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Industrial-process measurement, control and automation system interface between industrial facilities and the smart grid

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Industrial-process measurement, control and automation system interface between industrial facilities and the smart grid

INTERNATIONAL
ELECTROTECHNICAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INDUSTRIAL-PROCESS MEASUREMENT, CONTROL AND AUTOMATION SYSTEM INTERFACE BETWEEN INDUSTRIAL FACILITIES AND THE SMART GRID

FOREWORD

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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 TS 62872, which is a technical specification, has been prepared by IEC technical committee 65: Industrial-process measurement, control and automation.

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

Enquiry draft	Report on voting
65/590/DTS	65/598/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.

A review of this Technical Specification will be carried out not later than 3 years after its publication with the options of: extension for another 3 years; conversion into an International Standard; or withdrawal.”

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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- withdrawn,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.

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INTRODUCTION

The World Energy Outlook 2013 [13][1] reported that industry consumed over 40 % of world electricity generation in 2011. Furthermore, industry itself is a significant generator of internal power, with many facilities increasingly implementing their own generation, co-generation and energy storage resources. As a major energy consumer, the ability of some industries to schedule their consumption can be used to minimize peak demands on the electrical grid. As an energy supplier, industries with in-house generation or storage resources can also assist in grid load management. While some larger industrial facilities already manage their use and supply of electric power, more widespread deployment, especially by smaller facilities, will depend upon the availability of a readily available standard interface between industrial automation equipment and the "smart grid".

NOTE In this document "smart grid" is used to refer to the external-to-industry entity with which industry interacts for the purpose of energy management. In other documents this term may be used to refer to all of the elements, including internal industrial energy elements, which work together to optimize energy generation and use.

Standards are already being developed for home and building automation interfaces to the grid; however the requirements for industrial facilities differ significantly and are addressed in this Technical Specification. Specifically excluded from the scope of this Technical Specification are the protocols needed for the direct control of energy resources within a facility where the control and ultimate liability for such control is delegated by the industrial facility to the external entity.

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1 Numbers in square brackets refer to the bibliography.

INDUSTRIAL-PROCESS MEASUREMENT, CONTROL AND AUTOMATION SYSTEM INTERFACE BETWEEN INDUSTRIAL FACILITIES AND THE SMART GRID

1 Scope

This Technical Specification defines the interface, in terms of information flow, between industrial facilities and the “smart grid”. It identifies, profiles and extends where required, the standards needed to allow the exchange of the information needed to support the planning, management and control of electric energy flow between the industrial facility and the smart grid.

Industry is a major consumer of electric power and in many cases this consumption can be scheduled to assist in minimizing overall peak demands on the smart grid. In addition, many industrial facilities have in-house generation or storage resources which can also assist in smart grid load management. While some larger industrial facilities already manage their use and supply of electric power, more widespread deployment, especially by smaller facilities, will depend upon the availability of readily available standard automated interfaces.

Standards are already being developed for home and building automation interfaces to the smart grid; however the requirements of industry differ significantly and are addressed in this Technical Specification. For industry, the operation of energy resources within the facility will remain the responsibility of the facility operator. Incorrect operation of a resource could impact the safety of personnel, the facility, the environment or lead to production failure and equipment damage. In addition, larger facilities may have in-house production planning capabilities which might be co-ordinated with smart grid planning, to allow longer term energy planning.

Specifically excluded from the scope of this Technical Specification are the protocols needed for the direct control of energy resources within a facility where the control and ultimate liability for such direct control is delegated by the industrial facility to an external entity (e.g. distributed energy resource (DER) control by the electrical grid operator).

2 Normative references

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

IEC 62264-1, *Enterprise-control system integration - Part 1: Models and terminology*

IEC 62264-3, *Enterprise-control system integration - Part 3: Activity models of manufacturing operations management*

IEC TS 62443-1-1, *Industrial communication networks - Network and system security - Part 1-1: Terminology, concepts and models*

IEC 62443-2-1, *Industrial communication networks - Network and system security - Part 2-1: Establishing an industrial automation and control system security program*

IEC TR 62443-3-1, *Industrial communication networks - Network and system security - Part 3-1: Security technologies for industrial automation and control systems*

IEC 62443-3-3, *Industrial communication networks - Network and system security - Part 3-3: System security requirements and security levels*

3 Terms and definitions

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

3.1 General

3.1.1
profile
set of one or more base standards and/or other profiles and, where applicable, the identification of chosen classes, conforming subsets, options and parameters of those base standards, or profiles necessary to accomplish a particular function

[SOURCE: IEC/ISO TR 10000-1:1998, 3.1.4, modified – reference to international standard profiles has been removed]

3.1.2
level
group of functions categorized with the functional hierarchy model of production systems defined in IEC 62264-1

Note 1 to entry: The highest level, Level 4, typically includes enterprise resource planning and similar functions, while the lowest level, Level 0, represents the physical industrial process itself.

3.1.3
level 4
functions involved in the business-related activities needed to manage a manufacturing organization

[SOURCE: IEC 62264-1:2013, 3.1.16]

3.1.4
level 3
functions involved in managing the work flows to produce the desired end-products

[SOURCE: IEC 62264-1:2013, 3.1.17]

3.1.5
level 2
functions involved in monitoring and controlling of the physical process

[SOURCE: IEC 62264-1:2013, 3.1.17]

3.1.6
level 1
functions involved in sensing and manipulating the physical process

[SOURCE: IEC 62264-1:2013, 3.1.18]

3.1.7
level 0
actual physical process

[SOURCE: IEC 62264-1:2013, 3.1.19]

3.1.8
enterprise
one or more organizations sharing a definite mission, goals and objectives which provides an output such as a product or service

[SOURCE: IEC 62264-1:2013, 3.1.10]

3.1.9
area
physical, geographical or logical grouping of resources determined by the site

[SOURCE: IEC 62264-1:2013, 3.1.2]

3.1.10
site
identified physical, geographical, and/or logical component grouping of a manufacturing enterprise

[SOURCE: IEC 62264-1:2013, 3.1.39]

3.1.11
facility
industrial facility
manufacturing facility
site, or area within a site, that includes the resources within the site or area and includes the activities associated with the use of the resources

[SOURCE: IEC 62264-1:2013, 3.1.20]

3.2 Models in automation

3.2.1
asset
physical or logical object owned by or under the custodial duties of an organization, having either a perceived or actual value to the organization

Note 1 to entry: In the case of industrial automation and control systems the physical assets that have the largest directly measurable value may be the equipment under control.

[SOURCE: IEC TS 62443-1-1:2009, 3.2.6]

3.2.2
automation asset
asset with a defined automation role in a manufacturing or process plant

Note 1 to entry: It would include structural, mechanical, electrical, electronics and software elements (e.g. controllers, switches, network, drives, motors, pumps). These elements cover components, devices but not the plant itself (machine, systems). It would not include human resources, process materials (e.g. raw, in-process, finished), or financial assets.

3.2.3
process
set of interrelated or interacting activities that transforms input to output

[SOURCE: ISO 14040:2006, 3.11]

3.2.4
product
result of labour or of a natural or industrial process

Note 1 to entry: This term is defined by "any goods or service" in IEC 62430 and ISO 20140-1:2013. The European Commission adopts a similar understanding in the directive "Ecodesign requirements for energy-related products". In the context of this Technical Specification, the term "product" does not cover the automation assets but only the output of the manufacturing or process plant.

[SOURCE: IEC TR 62837:2013, 3.7.7]

3.3 Models in energy management system and smart grid

3.3.1
smart grid
utility grid
electric power system that utilizes information exchange and control technologies, distributed computing and associated sensors and actuators, for purposes such as to integrate the behaviour and actions of the network users and other stakeholders, and to efficiently deliver sustainable, economic and secure electricity supplies

Note 1 to entry: In this Technical Specification, smart grid is the counterpart system to which FEMS is connected.

[SOURCE: IEC 60050-617:2009, 617-04-13, modified by adding Note 1 to entry]

3.3.2
smart meter
SM
embedded-computer-based energy meter with a communication link

Note 1 to entry: In this Technical Specification smart meters are used to measure both the consumption and supply of energy by the facility. They may also be deployed within the facility to measure internal energy flows.

3.3.3
utility smart meter
USM
smart meter deployed by the utility company to measure energy consumption and supply by the facility

Note 1 to entry: This meter typically forms part of the advanced metering infrastructure of smart grid.

3.3.4
facility smart meter
FSM
smart meter deployed and used by the facility to measure energy flows

Note 1 to entry: This meter will normally communicate with the FEMS.

3.3.5
distributed energy resource
DER
energy resource, often of a smaller size, operated by the utility to augment the local supply of energy

Note 1 to entry: In this Technical Specification, DER, in contrast to FER, is used to refer to resources under the direct control of the utility. Such resources may include generation and/or storage capabilities.

3.3.6
facility energy resource
FER
energy resource, operated by the facility, which is used to supply energy to the facility and which may also be used to provide energy to the grid

Note 1 to entry: This terminology, rather than distributed energy resource (DER) terminology, is used to emphasize that the FER is operated by the facility and not under the direct control of the utility. Such resources may include generation and/or storage capabilities.

3.3.7
demand response
DR
mechanism to manage customer load demand in response to supply conditions, such as prices or availability signals

3.3.8
facility energy management system
FEMS
system providing the functionality needed for the effective and efficient operation of energy generation, storage and consumption within the industrial facility, and which provides the necessary information interface with the smart grid

[SOURCE: IEC TS 61968-2, 2.101:2011, modified – factory is replaced by facility in the term and in the definition "computer" is removed and "to the electrical grid" is replaced by "with the smart grid"]

3.3.9
utility gateway
UG
function within FEMS responsible for the connection with the smart grid

Note 1 to entry: It is a function within FEMS.

3.3.10
energy generation system
EGS
energy resource capable of creating electric energy from other sources of energy or process wastes

EXAMPLE combined heat and power systems, photo-voltaic cells, wind power generators.

3.3.11
energy storage system
ESS
energy resource capable of storing energy for later use

EXAMPLE batteries, flywheels, pumped hydro storage, electrical vehicles, fuel cells.

3.3.12
facility power line
network, which distributes energy to individual industrial equipment within a facility

3.3.13
schedulable processing task
task for which energy demand can be scheduled among multiple operating modes, where each mode has a different production rate and energy demand, such as heating, cooling, packaging, etc.

3.3.14
non-schedulable processing task
task for which energy demand must be satisfied immediately, such as rolling in steel manufacturing, assembling in automobile industry, etc.

3.3.15
monitor and control agent
MCA
agent that monitors and controls processing operations of a task

3.3.16
energy management agent
EMA
agent that monitors the energy consumption and controls the electric load of a task

3.3.17
power source switch
switch which selects the energy source of a task

3.3.18
non-shiftable equipment
NSE
equipment whose operation cannot be re-scheduled

3.3.19
controllable equipment
CE
equipment whose energy demand can be controlled among multiple operating levels, each of which has a different energy demand

3.3.20
shiftable equipment
SE
equipment that can be operated at an earlier or later time

3.3.21
production planner
personnel who develops, monitors and modifies the production plan based on facility requirements and the availability of inputs

Note 1 to entry: Example of inputs are equipment, labour, raw materials and energy.

3.3.22
operation manager
personnel who monitors facility operations responding to emerging changes related to shifting energy supplies, material disruptions, and equipment breakdowns

3.3.23
firewall
inter-network connection device that restricts data communication traffic between two connected networks

4 Abbreviations

APO	Advanced Planning and Optimization
CE	Controllable Equipment
CHP	Combined Heat and Power (co-generation) Equipment
CMM	Computerized Maintenance Management
DCS	Distributed Control System
DER	Distributed Electric Resource
DR	Demand Response
EGS	Energy Generation System
EMA	Energy Management Agent
EMS	Energy Management System
ERP	Enterprise Resource Planning

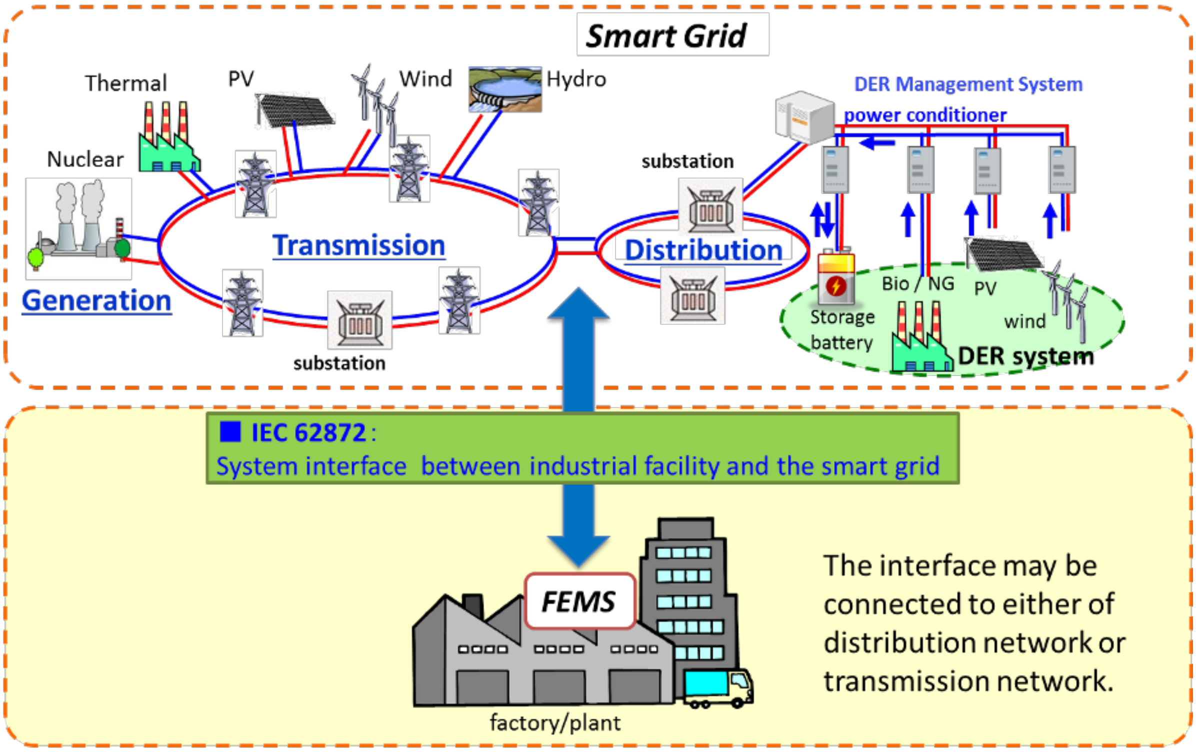
ESS	Energy Storage System
FEMS	Facility Energy Management System
FER	Facility Electric Resource
FG	Facility-Grid (Use Case)
FSM	Facility Smart Meter
FUS	Facility User Story
GW	Utility Gateway
HMI	Human Machine Interface
I/O	Input Output
ICT	Information and Communications Technology
LAN	Local Area Network
LIMS	Laboratory Information Management System
MCA	Monitor and Control Agent
MES	Manufacturing Execution System
NSE	Non-shiftable Equipment
NST	Non-schedulable Processing Task
PLC	Programmable Logic Controller
PV	Photo Voltaic
SCADA	Supervisory Control and Data Acquisition
SE	Shiftable Equipment
SG	Smart Grid
ST	Schedulable Processing Task
USM	Utility Smart Meter
UUS	Utility User Story
VEN	Virtual End Node
VTN	Virtual Top Node
WAN	Wide Area Network
WMS	Warehouse Management System

5 Requirements

5.1 General

As discussed in the Introduction, the efficient and safe management of energy consumption by industry, and energy supply by industry, can result in reduced peak smart grid loads and the ability to better use intermittent and less predictable energy sources such as wind and solar sources. It will also permit the smart grid and industry to co-operate to better address occasional and emergency energy shortages. To manage this flow of energy, a communications interface is required, as represented in Figure 1.

While industry is well placed to contribute in this way, such contributions need to take into account the priorities of industrial production. Typical industrial facilities operate according to production schedules, which once started can often not be suspended in the short term.



Red line: Electicity line, Blue line: Informational line

Figure 1 – Overview of interface between FEMS and smart grid

Power interruptions can impair safe facility operation or impact production quality. In most cases, all facility equipment is under the direct control of the facility control systems and is operated to meet the requirements of production, and these internal operations are at all times the responsibility of the facility operator. This represents a significant difference from building and home automation. Any direct control of internal facility equipment by external entities can raise potential facility safety, production quality, and facility liability concerns. Incorrect operation of a resource could impact the safety of personnel, the facility, the environment or lead to production failure and equipment damage.

The interface shall be designed to provide adequate confidence that cooperation with the smart grid cannot compromise the safety and security of the facility.

Although less common, some industrial facilities may, as a matter of policy or practice, delegate the control of internal energy resources to the smart grid operator or an intermediary such as an external energy broker. Such arrangements might occur for blocks of time when production at the facility is not required, or in cases where production can follow externally defined schedules. Traditionally the smart grid has considered such directly controlled energy resources as “distributed energy resources” (DER) and protocols to implement such direct control have been, and are being, developed within the IEC.

5.2 Architecture requirements

5.2.1 General

Figure 2 provides a physical view of how an industrial facility might make its electric power connection to the smart grid. In this example, two electrical connections are made to the smart grid to increase the reliability of power delivery. Internally, the facility might contain a range of electrical consuming, generation and storage equipment. Interconnection and synchronizing equipment is used to route and coordinate electric power flows internally within the facility, and between the facility and the smart grid. In many cases there may additionally be thermal energy transfers between the equipment and the industrial process, for example using combined heat and power (CHP) equipment.

