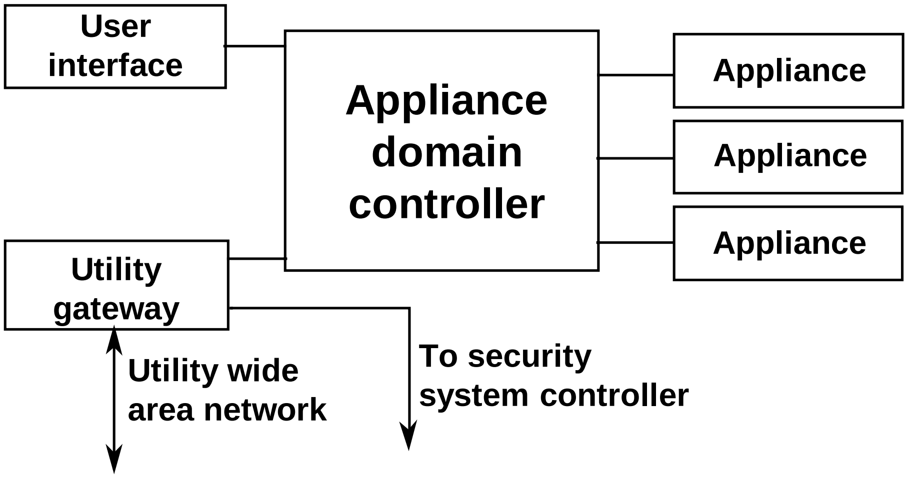


Figure 15~~15~~~~15~~ – Case 7: utility telemetry services, logical model

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 ~~a utility~~ an energy management gateway and one or more local application domain controllers[1], similar to the energy management agent. The local controllers, shown in Figure 14~~Figure 14~~~~Figure 14~~~~Figure 14~~ and Figure 15~~Figure 15~~~~Figure 15~~~~Figure 15~~ 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 that case, control functions are distributed among the network components comprising a fully distributed system.[2]

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, are designed 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 allocated for this purpose.

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1 Application domain – A logically related group of components that provides the functions of an application in a home or building. 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.

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.

7.4 Lexicon for HES energy management

7.4.1 HES message lexicon overview

The following messages are proposed 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 must support the features of each message. Messages will be chosen to support a specific implementation. These messages represent a variety of functionality, not necessarily implemented in any one system.

The purpose of this generic message lexicon is to facilitate interoperability among energy management systems that may be developed by competing equipment suppliers to the utility and home system industries. An interoperability framework is explained in ISO/IEC 18012-1.

These messages may be described using a formal XML-based lexicon, which shall comply with the interoperability framework of ISO/IEC 18012-2.

7.4.2 HES message list

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

7.4.2.1 Gateway ←→ user interface

The user interface may consist of lamps indicating predefined price levels for energy. Alternatively, the user interface may display character data or graphical images sent by the utility via the gateway. An expanded character display would accommodate data about changes in the price tiers and applicable times.

- ON/OFF messages
  - — Turn on the addressed indicator lamp in the user interface.
  - — Turn off the addressed indicator lamp in the user interface.
- Messages about rate tiers, or unusual conditions
  - — A string of characters to be displayed on a suitable user interface. A string length of about 40 characters should 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.
- Cost of over-ride
  - — This may be implemented using the method above for message display.
  - — The intent is to inform consumers of cost of over-riding a direct load control signal.

7.4.2.2 Gateway ←→ appliances

- ON/OFF messages
  - — Turn off the addressed appliance for a specified duration.
  - — Turn on the addressed appliance.
  - — (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 kW for a specific duration.
  - — Remove any kW 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.
  - (It is assumed 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. The format of the reports consists of parameters identified by field position or by keyword.

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

7.4.2.4 Energy management agent ←→ appliances

- Appliance capabilities
  - The energy management agent queries an addressed appliance about device information and energy requirements.
  - An appliance responds to a query from the energy management agent with static information (per 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.
- Appliance control
  - The energy management agent requests the addressed appliance turn off or limit operating modes or limit 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 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 it is turned off, out-of-service, or under manual control.

- The energy management agent informs an addressed appliance 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.

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

7.4.2.5 Energy management agent ←→ user interface

- 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.
  - In addition, a series of interactive menus is needed to configure the energy management system as appliances are added and deleted. A future network management computer may handle automatic configuration.

7.4.2.6 Energy management agent ←→ meter

These commands apply to electronic meters with communications capabilities. 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[3].
- 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.

