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Smart community infrastructures — Principles and requirements for performance metrics

Infrastructures communautaires intelligentes — Principes et exigences pour la métrique des performances

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee 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

Communities have various goals to achieve, such as increasing the quality of life, economic growth, poverty reduction, antipollution measures and congestion mitigation.

Community infrastructures such as energy, water, transportation, waste, information and communications technology (ICT) and education infrastructure are fundamental to support the operations and activities of communities. Investment in community infrastructure is an important enabler for communities in achieving the internationally recognized community goals, e.g. the United Nations Sustainable Development Goals (SDGs)[14] and promoting pro-poor growth[15]. The demand for community infrastructure will continue to expand significantly in the decades ahead, driven by major factors of change, such as population growth, and urbanization. According to the Organization for Economic Co-operation and Development (OECD)[16], total cumulative infrastructure requirements amount to about USD 53 trillion from 2010 to 2030.

It has long been argued that human activity is surpassing the capacity of the Earth. The imperative for further growth of infrastructure (e.g. improving living standards and addressing resource efficiency) sometimes conflicts with a path to sustainability. As a result, there is a need for community infrastructure to contribute to sustainability and resilience of communities more effectively and efficiently by balancing multiple perspectives and integrating decision making. Such solutions are often referred to as "smart." A number of plans and projects to build "smart cities" are currently underway. In addition, international trade for community infrastructure products and services has increased including solution-providing services.

Standards are an important source of technological information. They help governments and businesses of all shapes and sizes to work more efficiently, increase productivity, increase credibility and confidence, and access new markets. For example, as they define the performances that products and services have to meet in the global markets, standards help developing countries or small and medium-sized enterprises (SMEs) take part fairly in international trade.

The purpose of standardization in the field of smart community infrastructure is to promote the international trade of community infrastructure products and services and disseminate information about cutting-edge technologies to improve sustainability in communities by establishing harmonized product standards. The users and associated benefits of these metrics are illustrated in Figure 2.

This document gives principles and specifies requirements for community infrastructure performance metrics and gives recommendations for analysis of community infrastructure.

This document is intended to be useful to the following individuals and groups:

— national and local governments;

— regional organizations;

— community planners;

— developers;

— community infrastructure operators (e.g. in the field of energy, water, transportation, waste, ICT);

— community infrastructure vendors (e.g. constructors, engineering firms, system integrators or component manufacturers);

— non-governmental organizations (e.g. consumer groups);

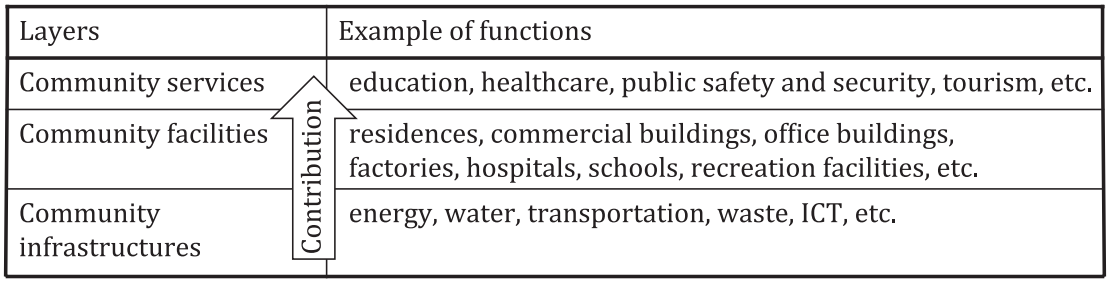
— citizens.

Using a model of the community functions in Figure 1, this document focuses on assessing the performance of the infrastructure layer and respects the societal or cultural diversity of communities as traits of each community.

As illustrated in Figure 1:

— Functions of community infrastructures are fundamental to support the other two layers.

— Products and services of community infrastructures are more technology-oriented and more internationally-tradable than those in other layers and therefore appropriate for international standardization.



SOURCE ISO/TR 37150:2014

Figure 1 — Layers of a community

NOTE 1 Because of the diversity of communities, it is not realistic to apply "one-size-fits-all" solutions.

NOTE 2 This document considers not only built or constructed community infrastructures but also the utilization of natural systems (i.e. green infrastructure which uses natural hydrologic features to manage water and provide environmental and community benefits).

NOTE 3 This document recognizes two types of ICT:

a) community infrastructure ICT, e.g. telecommunication, common databases.

b) ICTs which are integrated within a facility or equipment as a means for control.

This document is focused on a), although b) is often a useful means to achieve smart communities or smart community infrastructures.

NOTE 4 This document recognizes that solutions for similar problems in communities in different economic situations (e.g. developed and developing countries) can call for different importance of metrics or performance indicators of community infrastructures. This document is not a recommendation document for best practices. This document does not make recommendations, e.g. replicating existing specific smart infrastructures or levelling them up to the standards of such model projects at a large scale. It is left to the user whether to set targets or not when applying this document.

NOTE 5 Although this document does not address principles or requirements specific to a particular type of community infrastructure, compatibility of this document with existing International Standards for a particular type of community infrastructure (e.g. ISO 24510, ISO 24511 and ISO 24512) was considered.

Smart community infrastructures — Principles and requirements for performance metrics

1 Scope

This document specifies principles and requirements for the definition, identification, optimization and harmonization of community infrastructure performance metrics. It provides recommendations for the analysis of community infrastructure, including availability, interoperability, synergy, resilience, safety, security and sustainability.

Community infrastructure includes, but is not limited to, energy, water, transportation, waste and ICT.

The principles and requirements of this document are applicable to communities of any size sharing geographic areas that are planning, commissioning, managing, and assessing all or any element of its community infrastructure. However, the selection and the importance of metrics or (key) performance indicators of community infrastructures are a result of the application of this document and depends on the characteristics of each community.

In this document, the concept of smartness is addressed in terms of performance relevant to technologically implementable solutions, in accordance with the sustainable development and resilience of communities.

NOTE This document does not address measurement, reporting or verification. For possible deliverables related to this document, see ISO/TR 37150:2014, Clause 6. This document does not compare different communities, but allows communities to assess community infrastructure more effectively.

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 terminology databases for use in standardization at the following addresses:

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

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

3.1
community
group of people with an arrangement of responsibilities, activities and relationships

Note 1 to entry: In the context of this document, a community has defined geographical boundaries.

Note 2 to entry: A city is a type of community

[SOURCE: ISO 37100:2016, 3.2.2, modified — "In many, but not all, contexts" in Note 1 to entry is changed to "In the context of this document".]

3.2
community infrastructure
system of facilities, equipment and services that support the operations and activities of communities

Note 1 to entry: Such community infrastructure includes, but is not limited to, energy, water, transportation, waste and information and communication technologies (ICT).