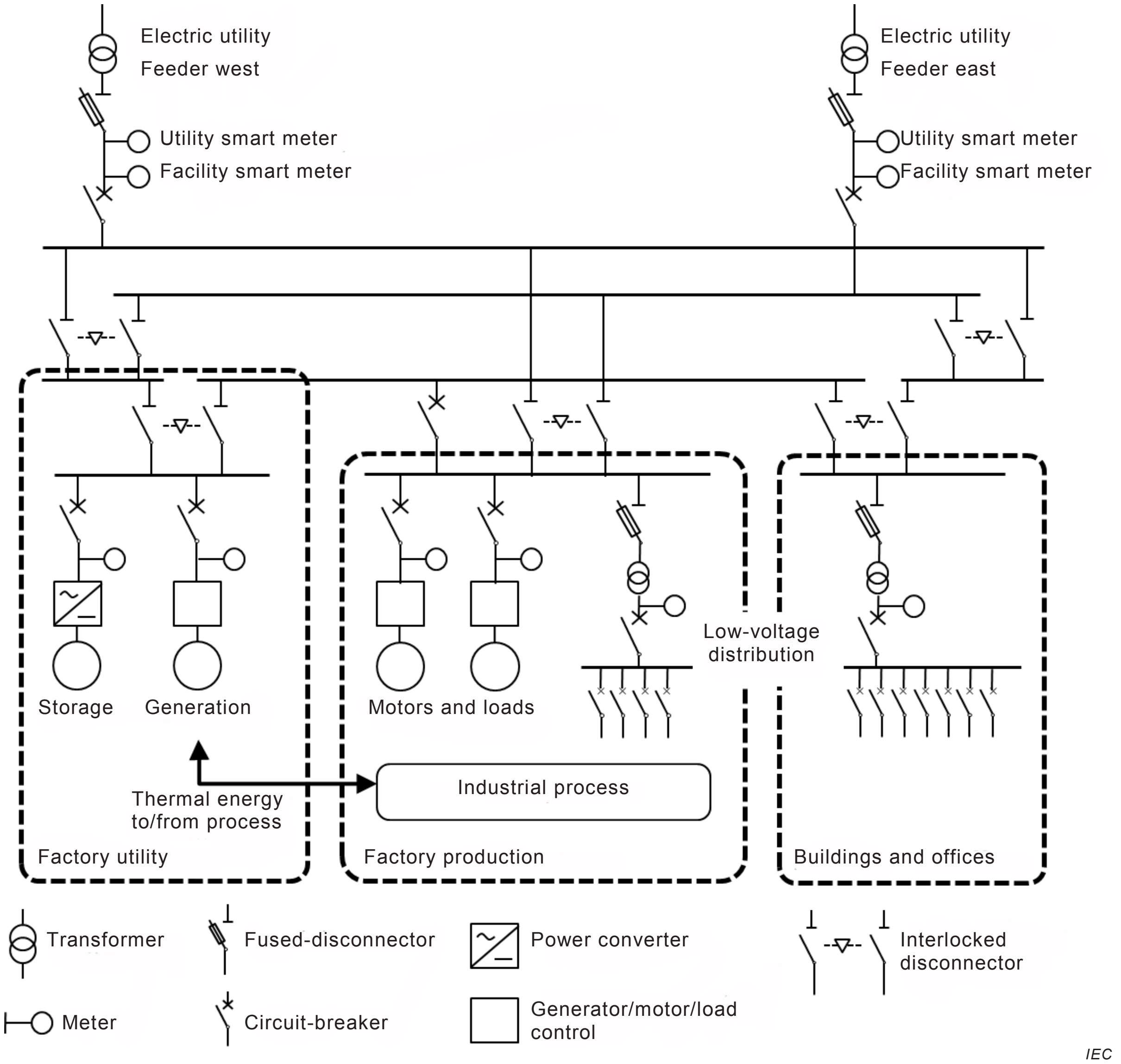


Figure 2 – Example facility electric power distribution

A typical facility will deploy various metering and control devices to manage the electric and thermal energy flows within the facility. Figure 2 depicts two smart meters at each of the facility's incoming feeders permitting independent metering by the smart grid and the facility. Internally, various meters might be deployed to allow the facility to manage and account for its own internal energy use. For example, the "factory utility" might operate as its own cost centre. Control devices will be deployed to manage storage, generation, and motors and loads, as well as to manage power synchronization and the interconnection of the equipment. These meters and control devices will form part of the facility enterprise and control systems described below.

Figure 3 presents a view of the facility enterprise and control systems aligned to the IEC/ISO 62264 standard. The operation of all resources within the facility will be under the control of the facility manager and facility automation. Resources will include generation and storage as well as capabilities to manage production planning. At the top of the figure, enterprise planning and logistics elements are used by facility management to manage production planning. For example, the facility may have options to schedule production -shifts with particular energy consumption or production (e.g. from cogeneration) profiles. Elements at lower levels of the hierarchy are used to implement production plans in real time and to ensure safe operation. For example, some processes, once started, cannot be stopped without impacting product quality or facility safety.

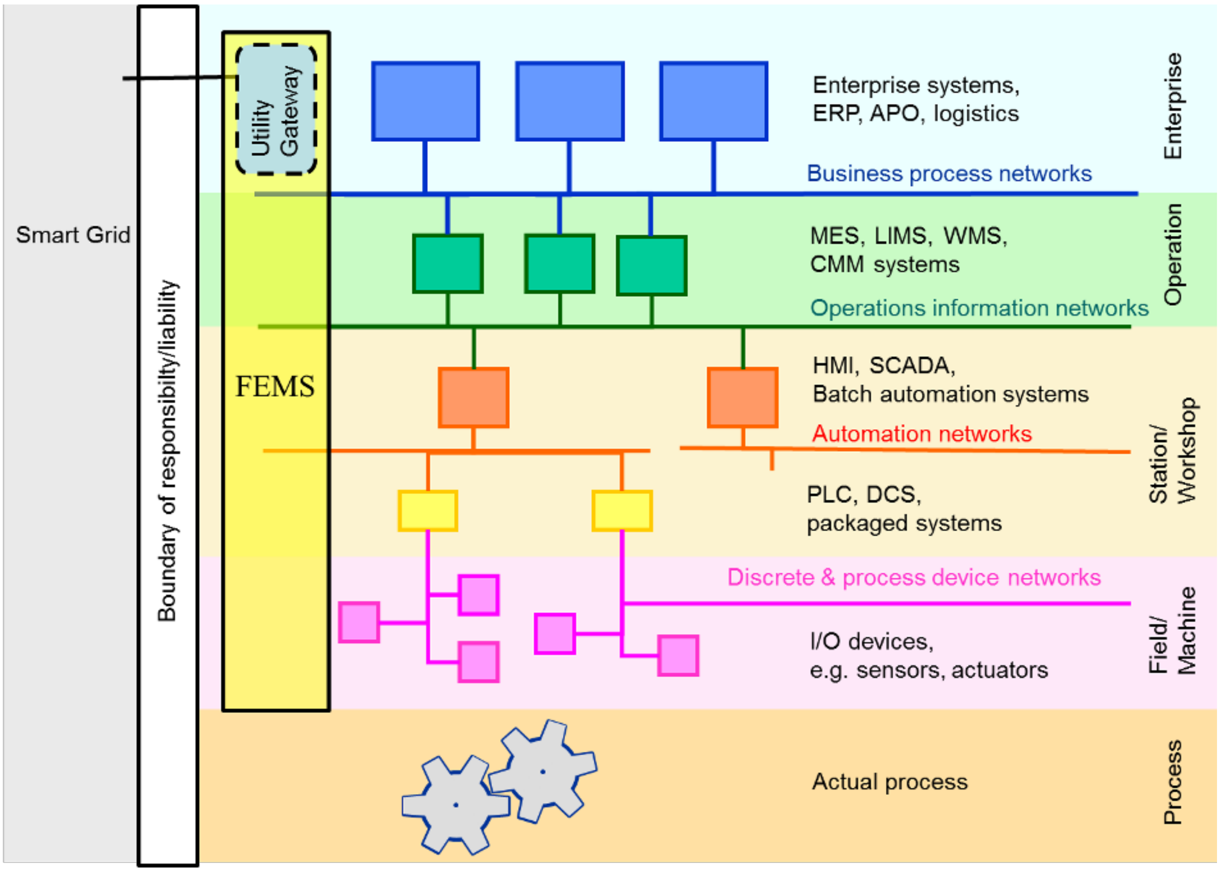


Figure 3 – Facility enterprise and control systems

The operation of the facility, and all liability issues related to such operation, will normally remain the responsibility of the facility manager and associated facility automation. The smart grid will need to be isolated from such control and facility operation liability.

NOTE Not shown in these figures is a potential arrangement whereby the external smart grid operator takes responsibility for the operation of internal facility generation or storage equipment. Such arrangements are out of scope of this Technical Specification. The interface standards needed to support such arrangements may be covered elsewhere.

Thus the utility gateway shall isolate the facility from the smart grid and direct control of facility equipment, while at the same time exposing sufficient characteristics of the facility, and production sequence options, to allow the effective planning and transfer of energy between the smart grid and the facility.

5.2.2 Energy management in industrial facilities

5.2.2.1 General

Energy management in industrial facilities differ significantly from that typically found in home and building environments. Industrial facilities often have far larger energy consumption, generation and/or storage capacities. They often include sophisticated energy planning and operating capabilities to ensure cost effectiveness, availability, compliance to regulations and safe operation of the equipment.

Clause A.1 discusses these characteristics in more detail, however in summary:

- Many facilities have significant energy demands and the ability to reschedule (“shift”) this demand to avoid times of peak demand in the smart grid.

- Many facilities have significant energy generation and/or storage resources associated with their industrial processes, and the potential ability to supply energy to the smart grid.
- Work centers (e.g. process cell, production unit, production line) within an industrial facility work together according to production plans to create a final product. In addition to the cost of energy, these plans normally take into account a range of other factors, including the availability of raw and intermediate materials, and labor. Thus many facilities have significant planning capabilities which can be used to develop energy plans to better co-ordinate the future use and potential supply of energy to the smart grid.
- Often the operation of an industrial process cannot be interrupted once started. A mismatch between the energy supply and demand can cause irretrievable technical and financial problems, such as equipment damage and production which does not meet quality requirements. Industrial facilities are typically very complex, with particular designs to meet specific manufacturing and production objectives. This diversity complicates the standardization of an interface for energy management.

In order to have a common understanding of energy management in industrial facilities, a common model is required for different industrial facilities. The model requires common definitions of:

- model elements of energy management in industrial facilities;
- model architecture of energy management in industrial facilities; and
- approaches of energy management in industrial facilities.

The rest of this Subclause 5.2.2 describes the planning and scheduling functions needed to coordinate the use and supply of energy to the smart grid.

5.2.2.2 Model elements

Figure 4 lists all the elements which are essential to build energy management model in industrial facilities. Each element is uniquely identified by one graphic symbol.

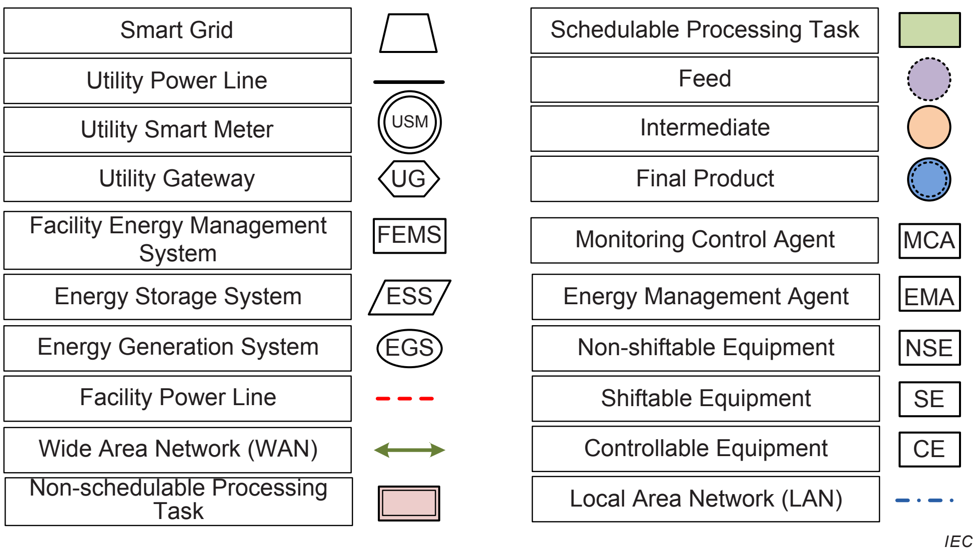


Figure 4 – Model elements

5.2.2.3 Model architecture

5.2.2.3.1 General

Figure 5 represents the energy management model in industrial facilities, which illustrates the interrelationship of model elements. The model architecture consists of main architecture (a) and task structure (b).

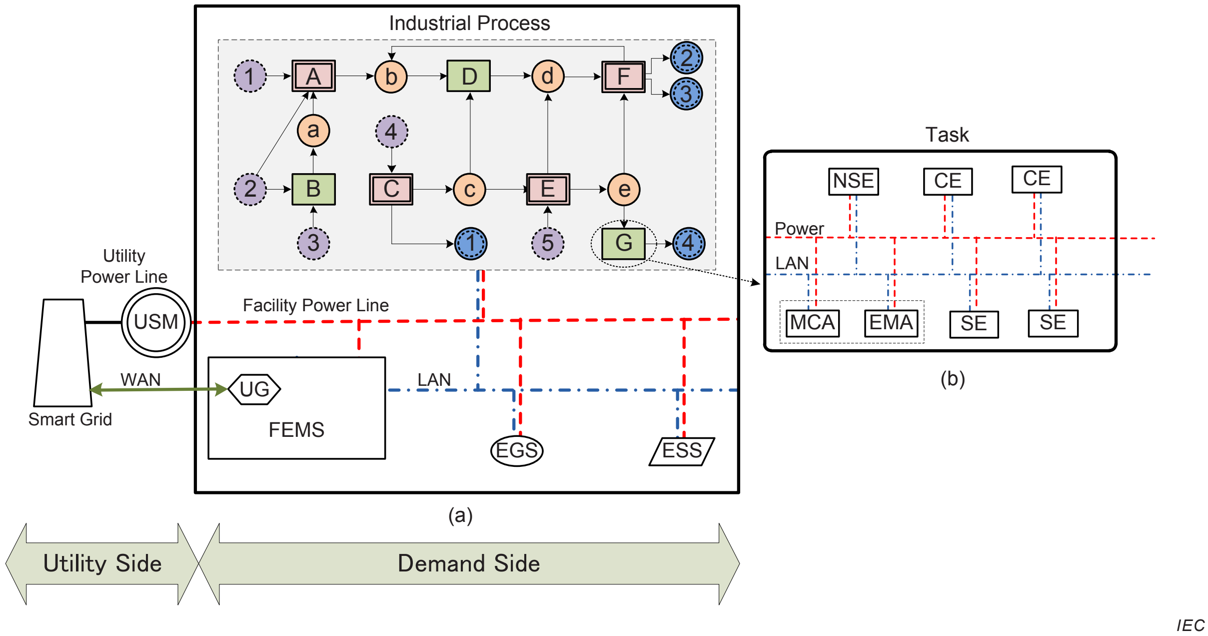


Figure 5 – Model architecture: (a) main architecture, (b) task structure

5.2.2.3.2 Main architecture

Figure 5(a) represents the main architecture which is divided into the smart grid (utility side) and industrial facility (demand side). In general, the smart grid reads the smart meter while the utility gateway (part of the FEMS) is in charge of smart grid communication. Communications within the industrial facility, represented by the LAN in this figure, may represent multiple networks within the facility as described in Figure 3.

The industrial facility has two kinds of interaction with smart grid. The first is the energy transmission and the second is the informational communications. Although there is some form of counterpart player for each interaction, the model does not make provision for differences and thus acts as a monolithic external smart grid player.

The industrial facilities consist of FEMS, EGS (optional), ESS (optional), LAN, facility power line, and industrial process. The FEMS receives the energy price information from the smart grid and schedules the energy demand of the industrial facilities according to preinstalled energy management algorithms and strategies. The EGS is able to generate energy using industrial waste heat, solar power, wind power, or other sources. The ESS can store energy from the facility power line and from the EGS. Both the EGS and ESS can serve as the energy sources for all or part of the industrial facilities. The LAN enables the exchange of messages among the elements in industrial facilities and the facility power line distributes energy to each element.

The industrial process part represents the topology of industrial facilities which produces final products from a series of raw materials and/or purchased semi-finished products with each task represents a group of processing operations. For example, feeds '2' and '3' are processed by task 'B' creating intermediate status 'a' which is further processed by non-schedulable processing task 'A' on route to becoming final products '2' and '3'.

Within the industrial process part, the energy demand of some tasks needs to be satisfied immediately (so called non-schedulable tasks). Otherwise, the reliability of industrial process may be affected or the product quality cannot be satisfied, etc. The energy demand of the other tasks can be scheduled among multiple operating modes (so called schedulable tasks).

EGS, ESS, and schedulable tasks are potential candidates of energy management in industrial facilities to balance the demand side and supply side to reduce the probability of an energy mismatch.

