



BSI Standards Publication

Virtual Power Plants

Part 2: Use Cases

National foreword

This Published Document is the UK implementation of IEC TS 63189-2:2023.

The UK participation in its preparation was entrusted to Technical Committee GEL/8, Systems Aspects for Electrical Energy Supply.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Published by BSI Standards Limited 2023

ISBN 978 0 539 00400 7

ICS 29.240.01

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2023.

Amendments/corrigenda issued since publication

Date	Text affected
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TECHNICAL SPECIFICATION



Virtual Power Plants- Part 2: Use Cases

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.240.01

ISBN 978-2-8322-7623-5

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

VIRTUAL POWER PLANTS –

Part 2: Use cases

FOREWORD

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IEC TS 63189-2 has been prepared by subcommittee 8B: Decentralized electrical energy systems, of IEC technical committee 8: System aspects of electrical energy supply. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
8B/136/DTS	8B/198/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 63189 series, published under the general title *Virtual power plants*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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INTRODUCTION

The virtual power plants use cases are developed to facilitate the standardization in this area from a system perspective. The use cases capture the basic information, business roles, actors, scenarios, and processes from practical business applications, pilot projects, and academic researches of virtual power plants in different countries. This document is developed to capture the requirements in the form of use cases that contain the scenarios and steps in a logical sequence so that it cannot only be understood by interested parties to obtain their related requirements, develop a virtual power plant, or operate a virtual power plant, but also establish a nomenclature for the functions, roles, etc. Meanwhile, the use cases in the document apply to any types of DER aggregation (physical, virtual, small and large), and also to microgrids.

Interested parties for this document include, but are not limited to:

- virtual power plant operator
- distributed generation operator
- demand response service operator
- electrical energy storage operator
- electric vehicle operator
- electric vehicle charging station with storage
- power system operator
- electricity market operator
- transmission and/or distribution company
- energy service company
- energy information provider
- regulator

The major objectives of this document include:

- to build common understanding of the business, system and functional requirements and thus to facilitate further development of VPPs;
- to investigate future standardization needs, in order to ensure the easy implementation, performance and interoperability of VPPs;
- to serve as an input to the IEC Use Case management repository, the purpose of which is to collect, administer, maintain, and analyze generic use cases.

VIRTUAL POWER PLANTS –

Part 2: Use cases

1 Scope

This document is applicable to virtual power plants (VPPs) that consist of distributed generation, controllable loads, and electrical energy storages.

This part of IEC 63189 is to provide VPPs use cases that capture the basic information, business roles, actors, scenarios, and processes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC SRD 62913-1:2019¹, *Generic smart grid requirements – Part 1: Specific application of the Use Case methodology for defining generic smart grid requirements according to the IEC systems approach*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

aggregator

party who contracts with a number of other network users (e.g. energy consumers) in order to combine the effect of smaller loads or distributed energy resources for actions such as demand response or ancillary services

[SOURCE: IEC 60050-617:2017, 617-02-18]

3.2

controllable load

CL

load of particular consumers which under contract shall be reduced, for a limited period of time, at the request of the distribution supply undertaking

Note 1 to entry: Controllable load can be increased as well as reduced, according to the request of the distribution supply undertaking.

¹ This publication was withdrawn.

[SOURCE: IEC 60050-603:1986, 603-04-42, modified — Addition of a Note 1 to entry.]

3.3 **demand response** **DR**

action resulting from management of the electricity demand in response to supply conditions

[SOURCE: IEC 60050-617:2011, 617-04-16]

3.4 **distributed energy resources** **DER**

generators (with their auxiliaries, protection and connection equipment), including load having a generating mode (such as electrical energy storage systems), connected to a low-voltage or a medium-voltage network

[SOURCE: IEC 60050-617:2017, 617-04-20]

3.5 **distributed generation** **DG**

generation of electric energy by multiple resources which are connected to the power distribution system

Note 1 to entry: Distributed generation in VPPs are usually in the form of renewable energy generation, such as wind power, photovoltaic generation.

[SOURCE: IEC 60050-617:2009, 617-04-09, modified — Addition of a Note 1 to entry.]

