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TECHNICAL SPECIFICATION

Network-based energy consumption measurement – Energy saving system – Conceptual model

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NETWORK-BASED ENERGY CONSUMPTION MEASUREMENT – ENERGY SAVING SYSTEM – CONCEPTUAL MODEL

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62654, which is a technical specification, has been prepared by technical area 12: AV energy efficiency and smart grid applications, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
100/1928/DTS	100/1987/RVC

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

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

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International Standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

Due to unusual climate change such as global warming, the need for technologies regarding energy efficiency and reduction of carbon dioxide emission through energy saving and efficient energy usage is growing. Especially in the IT industry, although its energy consumption is low compared to other business areas, an increase in energy efficiency for whole business areas is expected by using IT technologies. For example, a substantial reduction in energy consumption can be achieved in homes, where most of electrical energy is consumed.

As technologies evolve, the number of electric appliances in homes increases. Accordingly, the consumers tend to check the amount of energy consumption of each appliance and its rate. In addition, for users' convenience, many appliances including multi-media equipment are provided with remote controls, and become network-enabled. Thus, their standby power is increasing considerably.

If the energy consumption of home appliances can be monitored or shown in real time, energy consumption can be reduced by 10 % to 20 % according to statistics. Furthermore, by decreasing the standby mode power for the appliances that are not in use, additional power can be saved. Besides, the use of renewable energies like solar energy or wind energy is spreading in homes. Furthermore, smart grid, an intelligent power network, is expected to be introduced soon. So a system that manages production, consumption, and sales of energy is indispensable.

This specification defines an energy saving system (ESS) providing functions and architecture for a network-based energy consumption measurement model of AV multimedia equipment and systems, efficient usage of electric energy, intelligent energy saving, and a basic possible platform in homes for future power network systems. Specifically, it provides the following:

- basic architecture of ESS;
- functional requirements of an ESS client;
- functional requirements of an ESS server;
- classification of ESS clients;
- classification of ESS servers;
- energy consumption measurement of home electronic devices;
- energy consumption measurement of an ESS client.

NETWORK-BASED ENERGY CONSUMPTION MEASUREMENT – ENERGY SAVING SYSTEM – CONCEPTUAL MODEL

1 Scope

This Technical Specification defines the architecture and functional requirements of an energy saving system (ESS) that measures energy consumption of each home appliance, including AV multimedia equipment and systems, and shows how to reduce its standby power. With respect to energy consumption measurements, this specification extends only to AC power environments in premises.

2 Terms, definitions and abbreviations

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

2.1 Terms and definitions

2.1.1
ESS server
energy saving system server
component of an energy saving system which gathers power consumption data of home electric devices, measured by ESS clients through communication between an ESS server and clients

2.1.2
ESS client
energy saving system client
component of an energy saving system, which is physically located between an AC power source and a home electric device so as to supply or to block AC power

Note 1 to entry: An ESS client is operated by AC/DC power and it measures the power consumed by a home electric device connected to the ESS client. The result of the measurement is sent to an ESS server through communication with the ESS server.

2.1.3
ESS network
energy saving system network
network that consists of an ESS server and one or more ESS client(s) which communicate(s) with the ESS server

2.1.4
EPCM protocol
electric power control and monitoring protocol
application layer protocol between an ESS server and ESS clients

Note 1 to entry: This protocol controls power of the devices connected between the ESS server and an ESS client and gathers the power consumption data from the ESS client.

2.1.5
low-power communication module
communication module that supports low-power data transmission between the ESS server and ESS clients and that has the dedicated power that processes the EPCM protocol

Note 1 to entry: A low-power communication module is a hardware module in an ESS client and is responsible for low-power communication with an ESS server. It physically transmits data generated from a processing unit in an ESS client and receives data from the ESS server. Low-power communication is essential to ESS clients so as to minimize self-power consumption caused by frequent communication with an ESS server.

2.1.6
home electronic device
device group that includes home appliances

EXAMPLE Home electronic devices are multimedia equipment and systems, information appliances, home network devices, etc.

2.2 Abbreviations

EEC Energy Efficiency Class
EPCM Electric Power Control and Monitoring
ESS Energy Saving System
GUI Graphic User Interface
HED Home Electronic Device
LPCM Low-Power Communication Module
PLC Power Line Communication
PnP Plug and Play

3 Specification of operating modes

Operating modes of ESS server and clients are specified in Table 1.

Table 1 – Operating mode of ESS server and client

Mode	ESS server	ESS client
Disconnected	The ESS server is disconnected from all external power sources.	The ESS client is disconnected from all external power sources.
Off	The ESS server is connected to a power source, does not perform any functions specified in 5.1, and cannot be switched into any other mode with the remote control unit, an external or internal signal.	The ESS client is connected to a power source, does not perform any functions specified in 5.2, and cannot be switched into any other mode with the remote control unit, an external or internal signal.
Standby-passive	The ESS server is connected to a power source, does not perform any functions specified in 5.1, but can be switched into any other mode with the remote control unit or an internal signal.	The ESS client is connected to a power source, does not perform any functions specified in 5.2, but can be switched into any other mode with the remote control unit or an internal signal.
Standby-active	The ESS server is connected to a power source, does not perform any functions specified in 5.1 except a basic communication function for receiving a mode-change command from an external source, and can additionally be switched into another mode with that external command.	The ESS client is connected to a power source, does not perform any functions specified in 5.2 except a basic communication function for either receiving a mode-change command from an ESS server or waiting until an initial registration process finishes, and can additionally be switched into another mode with that external command.
On (measure)		The ESS client is connected to a power source and perfoms an energy consumption measurement.
On (communicate)	The ESS server is connected to a power source, performs functions specified in 5.1, and communicates with one or more ESS clients or an external source.	The ESS client is connected to a power source, performs functions specified in 5.2, and communicates with an ESS server.

