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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Next Generation Networks – Frameworks and functional architecture models

Framework for an energy-sharing and trading platform

Recommendation ITU-T Y.2072

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Recommendation ITU-T Y.2072

Framework for an energy-sharing and trading platform

Summary

To increase the efficiency of the electricity grid and reduce electricity grid wastage, it is important to support an open service platform with the capacity for more effective electricity markets and electricity trading. Thus, Recommendation ITU-T Y.2072 provides a framework for an energy-sharing and trading platform for integrated control and management, taking into account energy production, storage and consumption. After identifying key characteristics and core technologies of the platform, Recommendation ITU-T Y.2072 specifies requirements taking into account the energy value chain made up of various stakeholders. Then, Recommendation ITU-T Y.2072 provides an architectural overview specifying related interfaces and functional blocks. Finally, mechanisms for energy information exchange to support integrated control and management services on the energy-sharing and trading platform are described.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2072	2018-05-29	13	11.1002/1000/13614

Keywords

distributed energy resources, energy platform, energy market, energy sharing, energy trading.

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FOREWORD

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NOTE

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

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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1 Scope

To increase the efficiency of the electricity grid and reduce electricity grid wastage, it is important to support an open service platform with the capacity for more effective electricity markets and electricity trading. Thus, this Recommendation provides a framework for an energy-sharing and trading platform for integrated control and management taking into account energy production, storage and consumption.

This Recommendation covers:

– key characteristics and core technologies for an energy-sharing and trading platform;

– requirements taking into account the energy value chain made up of various stakeholders;

– architectural overview specifying related interfaces and functional blocks;

– mechanisms for energy information exchange.

2 References

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

[ITU-T X.1111] Recommendation ITU-T X.1111 (2007), *Framework of security technologies for home network.*

[ITU-T Y.2071] Recommendation ITU-T Y.2071 (2015), *Framework of a micro energy grid*.

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

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 aggregator: A system in smart grid for collecting the energy generated by residences and micro grids.

NOTE – Based on [b-ITU-T Smart-O-30].

3.2.2 customer: The end user of energy or services, who may also generate, store, and manage the energy.

NOTE 1 – Based on [b-ITU-T Smart-O-30].

NOTE 2 – Traditionally, three customer types are discussed, each with its own domain: residential, commercial, and industrial.

3.2.3 demand response (DR): A smart grid feature that allows consumers to reduce or change their electrical use patterns during peak demand, usually in exchange for a financial incentive. Mechanisms and incentives for utilities, business, industrial, and residential customers to cut energy use during times of peak demand or when power reliability is at risk. Demand response is necessary for optimizing the balance of power supply and demand.

NOTE – Based on [b-ITU-T Smart-O-30].

3.2.4 distributed energy resource (DER): An energy generation and energy storage facility located at the customer premises or power transmission and distribution systems.

NOTE – Based on [b-ITU-T Smart-O-30].

3.2.5 energy management system (EMS): A computer system comprising a software platform providing basic support services and a set of applications providing the functionality needed for the effective operation of electrical generation and transmission facilities so as to ensure adequate security of energy supply at minimum cost.

NOTE – Based on [b-ITU-T Smart-O-30].

3.2.6 energy storage: Energy storage provides storage functions of electricity using various types of batteries.

NOTE 1 – Based on [b-ITU-T Smart-O-30].

NOTE 2 – One example usage of energy storage is used to respond effectively to dynamic price mechanism from utility network. The electric energy is stored to the storage during lower price period relatively, while the stored electric energy may replace the higher price of electric power from utility network.

3.2.7 renewable energy certificate (REC): A tradable, non-tangible energy commodity that represents proof that energy was generated from an eligible renewable energy resource (renewable electricity) and was fed into the shared system of power lines that transport energy.

NOTE – An REC is also known as a "green tag", "renewable energy credit", "renewable electricity certificate", or "tradable renewable certificate".

3.2.8 service provider: An organization providing services related to smart grid to electrical customers and utilities.

NOTE – Based on [b-ITU-T Smart-O-30].

3.2.9 substation: A site where equipment for switching or regulating electrical voltage is located.

NOTE – Based on [b-ITU-T Smart-O-30].

3.2.10 supervisory control and data acquisition (SCADA): A computer system that monitors an industrial, infrastructure, or facility-based control process.

NOTE – Based on [b-ITU-T Smart-O-30].

3.2.11 utility provider: An organization that provides electric power, gas, and water. In the smart grid, a utility provider supplies electric power.

NOTE – Based on the definition of "utility company" in [b-ITU-T Smart-O-30].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

CBL Customer Baseline Load

DER Distributed Energy Resource

DNP Distributed Network Protocol

DR Demand Response

EI	Energy Interoperation
EIMA	Energy-Integrated Management Application Service
EIMC	Energy-Integrated Management Core Service
EIMS	Energy-Integrated Management System
EIPS	Energy Information Portal Service
EMIX	Energy Market Information Exchange
EMS	Energy Management System
ESPS	Energy Service Provider Service
ESS	Energy Storage System
ESTS	Energy information Sharing and Trading Server Service
ETC	Energy-Trading Client
ETOS	Energy-Trading Operation Service
ETS	Energy-Trading Server
M2M	Machine to Machine
OpenADR	Open Automated Demand Response
REC	Renewable Energy Certificate
SCADA	Supervisory Control And Data Acquisition
SEP	Smart Energy Profile
SOA	Service-Oriented Architecture
VEN	Virtual End Node
VTN	Virtual Top Node
XML	Extensible Markup Language

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

6 Introduction to an energy-sharing and trading platform

6.1 The concept of an energy-sharing and trading platform

As the smart grid shifs from the conceptual modelling phase to actual implementation, factors such as scalability, reliability and cyber security are becoming major issues. From the business perspective of the smart grid, it is also important to optimize energy supply and demand, as well as to stimulate the participation of energy-trading markets taking into account stakeholders such as wholesalers, retailers, third party service providers and consumers.

For energy-related services in a smart grid environment in particular, taking into account energy production, storage and consumption, it is essential to build up an intelligent energy-sharing and trading platform for energy consumption recognition and prediction through context awareness from sensing information using machine to machine (M2M) communications, as well as for more efficient

energy trading and delivery through DER clustering. The platform also has a significant role in market interoperability.