3.6 **electrical energy storage** **EES**

installation able to absorb electrical energy, to store it for a certain amount of time and to release electrical energy during which energy conversion processes may be included

Note 1 to entry: The term "electrical energy storage" may also be used to indicate the activity that an apparatus, described in the definition, carries out when performing its own functionality.

Note 2 to entry: The term "electrical energy storage" should not be used to designate a grid-connected installation, "electrical energy storage system" is the appropriate term.

[SOURCE: IEC 62933-1:2018, 3.1, modified — The example was deleted.]

3.7 **prosumer**

network user that consumes and produces electrical energy

[SOURCE: IEC 60050-617:2017, 617-02-16]

3.8 **use case**

specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system

[SOURCE: ISO/IEC 19505-2:2012, 16.3.6]

3.9 virtual power plant VPP

party or system that realizes aggregation, optimization and control of distributed generation, energy storage devices and controllable loads

Note 1 to entry: The aggregated distributed generation, energy storage devices and controllable loads are not necessarily within the same geographical area.

Note 2 to entry: The party or system is to facilitate the activities in power system operations and electricity market.

4 System requirements

4.1 General considerations

VPPs aim to effectively aggregate DG, EESs and CLs as one dispatchable and tradable unit by utilizing technologies in areas such as information, communication and control technologies. VPPs provide capacity and ancillary services to the power system operation and sell energy to electricity markets. VPPs enhance the overall system economics and reliability, promote efficient optimization in resources, and facilitate renewable energy consumption.

The general objective of this document is to collect actual business applications, pilot projects, and academic researches, and develop use cases that capture VPPs basic information, business requirements, actors and roles, scenarios, and processes. VPPs use cases help participants to understand an existing function or process, engineers to develop system and functional requirements, and stakeholders to reach common consensus on best practice processes.

Use cases in this document can also provide guidance to development teams on user's needs related to cyber security and data privacy.

4.2 Basic requirements

4.2.1 General

The system should be capable of aggregating, forecasting, optimizing, coordinating, and controlling distributed generation, energy storage systems, and controllable loads, as one dispatchable unit in power system operations and one tradable unit in electricity markets. Meanwhile, it should be capable of providing ancillary services, such as reserve to guarantee promised delivery, and communicating with the power system operator directly to provide the support in operators' tasks.

4.2.2 Privacy

The system should comply with applicable laws and regulations to ensure the integrity, security and privacy of related data acquired during the VPPs operation process.

4.2.3 Cyber security

VPPs' operation depends on cyber security to a large extent. The system should consider preventive measures to ensure cyber security and minimize risks that could cause network communication breakdowns in system failures.

4.2.4 Adaptability, flexibility and interoperability

The system should be adaptable to various software and hardware conditions, as well as flexible to incorporate customer needs, and interoperable among related equipment to realize coordinated operation.

4.2.5 Communication and information

The system should utilize the information and communication technologies to ensure the secure, reliable and effective communication to satisfy the technical and commercial needs.

4.2.6 Reliability

The reliability and security of the system should be ensured.

4.3 Operational risks of VPPs

4.3.1 General

Potential operational risks caused by the failure of a VPP equipment or system are classified into three levels, depending on the severity of potential damages to grid operations and electricity market.

4.3.2 Major

A failure in a VPP equipment or system is considered as major, if it could result in serious impacts or damages to grid operations and/or the market, including but not limited to:

- blackout;
- complete or large-scale loss of data acquisition and transmission;
- complete or large-scale failure of communication network;
- database crashes;
- application program outage;
- unable to cover the reserves.

4.3.3 Moderate

Abnormal operation of DER dispatch and control could result in moderate impacts or damages to grid operations and/or the market, including but not limited to:

- brownout or frequency drift;
- partial loss of stored data;
- failure of system upgrade;
- abnormal of software and/or hardware operation environment.

4.3.4 Minor

Abnormal operation of DER dispatch and control could result in minor impacts or damages to operations or the market, including but not limited to:

- redistribution of load or short-term unavailability of backup systems;
- terminal data collection deviation;
- failure of database backup;
- failure of data processing and calculation;
- interruption of access to network.