5.2.2.3.3 Task structure

Figure 5(b) represents the task structure. Each task is composed of MCA, EMA, power source switch, and industrial processing equipment. For local tasks, MCA (client process manager) monitors and controls processing with the objective to satisfy industrial requirements such as reliability, safety, product quality and others. EMA is the energy manager of a local task, which monitors energy consumption and manages the electric load of the task. Industrial process equipment can be classified as non-shiftable equipment (NSE), controllable equipment (CE) and shiftable equipment (SE). Energy demand of NSE needs to be satisfied immediately because an energy shortage for NSE may cause equipment damage, affect product quality, etc. CE support multiple operating levels with each level having different energy demand and operating characteristics. The energy demand of SE can be satisfied at an earlier or later time. (CE and SE only exist in schedulable tasks.)

For schedulable tasks, EMA categorizes multiple operating modes for the local task with each mode having a different production rate and energy demand, which facilitates energy management in industrial facilities.

5.2.2.4 Approaches to industrial facility energy management

In order to implement energy management in industrial facilities, the smart grid announces energy prices that reflect the energy supply and demand relationships at pre-specified time intervals (for example, intervals between 30 and 60 minutes). Low energy prices would be announced when the energy demand is low in order to encourage energy use, while high energy prices would be announced when the energy demand is high in order to discourage energy use.

After receiving the energy price for a stage, the FEMS of industrial facilities manages the energy demand based on preinstalled energy management algorithms and strategies through two approaches.

1) Approach 1: FEMS determines the operating mode for schedulable tasks in that stage.

   Under the premise of satisfying the requirements of industrial facilities (such as market demand, reliability, safety, resource storage, etc.), a low energy price encourages the FEMS to command schedulable tasks to operate in a mode that has high energy demand with fast production rates, while a high energy price encourages the FEMS to command schedulable tasks to operate in a mode that has low energy demand with slow production rate. As a result, the energy demand of industrial facilities is increased when the energy price is low and is decreased when the energy price becomes high.

2) Approach 2: FEMS commands the ESS to store energy from the smart grid or commands the ESS and EGS to supply energy to processing tasks.

   A low energy price encourages the FEMS to command the ESS to store energy from the smart grid and command the processing tasks to use the smart grid as their energy source, which increases the energy demand. A high energy price, on the other hand, encourages the FEMS to command the ESS and EGS to supply energy to some or all of the processing tasks, which decreases the energy demand of the industrial facility.

In summary, the energy demand of industrial facilities is shifted from peak-demand periods to off-peak demand periods using energy management approaches; this contributes to balancing the energy supply side and demand side.

5.3 System interface model between facility and smart grid

Figure 6 highlights the interface between the FEMS within the facility and the smart grid. The utility gateway may include security functions, for example using a firewall, to protect the FEMS from external attack. The FEMS is also shown connected to the facility smart meter (FSM), and in practice there may be more than one meter, and the connections to them are internal to the facility and out of scope of this document.

This Technical Specification represents the various entities and actors within the smart grid as a single actor called smart grid. Thus, Figure 6 depicts the FSM but not utility smart meter (USM), which exists as a part of the smart grid.

Despite the FEMS being presented as a single box in Figure 6, this should not imply that it is a single appliance. The FEMS represents a set of related functions where some tasks may be classified as level 4 functions while others may be associated with lower levels (as represented in Figure 3).

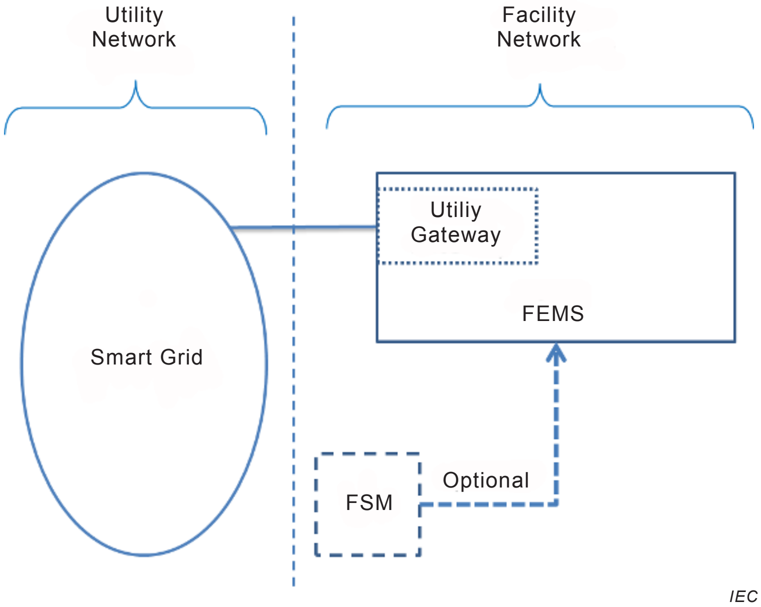


Figure 6 – Network architecture model

FEMS encompasses the functions needed for the managements of facility energy use. The internal operation of the FEMS, and the interfaces between FEMS and facility internal equipment is out of scope of this Technical Specification.

5.4 Security requirements

Cyber-attacks represent significant threats to industrial facilities where security breaches can place equipment, production quality, system reliability and facility safety at risk. Firewalls, software and other security protocols shall provide adequate security assurance levels by preventing the propagation of cyber-attacks within the FEMS.

Industrial security shares with smart grid security the primary aim of ensuring the protection of people, the environment and physical assets, and ensuring uninterrupted safe operation. This emphasis is unlike information and communications technology (ICT) security where the protection of information is typically most important. This differing emphasis significantly affects security strategies, for example industrial security often placing "integrity and authentication" and "fail-safe", above ensuring the confidentiality of information.

Security requirements for the FEMS shall be compliant with IEC TS 62443-1-1, IEC 62443-2-1, IEC TR 62443-3-1, and IEC 62443-3-3.

The security model shall be based on a graded approach. The interfaces shall be assigned to security degrees according to their importance to system security and characteristics. System security should adopt a multi layered approach rather than placing reliance on a single security measure.

The utility gateway shall be evaluated to ensure that it has the highest security assurance level since it is connected to an untrusted external network.

Accordingly all utility gateway communication shall be evaluated in the FEMS design phase to ensure that all external communications are adequately protected against security breaches.

More details are provided in Annex C.

5.5 Safety requirements

The operation of the interface shall not at any time impair the safe operation of the facility. The implementation of suitable safety instrumented systems, and other required safety measures, are outside the scope of this Technical Specification (for further information refer to IEC/ISO 61508 [1] and any related sector specific standards such as IEC/ISO 61511[2]).

The FEMS shall be responsible for ensuring that all information received from the smart grid is validated against permissible values and that any information that may affect the operation of facility resources is properly validated and authorized by facility.

5.6 Communication requirements

5.6.1 General

Communication between the FEMS and the external grid operator is expected to be supported using the global internet, using secure virtual private channels or other suitable security measures. Compatibility with existing common means for communications, and means used for communications with the smart grid, will be essential. Since the performance of an internet-based communications infrastructure cannot be guaranteed, the messaging protocols shall accommodate situations where message may be excessively delayed or lost. The communications requirements outlined in this Clause 5.6 shall be met by the communications network.

5.6.2 Use of common communications technology

Communications to support the facility interface to the smart grid should not require the deployment of additional technology unless suitable technology does not already exist. Thus existing Internet connections and firewall technology should be capable of being used if desired by the facility. This implies that the data transport protocols used by the interface should conform to common standard protocols and security protocols.

5.6.3 Communication security requirements

The Communications technology shall meet all of the security requirements identified in 5.4 including support for the secure communications standards needed to meet these security requirements.

In addition, to address the requirement to minimize the facility's vulnerability to externally initiated denial of service attacks (see 5.4) from the general network, the communications system shall not require the facility to accept communications initiated by external parties. Therefore, the FEMS shall always initiate communications. Such communications may be initiated by the FEMS periodically or in an event-driven manner. To prevent the cyber-attacks, unauthorized communications from and/or to utility gateway shall be discarded. It means related device shall be predefined and other communications shall be discarded.

5.6.4 Network availability

High network availability is required to ensure that the communications needed to manage manufacturing processes, costs and respond to energy emergencies, is not interrupted or delayed. Any communications failure shall be addressed promptly. Consideration should be given to using redundant links if adequate availability cannot be obtained using a single link.

The exchange of periodic messages over the link(s) will ensure that communications failures are detected in a reasonable time.

5.6.5 Time synchronization

A common understanding of time is essential for the correct interpretation of cost and planning information. Messages containing time stamps may also be used for audit purposes. Many facilities develop their own understanding of time based on GPS or other precision time sources.

In some cases the communications network may be used to maintain consistency within a reasonable range based on local agreement between the facility and the smart grid.

The security issues of the time synchronization approach selected should be assessed. For example, if network synchronization uses common protocols such as unsecured NTP, the facility should ensure that externally initiated attacks on the facility's understanding of time do not impact safety and ongoing operations.

5.7 Audit logging requirements

Many facilities will require that all communications with the smart grid be capable of being audited. Such auditing may be required to ensure that records are available to assist in the post-incident analysis of significant events, or for the purpose of ensuring that invoicing and billing functions accurately reflect purchases and sales of power.

For some arrangements it may be necessary to ensure that such records can withstand scrutiny by third parties, or meet evidentiary requirements. Such record keeping may require that significant communications between the FEMS and the smart grid be time-stamped and signed, include non-repudiation attributes, or be copied to trusted third party entities.

5.8 Information requirements

5.8.1 General

This Subclause 5.8 summarizes at a high level the information requirements for the messages identified in the use cases of Annex A. This assessment takes into account the ability of existing and planned standards to address the needs of industry. Many groups are developing such standards, and thus this assessment takes into account both existing and under development standards. Gaps are identified so that the needs of industry can be incorporated into future work.

5.8.2 Information attributes

Table 1 represents the expected information exchanged between smart grid and FEMS derived from the use cases in Annex A. Facility internal messages, such as between FEMS and LOAD or FER, are outside the scope of this Technical Specification. The smart grid internal messages are also out of scope of this Technical Specification.

The columns in Table 1 are used as follows. "UC" refers to the facility-grid (FG) use cases which are fully explained in A.3.3. "Interaction" refers to the specific interaction within the corresponding use case, as described in the correspondingly numbered paragraph of the detailed description within A.3.3. For example, the first entry in the table identifies interaction 3-4 of FG-100 which is explained in A.3.3.1.2.

Note that some of the interactions described in the use cases are internal to the facility or smart grid and do not represent interactions crossing the interface. The contents of these are a local matter and out of scope of this document. Thus for example, the semantics and data of interactions 1-2 and 2-2 of FG-100 are not included in Table 1.

"Dir" indicates the direction of the data flow between the smart grid and facility energy management system. For example, SG > FEMS indicates that information flows from SG to FEMS. "Function" provides a general description for the interaction. "Freq." identifies the approximate frequency of the interaction, for example "week/month" indicates that a corresponding interaction might occur every week or month. "Perf" identifies the approximate performance requirement, rated "low", "medium" or "high". These are relative measures where "low" indicates that delivery within several minutes is acceptable, while "high" implies that reliable delivery within about ten seconds is acceptable. "Semantic" represents the explanation of the interaction provided in A.3.3. "Example of data transferred" provides a list of example information which is expected to be transferred by the corresponding interaction.

Table 1 – Required information

UC	Interaction	Dir	Function	Freq.	Perf.	Semantic	Example of data transferred
FG-100	3-4	SG > FEMS	SG provides requested energy records	week/ month	low	Energy consumption, generation or other energy supply (e.g. as read from USM). Historical energy consumption, generation or other energy supply, along with billing and invoicing history Optional forward energy pricing information for sale and potential purchase of energy or other energy services available (see also FG-300). Historical and forward predicted power quality information as available. Other information as agreed, e.g. weather information.	Information as offered by the SG may include for example: – Energy consumption, generation or other energy service supply or use (e.g. as read from USM). – Historical energy consumption, generation or other energy service supply or use, along with billing and invoicing history. – Forward energy pricing information for sale and potential purchase of energy or other energy services available, including time of day, seasonal or other largely fixed (static) price lists (may overlap information provided using FG-300). – Historical and forward predicted power quality information as available. – Fixed (stable) characteristics of energy services made available to the Facility (e.g. SG ability to withstand rapid load changes). – Historical and current environmental impact data corresponding to energy services. – Other information as agreed, e.g. weather information

UC	Interaction	Dir	Function	Freq.	Perf.	Semantic	Example of data transferred
FG-100	4-3	FEMS > SG	FEMS provides requested energy records	week/ month	low	Information as offered by the Facility may include: Energy consumption, generation or other energy supply (e.g. as read from FSM). Historical energy generation or other energy supply, along with invoicing history Optional forward energy pricing information for sale of energy (generated by the Facility) or other energy services offered. Historical and forward predicted power quality information as available. Other information as agreed.	Information as offered by the Facility may include for example: – Energy consumption, generation or other energy service supply or use (e.g. as read from FSM). – Historical energy generation or other energy supply or use, along with invoicing history. – Forward energy pricing information for sale of energy (generated by the Facility) or other energy services offered. – Historical and forward predicted power quality information as available. – Fixed (stable) characteristics of Facility consumption, generation or other energy service supply or use (e.g. load change characteristics of Facility equipment, performance characteristics of Facility generation equipment). – As needed, Facility largely static equipment and configuration information (e.g. to support the transfer of IEC 61970-301 [5]“power grid model” information). – Historical and current environmental impact data corresponding to energy services. – Other information as agreed, e.g. local weather information.

UC	Interaction	Dir	Function	Freq.	Perf.	Semantic	Example of data transferred
FG-200	1-6	FEMS > SG	FEMS sends energy plan	day/ week	medium	Energy plan describes the consumption, generation, or any other energy services expected to be used during each pre-agreed interval during the planning period. Optionally, requested content of energy plan can be identified in advance between SG and FEMS.	Facility energy plan describes the planned consumption, generation, or any other energy services expected to be used or supplied during each pre-agreed interval for upcoming planning periods. This may include for example: – Multiple plans. – Each plan uniquely identified. – Plans may cover differing planning periods. – Plans may overlap (e.g. facility may not have a single plan active at any one time). – Plans may be used to define maximum consumption (peak load) of Facility for upcoming period. – Plans may be used to offer generation, storage or other energy services to be used at option of SG (e.g. emergency standby generation service or regulation service). – Plans may need to include energy service characteristics (e.g. ramp-up, ramp-down) of intervals within the planning period if not previously characterized (e.g. using FG-100). – Environmental impact data for energy services offered. – Link to manual communications (e.g. reference point to allow manual communications between SG and Facility staff) – Other information as agreed, e.g. to support SG energy planning.
FG-200	2-1	SG > FEMS	SG responds to plan	In response	high	Optional confirmation or rejection of plan.	SG response to the energy plan may include for example: – Acknowledgment of plan receipt. – Request to modify the plan. – Request to activate a plan (e.g. to accept offer to provide standby service). – Environmental impact data for energy services to be provided. – Link to manual communications.

UC	Interaction	Dir	Function	Freq.	Perf.	Semantic	Example of data transferred
FG-300	1-2	SG > FEMS	SG issues price, environmental and other schedules	day/ week/ month	medium	SG provides price schedules covering future period(s) which define the sale price of energy and if appropriate the purchase price of energy and any other energy services offered by the Facility. Formats may range from simple manually distributed fixed time-of-day sale prices for energy, to more detailed pricing distributed using this interface for specific intervals of future time.	SG provides price schedules covering future period(s) which may include for example: – The sale price of energy or other energy services offered by SG. – The offered purchase price of energy or other energy services offered by the Facility. – Environmental impact data for energy services. – Prices may range from simple manually distributed fixed time-of-day prices to more detailed prices for specific intervals of future time. – For larger Facilities where dynamic prices may be offered using FG-400, minimum and maximum prices may be indicated to allow Facility advanced planning.
FG-300	2-3	FEMS > SG	FEMS issues price, environmental and other schedules	day/ week/ month	medium	Optional FEMS provides equivalent information for the energy services it offers.	FEMS provides price schedules for the energy services it offers, which may include for example: – The offered sale price for the energy services offered by the Facility. – Prices may range from simple manually distributed fixed time-of-day prices to more detailed prices for specific intervals of future time. – Environmental impact data for energy services.
FG-400	1-2	SG > FEMS	SG issues price offer	minute/ hour/ day	high	SG provides price offer for energy service.	SG provides dynamic price offer for energy services, which may include for example: – Short term price for energy over next pre-agreed interval(s) of time (such pricing allows SG to attempt to manage hourly load or availability of facility provided generation and storage using price incentives). – Updated environmental impact data.
FG-400	3-1	FEMS > SG	FEMS responds to price offer	In response	high	FEMS accepts or rejects request. Contents of response is vary.	FEMS response to the offer may include for example: – Acknowledgment of offer only (acceptance can be designated using FG-500 if required).
FG-500	1-3	FEMS > SG	FEMS sends energy update	minute/ hour/ day	high	FEMS provides new or updated energy plan to SG.	FEMS provides new or updated energy plan to SG, which may include for example: – Indication of a change in energy service use or supply. – Identification and specification of a new energy plan (see FG-200). – Updated environmental impact data.