[SOURCE: ISO 37100:2016, 3.6.1]

3.3
smart community infrastructure
community infrastructure with enhanced technological performance that is designed, operated and maintained to contribute to sustainable development and resilience of the community

3.4
sustainability
state of the global system, including environmental, social and economic aspects, in which the needs of the present are met without compromising the ability of future generations to meet their own needs

Note 1 to entry: The environmental, social and economic aspects interact, are interdependent and are often referred to as the three dimensions of sustainability.

Note 2 to entry: Sustainability is the goal of *sustainable development* (3.5).

[SOURCE: ISO Guide 82:2019, 3.1]

3.5
sustainable development
development that meets the environmental, social, and economic needs of the present without compromising the ability of future generations to meet their own category of needs

[SOURCE: ISO Guide 82:2019, 3.2, modified — Note 1 to entry deleted.]

3.6
environment
surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelationships

[SOURCE: ISO 14050:2020, 3.2.2]

3.7
environmental impact
change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects

[SOURCE: ISO 14001:2015, 3.2.4]

3.8
interoperability
ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together

[SOURCE: ISO 21007-1:2005, 2.30]

3.9
life cycle
consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal

[SOURCE: ISO 14044:2006, 3.1]

3.10
life-cycle cost
total investment in product development, manufacturing, test, distribution, operation, support, training, and disposal

[SOURCE: ISO/IEC/IEEE 24765:2017, 3.2218]

3.11
metric
the defined measurement method and the measurement scale

[SOURCE: ISO/TR 37150:2014]

3.12
provider
person or organization involved in or associated with the delivery of products or services, or both

3.13
safety
freedom from unacceptable risk

3.14
indicator
quantitative, qualitative or descriptive measure

[SOURCE: ISO 15392:2019, 3.18]

4 Overview

4.1 General

This subclause provides an overview of Clause 4 to Clause 6 and the annexes of this document, while 4.2 describes possible uses of this document.

Clause 5 specifies the principles which provide the conceptual backbone to the definition, identification, optimization, and harmonization of community infrastructure performance metrics and provides understanding of the requirements and guidance in Clause 6.

Clause 6 provides the requirements and guidance for defining, identifying, optimizing and harmonizing smart community infrastructure performance metrics. 6.1 introduces a step-wise approach to identify community infrastructure performance metrics as a requirement. 6.2, 6.3, 6.4, and 6.5 provide requirements and guidance for conducting each step of the approach required in 6.1.

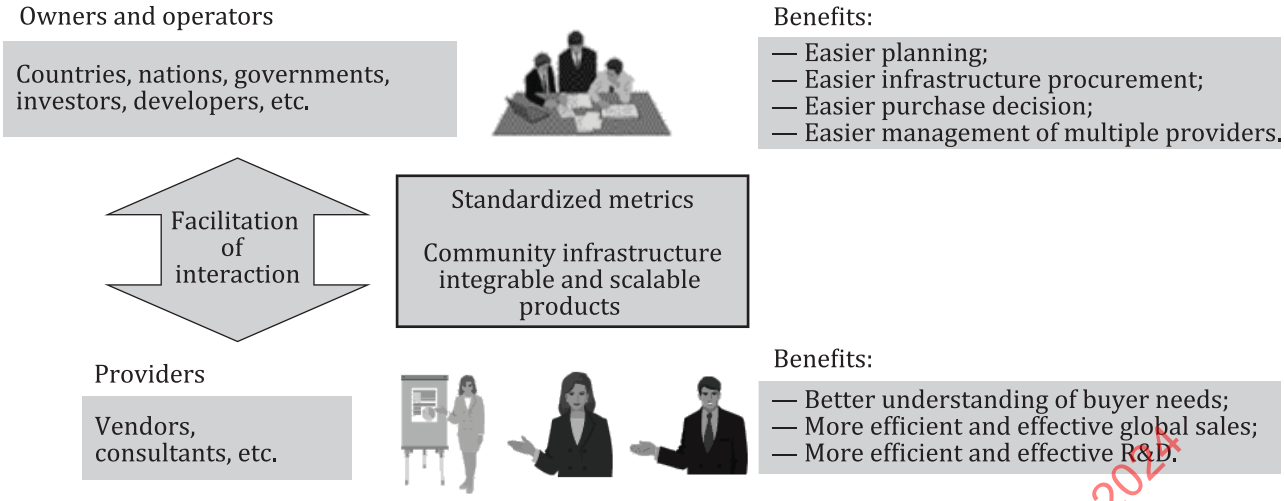
Annex A provides examples of the applicability of the step-wise approach to existing key performance indicators for specific types of community infrastructure.

Annex B provides an example of relating community issues onto community infrastructure performance.

4.2 Possible uses

4.2.1 General

This subclause describes non-exhaustive possible uses of this document. The users and associated benefits of these metrics are illustrated in Figure 2.



SOURCE ISO/TR 37150:2014, modified.

Figure 2 — Users of the metrics and associated benefits

4.2.2 Support tool for community managers

This document is intended to be used as a support tool for community managers, for example:

— to align the relationship between community issues and infrastructure performances;

— to prioritize investments in new community infrastructure and areas for improvement in existing community infrastructures among the different types of community infrastructures (e.g. to point out where to reach the highest effectiveness for investments in the community infrastructure by taking multiple perspectives into account);

— to identify metrics applied for the purpose of measurements of dynamic data that allow management and feedback to improve the community in terms of utilization and sustainability.

4.2.3 Facilitation tool

This document is intended to be used as a facilitation tool for both owners and operators, and providers of community infrastructure products and services, for example:

— to serve as a framework for discussion on the performances of community infrastructures to be introduced;

— to provide a common language among multiple stakeholders, including owners and operators, and providers of community infrastructure products and services, by helping identify performance characteristics of community infrastructures to contribute to community priorities when they discuss community issues and the introduction or improvement of community infrastructures;

— to help owners and operators compare multiple proposals of the introduction or improvement of community infrastructure products and services from multiple providers in terms of performances;

NOTE This document does not require its users to set targets.

5 Principles

5.1 General

This clause specifies the principles which provide the conceptual foundation to the definition, identification, optimization, and harmonization of community infrastructure performance metrics. 5.2 introduces the

ideal properties to be considered in the process of defining or identifying a set of community infrastructure performance metrics. 5.3 requires relating performance characteristics to community issues and priorities. 5.4 addresses the stakeholders of communities to be considered in the definition, identification, optimization and harmonization of community infrastructure performance metrics.

