IEC SRD 63152-2

Edition 1.0 2022-12

SYSTEMS REFERENCE DELIVERABLE

colour inside

Smart cities – City service continuity –
Part 2: Implementation guideline and city service cases

IEC SRD 63152-2:2022-12(en)

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.040.60; 03.100.70

ISBN 978-2-8322-6200-9

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FOREWORD

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The text of this Systems Reference Deliverable is based on the following documents:

Draft	Report on voting
SyCSmartCities/253/DTS	SyCSmartCities/263/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 Systems Reference Deliverable 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 63152 series, published under the general title *Smart cities – City service continuity against disasters*, 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- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

0.1 General

It is important that organizations providing services are able to develop and implement preparedness measures to maintain and restore required services in the event of a disaster.

Because many of the services depend on electricity, an electricity continuity plan (ECP) and an electricity continuity system (ECS) can help maintain and restore necessary services in power failure that is caused by a disaster. IEC 63152 describes the concept and minimum requirements of ECP and ECS based on a business continuity plan (BCP).

However, depending on the type, degree, and quality of services, there are various ways to respond to disasters, and ECP and ECS cannot be created in the same way.

This document is designed to serve as a guideline for the design of basic parts by showing the process and points to be noted in the preparation of ECP and ECS for power outages based on normal service.

It is assumed that ECP and ECS will be useful to urban developers, urban operators, public service providers, disaster managers and system integrators, and manufacturers of systems related equipment and facilities.

0.2 Why ECP and ECS are needed

Services in cities are not just public services. There are a lot of different types of services and service users such as residential services, transportation services, medical services, manufacturing services, etc. These services are also composed of various services.

Electricity is a very important resource to provide these services. Physical damage can be unavoidable due to a disaster, but even in areas not directly affected physically, the power disruption affects the surrounding areas, making it impossible to maintain normal services.

For example, what about the transportation system when there is a blackout due to a disaster?

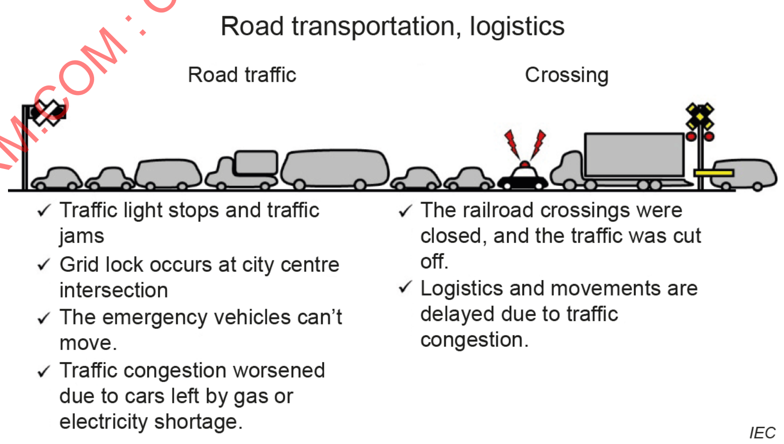


Figure 1 – Impact of power outage in traffic

During normal times, traffic signals display instructions regularly, and the traffic centre can control traffic signals based on traffic volume sensor information.

As shown in Figure 1, a power failure causes traffic jams in many places because traffic lights cannot display instructions. In that case, the traffic centre will not be able to grasp the traffic jam situation and will not be able to give appropriate instructions to emergency vehicles. Of course, the distribution will be delayed due to the traffic jam. Also, if the signal display disappears, there can be many accidents. (See Annex A for more examples.)

It would be helpful to have a system (ECS) in place to back up the power supply to important traffic signals, traffic sensors, etc., and to plan (ECP) activities to minimize the adverse effects on traffic with the minimum necessary information in the event of a power failure.

In addition, ECP and ECS cannot be used effectively if users are not familiar with them. It is important to conduct regular training to familiarize users with ECP and ECS. Furthermore, small power outages can be opportunities to check the effectiveness of ECP and ECS as well as identify points for improvements.

0.3 How to develop ECP and ECS using this document

With this in mind, this document shows as much as possible what should be considered when continuing service in the event of a power failure.

Here is how to develop the core ECP and ECS (See Figure 2).

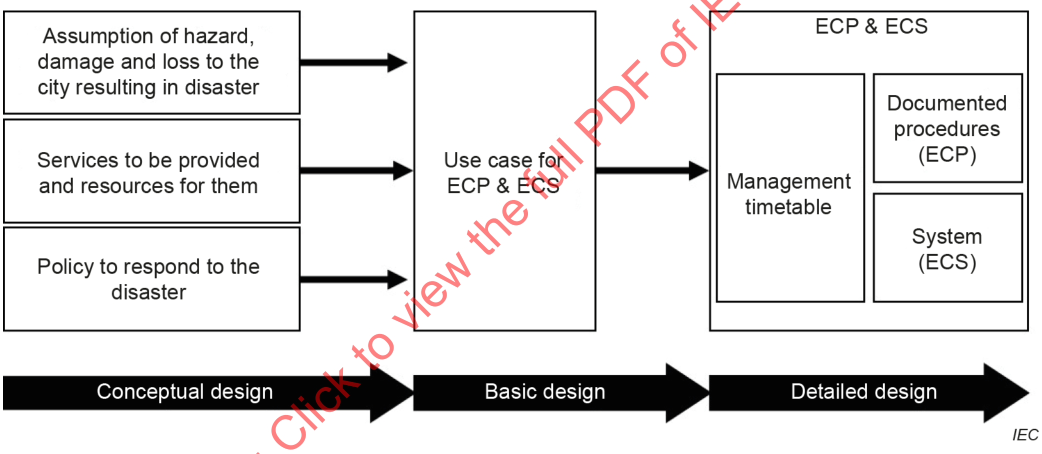


Figure 2 – Design flow image of ECP and ECS

First of all, a conceptual design is performed while clarifying the following points:

- assumption of disaster and level of damage to the city and to the organization;
- all services provided in the organization in normal time;
- policy and intention regarding what service and what level of service needs to be secured at the time of disaster.

Next, use cases for establishing ECP and ECS are described using templates to match the conceptual design, and basic requirements are summarized in the description as a basic design.

Finally, in the detailed design, the basic design is described in detail in the management timetable to clarify the overall picture of the disaster response, and then the ECP document is prepared and the ECS is designed.

0.4 What is the benefit?

There are many benefits to ECP and ECS, in addition to maintaining a certain level of service after a disaster. They include the following.

- Increase of the likelihood of early recovery.

  The implementation of ECP and ECS not only ensures that basic services are maintained for a period of time after a disaster, but also increases the likelihood of early recovery.

  If ECP and ECS maintain basic services during a power outage, they reduce the burden of responding to services that need to be restored after a power outage. In addition, they will reserve the capacity to create scenarios and preparation for the recovery during the power outage.

- ECP and ECS collaboration across multiple services.

  By considering ECP and ECS for each of the important services, and by understanding and coordinating the measures related among them, we can expand what can be covered by multiple ECP and ECS.

  As a result, we will be able to cover more facilities, more areas, and even apply them to the supply chain.

  If these efforts are accumulated, it will become possible to build cities that can respond to a variety of power outages, not just in times of disaster.

- Preparation and application for multiple disasters response (e.g. coronavirus + earthquake).

  Sometimes multiple disasters occur at the same time. For example, an earthquake can occur where an infectious disease, such as a coronavirus, is widespread.

  ECP controls human activity and ECS controls systems. When disasters are compounded in this way, staff shortages also need to be addressed. Several additional measures can be needed to identify gaps in staff and maintain ECP and ECS.

  The effectiveness of ECP and ECS can be enhanced by considering them in various disaster situations.

It is expected that the use of this document will enable many service providers to aim for more effective and advanced disaster response.

SMART CITIES – CITY SERVICE CONTINUITY –

Part 2: Implementation guideline and city service cases

1 Scope

This part of IEC 63152, which is a Systems Reference Deliverable, provides design guidelines for implementation of city service continuity (CSC) specified in IEC 63152 and includes city service cases for various target organizations (municipality, town developer, building administrator, etc.). The city service cases to be included are not only for emergency use but also for normal time use.

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 63152, *Smart cities – City service continuity against disasters – The role of the electrical supply*

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
business continuity plan
BCP
documented information that guides an organization to respond to a disruption and resume, recover and restore the delivery of products and services consistent with its business continuity objectives

[SOURCE: ISO 22301:2019, 3.4]

3.2
electricity continuity plan
ECP
documented procedures that guide organizations to ensure continuity of electricity supply to maintain city services in a business continuity plan that addresses disruption caused by a critical event

[SOURCE: IEC 63152:2020, 3.2]

3.3
electricity continuity system
ECS
system required to ensure reliable and effective implementation of functions which are necessary for ECP

[SOURCE: IEC 63152:2020, 3.3]

3.4
city service
service that is performed for the benefit of the public

Note 1 to entry: In this document, services depend on provision of electricity supply.

[SOURCE: IEC 63152:2020, 3.4]

3.5
city service continuity
CSC
status in which, and capability with which, city services (i.e. public, medical, transportation communication services) that are provided to users in normal times, continue to be fully or partly provided, even in a state of emergency in which the normal functions of city infrastructures are interrupted

[SOURCE: IEC 63152:2020, 3.5]

3.6
disaster
rapid or slow onset event that causes significant disruption to one or more city services for an extended period of time

Note 1 to entry: This can include natural disasters, failures of key components or systems whether in hardware or software, physical damage to systems, and cyber attacks.

[SOURCE: IEC 63152:2020, 3.6]

3.7
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: IEC 62559-2:2015, 3.1]

3.8
use case template
form which allows the structured description of a use case in predefined fields

[SOURCE: IEC 62559-2:2015, 3.4]

4 Overview of electricity continuity plan (ECP) and electricity continuity system (ECS) based on IEC 63152

4.1 Necessity of electricity continuity

Smart cities aim to provide more convenience and efficiency to their residents often through useful functions built on information and communication technology platforms powered by electricity. A smart city is advanced and complex due to the numerous functions it provides.

Therefore, if a smart city loses power, it will lose its ICT infrastructure and every function implemented for the smart city. This is one reason why electricity continuity is vitally important in smart cities.

There are various types of hazard that can bring damage and loss to a city resulting in disaster. Each city has its own weaknesses, and there are high-frequency disasters, depending on the nature of its location, climate and city composition. Loss of electricity due to a disaster brings big damage to the city. In situations where a hazard as shown in Figure 3 strikes the city, the first action to establish the countermeasures is to grasp what happens to electrical equipment and what problems will occur with each location, service or industry in a city, and then to assume damage when a hazard strikes a city and electricity is cut off.

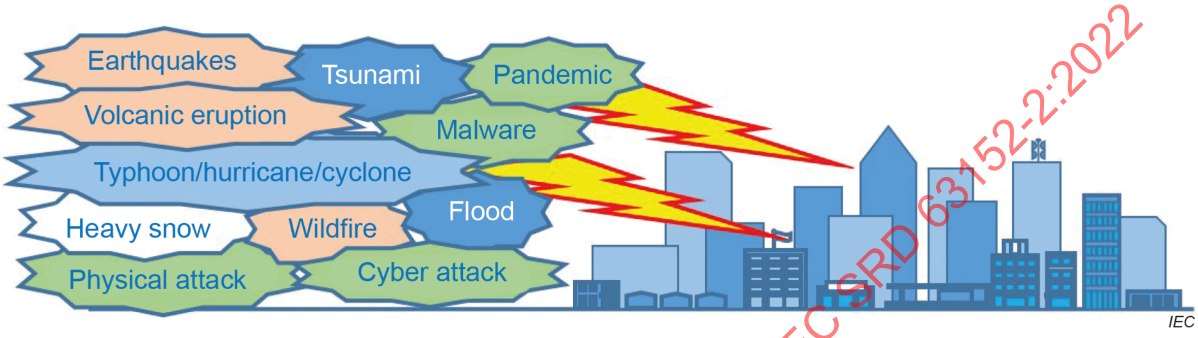


Figure 3 – Examples of hazards that can strike cities

Annex A shows a lot of issues as "impacts of power outage" caused by disasters in various fields of city services and activities as follows.

a) Life, home and buildings fields

When homes or buildings lose electricity, all electrical equipment stops, such as lighting, air conditioners, refrigerator, elevators, communication line, power supply to smartphone, computers, TV. Electronic keys of doors cannot work and mechanical parking locks up cars. Water supply also stops due to lack of power for pumps, then bath, shower and toilet cannot be used in addition to lack of drinking water. Fuel for emergency power generators will soon run out. Daily life will drastically change.

b) Mobility, transportation and logistics fields

Road and air traffic, public transportation, and logistics are affected.

When the road traffic control system loses electricity, traffic lights stop functioning and heavy traffic jams can occur, and many accidents can happen especially at night. Emergency vehicles cannot move, logistics and movements are delayed. The fuel shortage gets worse. Logistics is disrupted by traffic jams and fuel shortages. Stores are out of stock.

When railway networks and airports lose electricity, power and signal systems are down and trains cannot operate, the airport control system stops and aircraft are unable to take off or land.

c) Medical and commerce fields

Hospitals, medical services, retail, banking services, tourism, entertainments are affected.

Medical equipment, lighting, waterworks, pumps, air conditioners, refrigerators, elevators, etc. will stop working when a hospital runs out of fuel for its emergency generator. If there are more patients than usual due to the disaster, there will be a serious shortage of medical supplies and materials, combined with supply disruptions due to traffic congestion.

When retails lose electricity, not only do stores run out of stock on essential items including food, but electronic payment becomes unavailable and cashless payment such as credit cards or e-money is not possible. Banks are also unable to function; automated teller machines (ATMs) stop and the bank network stops.

d) Public and infrastructures fields

Public services, government services, shelters, education, communication, broadcasting, information services, gig economy, social infrastructures are affected.

When traffic jams occur due to power outage, rescue, search and fire extinguishing operations do not progress. Then the damage expands, resulting in a complex disaster.

When communication bases lose electricity and emergency power supply runs out, internet and phone services will be interrupted. Smartphones become disconnected and information cannot be accessed, which increases people's anxiety about the situation and prospects for recovery.

When social infrastructures lose electricity, such as drain pumps in lowlands, dams, floodgates and observation devices, holes occur in disaster prevention.

e) Industry and energy fields

When manufacturing or food industries lose electricity, the production stops. The impact of supply chain disruptions extends beyond disaster-affected areas to factories on the supply chain around the world. Shut down of food processing factories cuts off food supplies to consumption areas. Operations of petrol, oil and fuel refineries stop and their supply stops.

Agriculture lighting and control of greenhouse farming are halted. The refrigerator and freezer stop functioning, causing food spoilage in the dairy and fisheries industries.

Services or organizations in a city have complex interrelationships. Impacts of power outage for a service or organization propagate to adjacent or cascaded services or organizations, causing spread of damage. Understanding the interrelationships is important.

These examples, most of which have already been experienced in past disasters, seriously indicate the necessity of electricity continuity in a city, and the necessity for the countermeasures.

To solve the issue, the following points should be addressed.

- What happens to electrical equipment and what problems will occur with city services?
- How do we want to overcome the situation and what level of services do we want to secure at the time of disaster?
- What measures are necessary and effective, particularly from the perspective of electricity continuity?

Measures should include plans and systems for electricity continuity that are prepared prior to the disaster and operational during the disaster. Concept of and requirements for electricity continuity plan (ECP) and electricity continuity system (ECS), which are collectively called ECP & ECS, are introduced by IEC 63152 for this purpose. Specific procedures are given in the following clauses.

This document focuses on disaster preparedness and recovery on the demand side. Supply-side grid efforts will also enhance electricity resilience in complementary ways.

