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Smart community infrastructure — Electric power infrastructure — Measurement methods for the quality of thermal power infrastructure and requirements for plant operations and management

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Foreword

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 268, *Sustainable cities and communities*, Subcommittee SC 1, *Smart community infrastructures*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document describes methods for measuring the quality of thermal power infrastructure (QTPI) during the operational phase as well as the requirements for operations and management activities for the purpose of maintaining and improving the QTPI in the medium and long term in order to realize the objectives of the 3E+S (energy security, environmental conservation, economic efficiency, safety) energy policy. The 3E+S energy policy is a framework established to ensure QTPI during its operational phase.

Considering the importance of a sufficient and stable electric power supply to the economy, standard of living and day-to-day needs, electric power shortages or frequent power outages are serious risks to society. Maintaining and improving the QTPI is an important concern for all regions, particularly for regions in the process of rapid economic growth. A sufficient and stable electric power supply can be achieved by establishing thermal power infrastructure as planned and operating this effectively throughout its life cycle.

Reducing the environmental impacts associated with thermal power infrastructure, such as greenhouse gas (GHG) emissions, is a global issue and reduction of the impacts is a goal of this document. Minimizing the impacts needs to take into account the social costs of the environmental impact, the costs required for environmental protection measures and the effectiveness of these measures.

From these viewpoints, it is expected that efforts to maintain and improve the QTPI by applying appropriate operations and management will make society more sustainable. This document is intended to contribute to the Sustainable Development Goals outlined by the United Nations, specifically goal 7 (affordable and clean energy), goal 11 (sustainable cities and communities), goal 13 (climate action), goal 14 (life below water) and goal 15 (life on land).

Smart community infrastructure — Electric power infrastructure — Measurement methods for the quality of thermal power infrastructure and requirements for plant operations and management

1 Scope

This document specifies methods for measuring the quality of thermal power infrastructure (QTPI) during the operational phase and requirements for operations and management activities.

It is intended for use by electric power providers, including public utilities and independent power producers (hereinafter collectively referred to as power plant operators), as well as relevant stakeholders that intend to maintain and improve QTPI.

NOTE   The selection and importance of evaluation indicators resulting from the implementation of this document can vary depending on the characteristics of the power plant operator.

2 Normative references

There are no normative references in this document.

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:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
thermal power infrastructure
unit (3.2) or *plant* (3.3) generating electric power utilizing oil, gas, coal or biomass as fuel

3.2
unit
assembly of equipment required for operating one generator

Note 1 to entry: This could include, for example, a generator, turbine, boiler and balance of plant.

Note 2 to entry: When unit means a definite magnitude of quantity used as a standard of measurement, the term "unit of measure" is used in this document.

3.3
plant
entire premises including *units* (3.2) and the common facilities, land and buildings relating to the units

3.4
gross maximum capacity
GMC
maximum output power that a *unit* (3.2) can generate in a specific period

3.5
net maximum capacity
NMC
output power calculated by subtracting the power of the auxiliary systems used by the *unit* (3.2) from the *GMC* (3.4)

Note 1 to entry: Depending on the objective of using NMC, either of the following two calculation methods can be applied.

a)   Plant NMC: the output power calculated by subtracting the *total internal consumption of the plant* (3.6) from *the plant* (3.3) GMC.

b)   Unit NMC: the output power calculated by subtracting the power consumption of the auxiliary systems for the particular unit from the unit GMC.

3.6
total internal consumption of the plant
summation of the power consumption of the auxiliary systems and general power consumption within the *plant* (3.3)

Note 1 to entry: General power consumption includes energy consumption of administration offices such as lighting and air conditioning.