5.2 Ideal properties to be achieved

In the definition, identification, optimization or harmonization of community infrastructure performance metrics, the following ideal properties of smart community infrastructure performance metrics should:

— be harmonized;

— include items useful for as many stakeholders as possible involved in trades of community infrastructure products and services (e.g. local governments, developers, suppliers, investors and users);

— facilitate evaluation of the technical performance of community infrastructures, contributing to sustainability and resilience of communities;

— be applicable to different stages of the development of communities and community infrastructures;

— reflect the dynamic properties of the community infrastructures;

— be selected with consideration for the synergies and trade-offs of multiple issues or aspects that a community faces, such as environmental impacts and quality of community services. Addressing only a single issue or aspect can be considered non-smart;

— focus on advanced features of community infrastructures such as interoperability, expandability and efficiency rather than the status-quo;

— be applicable to a diverse range of communities (e.g. geographical location, sizes, economic structures, levels of economic development, stages of infrastructure development) and a diversity of individuals within communities by considering a full range of the population (e.g. age, gender, income, disability, ethnicity);

— allow consideration of multiple community infrastructures (e.g. energy, water, transportation, waste, ICT) that support the operations and activities of communities;

— allow technologically implementable solutions;

— allow a holistic perspective of multiple community infrastructures (more specifically, to consider an integrated system which includes the interaction and coordination of multiple community infrastructures);

— allow evaluation of the technical performance (e.g. efficiency, effectiveness) of community infrastructures rather than characteristics of specific technologies;

— be based on transparent and scientific logic.

5.3 Relating community issues onto community infrastructure performances

In the definition, identification, optimization or harmonization of community infrastructure performance metrics, performances characteristics to be measured should be related to community issues. This is to ensure that the identified community infrastructure performance metrics represent the community infrastructure performances that contribute to improve or cope with the community issues which are of interest to the users of this document.

NOTE 1 Community issues are challenges that a community faces. The issues and their priorities are usually different for different communities.

NOTE 2 Some indicators, e.g. indicators specified by ISO 37120 or SDGs, are useful to understand and align community issues.

One possible method to relate community issues with community infrastructure performances is to prepare a table showing the relationship between community infrastructure performance characteristics and community issues as shown in Table 1. For more details see Annex B.

Table 1 — Schematic representation of the relationship between community infrastructure performance characteristics and community issues

Community infrastructure performance characteristics	Community issues				
	Issue 1	Issue 2	Issue 3	Issue 4	Issue 5
Performance characteristics A	***	**	*		
Performance characteristics B	**	**	*		
Performance characteristics C	*	***	*		
Performance characteristics D	*	***	*		
NOTE The number of "*" indicates the degree of relations between the performance listed in the row and the issue listed in the column.					

5.4 Possible stakeholders to be considered

In general, a community has multiple stakeholders with multiple interests and it is not easy to meet all of them through conventional approaches. For example, it is easy to increase the convenience of public transportation by increasing the number of services. However, it is difficult to do so while reducing cost and environmental impacts at the same time. Therefore, community infrastructure performance metrics shall be identified in a well-balanced way which covers multiple perspectives of different stakeholders of communities. In the identification of community infrastructure performance metrics, the interests of the following stakeholders should be considered:

NOTE Key stakeholders of community infrastructures can be different for different users of this document according to their interests and purposes.

— People or citizens: People or citizens of the community are one of the major users of community infrastructure. Therefore, the diversity of perspectives of people or citizens is essential to identify community infrastructure performance metrics.

— Industry or enterprises: Industries or enterprises which have, or plan to have, activities in the community are another major type of user of community infrastructure. Therefore, their perspectives are essential to identify community infrastructure performance metrics. In addition, interests of industries or enterprises are also essential for community governors and planners because the performance of community infrastructure is an important prerequisite to attract and bring industries or enterprises which play an essential part in the economy and functions of a community.

— Municipalities: Municipalities are usually the administrators that regulate the operation of community infrastructure.

— Infrastructure operators: Because infrastructure operators are the direct providers of community infrastructure services, they are stakeholders to which community infrastructure performances are closely related.

— Product, service, and solution providers: Although product, service, and solution providers are not always the direct providers of community infrastructure services, they provide machines, components, systems, services, and solutions which are necessary for infrastructure operators to provide community infrastructure services. Thus, interests of these stakeholders are also essential to identify community infrastructure performance metrics.

— Financial institutions and investors: As the construction and operation of community infrastructure tend to be large-scale, long-span projects, the role of financial institutions and investors is essential. The planned, expected, and achieved performances of community infrastructure will be important for this group of stakeholders as part of the criteria for financing and investment.

— Academia and research institutions: R&D on infrastructure related to smart cities and communities are very frequently conducted. Academia and research institutions play an important role in evaluating community infrastructure.

6 Requirements for common approach to identify metrics

6.1 General requirements

The identification of community infrastructure performance metrics shall be conducted through a step-wise approach described below in accordance with the principles introduced in Clause 5:

Step a) Understand the perspectives of key stakeholders for community infrastructures as described in 5.4;

Step b) Identify the categories of needs which are important from the perspectives determined in a);

Step c) Translate the categories of needs identified in b) into performance characteristics;

Step d) Identify indicators which are appropriate to measure each of the performance characteristics identified in b) and c).

Table 2 illustrates the identification of community infrastructure performance metrics following this approach.

In step a) of the above approach, perspectives shall be determined so that they represent multiple interests of different stakeholders of communities including residents, community managers, and the environment or the equivalent of these.

NOTE 1 The identified community infrastructure performance metrics using this approach can be different for communities or for different users because the determinations of perspectives and identifications of the category of needs can be different.

NOTE 2 Those stakeholders can be found according to ISO 37120 and ISO 26000.

NOTE 3 Indicators [step d)] and performance characteristics [step c)] as well as categories of needs [step b)] can be interrelated in "n-by-m" correspondence.

Table 2 — Approach to identify community infrastructure performance metrics with examples of performance characteristics

Step a) Perspectives	Step b) The categories of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Indicators
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage	XXX
		Areal coverage	XXX
		Population coverage	XXX
		Stability	XXX
	Accessibility	Capability of being accessed and used by a wide range of people	XXX
	Affordability	Service price	XXX
	Safety and security	Safety	XXX
		Cyber security and data privacy	XXX
		Physical security	XXX
	Quality of service	Service capacity	XXX
		Easy procedure to understand and use	XXX
		Proper invoicing	XXX
		Community infrastructure-specific qualities	XXX
		Provision of information	XXX
Community managers	Operational efficiency	Interoperability	XXX
		Appropriate size of facilities	XXX
		Flexibility for the size of demands	XXX
		Operational efficiency	XXX
	Economic efficiency	Total life-cycle cost	XXX
		Investment efficiency	XXX
	Performance information availability	Customer communication	XXX
	Maintainability	Appropriateness of maintenance	XXX
		Efficiency of maintenance	XXX
	Resilience	Robustness	XXX
		Redundancy	XXX
		Substitutability	XXX
		Swiftness of recovery	XXX
Environment	Circularity	Efficiency of energy consumption	XXX
		Efficiency of natural resource consumption	XXX
		Net amount of waste	XXX
	Mitigation of climate change	Amount of greenhouse gas (GHG) emission	XXX
	Prevention of pollution	Amount of pollutant emission	XXX
		Level of sensory nuisance	XXX
	Conservation of ecosystem	Amount of green space	XXX
		Control of surface run-off and drainage	XXX
		Contribution to human and public health	XXX

NOTE 1 A detailed description of "environment" is given in 6.2.4.

NOTE 2 Annex A provides examples of existing metrics.