Figure 6-1 is a conceptual diagram of an energy-sharing and trading platform for integrated control and management. The platform is interconnected with various entities for energy production, storage and consumption in a home or public building environment with DERs. The platform is responsible for exchanging price, balancing supply and demand, and congestion management with the sharing of energy information while delivering energy to consumers, guaranteeing security of supply at all times. An open platform with application programming interfaces (APIs) enables integrated control and management in the processes of production, storage and consumption, while offering reliable and high-quality services, and closely interworking among energy markets.

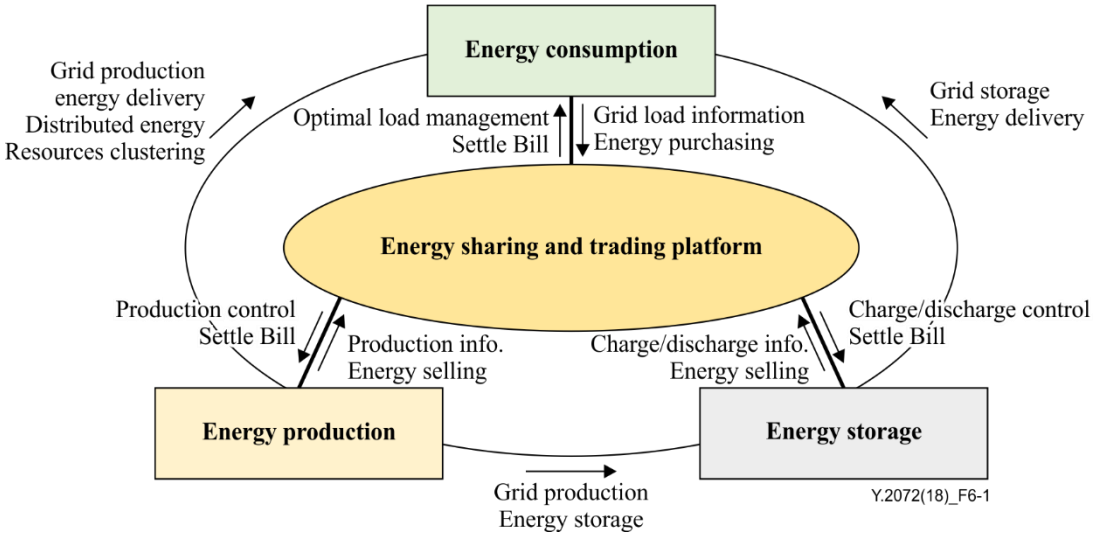


Figure 6-1 – A conceptual diagram of an energy-sharing and trading platform for integrated control and management

An energy-sharing and trading platform needs the following key technologies:

– M2M communications and big data analytics for energy control and operations in the integrated environment of various DERs [ITU-T Y.2071];

– optimized charge and discharge operations of an energy storage system (ESS);

– real-time price-based demand response (DR) control for energy assets, etc.

To support the key technologies listed in the previous paragraph, the platform should be designed taking into account:

– integrated control and management of energy production, storage and consumption for efficient energy-trading support with open services via APIs;

– accurate data analytics and prediction based on sharing information;

– energy-sharing networks and market operations;

– optimized energy consumption according to various pricing schemes (e.g., real-time pricing and peak pricing);

– interworking with various energy management systems (EMSs) and market interoperability.

6.2 The service concept in the energy market

This Recommendation considers a home or public building environment to provide an integrated energy management in the processes of energy production, storage and consumption. The energy-

sharing and trading platform provides a solution to efficiently manage and supply energy through the sharing and trading of the saved energy in the energy market.

6.2.1 Basic processes in the energy market

The energy market business can be viewed as a set of processes. The following explains the main activities as basic processes for related use cases.

– Plan: The messages defined in planning enable responsible parties for trade, production and consumption to send their schedules to system operators or the transmission capacity allocator in advance.

– Trade: In trading, the responsible parties buy and sell energy to fulfil their contractual obligations through market operators.

– Operate: Operations include message exchanges to handle the markets, e.g., a system operator orders up and down regulation to maintain balance in the system.

– Measure: Measurement covers all stages from the collection of metered data until the settlement and reconciliation phase. After collection and distribution, metered data are validated, aggregated and distributed to relevant roles.

– Settle: Settlement resolves imbalanced accounts of a market operator.

– Bill: Billing includes all message exchanges with consumers and internal billing within the energy market.

6.2.2 Service scenario for energy-sharing and trading

This clause describes a service scenario for energy-sharing and trading as follows:

– Stage 0: Energy market participation

  A customer (energy buyer or seller) can participate in the energy market through the relevant community in order to register energy resources and products that are pre-contracted in a home or public building.

– Stage 1: Provision of the available energy to the community

  The attribute information (e.g., the energy type, energy availability) is managed through the registration of energy equipment (e.g., distributed resource, energy storage device in a home or public building) to the community. An individual community monitors the status of resources in real time to enable production and storage of energy.

– Stage 2: Registration of energy assets in the energy market

  Energy production and storage devices pre-contracted to the community are registered as available energy assets in the energy market. After checking the energy type and energy serviceable level of the available registered energy assets in real time, the related energy information is updated to provide it to a customer.

– Stage 3: Disclosure and bidding for energy products to support energy sharing and trading

  Information about available energy registered to multiple communities is disclosed, and the customer participates in energy price bidding for the amount and duration of energy required. If the request for the absolute duration of energy for use is not met depending on situations, the customer needs to negotiate the energy price according to the actual amount and duration of energy.

– Stage 4: Establish contracts for the use of available energy

  The customer, for energy use scheduling, approves contracts for energy consumption in the energy market. Incentives and energy points are provided to the energy seller in the contract established. The energy buyer provides incentives to the energy seller and subtracts energy points.

– Stage 5: Surplus energy trading

  Surplus energy information is disclosed to the energy market in direct transactions or the energy is sold back to the energy company to obtain credit in the form of backward meter counting. The credit can be replaced by energy points.

