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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

Requirements and architecture for energy management services

Recommendation ITU-T F.747.9

ITU-T F-SERIES RECOMMENDATIONS

NON-TELEPHONE TELECOMMUNICATION SERVICES

TELEGRAPH SERVICE	
Operating methods for the international public telegram service	F.1–F.19
The gentex network	F.20–F.29
Message switching	F.30–F.39
The international telemessage service	F.40–F.58
The international telex service	F.59–F.89
Statistics and publications on international telegraph services	F.90–F.99
Scheduled and leased communication services	F.100–F.104
Phototelegraph service	F.105–F.109
MOBILE SERVICE	
Mobile services and multidestination satellite services	F.110–F.159
TELEMATIC SERVICES	
Public facsimile service	F.160–F.199
Teletex service	F.200–F.299
Videotex service	F.300–F.349
General provisions for telematic services	F.350–F.399
MESSAGE HANDLING SERVICES	F.400–F.499
DIRECTORY SERVICES	F.500–F.549
DOCUMENT COMMUNICATION	
Document communication	F.550–F.579
Programming communication interfaces	F.580–F.599
DATA TRANSMISSION SERVICES	F.600–F.699
MULTIMEDIA SERVICES	**F.700–F.799**
ISDN SERVICES	F.800–F.849
UNIVERSAL PERSONAL TELECOMMUNICATION	F.850–F.899
ACCESSIBILITY AND HUMAN FACTORS	F.900–F.999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T F.747.9

Requirements and architecture for energy management services

Summary

Recommendation ITU-T F.747.9 describes requirements, scenarios and functional architecture for user-side energy management service (EMS) where energy consumption equipment with heterogeneous metering and control capacities coexist. In user-side EMS systems, energy consumption data for both single device and device group need to be collected; these devices can be controlled by coarse-grained (on-off state) and fine-grained instructions. Furthermore, such operations are executed manually or automatically. The user-side EMS system makes energy-saving decisions based on multiple factors, such as the demands and optimization policies from users, pricing strategies from suppliers, government subsidies, device status.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.747.9	2017-03-01	16	11.1002/1000/13180

Keywords

Heterogeneous devices, metering and control, user-side energy management.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Table of Contents

Recommendation ITU-T F.747.9

Requirements and architecture for energy management services

1 Scope

This Recommendation describes requirements, scenarios and functional architecture for user-side energy management service (EMS) where energy consumption equipment with heterogeneous metering and control capacities coexist. This Recommendation covers the following:

– scenarios of user-side EMS;

– requirements of user-side EMS;

– functional architecture for user-side EMS.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.4252] Recommendation ITU-T Y.4252/Y.2064 (2014), *Energy saving using smart objects in home networks*.

[ITU-T Y.4409] Recommendation ITU-T Y.4409 (2015), *Requirements and architecture of the home energy management system and home network services*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 home energy management system [ITU-T Y.4409]: A computer system comprising a software platform providing basic support services and a set of applications providing the functionality needed for the effective operation of home equipment, such as home appliances and storage batteries, so as to assure adequate security of energy supply at minimum cost.

3.1.2 smart object [ITU-T Y.4252]: An object which is aware of its characteristic, context and situation. It shares and processes information, such as its identity, current location, physical properties and the information it senses from its surroundings, while performing object-to-object communications.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AMR Automatic Meter Reading

EMS Energy Management Service

HEMS Home Energy Management System

IoT Internet of Things

5 Conventions

In this Recommendation:

– The expression "**is required to**" indicates a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

– The expression "**is recommended**" indicates a requirement which is recommended but not absolutely required. Thus, this requirement need not be present to claim conformance.

6 Background

There are growing concerns about energy efficiency and emissions reduction among people from all aspects of life, which raises the demand for energy management for customers. With the development of information technology (e.g., Internet of things (IoT) [ITU-T Y.4252]), various smart objects, including sensors and actuators, can interconnect with one another to monitor and change the status of energy consumption equipment, which provides methods for energy management. Thus, user-side energy management service (EMS) is used to help consumers improve their energy efficiency as well as reduce their energy costs.

The user-side EMS provides raw data to users as well as processed information of energy consumption by collecting and monitoring energy consumption data from various equipment. It also makes energy-saving decisions based on multiple factors, such as user demands, supplier's pricing strategies, and optimization policies. Some other factors, such as government subsidies, device status and environmental conditions can also affect energy-saving decisions. For example, usage related information, such as the number of customers shopping in a mall, the occupancy rate of a hotel, the number of students enrolled in a school, or attendance at a stadium, can affect energy-decisions, e.g., which lights and air conditioners need to be turned on/off.