4 Architecture and basic functions of ESS

4.1 ESS network

An ESS network consists of an ESS server and one or more ESS clients, as shown in Figure 1. Each ESS client does not communicate with other ESS clients but the ESS server. The communication is enabled by the no-new-wire communication method such as wireless communication and PLC. Accordingly, it does not require extra wiring for configuring the home ESS network. Note that the ESS server can provide various network interfaces according to the network types that ESS clients can support. This specification does not specify the network interface types between the ESS server and ESS clients.

Each home electronic device (HED) can use the AC power provided from an ESS client regardless of its type and networking feature. The user can utilize the power consumption monitoring and power control functions for only the HEDs powered from ESS clients. This means that the user can connect only the desired devices to ESS clients and can use the ESS network services for the connected HEDs.

The ESS network can be configured separately from the existing home network and provides functions for energy consumption measurement, monitoring, and intelligent energy saving that are different from device control services, data services, and multimedia services provided by the existing home network.

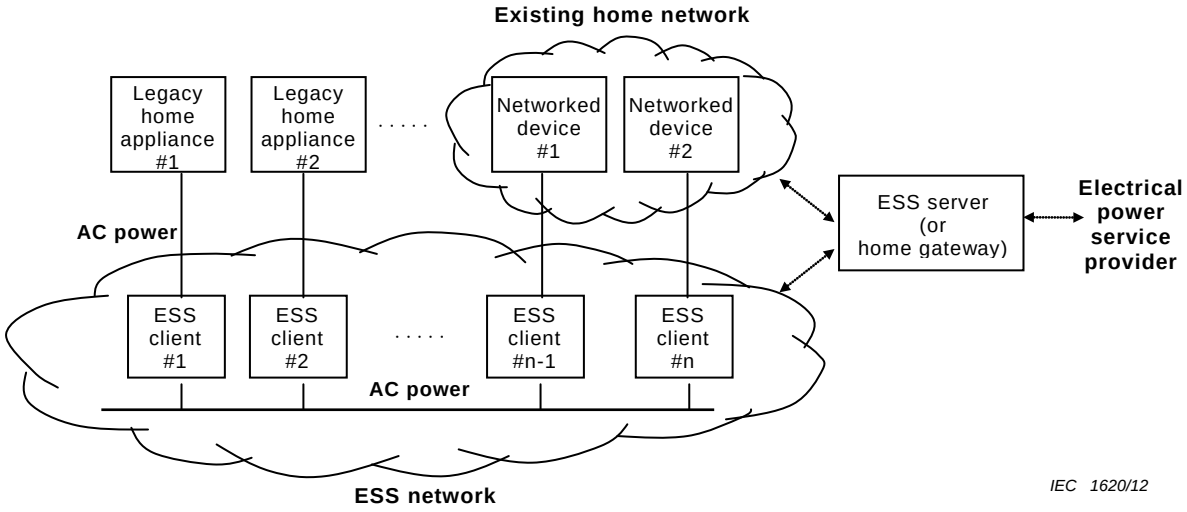


Figure 1 – Architecture of energy saving system

4.2 ESS server

As shown in Figure 2, the ESS server basically provides the physical link and upper layer network protocol that enable network interfaces to ESS clients. Based on this communication channel, the ESS server sends power control commands and gathers energy consumption data in real time by using an EPCM protocol. Among EPCM applications in the application layer, the basic application program processes the gathered data to display the consumed power-related information in the form of text or GUI in real time.

The ESS server can be implemented to additionally support the existing home network services. On the other hand, the existing home gateway or home server may include the functions of the ESS server. In this case, the EPCM functions may be integrated into the existing home network protocol or home network middleware. The ESS application program can also be implemented considering the scalability and compatibility toward the home network applications.

Furthermore, the ESS server can also be designed to interoperate with future power service applications (i.e. managing production and consumption of renewable energy, demand response, smart grid applications, etc.) or with the network run by a power service provider. By this extension of the network interfaces and application programs not only to the home network but also to the power service provider, a variety of electrical power services can be brought into home.