7 Requirements for an energy-sharing and trading platform

[b-NIST 1108] has specified a conceptual model of the smart grid, consisting of seven major functional areas called domains and the information flows between them, as well as the flow of electricity from power sources through transmission and distribution systems to customers. Table 7-1 gives a brief definition of these domains. For the entire market, bulk generation and transmission can be considered as a separate domain for the energy-sharing and trading platform. However, this Recommendation mainly focuses on an energy market platform for energy prosumers. Therefore, it defines functional requirements for the energy-sharing and trading platform from the remaining five domains, excluding bulk generation and transmission.

Table 7-1 – Domains and actors in the smart grid conceptual model

Domain	Actors in the domain
Customers	End users of electricity. This domain may also store and manage the use of energy. Traditionally, there are three customer types, each with its own domain: residential, commercial and industrial.
Markets	Operators and participants in electricity markets.
Service providers	Organizations providing services to electrical customers and utilities.
Operations	Managers of the movement of electricity.
Bulk generation	Generators of electricity in bulk quantities. This domain may also store energy for later distribution.
Transmission	Carriers of bulk electricity over long distances. This domain may also store and generate electricity.
Distribution	Distributors of electricity to and from customers. This domain may also store and generate electricity.

7.1 Customer domain

– The customer domain is required to monitor the safety status of the power generation facility and operate the generator according to the power generation schedule requested by the customer.

– It is required to monitor the charge or discharge status of the energy storage device and control it according to charge/discharge schedule.

– It is required to monitor the power consumption of energy overconsumption facilities and to control the operation mode of the load facilities in order to reduce the power peak load of the customer domain.

– It is recommended to provide a function to analyse and predict the power consumption patterns of the customer domain and individual consumption devices to optimize energy consumption.

– It is required to process DR events of the affiliated DR programme and provide the ability to integrate and control the energy generation and consumption resources within the domain to achieve the contracted load reduction capacity.

– It is required to measure the generation capacity of individual generation facilities and energy storage devices within the management domain.

7.2 Distribution domain

– The distribution domain is required to measure the amount of power flowing into or out of distribution lines connected to the management domain.

NOTE – It is necessary to measure the total power consumption of the management domain and the generated power flowing into the grid.

– It is recommended to collect the distribution status information from the monitoring and protection device of the distribution line and to provide the function to automatically control the distribution line in case of trouble.

7.3 Operation domain

– The operation domain is required to periodically collect and store energy measurement data.

– It is recommended to provide the ability to monitor and control the state of the power quality according to the terms of the contract.

– It is required to provide the customer and service provider with the power measurement data and the status information of the distribution line when requested.

7.4 Service provider domain

– The service provider domain is required to provide the ability to register as a resource to be managed after verifying that energy resources at the customer site are available for DR programmes and distributed resource trading.

– It is required to provide the ability to collectively monitor and control grouped resources.

– It is recommended to provide the function to predict the possible demand reduction and power generation capacity at the customer site.

– It is required to support grouping of DR resources and small power generation resources at customer sites and engaging in energy transactions on behalf of customers.

– It is required to notify the schedule information to the customers after generating the operation schedule of the small power generation resources according to the contract condition with the energy market.

– It is required to receive events related to energy demand reduction and generation control from the energy market, and then notify the customer of the events online.

7.5 Markets domain

– The markets domain is required to register and verify energy products consisting of customers' individual energy resources and their combination, and to enquire about details of energy products.

– It is required to manage the processing of electronic bidding contracts between a seller and a buyer for registered energy products.

– It is required to be interrogated and verified based on energy measurement data whether the traded energy product is generating or reducing demand by the contracted capacity.

– It is required to settle the energy sales price considering incentives and penalties according to whether the contract conditions of the traded energy products are fulfilled.

8 Architecture overview of an energy-sharing and trading platform

8.1 Generic architectural model of an energy-sharing and trading platform

To align with the domains and actors in the smart grid conceptual model listed in Table 7-1, Figure 8-1 shows the positioning of markets in relation to the seven domains, considering the energy-sharing and trading platform. Clauses 8.1.1 to 8.1.6 describe key features of each domain.

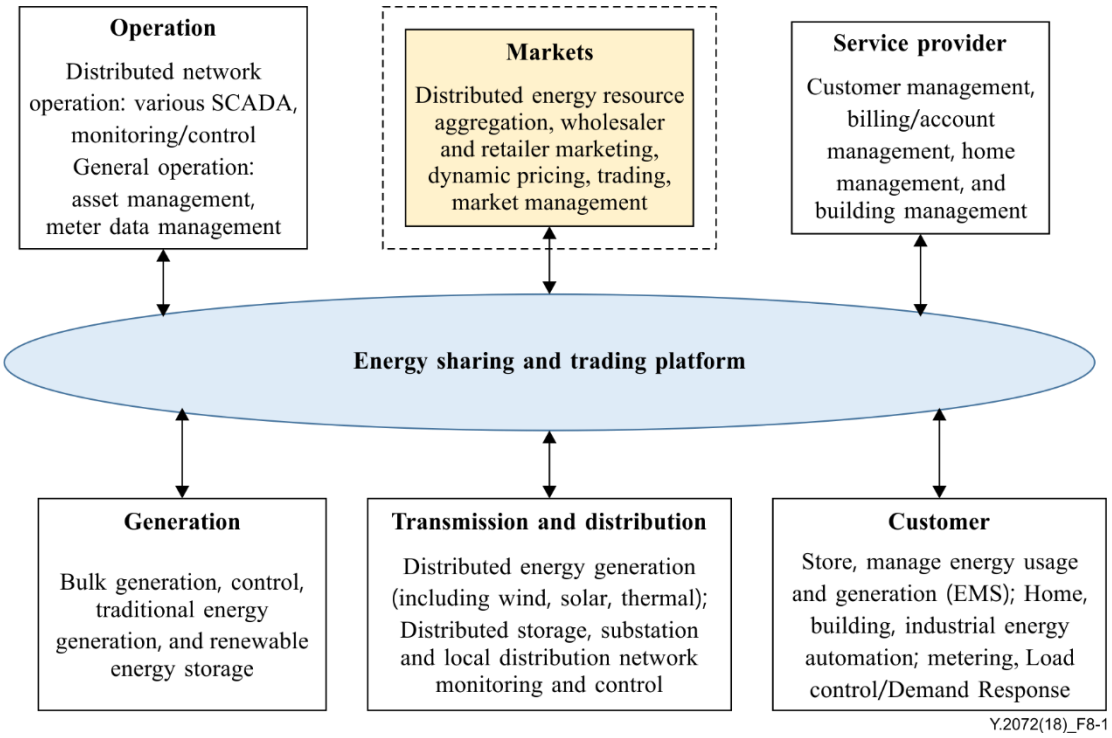


Figure 8-1 – A conceptual model for markets in a smart grid

8.1.1 Markets

– The main applications of the markets domain include DER aggregation, wholesaler and retailer marketing. Retailers sell power to customers and may play an aggregation role as a broker between customers and the market. Most retailers are connected to a trading organization to allow participation in the wholesale market.