7.4.2.7 Energy management agent ←→ other controllers

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

3. 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.

Annex A
(informative)

Premises equipment for energy management

A.1 On-premises equipment

The smart grid and demand response strategies can help manage electrical energy through the leverage provided by on-premises power conditioning or power conversion capabilities as part of the functionality of an energy management agent (EMA). Such power conditioning/conversion sub-systems work in conjunction with on-premises generation, storage, and use management. They may include the following functions:

- Solar PV inverter (DC from PV to AC grid)
- Smart battery charging (AC from grid to DC to battery or PV to battery)
- Battery feed to grid
- Grid frequency monitoring (detection of grid overload and automatic response)
- Power factor compensation
- Grid event monitoring and data logging
- Smart metering
- Customer display and control

The above functions can operate in an autonomous or semi-autonomous mode (with or without grid or utility communication or intervention). These can operate and enhance grid stabilisation in time scales of hours, minutes, milliseconds, and seconds.

A.2 Demand response – hours

Demand response (hours)—This is conventional DR and it is the simplest to understand. This operates over a time scale of hours. High-speed communication capability is not needed here. The EMA could provide switching control of several circuits for smart demand control for appliances like refrigerators, air conditioners, etc. The more intelligent approach is an EMA that never actually turns any thing off or on, but just changes the settings of the thermostats, pressures, and other parameters that have immediate large impacts on energy use. This form of DR can keep the grid from having to start up auxiliary (i.e., marginal generating) capacity and more expensive power plants at hours of peak use.

A.3 Demand response – seconds

Automatic surge assist (seconds)—Almost no one seems to be talking about this one although it could ultimately save as much money as demand response. Every power plant has some maximum capability. If the loads ever exceed this limit, then the frequency and voltage drops. When such changes occur the current drawn by inductive motors increases dramatically making the voltage drop even more. Since about 40 % of the loads on the grid are inductive motors, this effect is enough to collapse the grid, which is exactly what happens with most power failures. To guard against this, the grid must always operate significantly below this "red line" to avoid collapse.

Inductive motors are real machines with inertia so this process takes several seconds to a minute to unfold. The general move to higher efficiency generally increases the percentage of loads that are inductive motors as heating elements are replaced with heat pumps, and replacing incandescent lights with compact fluorescent lamps (CFLs) dramatically reduces the lighting part of the load. The EMA could provide this automatic surge assist from the energy stored in batteries of UPS systems and vehicle-based storage systems. This entire surge assist event normally is over within a minute or so and the ultimate stored energy drain on the batteries is negligible and will have no effect on the life of the battery. Because the EMA detects and performs this operation locally, there is no need for communication at all, let alone high speed communication.

Responding to surges is the most expensive problem for the grid utilities to address since they do not have time to fire up extra generators when this happens. Their only solution is extra capacity with the main power plants that are in use every day. The cumulative effect of this could be as much as two times the supply, which relates directly to capital expenditures and dwarfs most of the smart grid features that are in the spotlight right now.

A.4 Demand response – milliseconds

Automatic power factor compensation (milliseconds)—Again, this is left out of most smart grid plans, but this is a very real issue. CFL and LED lamps have a power factor of about 0,5 and computers often have a power factor of between 0,7 and 0,8. The time scale for power factor is milliseconds rather than seconds. This directly translates to not only the real usable power available from the power plant but also the real usable power from all of the power lines and transformers in the distribution system.

Even if the utility compensated for the power factor at the power plant or at major power distribution centres, it would not provide any help on the distribution lines and local transformers. The EMA could incorporate this feature into UPS systems and home and office renewable energy distributed generation systems at a scale that could totally compensate for all problem power factor devices locally. This is clearly out of the realm of effective high-speed communications and needs to be handled locally by an automatic means. This not only saves the grid companies money and infrastructure cost, but it improves the wave-shape of the AC power delivered by the grid.

A.5 Demand response – minutes

Local distributed renewable energy generation with communication (minutes)—This not only puts the renewable energy generation on free local real estate, but it is generally consumed locally so there is nothing lost to transmission. The ultimate energy security aspect of local renewable energy generation is endless while the EMA at each node could continue to operate if needed.

Real time communications and control with the grid allows for renewable energy to be significant, overcoming the present 1 % (or less) maximum barrier to implementing solar and residential-scale wind power. Aside from the raw value of the energy produced, it is hard to put a price on the value of energy security, but there are some examples from recent weather disasters. Even in the absence of major catastrophes, the cost of power interruptions is enormous and escalating.