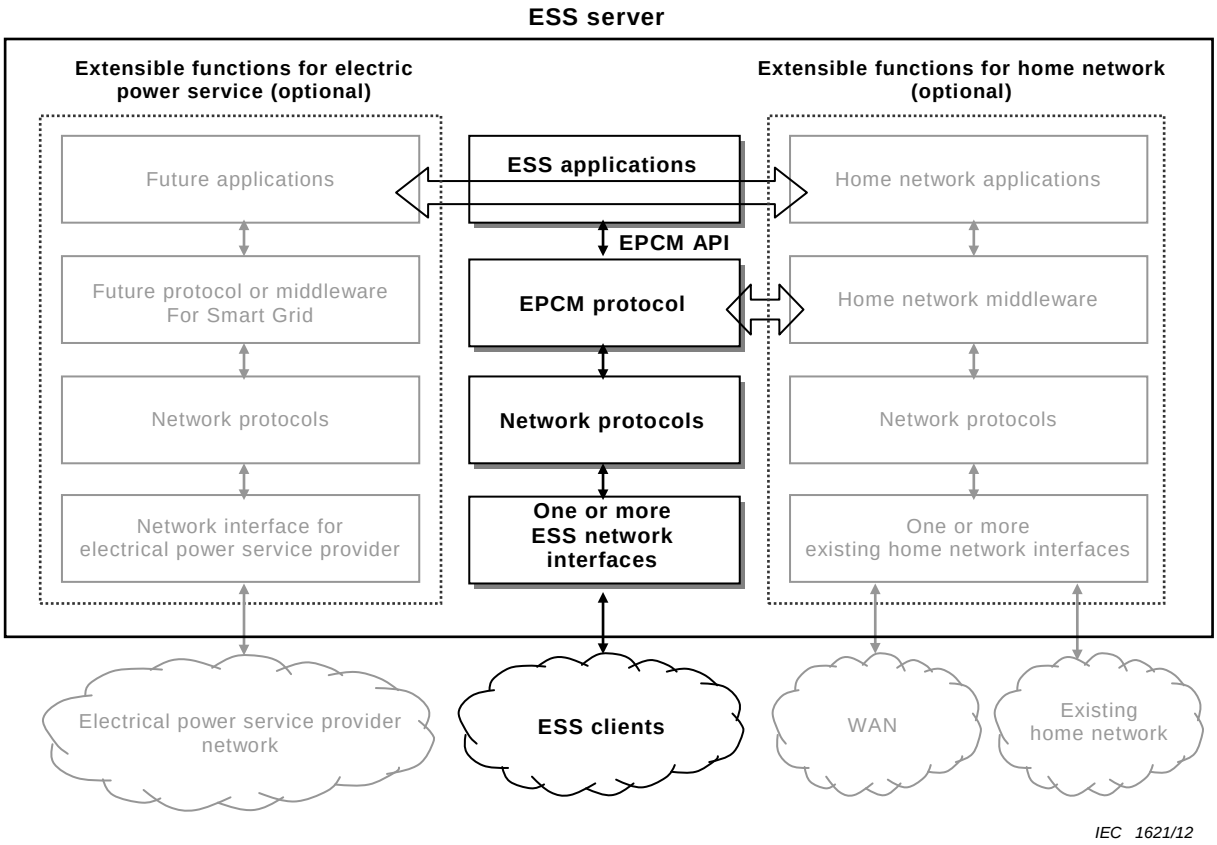


Figure 2 – Basic functions of an ESS server and its possible extensibility

By utilizing the EPCM protocol and basic functions of the ESS server, the following basic applications can be implemented.

- Real-time electric power consumption monitoring application for each HED.
- Real-time total home electric power consumption monitoring application.
- Standby power reducing application by finding HEDs in standby mode.
- User-configurable warning application that enables the users to set the rate, calculates the estimated rate of the upcoming month, and alerts when the estimated rate is expected to exceed.
- Power control application that switches each device power into on or off and restricts the use of a specific device during a specific period of time.
- Secured remote power control and monitoring application for the users outside the home.
- Other applications.

4.3 ESS client

An ESS client consists of an AC part and DC part, as shown in Figure 3. Additionally, a circuit protection module that protects the circuit from over-current, electric leak, and electric arc, can be added into the ESS client. The DC power on/off control module can also be optionally

added to supply DC power only when home appliances are connected to ESS clients. Thus, when an HED is not connected to an ESS client, extra power consumed by DC circuit in the ESS client can be additionally saved.

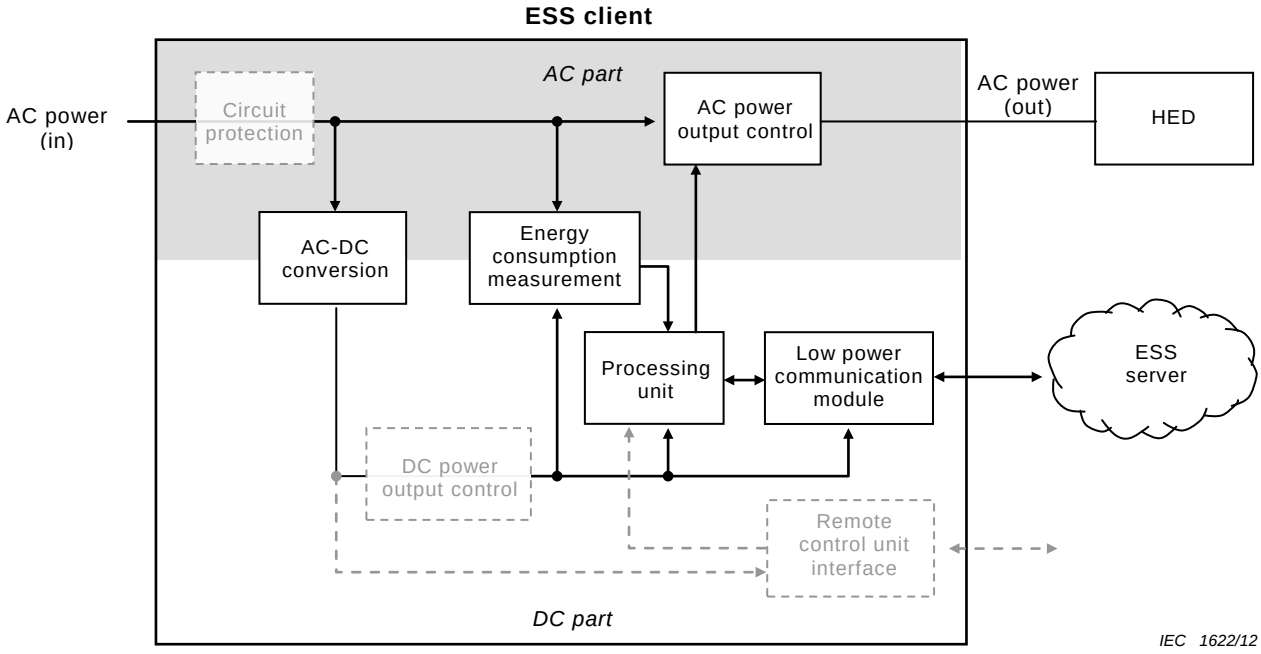


Figure 3 – Basic architecture of ESS client

Basically, an ESS client supplies AC power to a connected HED and can cut the supply of AC power off by an internal control signal from a processing unit. The internal control signal can be originally generated by either a control command from the ESS server or an internal software module that detects standby mode of the HED. In case of AC power control by a control command from ESS server, the related commands are based on the EPCM protocol. However, in case of AC power control by an internal software module, if an HED is in off mode, a remote control unit interface in the ESS client provides a way to re-supply the HED with AC power and to switch the HED into standby-passive mode by detecting external signal from a remote control unit operated by a user.