In recent years, various EMS systems have been developed and standardized. [ITU-T Y.4252] describes requirements and capabilities for saving energy by using smart objects in home networks. The home energy management system (HEMS) [ITU-T Y.4409] supports energy efficiency and reduction of energy consumption by monitoring and controlling devices. All these existing standards consider only smart objects which can be monitored and controlled automatically and remotely.

However, not all existing energy-consumption devices are smart objects. They are not only different in the type of consumed energy (e.g., electricity, gas, coal), but also different in the capacity of metering and control. For example, in practice, an electricity meter can measure the amount of electric energy consumed by one circuit, which may be wired with multiple electrical equipment located in a home or in a factory. It can also be wired with individual electrical equipment. Thus, both coarse-grained and fine-grained data of consumed electric energy are collected manually or through automatic meter reading (AMR). Also, many electrical devices can only be turned on and off manually, e.g., a light bulb with on-off switches. Some other electrical devices can be fine-tuned, e.g., temperature setting of an air conditioner. Furthermore, smart appliances can be controlled automatically and remotely.

Considering the cost of adding metering units for individual energy consumption equipment and the difficulties of updating all traditional devices to smart objects, various heterogeneous devices with different capacities of metering and control must be supported in a practical user-side EMS system. In such an EMS system, energy consumption data for both single device and device group need to be collected, and these devices can be controlled by coarse-grained (on-off state) and fine-grained instructions. Furthermore, such operations are executed manually or automatically.

This Recommendation describes the requirements and scenarios of user-side EMS as well as the functional architecture for user-side EMS with heterogeneous devices.

7 General requirements for user-side EMS

Several basic requirements of user-side EMS are given, including device management, data acquisition, policies management, energy consumption analysis, and decisions implementation.

7.1 Requirements for device management

DM-01: The user-side EMS is required to register and deregister energy-consumption devices, metering devices and controlling devices.

DM-02: The user-side EMS is required to maintain attribute information of energy-consumption devices, meter devices and control devices.

DM-03: The user-side EMS is required to associate the energy-consumption devices with the corresponding metering device(s) and control device(s).

7.2 Requirements for data acquisition

DA-01: The user-side EMS is required to collect and store the energy consumption data for each energy consuming device or device group.

DA-02: The user-side EMS is required to provide the raw data as well as pre-processed data for further energy consumption calculation, optimization, and device control.

DA-03: The user-side EMS is required to support at least one kind of mechanism (i.e., manual or automatic) of metering data collection.

DA-04: The user-side EMS is recommended to implement a metering adaptation layer which supports various data collection mechanisms, such as remote and manual meter reading.

DA-05: The user-side EMS is recommended to include the consumption of electricity, natural gas, wood, coal, gasoline, diesel and other energy resources as energy consumption data, if applicable.

DA-06: The user-side EMS is recommended to collect environmental data periodically.

7.3 Requirements for policies management

PM-01: The user-side EMS is recommended to fetch and store energy consumption demands and optimization policies of users.

PM-02: The user-side EMS is recommended to fetch and store the pricing policies of supply side.

7.4 Requirements for energy consumption analysis

EA-01: The user-side EMS is required to process the collected energy consumption data and provide the statistical energy consumption report to the user and the supplier if required.

EA-02: The user-side EMS is recommended to provide an energy efficiency evaluation. For domestic users and public buildings, this evaluation is based on the amount of energy used, the number of people, and the environmental conditions. For a factory, the evaluation takes the amount of production into consideration.

EA-03: The user-side EMS is recommended to provide data analysis such as statistical analysis, energy consumption prediction.

EA-04: The user-side EMS is recommended to generate an optimal energy-saving solution based on all the data and information collected, the policies related, and the demands of user.

EA-05: The user-side EMS is recommended to keep track of the change in energy consumption for one device or device group after applying each control command.

7.5 Requirements for energy-saving decisions implementation

ED-01: The user-side EMS is required to have the capability for users to implement energy-saving decisions manually.

ED-02: The user-side EMS is recommended to implement the energy-saving decisions automatically.

ED-03: The user-side EMS is recommended to implement controlling adaptation layer which supports various control mechanisms, such as remote and manual control.