3.7
equivalent unit derated hours
EUNDH
value calculated by dividing the product of the derated output power amount and the derated output power time by the *NMC* (3.5)

3.8
available hours
AH
time during which the *unit* (3.2) is available for service

3.9
period hours
PH
time the *unit* (3.2) was intended to operate excluding unintended shutdown time resulting from natural disasters

3.10
service hours
SH
time that the *unit* (3.2) is electrically connected to an electric power grid and generating electric power

3.11
equivalent availability factor excluding seasonal deratings
EAF, XS
portion of a given operating period in which a generating *unit* (3.2) is available without any outage

3.12
heat rate
HR
value calculated by dividing the fuel input to the *unit* (3.2) by the generated power

3.13
forced outage hours
FOH
time that a *unit* (3.2) did not operate due to forced outages

3.14
forced outage rate
FOR
rate that a *unit* (3.2) was not available due to forced outages

3.15
ability to adjust power supply to demand
ability of a *unit* (3.2) to adjust its output power according to changes in demand

3.16
restricted time of the ability to adjust power supply to demand
time that the ability to adjust output power according to changes in demand is restricted

Note 1 to entry: The total time of the following are included.

a) The time that the use of auto frequency control (AFC) or load frequency control (LFC) was restricted due to unplanned causes.

b) The time that the output power of the *unit* (3.2) was constant due to unplanned causes.

Note 2 to entry: AFC is defined as the adjustment of output power using AFC devices to maintain the frequency of the electric system within a standard value.

Note 3 to entry: LFC is defined as detecting frequency variations and interconnected power variations caused by load variations and controlling the output power to maintain the frequency and power flow within standard values during normal operation.

3.17
emission rate
emissions of a given pollutant per *unit* (3.2) of output power over a given time period

EXAMPLE   The value calculated by dividing the annual emissions by the annual power generation.

Note 1 to entry: Emission rate (of stacks) generally refers to SO_X, NO_X, CO_2 and particulate matter (PM) that are emitted from a unit.

3.18
industrial safety accident rate
number of people who became unable to work, the number of people whose work was restricted and the number of fatalities due to an accident per 200 000 or 1 000 000 man-hours worked

4   Evaluation indicators for the QTPI during the operational phase

4.1   QTPI

QTPI is an indication of the degree to which thermal power infrastructure consistently meets or exceeds requirements or expectations regarding:

— initial operation capability;

— supply stability;

— reliability;

— environmental and social considerations;

— safety;

— life cycle cost (LCC).

NOTE 1   The 3E+S is used to represent QTPI: energy security, environmental conservation, economic efficiency and safety.

NOTE 2   The three sub-elements of energy security which are specific to thermal power infrastructure are:

— initial operation capability;

— supply stability;

— reliability.

NOTE 3   Environmental and social considerations are both used to indicate general aspects of the quality of infrastructure.
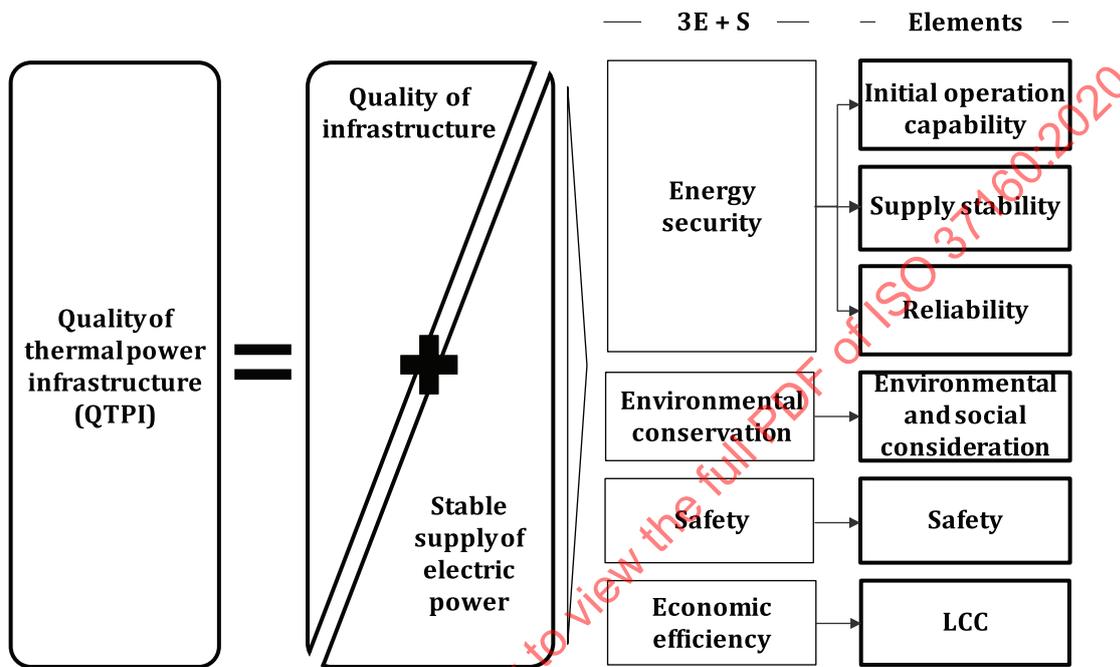
Figure 1 — Elements of the QTPI