4.2 Countermeasures to disasters

As countermeasures to power outage due to disasters, ECP & ECS support city services to continue their role in the event of disaster, together with BCP. Well preparedness before a disaster and sure operation during a disaster are key points of effective ECP & ECS.

During establishment of ECP & ECS, desired levels of services to be secured during a disaster are a key point to be determined. The following items should be considered in determining the levels.

- To assume that all functions, information and things that require electricity in normal time are stopped.

- To be isolated for a few days or more before full-scale external support revives.
- To cover all services in normal time including all electrical and electronic devices and equipment used in the service.
- To know impacts on services due to stoppage of these devices and equipment.
- To set criteria or priority to continue services during a power outage.
- To determine a mode switching process or rule from normal time to emergency and to normal time from emergency.
- To reach priority users such as one or both of personnel performing critical services and vulnerable persons for whom access to electricity is critical.

4.3 Implementation of disaster preparedness

ECP & ECS and BCP are closely related to each other, so coordination among them during planning, introduction and operation is important.

Figure 4 outlines the process of introduction and operation of BCP and ECP & ECS.

Overlapping of job for BCP with ECP and ECP with ECS indicate that close cooperation is needed in these areas.

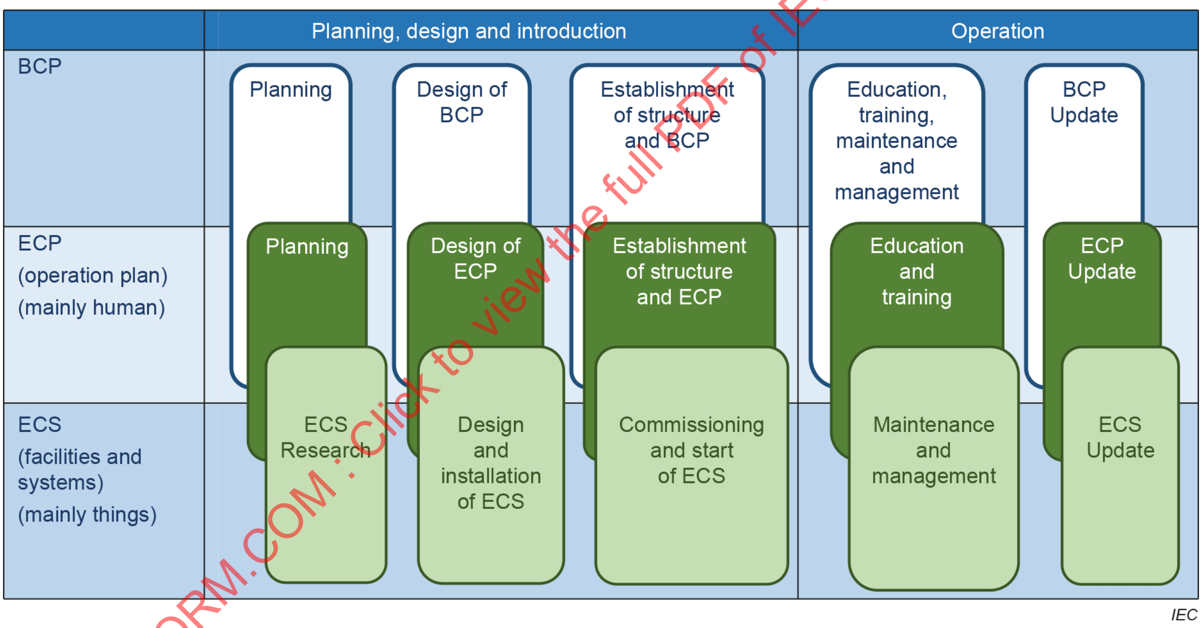


Figure 4 – Introduction and operation process of ECP & ECS

4.4 Planning, design and introduction of ECP & ECS

The ECP, as a part of BCP, should be prepared to respond to anticipated disaster in advance, and be operated in accordance with the established procedures and processes in the event of a contingency or disaster. As a feature of ECP & ECS, a considerable amount of investment for facilities and equipment is required to ensure electricity continuity.

Therefore, if the facility, service or organization is newly established, renewed, expanded or remodelled, it is important to seize this opportunity to develop the concept of electricity continuity in advance and to prepare for the inclusion of ECS facilities in the overall plan.

a) If the facility, service or organization is new:
   1) From the planning stage, the functional and performance requirements to be realized by ECP & ECS should be considered and included in the overall design specifications.

2) The knowledge and lessons learned from past similar operational experiences, the latest social and technological trends, and their predictions should be included in the requirements specifications.

3) If possible, the ECS facilities should be used in both normal and emergency situations to improve the cost performance of ECP & ECS functions.

4) When planning to implement interrelated ECP & ECSs, for example several facilities in an area or on a same service chain, collaboration of relevant ECP & ECSs should be considered to create a harmonized set of ECP & ECSs.

b) If the facility, service or organization exists:

1) Major enhancements to ECP & ECS facilities and functions can be facilitated by taking the opportunities of renewal expansion, or modification.

2) Knowledge and lessons learned from existing facility, service or organization operations should be included in specifications.

3) Furthermore, a)2), 3) and 4) also apply.

4.5 Operation of ECP & ECS

The operation plan of ECP is an important element for effective use of facilities and functions of ECS. For this reason,

- BCP experts and ECP & ECS technical experts should work together to develop operational plans,
- it is necessary to prepare an operational plan and structure in advance so that the ECP & ECS will function from its launch for the new facility, service or organization, and
- after the operation of a new facility, service or organization has started, the knowledge and experience gained from the actual operation in the field should be fed back to the operation plan regularly.

The following elements should be included in the operation plan in order to be always ready to execute the operation plan.

a) Initial education and training should be conducted to familiarize managers and staff with ECP & ECS facilities and functions.

b) Education and training should be provided to maintain and improve the proficiency level of managers and staff in charge.

c) ECP & ECS facilities and functions should be put into test, training and maintenance operations periodically to prepare for disaster.

d) Lessons and knowledge gained through the actual operation of ECP & ECS facilities and functions, such as exercises or activation, should be immediately reflected in the operation plan and updated.

5 Design guideline for ECP & ECS

5.1 Design flow of ECP & ECS

In this Clause 5, firstly, a template based on IEC 62559-2 to describe use cases for city service continuity is illustrated. Secondly, a procedure and recommendations for creation of ECP & ECS are shown. Lastly, an example of use cases for ECP & ECS and derivation of ECP and ECS from the use case are explained.

Figure 5 shows design flow diagram of ECP & ECS. During ECP & ECS design, conceptual design, basic design and detailed design are performed in order.

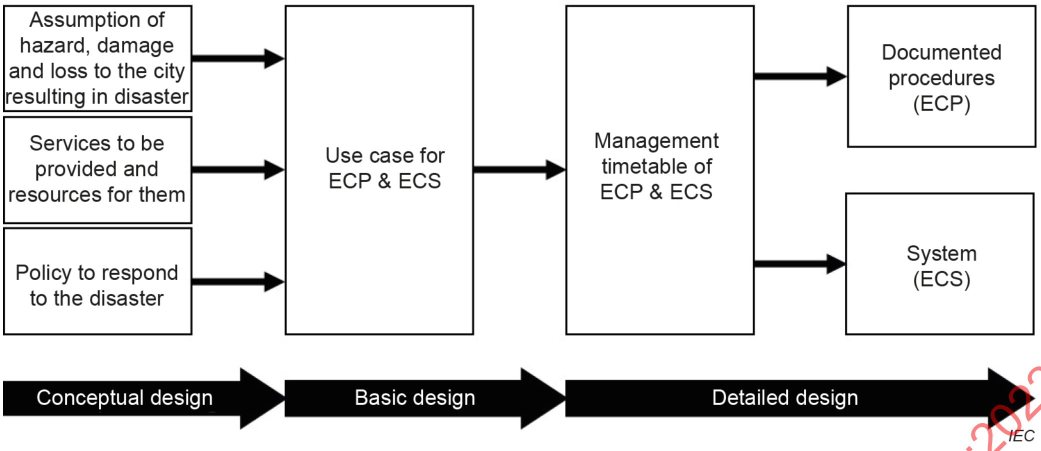


Figure 5 – Design flow diagram of ECP & ECS

In the first step for conceptual design, IEC use case methodology is applied to create the use case for ECP & ECS. The following points need to be clarified and input to the use case:

a) assumption of disaster and level of damage to the city and to the organization for which the ECP & ECS is designed;
b) all services provided and all electrical or electronic devices and equipment used for them in the organization in normal time;
c) policy and intention of the organization to establish the ECP & ECS, such as what service and what level of service to be secured at the time of disaster.

In the second step for basic design, the template of the use case for ECP & ECS is completed by defining required information of the template.

In the third step for detailed design, the management timetable is derived from the use case for ECP & ECS, which gives a whole picture of ECP & ECS.

In the final step also for detailed design, ECP and ECS are completed as shown in the following manner.

- ECP is documented procedures that guide organizations to ensure continuity of electricity.
- ECS is a system required to ensure reliable and effective implementation of functions necessary for ECP.

5.2 ECP & ECS creation by using use case template

5.2.1 Short use case template for city service continuity

Table 1 shows a use case template to create an ECP & ECS. The template utilizes a short use case template defined in IEC 62559-2. Descriptions in items of "Narrative of use case" are specially adapted for city service continuity.

Table 1 – Short use case template for city service continuity

Items	Contents		
Name of use case			
Date			
Name of author(s)			
Name	Institution		E-mail
Narrative of use case			
Short description	Following items should be included: 1. A kind of disaster assumed 2. Location where a disaster will strike 3. Service(s) in normal time 4. Service level(s) to maintain during disaster period		
Complete description	Actions prepared for or responding to issues due to power outage caused by the disaster should be listed along time-based 5 phases around disaster occurrence: 1. Preparedness for disaster 2. Disaster strike 3. Response 4. Recovery 5. Review for next preparation		
Diagram(s) of use case			
Actors			
Grouping		Grouping description	
"Grouping" may be used to classify actors by role or connections, or may not be used.			
Actor name	Actor type	Actor description	Further information specific to this use case

Procedures to fill in the template and recommendations for design consideration are explained step by step in 5.2.2 to 5.2.5.

5.2.2 The first step: conceptual design

5.2.2.1 Procedure

The first step is to assume and determine the following items, in order to determine services and their levels to secure in the event of a disaster:

- the kind of disaster and the location where the disaster will strike;
- services provided during normal time;
- issues with services due to power outage caused by the disaster;
- services to be secured even in power outage;
- levels and durations of the services to maintain.

Figure 6 illustrates "Short description" in the Narrative of use case. This field should include:

1) the kind of disaster assumed;
2) location where a disaster will strike;
3) service(s) in normal time;
4) service level(s) to maintain during disaster period.

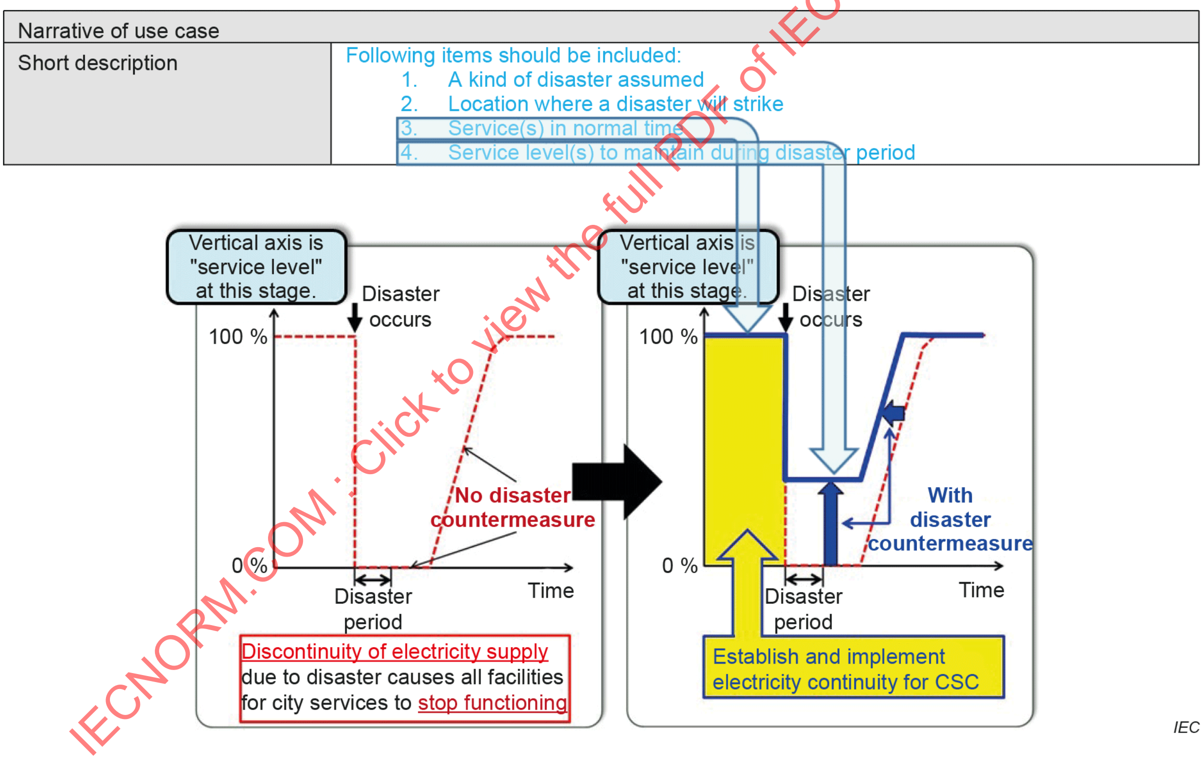


Figure 6 – Short description in the template

5.2.2.2 Recommendations

The following is a list of items that should be considered when implementing the procedures in this step.

a) Collaboration of ECP with BCP

In the conceptual design step, ECP should be studied as a part of BCP. Assumption of a disaster and damage caused by the disaster are a common base for the consideration for ECP as well as BCP. Policy, service level and organizational structure are also common issues to be resolved by the organization.

b) Characteristics of disaster progress

Because the extent of damage varies with the type of disaster, it is redundant to consider the design of each disaster.

For each possible disaster, it is recommended to assume the progression of damage (See Annex B). In addition, measures that are specific to disasters and measures that are common to anticipated disasters should be considered.

5.2.3 The second step: basic design

5.2.3.1 Procedure

The second step is to analyse and determine the following, in order to estimate necessary electricity and ensure means to secure services at a disaster.

- Power required to maintain each service:
  - electricity and its securing period; for evaluation of necessary electricity capacity, refer to Annex A of IEC 63152:2020.
- Means to ensure necessary electricity and disaster preparedness:
  - events at the moment of a disaster and emergency responses;
  - temporary measures taken immediately after a disaster;
  - full-scale measures implemented during the disaster recovery process.

Figure 7 illustrates "Complete description" in the Narrative of use case. This field should include actions prepared for or responding to issues due to power outage caused by the disaster. Actions should be determined for each phase[1] below by unfolding the above means:

1) Preparedness for disaster;
2) Disaster strike;
3) Response;
4) Recovery;
5) Review for next preparation.

In the Preparedness for disaster phase, to assume a disaster and its location, to assess risks to the target services, and to list the countermeasures to address the disaster risks.

In the Disaster strike phase, to assume what will just happen when power outage occurs suddenly due to the disaster, and what will help the situation.

In the Response phase, to assume what will be needed and how to use it to respond to the situation just after the disaster strike.

In the Recovery phase, to assume what will be needed and how to use it to recover from the disaster.

In the Review for next preparation phase, to review the effectiveness of the prepared countermeasure and update the plan against the disaster for future.

All actions above are for the first cycle for the disaster response, and after the first cycle, to return to the Preparedness for disaster phase and to update the countermeasures against the disaster.