6.2 Requirements for understanding the perspectives of key stakeholders for community infrastructures

6.2.1 General

This document takes into account three perspectives of stakeholders, i.e. residents, community managers, and environment from 6.1 step a). To facilitate field application of the required approach, multiple diverse perspectives of community stakeholders are represented by one of these three conceptual stakeholders (See Figure 3).

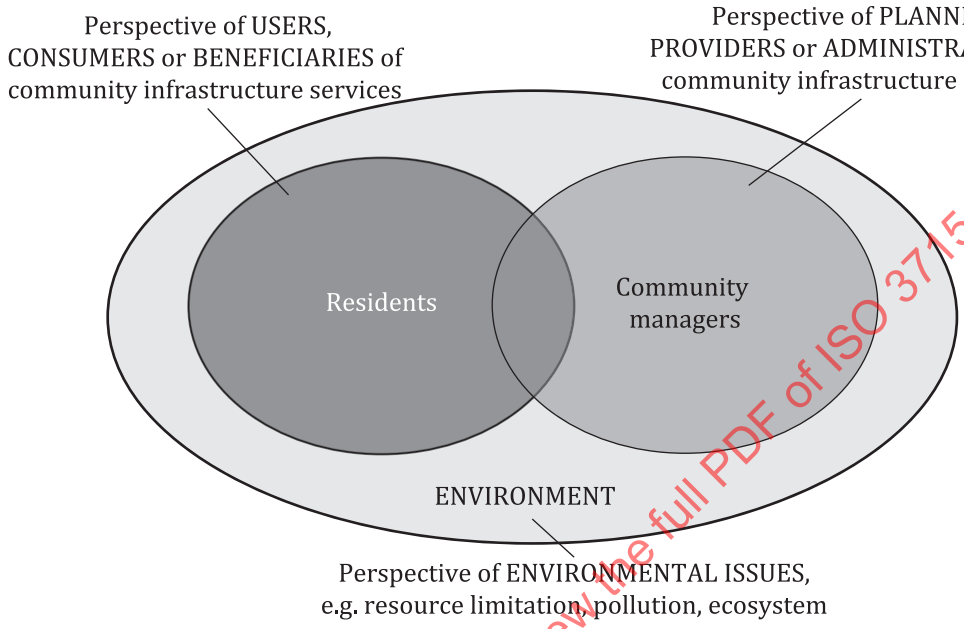


Figure 3 — Example of a model of multiple perspectives

6.2.2 Residents perspective

This perspective represents interests of users, consumers or beneficiaries of community infrastructure services, e.g. people, citizens, visitors, industries or enterprises. This perspective focuses on the community infrastructure performance characteristics which users directly sense and care about, e.g. accessibility, safety and security of community infrastructures services.

NOTE This perspective addresses residents as the direct users of community infrastructure services. Residents who suffer from side effects of the community infrastructure operation, e.g. environmental pollution including noise, are addressed in the environmental perspective.

6.2.3 Community managers perspective

This perspective represents the interests of planners, providers or administrators of community infrastructure services, e.g. municipalities and infrastructure operators.

This perspective focuses on the managerial performance category of needs with respect to providing services which users usually do not care about, e.g. operational efficiency, maintainability, expandability of community infrastructures.

6.2.4 Environmental perspective

This perspective represents environmental issues, e.g. resource limitations, pollution, ecosystem.

6.3 Requirements for identifying the category of needs

6.3.1 General

In step b) of the approach required in 6.1, the following categories of needs shall be considered as a minimum.

6.3.2 Category of needs related to residents

— Availability: the services are in place for the beneficiaries.

— Accessibility: beneficiaries have access to services regardless of their physical or mental conditions.

— Affordability: potential users can bear the expense of the service.

— Safety and security: the lives, bodies and properties of residents are not harmed or damaged by community infrastructure performance disruptions or other incidents.

— Quality of service: a community infrastructure operator provides differentiated services beyond the availability level.

6.3.3 Category of needs related to community managers

— Operational efficiency: the community infrastructure facility is designed with an appropriate size meeting the community demands and the capacity is efficiently utilized.

— Economic efficiency: the investment in community infrastructures is viable from socio-economic viewpoints.

— Performance information availability: performance information of community infrastructure is available.

— Maintainability: community infrastructure systems are easy to maintain.

— Resilience: community infrastructure systems are designed to continue providing services in emergencies and to quickly recover from damage and suspension of services.

6.3.4 Category of needs related to the environment

— Circularity: community infrastructure systems are designed to efficiently use natural resources such as materials and energy, including reduction of the amount of waste through the circular economy transition [13].

— Mitigation of climate change: community infrastructures are designed, operated, and maintained to mitigate the effect on climate change.

— Prevention of pollution: infrastructure systems are designed, operated and maintained to decrease the extent of pollution.

NOTE Pollution includes air pollution, water pollution, soil pollution, vibration, noise, odour generated within or released to the outside of the community.

— Conservation of ecosystems: community infrastructures are designed, operated and maintained to conserve or to enhance the ecosystem(s).

6.4 Guidance for translating the categories of needs into performance characteristics

6.4.1 General

In step c) of the approach required in 6.1, the following performance characteristics can be considered.

NOTE There can be performance characteristics specific to the type of community infrastructure.

6.4.2 Performance characteristics related to residents

a) Performance characteristics for availability:

   1) Temporal coverage: the available hours of community infrastructure services.

   2) Areal coverage: the extent to which the community infrastructures physically cover the area of a community.

   3) Population coverage: the proportion of the population of a community that is served by the community infrastructure.

   4) Stability: the extent to which the community infrastructures operate without interruption.

b) Performance characteristics for accessibility:

   1) Capability of being accessed and used by a wide range of people: the extent to which the community infrastructures are accessible for people regardless of their individual language, disability, etc.

c) Performance characteristics for affordability:

   1) Service price: the fee to use the community infrastructures.

d) Performance characteristics for safety and security:

   1) Safety: the extent to which community infrastructures are designed, operated and maintained to reduce risk to a tolerable level, which can vary among communities and types of community infrastructures.

   2) Cyber security and data privacy: the extent to which community infrastructures are designed, operated, and maintained to protect information and control systems against unintended accesses, manipulation or unintended distribution of data.

   3) Physical security: the extent to which community infrastructures are designed, operated, and maintained to protect people and properties against intentional attacks, e.g. terrorism, crimes, or mischief.

e) Performance characteristics for quality of service:

   1) Service capacity: the extent to which the community infrastructures have capacity to provide services without causing congestion or a limitation on the amount of use.

   2) Easy procedure to understand and use: the extent to which community infrastructures can be used via relatively easy procedure, including user interface (e.g. supported by community governmental services using electrical data basis to access, by adaptable to internationally recognized transaction system).

   3) Proper invoicing: the extent to which fees for community infrastructures are properly invoiced in terms of amount, timing and quality of services.

   4) Community infrastructure-specific qualities: attributes particularly relevant to an individual community infrastructure, e.g. duration for transportation or taste of drinking water, personnel mobility in the community.