5 Business roles

5.1 VPP participant

A VPP participant can be an aggregator or VPP operator to group distinct agents in a power system (i.e. consumers, producers, prosumers, etc.) to act as a single entity when interacting with various market operator or providing services to system operator.

5.2 DER owner

A DER owner is a party who owns physical assets of the distributed resources to participate in VPP, including DG, EES, CL and electric vehicle (EV) charging station.

5.3 System operator

The system operator is responsible for the safe and reliable operation of a part of the power system in certain area and for connection to other parts of the power system.

5.4 Electricity market operator

The electricity market operator is responsible for operation of the electricity market through managing the selling and buying prices with the objective of maximizing profit while ensuring satisfaction of customers' needs.

6 Actors

An actor can be a person, an equipment, or an organization that plays a role in use cases developed in this document.

Common actors derived from stakeholders are listed as follows.

- VPP service provider
- DG operator
- demand response service operator
- EES operator
- electric vehicle operator
- EV charging station with storage
- system operator
- electricity market operator
- transmission and/or distribution company
- energy service company
- energy information provider
- regulator

7 Application scenarios and functions

7.1 Overview

Primary application scenarios and functions of VPP are categorized into five types:

- 1) aggregation and optimization;
- 2) analysis and forecast;
- 3) energy system management;

- 4) trading and settlements;
- 5) communication.

7.2 Functions

- Aggregation and optimization

Aggregation refers to the function that multiple distributed resources, such as DG, electrical energy storage and CLs are grouped together to act as one operating unit that is dispatchable and tradable.

Optimization refers to the function that improves the VPP system's operational and economic performance through maximizing or minimizing certain parameters.

- Analysis and forecast

Analysis refers to the functions conducted via quantitative calculations. The results can be provided to VPP stakeholders for investigation, inspection and survey purposes.

Forecast refers to the function that predicts DG's output, CL's consumption, etc.

- Energy system management

Energy system management refers to the function that VPP decomposes power system's dispatchments and send controls to individual DER based on interaction with power system operator.

- Trading and settlements

Trading refers to the function that realizes VPP buys or sells in electricity market.

Settlements refer to the function that performs financial settlements between VPP and the market, as well as financial settlements between a VPP service provider and an individual VPP component.

- Communication

Communication refers to the function that realizes information transfers and data exchanges (such as dispatch order, schedules, bids and offers, etc.) between VPP and system operator, VPP and electricity market, a VPP service provider and an individual VPP component.

8 VPP use case

8.1 Overview

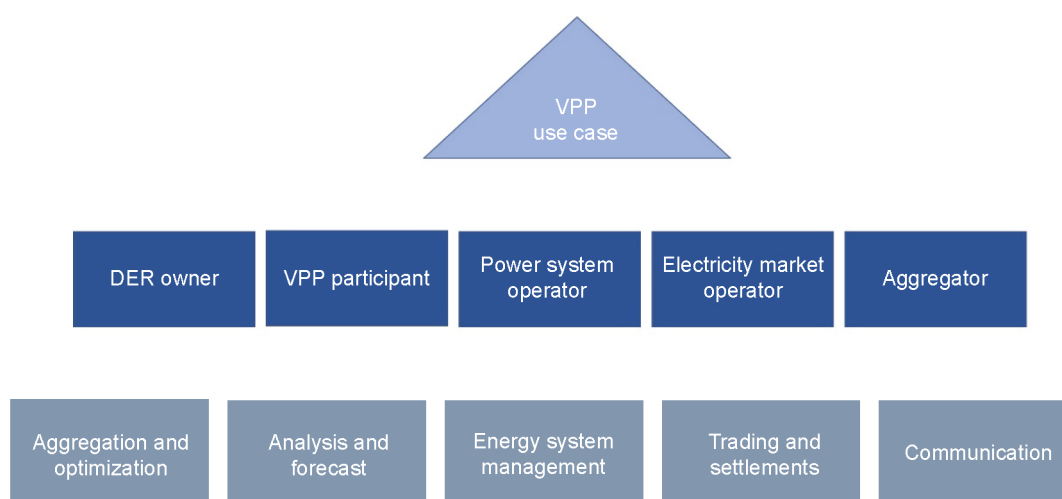
This clause is to present the use case template and use case matrix applied in the development process of VPP use cases.