UC	Interaction	Dir	Function	Freq.	Perf.	Semantic	Example of data transferred
FG-500	2-1	SG > FEMS	SG responds to energy update	In response	high	SG response to energy update, e.g., accepting energy generation if it is offered in updated plan.	SG response to the updated energy plan may include for example: – Acknowledges new energy plan. – Rejection of new energy plan (e.g. if SG cannot provide requested increased energy or cannot tolerate load shed). – Link to manual communications.
FG-600	1-1	SG > FEMS	SG sends risk notice	event-based	high	SG provides: a) an indication of the probability of power interruption or power degradation b) specific information about a rolling blackout or brownout along with scheduling information	SG sends a risk notice to the Facility which may include for example: – The identification of increased risk of a power interruption or power quality degradation along with its expected duration and reason. – Specific information about a rolling blackout, brownout or other power quality deviation along with scheduling information. – Weather or other information which may affect identified risk. – Other information as pre-arranged, e.g. a request for emergency energy supply. – Link to manual communications.
FG-600	2-7	FEMS > SG	FEMS responds to notice	In response	high	FEMS acknowledges request. a) with offer to reduce of limit load for risk period b) other response as previously agreed (e.g. request for delay)	FEMS response to the notice may include for example: – An offer to reduce or limit load for risk period. – Other response as previously agreed, e.g. offer of emergency supply.
FG-700	1-2	SG > FEMS	SG sends energy change request	event-based	high	SG sends request for alteration of energy profile.	SG sends energy change request which may include for example: – Request to reduce (curtail) or increase load, generation, or other energy service according to schedule (start and end times) provided in this request or in previously provided energy plan. – Request to limit consumption by load group or other specification. – Election to consume energy service offered by Facility in a pre-specified energy plan (e.g. SG elects to consume regulation service provided by Facility according to pre-specified energy plan). – Priority of request (degree of urgency). – Updated environmental impact data.

UC	Interaction	Dir	Function	Freq.	Perf.	Semantic	Example of data transferred
FG-700	2-1	FEMS > SG	FEMS responds to request	In response	high	FEMS accepts or rejects request. FEMS specifies accepted amount or Group ID depends on contract	FEMS response to energy change request may include for example: – Acceptance or rejection of request (as previously agreed).

Annex A
(informative)

User stories and use cases

A.1 General

Industrial facilities have requirements for such communications which exceed, for example, the needs of home and building automation applications. These differences can be summarized as follows:

1) Many industries have significant options for production scheduling given sufficient notice, but they can seldom respond to unplanned energy shortages by simply reducing their short term demand across the board. Unlike typical consumer applications where loads can be reduced, for example by acting on heating, ventilation, cooling and lighting, it is often critical that energy supply be kept in planned conditions once industrial production has started to ensure that production quality, facility safety and security are maintained. Some types or phases of production, once started, cannot be stopped immediately without damage to equipment. Thus the criteria used to respond to unplanned demand events and energy fluctuations differ from those that can be used for home and building automation. The consequences of unplanned changes are factored into operations and into the design of the industrial facility itself.
2) Some industrial facilities can postpone or reduce production at times of predicted energy shortage if given sufficient notice. Industrial facilities can be designed to adjust the production quantity, e.g. through parallelism, and the scheduling of activities across shifts. Industrial facilities could choose to reduce production if the current energy cost makes the incremental cost of production exceed the incremental product's value. Industry could choose to operate energy intensive operations during periods when energy costs are low. Simple time-of-day pricing would not always provide the flexibility needed to allow full exploitation of the scheduling possible. The time scales over which such negotiations and commitments to energy supply would be made will typically vary between industries.
3) Many larger industries have significant internal energy generation and/or storage capabilities. A facility with in-house hydroelectric generation could draw energy from the smart grid during off-peak times and use the corresponding saved hydroelectric power to supply energy to the smart grid at peak times, thus providing the equivalent of pumped energy storage. Facilities with co-generation facilities could also assist the smart grid in meeting normal and emergency energy demands. These situations can only be addressed if the smart grid operator and industry can dynamically negotiate and plan such arrangements on a short -term basis.

To implement such applications, industry will require an interface to smart grid which provides sophisticated strategic planning and, in the future negotiation capabilities along with the tactical communications needed to support agreed day-to-day and second-by-second power transfers.

A.2 User stories

The high level facility user stories (FUS) applicable to industrial facilities are summarized in Table A.1. Utility user stores (UUS) applicable from the smart grid perspective are summarized in Table A.2.

Table A.1 – Facility user stories: facility manager view points

Facility user story ID	Description
1	Production planner receives information, including current and future pricing information, from the smart grid to use as input to production planning and scheduling. NOTE 1 Such advanced pricing information may involve price ranges with final pricing only available nearer to the time of consumption or supply.
2	Production planner develops the production plan based on production requirements, cost and availability of input materials, equipment, labour, energy, etc. The planner designs production plan and schedule to minimize costs. The planner may provide resulting energy plan and schedule to the smart grid operator. For larger facilities, and in the future if supported, the facility may negotiate energy use and supply with the smart grid operator, include agreements on price (or range of pricing) and quality/performance during planned and identified production time intervals.
3	Production planner monitors current production and unit/equipment/labour status in the facility, including pricing updates from the smart grid. The planner modifies production plan as needed and as possible to address significant changes from originally identified input conditions. As needed, planner notifies smart grid operator of significant changes in energy use or supply. (Updates to contracted pricing are forwarded to facility management.) NOTE 2 The production planner will likely be limited in their ability to reschedule production once production has begun.
4	Operation manager (facility operator) monitors facility operation and responds to deviations from planned operations; including deviations from planned energy use or generation. For example, should energy demand exceed planned demand, the operator might increase internal generation, use internal storage (battery) resources, or request additional supply from the smart grid. If generation exceeds that planned, the operator might offer additional generation to the smart grid or divert the excess to local storage. NOTE 3 The operation manager provides sufficient responses to these deviations to ensure continued safe operation of the facility, to avoid damage to equipment and to avoid reductions in product quality.
5	Operation manager (facility operator) receives information from the smart grid operator regarding deviations from planned energy supply or use arrangements. For example, operation manager needs to be informed of rolling blackout and/or risk of blackout from the smart grid so that changes to operation procedure and/or control strategies can be made to avoid any damage in production. Smart grid operator may request the emergency supply of energy and the facility operator may respond with changes to operation procedures to supply the requested power.
6	FEMS receives energy consumption and supply measurements from FSM or utility company operator and final contract pricing information, for the purpose of accumulating cost information for utility bill reconciliation and for the generation of invoices (if needed) for supplied power.
7	Quality assurance department wants to have energy related information per product (e.g. specific energy consumption and some other attributes), and provide it as energy foot print to users when supply chain management requests.
8	Facility accumulates records of all significant transactions and information to allow post-incident analysis, billing discrepancy audits, and to provide historical performance information in support of future production and operations planning. These records may be needed to meet evidence requirements for post-incident audits or billing discrepancy audits.

Table A.2 – Utility user stories: utility operator view points

Utility user story ID	Description
1	Utility-side operation receives information from facility regarding availability of load shedding, generation and storage over future time periods. Information may include ramp-up and ramp-down characteristics, cost/pricing information, emergency commitments, etc. This information may be used by the smart grid-side operator to plan future operations.
2	Utility-side operation receives from FEMS forward predictions of energy consumption and energy supply (as appropriate). Smart grid requires option to request changes to these plans to FEMS.

A.3 Use cases

A.3.1 Use case analysis

This Clause A.3 derives specific facility-grid (FG) use cases based on the high level facility user stories (FUS) and utility user stories (UUS). These use cases will be used to evaluate candidate solutions (existing and under development standards capable of supporting the corresponding use cases).

All the use cases described below may not be applicable to all industrial facility arrangements. For example, facilities which only require access to past and/or future pricing and billing information for planning or bill reconciliation purposes would only need use case FG-100.

The dependency between user stories and use cases is shown in Table A.3.

Table A.3 – Dependency between user stories and use cases

User story	FG-100	FG-200	FG-300	FG-400	FG-500	FG-600	FG-700	FG-800
FUS1	x		x					
FUS2		x						
FUS3			x	x				
FUS4				x	x	x		
FUS5						x	x	
FUS6	x							
FUS7	x		x					
FUS8	x							
UUS1	x		x					
UUS2		x		x	x		x	
NOTE The FG-800 column is greyed out, since it is for future study.								

Each of use case is summarized below.

1) FG-100: Facility and smart grid obtain current and past energy information.

   The facility obtains electronic access to current and past energy consumption, supply, billing and other available information from the smart grid. Similarly, the smart grid obtains current and past energy information as made available by the facility.

   NOTE 1 This use case addresses the requirements of FUS1, 6, 7 and 8 and UUS1.

2) FG-200: Facility provides energy consumption and supply plan to smart grid.

   The facility defines its general forward (predicted) energy consumption and supply plan (facility energy plan) to the smart grid. This information will be useful to the smart grid operator to assist in longer term energy planning.

   NOTE 2 This use case addresses the requirements of FUS2 and UUS2.

3) FG-300: Smart grid provides stable (long term) price schedule to facility.

   The smart grid provides pricing and related information to support facility development of daily or longer production plans. For similar customers, the SG might issue the same price schedule to many customers. Both selling and purchase (if appropriate) prices, along with coefficients of environmental impact, may also be provided.

   NOTE 3 This use case addresses the requirements of FUS1, 3 and 7 and UUS1.

4) FG-400: Smart grid provides dynamic (short term) pricing to facility.

The smart grid issues short term pricing incentives near to the time of energy use or supply as an incentive for the facility to adjust is energy use or supply. The objective of the SG is to maintain balance between generation and supply near the time of use.

NOTE 4 This use case addresses the requirements of FUS3 and 4 and UUS2.

5) FG-500: Facility informs smart grid about upcoming consumption and supply.

The facility provides more timely information than in use case FG-200 about its upcoming consumption and supply, including possible updates to any previous energy plans.

NOTE 5 This use case addresses the requirements of FUS4 and UUS2.

6) FG-600: Smart grid informs facility of blackout notice.

The smart grid predicts the risk of blackout, brownout, or other abnormal power situation and informs the facility about any mitigation plans which will impact the facility. This will allow the facility to respond by taking the measures necessary to protect the facility, its staff and any ongoing production.

NOTE 6 This use case addresses the requirements of FUS4 and 5.

7) FG-700: Smart grid requests facility to alter consumption or supply

The smart grid requests the facility to shed loads, alter proposed upcoming consumption or supply plans or to provide emergency power.

NOTE 7 This use case addresses the requirements of FUS5 and UUS2.

8) FG-800: Facility and smart grid negotiate price schedule.

This future use case contemplates arrangements whereby the facility and smart grid electronically negotiate price, consumption and supply. This use case is for future study.

NOTE 8 The audit user story does not require a separate use case since it only requires enhancements to the existing cases to ensure that auditable records of significant transactions are retained.

NOTE 9 Not listed as a use case is the requirement for a potential “registration” case where the FEMS and smart grid exchange enrolment and set-up information to define the future extent of their interactions.

A.3.2 Actor names and roles

Figure A.1 and Table A.4 describe the actors/stakeholders and their relationship. In Figure A.1, the shadowed rectangle represents the interface between the smart grid and the FEMS, the main focus of this Technical Specification. The dotted red and blue lines in the diagram represent the flow of energy and information respectively.

The balance of this Annex A provides a more detailed description of each of the use cases.

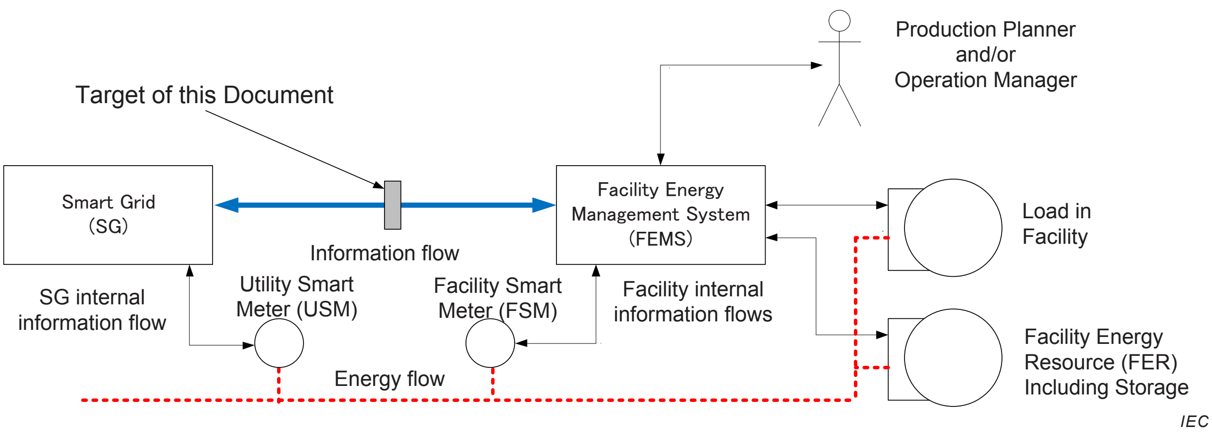


Figure A.1 – Generic communication diagram between the smart grid and the FEMS

Table A.4 – Actors and roles

Actor	Role
Facility energy management system (FEMS)	FEMS is any device/software or group of them installed in the industrial facility which provides the functions of energy management, control and planning in conjunction with responsible facility management (see production planner and operations manager, below). The FEMS functions are accomplished by one or more parts of an integrated facility automation control and enterprise system which is modelled in this Technical Specification according to the IEC 62264 standard. This actor can communicate with all of the other actors.
Production planner	This actor is a human function responsible for decision making in production planning and scheduling in production control. Production planner may have role of generation planning and may coordinate with generation planner. Production planner receives all necessary information, e.g. requested cost, requested delivery, product quality, as well as conditions such as utility price, environmental factors, to decide appropriate actions in production. Production planning is considered part of business planning and logistics and modelled at level 4 in IEC 62264.
Operation manager	This actor is responsible for the carrying out production plans and is authorized to respond to real-time changes based on feed-back from the process and other internal or external events. These functions are considered part of production operations management (at Level 3) and monitoring, supervisory control and automation (at levels 1 and 2) in the IEC 62264 model.
Smart grid (SG)	External-to-facility electrical grid actor (smart grid market role) which interacts with FEMS. This actor is used to represent a range of potential external entities, including an electrical grid operator, independent (electrical) system operator, energy aggregator, etc. This actor is shown interacting with the FEMS and the smart grid owned smart meter.
Utility smart meter (USM)	Device which measures energy consumption or generation per time tariff and provides this information to utility company. Since this information may be used for billing purposes, its operation and metrological accuracy is normally subject to regulatory oversight. Secure communications with this device is provided by the smart grid. Read-only access to this information may be provided to the facility, although typically this information is only available indirectly from the utility company itself.
Facility smart meter (FSM)	Device which measures energy consumption or generation per time and makes available the information of total power consumption and generation in the facility to FEMS internally.
Load in facility	This actor represents all of the energy consumers in the facility. It consists of all of the loads managed by the FEMS from an energy perspective. This actor communicates with FEMS for the purpose of optimizing its operation.
Facility energy resource (FER)	This actor represents all of the energy generation and storage resources in the facility. These resources may be used to supply loads in the facility or might be used to supply power to the smart grid. Energy resources include combined heat and power (CHP) systems. These resources are managed by the FEMS from an energy perspective.

A.3.3 Use case descriptions

A.3.3.1 FG-100: Facility and smart grid obtain current and past energy information

A.3.3.1.1 General description

The facility obtains access to their current and past energy consumption, supply, billing and other available information records from the smart grid. The purpose of such access is, for example, to:

- permit access to the accumulation of historical data, and “energy footprints”, in support of future planning and quality assurance,
- assist in budgeting by providing access to power consumption and supply costs and revenues,
- permit FEMS to monitor on-going operations and detect deviations from plans,
- permit enterprise systems (via FEMS) to reconcile billing information, and
- support audit systems (if used).

The smart grid obtains access to current and past energy records, as made available by the facility. The purpose of such access is, for example, to:

- permit access to the accumulation of historical data, and “energy footprints”, as available and recorded by the facility, in support of SG future planning,
- assist in budgeting by providing, when available, access to power generation, storage and other service pricing as offered by the facility,
- permit SG access to FEMS monitoring data, for example power quality measurements made by the facility, and
- assist SG planning by providing access to the characteristics of power generation, storage, consumption and other relevant energy capabilities of the facility.

NOTE Some power utilities model the energy grid in support of forward energy planning. For larger facility interconnections, the characterization of significant facility energy loads and resources might be conveyed using this use case, for example by providing information according to the IEC/TC57 common information model (CIM) IEC/ISO 61970-301[5].

A.3.3.1.2 Detailed description

The numbered items in this Subclause A.3.3.1.2 correspond to the similarly numbered items in the sequence diagram of Figure A.2. For example, item 1) describes the sequence identified with the number (1) in the figure and consisting of interactions (1-1) and (1-2) in the figure. For interactions which cross the facility and smart grid interface, their contents are summarized in Table A.5.

The first two items below describe assumed ongoing internal operations within the SG and facility which accumulate current and historical energy data that may be made available to the other party. Since these operations do not result in an interaction crossing the interface, they are not included in Table A.5.

1) Smart grid gathers and records billing and other data. How this is done depends upon the internal procedures of the SG and thus is out of scope of this document. However typically the SG will read utility smart meter(s) via their own networks (or using manual procedures), compute billing data, record performance, environmental and quality data, maintain customer billing accounts, and store this information for future use.

   NOTE 1 In less typical situations, the SG may access a facility smart meter (FSM), for example when no USM is available; this is shown by the dotted line in Figure A.2. However, such a connection may represent an unacceptable security risk to the facility since it potentially bypasses the security protection provided by the FEMS. Possible approaches to allow access to FSM data by SG include the enforcement of unidirectional communications, the provision of a secure isolating conduit (tunnel) between the FSM and SG or the routing of this information via the FEMS (as indicated in item 4) of this Subclause A.3.3.1.2). Except as discussed in item 4), such alternate communications is out of scope of this document.