   5) Provision of information: the extent to which residents are provided with all relevant information about community infrastructures, including scheduled suspension of operation, damage status, evacuation information and expected recovery period in an emergency and information about replacement services.

6.4.3 Performance characteristics related to community managers

a) Performance characteristics for operational efficiency:

1) Interoperability: the extent to which a community infrastructure provides services to and accepts services from other community infrastructures and to use the exchanged services to enable them to operate effectively together.

2) Appropriate size of facilities: the extent to which the physical size of the facilities is appropriate in comparison with the amount of demand to be met.

EXAMPLE The total length of the pipe network of the civil water system or the capacity of a water treatment plant.

3) Flexibility for the size of demands: the extent to which community infrastructures are designed, operated, and maintained to flexibly adjust themselves to the increases or decreases of demands resulting from a long-term change of communities, including demographics and industrial structure.

4) Operational efficiency: the extent to which the prepared service capacity is efficiently delivered and used. The extent to which delivery losses and opportunity losses are controlled under a certain level.

b) Performance characteristics for economic efficiency:

1) Total life-cycle cost: consecutive and interlinked costs of a community infrastructure project including initial construction, operation, maintenance, and decommissioning.

2) Investment efficiency: the extent to which investments in community infrastructures are economically efficient.

c) Performance characteristics for performance information availability:

1) Customer communication: the extent to which community infrastructures are designed, operated and maintained to obtain the performance information at the user level and provide necessary information.

d) Performance characteristics for maintainability:

1) Appropriateness of maintenance: the extent to which community infrastructures are supported with a system or an activity to properly maintain the facilities, such as asset management or maintenance and renewal plans.

2) Efficiency of maintenance: the extent to which the design of community infrastructures is already based on the idea of (future) ease of maintenance, e.g. less-maintenance, longevity, seamlessly operable, modularity, remote maintenance.

e) Performance characteristics for resilience:

1) Robustness: the extent to which community infrastructures, including physical facilities, are hardened against destruction by emergencies, including natural disaster and intended attacks.

2) Redundancy: the extent to which community infrastructures have redundant structures and are able to continue providing services to a certain extent even if some parts of the system are damaged and lose their functions during an emergency.

3) Substitutability: the extent to which community infrastructures are provided with substitution means for emergencies and can continue providing services to a certain extent.

4) Swiftness of recovery: the extent to which community infrastructures are able to swiftly recover from the aftermath of emergencies.

6.4.4 Performance characteristics from the environmental perspective

a) Performance characteristics for circularity:

1) Efficiency of energy consumption: the extent to which the net unit consumption of energy of community infrastructures is reduced (e.g. by recovery).

NOTE 1 "Unit consumption" means amount of consumption divided by output amount, e.g. Joules per litre.

2) Efficiency of natural resource consumption: the extent to which the net unit consumption of natural resources of community infrastructures is reduced (e.g. by reuse or recycle).

NOTE 2 Natural resources include raw materials and water.

3) Net amount of waste: the extent to which the net unit amount of generated waste of community infrastructures is reduced (e.g. by reuse or recycle).

NOTE 3 "Unit amount of generated waste" means amount of generated waste divided by output amount, e.g. kilogram per litre.

b) Performance characteristics for mitigation of climate change:

1) Amount of greenhouse gas (GHG) emission: the extent to which community infrastructures are designed, operated and maintained to reduce GHG emissions by introducing, e.g. renewable energy, carbon capture and storage (CCS), and highly-efficient fossil-fuel power generation.

c) Performance characteristics for prevention of pollution:

1) Amount of pollutant emission: the extent to which the absolute amount of pollutant emissions from community infrastructures is reduced.

EXAMPLE Nitrogen oxides (NO_x), sulfur oxides (SO_x) and particulate matter (PM) in exhaust gas, and chemical oxygen demand (COD) and biochemical oxygen demand (BOD) in waste water.

2) Level of sensory nuisance: the extent to which the level of sensory nuisance caused by community infrastructures (e.g. noise, vibration and odour) is reduced.

d) Performance characteristics for conservation of ecosystems:

1) Amount of green space: the extent to which community infrastructures are designed, maintained, and operated to limit impacts on existing green space (e.g. parks, wetlands, watercourse buffers, existing trails) and infrastructures adopt the no net loss principle.

2) Control of surface run-off and drainage: the extent to which community infrastructures are designed, operated, and maintained to limit the amount of run-off which would reduce environmental impacts (e.g. pollutants such as petrochemicals can be deposited into adjacent watercourse).

3) Contribution to human and public health: the extent to which community infrastructures are designed, operated, and maintained to reduce adverse impacts on healthy and productive ecosystems. These ecosystems in turn support the base for economic activity, for social welfare and for health.

6.5 Requirements for identifying indicators

In step d) of the approach required in 6.1, the indicators shall be identified so that they meet the following criteria:

a) An indicator shall have a name.

b) An indicator may have a classification of what sector, system, market, and locality it covers.

c) An indicator shall have a description which states what it measures:

   1) in terms of the system, flow, activity or dynamic that the metric covers;

   2) in terms of the units in which the metric is measured;

   3) in terms of its conditions for measurement;

   4) in terms of stakeholder perspective.

d) An indicator shall have a description which states how it can be measured:

   1) in terms of a possible data section which provides the data items based on the above;

   2) in terms of a possible method to collect or obtain the data items;

   3) in terms of a possible coding.

e) An indicator for safety shall be identified by at least regarding the analysis of related risk.

NOTE 1 The identified community infrastructure metrics using this approach can be different for different communities or for different users because the determination of perspectives and identification of the category of needs can be different.

NOTE 2 When the direct measurement of a community metric is not allowed but is obtained at a regional level, the metric can be calculated weighting the measurement by area or population.

NOTE 3 If the indicator is not quantitative, then an alternative method for measurement can be applied.

Annex A
(informative)

Examples of applicability of the step-wise approach to existing key performance indicators for particular types of community infrastructure

A.1 General

This Annex, including Tables A.1 to A.8, contains examples of existing key performance indicators for specific types of community infrastructure from the step-wise approach in Clause 6, e.g. energy, water, transportation, waste and ICT.