4.2   Elements of the QTPI

4.2.1   General

Power plant operators shall consider the elements listed from 4.2.2 to 4.2.7 in order to maintain and continuously improve the QTPI during the operational phase. See Figure 1.

4.2.2   Initial operation capability

Initial operation capability means the ability to begin operation of thermal power infrastructure as planned and scheduled in accordance with relevant specifications and unit-specific conditions.

4.2.3   Supply stability

Supply stability means the ability of thermal power infrastructure to consistently supply electric power when required.

4.2.4   Reliability (reliable operation and fast recovery)

Reliable operation means to minimize internal forced outages of thermal power infrastructure as much as is practical and to safely deactivate the infrastructure without damaging the equipment.

Fast recovery means to recover from a forced outage as soon as is practical.

NOTE   Internal forced outage refers to a shutdown or output power suppression that is within the control of the power plant. They can be caused by external and internal incidents, excluding shutting down or limiting output power due to events such as planned maintenance.

4.2.5   Environmental and social considerations

Environmental and social considerations means the consideration given to the prevention or control of environmental impacts attributable to the thermal power infrastructure and to the need to coexist with the local community.

NOTE 1   The factors that need to be considered from the viewpoint of reducing adverse environmental impacts can include, but are not limited to, the control of air pollutants, waste water, effluents, noise, other waste and GHG emissions.

NOTE 2   The factors that need to be considered from the viewpoint of addressing social aspects can include, but are not limited to, community engagement, operational transparency and public disclosure. For details of social considerations refer to ISO 26000.

4.2.6   Safety

Safety means the ability to prevent injury to humans.

4.2.7   LCC

LCC in the context of thermal power infrastructure means the summation of the costs incurred throughout the life cycle of the thermal power infrastructure, provided that it satisfies all requirements of the QTPI elements specified above.

Note that LCC can generally be classified into engineering, procurement and construction (EPC) costs, operating and maintenance costs and demolition costs, including disposal costs. In the case of a thermal power infrastructure, fuel costs typically account for a large portion of operating costs. The LCC also includes other costs such as costs caused by forced outages or the costs associated with compensation or penalties incurred as a result of failing to meet requirements for emissions or pollutants.

4.2.8   Performance indicators and evaluation of the QTPI

Power plant operators shall collect the data required for evaluation by evaluators as specified in Table 1 to Table 10. Evaluators may include stakeholders such as insurance underwriters, governments, power providers, NGOs and environmental organizations. Evaluators may utilize the indicators shown in 4.3 for appropriate measurement of the QTPI during the operational phase of the thermal power infrastructure. The evaluation methods and formulas shall be reviewed, as appropriate, so that evaluations can accommodate relevant changes in requirements or circumstances.

4.3   Evaluation indicators

4.3.1   Supply stability

4.3.1.1   Availability

Table 1 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess, at planned intervals, operation and maintenance capability of the thermal power infrastructure and the quality of unit.

Table 1 — Evaluation indicator of supply stability: Availability

Evaluation method	Compute the equivalent availability factor excluding seasonal deratings (EAF, XS) of the unit concerned.
Formula	$F_{EAF,XS} = (t_{AH} - t_{EUNDH})/t_{PH} \times 100$ where $F_{EAF,XS}$ is the EAF, XS; t_{AH} is the AH; t_{EUNDH} is the EUNDH; t_{PH} is the PH.
Evaluation period	Determined by evaluator (e.g. 5 years)
Unit of measure	%
Scope of evaluation	Unit

4.3.1.2 Changes to heat rate (HR)

Table 2 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess the change in HR of the unit or plant.