2) The FEMS gathers and records various performance, invoicing and other data (as determined by the facility). The procedures used and records maintained are determined by the facility and thus are out of scope of this document. However typically the facility will read data from FSM(s) and internal load, generation, storage and other equipment, potentially compute invoicing data for generation, storage or other services provided to the SG, record performance, environmental and quality data, and store this information for future use.

   NOTE 2 In less typical situations, the facility may access a USM, for example when no FSM is available; this is shown by the dotted line in Figure A.2. While manual readings of the USM might be provided safely, any direct non-read-only electronic connection may represent an unacceptable security risk to the SG. Such alternate communications is out of scope of this document.

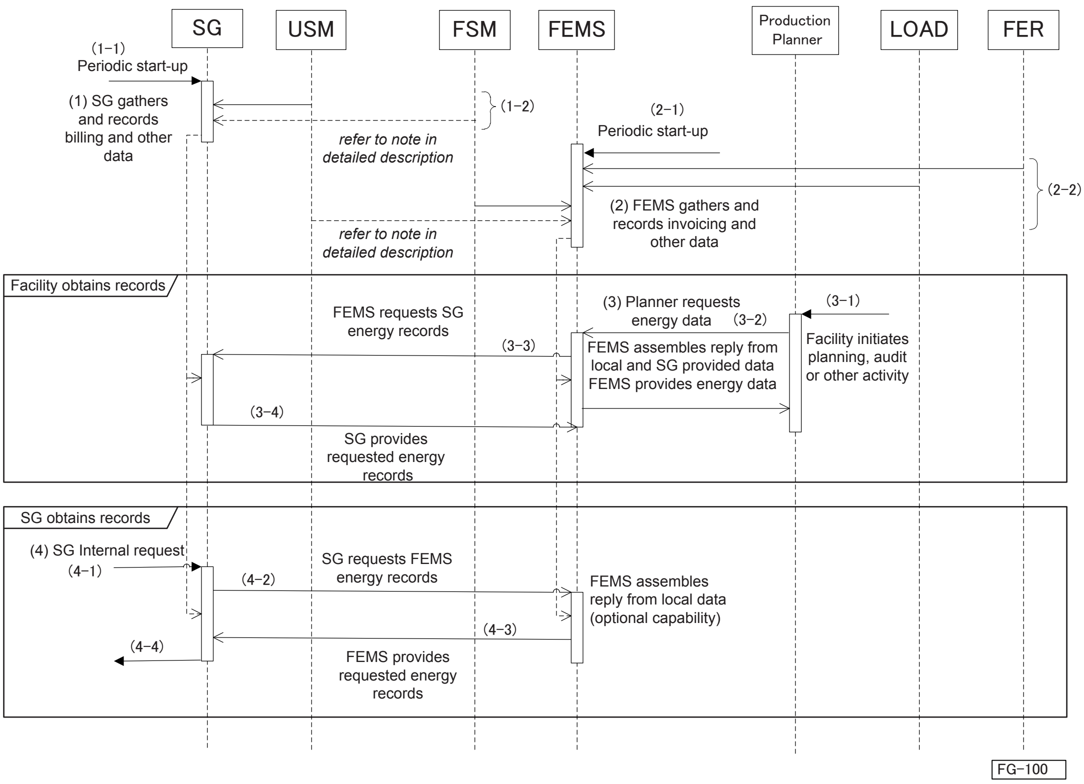
3) The production planner or other entity within the facility makes an internal request for energy data from the FEMS. The FEMS initiates a request to the SG for energy data and the SG responds with the requested data. The SG data is combined with any local energy data and returned to the requestor. Data provided by the SG may include a range of data, including environmental (e.g. CO_2) emission data. The solution identified to support this transfer needs to be flexible enough to meet current and future needs. A preliminary identification of the kinds of information to be supported is provided in Table A.5.

NOTE 3 The language "FEMS initiates" used here does imply that the SG must respond to externally initiated communications. Due to security concerns both the SG and FEMS may prefer to only initiate communications. Some candidate communications solutions utilize a common intermediate server infrastructure to manage interparty communications, e.g. using XMPP. In such configurations, the parties poll the infrastructure for messages and thus do not need to respond to communications initiated by others.

4) An entity internal to the SG initiates a request for energy data from the facility. This request is received by the FEMS and the FEMS responds with the requested available data. Typical information provided might be measurements taken by FSM(s) or other quality and performance measuring devices, invoice data for services sold to the SG, the characterization of facility equipment, or other information previously agreed-to. This data provided by the FEMS may include a range of data, and the solution identified for this case needs to be flexible enough to meet current and future needs.

NOTE 4 The language "FEMS responds" used here does imply that the facility must respond directly to externally initiated communications. As per previous Note, solutions employing an intermediate server infrastructure are available.

The above analysis indicates that a request/reply protocol solution, capable of being initiated by either party, and having sufficient flexibility to covey an extensible range of "energy" data could meet the requirement of this FG-100 use case.



IEC

Figure A.2 – Sequence diagram for FG-100

Table A.5 – Exchanged information in FG-100

Interaction	From > To	Function	Semantics
3-4	SG > FEMS	SG provides requested energy records	Current energy consumption, generation or other energy supply (e.g. as read from USM). Historical energy consumption, generation or other energy supply, along with billing and invoicing history Optional forward energy pricing information for sale and potential purchase of energy or other energy services available (see also FG-300). Historical and forward predicted power quality information as available. Other information as agreed, e.g. weather information.
4-3	FEMS > SG	FEMS provides requested energy records	Information as offered by the facility may include: Current energy consumption, generation or other energy supply (e.g. as read from FSM). Historical energy generation or other energy supply, along with invoicing history Optional forward energy pricing information for sale of energy (generated by the facility) or other energy services offered. Historical and forward predicted power quality information as available. Other information as agreed.

A.3.3.2 FG-200: Facility provides energy consumption and supply plan to smart grid

A.3.3.2.1 General description

The facility provides the smart grid with its predicted consumption, supply, storage and other energy use or supply service plan (facility energy plan). This information may be derived from the upcoming facility production plan, for example based on historical knowledge of the energy consumption and excess generation associated with production, or the absence of production. The availability of unused, and thus available to SG, storage, generation, regulation or emergency energy supply services could also be indicated.

It may include facility generation/storage, load shedding/generation, ramp-up/ramp-down options, and other information as previously agreed. This use case addresses the provision of largely static information associated with the planned operation of the facility for an agreed future period of time. The period of time and the size of the discrete intervals used to characterize the energy plan would be as previously agreed, and aligned with internal fFacility and Smart Grid scheduling. As an example, FEMS might provide an upcoming prediction of energy use and energy service availability during each 15 minute interval over a future 5 day production period.

This provision of a general prediction of future energy consumption and supply is useful to the smart grid operator to assist in longer term strategic planning.

Some industrial facilities may not be capable of generating the energy forecasts needed for the advanced planning supported by this use case. For such arrangements where only more real-time energy information is available, or for situations where real-time updates to FG-200 information are needed, use case FG-500 is defined.

A.3.3.2.2 Detailed description

The numbered items below correspond to the similarly numbered items in the sequence diagram of Figure A.3. For interactions which cross the facility and smart grid interface, their contents are summarized in Table A.6.

1) The production planner or other entity within the facility initiates the development of a production plan. The extent to which production planning is carried out, and how this is done will depend upon the facility. In general, the planner will identify production targets, assess input costs and the availability of resources, and establish a production plan for a future period of time. The cost of energy, and opportunities to sell generation and other energy services to the SG, may be factors in the design of such production plans.

   The planner obtains energy and other historical information from the FEMS, including energy pricing information gathered as described in FG-300 or FG-100. The FEMS may provide tools to assist in the energy planning component of the production plan, to allow the planner to obtain a better understanding of the energy profiles of production systems.

   The planner develops and obtains internal facility approval of the production plan. The plan, or an abstract of the plan, is sent to the FEMS which extracts the plan's energy profile and sends this information to the SG.

   The energy plan shall define the energy profile of the corresponding production plan. Such plans should also identify periods of non-production, so that the availability of unused facility energy resources can also be identified.

   High level information to be included is summarized in Table A.6 and may include information and other availability data as needed to characterize loads, generation/storage, ramp-up/ramp-down and other requirements when they differ from previously established values (e.g. as per use case FG-100). The energy plan will cover the planned production period, identifying planned loads, available generation, or other energy services, during discrete intervals of time during the period. Depending upon the locality, these discrete time intervals typically vary between 5 and 15 minutes, but defining the interval is out of scope of this document.

2) Optionally the SG acknowledges the energy plan and sends a response to the FEMS, which in turn forwards a response to the planner. This optional information flow may be required for arrangements where the facility proposes in the energy plan a more complex energy arrangement for one or more intervals. For example, if the facility has no production scheduled, and has internal energy generation resources available, the SG may wish to explicitly accept an offer of standby generation at this time. The acceptance of such an offer could then be incorporated in the planner's production plan. Refer also to FG-700 which might be used to support later acceptance of such offers.

   More complex arrangements of this type are for further study. However during the review of candidate standards, the flexibility of the candidate to support such extensions should be considered.

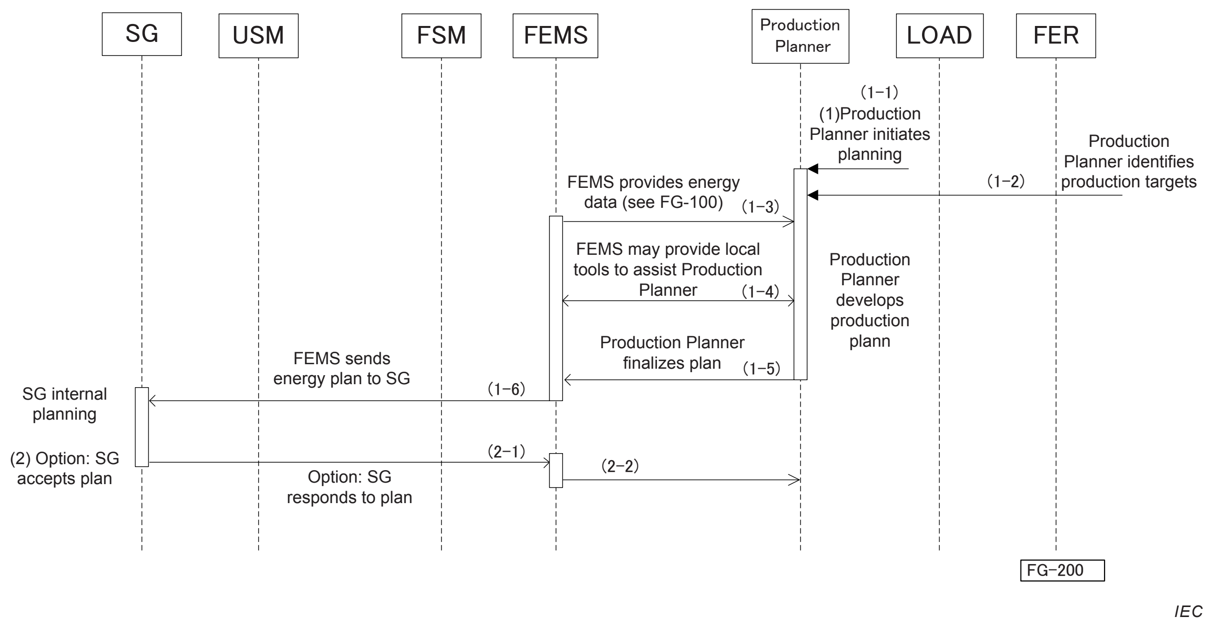


Figure A.3 – Sequence diagram for FG-200

Table A.6 – Exchanged information in FG-200

Interaction	From > To	Function	Semantics
1-6	FEMS > SG	FEMS sends energy plan	Energy plan describes the consumption, generation, or any other energy services expected to be used during each pre-agreed interval during the planning period. Optionally, requested content of energy plan can be identified in advance between SG and FEMS.
2-1	SG > FEMS	SG responds to plan	Optional confirmation or rejection of plan.

A.3.3.3 FG-300: Smart grid provides stable (longer term) price schedule to facility

A.3.3.3.1 General description

The smart grid provides pricing and related information to the FEMS to support facility development of daily or longer production plans. Selling price for energy sold to the facility and if appropriate purchase price for energy purchased from facility along with coefficients of environmental impact, etc. may be provided. Pricing information is developed by the SG operator using their internal procedures, typically based on generation and delivery costs and efforts to match longer term consumption to supply using price incentives.

The facility planning to be supported by this use case normally aims to organize the resources, including staffing, needed to meet manufacturing targets. Since these plans are normally made for daily or greater time periods, the pricing information needs to remain valid for time frames to support production planning. However it is recognized that for larger customers, the SG may offer pricing on a much shorter time scale, with such pricing only determined closer to the time of consumption or supply. Thus two use cases are identified: longer term pricing supported by this use case and shorter term pricing (or price updates) by use case FG-400.

The intent of this use case is the provision of price and related data on the time-scale of the (human) production planner. It could be an annually provided schedule with simple seasonal and time-of-day prices, or it could be a schedule updated monthly or weekly providing more detailed information. The SG issues these schedules, and updated schedules; and the production planner aligns consumption and potential supply with the lowest price, environmental impact or highest revenue time periods as previously discussed in FG-200. This use case does not envisage any negotiation on price, such complex arrangements are identified for future work in use case FG-800.

If only annual or seasonal (“time-of-day”) pricing information is provided, then this use case might be satisfied with manual procedures.

A.3.3.3.2 Detailed description

The numbered items below correspond to the similarly numbered items in the sequence diagram of Figure A.4. For interactions which cross the facility and smart grid interface, their contents are summarized in Table A.7.

1) The SG periodically assesses its generation and delivery costs, and the pricing strategies needed to manage, over the longer term, supply and demand; and generates a pricing schedule for the sale and, as appropriate, purchase of energy (or other energy services from the facility). The contents of such schedules and their creation will follow SG internally defined procedures. However, it is expected that the SG will provide sufficient information in such schedules to assist in production planning. For facilities capable of supplying generation, storage, or other energy services to the grid, purchase information may also be included. Where environmental impacts are to be considered, environmental data (e.g., CO_2 emission coefficients) would also be required.

   The SG may internally create a number of schedules, each aimed at customers with specific ranges of capabilities and needs. For customers with a limited ability to adjust consumption, simple fixed seasonal time-of-day energy purchase price schedules may be sufficient. For facilities better able to adjust consumption, more detailed schedules would be appropriate. For facilities able to provide generation and other energy services, the SG may provide pricing for their purchase of these services from the facility. In some cases, the SG may only provide price ranges, with final pricing only able to be established nearer the time of consumption or supply as described in FG-400.

In many situations today, in addition to the price of energy, it is important to recognize the environmental impact of the type of energy being used. Thus this use case also assumes that the SG may calculate the environmental emission coefficient associated with the energy it provides. Environmental emission coefficients will vary depending upon the energy generation profile within the SG. As available, the provision of this information along with pricing information will allow Factory planners to take the environmental emission coefficient of external energy sources into account in their planning.

NOTE The SG may require information from FEMS to identify any specific tailoring needed for the schedule. For example, it may require general information about the availability of generation or storage capacity in order to determine the purchase price to be offered for these resources. Such information could be obtained using use case FG-100.

2) Optionally, the facility may provide pricing information for energy generation or other services it is prepared to sell to the SG. This may be accompanied with corresponding environmental emission coefficient information. Services which might be offered to the SG include not only generated and supplied electric power, but regulation, storage, emergency standby backup or other services. The standard selected to meet this use case should be capable of supporting a range of energy services. This optional use case is identified here since it might be satisfied by the same protocol should it be capable of being operated in a symmetric manner.

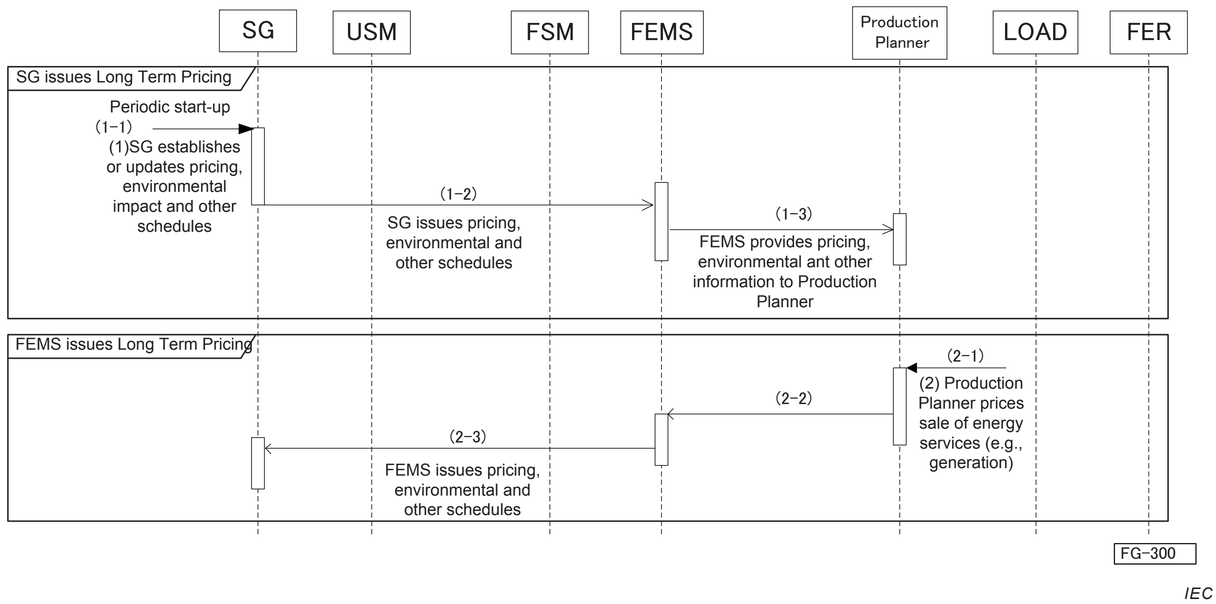


Figure A.4 – Sequence diagram for FG-300

Table A.7 – Exchanged information in FG-300

Interaction	From > To	Function	Semantics
1-2	SG > FEMS	SG issues price, environmental and other schedules	SG provides price schedules covering future period(s) which define the sale price of energy and if appropriate the purchase price of energy and any other energy services offered by the facility. Formats may range from simple manually distributed fixed time-of-day sale prices for energy, to more detailed pricing distributed using this interface for specific intervals of future time.
2-3	FEMS > SG	FEMS issues price, environmental and other schedules	Optional FEMS provides equivalent information for the energy services it offers.