Annex B
(informative)

Demand-side management

B.1 Demand-side management overview

Electricity consumption patterns have peaks daily and seasonally. During weather extremes of heat and cold the demand for electricity rises sharply. To meet these occasional peak demands, some utilities need to keep relatively expensive generators running or must build new plants.

As the electric utility industry developed, electricity companies expanded supplies to meet growing customer demand for power. The electric companies built new generators and transmission / distribution grids to reach an expanding customer base. Some laws mandate that utilities maintain the supply of electricity sufficient to meet any demand. However, this is becoming less practical because of the cost of new electricity plants, public resistance to new plants and transmission lines, and government environmental regulations controlling pollution. The pressure for plants to meet peak demands could be reduced if customers evened out their power consumption so the peaks are flattened.

Therefore, the electric utility industry with encouragement from some governments has been developing methods for influencing the customer demand for electricity. The objective is to reduce demand when supplies are reaching capacity.

Utilities have developed specific programs to influence the customer demand for power in order to align with the available supply. Such utility programs are called demand-side management (DSM).

DSM programs and associated tools enable utilities to modify the cumulative demand for energy, known as the load shape when plotted over a one-day interval. Utilities have developed a variety of DSM programs to manipulate the load shape. Different programs have different load shape goals, with the majority intended for peak clipping, as explained in B.3.

Utilities have developed more deterministic methods for influencing the demand through DSM. Since DSM programs may not involve explicit management by the utility, the term *demand response* (DR) is being widely used in the industry. DR is implemented with various methods as described in B.4 that facilitate responses to supply/demand imbalances from the customer demand side.

~~B.1~~B.2 Demand-side management incentives

Demand-side management (DSM) programs initially focused on providing incentives for using electricity more efficiently. Customer co-operation may be obtained by offering a financial incentive, such as an up-front rebate, a loan guarantee, a lower rate for electricity, or free energy efficient planning and evaluation services. Some programs offer rebates for switching from tungsten to compact fluorescent lamps, for adding building insulation, and for purchasing energy efficient appliances.

~~B.2~~B.3 Peak clipping

When the goal of DSM is peak clipping, the typical target is to reduce peak demands for electricity by about 5 % up to 100 h per year, according to a December 2005 report of the Demand Response and Advanced Metering Coalition (DRAM) (see Bibliography).

~~NOTE: Demand Response and Advanced Metering Coalition (DRAM), comments filed in Docket AD06-2, December 19, 2005, 5. Reported in FERC (U.S. Federal Energy Regulatory Commission), Assessment of Demand Response and Advanced Metering Staff Report, Docket AD06-2-000, August 2006.~~

The Electric Power Research Institute (EPRI) estimated (see Bibliography) in 2001 that "… a 2,5 % reduction in electricity demand state-wide could reduce wholesale spot prices in California by as much as 24 %; a 10 % reduction in demand might slash wholesale price spikes by half."

~~NOTE: Taylor Moore, "Energizing Customer Demand Response in California," EPRI Journal, Summer 2001, p. 8.~~

~~B.2~~B.4 Demand response

B.4.1 Demand response via direct load control

Some large industrial customers volunteer for lower electric rates in exchange for deliberate service interruptions. When utilities are facing a supply limitation, perhaps on a hot summer day, they order these volunteers to reduce or to curtail some energy consuming equipment. The analogous program for residential customers is "direct load control." This program may be offered by utilities or by third-party suppliers.

Note: Customers may be offered a financial incentive to participate in direct load control.

B.4.2 Time-of-use pricing

An indirect method of load control is based on electric rates that vary over time or a notice to customers of a pending event, such as a partial supply interruption, requiring consumption reductions.

Time-of-use rates vary the price according to the time of day. Typically, on-peak and off-peak rates are announced. The hours for each rate are fixed for each day, or at least for work days, similar to telephone rates. Rates that change dynamically with one-day or even no advanced notice constitute real-time pricing. Time-of-use rates are usually static compared to real-time pricing.

Note: In many countries electricity traditionally was sold at a flat rate or a volume-sensitive rate. New pricing schemes are adding time as a factor.

TOU pricing typically involves pricing electricity higher during specified hours, such as 4 PM to 6 PM when the wholesale cost of power is higher. Some utilities set the ratio of on-to-off peak pricing high enough to motivate customers to defer heavy power-consuming appliance usage to the off-peak times.