A processing unit in an ESS client gathers power consumption data from the energy consumption measurement module and sends the gathered data to the low-power communication module (LPCM), which finally forwards them to the ESS server by using the EPCM protocol. In this case, with a request of the processing unit, the energy consumption measurement module can send to the processing unit module the power consumption data such as electric current, active power, or energy consumed by HED connected to an ESS client.

The LPCM also supports low-power communication, which minimizes the total amount of power consumption for an ESS client during data transmission. In addition, for low-power communication of additional ESS clients, the LPCM module can be switched to standby-active mode through an ESS server's command. In this standby-active mode, the energy consumption measurement module and processing unit can stop measuring operation and wait for only the command to be switched into on mode.

5 Functional requirements of ESS

This clause defines the functional requirements for ESS server and ESS clients.

5.1 Functional requirements of ESS server

5.1.1 General

The functional requirements for the ESS server contain the information details as shown in Table 2.

Table 2 – Functional requirements of ESS server

	Functional requirements
Basic functions	Network interface with ESS client
	Support of EPCM protocol
	Gathering and monitoring of energy consumption information
	Provision of basic user interface
	Types of ESS server
Additional functions	Support of sleep mode
	Automatic cut-off of passive standby power of HED
	Re-supply of AC power to HED
	Study of standby mode
	Internal interface with existing home network
	External interface with electric power service provider
	Demand and supply management of renewable energy
	Estimation of monthly electricity rate
	Provision of advanced user interface

5.1.2 Network interface with ESS client

An ESS server provides one or more wired or wireless network interfaces for exchanging data and commands with ESS clients. In order to evade newly wiring problems for a new ESS network, it is recommended to connect an ESS server and ESS clients through a wireless network or the existing telephone or power line network.

5.1.3 Support of EPCM protocol

An ESS server supports an EPCM protocol for power control and power consumption monitoring. Basic functions of the EPCM protocol are as follows. (The functional requirements of EPCM are not included in this specification.)

- The EPCM protocol provides a secure way for ESS clients in home to register to the only one designated ESS server. In other words, EPCM protocol can provide the secured PnP function.
- The EPCM protocol provides a method for the ESS server to send commands to ESS clients in order to start, stop, pause, and restart measurement of energy consumed by the connected HED.
- Depending on the measurement command, ESS clients send the measured power data to the ESS server at the specified interval by using the EPCM protocol.
- The ESS server provides the method to check whether a specific ESS client is running or not through EPCM commands.

- The ESS server can forcibly change the LPCM operation mode into one of active mode, standby mode, and power-down mode in an ESS client through EPCM commands.
- The ESS server can forcibly switch the power of an HED connected to an ESS client through EPCM commands.
- An ESS client can report to the ESS server whether any HED is connected to the ESS client or not through EPCM commands.
- An ESS client can report to the ESS server on the status of power supply to HED by using EPCM commands whenever it is changed.

5.1.4 Gathering and monitoring of energy consumption information

The ESS server gathers HEDs' energy consumption data through the EPCM protocol and process the gathered data to show users the real-time energy consumption data for each device.

5.1.5 Provision of basic user interface

In order to provide the EPCM functions, the ESS server provides user interfaces such as GUI, touch screen, remote controller unit, etc. for showing users HEDs' consuming power data in real time and also for the control of the power of HEDs.

5.1.6 Types of ESS servers

The ESS server can be implemented using any of multiple types in Table 3. This Technical Specification does not include specifications for the types (e.g. size, electric features).

Table 3 – ESS server types

Types of ESS server	Descriptions
Type A	Implemented with ESS server functions added in the hand-held terminals such as PDA, mobile phone, etc.
Type B	Implemented with ESS server functions added in the display devices such as wall-pad, TV, etc.
Type C	Implemented with ESS server functions added in the home gateway or home server.
Type D	Implemented with ESS server functions added in PC.
Type E	Implemented with ESS server functions added in the always on home appliances such as refrigerators.

5.1.7 Support of sleep mode

The ESS server in normal operation mode can be changed to the sleep mode when no user uses it and no data is received from ESS clients for a specific time. When it is reused by a user or any data is received from an ESS client in sleep mode, it can return to the normal operation mode.

5.1.8 Automatic cut-off of passive standby power of HED

The ESS server can find any HED that is not being used for a specific time by using the HED energy consumption data from ESS clients. It has to determine the passive standby mode for a specific HED. In this case, using EPCM commands, it can automatically block the passive standby power for the corresponding HED by controlling the AC power output of an ESS client.

5.1.9 Re-supply of AC power to HED

Once an ESS client is switched off, the power source to an HED is blocked. In this case, the ESS server can provide a user interface that users can make use of to supply power to the blocked HED again.

5.1.10 Study of standby mode

Because the standby power consumption generally varies depending on the HED type, the ESS server can learn the standby mode of a specific HED through a user interface. Based on this learning program, when the corresponding HED operates for over the specific time in standby mode, it can determine its standby mode and automatically block the standby power as described in 5.1.8.

5.1.11 Internal interface with existing home network

The ESS server of type C defined in Table 3 (i.e., an ESS server quipped with home network functions or a home gateway equipped with ESS server functions) can provide internal network interface including the physical link, communication protocol, and applications for the existing home networks, and also interoperability between ESS network and the existing home network.

5.1.12 External interface with electric power service provider

As shown in Figure 2, the ESS server can interoperate with the network run by an external power service provider. The users can interoperate with future Smart Grid and receive additional services provided by the power service provider. For an interface between the ESS server and the power service provider, the following methods can be used.

- Adding a physical interface to the ESS server for directly connecting to the network run by the power service provider.
- Or adding an interface to the home gateway for indirectly connecting to the network run by the power service provider through WAN.