– Other applications include dynamic pricing, trading and market management. Traders are participants in markets and include aggregators for provision, consumption and curtailment, as well as other qualified parties.

Markets are connected to three domains (namely generation, transmission and distribution, and customer) via the energy-sharing and trading platform. The interfaces between the markets domain and those domains containing generation are critical, because efficient matching of production with consumption relies on markets. Besides the generation domain, electricity generation also takes place in the transmission and distribution, and customer domains.

In addition, the markets domain interacts with the operation and service provider domains.

8.1.2 Generation

– The main applications in the generation domain include bulk generation plant control, measurement and traditional energy generation. Measurement is used to provide visibility to the flow of power and to indicate the condition of the systems in the field remotely.

8.1.3 Transmission and distribution

– The main applications of the transmission and distribution domain include distributed energy generation, distributed storage, substation, and local distribution network monitoring and control. Substation management and control contains switching, protection and control equipment (e.g., substations connecting generation and storage with distribution).

8.1.4 Customer

– The customer domain consists of several sub-domains (e.g., homes, commercial premises or public buildings and industrial premises). Hence, applications can be categorized into energy

store, management and generation for homes, public buildings and industrial premises, respectively.

8.1.5 Operation

– The operation domain consists of applications for distributed network operation, including supervisory control and data acquisition (SCADA) systems to monitor and control the status of devices in the bulk generation, transmission and distribution domains.

– This domain also consists of applications for general operations, including asset management and meter data management (i.e., energy usage, energy generation, meter logs and meter test results) to make energy data available to authorized parties.

8.1.6 Service provider

– The service provider domain consists of applications such as customer and account management and installation management. The aim of customer management is to manage customer relationships by providing point-of-contact and resolution for customer issues and problems. Conversely, the aim of installation management is to install and maintain the equipment on the premises that interacts with the smart grid.

– This domain also consists of applications such as management of billing or accounts, homes and buildings.

The conceptual model in Figure 8-1 consists of six domains for markets in a smart grid. For the entire market, the generation domain can be considered as a separate domain for the energy-sharing and trading platform. However, this Recommendation mainly focuses on the platform over the small distributed resource brokerage and the reduction of demand resources for energy prosumers. Therefore, it defines core systems, control equipment, generation and consumption sources, as well as energy measurement devices for the remaining five domains, excluding the generation domain as shown in Figure 8-2.

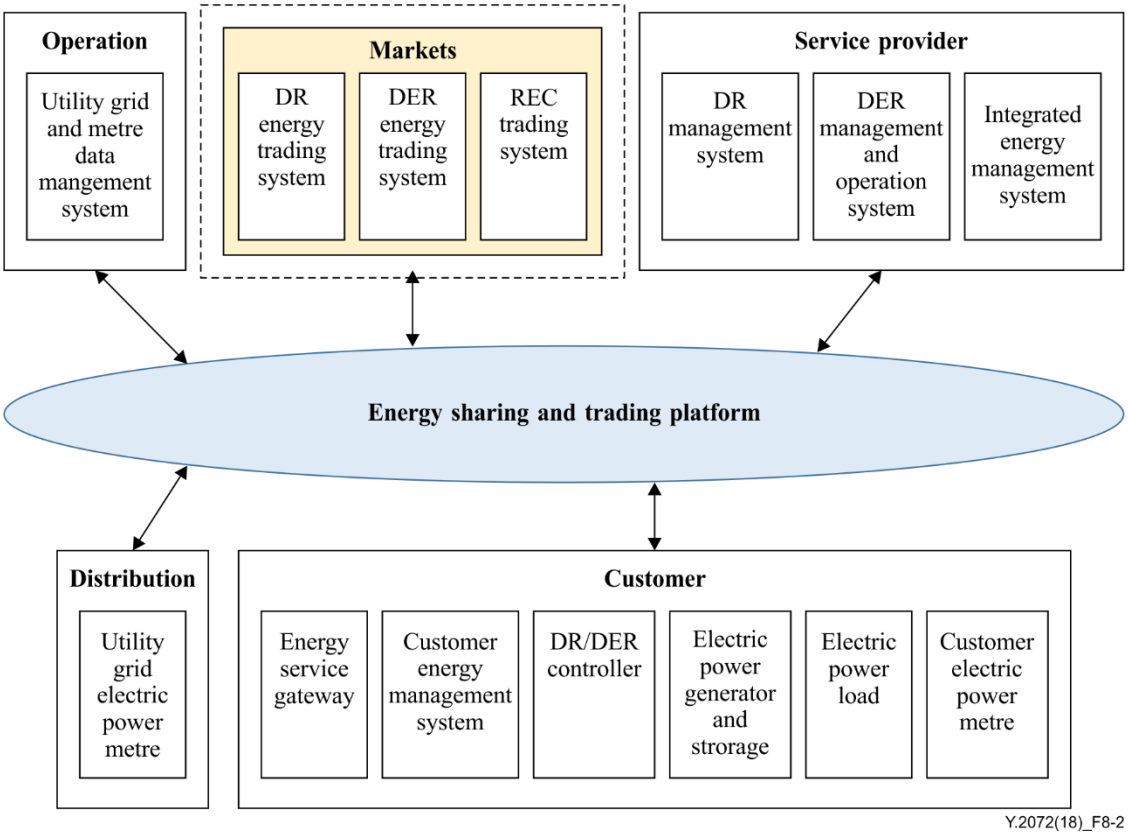


Figure 8-2 – Key system components of the energy-sharing and trading platform

A description of key systems and devices in each domain is given in clauses 8.1.7 to 8.1.11.:

8.1.7 Market

– DER energy-trading system
  - This system sells the surplus power produced from the power generation source or the energy storage device owned by energy consumers in a home or public building to other energy consumers.
  - It also arbitrates during the purchase of surplus power owned by other energy consumers.
  - It mediates energy trading so that energy commodities (e.g., virtual energy sources integrated by small-scale distributed generation sources) can be sold to wholesale and retail operators.