8.2 Use case template

The use case template provided in IEC SRD 62913-1 shall be adopted to facilitate the collection of relevant information and ensure the consistency of all use cases.

8.3 Use case matrix

A use case matrix is developed to fully cover the application scenarios, functions, business roles, as illustrated in Figure 1.



IEC

Figure 1 – Use case matrix development methodology

8.4 Use case development

8.4.1 General

VPPs use cases are developed to cover each application scenarios and functions listed in use case matrix defined in 8.3, using the provided use case template required in 8.2.

8.4.2 Description of the use case

8.4.2.1 Use case list

Table 1 lists all use cases described in this document.

Table 1 – Use case list

Use case identification		
ID	Area/Domain(s)/Zone(s)	Name of use case
BUC-1	Area: Energy systems Domains: VPP, DER Zone: Energy market, operation	Virtual power plant operation in peak shaving and regulation energy market in China
BUC-2	Area: Energy systems Domains: VPP, DER, customers Zone: Frequency control market, operation	Virtual power plant operation in providing frequency control ancillary services in China
BUC-3	Area: Energy systems Domains: VPP, DER, Customers Zones: Energy services, business operation	Virtual power plant operation in providing comprehensive energy services in China
BUC-4	Area: Energy systems Domains: VPP, DER Zone: Energy market, operation	Virtual power plant operation platform and its practice in Japan
BUC-5	Area: Energy systems Domains: DER, VPP Zones: Energy market, frequency control market, operation	Virtual power plant demonstrations in the Australian National Electricity Market (NEM)
BUC-6	VPP, DER	Generic commercial use case of virtual power plants in Australia
BUC-7	Area: Energy systems, Domains: DER, VPP Zones: Energy market, frequency control market, operation	Virtual power plant for Power Supply Co., Ltd. in Germany

Use case identification		
ID	Area/Domain(s)/Zone(s)	Name of use case
SUC-1-a	VPP, DER	Normal mode of participating in power system operation
SUC-1-b	VPP, DER	Emergency mode of alleviating power system contingencies
SUC-1-c	VPP, DER	Participating in peak shaving and regulation energy market
SUC-1-d	VPP, DER	Local energy management and coordinated control of distributed energy resources
SUC-2-a	VPP, DER	Virtual power plant participating in primary frequency control
SUC-2-b	VPP, DER	Virtual power plant participating in secondary frequency control
SUC-7-a	VPP, DER	Virtual power plant participating in system frequency control
SUC-7-b	VPP, DER	Virtual power plant participating in voltage optimization

8.4.2.2 Scope and objectives of use case

Table 2 lists scope and objectives of all use cases in this document.

Table 2 – Scope and objectives of use case

Scope and objectives of use case	
Scope	BUC-1, SUC-1-a, SUC-1-b, SUC-1-c & SUC-1-d: These use cases are applicable to the VPPs that integrate industrial and commercial facilities, electric vehicles and charging stations, smart homes and buildings, electric heating devices, air conditioning and cooling systems, distributed photovoltaic systems, etc. These VPPs participate in the normal/emergent modes of power system operation and valley filling energy market via local energy management. BUC-2, SUC-2-a & SUC-2-b: These use cases describe the VPPs providing primary frequency control services and participating in secondary frequency control ancillary service market. BUC-3: This use case describes VPPs providing comprehensive energy services for DER, including energy utilization optimizations, economic analysis to increase incomes, and comprehensive analysis to maximum social benefits. BUC-4: This use case describes VPPs that consist of DG, CL and EES, which are integrated to the VPP operation platform. BUC-5: To explore the capabilities of aggregated DER/VPPs to deliver frequency control following contingencies (in the NEM frequency control ancillary service market), and better understand how VPPs respond to market price signals. BUC-6: This use case describes business/commercial, low voltage, "behind the meter" VPPs in Australia as of 2020, consisting of distributed solar PV generation and EES. BUC-7, SUC-7-a & SUC-7-b: To explore the capabilities of aggregated DER/VPPs to increase the grid stability.
Objective	BUC-1: This VPP pilot project has a total capacity of 357.6 MW including both 256.7 MW CL, 106 kW DG and 800 kW EES, where CL includes 73.2 MW industrial and commercial loads, 259.7 MW electric heating devices, and 23.8 MW other types of CL. The project covers multiple regions in Jibei power system including Zhangjiakou, Langfang and Qinhuangdao cities. The objectives of the use case mainly include: – to investigate and develop key technologies of VPPs This use case is supposed to take on new roles as market intermediaries between power system operators and local DER. This use case aims to investigate and develop the key technologies of VPPs including operation framework, communication architecture, market mechanism, etc. – to provide regulation services for power system operation This use case aims to provide regulation services for power system during peak/valley periods of load profiles. With the dispatchable resources provided by VPPs, thermal power plants can reduce the needs for peak shaving and thus save operational costs. Local DER can be utilized to balance renewable generation and load. In addition, this VPP project in China is able to provide 154-MW capacity for regulation. – to test and verify the emerging technologies applied in energy industries This use case provides an opportunity to apply emerging technologies, such as 5G, Artificial Intelligence, Internet of Things, etc. These technologies can be verified and used to accelerate the innovations in energy industries and support the development of business models and economies of VPPs. – to provide policy suggestions for the development of VPPs This use case aims to provide operation and regulatory approaches/policy suggestions for the development of VPPs. It can also promote the transition of China's regulated electric power industry toward the deregulated electricity market.