5.1.13 Demand and supply management of renewable energy

As Smart Grid furthermore evolves in the future, home can produce renewable energy, sell surplus energy, and demand power supply, if required. In this environment, the ESS server can manage the energy related information including home produced energy, consumed energy, supplying energy to the power service provider, and supplied energy from the power service provider.

5.1.14 Estimation of monthly electricity rate

The ESS server can calculate the estimated monthly electric rate by analyzing the power consumed by HEDs that are connected to ESS clients.

5.1.15 Provision of advanced user interface

The ESS server can provide the following advanced user interfaces.

- Provision of user settings and alarm functions: The ESS server can provide an environment for users to set the maximum monthly rate and can send alarms to users when it is expected to exceed the specified amount after analyzing the current electricity use.
- Power control of HEDs: The ESS server can provide an environment for users to switch the HED power to on or off through a user interface.
- Automatic power control of HEDs: The ESS server can provide an environment for users to switch a specific HED to on or off in the specified period of time. In addition, depending on the specified value, the ESS server can switch the power of a specific HED to on or off in the specified period of time with no user intervention.

5.2 Functional requirements of the ESS client

5.2.1 General

The functional requirements for the ESS client contain the information details as shown in Table 4.

Table 4 – Functional requirements of ESS client

	Functional requirements
Basic functions	Network interface with ESS server
	Support of EPCM protocol
	Measurement of energy consumption
	Provision of user settings
	Energy usage modeling
	Types of ESS clients
Additional functions	Support of circuit protection
	Internal DC power control
	Automatic cut-off of passive standby power of HED
	Re-supply of AC power to HED
	Operation modes

5.2.2 Network interface with ESS server

The ESS client provides a wired or wireless network interface to communicate with an ESS server. In order to evade wiring problems for a new ESS network, it is recommended to connect a wireless network or use the existing telephone or power line network.

5.2.3 Support of EPCM protocol

The ESS client supports the EPCM protocol for power control and power consumption monitoring. Basic functions of the EPCM protocol is described in the 5.1.3 and the functional requirements for EPCM are excluded in this specification.

5.2.4 Measurement of energy consumption

The ESS client sends the energy data consumed by a specific HED to the ESS server by using the EPCM protocol in real time. At this time, the ESS client measures energy, and active power. In addition to that, the measured electric current and voltage can be sent to the ESS server. When the ESS client measures the power consumption of HED, its own power consumption should not be included. This specification does not provide the error tolerance but the 5 % measurement accuracy is normally recommended for household purposes. An example for suitable values for measurement item, measurement unit, recommended maximum range, and recommended minimum resolution is shown in Table 5. Recommended minimum resolution in Table 5 is applicable to both calculating measurement items and displaying measurement results on the user's display device.

Table 5 – An example for measurement items, range and resolution

	Measurement items	Measurement unit	Recommended maximum range	Recommended minimum resolution
Basic measurement items	Energy	Wh	–	0,1 Wh
	Active power	W	–	0,1 W
	RMS current	A	0 A ~ 15 A	0,1 A
	RMS voltage	V	0 V ~ 250 V	0,1 V
Additional measurement items	Frequency	Hz	–	1 Hz
	Power factor	%	0 % ~ 100 %	1 %
	Reactive power	var	–	0,1 var
	Apparent power	VA	–	0,1 VA

5.2.5 Provision of user settings

The ESS client provides an environment for user settings as shown in Table 6.

Table 6 – User settings of ESS client

User settings	Descriptions
ESS client	ESS client provides original functions of the ESS client.
Always on	In this mode, the ESS client constantly supplies the AC output power to HED. This mode is useful when the user does not want functions of the ESS client or when there is failure in the ESS client.
Always off	In this mode, the ESS client always blocks the AC output power to an HED. This mode is useful when an HED is not being used for a long time or when a user wants an HED to be shut down for safety reasons.

5.2.6 Energy usage modeling

After establishment of communication channel between an ESS client and an ESS server, the ESS client generally starts to measure energy consumption and transmits a corresponding EPCM packet to the ESS server on a regular basis. In this process, more frequent communication causes more energy consumption of both ESS clients and server. However, in some cases, the ESS client does not need to communicate often with the ESS server repeatedly. For example, if the ESS server is not in the active mode or if no user operates the ESS server, which does not need to display current energy consumption status on its screen, the ESS client can provide energy usage modeling function which enables the ESS client to store measurement data in its allowable memory space and to send it to the ESS server upon request.

5.2.7 Types of ESS clients

The ESS client can be implemented with any of the listed types as shown in Table 7. This specification does not specify size and electrical characteristics of each type.

Table 7 – ESS client types

Types of ESS client	Descriptions
Type A (electric outlet type)	Implemented with an electric outlet. The ESS client functions described in this specification can be implemented in the outlet.
Type B (adaptor type)	Implemented with an adaptor that connects to the existing electric outlet. The ESS client functions described in this specification can be implemented in the adaptor.
Type C (built-in type)	Implemented with built in HED. The ESS client functions described in this specification can be implemented in the built-in type.

5.2.8 Support of protection circuit

An ESS client can include the hardware type of protection circuit to prevent potential electrical hazards that can cause electrical fire and breakdown of HEDs connected to the ESS clients.

5.2.9 Internal DC power control

In order to minimize the power consumption of an ESS client in itself, the ESS client can automatically block the internal DC power when the following conditions are met. It can provide this internal DC power control function automatically regardless of user settings.

- In case that HED is not connected to the ESS client.
- In case that the operation mode of an ESS client is forcibly changed to the power-down mode through the EPCM commands.

5.2.10 Automatic cut-off of passive standby power of HED

An ESS client can determine the passive standby mode of an HED and cut the supply of AC power to the HED by using the energy consumption data and AC power output control module in Figure 3. In this case, it can directly control the AC power output, automatically block the passive standby power without any intervention of an ESS server, and report the result to the ESS server through the EPCM protocol.