– DR energy-trading system
  - This system mediates the sale or purchase of energy based on the customer baseline load (CBL) within the term of the DR contract. CBL means a normal consumption pattern when there is no enforced load reduction.

– Renewable energy certificate (REC) trading system
  - This system aims to distribute renewable energy supply among government-affiliated energy management agencies in each country to reduce carbon emissions. Renewable energy suppliers can issue certificates (i.e., RECs) and sell their certificates.

    NOTE – Existing generation operators (e.g., nuclear and thermal power plants) can directly produce renewable energy to keep the obligatory amount under its own power generation by government regulations or can obtain through the purchase of RECs.

• Under this regulatory environment, the system mediates the REC deal so that renewable energy providers are able to sell RECs to generation operators.

8.1.8 Service provider

– DR management system
  - This system is for integrated management of demand reduction resources accumulated through contracts with energy consumers.
  - It manages grouping resources with similar characteristics, depending on the load characteristics of demand reduction resources.
  - It allows customers to participate in various DR programmes.

– DER management and operation system
  - This system is an integrated operations management system for large-scale virtual power generation sources through the accumulation of small-scale distributed generation sources that are distributed to homes or public buildings.
  - The integration of small-scale power generation sources with no commercial value enables them to participate with bidding power equal to that of existing power generation sources in the electricity trading market as part of the virtual generation source.
  - The integrated large-scale power generation resources are regularly monitored and the supply schedule is managed in accordance with the contract terms as an energy product.

– Integrated EMS
  - This system monitors in real-time generation of distributed energy sources and power consumption of the load resources simultaneously in homes or public buildings without their own EMSs.

- It also analyses collected measurement data to predict customer as well as individual resource demands, and manages to minimize the maximum load power and energy consumption of the customer site.

8.1.9 Customer

– Energy service gateway
  - This gateway is an interface device for interworking between service provider systems and EMSs within a customer's site.
  - It also can support a dynamic application execution platform for provisioning energy management services in support of a service provider;
  - The information (e.g., power measurement, resource status, operations and schedules, service providers' events) is delivered to a device within the customer's site or service provider system through this interface.
– Customer EMS
  - This system collects and analyses power production and consumption of customer energy resources from the power meter within a customer's site.
  - It reduces peak load and energy consumption by forecasting the demand of the customer site based on analytical data.
– DR/DER controller
  - This controller controls energy production, storage and consumption devices within a customer site according to the operation schedule received from the DR and DER management systems.
– Electric power generator and storage
  - This generates and stores electric power within a customer site.
– Electric power load
  - This is a power consumption source within a customer site.
– Customer electric power meter
  - The meter measures electric power flows into and out of the utility grid at a customer site.
  - It measures electric power generation and consumption of the energy resources within a customer site.

8.1.10 Operation

– Utility grid and meter data management system
  - This system periodically collects and manages meter data from utility grid electric power meters.

8.1.11 Distribution

– Utility grid electric power meter
  - This meter measures the electric power flows into and out of the utility grid at a customer site.

8.2 Functional architecture for an energy-sharing and trading platform

An energy-sharing and trading platform has an important role for energy information exchanges between a seller (e.g., a producer) and a buyer (e.g., a consumer). As shown in Figure 8-3, the platform interacts with market participants (i.e., sellers and buyers) that are in charge of the production, storage and consumption of energy. Then, actual physical power is delivered between them based on the

processing results of energy information for production control, charge/discharge control, optimal load management, etc.

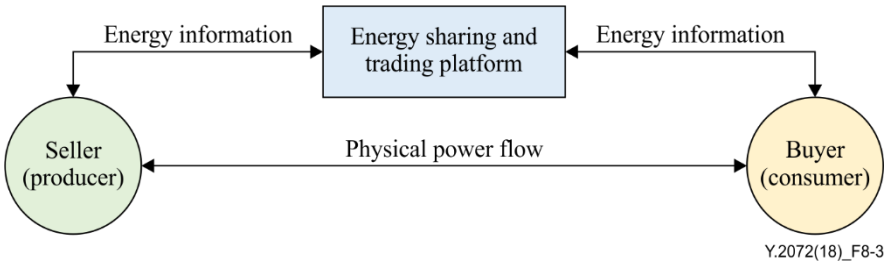


Figure 8-3 – A high-level view of an energy-sharing and trading platform

There are various actors as participants in an energy market:

– generator: generate and (may also) store energy;

– transmission/distribution operator: delivers electrical power from generator to consumer;

– aggregator: a mediator in the energy market between power generators and consumers;

– energy service provider: supports the business processes of generators, operators and consumers;

– consumer: generates, stores energy and manages the use of energy in household, commercial building and industrial facilities.

Based on key system components and various actors, the energy-sharing and trading platform has four main functional groups as follows:

– Energy market functions
  - Registration and advertisement of market participants' energy commodities.
  - Contract bidding and purchase processing for sales of energy commodities.
  - Sales and contract management of energy commodities based on energy measurement data.
  - The final confirmation and settlement of selling/buying energy commodities.

– Resource aggregator functions
  - Resource registration and grouping of participating customers.
  - Status monitoring, analysis and supply/demand forecast of participating customers' resources.
  - Handling of DR events.
  - Resource operations and schedule management in accordance with the terms and conditions of energy commodities.

– Energy prosumer functions
  - State information gathering and monitoring of power generation, storage and consumption resources within a customer site.
  - Power generation and consumption measurement of the whole customer site and individual resources.
  - Reception and treatment of resource aggregator events.
  - Resource control schedule registration and schedule-based resource management.

– Utility grid functions
  - Measurement and management of customer site meter data on the utility grid.

Figure 8-4 shows the four functions and their features described in the previous paragraph, including interactions between functional blocks.