8 Functional architecture for user-side EMS

The functional architecture of user-side EMS is shown in Figure 8-1.

As shown in Figure 8-1, the user-side EMS interacts with EMS clients, supply-side EMS and various energy-consumption devices. There are six modules of user-side EMS which interact with other systems and provide energy management for users.

1) The device management module registers and deregisters various energy consumption equipment and other devices (i.e., meters and controllers). The relationships among the energy consumption equipment, metering and control devices are maintained. The attribute information of energy consumption equipment, metering devices, and control devices is also maintained.
2) The metering data management module records real-time energy consumption data for each energy consuming device or device group. The consumed data of all types of energies, including gas, electricity, coal and other energy resources, are collected and submitted to the metering data management module manually or through AMR.
3) The control management module generates control instructions which are executed manually or automatically.
4) The strategy module interacts with EMS clients and maintains user-side strategies. The EMS client collects user demands, including the energy consumption demand, efficiency goals, and energy-saving strategies, and sends them to this module.
5) The supply-side price module keeps a record of the pricing policies and energy plan provided by the supply-side EMS.
6) The energy consumption data processing and optimization module performs the energy consumption statistics and makes energy-saving decisions. The statistical results are sent to supply-side EMS which can be used to help the energy supplier make energy supply plan and pricing policies. The results also are sent to the EMS client for displaying.