A.3.3.4 FG-400: Smart grid provides dynamic (short term) pricing to facility

A.3.3.4.1 General description

The smart grid provides short term pricing as an incentive for the facility to adjust its energy use or supply. This information is developed by the SG using internal procedures to maintain balance between generation and supply near the time of use (grid balance). This use case covers the use of pricing as the means to influence energy demand and supply; FG-700, addresses the use of other means. Typically this information will be used by facilities to manage their current operating consumption and supply of power taking an advantage of hourly variations in the price of energy.

This information would be used by facility control systems to control resources, subject to ensuring that all production safety, performance and product quality requirements are maintained.

A.3.3.4.2 Detailed description

The numbered items below correspond to the similarly numbered items in the sequence diagram of Figure A.5. For interactions which cross the facility and smart grid interface, their contents are summarized in Table A.8.

1) The SG implements internal measures to maintain “grid balance”. It determines that one option is to offer pricing incentives for a facility to reduce load or provide generation or storage. For example, a facility may decide to accept a request to provide generation if the proposal is acceptable.
2) The FEMS receives the offer from the SG and validates that it is within the current capabilities of the facility and that acceptance would be beneficial in meeting financial targets. This validation may be done in conjunction with the production planner and other entities, including automated entities, within the facility, however it is expected that a prompt decision will need to be made to ensure a prompt reply can be made to the SG.

   Acceptance of the offer should also be validated against the ongoing requirements of production, to ensure continued facility safety and the maintenance of production and quality targets. The impact of the requested changes to load and FER should be assessed.

   NOTE Figure A.5 identifies the production planner as being concerned with this use case. For some facilities, the operations manager may be responsible for the activities of this use case.

   The overall ability and desirability of accepting the SG offer is then returned to the SG. Should the offer be accepted, the FEMS would facilitate the updating of any facility production plans and any other measures needed to implement the corresponding load reduction or energy service. Optionally the FEMS may initiate FG-500 to report updated energy plan to the SG. Should the requested change not be accepted, the SG would need to compensate by taking any other measures needed.

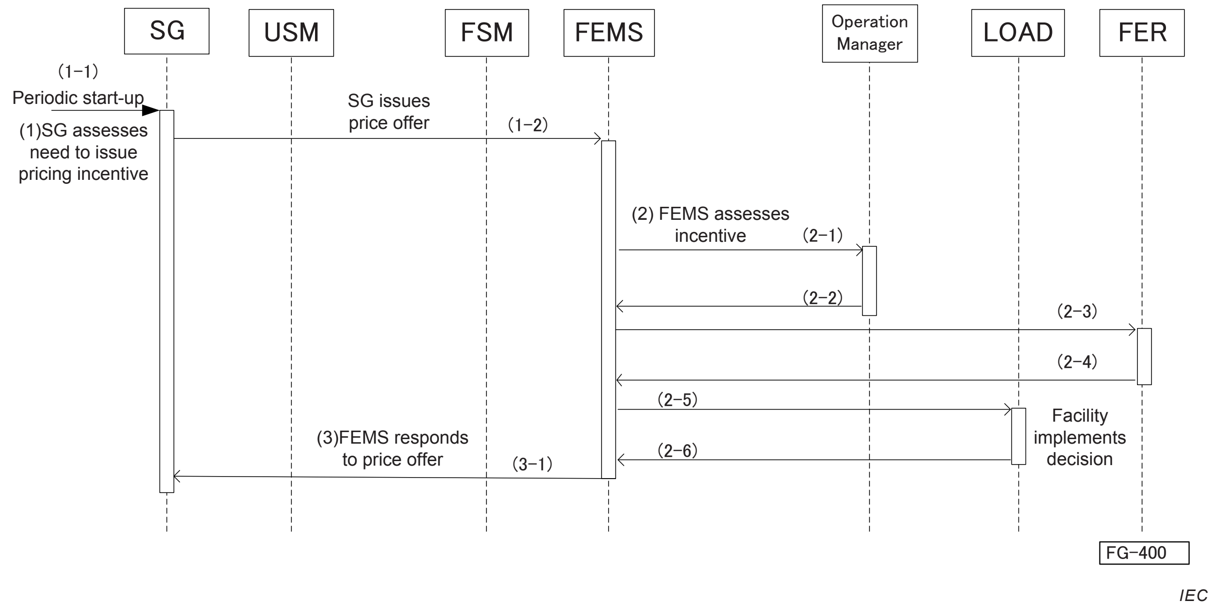


Figure A.5 – Sequence diagram for FG-400

Table A.8 – Exchanged information in FG-400

Interaction	From > To	Function	Semantics
1-2	SG > FEMS	SG issues price offer	SG provides price offer for energy service.
3-1	FEMS > SG	FEMS responds to price offer	FEMS accepts or rejects request. Contents of response are various.

A.3.3.5 FG-500: Facility informs smart grid about upcoming consumption and supply

A.3.3.5.1 General description

The facility provides information about its upcoming consumption and supply plans to the smart grid. This information is generated nearer to the time of consumption or supply than use case FG-200, and will allow the facility to provide more accurate and timely information. This use case could update previously provided FG-200 information or could be used to provide energy information in cases where the advanced planning supported by FG-200 is not available.

For example, the smart grid may provide discounts if sufficient advance notice of a change in consumption is given, or the facility may need to indicate to the SG upcoming changes to the facility's ability to supply generated energy. Typically this information may be used by the SG to manage their upcoming estimates of energy use and supply.

NOTE This use case may also facilitate the transfer for defined periods of time responsibility for the operation of the FER to the smart grid, as discussed in the Note in A.3.3.7.1 (FG-700). This is for further examination.

A.3.3.5.2 Detailed description

The numbered items below correspond to the similarly numbered items in the sequence diagram of Figure A.6. For interactions which cross the facility and smart grid interface, their contents are summarized in Table A.9.

1) The facility determines that a significant change in its expected energy use or supply should be reported to the SG. The requirements for such reporting will depend upon the

agreed arrangement between the facility and SG. For example, agreements may be in place requiring the facility to provide minimum notice if it plans to exceed pre-agreed consumption levels or change consumption or supply (ramp-up/ramp-down) at greater than normal rates. In other cases the availability of unexpectedly available generation capacity could be reported to the SG.

NOTE "Expected energy use or supply" may be that identified previously in use case FG-200 or may simply be the normal energy profile of the Facility.

Events leading to such required changes would typically include unexpected non-availability of input resources for production, equipment breakdown, changes in production targets or weather conditions, or more serious events such as safety issues, earthquakes or floods.

2) The SG receives the report from the facility and incorporates the information into their forward SG planning. The SG replies to the update, for example to respond to an offer of generation (if supported).

The FEMS receives any reply provided and assesses whether its contents impacts the facility and takes action as needed.

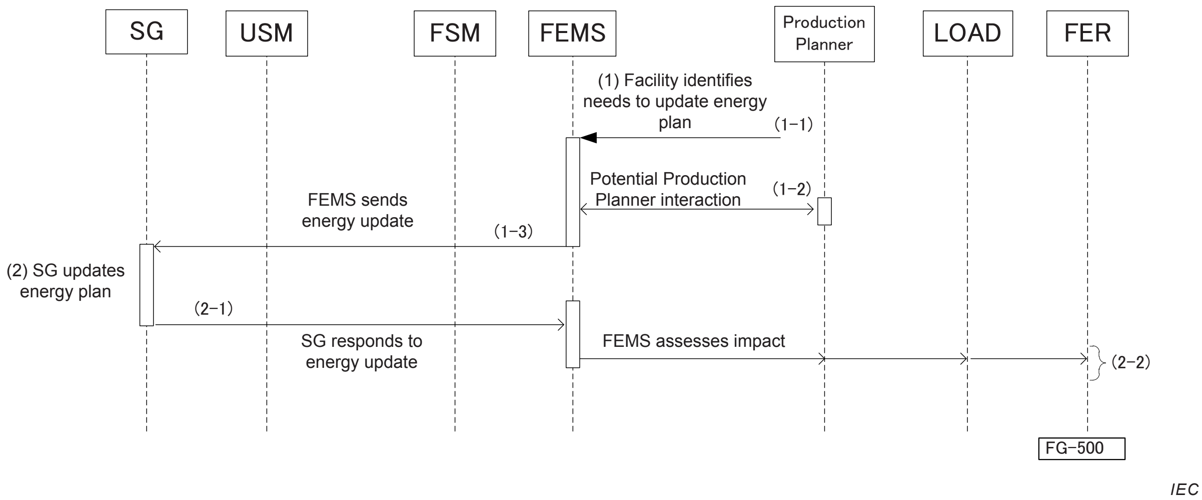


Figure A.6 – Sequence diagram for FG-500

Table A.9 – Exchanged information in FG-500

Interaction	From > To	Function	Semantics
1-3	FEMS > SG	FEMS sends energy update	FEMS provides new or updated energy plan to SG.
2-1	SG > FEMS	SG responds to energy update	SG response to energy update, e.g., accepting energy generation if it is offered in updated plan.

A.3.3.6 FG-600: Smart grid informs facility of blackout notice

A.3.3.6.1 General description

The smart grid predicts the risk of blackout, brownout, or other abnormal power situation based on weather, equipment availability and status, predicted consumption, and other factors. The SG may develop mitigation plans, such as blackout or brownout schedules, to minimize system wide impacts. Risk and mitigation plans are communicated to the facility which responds by changing energy consumption, power generation or production plans and any other measures necessary to protect the facility, its staff and any ongoing production.

A.3.3.6.2 Detailed description

The numbered items below correspond to the similarly numbered items in the sequence diagram of Figure A.7. For interactions which cross the facility and smart grid interface, their contents are summarized in Table A.10.

1) The SG estimates the risk of energy interruption or degraded quality using their internal procedures. For example, such risks may correlate to weather forecasts or the shut-down of significant energy supply or distribution elements. The SG may put into place response plans which involve for example, the implementation of rolling blackouts (scheduled complete power interruptions rotated among delivery areas) or brownouts (reduced voltage delivery).

   The SG issues corresponding risk notices providing information about the risk and the implementation of any plans to address the risk, for example a brownout notice.

   The content of such notices may vary and will depend upon the information made available by the SG. For most facilities, it will be important to obtain notice in advance of the implementation of a rolling blackout or brownout so that suitable action can be taken to protect the facility and any ongoing production. For larger facilities, notices providing risk estimates of future power interruptions, for example based SG predictions of potential energy shortages due to weather or other factors, would allow the facility to adjust upcoming production plans to avoid significant consumption, or even provide generation, during high risk periods.

2) Upon receipt of the notice the FEMS updates its energy management plan as appropriate. The facility operations manager (or planner if sufficient time is available) revises production plans to take into account the risks and potential impact. For example, the manager may delay or suspend production at a safe point within the production schedule, if an upcoming power interruption, or high risk of an interruption, has been indicated. Energy plans are distributed to the load and FER. The FEMS responds to the SG.

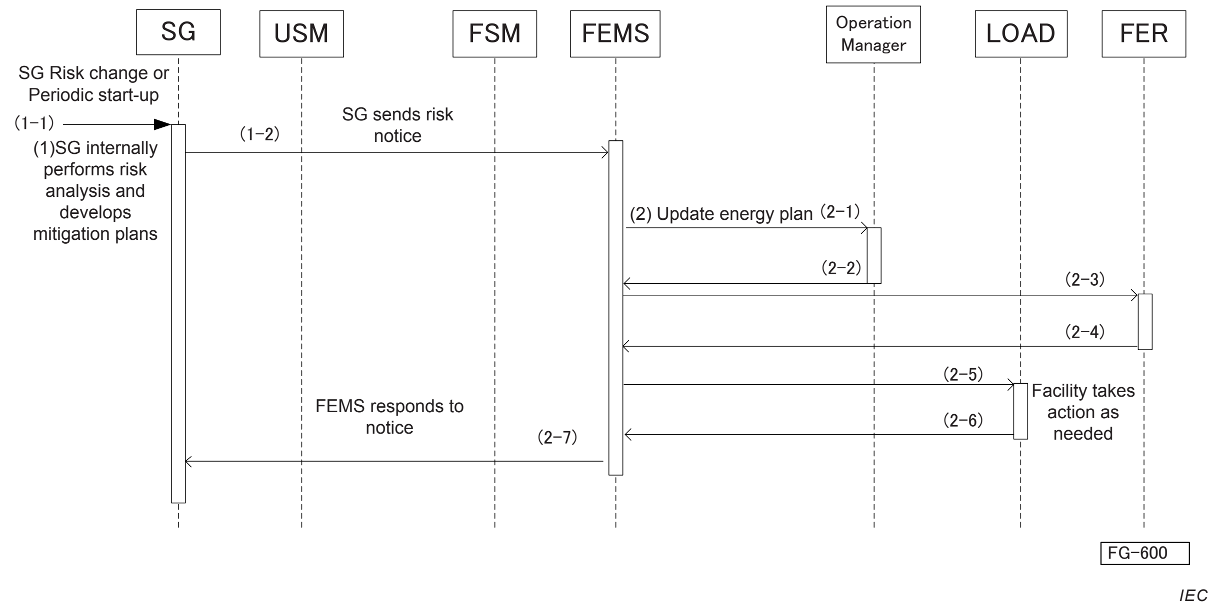


Figure A.7 – Sequence diagram for FG-600

Table A.10 – Exchanged information in FG-600

Interaction	From > To	Function	Semantics
1-1	SG > FEMS	SG sends risk notice	SG provides: a) an indication of the probability of power interruption or power degradation b) specific information about a rolling blackout or brownout along with scheduling information
2-7	FEMS > SG	FEMS responds to notice	FEMS acknowledges request. a) with offer to reduce of limit load for risk period b) other response as previously agreed (e.g. request for delay)

A.3.3.7 FG-700:Smart grid requests facility to alter consumption or supply

A.3.3.7.1 General description

Smart grid requests that the facility decrease energy consumption, increase energy generation or provide other energy services as previously agreed. This use case is similar to use case FG-400 except that a specific request is made to make the adjustment rather than using a pricing incentive. The energy services that might be adjusted would be subject to previous agreement, either determined manually, or identified using a different use case. For example, Use case FG-200 supports the provision of an energy plan by the facility which could indicate that generation is available during specific future intervals of time.

In response the facility may shed loads, alter proposed upcoming consumption or supply plans, provide emergency power or provide other pre-agreed energy service. Whether such a request can be rejected by the facility would be according to the agreement previously reached between the parties in respect to the affected energy service.

This use case allows the smart grid to request changes to the facility energy profile to manage peak loads and address emergency situations. It extends the tools available to the smart grid for load balancing beyond the use of simple short and long term pricing incentives. For example, the smart grid may provide special price points for the purchase of power subject to load shedding. The facility manages the load and FER in the facility according to the request.

NOTE In some situations where facility production would not be affected by the direct control of facility energy resources, direct control of these resources by the SG might be permitted by the facility for certain periods of time. Standards for such direct distributed energy resource control are being developed by others, and are not the subject of this document. However, this use case, and use case FG-200, could provide mechanisms by which responsibility for such control, and the subsequent use of the standards developed by others for direct control, could be transferred for specific intervals of time. For example, a generation resource normally an integral component of production, might be transferred to SG control during periods of non-production or in emergency situations.

A.3.3.7.2 Detailed description

The numbered items below correspond to the similarly numbered items in the sequence diagram of Figure A.8. For interactions which cross the facility and smart grid interface, their contents are summarized in Table A.11.

1) The SG periodically reviews its energy plan and identifies potential energy shortfalls, or opportunities to reduce peak demand or leverage lower cost energy sources. For example, a facility may offer a “load shedding” service whereby it will shed specific loads on request. Another facility may offer energy generation which may be a cost effective energy source during some time periods.

   The SG issues the corresponding request to the FEMS.

   The FEMS receives and assesses the request in conjunction with facility operations and appropriate staff. Should the request be accepted, adjustments to any production plans (see use case FG-200) are made and appropriate actions taken by the facility to satisfy the request. Optionally the FEMS may initiate FG-500 to report updated energy plan to the SG.

2) A response is sent to the SG indicating acceptance or rejection of the request.

NOTE The ability to reject such requests would be established by prior agreement between the parties. It is assumed that such agreements will define whether such requests can be rejected or not.