[1] IEC White Paper, Microgrids for disaster preparedness and recovery, with electricity continuity plans and systems

Figure 8 illustrates "Diagram(s) of use case" and "Actors" in the template. Means to ensure necessary electricity and disaster preparedness adopted in the "Complete description" include various resources.

The diagram(s) in the template should include all major facilities, equipment, systems, functions, personnel and their connections and interactions. These resources can also be selected as "Actors" in the template from detailed actions in each phase or from system diagram. Actors may be grouped in order to provide a better overview.

5.2.3.2 Recommendations

The following is a list of items that should be considered when implementing the procedures in this step.

a) References of multiple phases

Similar concepts and useful information for disaster management cycle consisting of multiple phases are disseminated by several organizations such as UNDRR[2], FEMA[3], etc.

b) Clarification and quantification of means

Clarification and quantification of means to secure necessary power will make the means effective in the event of a disaster. The following items are typical specifications that should be taken into account in the ECP & ECS design:

- system configuration;
- division of roles;
- communication or sharing channels;
- time limit or deadline;
- electricity sharing rules and regulations;
- maintenance of resources;
- supply chain, etc.

2 United Nations Office for Disaster Risk Reduction

3 Federal Emergency Management Agency

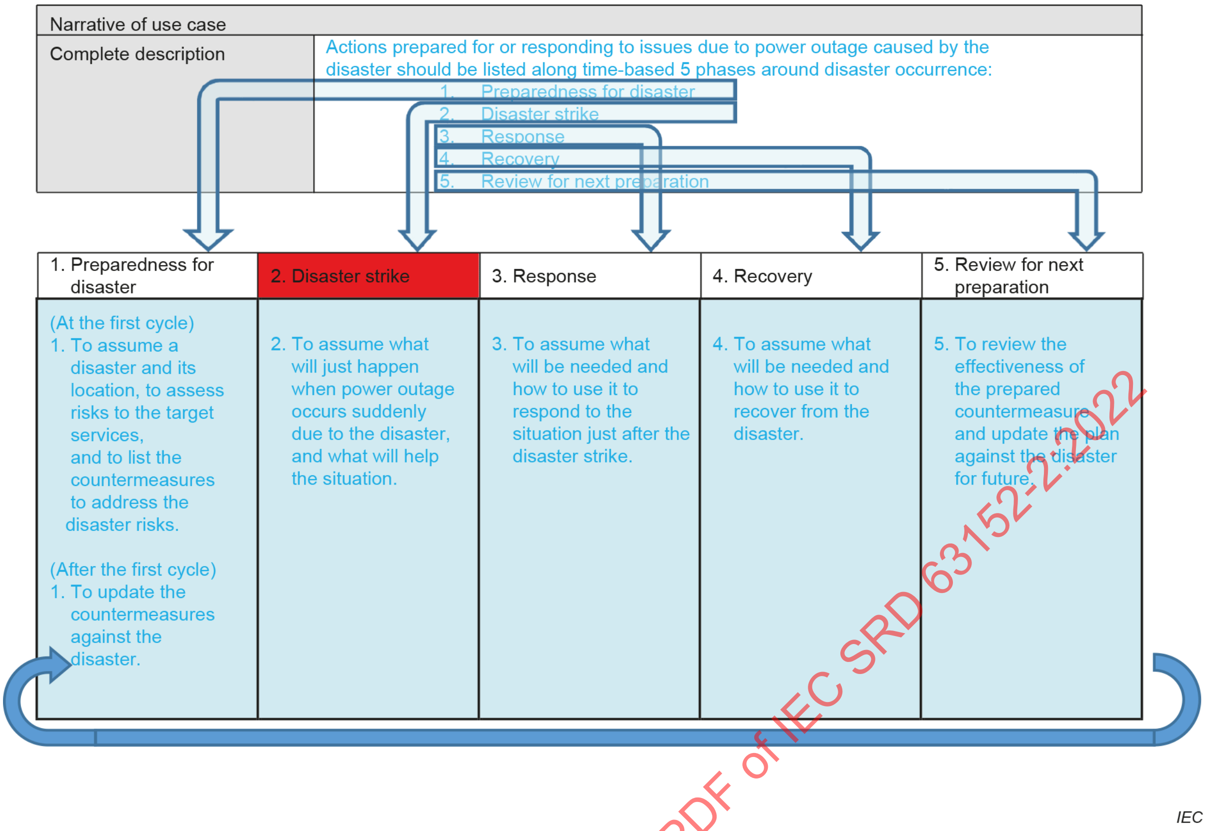


Figure 7 – Complete description in the template

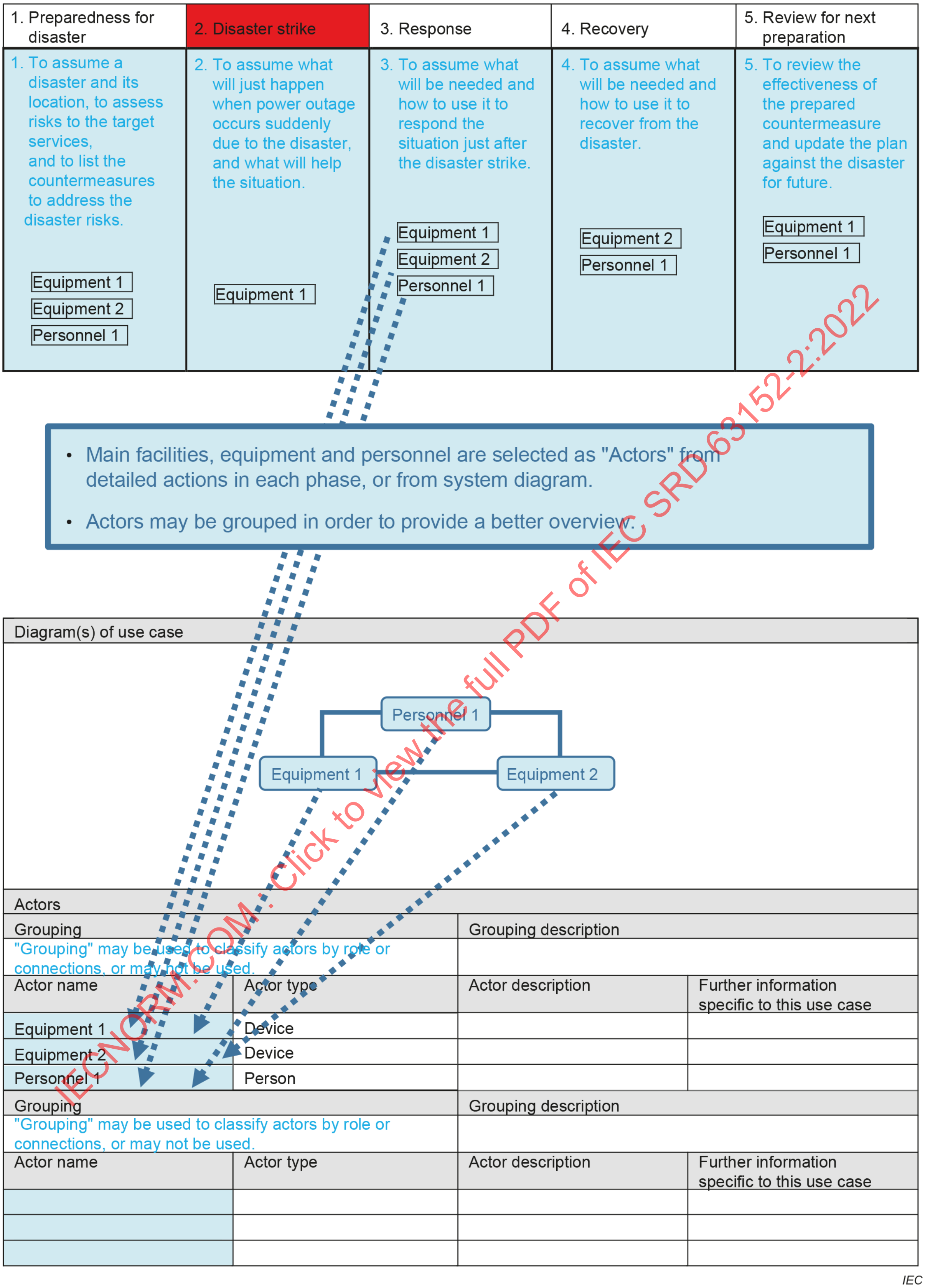


Figure 8 – Diagram(s) of use case and actors in the template

5.2.4 The third step: detailed design – Management timetable of ECP & ECS

5.2.4.1 Procedure

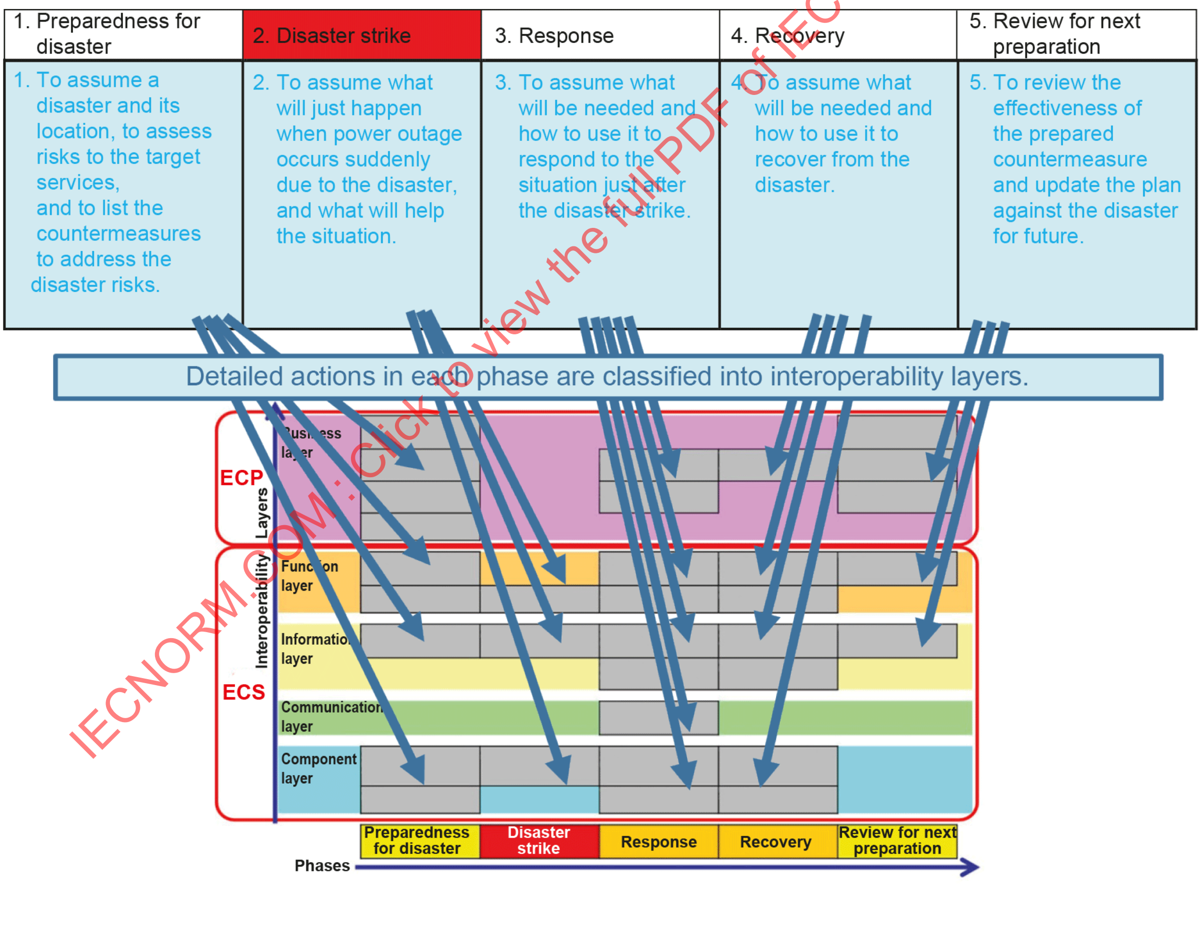
The third step is to create the management timetable of ECP & ECS.

Figure 9 illustrates derivation of management timetable of ECP & ECS from the short use case.

Detailed actions of all actors in each phase are classified in accordance with their roles and arranged on the management timetable of ECP & ECS. As for management timetable, refer to Annex D of IEC 63152:2020.

To derive the management table of ECP & ECS, the following steps are effective.

- Specifically, the contents of each phase in "Complete description" are broken down and assigned to each actor's cell.
- Actors are sorted into "interoperability layers" corresponding to their roles. An actor may span over multiple layers.
- The actions required in each phase will be further detailed and made into specific specifications in the final step.



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NOTE Management timetable in Figure 9 is quoted from Figure D.1 of IEC 63152:2020 for explanation purposes only. Description of cells in the figure is not relevant.

Figure 9 – Derivation of management timetable of ECP & ECS

Management timetable gives a whole picture of ECP & ECS. All major means and personnel are included in the timetable as elements with important requirements or actions required. Details of each element are further designed and linked to or referred from this timetable.

Table 2 shows relationship of interoperability layers[4] to ECP or ECS.

Table 2 – Relationship of interoperability layers to ECP or ECS

Layer no.	ECP or ECS	Interoperability layers
5	ECP	Business layer
4	ECS	Function layer
3		Information layer
2		Communication layer
1		Component layer

Content included in each of the interoperability layers is as follows.

a) Business layer:
   1) Actions such as planning, decisions and instructions to realize the objectives or maintain the services, and means for them.
b) Function layer:
   1) Functions and their elements comprising a service to be realized.
c) Information layer:
   1) Information to be exchanged between layers.
d) Communication layer:
   1) Channel and means for transmitting data from and to components.
e) Component layer:
   1) Components such as devices, equipment or facilities to execute operations to realize the function.
   2) Elements included in each of the interoperability layers have connection to related elements in other layers.

For example, status of a component such as charge level of a battery (Component layer) is sensed, transmitted via local area network (Communication layer) to upper layer, interpreted as residual electricity (Information layer) at the control centre, and utilized for battery monitoring function (Function layer) for a manager. Then the manager makes a decision on distribution of power to demanding equipment according to a priority supply plan prepared in advance, or issuance of instruction to save electricity (Business layer).

5.2.4.2 Recommendations

The following is a list of items that should be considered when implementing the procedures in this step.

a) Supplementation

   After the "Complete description" of each phase is broken down and assigned to appropriate actors, if some actors do not have actions in some phase, check if the actors need to have any actions in that phase and then supplement actions, when necessary, in order to make the overall action consistent across phases.

[4] Similar concept in SGAM (Smart Grid Architecture Model) framework.

b) Flexibility and adaptability

Connections between the elements may vary with progress along the phases and are subject to a situation such as damage caused by a disaster or restoration from the disaster.

5.2.5 The final step: detailed design completion – Specifications of ECP & ECS

5.2.5.1 Procedure

The final step is to create specific specifications of ECP and ECS.

The description format of ECP & ECS may be freely determined by the organization.

- ECP should cover all actions defined in the Business layer and define each procedure and plan to manage and operate the organization.
- ECS should cover the whole system and its components in the other four layers and define specifications of individual components and the system design.

Main role of ECP & ECS is to formulate and implement measures according to the management timetable in advance: (e.g. prioritization, duration time, electricity level control). Services that demand electricity and their priorities can be listed in a table to estimate the demand for electricity. For further detail, refer to Table 4 and Table 5.

Basic model of ECP & ECS is introduced in IEC 63152:2020, Clause A.2, where the following are defined.

– ECP is included in BCP. ECS is implemented based on ECP.
– ECS should be able to receive disaster information in order to trigger the ECS and wake it.
– ECS might need to have two connections – status information and power to help with exchanging electricity among other ECSs.