	– to support 100 % Green Winter Olympics in 2022 This use case will help to fulfil the promise on "100 % Green Olympic" made for 2022 Beijing Winter Olympics. By integrating and controlling DGs, EESs and controllable loads in Olympic zones, the VPP pilot project can dynamically balance renewable generation and load in Olympic stadium through day-ahead and real-time energy markets. – to accelerate energy transition toward a clean and sustainable system This use case is developed to verify the operation architecture, technology, and mechanism of VPPs. The VPP pilot project can reduce renewable energy curtailment and operation costs for generators, explore the regulation capability and the cost savings on electricity bills for customers, and defer the investment in utility infrastructures. This use case provides an effective solution to accelerate a clean and sustainable energy transition. BUC-2: This use case includes two types of VPPs. The first type is VPPs that are mainly composed of DG, EES, etc. This type of VPPs has the capability and task to provide primary frequency control service. Therefore, they should meet the requirements of grid code and provide primary frequency control capability. Besides, this type of VPPs can participate in the secondary frequency control ancillary service market. The second type is VPPs that only participate in the second frequency control. The objectives of the VPP project mainly include the following aspects: – VPPs mainly composed of DGs provide primary frequency control service. – VPPs participate in secondary frequency control ancillary service market. BUC-3: The objectives of the VPPs providing comprehensive energy services mainly include: – the operational process of VPPs that provide comprehensive energy services for DER VPPs collect, and analyse real-time and historical energy utilization data of DER. VPPs provide diversified and targeted comprehensive energy services for DER. – the business mechanisms for three types of energy services including energy utilization optimization, increasing revenue of DER, and maximizing social benefits of DER BUC-4: The objectives and importance of VPP use cases in Japan are as follows: – enhance economic efficiency of power system By using VPPs to decrease the peak demand, it can reduce maintenance costs and capital investment for power generation equipment, also to suppress the increase in output of thermal power plants with high fuel costs. These measures can reduce power generation costs, leading to more economical use of energy. – higher penetration of renewable energy With the penetration of renewable generation such as solar and wind generation increasing, the amount of generated power may exceed demand during the day. In such cases, it is necessary to maintain the balance between supply and demand by suppressing renewable energy. But if VPPs can control energy resources such as EES to increase the demand, it is possible to effectively use the generated power. These measures will contribute to the introduction of more renewable energy. – reduction of power system stabilization cost Conventionally, power generation for peak demand such as thermal power and pumped-storage hydro power have been utilized in order to supply electricity stably. Since VPPs use the DER on the demand side for purposes different from the original one, it is expected to reduce the capital cost and stabilize the power system at lower cost.
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	BUC-5: The objectives of the demonstration are intended to allow the system operator to explore: – the operational capability for market participation This relates to the VPPs' reliability to deliver contingency frequency control ancillary services (FCAS). In the Australian National Electricity Market Contingency FCAS is facilitated through a market that is co-optimised with the energy market. The purpose of the contingency FCAS market is to assist in correcting supply unbalances following a major contingency event, such as a loss of a generating unit/major load or large transmission element. The contingency FCAS market consists of several markets, relating to response timeframes to the frequency event (e.g. 6 seconds, 60 seconds, 5 minutes). The VPP demonstrations explore the capability of VPPs to deliver contingency FCAS, such as whether they can deliver the frequency response they are enabled for and what may be a typical extra fleet capacity VPP operators dispatch over and above their enabled contribution to reliably meet that target. – gain operational visibility of aggregated DER To understand VPPs' impact on power system security, local power quality, and how they interact with the market. A series of application programming interfaces (APIs) are established for participants to submit operational forecasts and actual performance data, this is necessary because the VPP demonstration participants operate un-scheduled in the energy market. – operational and policy ongoing arrangements In addition, the demonstrations will assist determining appropriate operational and regulatory arrangements for DER to participate in FCAS and energy markets on an ongoing basis (following the demonstrations). This will be done by assessing the suitability of a new approach for FCAS DER specifications and will inform required changes to regulatory frameworks and operational process to ensure VPPs are better integrated in the NEM electricity markets. – market dynamics and planning This aspect explores the extent that VPPs' response to energy market price signals. If this can be extrapolated to very large VPPs, what impacts could this have on energy markets and how much reliance should be placed on VPPs responding to energy market signals for planning studies. BUC-6: The first objective of Australian VPPs is to demonstrate the role of virtual power plants in enabling higher penetrations of distributed renewable generation in the grid, and help further understanding of the role of distributed "smart" storage in supporting grid resilience and reliability. The second objective is to address growing "prosumer" interest and demand for greater control over their electricity bills as well as to achieve greater energy independence against a backdrop of high retail energy costs. Thirdly, the VPP would also enable VPP retailers/aggregators to derive additional value streams during specific network and wholesale market events, through coordinated/orchestrated VPP dispatch. Collectively, the 2nd and 3rd objectives can ultimately reduce the cost of the system to the end customer, while reducing the energy costs going forward. Lastly, this document is a contribution to the IEC use case management repository, the purpose of which is to collect, administer, maintain, and analyse use cases.
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	BUC-7: The objectives of the VPP are intended to allow DER to response to – demand-response signals based on the current availability/flexibility of each asset – cold load pickup support based on the current availability/flexibility of each asset – system frequency control signals based on the predefined reserve band – voltage optimization signals to improve the reliability and power quality of distribution network operation
Related business case(s)	– energy management system use case – microgrid use case – TBC