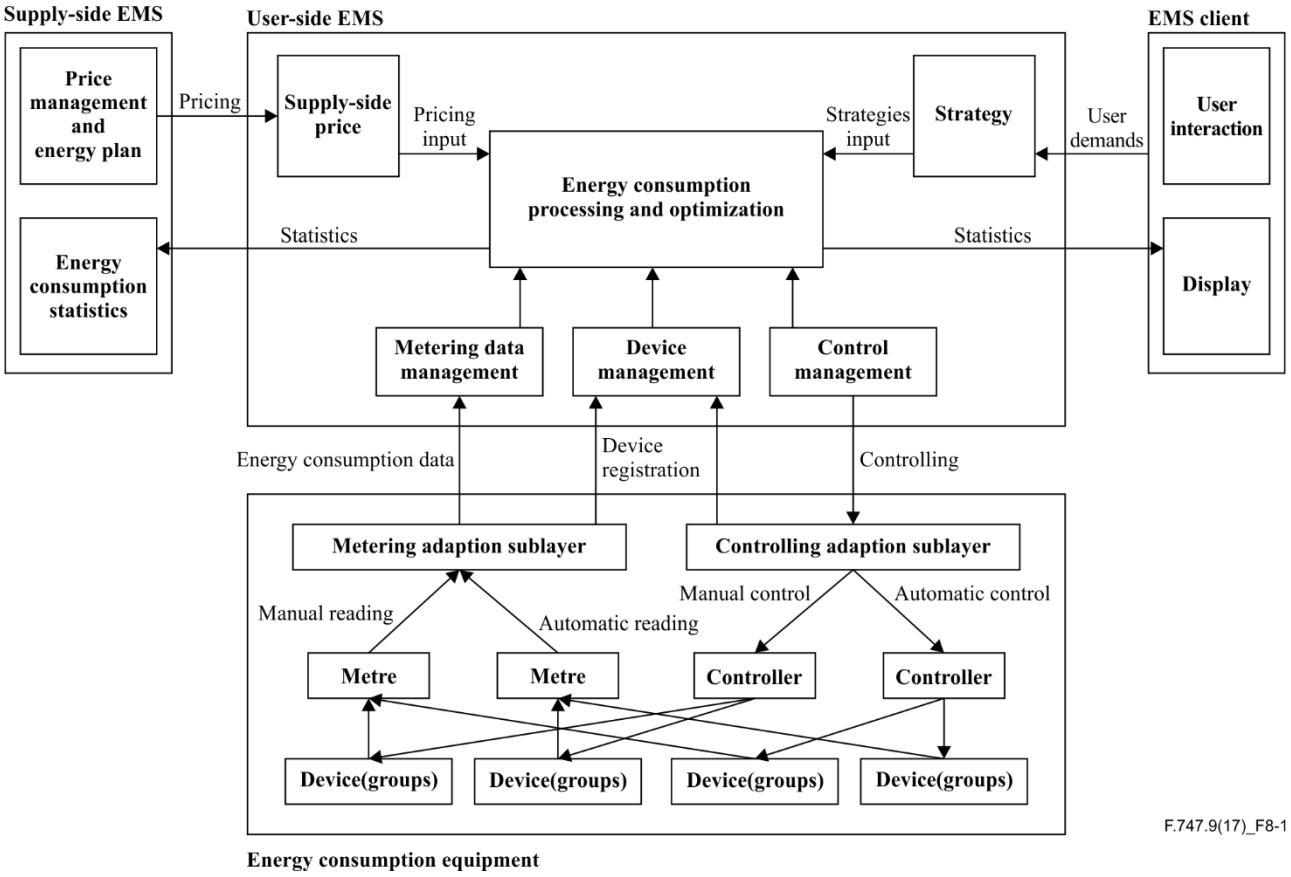

Figure 8-1 – A framework of user-side EMS

In clauses 8.1 and 8.2, an outline of supported metering and control devices is described.

8.1 Supported energy-metering devices

The acquisition of energy consumption data provides the input data for user-side EMS. Two steps are involved: energy consumption metering and data collection.

Metering devices can be classified based on the number of monitored devices and the method of metering data collection.

According to the number of monitored devices, there are two types of metering devices:

1) Meters which measure the energy consumption data of one device. For example, with the emergence of sockets with metering, the consumed power of a specific device can be metered independently.

2) Meters which measure the energy consumption data of one device group (a set of devices). For example, one conventional electricity meter can only meter the total power consumption for one ordinary house, which means that all the household electrical appliances are wired with the same circuit and considered as a whole.

According to the method of metering data collection, there are two types of metering devices:

1) Meters whose data must be collected manually.

2) Meters which support AMR.

Figure 8-2 shows a conventional electricity meter, a conventional gas meter and a socket with metering, the measurement data of which is collected manually.

Figure 8-2 – Ordinary electricity meter, ordinary gas meter and socket with metering

Two meters supporting remote meter reading are shown in Figure 8-3.

Figure 8-3 – Electricity meter and gas meter supporting AMR

The shortcomings of collecting data manually include the high cost of human resources and inefficiency of data collection. However, updating all meters to support AMR is very expensive. In a home, there are various household energy-consumption devices such as light bulbs, chargers, air conditioners/fans, refrigerator, electric/gas water heater, and gas stove. It is unnecessary to add meters for each device. Thus, in practice, one metering device is often used to measure the energy consumption data of one device group and most metering devices are still needed to collect data manually.

For user-side EMS, the device diversity in metering capacity and data collection method must be fully taken into account.

8.2 Supported energy control device

An energy control device can prevent or change the transmission of energy and thus change the status of one or multiple energy-consumption devices.

Energy control devices can be classified based on the number of controlled devices, the method of control and the granularity of control.

According to the number of controlled devices, there are two types of energy control devices.

1) Energy control device which controls one device. For example, one power switch controls one light bulb, i.e., one-to-one mode.
2) Energy control device which controls one set of devices. For example, one power switch controls one set of light bulbs, i.e., one-to-many mode.

According to the method of control, there are two types of energy control devices.

1) Energy control devices which are manually operated. For example, one conventional power switch and one gas switch shown in Figure 8-4.
2) Energy control devices which can be operated automatically and remotely. For example, a user controls the on-off state of the smart sockets and smart appliances remotely as shown in Figure 8-5.

According to the granularity of control, there are two types of energy control devices:

1) Energy control devices which control the "on" and "off" states of the energy-consumption equipment.

2) Energy control devices which fine-tune the consumed energy of energy-consumption equipment. For example, adjusting the temperature setting of a room changes the consumed energy of the air conditioner in that room.

Figure 8-4 – Conventional power switch and gas switch

Figure 8-5 – Smart socket and gas switch gas meter supporting remote control

9 Security considerations

It is recommended that the security requirements of [b-ITU-T Y.2201], [b-ITU-T Y.2701], and applicable ITU-T X-series, ITU-T Y-series and ITU-T M-series security Recommendations be taken into consideration, which includes access control, authentication, data confidentiality, communications security, data integrity, availability and privacy.

Annex A

Scenarios for user-side EMS

(This annex forms an integral part of this Recommendation.)

In the domestic usage case, the user-side EMS is used to serve individual families or houses which are the basic units of human society. User-side EMS can not only save energy but also enhance public awareness of energy savings.

In the case of user-side EMS for public buildings, the application area of user-side EMS is expanded, from inside a building or house for a family, to an architectural complex.