Table 2 — Evaluation indicator of supply stability: Change in HR

Evaluation method	Compute the difference between the measured HR and the HR at the time of initial performance test. Since a performance test is generally performed during periodic maintenance, the values measured during the most recent performance tests shall be adopted.
Formula	$D_{HR} = H_{R,PEV} - H_{R,1PEV}$ where D_{HR} is the change in HR; $H_{R,PEV}$ is the HR at the time of the performance test (performance evaluation) in the evaluation period; $H_{R,1PEV}$ is the HR at the time of initial performance test.
Evaluation interval	Determined by evaluator
Unit of measure	kJ/kWh
Scope of evaluation	Unit

4.3.1.3 Ability to adjust power supply to demand

Table 3 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess the ability of the unit to adjust output power in response to changes in demand.

Table 3 — Evaluation indicator of supply stability: Ability to adjust power supply to demand

Evaluation method	Compute the percentage of the time that the ability to adjust the power supply to demand is functioning to service hours (SH)[6] of the unit.
Formula	$R_{DSA} = \left(1 - t_{DSA,NA} / t_{SH}\right) \times 100$ where $\quad R_{DSA}$ is the ratio of demand and supply adjustment (%); $\quad t_{DSA,NA}$ is the restricted time of the ability to adjust power supply to demand; $\quad t_{SH}$ is the SH.
Evaluation period	Determined by evaluator (e.g. 5 years)
Unit of measure	%
Scope of evaluation	Unit

4.3.2 Reliability (reliable operation and fast recovery): Forced outage rate (FOR)

Table 4 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess the reliability of the power plant and the ability to recover quickly from any event.

Table 4 — Evaluation indicator of reliable operation and fast recovery: FOR

Evaluation method	Compute the FOR of the unit concerned.
Formula	$R_{FOR} = t_{FOH} / \left(t_{SH} + t_{FOH}\right) \times 100$ where $\quad R_{FOR}$ is the FOR; $\quad t_{FOH}$ is the FOH; $\quad t_{SH}$ is the SH.
Evaluation period	Determined by evaluator (e.g. 5 years)
Unit of measure	%
Scope of evaluation	Unit

4.3.3 Environmental and social considerations

4.3.3.1 SO$_X$, NO$_X$ and PM emission rates

Table 5 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess emission rates of atmospheric pollutants.

Table 5 — Evaluation indicator of environmental and social considerations: SO_X, NO_X and PM emission rates

Evaluation method	Compute the emission rates of various atmospheric pollutants emitted by the stack of the unit concerned. GMC is recommended for evaluation purposes; however, NMC is acceptable if GMC is not available.
	SO_X will be computed based on the sulphur concentration of the fuel or measured by SO_X emissions monitoring.
	NOx will be computed based on the results of regular exhaust gas measurements. If the measurements are conducted multiple times a year, the average will be utilized.
	PM will be computed based on the results of regular exhaust gas measurements. If measurements are conducted multiple times a year, the average will be utilized. Load frequency is not considered as the impact can be considered minimal.
	NOTE For comparison with other facilities, the value of the ratio differs depending on auxiliary power.
Formula	$U_{SOx} = M_{SOx,AEM} / P_{g,A}$ $U_{NOx} = M_{NOx,AEM} / P_{g,A}$ $U_{PM} = M_{PM,AEM} / P_{g,A}$ where U_{SOx}, U_{NOx}, U_{PM} are the unit requirement for SO_X, NO_X and PM emission rates; $M_{SOx,AEM}, M_{NOx,AEM}, M_{PM,AEM}$ are the annual SO_X, NO_X and PM emissions (g); $P_{g,A}$ is the annual power generation (kWh).
Evaluation period	Determined by evaluator (e.g. 5 years)
Unit of measure	g/kWh
Scope of evaluation	Unit

4.3.3.2 CO_2 emission rates

Table 6 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess CO_2 emission rates.

Table 6 — Evaluation indicator of environmental and social considerations: CO_2 emission rates of stacks

Evaluation method	Compute the CO_2 emission rate for the unit concerned.
	GMC is recommended for evaluation purposes; however, NMC is acceptable if GMC is not available.
Formula	$U_{CO2} = M_{CO2,AEM} / P_{g,A}$ where U_{CO2} is the unit requirement for CO_2 emission rate; $M_{CO2,AEM}$ is the annual CO_2 emissions (kg); $P_{g,A}$ is the annual power generation (kWh).
Evaluation period	Determined by evaluator (e.g. 5 years)
Unit of measure	kg/kWh

Table 6 *(continued)*

Scope of evaluation	Unit

4.3.3.3 Water quality

Table 7 shows the evaluation method, data requirements, evaluation period, unit of measure and scope required to assess the impacts of thermal power infrastructure on water quality.