Figure 10 shows Basic model of ECP & ECS and its configuration.

Basic model of ECP & ECS consists of three basic functions (electricity or energy receiving and generation, storage, utilization), controller and manager.

Further details of Basic model are shown in Figure 11.

Electricity demand and supply should be balanced. Electricity flow and stock management to control the three basic functions (electricity or energy receiving and generation, storage, utilization) is the means to balance the demand and supply, which is a core function of ECP & ECS.

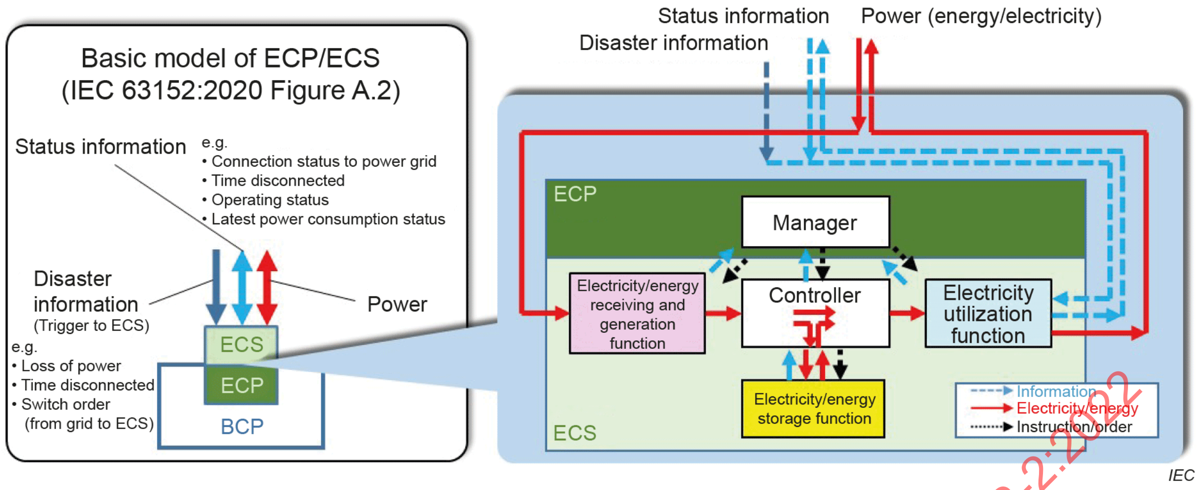


Figure 10 – Basic model of ECP & ECS and its configuration

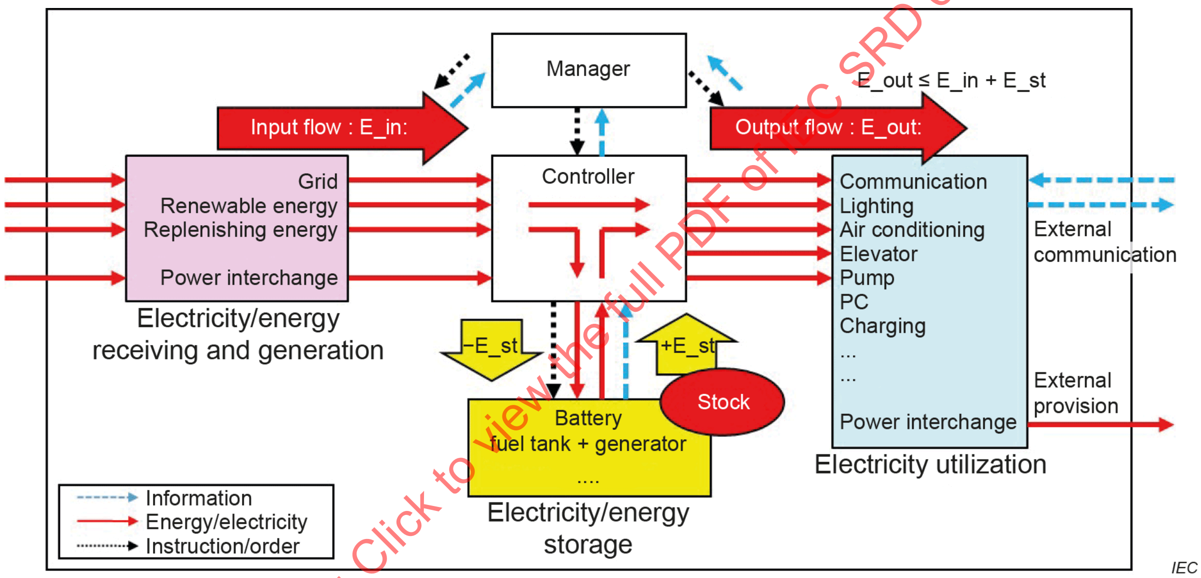


Figure 11 – Basic model of ECP & ECS – internal configuration

Referring to the internal configuration in Figure 11, the design policy for three core functions of ECP & ECS is generalized as follows.

a) For electricity or energy receiving and generation function:
   1) to get the necessary power in a timely and reliable manner.
b) For electricity or energy storage function:
   1) to save up the necessary power on storage in a reliable manner;
   2) to provide the necessary power to demand side in a timely manner.
c) For electricity utilization function:
   1) to prioritize the target and estimate the necessary power;
   2) to utilize the necessary power in a timely and reliable manner, according to the priority;
   3) to save power consumption;
   4) to communicate with external parties.

All actions taken by ECP & ECS can be sorted to one of the above objectives given to the three basic functions. ECP & ECS should be so designed as to identify all actions related to the above objectives and to specify the detailed actions.

5.2.5.2 Recommendations

The following is a list of items that should be considered when implementing the procedures in this step.

a) Estimation of electricity balance.

At first, electricity demand should be estimated by summing up the prioritized utilization, then electricity supply should be estimated by summing up received and generated power, or provided by the storage if the demand and supply need to be balanced. Example is given in 5.3.5.

b) Implementation on EMS.

Basic model of ECP & ECS is a kind of energy management system (EMS). If an organization has a plan to introduce EMS, then implementation of ECP & ECS on the EMS will save the introduction cost and bring better resilience against a disaster.

c) In-depth considerations for a timely and reliable manner.

In order for the power receiving and generation functions to obtain the power required in a timely and reliable manner, and for the storage functions to store and supply the power required in a timely and reliable manner, facilities such as microgrids and EMSs should not only operate properly, but should also be installed in a safe location to prevent them from sinking in floods and tsunamis, or from being destroyed or damaged by flying debris in strong typhoon winds, referring to hazard maps prepared by the government or municipality in preparation for possible disasters.

Similar considerations should be given to wiring, plumbing and ancillary equipment to the facility itself, and to human resources required to operate it.

5.2.6 Useful information for ECP development

The following is a list of information that is useful in developing an ECP.

a) Consideration based on services:

1) to organize activities by service element for regular services provided within the facility (if possible, prepare a process for entire regular service);
2) to extract activities from BCP activities items along the phase;
3) to list electrical equipment and devices used in the extracted activities and also verify that each piece of equipment and device can work on battery power;
4) to confirm the location of each equipment (excluding battery-operated equipment) and the connected power distribution system;
5) to determine the required power capacity of each distribution line along the phase;
6) to plan how electrical equipment and devices are powered according to the management timetable.

b) For effective and flexible ECP:

1) identify what kind of electrical equipment or devices are installed and where they are located. Most of them cannot be easily moved;
2) develop ECP & ECS with the distribution system in mind. If the ECP & ECS is developed without considering the power distribution lines, it might not be possible to accurately distribute power to critical equipment;
3) consider those who are not familiar with electricity in each of the ECP activities. Their sense of security is one of the necessary factors for the proper implementation of ECP;
4) prepare backup ECP in case the period of blackout is longer than estimated;
5) have a program that asks for help in case of running out of power.

c) Useful information for ECP activities:

1) lists of electrical equipment and devices (ID and details) and their locations (map of the facilities);

2) locations of outlets and their distribution line, outlet types;

3) list of electrical equipment by each distribution line (or a list of electrical equipment and the IDs of the outlets to which the electrical equipment is connected);

4) storage locations for accessories and assistive devices, and lists of accessories and assistive devices stored by storage location. Examples of accessories are

i) portable batteries and their types and sizes,

ii) power extension cords and hubs, and

iii) lighting fixtures, light bulbs and fluorescent tubes.

d) Useful information to help each other (e.g. site, facility, area):

1) procedure to connect to and disconnect from power grid;

2) operational status of emergency power supply;

3) remaining capacity of emergency power supply;

4) spatial location of priority users, priority equipment and emergency supply.

5.3 ECP & ECS creation example

5.3.1 System configuration (example) – Community centre and public shelter

There are various locations, services and industries where electricity continuity is required in a city in the event of a disaster. A community centre in a city is taken as a typical example. This will be a good tutorial of ECP & ECS design for an organization in charge of ECP & ECS. Further examples are shown in Annex C.

This facility is used for community meetings, club activities and meeting places in normal time, and in the event of a disaster it will be used as a public shelter.

Figure 12 shows the system configuration of a community centre and public shelter from electricity viewpoint. Each actor has one or more connections with other actors by information, energy, and instruction or order. Here, energy includes electricity and its sources, such as fuel for emergency generator, solar for solar power generator or wind for wind power generator.

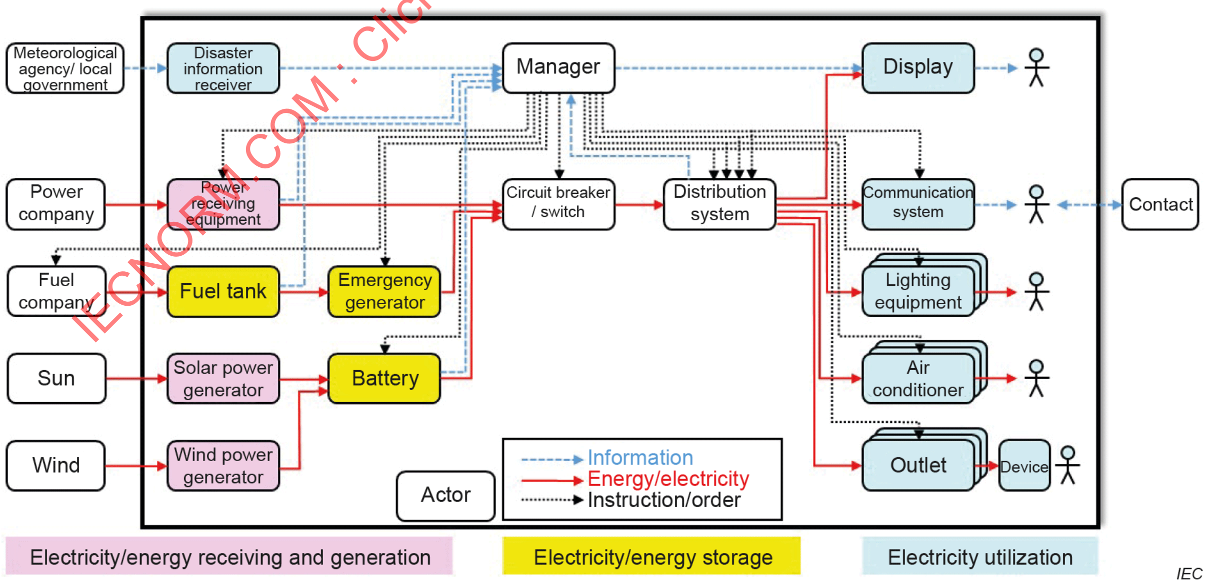


Figure 12 – System configuration of a community centre and public shelter

The facility is managed by a manager both in normal time and during a disaster period. An earthquake is assumed to strike the city, then grid power stops, and the community centre loses power.

During a disaster, the community centre, functioning as a public shelter, provides minimum necessary lighting and air conditioning, communication lines for external communication, outlets for charging smartphones, PCs, TVs, radios, etc., and disaster information reception and information display services to people in the facility.

An example of use case is described in 5.3.2 to 5.3.5 to explain how to prepare for a power outage in the event of a disaster, according to procedures using a short use case template shown in 5.1.

5.3.2 The first step: conceptual design

Short description in the Narrative of use case is described to determine services and their levels to secure in the event of a disaster.

Figure 13 shows Narrative of use case "Short description".

Items	Contents
Name of use case	Community centre / temporary shelter
Date	2020 / 2 / 20

Narrative of use case	
Short description	Following items should be included: 1. A kind of disaster assumed 2. Location where a disaster will strike 3. Service(s) in normal time 4. Service level(s) to maintain during disaster period

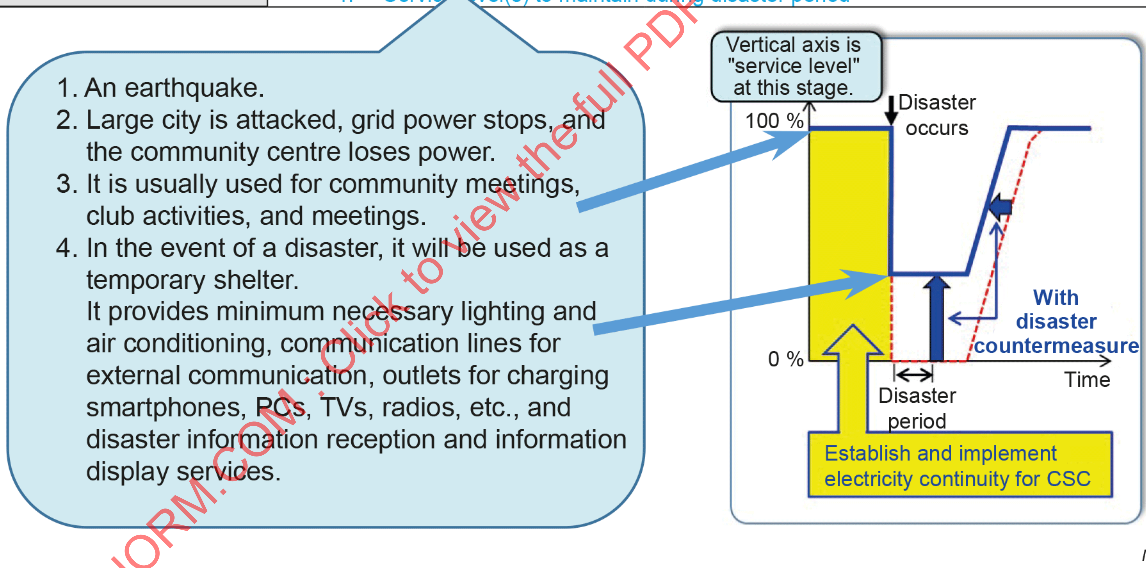


Figure 13 – Narrative of use case "Short description"

5.3.3 The second step: basic design

Complete description in the Narrative of use case is described to estimate necessary electricity and ensure means for the electricity to secure services at a disaster.

Figure 14 shows Narrative of use case "Complete description" for the Preparedness for disaster phase, as an example.

Similarly, Figure 15 through Figure 18 show the Narrative of use case "Complete description" for the Disaster strike phase, the Response phase, the Recovery phase and the Review for next preparation phase, respectively.

Figure 19 shows the procedure to extract a list of actors from the system diagram.

Table 3 shows completed Header and Narrative of Short use case using the template.

Table 3 also shows completed actors list of Short use case using the template.