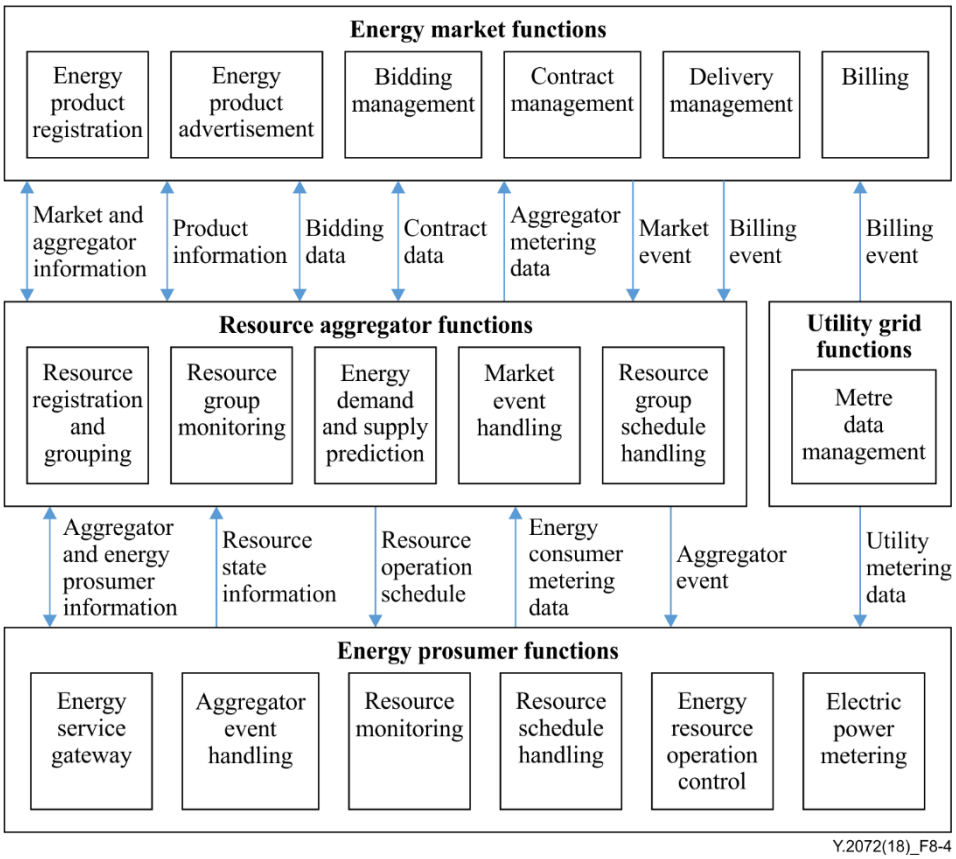


Figure 8-4 – Key functions of an energy-sharing and trading platform

The four functional groups include the detailed features described in clauses 8.2.1 to 8.2.4.

8.2.1 Energy market functions

– Energy product registration
  - Information registration and management for energy commodities that participants (e.g., a resource aggregator or energy prosumer) in the energy market hold;
  - Energy commodities comprise basic attribute information (e.g., the generated voltage, current, resource characteristics and the maximum power capacity) of each resource and resource group.

– Energy product advertisement
  - Notification of registered information related to energy commodities to energy market participants.
  - Advertisement enables energy market participants to maintain up-to-date information for energy commodities.

– Bidding management
  - Registration management of energy commodity bidding information (e.g., the lowest bidding price, bid expiration time, generation schedule, generation capacity and resources quality condition);
  - Notification of successful bid results to all participants through the management of participants bidding for each energy commodity.

– Contract management

- Control of energy market participation and energy commodity registration based on CBL and actual electricity usage patterns.
- Integrated management for events (e.g., the terms and conditions change, contract cancellation and rebidding) that may occur before execution after contract signature.

– Delivery management
  - Management of the delivery of meter data from market participants.

– Billing
  - Calculation of the actual transaction volume compared to CBL and billing in accordance with the contractual conditions.

8.2.2 Resource aggregator functions

– Resource registration and grouping
  - Registration and management of power generation and demand reduction resources that participating customers (e.g., energy prosumer and customer) hold.
  - Resource grouping and energy commercialization based on resource characteristics.

– Resource group monitoring
  - Monitoring and analysis of the operation status of each resource group.

– Energy demand and supply prediction
  - Energy demand pattern and supply forecasting of participating customers based on environmental information (e.g., climate) and historical data.

– Market event handling
  - Handling of energy market events, such as market price and grid reliability information.

– Resource group schedule handling
  - Operation schedule management for the resources of the participating customers in accordance with the terms and conditions of energy commodities.

8.2.3 Energy prosumer functions

– Energy service gateway
  - An interface for transmitting power measurement data, resource status information, operating schedules and energy market events between resource aggregator and energy prosumer.

– Aggregator event handling
  - Processing of the event (e.g., DR event or resource operation schedule registration event) received from a resource aggregator.

– Resource monitoring
  - Operation status monitoring of power generation, storage and consumption resources within a customer site.

– Resource schedule handling
  - Operation scheduling of power generation, storage and consumption resources within a customer site.

– Energy resource operation control
  - Integrated control of power generation, storage and consumption resources in accordance with the resources operating schedules.

– Electric power metering

  • Measurement of power generation and power consumption through the participating customer's electric power meter installed at the customer site.

8.2.4 Utility grid functions

– Meter data management

  • Measurement and management of customer power generation and consumption through utility grid electric power meters.

9 Mechanisms for energy information exchange

The rapid increase and spread of renewable energy sources and ESS provide opportunities for energy prosumers to create added value through surplus energy trading. To this end, the energy-sharing and trading platform for energy prosumers has capabilities for monitoring energy consumption facilities, energy storage devices and renewable energy sources within the customer domain, as well as integrating with the energy market, service provider systems and DR/DER control devices.

The energy-sharing and trading platform provides a standard interface for matching with various standard protocols to support interworking. Based on this standard interface, the energy-sharing and trading platform is able to:

– monitor various energy consumption and supply resources and control a group of these resources;

– balance the energy demand and supply of customer domains;

– sell surplus resources across the market.

Figure 9-1 shows the four important features and data management items provided in the energy-sharing and trading system. Related standards from different stakeholders are interfaced to support interoperability with external systems and devices.