Table 7 — Evaluation indicator of environmental and social considerations: Water quality

Evaluation method	The evaluation will be based on the measurement of various aspects of water quality discharged from the plant. If water quality is measured multiple times a year, the average of the measured values shall be adopted.
Data requirements	Examples of the items to be measured are pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), N-hexane, total nitrogen, total phosphorus, suspended solids (SS), *Escherichia coli*, and the temperature difference between water intake and water discharge.
Evaluation period	Determined by evaluator (e.g. 5 years)
Unit of measure	pH: (-) BOD, COD, N-hexane, total nitrogen, total phosphorus, SS: (mg/l) *Escherichia coli*: (number of cells /cm^3) Temperature difference between water intake and water discharge: (K)
Scope of evaluation	Plant

4.3.3.4 Waste recycling rate

Table 8 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess the quality of environmental considerations for waste.

Table 8 — Evaluation indicator of environmental and social considerations: Waste recycling rate

Evaluation method	Compute the waste recycling rate for the waste per unit that the power plant operator is responsible for disposing of (e.g. fly ash, desulphurized gypsum, sludge from waste water). Recycling includes material recycling, thermal recycling and sale of recycled items.
Formula	$R_r = \sum W_{w,r} / \sum W_w \times 100$ where R_r is the waste recycling rate; $W_{w,r}$ is the recycled amount of waste generated by the plant (kg); W_w is the amount of waste generated by the plant (kg).
Evaluation period	Determined by evaluator (e.g. 5 years)
Unit of measure	%
Scope of evaluation	Plant

4.3.4 Safety: number of injuries caused by industrial safety accidents

Table 9 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess the adequacy of measures to prevent industrial safety accidents to workers in relation to natural disasters, equipment problems and operations or maintenance in the thermal power infrastructure.

Table 9 — Evaluation indicator of safety: Number of injuries caused by industrial safety accidents

Evaluation method	Compute the number of injuries caused by industrial safety accidents by calculating the number of employees who were unable to work, were subjected to some restriction on work for one or more days following an industrial safety accident or were fatally injured among all employees at the plant.
Formula	$$R_{\text{ISA}} = \left[\frac{N_{\text{olt}} + N_{\text{orta}} + N_{\text{of}}}{t_{\text{nsmhw}}} \right] \times t_{\text{omh}}$$ where R_{ISA} is the industrial safety accident rate; N_{olt} is the number of workers who were unable to work for one or more days following the day of an industrial accident (number of lost time); N_{orta} is the number of workers who were subjected to restriction on work for one or more days following the day of an industrial accident (restricted time accidents); N_{of} is the number of deaths from industrial accidents (fatalities); t_{nsmhw} is the total man-hours worked within the power plant (number of plant man-hours worked); t_{omh} is the 200 000 man-hours worked or 1 000 000 man-hours worked.
Evaluation period	Determined by evaluator (e.g. 5 years)
Unit of measure	Number of people
Scope of evaluation	Plant

4.3.5 LCC (LCC considering the five other elements of QTPI)

Table 10 shows the evaluation method, formula, evaluation period, unit of measure and scope required to assess the balance of the total benefit (total power generation) and total costs (sum of total power generation costs and social costs) of the power plant during the operational phase.

Table 10 — Evaluation indicator of LCC: LCC

Evaluation method	Evaluate the adequacy and economic efficiency of the unit or plant by considering the total costs and total power generation.
Formula	$C_{\text{lcc}} = \Sigma\left(C_{\text{tpg}} + C_{\text{s}}\right)/\Sigma\left(P_{\text{tpg}}\right)$ where C_{lcc} is the LCC of the thermal power infrastructure; C_{tpg} is the total power generation costs, EPC costs, fuel costs, operation and maintenance costs, and demolition costs including disposal costs; C_{s} is the total social costs based on those costs that can be quantitatively evaluated (e.g. CO_2 emissions); P_{tpg} is the total power generated. The net actual power generated will be used for operations carried out in the past. In the case of evaluating future operations only past EPC costs, fuel costs, operation and maintenance costs and social costs shall be excluded.
Evaluation period	From the time of evaluation until the completion of demolition
Unit of measure	US\$ or local currency/kWh
Scope of evaluation	Unit or plant

EXAMPLE   The LCC can be calculated by the service-year levelized cost of electricity adopted by the Organization for Economic Cooperation and Development (OECD).