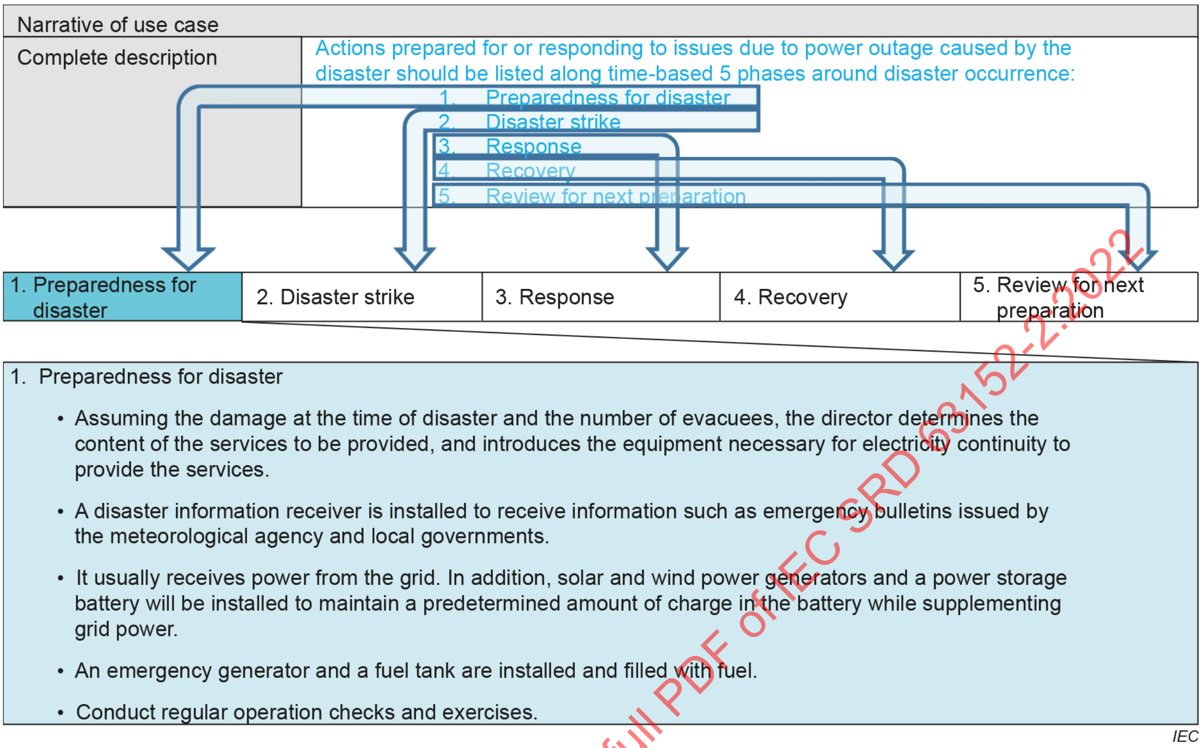


Figure 14 – Narrative of use case – Preparedness for disaster phase

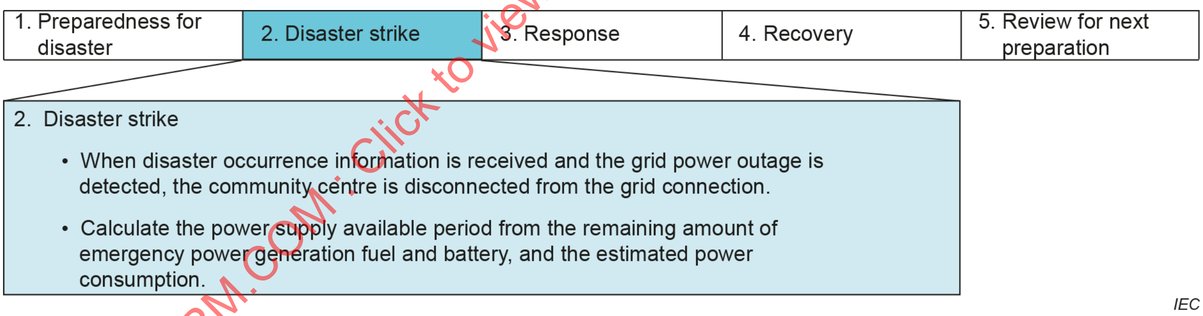


Figure 15 – Narrative of use case – Disaster strike phase

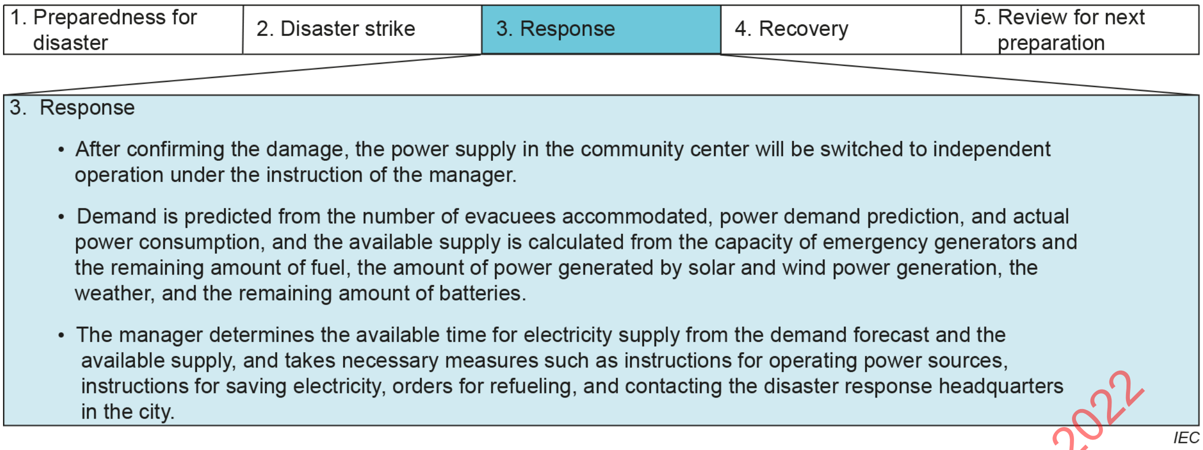


Figure 16 – Narrative of use case – Response phase

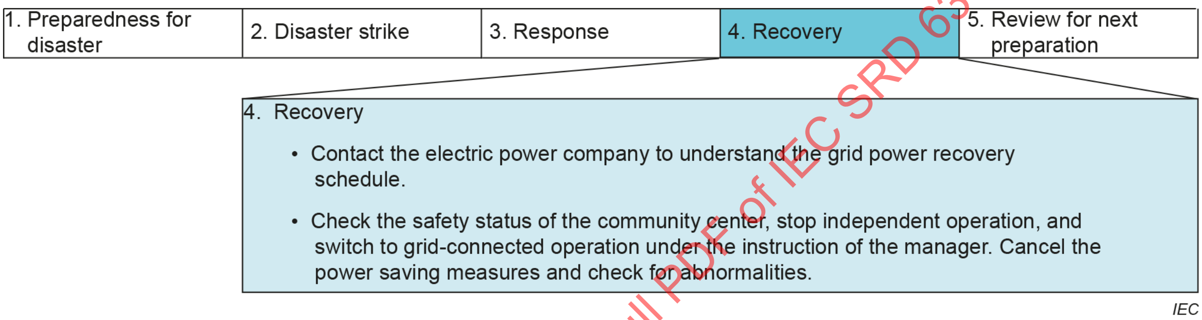


Figure 17 – Narrative of use case – Recovery phase

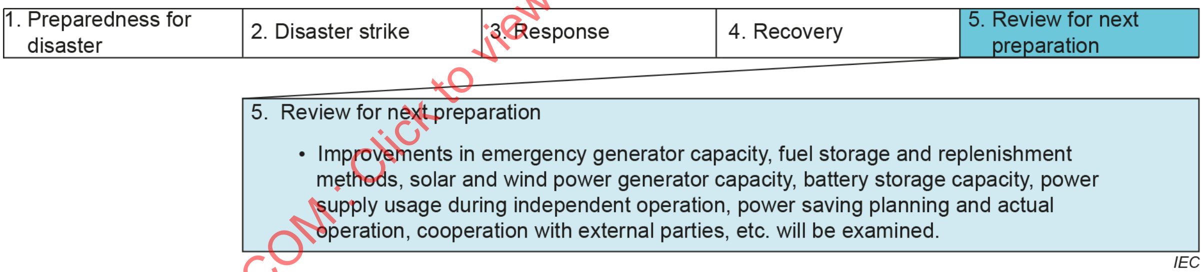
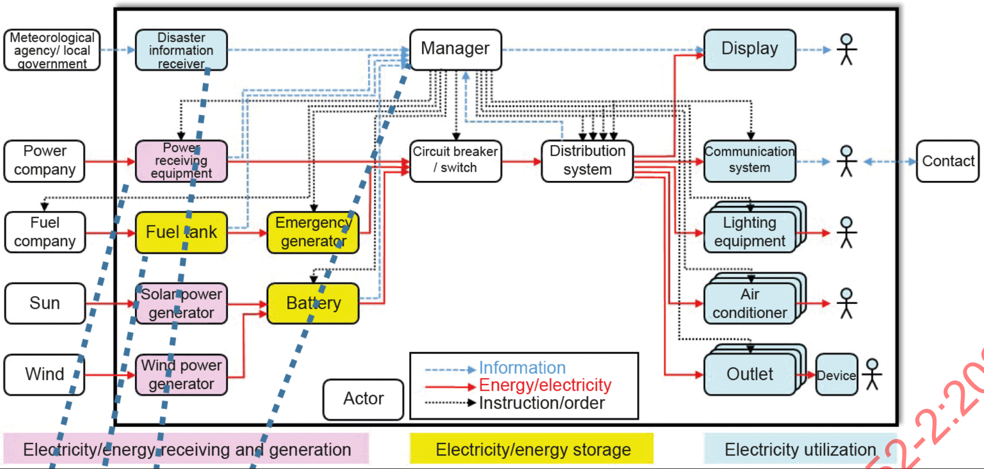


Figure 18 – Narrative of use case – Review for next preparation phase

Diagram(s) of use case



Actors			
Grouping		**Grouping description**	
Information transmission and overall control		Receive external information, make decisions, issue instructions, and provide information	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Manager	Person		
Disaster information receiver	Device		
Display	Device		
Grouping		**Grouping description**	
Power supply equipment		Facilities that receive power from outside or generate and supply power	
Actor name	**Actor type**	**Actor description**	**Further information specific to this use case**
Power receiving equipment	Device		
Fuel tank	Device		

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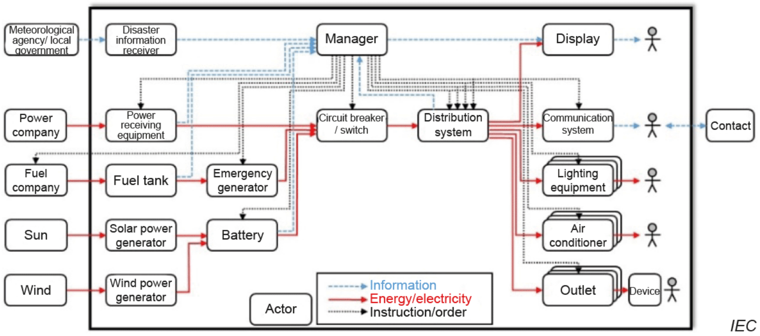
Figure 19 – Diagram(s) of use case and actors list

Table 3 – Use case using the template

<table>
<tr><th>Items</th><th colspan="2">Contents</th></tr>
<tr><td>Name of use case</td><td colspan="2">Community centre / Temporary shelter</td></tr>
<tr><td>Date</td><td colspan="2">2020/2/20</td></tr>
<tr><td colspan="3">Name of author(s)</td></tr>
<tr><td>Name</td><td>Institution</td><td>E-mail</td></tr>
<tr><td>Nakane Kazuhiko</td><td>Mitsubishi Electric Corporation</td><td>Nakane.Kazuhiko@ ....</td></tr>
<tr><td colspan="3">Narrative of use case</td></tr>
<tr><td>Short description</td><td colspan="2">1. An earthquake.
2. Large city is attacked, grid power stops, and the community centre loses power.
3. It is usually used for community meetings, club activities, and meetings.
4. In the event of a disaster, it will be used as a temporary shelter.
It provides minimum necessary lighting and air conditioning, communication lines for external communication, outlets for charging smartphones, PCs, TVs, radios, etc., and disaster information reception and information display services.</td></tr>
<tr><td>Complete description</td><td colspan="2">1. Preparedness for disaster
Assuming the damage at the time of disaster and the number of evacuees, the director determines the content of the services to be provided, and introduces the equipment necessary for electricity continuity to provide the services.
A disaster information receiver is installed to receive information such as emergency bulletins issued by the meteorological agency and local governments.
It usually receives power from the grid. In addition, solar and wind power generators and a power storage battery will be installed to maintain a predetermined amount of charge in the battery while supplementing grid power.
An emergency generator and a fuel tank are installed and filled with fuel.
Conduct regular operation checks and exercises.
2. Disaster strike
When disaster occurrence information is received and the grid power outage is detected, the community centre is disconnected from the grid connection.
Calculate the power supply available period from the remaining amount of emergency power generation fuel and battery, and the estimated power consumption.
3. Response
After confirming the damage, the power supply in the community centre will be switched to independent operation under the instruction of the manager.
Demand is predicted from the number of evacuees accommodated, power demand prediction, and actual power consumption, and the available supply is calculated from the capacity of emergency generators and the remaining amount of fuel, the amount of power generated by solar and wind power generation, the weather, and the remaining amount of batteries.
The manager determines the available time for electricity supply from the demand forecast and the available supply, and takes necessary measures such as instructions for operating power sources, instructions for saving electricity, orders for refueling, and contacting the disaster response headquarters in the city.
4. Recovery
Contact the electric power company to understand the grid power recovery schedule.
Check the safety status of the community centre, stop independent operation, and switch to grid-connected operation under the instruction of the manager. Cancel the power saving measures and check for abnormalities.
5. Review for next preparation
Improvements in emergency generator capacity, fuel storage and replenishment methods, solar and wind power generator capacity, battery storage capacity, power supply usage during independent operation, power saving planning and actual operation, cooperation with external parties, etc. will be examined.</td></tr>
<tr><td colspan="3">Diagram(s) of use case</td></tr>
<tr><td colspan="3"></td></tr>
</table>

Actors			
Grouping		Grouping description	
Information transmission and overall control		Receive external information, make decisions, issue instructions, and provide information	
Actor name	Actor type	Actor description	Further information specific to this use case
Manager	Person	Manage power supply in the community centre	
Disaster information receiver	Device	Receive information from agency on disasters	
Display	Device	Provide information for community centre	
Grouping		Grouping description	
Power supply equipment		Facilities that receive power from outside or generate and supply power	
Actor name	Actor type	Actor description	Further information specific to this use case
Power receiving equipment	Device	Receiving power from the power grid	
Fuel tank	Device	Fuel tank for emergency generator	
Emergency generator	Device	Emergency generator used during power outage	
Solar power generator	Device	Generate electricity with sunlight	
Wind power generator	Device	Generate electricity by wind	
Battery	Device	Store electricity generated by solar power and wind power	
Circuit breaker / switch	Device	Send or cut power from source to distribution	
Distribution system	Device	Distribute power inside the community centre	
Grouping		Grouping description	
Power demand equipment		Equipment that consumes power	
Actor name	Actor type	Actor description	Further information specific to this use case
Communication system	Device	Communication means for contacting outside	
Lighting equipment	Device	Indoor lighting	
Air conditioner	Device	Indoor heating and cooling	
Outlet	Device	Power outlet for electrical equipment	
Grouping		Grouping description	
External parties		Outside of the community centre	
Actor name	Actor type	Actor description	Further information specific to this use case
Meteorological agency / local government	Organization	Send information on the occurrence and situation of emergency situations such as disasters	
Power company	Organization	Supply power in the power grid	
Fuel company	Organization	Supply fuel for emergency generators	
Sun	Nature	Power source, depends on time and weather conditions	
Wind	Nature	Power source, depends on weather conditions	
Contact	Person	Outside contacts of the manager during emergency	

5.3.4 The third step: detailed design – Management timetable of ECP & ECS

Management timetable of ECP & ECS is derived from short use case descriptions to make the means determined in the second step effective and to secure power requirements at a disaster.