5.2.11 Re-supply of AC power to HED

The ESS client can provide a way to supply AC output power again when the blocked HED is reused. Once the AC output power of an ESS client is cut off, there are only two ways to switch the HED on again. The first method is that an ESS server switches its AC power on/off control module on by sending an EPCM control command. The second method can be used if an HED is operated by a remote control. In this case, it is possible for the ESS client with a remote control to supply the blocked HED with the AC power output, provided that the users' activate the remote control once the ESS client has learned/recognized the signals of the remote control. When the AC power is supplied again, the ESS client can also report the result to the ESS server through the EPCM protocol just like the case of automatic cut-off of passive standby power specified in 5.2.10.

5.2.12 Operation modes

An ESS client operates in any of modes specified in Table 1.

6 Classification of ESS

6.1 Classification of ESS server

The ESS server has three classes, from class 1 to class 3 depending on the supportable functions as shown in Table 8.

Table 8 – ESS server classes

Classes	ESS server functions
Class 1	An ESS server of class 1 can provide only basic functions in Table 2.
Class 2	An ESS server of class 2 can provide all basic functions and some additional functions in Table 2, and doesn't need to provide additional physical interfaces extensible to a power service provider network and (or) home network.
Class 3	An ESS server of class 3 can provide all basic functions and some additional functions in Table 2, and can also provide additional physical interfaces extensible to a power service provider network and (or) home network.

6.2 Classification of ESS client

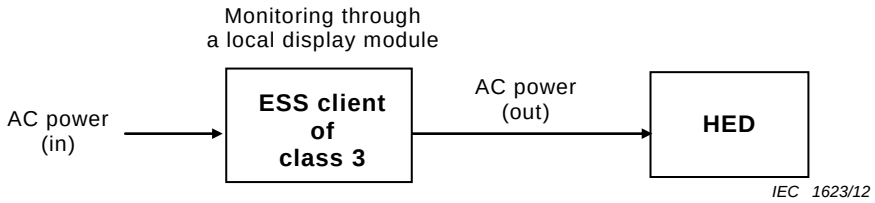
The ESS client has three classes, from class 1 to class 3 depending on the supportable functions as shown in Table 9.

Table 9 – ESS client classes

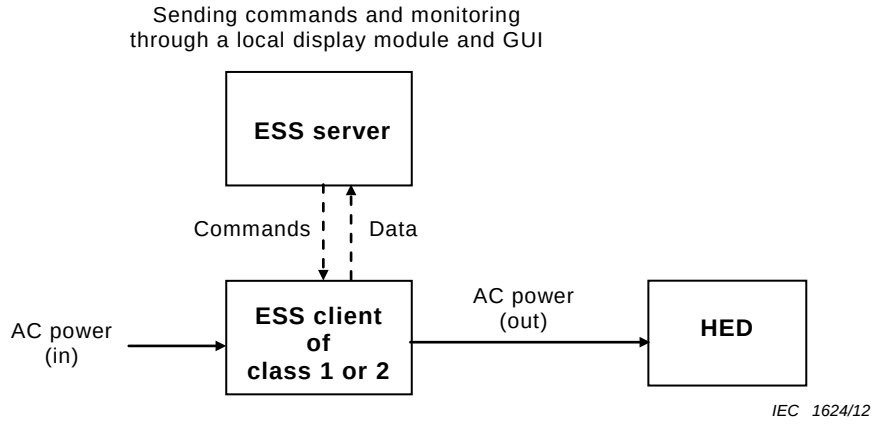
Classes	ESS client functions
Class 1	A non-network ESS device, that is a stand-alone type without any communication to an ESS server, and that has a local display module.
Class 2	An ESS client of class 2 can only provide the basic functions as indicated in Table 4.
Class 3	An ESS client of class 3 can provide all basic functions of 5.2.2 and some additional functions related to low-power operations as indicated in Table 4.

7 Energy consumption measurement of HED

An ESS client of any class specified in Table 9 can be used to measure energy consumed by an HED. Especially, in order to check the energy consumption values, there are two possible methods using only one ESS client of class 3 and using one ESS server of any class with an ESS client of class 1 or 2, as shown in Figure 4.



(a) energy consumption measurement by using one ESS client of class 3



(b) energy consumption measurement by using an ESS server and an ESS client

Figure 4 – Example of non-network energy measurement device

Annex A
(informative)

Energy consumption measurement of ESS client

A.1 General

The energy consumed by an ESS client is in itself a significant factor to assess energy efficiency of the ESS client especially in case that multiple ESS clients are used in homes. Once the ESS client shuts the AC power output off and is switched into standby active or standby passive mode, it usually consumes standby power while waiting for a specific command to change the current mode into another. During this standby mode, it is desirable that the ESS client consumes less standby power than an HED does. However, it usually depends on the type of HED and its electrical characteristics. This annex specifies the methods for energy consumption measurement of the ESS client.

In order to measure accurate electric energy consumption factors such as RMS current, RMS voltage, active power, energy and so on, it is recommended to use stable clean power supply with less than 2 % harmonics and an energy metering instrument with fundamental active power accuracy of 0,5 % or better, which complies with IEC 62301.

A.2 Measurement in off mode

As shown in Figure A.1, in case of measuring electric power consumption factors of an ESS client in off mode, an ESS client can simply be connected to an energy metering instrument.