A.2 Examples of applicability to existing key performance indicators for road transportation and ICT (Contribution by China, Germany, Japan and France)

Table A.1 — Examples of applicability to existing key performance indicators for road transportation and ICT (China)

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Road transportation	ICT
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage		
		Areal coverage	a) density of road network b) coverage ratio of bus stop c) coverage ratio of non-motorized traffic	a) number of wireless base stations per km^2
		Population coverage	a) density of public transit routes b) bus travel sharing rate c) number of reserved vehicles	a) internet penetration rate
		Stability	a) mean time between failure (MTBF) of (urban rail transit, etc.)	a) drop rate of wireless network b) duration when voice service being interrupted c) duration when data service being interrupted
	Accessibility	Capability of being accessed and used by a wide range of people	a) coverage rate of the track for visually-impaired people b) coverage rate of barrier-free access	

Table A.1 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Road transportation	ICT
	Affordability	Service price	a) parking charge b) public transit fares c) traffic congestion pricing d) the rate of bus fares and income of residents	a) price of voice services b) price of data services c) price of value-added-service (VAS)
	Safety and security	Safety	a) death number per 10 000 vehicles b) average annual fatal accident rate c) seatbelt usage rate	
		Cyber security and data privacy		
		Physical security		
	Quality of service	Service capacity	a) average travel time b) average travel speed c) public transit service level d) mean vehicle travel speed e) capacity of city road network of motoring lane	a) number of admissible users b) number of online users c) bandwidth of output d) success rate of wireless network access e) download speed [by file transfer protocol (FTP)] f) average delay of transmission control protocol (TCP) g) service answer duration h) time to arrive at the site i) expandability of memory capacity
		Easy procedure to understand and use		
		Proper invoicing		
		Community infrastructure-specific qualities		
		Provision of information	a) information service of traffic guidance system	
Community managers	Operational efficiency	Interoperability	a) door to door travel time b) sharing rate of travel mode	
		Appropriate size of facilities	a) bus transfer distance	
		Flexibility for the size of demands		
		Operational efficiency	a) bus transfer efficiency b) road capacity c) level of service (LOS)	

Table A.1 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Road transportation	ICT
	Economic efficiency	Total life-cycle cost		
		Investment efficiency	a) benefit-cost ratio in investment	
	Performance information availability	Customer communication		
	Maintainability	Appropriateness of maintenance	a) road maintenance cost	a) frequency of inspection (or maintenance)
		Efficiency of maintenance	a) mean time to repair (MTTR)	
	Resilience	Robustness		
		Redundancy		a) redundancy level of duplication of server/network/storage
		Substitutability		
		Swiftness of recovery		
Environment	Circularity	Efficiency of energy consumption	a) corresponding carbon emission per unit of gross domestic product (GDP) or per million USD of GDP	a) power usage effectiveness (PUE)
		Efficiency of natural resources consumption		
		Net amount of waste		
	Mitigation of climate change	Amount of greenhouse gas (GHG) emission	a) carbon emission at a given area b) carbon emission factor	
	Prevention of pollution	Amount of pollutant emission	a) nitrogen oxide (NO_X) emission at a given area b) NO_X emission factor	
		Level of sensory nuisance	a) sound level caused by transportation	a) level of noise
	Conservation of ecosystem	Amount of green space		
		Control of surface run-off and drainage		
		Contribution to human and public health		

A.3 Examples of applicability to existing key performance indicators for water (Contribution by Germany)

Table A.2 — Examples of applicability to existing key performance indicators for water (Germany)

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures
			water[a]
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage	— minutes per year without service
		Areal coverage	— % of severed area
		Population coverage	— % of served residents
		Stability	— number of restrictions on water supply (in predetermined period)
	Accessibility	Capability of being accessed and used by a wide range of people	— % of same service (e.g. water quality) to all residents
	Affordability	Service price	— price of service
	Safety and security	Safety	— without sufficient drinking water quality (e.g. minutes per year) — flooding of properties from combined sewers (e.g. minutes per year) — sewer blockages
		Cyber security and data privacy	— existence of a risk management (Yes / No)
		Physical security	— existence of crisis management (Yes / No) — existence of security concept of protection of physical water assets (Yes / No)
	Quality of service	Service capacity	— served pressure of drinking water supply on agreed level[b]
		Easy procedure to understand and use	— provision of the service — existence of a participation scheme with users — notification on restrictions and interruptions
		Proper invoicing	— accuracy of billing — clarity of billing[c] — error in metering — number of complains
		Community infrastructure-specific qualities	— aesthetic aspects of water — taste (e.g. in terms of chlorine) — smell (e.g. in terms of chlorine)
		Provision of information	— availability of service information — participation of the users

[a] The majority of listed performance indicators are taken from ISO 24510, ISO 24511, ISO 24512 or the International Water Association (IWA) Handbook, but in this table, it is much simplified. It is important for the usage of a PI to respect the exact definition. For the application of this indicators, please use the given definition in the referred standards or the IWA Handbook.

[b] It is possible that agreed level is a separate KPI.

[c] Performance indicator: clarity of the bill complaints and queries (number/customer/year).

NOTE Definition: (number of complaints and queries regarding the clarity of the bill during the assessment period × 365)/(assessment period × number of registered users).

Table A.2 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures
			water[a]
Community managers	Operational efficiency	Interoperability	— % of water delivered by other communities
		Appropriate size of facilities	— grade of redundancies (e.g. n-1)
		Flexibility for the size of demands	— height of minimum pressure fitness of every pipeline
		Operational efficiency	— water losses (m^3/h × length for mains; m^3/h × connection for connection pipes)
	Economic efficiency	Total life-cycle cost	— total cost coverage ratio
		Investment efficiency	— % pipe rehabilitation based on pipe condition assessment
	Performance information availability	Customer communication	— customer service personnel per user
	Maintainability	Appropriateness of maintenance	— existence of asset management plans based among other things on asset condition assessment (Yes / No)
		Efficiency of maintenance	— failure rate of mains — water losses (m^3/h × length for mains; m^3/h × connection for connection pipes)
	Resilience	Robustness	— % of pipe length reinforced to endure earthquake per total pipe length
		Redundancy	— rate of redundancies (e.g. n-1)
		Substitutability	— existence of crisis management (Yes / No)
		Swiftness of recovery	— number of emergency units
Environment	Circularity	Efficiency of energy consumption	— rate of renewable energy use — efficiency rate of pumps
		Efficiency of natural resources consumption	— rate of water re-use — years of life cycle of pipes
		Net amount of waste	— rate of waste water as a result of flushing filters
	Mitigation of climate change	Amount of greenhouse gas (GHG) emission	— rate of energy saved by pumping storage power stations

[a] The majority of listed performance indicators are taken from ISO 24510, ISO 24511, ISO 24512 or the International Water Association (IWA) Handbook, but in this table, it is much simplified. It is important for the usage of a PI to respect the exact definition. For the application of this indicators, please use the given definition in the referred standards or the IWA Handbook.

[b] It is possible that agreed level is a separate KPI.

[c] Performance indicator: clarity of the bill complaints and queries (number/customer/year).

NOTE Definition: (number of complaints and queries regarding the clarity of the bill during the assessment period × 365)/(assessment period × number of registered users).

Table A.2 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures
			water[a]
	Prevention of pollution	Amount of pollutant emission	
		Level of sensory nuisance	— rate of pipe construction together with other infrastructure
	Conservation of ecosystem	Amount of green space	
		Control of surface run-off and drainage	
		Contribution to human and public health	— existence of a risk management (Yes / No)

[a] The majority of listed performance indicators are taken from ISO 24510, ISO 24511, ISO 24512 or the International Water Association (IWA) Handbook, but in this table, it is much simplified. It is important for the usage of a PI to respect the exact definition. For the application of this indicators, please use the given definition in the referred standards or the IWA Handbook.