8.4.2.3 Narrative of use case

Table 3 lists narrative of all use cases in this document.

Table 3 – Narrative of use case

Narrative of use case	
Short description	BUC-1, SUC-1-a, SUC-1-b, SUC-1-c and SUC-1-d: These use cases are developed from the VPP project in China which has been put into operation since December 2019. Involved activities include: • participating in power system operation in normal or emergency mode • participating in electricity market enabling purchases, through bids to buy, and sales, through offers to sell • providing peak shaving and regulation services and participating in energy market • local energy management and coordinated control of DER BUC-2, SUC-2-a and SUC-2-b: These use cases describe application scenarios which include: • providing primary frequency capability and making the VPPs meet the requirements of grid code • participating in frequency control ancillary service market BUC-3: This use case describes application scenarios where VPP provides comprehensive energy services including energy utilization optimization, increasing revenue of DER, and maximizing social benefits. BUC-4: This use case describes application scenarios in which VPPs can achieve commercial goals of both residential customers as well as the VPP retailers/aggregators while supporting power system reliability and security.

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BUC-5: This use case is opened for a period of at least 12 months from July 2019 (with a possible extension). This involved: • enrol in the VPP demonstration as a trial participant. • enrol/register their VPP demonstration in the contingency frequency control ancillary services markets • participate in contingency frequency control market and responding to energy price signals as non-scheduled resources • analyze response to frequency deviations in accordance with bids/enablement in the frequency control markets • analyze response to energy market price signals as non-scheduled resources BUC-6: This use case describes application scenarios in which VPPs can achieve commercial goals of both residential customers as well as the VPP retailers/aggregators while supporting power system reliability and security. BUC-7, SUC-7-a & SUC-7-b: These use cases involve: • participate in electricity market, including peak shaving service, valley filling service, etc. • participate in system frequency regulation • participate in voltage optimization	Complete description BUC-1, SUC-1-a, SUC-1-b, SUC-1-c and SUC-1-d: These use cases are developed from the VPP pilot project in State Grid Jibei in China. The first phase of the VPP pilot project has a total capacity of 160 MW with 11 kinds of DER integrated. The VPP aggregates 80-MW DER to participate in the valley filling energy market in North China. From the perspective of operational performance, the VPP can actively respond to real-time dispatch orders sent by power system. The VPP can effectively reduce peak load and shift load at night hours when reserve capacity is insufficient. The VPP pilot project demonstrates that the revenue is increased and the wind power curtailment rate is reduced. BUC-2, SUC-2-a and SUC-2-b: These use cases are developed from the VPP pilot project in China, including DG, EESs and CLs. • providing primary frequency control capability, which helps to meet the requirements of integration and reduce the frequency deviation of the whole system • participating in the secondary frequency control market, which can help to maintain the frequency balance of the power system BUC-3: The business use case covers VPPs providing comprehensive energy services for DER. There are three types of comprehensive energy services involving energy utilization optimization, increasing revenue of DER, and maximizing social benefits. Two