Annex A shows an example of an LCC formula.

5 Operation of thermal power infrastructure

5.1 General

The application of a "self-elevating mechanism for sustainable operations and management"[2] by the power plant operator is a determinant factor for maintaining and further improving QTPI during the operational phase of thermal power infrastructure (see Figure 2).

In order to maintain and further improve QTPI by taking into account internal and external factors, the power plant operator shall establish, implement and maintain processes for measurement, data control, analysis, response to risks, operational control and integrated management as shown in 5.2 to 5.7.
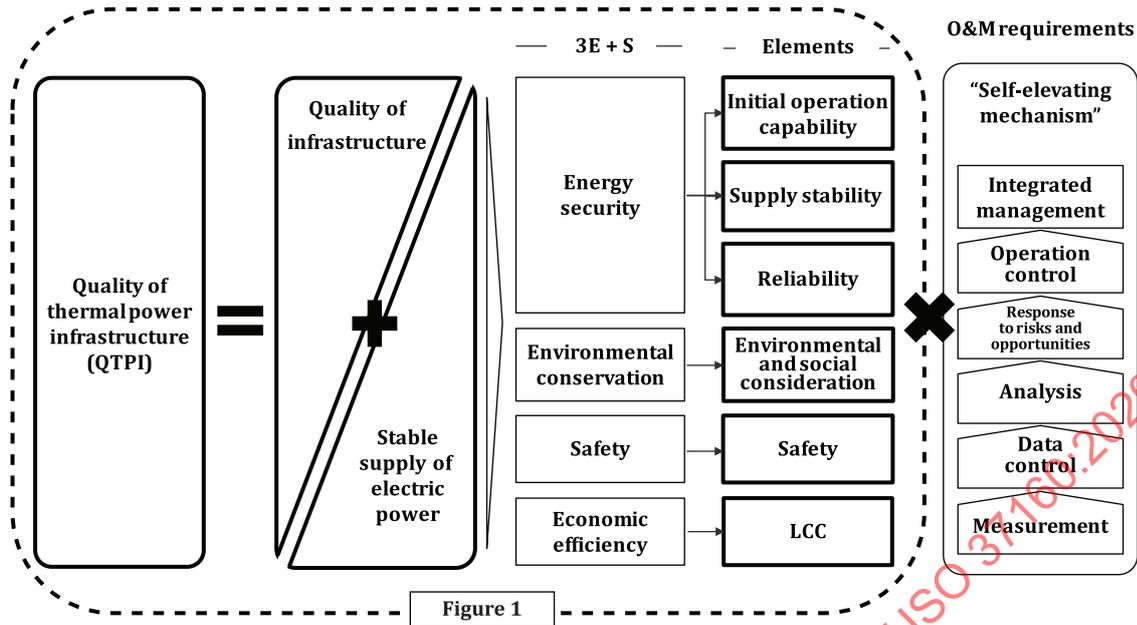
Figure 2 — Self-elevating mechanism for sustainable operations and management

5.2 Measurement

The power plant operator shall:

a) determine what needs to be monitored and measured;

b) determine the appropriate frequency of measurement;

c) determine the methods for monitoring and measurement;

d) adopt appropriate devices or systems for monitoring and measurement;

e) assign responsibility for monitoring and measurement to appropriate personnel.

When determining what needs to be monitored and measured, consideration shall be given to operational and maintenance requirements and the need to provide information to stakeholders.

The measurement accuracies required shall be considered when determining measurement methods.

A device or system utilized for monitoring or measurement shall have adequate capability.