Figure 20 and Figure 21 show management timetable of ECP & ECS and its derivation process. Use case descriptions for five phases are broken down and assigned to each actor's cell.

↓ Interoperability layers	Phase	1. Preparedness for disaster	2. Disaster strike	3. Response	4. Recovery	5. Review for next preparation
	Short description	It is usually used for community meetings, club activities and meetings	In the event of a disaster, it will be used as a temporary shelter. It provides minimum necessary lighting and air conditioning, communication lines for external communication, outlets for charging smartphones, PCs, TVs, radios, etc. and disaster information reception and information display services.			
	Complete description	Assuming the damage at the time of disaster and the number of evacuees, the director determines the content of the services to be provided and introduces the equipment necessary for electricity continuity to provide the services. A disaster information receiver is installed to receive information such as emergency bulletins issued by the meteorological agency and local governments. It usually receives power from the grid. In addition, solar and wind power generators and a power storage battery will be installed to maintain a predetermined amount of charge in the battery while supplementing grid power. An emergency generator and a fuel tank are installed and filled with fuel. Conduct regular operation checks and exercises.	When disaster occurence information is received and grid power outage is detected, the community centre is disconnected from the grid connection. Calculate the power supply available period from the remaining amount of emergency power generation fuel and battery, and the estimated power consumption.	After confirming the damage, the power supply in the community centre will be switched to independent operation under the instruction of the manager. Demand is predicted from the number of evacuees accommodated, power demand prediction and actual power consumption, and the available supply is calculated from the capacity of emergency generators and the remaining amount of fuel, the amount of power generated by solar and wind power generation, the weather and the remaining amount of batteries. The manager determines the available time for electricity supply from the demand forecast and the available supply and takes necessary measures such as instructions for operating power sources, instructions for saving electricity, response headquarters in the city.	Contact the electric power company to understand the grid power recovery schedule. Check the safety status of the community centre, stop independent operation, and switch to grid-connected operation under the instruction of the manager. Cancel the power saving measures and check for abnormalities.	Improvements in emergency generator capacity, fuel storage and replenishment methods, solar and wind power generator capacity, battery storage capacity, power supply usage during independent operation, power saving planning and actual operation, cooperation with external parties, etc. will be examined.

Use case description for 5 phases are broken down and assigned to each actor’s cell.

5	Phase Actors	1. Preparedness for disaster	2. Disaster strike	3. Response	4. Recovery	5. Review for next preparation
	Director/ manager	• Assuming the damage at the time of disaster and the number of evacuees, the director determines the content of the services to be provided and introduces the equipment necessary for electricity continuity to provide the services. • Install a disaster information receiver to receive information such as emergency bulletins issued by the meteorological agency and local governments. • Install solar and wind power generators and a power storage battery • Install an emergency generator and a fuel tank. • A fuel tank is filled with fuel. • Conduct regular operation checks and exercises.	• Manager decides to disconnect the community centre from the grid connection when disaster occurrence information is received and the grid power outage is detected. • Calculate the power supply available period from the remaining amount of emergency power generation fuel and battery, and the estimated power consumption.	• Confirm the damage • Switches the power supply to independent operation in the community centre. • Predicts demand from the number of evacuees accommodated, power demand prediction and actual power comsumption. • Calculates the available supply from the capacity of emergency generators and the remaining amount of fuel, the amount of power generated by solar and wind power generation, the weather and the remaining amount of batteries. • Determines the available time for electricity supply from the demand forecast and the available supply and takes necessary measures such as; • instructions for operating power sources • instructions for saving electricity • orders for refueling • contacting the disaster response headquarters in the city, etc.	• Contact the electric power company to understand the grid power recovery schedule. • Check the safety status of the community centre. • Stop independent operation, and switch to grid-connected operation. • Cancel the power saving measures and check for abnormalities.	• Improvements in the following will be examined: • emergency generator capacity • fuel storage and replenishment methods • solar and wind power generator capacity • battery storage capacity • power supply usage during independent operation • power saving planning and actual operation • cooperation with external parties, etc.

continued to (2/2)

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Figure 20 – ECP & ECS management timetable (top half)

continued from (1/2)

	Phase / Actors	1. Preparedness for disaster	2. Disaster strike	3. Response	4. Recovery	5. Review for next preparation
5	Meteorological agency/local government	• Send information such as emergency bulletins.	• Send disaster occurrence information.	• Send disaster related information.	← Same as left	• Send information such as emergency bulletins.
5	Power company	• Supply power to the grid.	• Power grid transmission stops.	<Restoration activities>	• Notify the grid power recovery schedule. • Switch to grid-connected operation.	• Supply power to the grid.
5	Fuel company	• Fill fuel to fuel tank.		• Receive refueling order and refill fuel tank.	← Same as left	← Same as left
5	Contact			• The disaster response headquarters is contacted by the manager. • The fuel company is contacted by the manager.	• The electric power company is contacted by the manager.	
3	Disaster information receiver	• Receives information such as emergency bulletins issued by the meteorological agency and local governments.	• Receive disaster occurrence information.	• Receive disaster related information.	← Same as left	• Receives information such as emergency bulletins issued by the meteorological agency and local governments.
3	Display	• Shows guidance to guests of the community centre	• Change automatically to show disaster occurrence information.	• Show disaster information. • Show instructions for saving electricity.	← Same as left	• Shows guidance to guests of the community centre.
2	Communication system	• Provide communication with the inside or outside of the community centre.	<Blackout>	• Provide communication with the disaster response headquarters. • Provide communication with the fuel company	• Provide communication with the electric power company.	• Provide communication with the inside or outside of the community centre.
1	Power receiving equipment	• Receives power from the grid.	• Detect grid power outage. • Disconnect from the power grid.	<Stopped>	• Connect to the power grid.	• Receives power from the grid.
1	Fuel tank	• Filled with fuel.	• Reports the remaining amount of fuel.	• Reports the remaining amount of fuel. • Receive refueling.	← Same as left	• Filled with fuel.
1	Emergency generator	• Conduct regular operation checks and exercises.	<Stopped>	• Follow the instructions for operating power sources.	← Same as left	• Conduct regular operation checks and exercises.
1	Solar power generator	• Supplements grid power.	← Same as left	• Follow the instructions for operating power sources.	← Same as left	• Supplement grid power.
1	Wind power generator	• Supplements grid power.	← Same as left	• Follow the instructions for operating power sources.	← Same as left	• Supplement grid power.
1	Battery	• Maintains a predetermined amount of charge in the battery.	• Reports the remaining amount of battery charge.	• Report the amount of power generated by solar and wind power generation and the remaining amount of batteries. • Follow the instructions for operating power sources.	← Same as left	• Maintains a predetermined amount of change in the battery.
1	Circuit breaker/ switch	• Sends grid power and solar and wind power to the distribution system.	• Disconnect from the grid connection.	• Switches the power supply to independent operation in the community centre under the instruction of the manager.	• Stop independent operation and switch to grid-connected operation under the instruction of the manager.	• Sends grid power and solar and wind power to the distribution system.
1	Distribution system	• Distributes power to demand equipment.	<Blackout>	• Report actual power consumption.	← Same as left	• Distributes power to demand equipment.
1	Lighting equipment	• Provides light.	<Blackout>	• Follow the instructions for saving electricity.	• Cancel the power saving measures. • Check for abnormalities.	• Provides light.
1	Air conditioner	• Provides warm or cool conditioned air.	<Blackout>	• Follow the instructions for saving electricity.	• Cancel the power saving measures. • Check for abnormalities.	• Provides warm or cool conditioned air.
1	Outlet	• Provides power to equipment.	<Blackout>	• Follow the instructions for saving electricity.	• Cancel the power saving measures. • Check for abnormalities.	• Provides power to equipment.
1	Sun	• Source of the solar power generator.	← Same as left	← Same as left	← Same as left	← Same as left
1	Wind	• Source of the wind power generator.	← Same as left	← Same as left	← Same as left	← Same as left

↑ Interoperability layers: "5": Business layer, "4": Function layer, "3": Information layer, "2"; Communication layer or "1": Component layer

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Figure 21 – ECP & ECS management timetable (bottom half)

5.3.5 The final step: detailed design completion – Specifications of ECP & ECS

5.3.5.1 Specifications of ECP

ECP should cover items for the Business layer. As an example of summary of ECP, Business layer related descriptions for Manager are selected from the management timetable shown in Figure 20 and Figure 21, and listed in Table 4 with items to be clarified or executed for each description.

Table 4 – Summary of ECP (for Manager)

Phase	Description in the management timetable	Items to be clarified or executed
Preparedness for disaster	Assuming the damage at the time of disaster and the number of evacuees, the director determines the content of the services to be provided, and introduces the equipment necessary for electricity continuity to provide the services.	– Disaster to be assumed – Number of evacuees to be assumed – Services to be provided – Introduction of equipment necessary for electricity continuity to provide the services – Emergency response system and rules – Cooperation with external parties
	Install a disaster information receiver to receive information such as emergency bulletins issued by the meteorological agency and local governments.	– Contact window for disaster information – Contract with meteorological agency and local governments
	Install solar and wind power generators and a power storage battery.	– Specifications of solar power generator – Specifications of wind power generators – Specifications of power storage battery
	Install an emergency generator and a fuel tank. A fuel tank is filled with fuel.	– Specifications of emergency generator – Specifications of a fuel tank – Contract with fuel company
	Conduct regular operation checks and exercises	– Specifications of regular operation checks – Plan and execution of regular operation exercises
Disaster strike	Manager decides to disconnect the community centre from the grid connection when disaster occurrence information is received and the grid power outage is detected.	– Procedure to make decision – Contact window for power grid information and disaster occurrence information
	Calculate the power supply available period from the remaining amount of emergency power generation fuel and battery, and the estimated power consumption.	– Means to get information on remaining amount of emergency power generation fuel and battery – Means to calculate the power supply available period – Means to estimate power consumption, or data prepared in advance – Persons in charge for each job
Response	Confirm the damage	– Procedures and means to check damage – Persons in charge for each facility and equipment
	Switches the power supply to independent operation in the community centre.	– Procedures to switch the power supply to independent operation – Agreement with electric power company – Persons in charge
	Predicts demand from the number of evacuees accommodated, power demand prediction, and actual power consumption.	– Means to predict demand from the number of evacuees accommodated – Means to get power demand prediction

Phase	Description in the management timetable	Items to be clarified or executed
		– Means to get actual power consumption – Persons in charge
	Calculates the available supply from the capacity of emergency generators and the remaining amount of fuel, the amount of power generated by solar and wind power generation, the weather, and the remaining amount of batteries.	– Means to calculate the available supply • Data of capacity of emergency generators • Means to get the remaining amount of fuel • Means to get the amount of power generated by solar and wind power generation • Means to get the weather forecast • Means to get the remaining amount of batteries – Persons in charge
	Determines the available time for electricity supply from the demand forecast and the available supply, and takes necessary measures such as: – instructions for operating power sources, – instructions for saving electricity, – orders for refuelling, – contacting the disaster response headquarters in the city, etc.	– Means to determine the available time for electricity supply – Authorized procedure to take action such as: • instructions for operating power sources, • instructions for saving electricity, • orders for refuelling, • contacting the disaster response headquarters in the city, etc. – Power saving planning – Persons in charge for each item above
Recovery	Contact the electric power company to understand the grid power recovery schedule.	– Contact window of the electric power company – Predetermined procedure to get grid power recovery schedule
	Check the safety status of the community centre.	– Procedures to check the safety status of the community centre – Persons in charge
	Stop independent operation, and switch to grid-connected operation.	– Procedures to stop independent operation, and switch to grid-connected operation – Agreement with electric power company – Persons in charge
	Cancel the power saving measures and check for abnormalities.	– Procedures to cancel the power saving measures – Procedures to check for abnormalities.
Review for next preparation	Improvements in the following will be examined: – emergency generator capacity, – fuel storage and replenishment methods, – solar and wind power generator capacity, – battery storage capacity, – power supply usage during independent operation, – power saving planning and actual operation, – cooperation with external parties, etc.	– Plan and execution of the review

Following the summary of ECP for Manager in Table 4, each item which needs to be clarified or executed is extended to individual specifications or actions by quantification, identification, contract, etc. Items listed in the phases from "Disaster strike" through "Review for next preparation" are executed in each assigned phase, but the phase of "Preparedness for disaster" should be prepared in advance in normal time.

As an example of quantification in the ECP, estimation of electricity demand is illustrated in Table 5. As for evaluation of necessary electricity capacity, refer to Annex A of IEC 63152:2020.

All components of electricity demand side are listed, and the purposes of each component are classified into four priority levels. Most important thing is to correctly evaluate the priority of purposes and properly assign the priority, according to their importance by analysing the minimum level of services acceptable for the facility with the standing time.

Definition of the priority is given in Table 5. Four priorities are set in this example. If electricity for purposes of priority 1 (Fatally essential) were not provided, the most important service of the facility, public shelter in this case, would be stopped and evacuees could not stay long. Purposes of priority 2 (Necessary) have next importance.

Table 5 – Estimation of electricity demand

No.	Component name	Purpose	Electricity demand				
			Normal time	Emergency time			
				Priority 1	Priority 2	Priority 3	Priority 4
1	Communication	Phone, SMS	d10	d11			
		Internet, ECS control			d12		
						d13	
		Private chat for fun					d14
2	Lighting	Control room	d20	d21			
		Basement, Toilet			d22		
		Living room (night time)				d23	
		Corridor, Entrance					d24
3	Air conditioning	Living room, Control room	d30	d31			
		Equipment room			d32		
		Corridor				d33	
		Basement, Toilet, Entrance					d34
-	.....						
N			dN0	dN1			
					dN2		
						dN3	
							dN4
	Accumulation	For priority 1	D0	D1			
		For priority 1 + 2		D2			
		For priority 1 + 2 + 3		D3			
		For all demands		D4			
Definition of priority Priority 1: Fatally essential Priority 2: Necessary Priority 3: Convenient Priority 4: Reducible			To match electricity demand with electricity source and storage, taking variations into account.				

Electricity demand of a component is separately estimated for plural purposes. Accumulation D1, D2, D3 and D4 give electricity demands estimated for four cases, each of which corresponds to a case to meet the electricity demand for different priority. Since electricity demand depends on actual consumption by electric facility and equipment, so it varies with time.

Estimation example of electricity supply from source and storage is illustrated in Table 6.

Five kinds of electricity sources and storages are listed with their characteristics. Grid power goes to zero in emergency time in response and recovery phases, when the electricity supplied by the other sources will be necessary. Actual supply can be different from the planned one. Supply from solar power generator and wind power generator depend on climate and time conditions. Battery and emergency use oil generator have limitation on the maximum capacity, so charging or refuelling in time is necessary to continue electricity. Accumulation of these supplies gives total capacity to meet the demand.

Table 6 – Estimation of electricity source and storage

No.	Component name	Characteristics	Electricity supply				
			Normal time	Emergency time			
				Planned		Actual	
				Response phase	Recovery phase	Response phase	Recovery phase
1	Grid	No limitation in normal time, but down at disaster	s10	0	0	0	0
2	Solar power generator	Variable power supply, depending on climate and time	s20	s21	s22	s21a	s22a
3	Wind power generator	Variable power supply, depending on climate	s30	s31	s32	s31a	s32a
4	Battery	Limited maximum capacity, need to charge	s40	s41	s42	s41a	s42a
5	Oil generator	Limited maximum capacity, need to refuel	0	s51	s52	s51a	s52a
	Total		S0	S1	S2	S1a	S2a
			To match electricity demand with electricity source and storage, taking variations into account.				