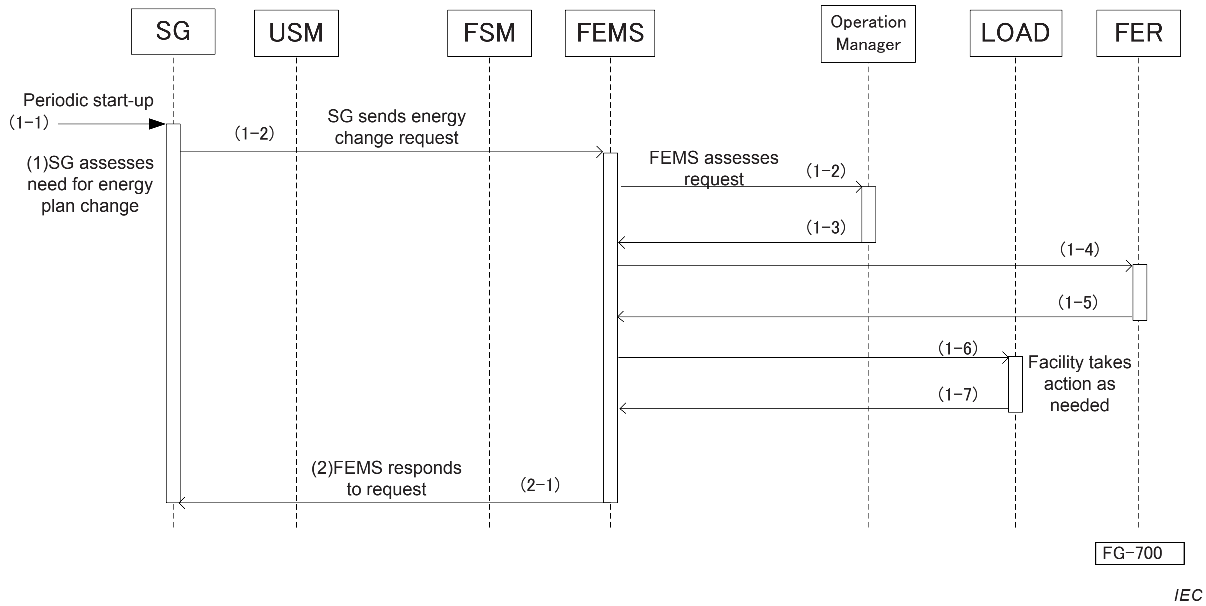


Figure A.8 – Sequence diagram for FG-700

Table A.11 – Exchanged information in FG-700

Interaction	From > To	Function	Semantics
1-2	SG > FEMS	SG sends energy change request	SG sends request for alteration of energy consumption and supply.
2-1	FEMS > SG	FEMS responds to request	FEMS accepts or rejects request.

A.3.3.8 FG-800: Facility and smart grid negotiate price schedule

This user case is for future work. For larger facilities, and when available, the FEMS and smart grid interface may support the negotiation of pricing and consumption/supply plans. It is assumed that this enhanced use case would only be appropriate for larger facilities with significant energy resources and the infrastructure needed to support such interactions. Support for this use case might leverage existing standards in use by larger energy providers who interact with, for example, independent system operators.

Annex B
(informative)

An application example of demand response energy management model

B.1 General

Annex B provides an application example for the demand response energy management model based on steel industrial facilities as shown in Figure B.1. The graphic symbols have same meanings as described in 5.2.2.3.

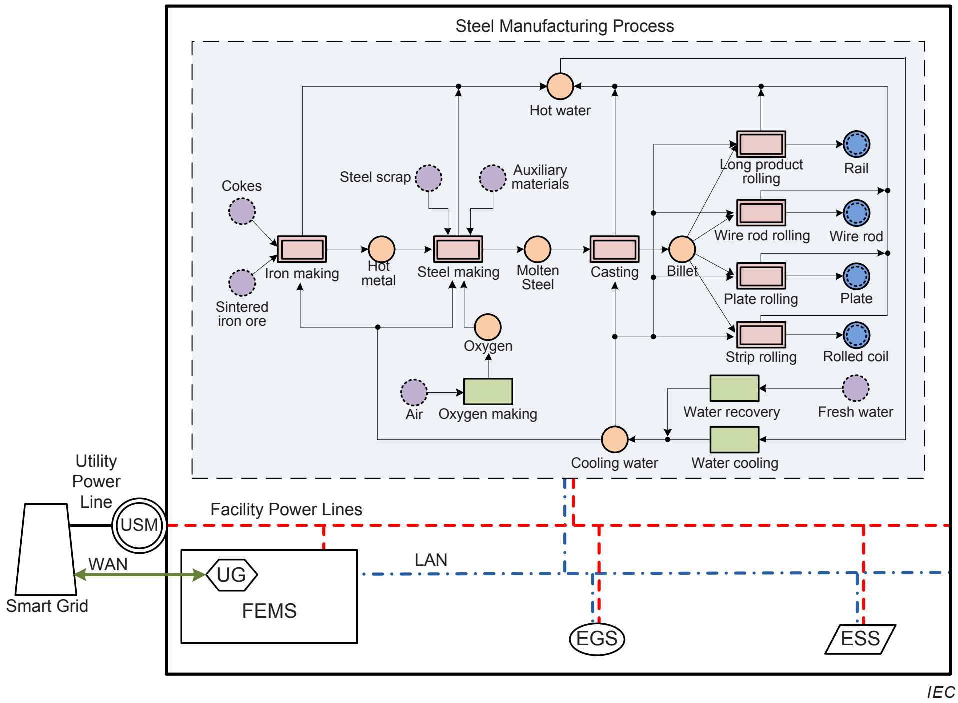


Figure B.1 – An application example of demand response energy management model

B.2 Main architecture

In this example, the steel manufacturing facility consists of EMS, EGS, ESS, steel manufacturing process equipment, facility power line and LAN. The topology of steel manufacturing process is modeled based on state-task network. Task nodes consist of non-schedulable tasks (double-border rectangles including iron making, steel making, casting, long product rolling, wire rod rolling, plate rolling, and strip rolling) and schedulable tasks (single-border rectangles including water cooling, water recovery, and oxygen making). The state nodes include feeds (broken circles including coke, sintered iron ore, steel scrap, auxiliary materials, air, and fresh water), intermediates (solid circles including hot metal, molten steel, oxygen, steel billets, cooling water, and hot water), and final products (inside-broken and outside-solid circles including steel rails, wire rods, plates, and rolled coils). Arrows indicate the relationship between tasks and states.

The functionality of each task is as follows: the iron making task produces hot metal from coke and sintered iron ore; the steel making task produces molten steel from hot metal, steel scrap, auxiliary materials, and oxygen; the casting task makes billets from molten steel; these billets are used in the long product rolling, wire rod rolling, plate rolling, and strip rolling tasks to produce the final steel products, such as rails, wire rods, plates, and rolled coils; the oxygen making task generates oxygen from air; the water cooling task cools hot water produced by the other tasks, and the water recovery task restores lost cooling water directly using fresh water.

B.3 Structure of a task

Taking water cooling task as an example, Figure B.2 shows the inner structure of the task. The hot water from other tasks is first stored in the hot water pool that contains hydraulic pressure sensors to monitor the water level of the pool continuously. The pumps transfer hot water from the pool to the cooling tower where the temperature of the hot water is reduced. The self-cleaning filter between the pumps and the cooling tower provides filtration and removes any sediment from the hot water. The resulting cooling water is stored in the cooling water pool, which also contains hydraulic pressure sensors to monitor the water level.

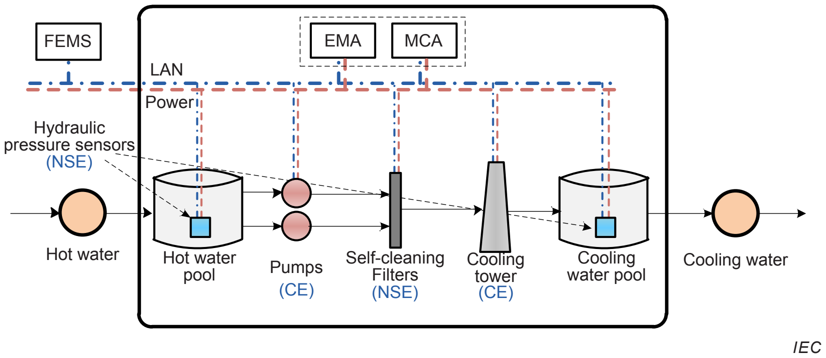


Figure B.2 – Structure of water cooling task

In this task, the NSE includes the hydraulic pressure sensors that always monitor the water level in the pools, and the self-cleaning filters that operate when water flows from the pumps to the cooling tower. The energy demand of hydraulic pressure sensors and self-cleaning filters is neither shiftable nor controllable. The CE includes pumps and the cooling tower because they both support multiple operating levels, each of which has a different energy demand, which can be achieved by changing the rotary speed of the pumps and the fan speed in the cooling tower.

By managing the operating level of the pumps and the cooling tower, the EMA defines multiple operating modes for the water cooling task, with each mode having a different generation rate of cooling water production and energy demand. The modes with fast generation of cooling water have high energy demands, and the modes with slow generation of cooling water have low energy demands. The characteristics of each operating mode are transmitted to the EMS which finally determines the operating mode according to energy prices and storage level of hot and cooling water pools.

B.4 Approaches of energy management

B.4.1 General

Utilities suppliers announce energy prices based on energy supply and demand relationships at pre-specified time interval (e.g. between 30 and 60 minutes). High energy prices are announced during peak demand periods and low energy prices are announced during off-peak demand periods.

After receiving the energy price for a stage, the EMS manages the energy demand of steel manufacturing facility using two approaches that can be implemented separately or jointly.

B.4.2 Approach 1

When the energy price is low, the EMS controls the oxygen making task to generate more oxygen and controls water cooling task and water recovery task to generate more cooling water, which requires more energy. The surplus oxygen and cooling water can be stored in an oxygen tank or cooling water pool for future use.

When the energy price is high, the EMS controls the oxygen making task to generate less oxygen (or even turn it off) and controls water cooling task and water recovery task to generate less cooling water (or even turn them off), which requires less energy. In this case, tasks requiring oxygen or cooling water can use the oxygen in an oxygen tank or cooling water in cooling water pool to continue their operations.

Through this approach, part of the energy demand of steel manufacturing facility is shifted from peak demand period to off-peak demand period.

B.4.3 Approach 2

When the energy price is low, the EMS controls the ESS so that it is charged from the smart grid, which increases energy demand.

When the energy price is high, the EMS controls EGS and ESS to supply energy to the steel manufacturing process, which decreases the energy demand on the smart grid.

In summary, ESS helps shift part or all of the energy demand from peak demand period and EGS helps reduce the energy demand during peak demand period.

B.5 Mapping industrial demand response energy management model to use cases

Clause B.5 provides the mapping between industrial demand response energy management model and use cases. The communication between the smart grid and industrial facility in industrial demand response energy management model will be described by using the use cases of Annex A.

The main architecture of industrial demand response energy management model can be modelled according to the architecture described in 5.2.2.3.2.

The smart grid announces energy prices at pre-specified time intervals using FG-300 (smart grid provides stable (long term) price schedule to facility). By using FG-400 (smart grid provides dynamic (short term) pricing information to facility), low energy prices would be announced when the energy demand is low in order to encourage energy usage, while high energy prices would be announced when the energy demand is high in order to discourage energy usage.

After receiving the energy price, the FEMS of industrial facilities manages the energy demand based on preinstalled energy management algorithms and strategies through two approaches.

1) Approach 1: FEMS determines the operating mode for schedulable tasks in that stage.

   Under the premise of satisfying the requirements of industrial facilities (such as market demand, reliability, safety, resource storage, etc.), a low energy price encourages the FEMS to command schedulable tasks to operate in a mode that has high energy demand with fast production rates, while a high energy price encourages the FEMS to command schedulable tasks to operate in a mode that has low energy demand with slow production rate. As a result, the energy demand of industrial facilities is increased when the energy price is low and is decreased when the energy price becomes high. In the end of this stage, the FEMS provides energy consumption plan to smart grid by using FG-200, and informs smart grid about upcoming consumption by using FG-500.

2) Approach 2: FEMS commands the ESS to store energy from the smart grid or commands the ESS and EGS to supply energy to processing tasks.

A low energy price encourages the FEMS to command the ESS to store energy from the smart grid and command the processing tasks to use the smart grid as their energy source, which increases the energy demand. A high energy price, on the other hand, encourages the FEMS to command the ESS and EGS to supply energy to some or all of the processing tasks, which decreases the energy demand of the industrial facility. In the end of this stage, the FEMS provides general energy consumption and supply plan to smart grid by using FG-200, and informs smart grid about upcoming consumption and supply by using FG-500.

Annex C
(normative)

Security services

While the requirements of the interface are expected to conform to the requirement identified using IEC TS 62443-1-1, IEC 62443-2-1, IEC TR 62443-3-1, and IEC 62443-3-3, Annex C defines further security considerations:

a) The components of the facility accessed from the utility gateway should support technical measures for an effective authentication procedure before access is permitted.

b) The logs auditing system should be established and managed for the facility's interface system performing security functions (e.g. firewall).

c) The number of access points from the smart grid to FEMS shall be reduced as far as possible to minimize vulnerability.

d) Provisions for security anomaly detection should be implemented and alarms should be analysed.

e) Inside the facility the utility gateway shall be treated as having high security degree since it is a front-end device for external smart energy management system of smart grid.

f) The utility gateway shall grant the legal access rights to the authorized user to modify and access data.

g) The utility gateway shall only authorize access when the source of incoming communication has been authenticated.

h) The information to be exchanged between Utility Gateway and Smart Grid has significant meaning for manufacturing process in the facility. Thus, they shall be guaranteed that it is not modified while being transmitted between them. In addition, the information shall be protected against eavesdropping on the communication path.

i) And the following security services:

   - availability;
   - integrity;
   - confidentiality;
   - access control;
   - non-repudiation;
   - audit and accountability; and
   - supporting security requirements to include:
     - authentication (this supports more than one primary security service so it needs to be considered a supporting service), and
     - assurance (making sure all services are present in the deployed configuration).

Annex D
(informative)

Solutions for information requirement

D.1 General

Annex D addresses the solution for the required information introduced in 5.8. Since there are a number of smart grid related activities, this technical specification tries to harmonize with the activities. Thus, Clause D.2 introduces existing standards and analyses how the standards are applicable to each use case. In Annex D, FG-100 to FG-700 are discussed. FG-800 is not discussed since it is for future work.

D.2 Existing standards

Table D.1 represents the overview of applicability of candidate existing standards for each use case. Detailed analyses are described in Clause D.3.

Table D.1 – Overview of existing standard applicability

Standard	Title/Description	Use case and exchanged information number													
		FG-100		FG-200		FG-300		FG-400		FG-500		FG-600		FG-700	
		3-4	4-3	1-6	2-1	1-2	2-3	1-2	3-1	1-3	2-1	1-1	2-7	1-2	2-1
OpenADR 2.0b [7]	Demand response (DR) and distributed energy resources (DER) communications and security, as well as price distribution for wholesale and retail markets.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
OASIS Energy Interoperation 1.0 [14]	Demand response (DR) and distributed energy resources (DER) communications as well as price communication and market transactions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NAESB Energy Services Provider Interface (ESPI) [15], and GreenButton [16]	ESPI Standard and GreenButton application.	X		X	X			X	X					X	X

Standard	Title/Description	Use case and exchanged information number													
		FG-100		FG-200		FG-300		FG-400		FG-500		FG-600		FG-700	
		3-4	4-3	1-6	2-1	1-2	2-3	1-2	3-1	1-3	2-1	1-1	2-7	1-2	2-1
ISO/WD 17800 Facility Smart Grid Information Model (FSGIM) [12]	An information model to represent smart grid related energy information within a facility, and specifically the information that may need to be communicated to/from electrical grid service providers across the SGUI (working draft; under development in ASHRAE/NEMA SPC 201P).	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SEP 2.0 (IEEE P2030.5) [17]	Communications of pricing, DR signals, messaging, and energy usage to in-home devices.	SEP 2.0 (IEEE P2030.5) is being considered by IEC/PC118. Its applicability specifically to the use cases of this document is for further work													

D.3 Analysis for each use case

D.3.1 General

This Clause D.3 provides additional detail regarding the applicability of the existing standards summarized in Table D.1. Each subclause addresses each standard separately.

D.3.2 Analysis of "OpenADR2.0b"

D.3.2.1 General

Table D.2 reproduces the "OpenADR2.0b" [7] row of Table D.1.

Table D.2 – "ADR2.0b" applicability

Standard	Title/Description	Use case and exchanged information number													
		FG-100		FG-200		FG-300		FG-400		FG-500		FG-600		FG-700	
		3-4	4-3	1-6	2-1	1-2	2-3	1-2	3-1	1-3	2-1	1-1	2-7	1-2	2-1
OpenADR 2.0b [7]	Demand response (DR) and distributed energy resources (DER) communications and security, as well as price distribution for wholesale and retail markets.	X	X	X	X	X	X	X	X	X	X	X	X	X	X

D.3.2.2 FG-100

During the initial system setup, the facility and the smart grid agree on specific information that should be exchanged with regards to current and past energy information. This is usually based on contractual negotiations.

Figure D.1 shows the OpenADR 2.0b [7] interaction to register the required reports. Initially the parties register the type of report and the necessary parameters. The parties can then specify the specific requests (time frame, sampling period, frequency, energy amount etc.) for the requested reports.