5.3 Data control

The power plant operator shall, as applicable:

a) implement automated recording and accumulation of operational data in a general purpose format;

   NOTE 1   The data that need to be automatically recorded in a general purpose format are typically process data resulting from real-time measurements of the equipment. Other operating and maintenance data can be in the form most appropriate for the power plant operator.

b) accumulate and store data for a period consistent with applicable retention requirements and stakeholder needs;

c) make accumulated data suitably accessible to ensure timely analysis;

d) adequately protect data from loss, improper access or improper use. This includes adequate cybersecurity control measures where applicable;

e) provide appropriate data to stakeholders (e.g. to support demand and supply management or disaster management).

NOTE 2   ISO 37156 addresses the principle of data sharing and exchange.

5.4 Analysis

The power plant operator shall, as applicable:

a) comprehensively analyse the measured results of the evaluation indicators in 4.2 and identify problems by benchmarking the results against other plants. When benchmarking, consideration shall be given to the following:

1) ensuring security of the data;

2) ensuring the data are of adequate quality;

3) managing the data responsibly.

b) appoint personnel with the required skills for data analysis and assign the work appropriately;

c) determine the appropriate format of the data for analysis.

5.5 Response to risks and opportunities

In order to maintain and further improve QTPI, it is necessary to continuously identify risks, minimize the adverse effects, resolve consequential issues and promote opportunities to improve QTPI. Risks include both internal risks and external risks. The power plant operator shall implement, maintain and improve processes to mitigate risks, including:

a) determining internal and external risks to the thermal power infrastructure based on the results of analysis in a timely manner, establishing a plan for dealing with them in advance and periodically carrying out drills, simulations or other exercises to prepare for an incident;

1) internal risks can include:

i) equipment failures, electric and machinery breakdown (forced outages, output power limitation);

ii) deviation from controlled values;

iii) human error;

iv) fire and explosions in the plant;

v) accidents causing injury and ill-health.

2) external risks can include:

i) power grid failure;

ii) terrorism, war, strikes, riots and civil commotions;

iii) cyberattack, including cyber physical attack, and physical attack on the plant;

iv) fuel procurement and water availability;

v) natural disasters (e.g. earthquake, typhoon, tsunami, flood, forest fire).

b) investigating the cause of incidents, taking actions to prevent reoccurrence considering the degree of importance and establishing a scheme for evaluating the adequacy of preventive actions;

c) developing a preventive and predictive maintenance program in order to minimize forced outages;

d) determining the necessary spare parts to allow for fast recovery in the event of a forced outage;

e) optimizing system controls to minimize emissions and improve performance;

f) implementing where practical the latest technologies and practices for improved operational flexibility;

g) optimizing intervals and duration of the unit inspection in order to reduce LCC.

NOTE 1 For more information on cyberattacks, see the IEC 62443 series.

NOTE 2 For more information on natural disasters, see IEC 63152.

NOTE 3 The risk of terrorism can be minimized both by planning by the power plant operator and by appropriate governmental agencies.

5.6 Operation control

The power plant operator shall implement, maintain and continually improve a management system for the measurement, data control, analysis and risk response processes identified in the self-elevating mechanism for sustainable operations and management to ensure:

a) an effective operating and maintenance program is implemented and maintained, including the development of a knowledge database to improve the reproducibility of the process from measurement to response to risks;

b) an effective training and development program is regularly implemented and maintained for power plant operators to ensure they acquire the necessary operational and maintenance skills and that systematic evaluation of the training and development program is performed.

5.7 Integrated management

The power plant operator shall establish processes to maintain and further improve QTPI by:

a) ensuring management commitment to the improvement of QTPI;

b) conducting periodic reviews of, and developing improvement plans with respect to, the:

1) results of previous reviews and the effectiveness of any actions taken;

2) results of the evaluation indicators described in 4.3;

3) adequacy of operation controls for maintaining effective operation;

4) status of related communication with stakeholders;

5) business environment (e.g. effectiveness of fuel procurement risk management);

6) adaptation of the latest technology and devices (e.g. the Internet of things);

7) ability to respond to changes in the social environment;

8) ability to respond to the needs of stakeholders (e.g. supply-and-demand adjustment due to increase in renewable energy).

c) maintaining awareness of social responsibilities and establishing policies and plans to address social responsibilities considering the following:

1) protection of human rights;

2) rights of workers including occupational health and wellbeing;