The estimated electricity supply is one of S1, S2, S1a, or S2a, which is the maximum limit of electricity, and it will be provided to satisfy the prioritized estimated demands, which is determined from one of D1, D2, D3 and D4. Since both electricity demands and supply vary with time, charging the battery or refuelling the tank and providing the electricity should be carefully scheduled. During emergency time, D1 should be secured. Whether D2, D3 and D4 are secured or not, and how to make the decision, should be defined in the ECP.

The solar power and wind power generators with battery, controlled by an energy management system, work in normal time as well as in emergency time.

5.3.5.2 Specifications of ECS

ECS should cover items for the Function layer, Information layer, Communication layer and Component layer. ECS related descriptions can be selected from these four layers on the management timetable shown in Figure 20 and Figure 21.

Action items in Business layer, which is defined in ECP, require actors in the lower four layers to upload information and issue instructions or orders to actors in these lower layers. Therefore, specifications defined in the ECS should correspond to specifications required by the ECP. Also, specifications for elements in different layers within the ECS, which exchange information and instruction, should be consistent with each other.

Table 7 shows a part of summary of ECS, for Battery, as an example. Similarly to Table 4, descriptions related to the four layers in the management timetable shown in Figure 20 and Figure 21 are selected. The descriptions are examined and items to be clarified or executed are listed.

Table 7 – Summary of ECS (for Battery)

Phase	Component	Descriptions in the management timetable	Items to be clarified or executed
Preparedness for disaster	Battery	Maintains a predetermined amount of charge in the battery.	– Method, person in charge and procedure to define predetermined amount of charge in the battery – Predetermined amount of charge
Disaster strike	Battery	Reports the remaining amount of battery charge.	– Means to report the remaining amount of battery charge – Procedure of how to report the remaining amount of battery charge
Response	Battery	Report the amount of power generated by solar and wind power generation and the remaining amount of batteries.	– (Same as above for battery) – Means to report the amount of power generated by solar and wind power generation – Procedure of how to report the amount of power generated by solar and wind power generation
		Follow the instructions for operating power sources.	– Means and procedure to receive the instructions for operating power sources and execute them.
Recovery	Battery	(same as Response phase)	(same as Response phase)
Review for next preparation	Battery	Maintains a predetermined amount of charge in the battery.	– Predetermined amount of charge

Following the summary of the ECS, each item which needs to be clarified or executed is extended to individual specifications or actions.

6 Operation guideline for ECP & ECS

6.1 Outline of ECP & ECS operation

Once the ECP & ECS is implemented and operational, the ECP & ECS executes the following three operations in rotation, depending on the disaster situation:

- normal time operation;
- emergency time operation;
- update operation.

Necessary actions executed or assumed during the operation of ECP & ECS should be prepared in advance, by defining in the ECP and implementing in the ECS.

Figure 22 shows relationship of the ECP & ECS operations with the disaster phases.

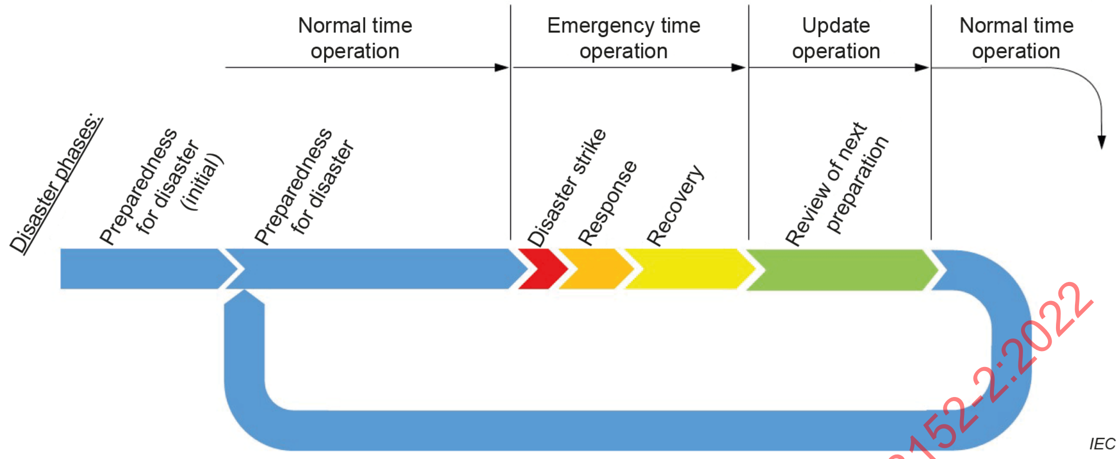

Figure 22 – Relationship of the ECP & ECS operations with the disaster phases

6.2 Normal time operation

Normal time period corresponds to the "Preparedness for disaster" phase in the management timetable. ECP & ECS runs with the normal time operation almost all period. ECP & ECS managers and staff should carry out the defined actions to prepare for emergency time caused by a disaster that rarely occurs.

In operation, the following actions should be executed in accordance with the ECP:

a) Education and training:
   1) initial education and training for managers and staff (including new members);
   2) periodical education and training for managers and staff to maintain and improve their proficiency level;
   3) review and follow-up after training.
b) Execution of ECP & ECS (in the event of a small power failure or abnormality).
c) Operation check of ECS.
d) Periodical maintenance of key equipment.
e) Replacement of consumables.
f) Fixing the issues found from the above actions.

Accompanying the actions above, the following should be recorded:

- history of education and training for managers and staff;
- history of ECP & ECS execution with results;
- history of ECS operation check with results;
- history of maintenance of key equipment;
- history of replacement of consumables;
- history of improvements.

6.3 Emergency time operation

Emergency time period corresponds to "Disaster strike" phase, "Response" phase and "Recovery" phase in the management timetable. ECP & ECS for disaster response shall activate, ECP & ECS managers and staff shall carry out the defined actions to respond to the disaster and take necessary actions to recover from the disaster, referring to the established ECP.

Actual situations caused by the disaster often differ from assumptions such as number of evacuees or victims, electricity demands and ECS facility performance. Therefore, managers and staff should respond flexibly to the actual situations and make effort to ensure essential electricity for the priority demand by electricity flow and stock management of the ECS.

In operation, actual needs and actions taken for the needs should be recorded.

6.4 Update operation

Update period corresponds to "Review for next preparation" phase in the management timetable. Actual situations caused by the disaster, actions taken for the situation and the results should be reviewed based on the records, in accordance with the ECP, to find improvements for next preparation.

In operation, ECP & ECS should be reviewed in accordance with the ECP from following aspects.

- Assumption of damage due to disaster.
- Given role and actions of managers and staff.
- Proficiency level of managers and staff.
- Management status of consumables.
- Procedures defined in the ECP:
  - Identify and update procedures that are insufficient, inconsistent, unreasonable, wasteful, unsuitable and incompatible. Add missing procedures.
- System functions implemented in the ECS:
  - Identify and update system functions that are insufficient, inconsistent, wasteful, unsuitable and incompatible. Add missing functions.

7 Collaboration across ECP & ECS for plural city services

7.1 Collaboration between related services

Few city services can play their given role by themselves; most of them require cooperation with or use of other services.

For example, an ambulance for medical service is affected by road traffic. If a traffic signal or road control stops due to a power outage and a traffic jam occurs, it cannot fulfil the role of patient transportation.

For another example, web business or gig economy depends heavily on communications, transportation and distribution, so disruption in communications and traffic congestion due to power outages fatally impact the service.

While implementing ECP & ECS of a service, it is important to have a broad understanding of the dependencies on other services. If ECP & ECS did not have a step to consider situation of other related services in a design of ECP & ECS, it would not function effectively in the event of a disaster.

When a service or facility has a management timetable on which some part of the Business layer relates to other Business layer for another service or facility, actors involved on both layers should be bridged to collaborate with each other, in order to develop an ECP which effectively realizes the electricity continuity.

Figure 23 shows an example of collaboration between management timetables for two facilities providing different services. The horizontal axis is phase, the vertical axis is interoperability layer, and the service or facility is located along the depth axis.

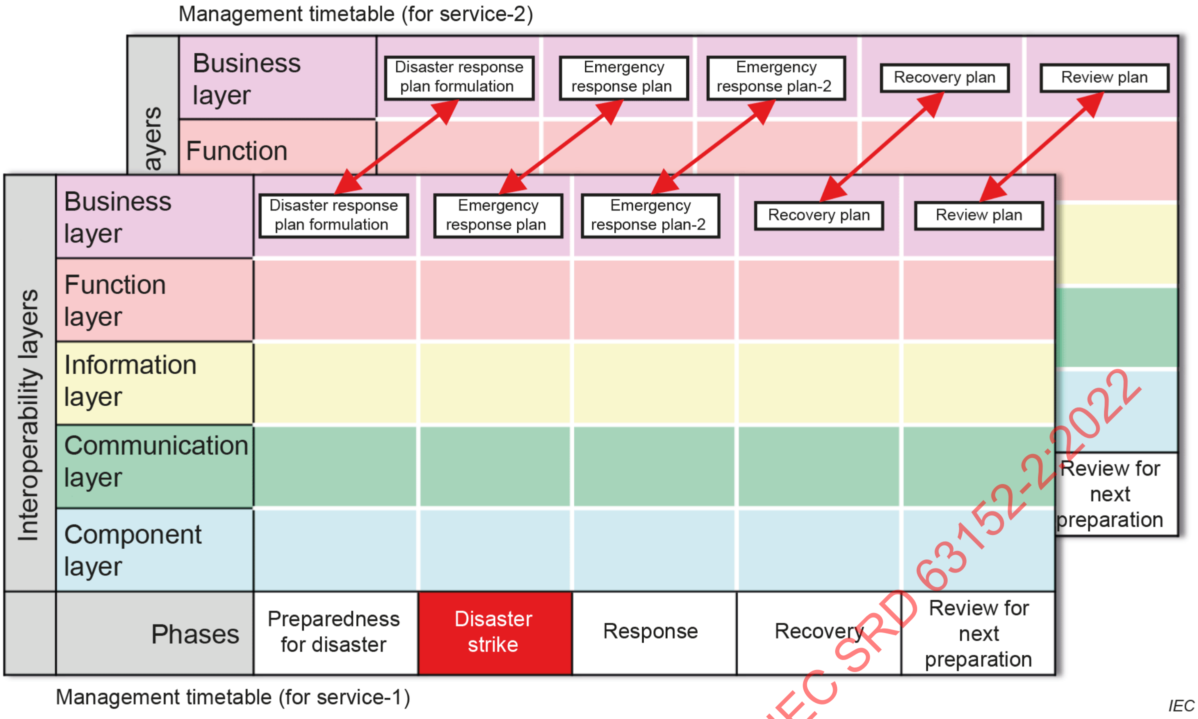

Figure 23 – Collaboration between related services on management timetables

For example, if two facilities, both of which have electric vehicles (EVs), make an agreement in advance to collaborate together in the event of a disaster, they can incorporate procedures to exchange power status information with each other. When one facility runs out of power due to a power outage, the other can dispatch a fully charged EV to provide power that has been prepared in advance.

In this case, management timetables are bridged not only between the Business layers, but also between the Component layers (EVs and their charging), the Communication layers (communication channel) or the Information layers (exchanging power status information).

7.2 ECP & ECS collaboration model for city services

When multiple services and facilities jointly develop their ECP & ECSs, it is not efficient to establish collaboration among them by repeated bilateral bridging of the relevant management timetables.

Instead, it is possible to design the ECP & ECSs efficiently and with good visibility by expanding the layer plane horizontally to cover all target services and facilities and by arranging the involved actors and their connections on the layer plane.

Figure 24 shows a collaboration model of ECP & ECSs utilized for joint development for plural services and facilities linked to each other. The horizontal axis is phase, the vertical axis is interoperability layer, and the depth axis is service or facility domain.

While Figure 23 is viewed as a depth-wise arrangement of management timetable for each service or facility, Figure 24 is viewed as a vertical stack of five-layer planes.

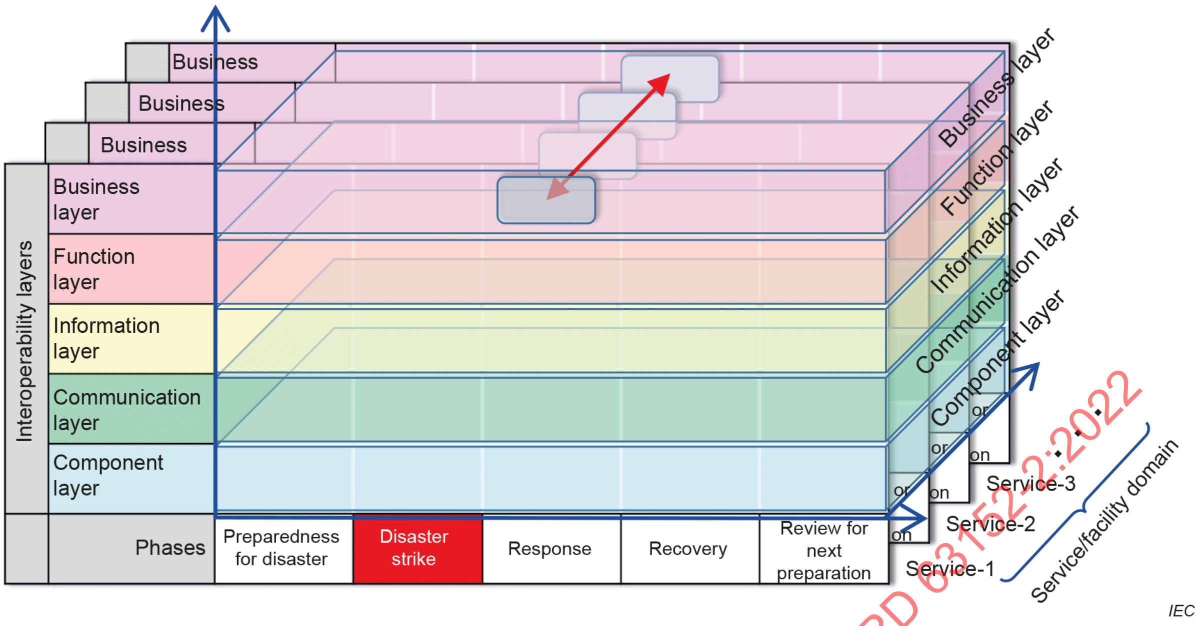

Figure 24 – ECP & ECS collaboration model for city services

By expanding the layer plane to cover target services and facilities in a city, it will be possible to develop a broad coverage ECP & ECS that includes a broad range of relevant services and facilities. In this way, resilience of the whole city is strengthened by cooperation of the ECP & ECS of related services and organizations in the city.

The 3D structure of ECP & ECS collaboration model is an integration of 2D management timetables and provides a complete picture of the electricity continuity for the relevant city services, so it can be called an ECP & ECS reference architecture for city services.

A management timetable for a service is a vertical slice of the ECP & ECS collaboration model for the target city service.

7.3 Adaptation of 3D ECP & ECS collaboration model

7.3.1 Adaptation procedure of ECP & ECS collaboration model

The procedure to create a set of ECP & ECS for relevant city services by adapting the ECP & ECS collaboration model is as follows.

- Target a city service and collect relevant city services.
- Create a use case of each service, including actions served by actors that belong to another relevant service.
- Derive a management timetable for each service.
- Arrange the management timetables of all relevant services along the Domain axis and pull out each layer to confirm the collaboration situation among relevant services.
- When a layer of a service (demanding service) includes an action served by actors belonging to another service (responding service), check whether the responding service includes the actors and actions in its management timetable and fill in the gap if it exists.

By checking similarly all actions served or requested by actors in relevant services, the integrated set of management timetables for the target city services is completed.

7.3.2 Application to CSC planning

CSC planning method is given in Annex C of IEC 63152:2020 to ensure the sustaining level of city services. ECP & ECS collaboration model is a suitable tool to apply for CSC planning.