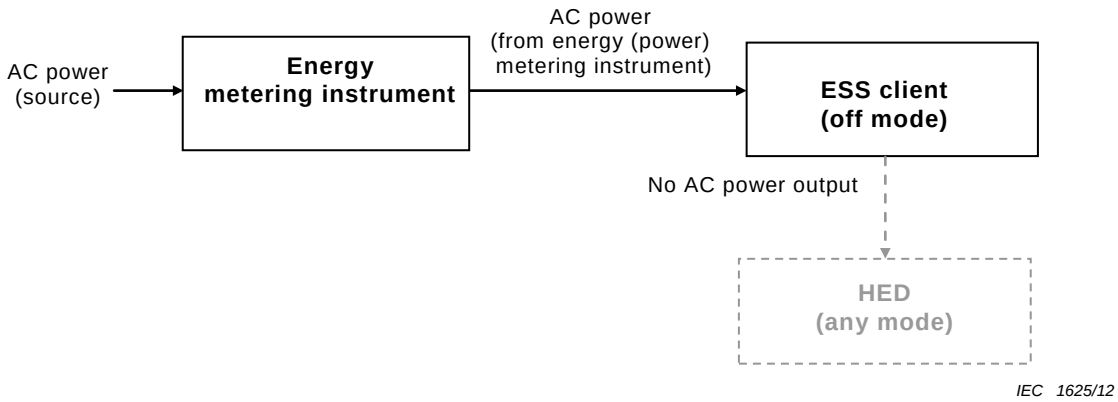


Figure A.1 – Measurement in off mode of the ESS client

A.3 Measurement in standby passive mode

Figure A.2 shows a method for measuring electric energy consumption of an ESS client in standby passive mode. In this mode, the ESS client can be connected to an energy metering instrument, should not perform functions related to measurement and communication with an ESS server, but can be switched into any other mode with the remote control unit or an internal signal. For example, an ESS client can be switched into this mode after shutting off the standby power consumed by an HED or when an HED is not connected to (or unplugged from) an ESS client. In both cases, an ESS client can be connected to an energy metering instrument.

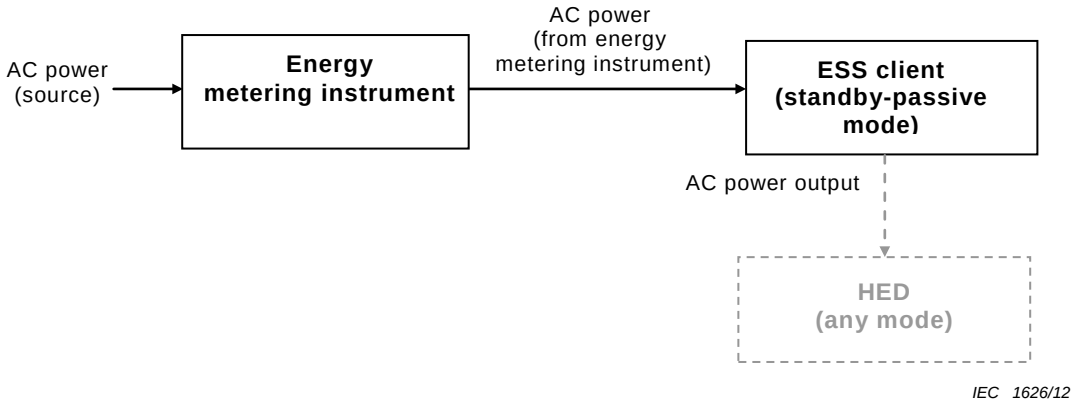


Figure A.2 – Measurement in standby passive mode of ESS client

A.4 Measurement in standby active mode

Figure A.3 shows a method for measuring electric energy consumption of an ESS client in standby active mode. In this mode, the ESS client is connected to a power source, does not perform functions related to measurements, but can be switched into any other mode with an EPCM command from an ESS server. For example, an ESS client in standby-active mode can be switched into on (measure) mode after receiving an EPCM command to start measuring. In this case, an ESS client can be connected to an energy metering instrument only, not to an HED or an electric load in order to measure exact standby power consumption of the ESS client.

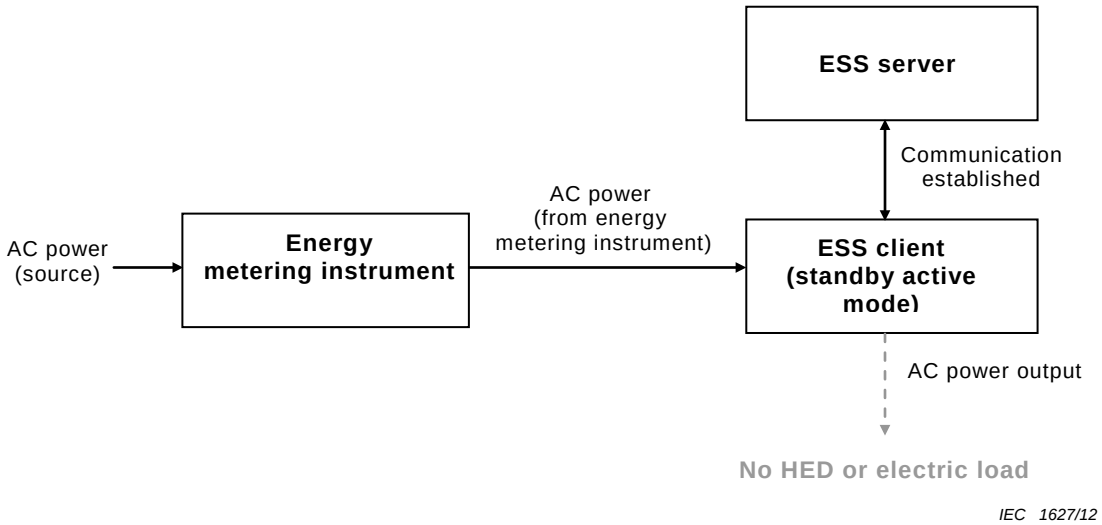


Figure A.3 – Measurement in standby active mode of an ESS client

A.5 Measurement in on mode

Figure A.4 shows a method for measuring electric energy consumption of an ESS client in on (measure and communicate) mode. In this mode, the ESS client can be connected to an energy metering instrument, and perform energy consumption measurement and communication with an ESS server. It can also be switched into any other mode with an EPCM command from an ESS server. In order to measure energy efficiency of an ESS client, some constraints and conditions for measuring methods listed in Table A.1 can be followed. Through this test procedure, energy efficiency class (EEC) of an ESS client is finally calculated, and useful for users to make a choice among a wide range of ESS clients, which is also a significant factor when implementing energy-efficient ESS clients.