In the case of user-side EMS for a factory, various types of energy resources, such as electricity, gas, coal and heat, are involved.

There exist great opportunities to achieve greater energy efficiency in these scenarios.

The study of other scenarios is encouraged and welcomed.

A.1 User-side EMS for domestic users

The scenario of user-side EMS for a domestic user is shown in Figure A.1.

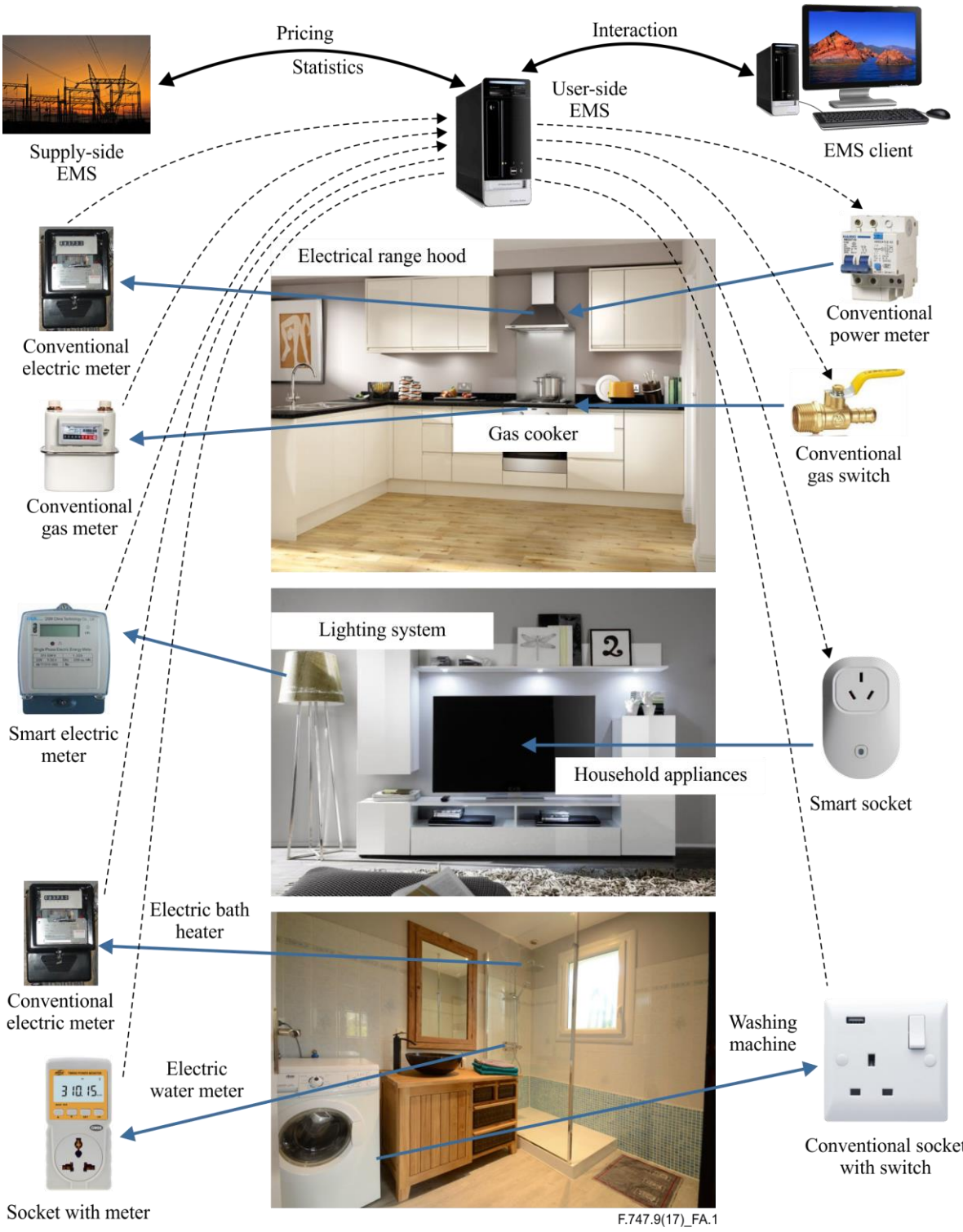

Figure A.1 – Scenario of EMS for domestic user

In a home, there are two common types of energy consumption equipment, namely electric equipment and gas equipment. The electric equipment includes lights, decorative lamps, television, washing machine, refrigerator, air conditioner, electric water heater, electric stove, kettle and many others. The typical gas equipment includes gas water heater, gas stove and gas heater.