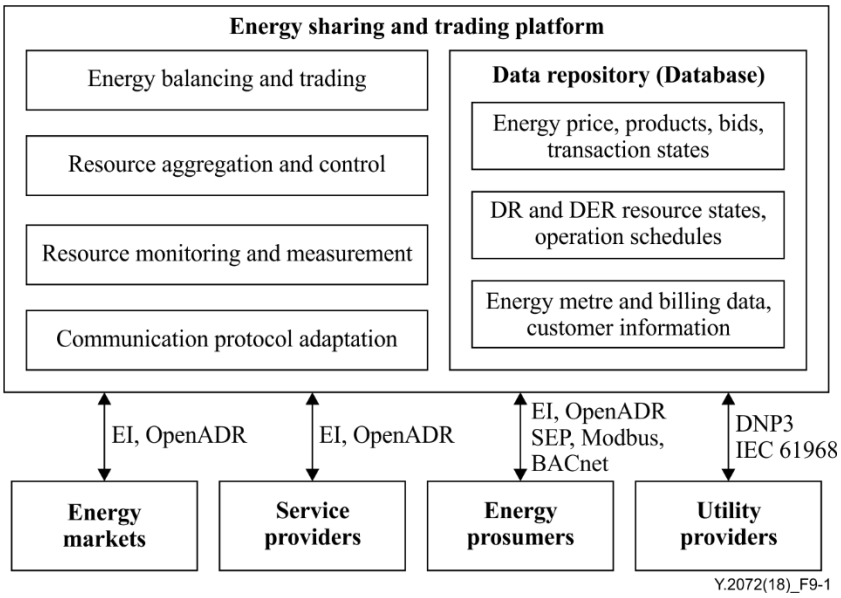


Figure 9-1 – Energy information exchange in an energy-sharing and trading platform

9.1 Communication protocol adaptation

– An energy-sharing and trading platform serves as a bridge or gateway platform connecting energy prosumer devices with service providers, energy markets, and utility providers. To this end, the communication protocol adaptation layer supports existing standard protocols

[e.g., energy interoperation (EI)] and provides an abstracted common service interface for interworking with other systems and devices to upper layers:

- this layer serves as a communication interface to support interworking with key system components of the energy-sharing and trading platform shown in Figure 8-4;
- this layer supports standard information models and communication protocols [e.g., EI, open automated demand response (OpenADR), and smart energy profile (SEP)] for DR/DER management services and energy trading;
- this layer also supports standard information models and communication protocols {e.g., the distributed network protocol 3 (DNP3) [b-IEEE 1815] and IEC 61968 [b-IEC 61968-9]} to collect energy metering information from utility grid management servers and energy meters.

9.2 Energy resource monitoring and measurement

– Energy-sharing and trading platforms need to monitor the status of energy resources in an integrated manner. The performance and safety status of each managed resource should be periodically checked, and the power consumption and supply of each resource should be measured and collected. The energy resource monitoring and measurement layer performs the following roles:

- this layer serves as a resource information collector to gather and monitor the status of DER through the abstracted common service interface provided by the communication adaptation layer;
- this layer collects power generation and consumption information measured by electric power meters;
- the utility grid electric power meter measures the total amount of power consumed and generated at the customer site, and the customer electric power meter measures the amount of power generated by each distributed resource.

9.3 Resource aggregation and control

– Energy-sharing and trading platforms need to integrate various resources to create one virtual bulk generation resource considering their characteristics. The resource aggregation and control layer performs the following roles:

- this layer groups and controls resources according to the DR programme or considering the characteristics of the individual resources registered;
- this layer serves as a DER manager to effectively cluster and control distributed resources by monitoring their availabilities and analysing driving probabilities based on the collected resource state information;
- this layer schedules the demand reduction of DR resources and controls them according to the schedule;
- this layer also controls the DER contracted through the energy market to manage the operating schedule of the resources.

9.4 Energy balancing and trading

– The energy-sharing and trading platform balances the power demand and supply within the management domain by maximizing the available DR resources, power generation resources and energy storage devices within the management domain. In addition, energy prosumers provide opportunities to create added value through surplus energy trading within the management domain. To this end, the energy balancing and trading layer performs the following roles:

- this layer regulates the power demand and supply balance of the management domain by using the real-time status information of the managed energy resources;
- this layer calculates an actual amount of power, generated by the DER on the managed customer domain, in comparison with a contracted amount of power, using the data measured from electric power meters – it also determines whether the actual amount of power generated by the DER falls within an acceptable limit of the contracted amount of power;
- this layer also serves as a DR manager configured to receive an electricity demand reduction instruction message notified from the DR market system, monitor a state of the DR resources and perform a DR control, as well as setting an electricity demand reduction and electricity generation schedule so that an electricity consumption can be within the range of the contracted target value;
- this layer compares the DR capacity target value with a maximum DR capacity prediction value to determine whether to purchase electricity to make up for a shortfall in DR capacity.

9.5 Data repository

– The energy-sharing and trading platform carries out the four core functions in clause 9.4 to efficiently maintain the integrated demand and supply balance in the process of energy production, storage, consumption and transaction management.

– The data repository stores information about the following three essential management items:
  - energy market information: energy price, energy products, bids, transaction states;
  - energy resource information: energy resource states, resource group information, resource operation schedules, resource availability, operation probability;
  - energy metering and customer information: customer information, billing data, energy measurement data.

10 Security considerations

The security considerations of an energy-sharing and trading platform should be in accordance with the security requirements in [ITU-T X.1111] and [ITU-T Y.2701]. General security requirements and technologies are described in [ITU-T X.1111]. This Recommendation applies the technologies in [ITU-T X.1111] to the key system components of an energy-sharing and trading platform.

An energy-sharing and trading platform should take into account aspects of physical, system and operational security as follows:

– verifying the identity of an entity (e.g., user, process or device) for accessing resources in a system for the energy-sharing and trading platform;

– determining the adequacy of security requirements and ensuring compliance with the established security policy and procedures for an energy-sharing and trading platform;

– authorization to use various services in a system for an energy-sharing and trading platform;

– supporting cryptography and validation mechanisms for data integrity in an energy-sharing and trading platform;

– providing the privacy considerations with respect to an energy-sharing and trading platform.