scenarios of enrolment in VPPs, and providing comprehensive energy services for DER are included. BUC-4: Due to the tight supply-demand balance of electricity caused by the Great East Japan Earthquake in 2011, it was strongly recognized that it is important not only to promote the conventional energy saving but also to perform energy management. In addition, after the earthquake, the introduction of renewable energy such as solar power and wind power generation has greatly expanded. On the other hands, the introduction of distributed energy resources on the consumer side such as cogeneration systems consisting of residential PV panels and fuel cells, storage batteries, electric vehicles have been promoted. From this background, the traditional power supply system relying on centralized large-scale power plants has begun to be reconsidered, and a mechanism to utilize energy resources on the consumer side for the power system is being developed.

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Each distributed energy resource introduced in factories and households is small in scale and has only a limited impact on the power system. But with advanced energy management technology utilizing Internet of Things, if these are aggregated and remotely controlled as a VPP system, it can be contributed to realize stable and flexible power systems. Therefore, VPP is expected to play an important role in power systems as functions including peak shaving, avoidances of the renewable energy curtailment, supply in case of power shortage, etc. BUC-5 & BUC-6: The business case covers VPP demonstrations that include aggregated portfolios of controllable assets at various points on the network (for assets <5 MW at each individual connection point), to deliver frequency response and/or respond to energy market signals. For VPPs that will participate in frequency control trials, they can be provided by either proportional/variable or switched style response. The proportional control is proportional to the size of frequency deviation (such as through a droop controller) and switched style involve an on/off switch to the frequency deviation (e.g. switching off a pool pump). Once enrolled to participate in the VPP demonstrations and set up to interact with and be included in appropriate market systems, the VPP will participate in contingency frequency control markets (six in total). The VPP demonstrations exclude grid scale generation and grid scale energy storage. VPPs responding to energy market signals are not scheduled and do not (at this stage) submit bids specifying their generation intentions. However, forecasting data is required so that an understanding can be gained for possible future scheduling and energy market participation. The system operator will observe and monitor the various VPP demonstrations for their responses to frequency deviations (where participating in this area) and responses to the energy market. The demonstrations have been opened for a minimum 12-month period and are used to determine overall efficacy of the VPPs to meet the use case objectives. BUC-7, SUC-7-a & SUC-7-b: The business case covers VPP demonstrations that include aggregated portfolios of controllable assets, like solar, batteries, HVACs and a charging station, at various points on the grid to participate in load pickup support, demand response and/or voltage optimization. Once enrolled to participate in the VPP demonstrations and set up to interact with and be included in appropriate market systems, the VPP will participate in contingency frequency control markets. The VPP demonstrations exclude grid scale generation, grid scale energy storage and controllable loads. The system operator will observe and monitor the various VPP demonstrations for their responses to the system calls.