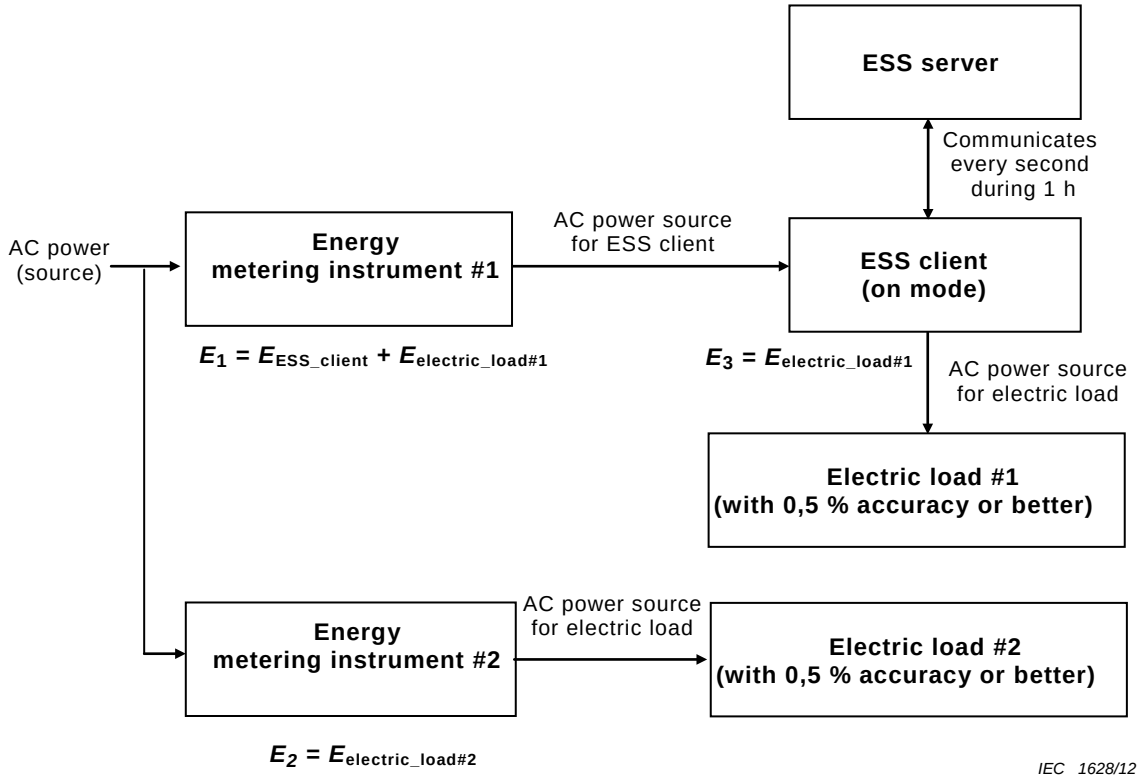


Figure A.4 – Measurement in on mode of an ESS client

Table A.1 – Conditions for measurement in on mode and performance evaluation indices

Measuring constraints or conditions		Descriptions
Equipment	Energy metering instrument #1 and #2	Both energy metering instruments #1 and #2 should be connected to the same AC power source.
	Electric load #1	An electric load #1 should be connected to (should be provided with AC power by) an ESS client instead of an HED, and grant a high accuracy of 0,5 % or better.
	Electric load #2	An electric load #2 should be connected to (should be provided with AC power by) an energy (power) metering instrument, and grant a high accuracy of 0,5 % or better.
	ESS client	An ESS client should be connected to (should be provided with AC power by) an energy (power) metering instrument, and be set to on (measure and communicate) mode. During the measuring process, it measures and sends only the energy (E_3 in Figure A.4) consumed by the electric load #1 to an ESS server after every second./in an interval of 1 s.
Test conditions (Reference IEC 62301)	Ambient temperature	23 °C ± 5 °C
	Relative humidity	10 % ~ 80 %
	Supply voltage	115 (±1 %) V AC, 60 Hz (±1 %) (North America/Taiwan) 230 (±1 %) V AC, 50 Hz (±1 %) (Europe/Australia/New Zealand) 100 (±1 %) V AC, 50 Hz (±1 %)/60 Hz (±1 %) (Japan)
	Total harmonic distortion (THD) (voltage)	<2 % THD
Methods	Measurement duration	1 h
	Report period (from ESS client to ESS server)	1 s
	Measurement item (E_1, E_2, E_3, E_{ESS_client})	The energy values measured by both energy metering instruments should be initially set to zero. In Figure A.4, E_1 is a total energy consumption value of an ESS client and an electric load #1 for 1 h, which is measured by an energy metering instrument #1. Likewise, E_2 is a total energy consumption value of an electric load #2 for 1 h, which is measured by an energy metering instrument #2. E_3 is a total energy consumption value of an electric load #1 for 1 h, which is measured and reported by an ESS client. In this test environment, the energy solely consumed by an ESS client can be roughly $E_1 - E_2$ as shown below. $E_{ESS\_client} = E_1 - E_2$
Performance evaluation indices	Degree of accuracy (or precision)	The degree of accuracy (or precision) of an ESS client can be calculated by using E_2 and E_3 measured by the energy metering instrument #2 and the ESS client, respectively. For example, an ESS client can be classified as ±1 % accuracy ESS client when it satisfies $0 \leq \lvert E_2 - E_3 \rvert / E_2 \leq 0{,}01$.

Bibliography

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