The user-side EMS collects and processes energy consumption data of these devices to provide raw data as well as processed information of energy consumption to home users. The EMS system helps users to understand how their own behaviours affect the usage of energy.

The EMS also provides users with guidelines or suggestions about how to improve energy efficiency as well as save energy. The pricing policies of supply side (e.g., the power companies and gas companies) can affect these decisions. For instance, in order to reduce energy demand during peak hours, power companies usually introduce a step-tariff, i.e., charging higher prices at peak hours and lower prices at off-peak hours to regulate energy consumption. Thus, if a washing machine has a timer or can be controlled remotely, the EMS may suggest doing laundry at off-peak hours. The user does this by setting the timer manually or the EMS starting the washing machine remotely at the right time.

Another typical scenario is related to the energy-saving decision for bathing. For an electric water heater, in conjunction with a socket with metering, the consumed energy required for a bath can be metered and submitted to the EMS manually. Similarly, the consumed gas required for a bath can also be collected. Then, the EMS can calculate the fee paid for one bath based on the consumed gas or electric power and recommend appropriate money-saving decisions to the user.

A.2 User-side EMS for public buildings

A public building is a general term for civil architecture which covers all of the buildings used for social activities rather than for an individual family. It mainly includes large buildings (e.g., office premises, shopping malls, hotels, hospitals), transportation hubs (e.g., airports, bus stations) and sports buildings (e.g., public gymnasiums, stadiums). As shown in Figure A.2, the application area of the user-side EMS for public buildings is expanding from inside a building or house for a family as the EMS for domestic users, to an architectural complex.

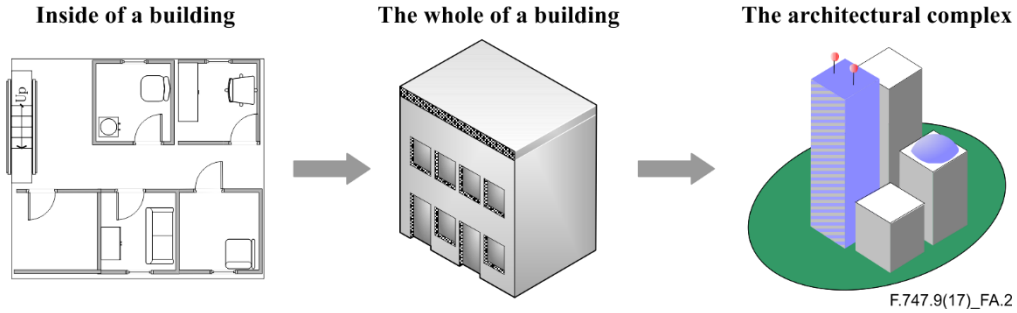

Figure A.2 – Application area of the user-side EMS for public buildings

Figure A.3 shows one scenario of the user-side EMS for public buildings. In order to create a comfortable environment, public buildings are generally equipped with adequate lighting and air-conditioning facilities. For example, in northern China, a central heating system is often employed in winter. Typically, this central heating system is charged by the size of the building regardless of the amount of actual consumed energy. The Ministry of Housing and Urban-Rural Development of China is now vigorously promoting the mandatory installation of meters for heating in new constructions, and also is forcing the installation of meters in existing buildings, meaning people need to pay according to the actual amount of consumed heat. Thus, reducing energy consumption and the cost will become an important task for public building management.

The consumed energy for a building is always varying. For example, after normal working hours, some people may still remain in the building to work. In this case, the building manager can continue using the central heating system or using air conditioners in the appropriate rooms in the building. The building manager can manually count which rooms are still in use and offer this information to the EMS which will make decisions to save energy.