Figure 25 shows how to use ECP & ECS collaboration model for CSC planning.

Each service has its own ECP & ECS to ensure necessary sustaining level. ECP & ECS is derived from the management timetable and is implemented based on Basic model of ECP & ECS, which becomes the unit of ECP & ECS. Or in other words, an organization which provides the service is a unit of ECP & ECS.

When ECP & ECSs of many services in the city relate to each other, the many management timetables can be soundly harmonized by applying the ECP & ECS collaboration model.

Figure 25 illustrates an example to construct Power Cooperation Area (CSC type 3) and Information Cooperation Area (CSC type 2) in a city, where the Area and the CSC types are defined in Clause 4 and Annex B, respectively, of IEC 63152:2020. Power status information and disaster related information, etc. are shared among organizations that belong to the same area and between organizations connected to each other and, in addition, power interchange is done in the Power Cooperation Area in the event of disaster. Collaboration model is an effective tool to plan and implement such a complex cooperation scheme.

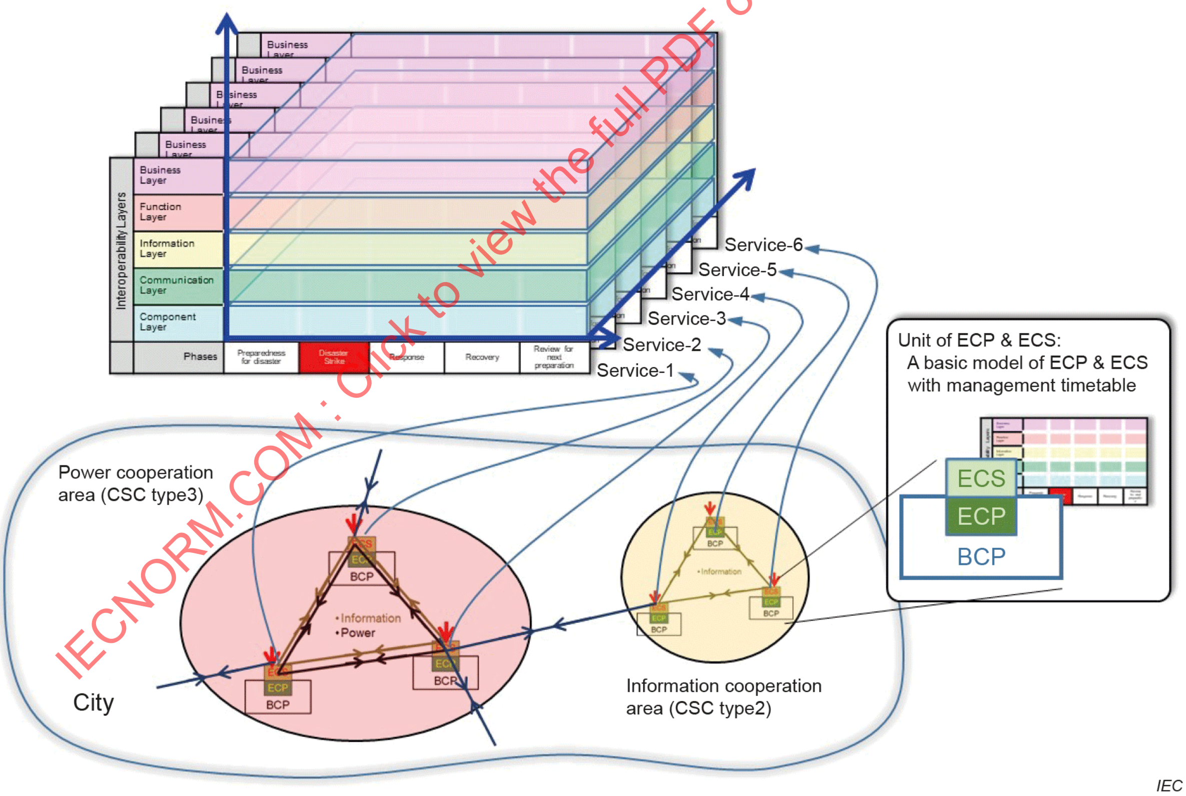

Figure 25 – ECP & ECS collaboration model for CSC planning

Annex A
(informative)

Necessity of electricity continuity in a city

A.1 Impacts of power outage

To assume damage when a disaster strikes a city and electricity is cut off, it is important to grasp what happens to electrical equipment and what problems will occur with each location, service or industry in a city.

Services or organizations in a city have complex interrelationships. Impacts of power outage for a service or organization propagate to adjacent or cascaded services or organizations, causing spread of damage. Understanding the interrelationships is important.

In Clause A.2, typical examples of impacts of power outage on various locations, services or industries in a city are listed. These examples give a strong message of necessity for electricity continuity in a city.

A.2 Examples of impacts of power outage

A.2.1 Life, home and buildings fields

Figure A.1 illustrates typical examples of exposure to risks during a power outage in life, home and buildings fields.

Figure A.1 – Life, home and buildings fields

Experienced so far or possible problems and damage are as follows.

a) The lights go out and it goes dark.

b) Air conditioner stops:
   1) risk of heat stroke due to heat and water outage in the hot season;
   2) danger to life due to lack of warmth during the cold season.

c) Electric water heater shuts off:
   1) bath or shower cannot be used.

d) Refrigerator stops:
   1) food goes bad.

e) Electric cooker cannot be used.

f) Food preparation is not possible.

g) TV, radio, PC are dead.

h) Smartphone is dead:
   1) information cannot be accessed;
   2) unsure of the situation and outlook, increasing anxiety.

i) Life support equipment for home medical care will stop.
j) The more people there are, the faster the stockpiles of batteries, fuel, food, and water will run out.
k) In an apartment and building:
   1) emergency power supply stopped due to fuel shortage;
   2) elevator stopped:
      i) no access to upper floors;
   3) the water supply pump stopped:
      i) the water supply was cut off,
      ii) the toilet and bath are not available,
      iii) cleaning and washing is not possible;
   4) relief activities to deliver water to upper floors are increasingly difficult due to communication problems;
   5) automatic door and electronic key cannot be used;
   6) mechanical parking locks up cars.
l) In a business building:
   1) control centre is down;
   2) LAN in the building is down;
   3) information communication with the outside is stopped;
   4) security management stopped;
   5) workers need to work from home:
      i) productivity can drop.

A.2.2 Mobility, transportation and logistics fields

Figure A.2 illustrates typical examples of exposure to risks during power outage in road traffic and logistics fields.

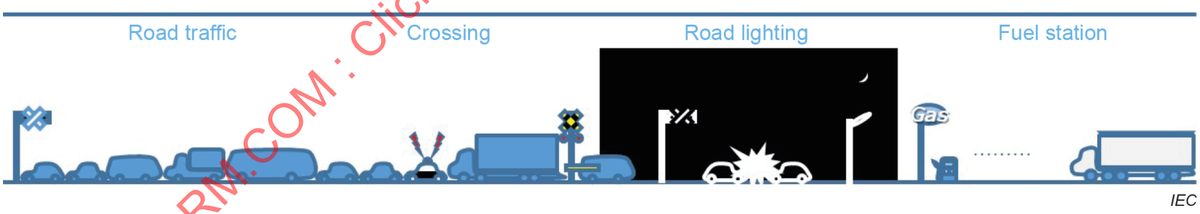

Figure A.2 – Mobility, road traffic and logistics fields

Experienced so far or possible problems and damage are as follows.

a) Traffic lights stop and traffic jams occur.
b) Gridlock occurs at city centre intersection.
c) The emergency vehicles cannot move.
d) Traffic congestion worsened because of cars that are left due to petrol or electricity shortage.
e) The railway crossings were closed and the traffic was cut off.
f) Logistics and movements are delayed due to traffic congestion.
g) Traffic lights and road lights went out at night, causing many accidents.
h) The road is dark and pedestrians cannot walk.
i) The filling pump might not work at the petrol station.

j) Cars rush to the petrol station, and the storage runs out.
k) Unable to carry refill to petrol station due to congestion.
l) For electric vehicle recharge stations, without electricity EVs cannot be charged.

Figure A.3 illustrates typical examples of exposure to risks during power outage in public transportation and logistics fields.

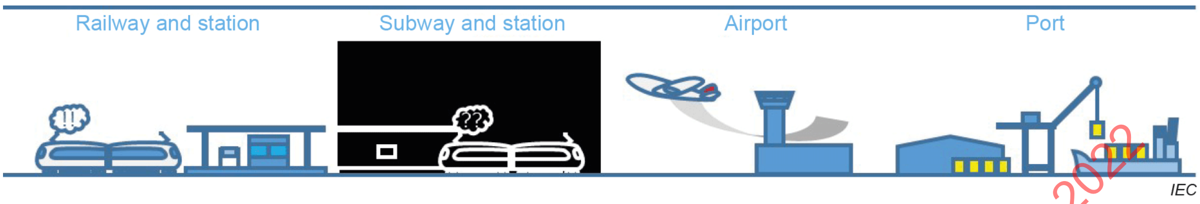

Figure A.3 – Public transportation, air traffic and logistics fields

Experienced so far or possible problems and damage are as follows.

a) Power and signal systems are down:
   1) a train cannot operate;
   2) a train gets stuck between stations and traps passengers;
   3) the air conditioner stops in the car.
b) A station or airport becomes unusable:
   1) lights, signs, ticket and check-in counters, gates, elevators, air conditioning, water, toilets, etc. are disabled;
   2) a large number of passengers will require a large amount of power during a temporary evacuation, and the emergency power supply will run out quickly;
   3) surveillance equipment will be shut down, making it impossible for managers to monitor the situation on site.
c) Cannot commute.
d) Subway trains stop in a dark tunnel.
e) Lights go out and passengers are left in dark trains or stations.
f) Access traffic stopped:
   1) passengers are stuck at stations and airports.
g) Airport control system stops.
h) The airport radar stops:
   1) aircraft are unable to take off or land.
i) The cargo management system stops.
j) The crane does not move:
   1) the port function stops.
k) The transport equipment does not work:
   1) the warehouse stops.

A.2.3 Medical and commerce fields

Figure A.4 illustrates typical examples of exposure to risks during power outage in medical and commerce fields.

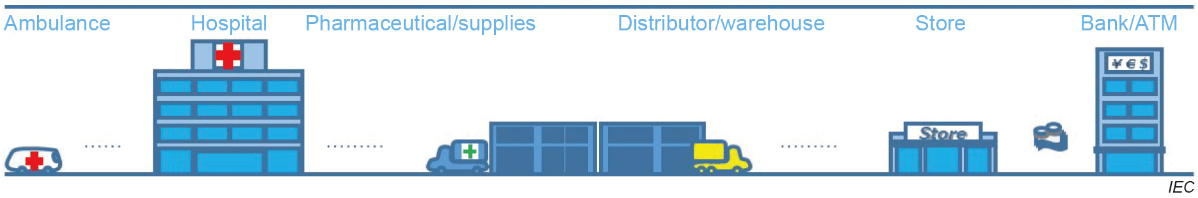

Figure A.4 – Medical and commerce fields

Experienced so far or possible problems and damage are as follows.

a) Concentration of patients in disaster-based hospitals, requiring more resources than usual.
b) Hospitals other than disaster-based hospitals have limited emergency power sources and are unable to accept external patients.
c) Run out of emergency fuel.
d) Medical equipment, lighting, water, pump, air conditioner, refrigerator, elevator, etc. stopped.
e) The supply of fuel for the emergency power supply, medical supplies and materials has stopped.
f) Severe patients (dialysis, ventilation, and heart disease) are at risk of death if there is a power failure.
g) When the power supply runs out, the hospital equipment cannot be used. Severe patients need to change hospitals.
h) Risk and heavy burden to change hospitals due to traffic jams and fuel shortages.
i) Communication problems make it difficult for hospitals to work together.
j) Logistics is disrupted by traffic jams and fuel shortages.
k) The product sorting system stopped:
    1) time delay and backlog caused by only human labour;
    2) stores and supermarkets are out of stock;
    3) food is lost without refrigeration;
    4) food supply chain is stopped.
l) Cashier stops, cannot pay:
    1) cash only.
m) Electronic payment is not available, cashless payment is not possible (credit cards and e-money cannot be used).
n) ATM stops:
    1) unable to dispense cash.
o) Security door of a bank is locked:
    1) bank staff cannot enter without a physical key.
p) Transport of cash stops:
    1) unable to meet cash demand.
q) Risk of bank network outage:
    1) financial functions stop.

Figure A.5 illustrates typical examples of exposure to risks during power outage in tourism and entertainment fields.

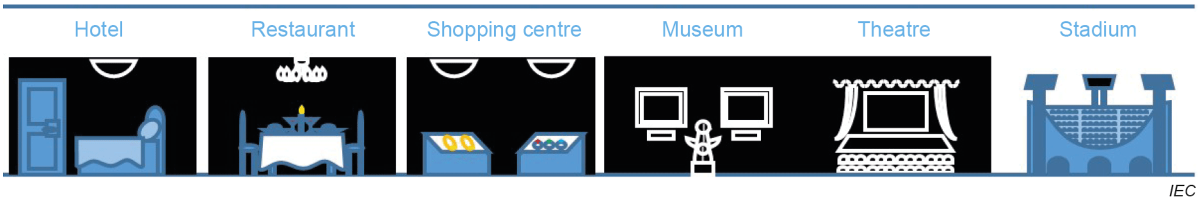

Figure A.5 – Tourism and entertainment fields

Experienced so far or possible problems and damage are as follows.

a) In hotels, in addition to A.2.1 a) to l):
   1) electronic room key disabled;
   2) phone extension will not work;
   3) wi-fi service for guests stops;
   4) credit card cannot be used when checking out;
   5) reservation or cancellation cannot be done.
b) In restaurants:
   1) cooking is not possible;
   2) refrigerator stops. Food and wine go bad;
   3) lighting goes out except for candles.
c) In shopping centre, in addition to A.2.1 a) to l):
   1) discomfort to the customers, unhappy, when air conditioner stops;
   2) wi-fi service for customers stopped;
   3) shop theft or facility damage can happen when security management has stopped.
d) Commercial loss due to customers leaving the mall:
   1) mid- to long-term brand damage.
e) Museums and theatres cannot be operated without lighting.
f) If the air conditioning stops, the storage condition of the collection can deteriorate.
g) The lights in the museum can go out and the exhibits can be damaged when the audience is evacuated.
h) The lights in large-scale theatres and stadiums go out, a packed audience is at risk of panic.
i) Water and sewer pumps shut down and many spectators cannot use toilets.
j) Signage and audio systems used to guide spectators and crowds will stop.
k) Cameras and sensors stop working, making it impossible for administrators to monitor the situation on site.

A.2.4 Public and infrastructures fields

Figure A.6 illustrates typical examples of exposure to risks during power outage in public service fields.

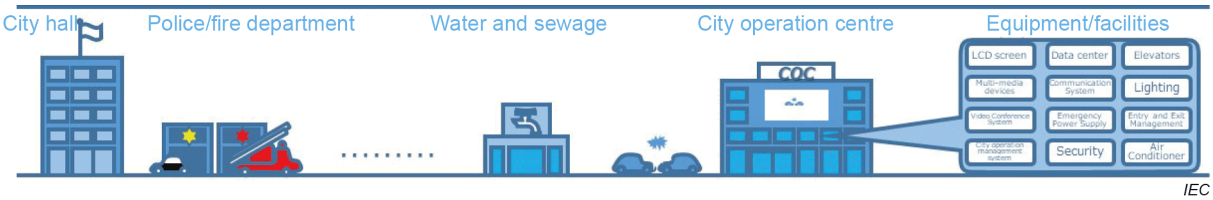

Figure A.6 – Public service fields