[b] It is possible that agreed level is a separate KPI.

[c] Performance indicator: clarity of the bill complaints and queries (number/customer/year).

NOTE Definition: (number of complaints and queries regarding the clarity of the bill during the assessment period × 365)/(assessment period × number of registered users).

A.4 Examples of applicability to existing key performance indicators for energy, water, transportation, waste and ICT (Contribution by Japan)

Table A.3 — Examples of applicability to existing key performance indicators for energy and waste (Japan)

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures		
			Energy (Electricity)	Energy (Gas)	Waste
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage		— supply hours per day	— number of operating days of waste collection service
		Areal coverage			— percentage of the area with waste collection service
		Population coverage	— ratio of electrification		— percentage of the population with waste collection service
		Stability	a) average interruption duration per year per customer b) average interruption frequency per year per customer c) frequency d) voltage	a) standard heat and minimum heat of gas supplied b) standard pressure and minimum pressure of gas supplied	

Table A.3 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures		
			Energy (Electricity)	Energy (Gas)	Waste
	Accessibility	Capability of being accessed and used by a wide range of people			— percentage of waste collection sites with instructions in more than one language/ total number of sites
	Affordability	Service price	— power rates	— gas rates	— waste collection fee
	Safety and security	Safety			— number of accidents during waste collection
		Cyber security and data privacy			— number of disposal companies of confidential documents
		Physical security			
	Quality of service	Service capacity		— capacity of gas production	— capacity of waste management plants
		Easy procedure to understand and use			— number of waste collection sites
		Proper invoicing			
		Community infrastructure-specific qualities	a) frequency b) voltage	a) standard heat and minimum heat of gas supplied b) standard pressure and minimum pressure of gas supplied	
		Provision of information			— number of means to provide waste collection information

Table A.3 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures		
			Energy (Electricity)	Energy (Gas)	Waste
Community managers	Operational efficiency	Interoperability			— rate of waste incineration plants recycling waste heat
		Appropriate size of facilities		— capacity margin	— rate of operation of waste management plants
		Flexibility for the size of demands			
		Operational efficiency			a) cost of waste management operation b) amount of specific material recovered from waste
	Economic efficiency	Total life-cycle cost			— total life-cycle cost of waste management plants
		Investment efficiency			— payback period of investment for waste management plants
	Performance information availability	Customer communication		a) existence of an advanced information provision service to inform the gas consumption amount b) percentage of gas customers (households) using the advanced information provision service above/total number of households in the community	
	Maintainability	Appropriateness of maintenance		a) existence of central monitoring system b) existence of sampling inspection of regular maintenance activities	a) frequency of inspections of waste management plants b) number of inspection items of waste management plants
		Efficiency of maintenance			— maintenance time for waste management plants

Table A.3 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures		
			Energy (Electricity)	Energy (Gas)	Waste
	Resilience	Robustness			— rate of earthquake-resistant buildings in waste management plants
		Redundancy			
		Substitutability			
		Swiftness of recovery			— MTTR of waste management plants
Environment	Circularity	Efficiency of energy consumption	a) power generation efficiency b) loss rate of electricity transmission and distribution	— diffusion of high efficiency equipment, including fuel cells, latent heat recycling boiler or combined heat and generation systems	— amount of recovered energy from wastes
		Efficiency of natural resources consumption			— amount of fuel used in waste management plants
		Net amount of waste			a) amount of incinerated ash left by waste incineration b) recycling rate in waste management
	Mitigation of climate change	Amount of greenhouse gas (GHG) emission	a) greenhouse gas (GHG) emission (CO_2 emission) b) CO_2 emission intensity	a) GHG emission (CO_2 emission) b) CO_2 emission intensity	— amount of CO_2 emission from waste treatment
	Prevention of pollution	Amount of pollutant emission		— percentage of the amount of natural gas/total amount of gas supplied	— amount of pollutant emissions from waste management plants
		Level of sensory nuisance			— amount of malodorous substance
	Conservation of ecosystem	Amount of green space			— rate of green space in waste landfill sites
		Control of surface run-off and drainage			
		Contribution to human and public health			a) rate of waste burned openly b) rate of waste collection sites enclosed with walls

Table A.4 — Examples of applicability to existing key performance indicators for water (Japan)

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Water	Water (Sewage)
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage	— operating hours of drinking water supply service	
		Areal coverage		— rainwater drainage control coverage rate
		Population coverage	— population served by water supply	— percentage of sewered population
		Stability	— restricted water supply; water supply pressure inadequacy ratio; hour of water interruption or turbidity	— number of sewer clogging accidents etc. per 100 000 persons
	Accessibility	Capability of being accessed and used by a wide range of people		
	Affordability	Service price	— charge for one month per 10 m^3 for domestic — charge for one month per 20 m^3 for domestic	— wastewater service charges for households — unit tariff of wastewater treatment
	Safety and security	Safety	— automatic water quality monitoring; violation ratio of water quality standard; water quality compliance; ratio of lead service lines; user ratio of drinking water from taps without any domestic treatment	— number of road cave-in per 1 km sewer; — number of accidents resulting in injury or death of third persons per 100 000 persons
		Cyber security and data privacy		
		Physical security	— ratio of facility installed alarm system	
	Quality of service	Service capacity	— transmission input per population supplied	
		Easy procedure to understand and use		
		Proper invoicing	— meter misreading ratio	
		Community infrastructure-specific qualities	— achievement ratio of comfortable water based on musty odour/odour of chlorine	
		Provision of information	— ratio of water service information to public	

Table A.4 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Water	Water (Sewage)
Community managers	Operational efficiency	Interoperability		
		Appropriate size of facilities	— service reservoir capacity; distribution mains density; rate of facility utilization; maximum rate of operation; efficiency of fixed assets utilization; average yearly pump operating ratio	
		Flexibility for the size of demands		
		Operational efficiency	— revenue water ratio; average rate of loading; transmission input per employee; leakage ratio	— annual revenue water volume per staff; revenue water ratio
	Economic efficiency	Total life-cycle cost	— ratio of depreciation cost for revenue on water sales; cost to water supply	— maintenance cost; cost of wastewater treatment (total cost, running cost and capital cost)
		Investment efficiency	— rate of total returns; ratio of tariff to production cost; ratio of principal redemption cost on revenue bond to depreciation cost; turnover of fixed assets; non-payment ratio	— percentage of population served by wastewater treatment facilities; ratio of current expense to current income; recover rate of cost (total cost, maintenance cost and capital cost)
	Performance information availability	Customer communication		
	Maintainability	Appropriateness of maintenance	— pipeline inspection ratio; aging of water treatment facilities/electric and mechanical equipment/mains; mains rehabilitation/relining; valves replacement; Installation inspection implementing ratio	— percentage of aged facilities (sewers/major facilities); sewers inspection ratio; percentage of improved sewers; collecting sewers inspection ratio; number of improved collecting sewers
		Efficiency of maintenance	— valve density	— maintenance cost per 1 m sewer
	Resilience	Robustness	— ratio of earthquake-resistant treatment facility/ pumping station/service reservoir/pipeline; ratio of ductile iron and steel mains	— percentage of earthquake-proof facilities (architecture)
		Redundancy	— surplus capacity of resources; water storage volume per population supplied; surplus capacity of purification; ratio of non-utility generation facility	— surplus ratio of wastewater treatment process; percentage of wastewater treatment plants equipped with emergency power source