In some countries, TOU pricing also includes a demand charge. The consumer pays a special charge called a "demand charge" if the total electricity consumed during a short interval (typically 15 min or 30 min) exceeds a pre-set limit. The penalty may be higher charges or even interruption of power flow.

As with telephone tariffs, customers are notified of the TOU rates and are expected to adjust consumption accordingly. For this technique, called *local control*, to be effective the customer must:

- Remember the time period for off-peak pricing of power.
- Know which appliances consume relatively large amounts of energy.
- Know which combination of appliances may result in a demand charge if imposed by the utility.
- Not be significantly inconvenienced by deferring appliance operation to off-peak times.

B.4.3 Real-time pricing

Utilities can better match electricity supply with customer demand by dynamically varying the price of electricity as market conditions change, a method known as real-time pricing (RTP). Eventually, utility policy makers would like to adjust prices according to the wholesale market price of electricity to reflect actual utility costs. The utility has the opportunity to change prices when a peak demand is expected.

Note: In some countries regulations do not presently permit residential users to be offered fully flexible real-time pricing. Utilities may be permitted tariffs with two or more price tiers to reflect their costs of energy generation and distribution. In countries with a competitive market, third-party suppliers may set the retail rates.

Some utilities are capable of accurately forecasting the cost of energy in the near future, typically 24 h in advance, and supplying this information to the residential consumer. The prediction of such forecast pricing enables peaks in demand to be smoothed , thereby reducing the impact of such measures on consumer comfort and convenience. As these innovative pricing schemes lower the peak demand, utility costs are reduced.

B.4.4 Demand response via distributed load control

Distributed control enables users to respond effectively to utility price variations and event notices with minimal involvement or inconvenience by using computer-based agents such as the energy management agent described in 6.3 operating in conjunction with smart appliances. Forecasted pricing enables the consumer, or an intelligent energy management system, to “draw forward” on consumption in anticipation of peak pricing. This may involve comparatively simple measures such as ensuring that heat storage devices, water heaters, and similar appliances are fully charged when the peak-price period starts.

There are two important problems for effective use of the changing cost of power. First, the price data must be delivered to the customer in a timely fashion. Second, the customer must interpret the data and apply it to appliance operation. Since most customers do not understand electricity measurements, such as kilowatt-hours, they are not likely to use these data correctly. Here is where home control technology can benefit the consumer and the utility by insulating the customer from the complexity of dynamic energy management and enabling distributed load control.

B.4.5 Demand response and customer privacy

The customer and the utility shall agree if and how frequently usage data are collected. The more frequently the usage data are sent, the more detailed a record of household activities and preferences can be accumulated, thereby impacting customer privacy.

Aggregated energy consumption data, weighted by the price when consumed, are the only required data to be sent to the utility for billing. The customer shall decide how often the total consumption data and any detailed data are sent to the utility based on the tariffs offered by the utility. Detailed usage data by appliance (such as HVAC, refrigerator, water heater, etc.) are called “disaggregated data.” Consumers may choose to share such data with utilities or service providers for enhanced energy management or ancillary services such as appliance diagnostics.

NOTE: Privacy requirements extend beyond technical issues. Such requirements reflect a combination of agreements between consumers and service providers as allowed or mandated by government policies.

Annex C
(informative)

Value-added services

In a competitive market for energy, utilities are considering additional services called value-added services in order to retain customers and to generate additional revenue from offerings ancillary to power. Collectively, these are known as value-added services. Some governments have mandated that utilities, which traditionally were granted monopolies, start planning for competition. Therefore, utilities are seeking value-added services to make their products more attractive to customers. Utilities and third-party suppliers that implement demand response in compliance with this standard may implement one or more of these value-added services.

Potential value-added services for electric utilities beyond load control are listed. The services preceded by a check mark (✓) may be sold for additional revenue beyond the usual energy charges. The choice of service and revenue arrangement depend on the utility, the market, and local regulations.

- Automatic meter reading
- Remote connect/disconnect
- ✓ Offer disaggregated bills with details about consumption by major appliances
- Monitor power delivery
- ✓ Monitor power quality
- ✓ Offer load profiles
- Control customer access when customers move or don't pay bills
- Stagger power restoration in a neighbourhood after a power failure
- Detect tampering
- ✓ Diagnose appliances problems and notify the customer
- ✓ Offer information and telemetry services
- Compute the environmental impact of customer energy consumption

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