Appendix I

A possible system model for an energy-sharing and trading platform

(This appendix does not form an integral part of this Recommendation.)

This appendix illustrates a possible system model for an energy-sharing and trading platform. An energy-sharing and trading platform is implemented by various systems and related standard interfaces and protocols.

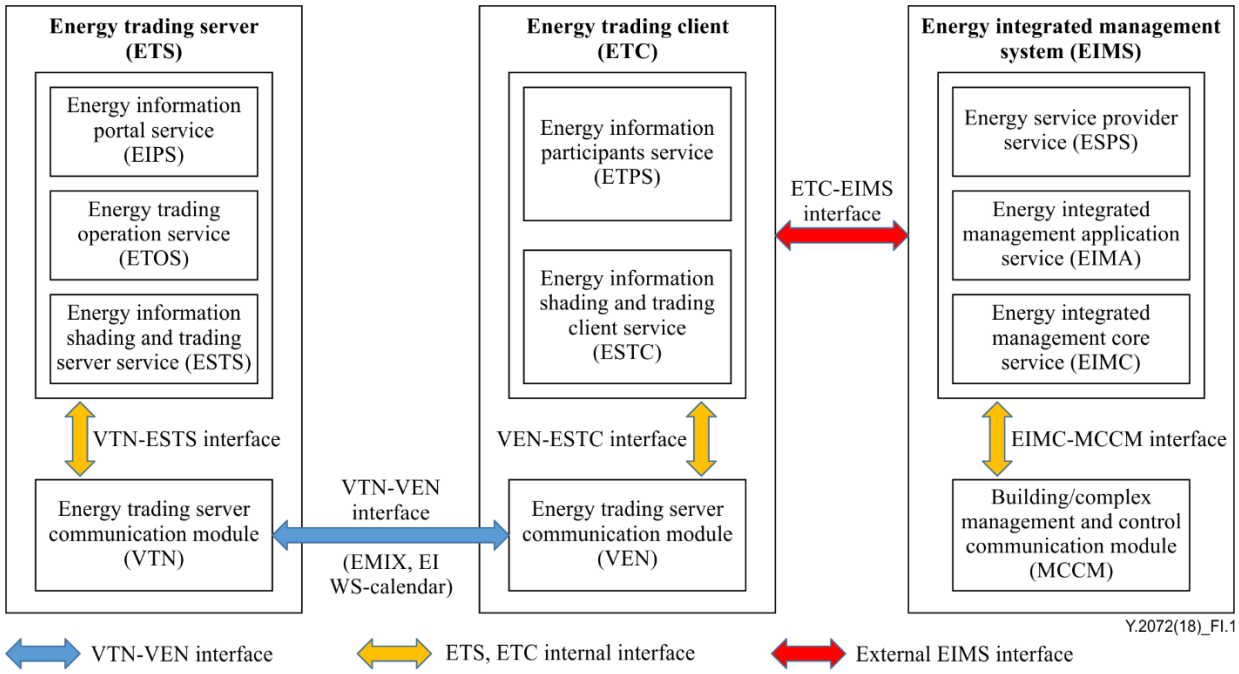
Figure I.1 shows an example of the overall system model for an energy-sharing and trading platform. The system consists of three main sub-systems: an energy-trading server (ETS), energy-trading client (ETC) and energy-integrated management system (EIMS). Each subsystem has related functional modules for supporting energy trading between sellers and buyers.

For energy-trading services requiring the sharing of energy information, standard interfaces are used as follows:

– interface between ETS and ETC [i.e., a virtual top node-virtual end node (VTN-VEN) interface];

– internal interface in ETS and ETC (i.e., VTN-ESTS interface, VEN-ESTC interface);

– external interface for EIMS (i.e., ETC-EIMS interface).



NOTE – VTN: Virtual top node , VEN: Virtual end node, EMIX: Energy market information exchange, EI: Energy interoperation

Figure I.1 –System overview of an energy-sharing and trading platform

I.1 ETS

An ETS consists of three services:

– Energy information portal service (EIPS)

The EIPS provides energy profiles including key statistics, policies and actors.

– Energy-trading operation service (ETOS)

An ETOS is a server to support energy-trading operations.

– Energy information sharing and trading server service (ESTS)

An ESTS provides services on the server side to support energy information sharing and trading.

I.2 ETC

– Energy-trading participants service (ETPS)

An ETPS provides client support for participation in energy trading.

– Energy information sharing and trading client service (ESTC)

An ESTC provides services on the client side to support energy information sharing and trading.

I.3 EIMS

– Energy service provider service (ESPS)

An ESPS providing energy services to final customers, including the supply and installation of energy efficient equipment or building refurbishment, has started to operate on the energy market.

– Energy-integrated management application service (EIMA) and energy-integrated management core service (EIMC)

An EIMA and EIMC provide applications and core services for energy-integrated management, including risk identification and management, planning, training, reporting, auditing and review in the energy-trading process.

I.4 Energy-trading communication module

– Server entity is a VTN

ETS communication module.

– Client entity is a VEN

ETC communication module.

I.5 Energy information exchange protocols

– Energy market information exchange (EMIX)

An EMIX provides methods for exchanging energy characteristics, availability and schedules to support the free and effective exchange of information. [b-OASIS EMIX] defines an information model and extensible markup language (XML) vocabulary for the interoperable and standard exchange of prices and product definitions in transactive energy markets: price information, bid information, time for use or availability, units and quantity to be traded, characteristics of what is traded.

– EI

[b-OASIS EI] describes information and communication models to enable collaborative and transactive use of energy, service definitions consistent with the OASIS service-oriented architecture (SOA) reference model, and XML vocabularies for the interoperable and standard exchange of: dynamic price signals, reliability signals, emergency signals, communication of market participation information such as bids, load predictability and generation information.

– WS-Calendar

WS-Calendar describes a semantic (or information) model for exchange of calendar information to coordinate activities and a means of synchronizing and maintaining calendars. [b-OASIS WS-Calendar] includes XML vocabularies for the interoperable and standard exchange of: schedules, including sequences of schedules, intervals, including sequences of intervals, other calendar information consistent with the IETF iCalendar standards.

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