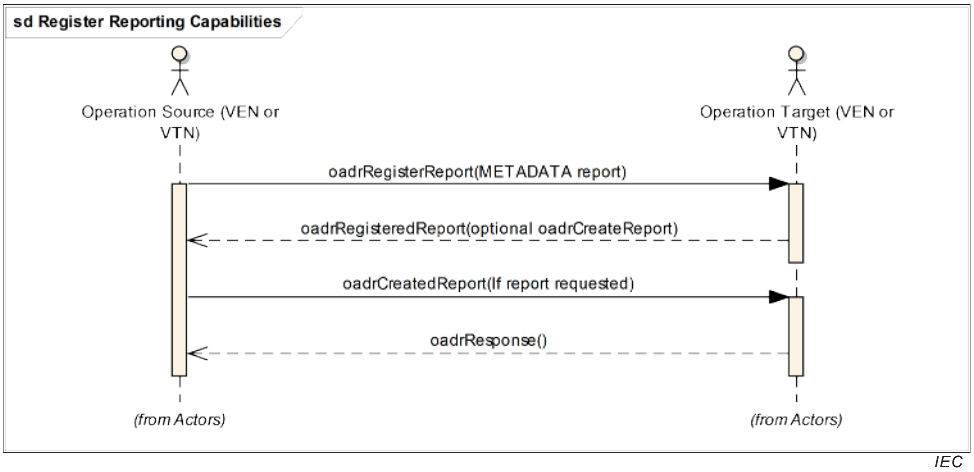


Figure D.1 – Interaction to register report

Figure D.2 shows the sequence to request the previously negotiated reports. Reports can contain past, current, or forecast data.

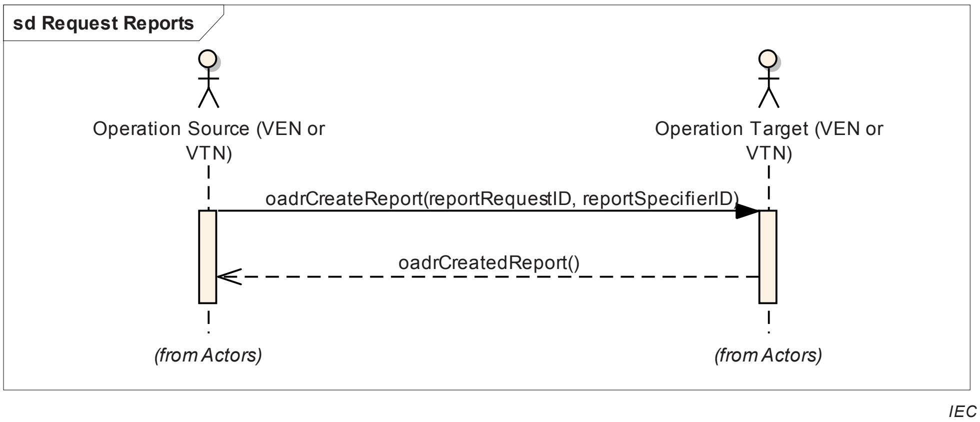


Figure D.2 – Interaction to request report

D.3.2.3 FG-200

Refer to FG-100, the EiReport service can be used.

Furthermore, if the facility responds to a curtailment request, the OpenADR 2.0b [7] profile specifies the EiOpt service to create and communicate Opt-In and Opt-Out schedules from the virtual end node (VEN) to the virtual top node (VTN). These schedules define temporary changes in the availability, and may be combined with longer term availability schedules and the market context requirements to give a complete picture of the willingness of the facility to respond to EiEvents received by the VEN. Figure D.3 shows the simple setup exchange.

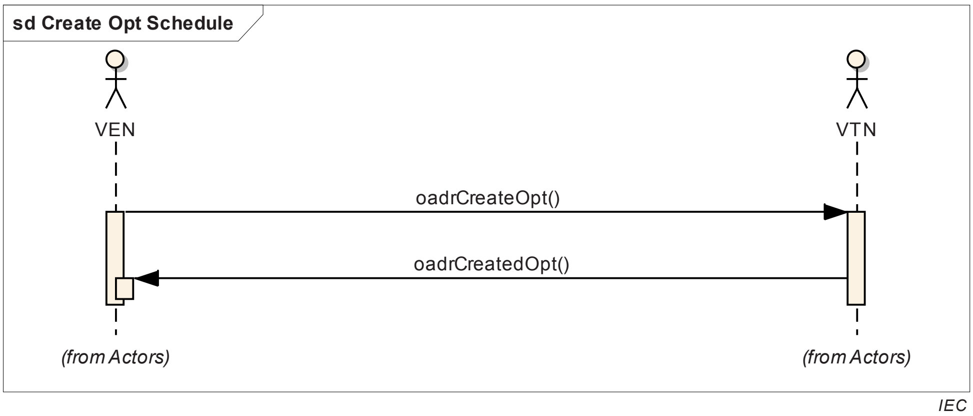


Figure D.3 – Simple setup exchange

D.3.2.4 FG-300

The simplest way to achieve this use case with OpenADR 2.0b [7] is to use baselines. The EiEvent service can be used to provide the facility with a price baseline with nearly infinite granularity.

Events are generated by the VTN (the smart grid) and sent to the VEN (facility) using the oadrDistributeEvent payload containing one or more events described by the oadrEvent element. Some events require a response and others do not as indicated by the oadrResponseRequired element in the event description. If a response is required, the VEN acknowledges its opt-in or opt-out disposition by responding with an oadrCreatedEvent payload containing eventResponse elements matching each oadrEvent. If no response is required, the VEN does not reply with oadrCreatedEvents (or oadrCreateOpt) payloads for this event.

The event can contain price information for specific time intervals. For example, one event can last for 24 hours (00:00 – 23:59) and have 24 intervals with different price information for each hour of the day. The number of intervals is not limited so that the granularity can be set as needed.

D.3.2.5 FG-400

Refer to FG-300. Pricing can be transmitted for any desired time period.

D.3.2.6 FG-500

Refer to FG-200. Time scales for information exchanges can be flexible to accommodate near term or far term information.

D.3.2.7 FG-600

Currently OpenADR 2.0b [7] does not specifically use blackout signals. However, it is conceivable that a DR program uses the simple levels (1 through 4) as an indicator of risk and grid reliability within a specific context.

An EiEvent payload can be set up as a simple level transport. Upon definitions, these levels could be assigned specific risk assessments and they can be assigned time frames and durations.

D.3.2.8 FG-700

This is the standard demand response use case for which OpenADR was originally designed. Demand response events are generated by the VTN (the smart grid) and sent to the VEN (facility) using the oadrDistributeEvent payload containing one or more events described by the oadrEvent element. Some events require a response and others do not as indicated by the oadrResponseRequired element in the event description. If a response is required, the VEN acknowledges its opt-in or opt-out disposition by responding with an oadrCreatedEvent payload containing eventResponse elements matching each oadrEvent. If no response is required, the VEN does not reply with oadrCreatedEvents (or oadrCreateOpt) payloads for this event. The event can contain different signal types for different response strategies.

D.3.3 Analysis of "OASIS Energy Interoperation 1.0"

D.3.3.1 General

Table D.3 reproduces the "OASIS Energy Interoperation Version 1.0" [14] row of Table D.1.

Table D.3 – "OASIS Energy Interoperation 1.0" applicability

Standard	Title/Description	Use case and exchanged information number													
		FG-100		FG-200		FG-300		FG-400		FG-500		FG-600		FG-700	
		3-4	4-3	1-6	2-1	1-2	2-3	1-2	3-1	1-3	2-1	1-1	2-7	1-2	2-1
OASIS Energy Interoperation 1.0 [14]	Demand response (DR) and distributed energy resources (DER) communications as well as price communication and market transactions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X

D.3.3.2 FG-100

This use case can be achieved by report service of “OASIS Energy Interoperation Version 1.0” [14] (EI Ver. 1.0). Report service utilizes data format defined in OASIS WS-Calendar [19] to represent standardized schedules or intervals in the consumption history. In addition, report service utilizes OASIS Energy Market Information Exchange (EMIX) [18] product definitions to represents price information. EMIX also utilizes WS-Calendar to represent standardized schedules or intervals for price and historical information.

EI Ver. 1.0 focuses on DR/DER/Price communication and does not cover environmental information nor local weather information. EI Ver. 1.0 can be extended through other services.

D.3.3.3 FG-200

This use case can be achieved by EiEvent, EiQuote, EiAvail, EiMarketContext, and EiReport services of EI Ver. 1.0. The EiReport service utilizes data format defended in OASIS WS-Calendar [19] to represent standardized schedules or intervals in the consumption schedule.

D.3.3.4 FG-300

This use case can be achieved by EiEvent, EiQuote, EiAvail, EiMarketContext, and EiReport services of EI Ver. 1.0. The EiReport service utilizes data format defended in OASIS EMIX [18] to represents price information. EMIX utilizes WS-Calendar [19] to represents standardized schedules or intervals in the price schedule.

EI Ver. 1.0 focuses on DR/DER/Price communication and does not cover environmental information nor local weather information. EI Ver. 1.0 can be extended through other services.

D.3.3.5 FG-400

This use case can be achieved by EiEvent, EiQuote, EiMarketContext and EiReport services of EI Ver. 1.0. The EiReport service utilizes data format defended in OASIS EMIX [18] to represents price information. EMIX utilizes WS-Calendar to represents standardized schedules or intervals in the price schedule.

D.3.3.6 FG-500

This use case can be achieved by EiEvent, EiQuote and EiMarketContext services of EI Ver. 1.0. EiReport service utilizes data format defended in OASIS WS-Calendar [19] to represent standardized schedules or intervals in the consumption schedule.

D.3.3.7 FG-600

This use case can be achieved by EiEvent and EiMarketContext services of EI Ver. 1.0. The EiEvent service utilizes data format defended in OASIS WS-Calendar [19] to represent standardized schedules or intervals in the event schedule.

EI Ver. 1.0 focuses on DR/DER/Price communication and does not cover environmental information nor local weather information. EI Ver. 1.0 can be extended through other services.

D.3.3.8 FG-700

This use case can be achieved by EiEvent, EiMarketContext and EiReport services of EI Ver. 1.0. The EiEvent service utilizes data format defended in OASIS WS-Calendar [19] to represent standardized schedules or intervals in the event schedule.

EI Ver. 1.0 focuses on DR/DER/Price communication and does not cover environmental information nor local weather information. EI Ver. 1.0 can be extended through other services.

D.3.4 Analysis of "NAESB Energy Services Provider Interface (ESPI)"

D.3.4.1 General

The North American Energy Standards Board (NAESB) is a forum consisting of various members from the energy industry. The NAESB consists of members from the energy sector; an example would be the independent electricity system operator (IESO).

The NAESB has developed standards for the purposes of:

– common pricing and scheduling;
– demand response of distributed energy;
– cyber security and smart grid interoperability.

The following comparison references the NAESB use cases for demand response of distributed generation systems defined in "NAESB Energy Services Provider Interface (ESPI)" [15] and “GreenButton” [16].

Table D.4 reproduces the "NAESB Energy Services Provider Interface (ESPI)" [15] and GreenButton [16] row of Table D.1.

Table D.4 – "NAESB Energy Services Provider Interface (ESPI)" applicability

Standard	Title/Description	Use case and exchanged information number													
		FG-100		FG-200		FG-300		FG-400		FG-500		FG-600		FG-700	
		3-4	4-3	1-6	2-1	1-2	2-3	1-2	3-1	1-3	2-1	1-1	2-7	1-2	2-1
NAESB Energy Services Provider Interface (ESPI) [15] and GreenButton [16]	ESPI Standard and GreenButton application.	X		X	X			X	X					X	X

NOTE 1 NAESB standard focuses on use cases with the consideration of wholesale activities in mind.

NOTE 2 Demand response use cases utilized by the NAESB focus on distributed generation as opposed to industrial/manufacturing activities specified in this Technical Specification.

NOTE 3 NAESB standard separates most of the use cases by “economic” and “reliability”.

D.3.4.2 FG-100

The “GreenButton” application [16] of the ESPI allows data to be exchanged between Utilities, Customers, and Third Party Services Providers. It provides access to energy usage information by a retail customer from a data custodian (typically a utility) using web protocols.

D.3.4.3 FG-200

The NAESB use case “Measurement and Performance – Baseline” is defined as: “A use case which documents the steps used to collect demand resource data and prepare the determinants for settlement”.

In this case the demand response provider requests data from the metering authority. The data collected by the demand response provider is then used to calculate a baseline which is used to determine an “event reduction amount”, or “event performance ratio”. Calculated values are then sent to the system operator who determines whether the calculated values are complete.

The major difference in this use case compared to the FG-200 is that the NAESB standard does not require a supply plan with the energy consumption data. Instead, the calculated baseline, event reduction amount, and performance ratio are then used for the “Measurement & Performance business process”.

NOTE The settlement and business process described in the use cases are not defined in the NAESB standard.

D.3.4.4 FG-300

Not currently supported

D.3.4.5 FG-400

“Deployment and Real-Time Communications” is an NAESB use case which “describes the process for real-time communications to demand resources providing market-based services on a real-time basis”.

The following use case begins with the system operator evaluating real-time system conditions based on market demand. The resulting data allows the system operator to issue dispatch instructions to the designated dispatch entity. In turn, the dispatch entity forwards the request for demand response to the demand response provider via proprietary communication protocol. A response from the designated dispatch entity is then received by system operator in real-time in order to evaluate system state. Data is then made available for the update process of market demand.

In this NAESB use case, the major difference from the FG-400 is the additional process of providing demand response instruction. The NAESB use case combines both market pricing, with demand response instruction as opposed to the FG-400 where market pricing is only used as an incentive for demand response. This NAESB use case can be combined with both the FG-400, and the FG-700.

D.3.4.6 FG-500

Not currently supported.

D.3.4.7 FG-600

Not currently supported.

D.3.4.8 FG-700

The “Scheduling and Award Notification” NAESB use case is defined as a “process which describes the process from offer submission to award notification”.

In this case the scheduling entity begins the process by supplying an offer to the system operator. The system operator evaluates the offer based on market demand which results in a dispatch instruction. A schedule is the made available by the system operator, which is retrieved by the scheduling entity. The scheduling entity then forwards the available schedule to the demand response provider via proprietary protocol.

One of the major differences in the NAESB use case is the combination of system evaluation, and scheduling. The FG-700 use case is specifically used for the alteration of consumption & supply with a single request, whereas the NAESB use case provides a request to adjust supply with advanced notice by use of a schedule.

This NAESB use case also contrasts the FG-200 by having the system provide a schedule to the facility, whereas in the FG-200, the facility provides a schedule to the system.

D.3.5 Analysis of "ISO/WD 17800 Facility Smart Grid Information Model” (FSGIM)

D.3.5.1 General

Table D.5 reproduces the "ISO/WD 17800 Facility Smart Grid Information Model” (FSGIM) [12] row of Table D.1.

FSGIM is a data model not a protocol. It provides the class and attributes data. The following FSGIM comments apply to the ability to receive and store smart grid data; produce data aggregations and metadata; and forward this data back to the smart grid. However, FSGIM does not prescribe the payloads by which this data is transported.

Table D.5 – "ISO/WD 17800 Facility Smart Grid Information Model" applicability

Standard	Title/Description	Use case and exchanged information number													
		FG-100		FG-200		FG-300		FG-400		FG-500		FG-600		FG-700	
		3-4	4-3	1-6	2-1	1-2	2-3	1-2	3-1	1-3	2-1	1-1	2-7	1-2	2-1
ISO/WD 17800 Facility Smart Grid Information Model (FSGIM) [12]	An information model to represent smart grid related energy information within a facility, and specifically the information that may need to be communicated to/from electrical grid service providers across the SGUI (working draft; currently under development in ASHRAE/NEMA SPC 201P).	X	X	X	X	X	X	X	X	X	X	X	X	X	X

D.3.5.2 FG-100

The FSGIM data model supports the reception and transport of historical, present, forecasted demand and consumption data. This aggregate data may be for a single or collection of devices. Pricing is not supported, work in progress.

D.3.5.3 FG-200

The FSGIM data model supports forecasts of energy and demand data for both energy consuming (load) and energy supplying (generator) devices. This data could be forwarded to the grid using whatever transport is selected (e.g. OpenADR[7]).

D.3.5.4 FG-300

The FSGIM can accept price schedules and operate on such schedules across any reasonable time frame. FSGIM also provides environmental data. Pricing is not supported, work in progress

D.3.5.5 FG-400

The pricing is within FSGIM scope and will be supported. The acceptance (or rejection) of the price is out of scope and will be provide by other layers.

D.3.5.6 FG-500

The FSGIM supports plan revisions for loads, generators, and storage devices. Furthermore, FSGIM supports aggregations of these revisions across the facility. The acceptance (or rejection) of the revisions is out of scope and will be provide by other layers.

D.3.5.7 FG-600

The FSGIM supports the needed classes and attributes for all the features listed in this use case.

D.3.5.8 FG-700

The FSGIM does not allow the supplier to discriminate as to how demand is increased or decreased. However, FSGIM does support multiple simultaneous energy programs. If these programs are setup to discriminate the loads from generators, it would be supported

D.3.6 Analysis of "SEP 2.0 (IEEE P2030.5)"

Table D.6 reproduces the "SEP 2.0 (IEEE P2030.5)" [17] row of Table D.1.

Table D.6 – "SEP 2.0 (IEEE P2030.5)" Applicability

Standard	Title/Description	Use Case and exchanged information number													
		FG-100		FG-200		FG-300		FG-400		FG-500		FG-600		FG-700	
		3-4	4-3	1-6	2-1	1-2	2-3	1-2	3-1	1-3	2-1	1-1	2-7	1-2	2-1
SEP 2.0 (IEEE P2030.5) [17]	Communications of pricing, DR signals, messaging, and energy usage to in-home devices.	SEP 2.0 (IEEE P2030.5) is under consideration for standardization by IEC/PC118.													

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BSI Group Headquarters

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