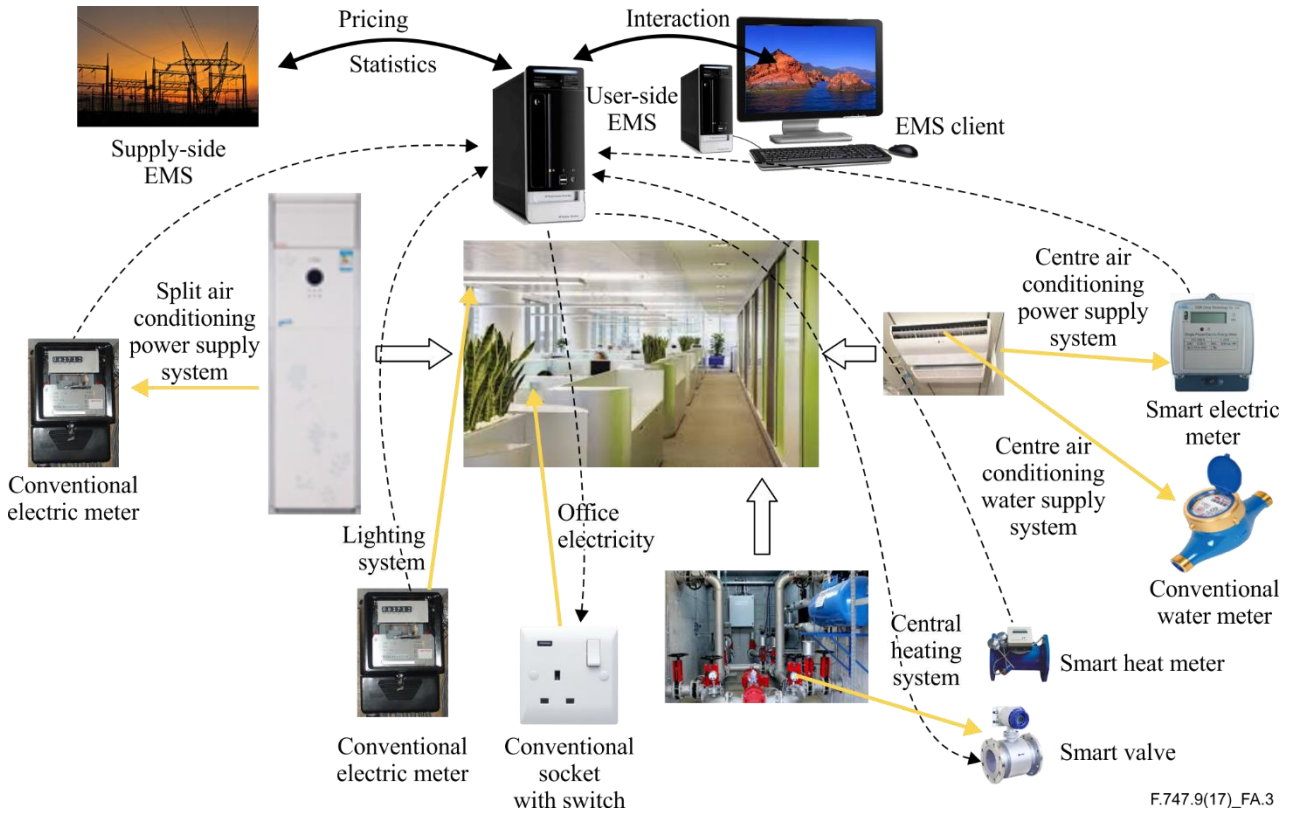

Figure A.3 – Scenario of the user-side EMS for public buildings

A.3 User-side EMS for factories

A large portion of energy is consumed by factories such as steel, mining, petroleum, chemicals, metallurgy, tobacco, food processing, and textile manufacturing.

Due to a lack of technologies and money, the energy consumption information of many factories, especially small and medium-sized enterprises, is still collected and managed manually. As for many large-scale and energy-intensive industries, the user-side EMS is still in its early stage,

The EMS for a factory manages multiple energy resources. For example, in a coal mine, there are many devices (e.g., central pump, winches, shearers, coal feeders, belt conveyors and air compressors) which are located at various locations and are powered by different resources (e.g., coal, electricity and gas). Diversified data must be collected.

Further, the energy-saving decisions are influenced by policies such as government subsidies or other incentive mechanisms, and mandatory regulations. The security of the EMS related data and information is also critical for factory owners.

The EMS is helpful for finding the composition of energy use and predicting the trend of energy consumption. Furthermore, the accurate data collected by the EMS can be used by energy suppliers such as power companies to improve the efficiency, reliability, and sustainability of the production and distribution of electricity. It can also be used by regulators to make better energy related polices.

Bibliography

[b-ITU-T Y.2201] Recommendation ITU-T Y.2201 (2009), *Requirements and capabilities for ITU-T NGN*.

[b-ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

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Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	**Non-telephone telecommunication services**
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
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Series S	Telegraph services terminal equipment
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