Table A.4 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Water	Water (Sewage)
		Substitutability	— water supply points density in emergency; capacity for interconnection of raw water; water truck	
		Swiftness of recovery		
Environment	Circularity	Efficiency of energy consumption	— electric power consumption per 1 m^3 transmission input; Energy consumption per 1 m^3 transmission input; renewable energy use ratio	— unit electric power consumption in wastewater treatment
		Efficiency of natural resources consumption	— resources availability ratio — effective raw water ratio	— percentage of wastewater recycling
		Net amount of waste	— recycling ratio of generated sludge from purification plants recycling ratio of construction by-products	— percentage of recycled sludge
	Mitigation of climate change	Amount of greenhouse gas (GHG) emission	— emission of CO_2 per 1 m^3 transmission inputs	— emission of greenhouse effect gases per sewered population
	Prevention of pollution	Amount of pollutant emission		— compliance of standards — percentage of improved combined sewer systems
		Level of sensory nuisance		— observance of standards (odours)
	Conservation of ecosystem	Amount of green space		
		Control of surface run-off and drainage		— percentage of population served by advanced wastewater treatment to meet environmental standards
		Contribution to human and public health		

Table A.5 — Examples of applicability to existing key performance indicators for transportation (Japan)

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Transportation (Railway)	Transportation (Road)
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage		

[a] OD: Origin and destination

Table A.5 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Transportation (Railway)	Transportation (Road)
		Areal coverage	a) influential areas of stations b) spread of transportation networks or km of high capacity public transport systems per 100 000 population c) km of light passenger public transport systems per 100 000 population	a) construction rate of the city planning road b) spread of transportation networks
		Population coverage	a) annual number of public transport trips per capita b) percentage of commuters using a travel mode to work other than a personal vehicle	a) to b) same as on the left c) number of personal automobiles per capita d) number of motorcycles per capita
		Stability	— punctuality	
	Accessibility	Capability of being accessed and used by a wide range of people	a) numbering or encoding of station names b) rate of barrier-free service c) installation rates of guidance display boards with Braille points, the display boards with multilingual notation and priority seats into transportation vehicles	— installation rates of guidance display boards with braille points, the display boards with multilingual notation
	Affordability	Service price	a) minimum section charge level b) transportation charge	— transportation charge
	Safety and security	Safety	a) train protection systems secured by signalling b) installation rates of obstruction warning indicators, platform doors and train protection switches	
		Cyber security and data privacy	— installation of inter-departmental communication	
		Physical security	a) abolition of level crossings b) installation rate of emergency alarm devices	— transportation fatalities per 100 000 population

[a] OD: Origin and destination

Table A.5 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Transportation (Railway)	Transportation (Road)
	Quality of service	Service capacity	a) track capacity b) traffic volume between stations c) station intervals d) traffic density e) load factor at peak-hour	— impact of the traffic jam
		Easy procedure to understand and use	a) availability and applicability of e-tickets in other transportation systems and commercial fields b) capability to inspect tickets by machines c) train connection d) comfort index of trains e) installation rate of on-line information systems for public transportation f) diffusion rate of e-tickets g) installation rate of auto fare collection equipment	a) accuracy of the promise transportation time b) the number of the service stations c) mean repair time
		Proper invoicing		
		Community infrastructure-specific qualities	a) ride comfort b) MTBF c) introducing rate of ATC and ATP d) promptness of travel by public transportation e) installation rate of air-conditioning systems in vehicles	
		Provision of information	a) timing and location to give customers information on current traffic conditions and irregular services anticipated in the immediate future b) installation rate of guidance display boards in a station	— timing (location) to give customers information on current traffic and maintenance conditions
Community managers	Operational efficiency	Interoperability		
		Appropriate size of facilities	a) number of operable rolling stock / origin and destination b) average carrying efficiency	— loss time caused by traffic jam

[a] OD: Origin and destination

Table A.5 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Transportation (Railway)	Transportation (Road)
		Flexibility for the size of demands	a) flexibility of train schedules b) installation rate of accommodation-capacity changeable vehicles in service	
		Operational efficiency	a) number of train crew/ origin and destination b) average transport efficiency c) introducing rate of automatic train operating device (ATO)	
	Economic efficiency	Total life-cycle cost	— life cycle cost	
		Investment efficiency	a) payback period b) internal rate of return (IRR)	
	Performance information availability	Customer communication	a) timing to provide customers with information of transportation performance b) time lags from an accident or incident occurrence to the furnishing of correct information to customers	— same as on the left
	Maintainability	Appropriateness of maintenance	a) waiting time for vehicles exchange b) track maintenance distance	— construction period on the street
		Efficiency of maintenance	a) fuel consumption rate b) cost for maintenance and replacement	— same as on the left
	Resilience	Robustness	— recovery strength from disturbed train schedules	
		Redundancy		
		Substitutability	— number of detour routes at transportation service disturbance	— same as on the left
		Swiftness of recovery	— mean time to repair	

[a] OD: Origin and destination

Table A.5 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Transportation (Railway)	Transportation (Road)
Environment	Circularity	Efficiency of energy consumption	a) diffusion rate of environment-friendly vehicles b) regenerative factor	— kilometres of bicycle lanes per 100 000 population
		Efficiency of natural resources consumption	a) energy consumption rate b) environmentally friendly energy and system introduction rate	— same as on the left
		Net amount of waste		
	Mitigation of climate change	Amount of greenhouse gas (GHG) emission	— GHG emission per function unit	— same as on the left
	Prevention of pollution	Amount of pollutant emission	a) pollutants emission per function unit b) introducing rate of environmental materials c) KPIs defined by an analyst	a) to c) same as on the left d) particulate matter (PMx), NO_2, SO_2, and O_3
		Level of sensory nuisance	a) enhancement degree of measures b) noise c) KPIs defined by an analyst	— same as on the left
	Conservation of ecosystem	Amount of green space	a) enhancement degree of measures b) KPIs defined by an analyst	— same as on the left
		Control of surface run-off and drainage	— same as above	— same as on the left
		Contribution to human and public health	— same as above	— same as on the left

[a] OD: Origin and destination

Table A.6 — Examples of applicability to existing key performance indicators for ICT (Japan)

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures		
			ICT		
			Telecommunication	Computing platform	ICT services
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage	— telephone service time	— internet service time	— ICT service time
		Areal coverage	— available area/ community —stations/km^2	— available area/ community	— same as on the left
		Population coverage	— user/population	— same as on the left	— same as on the left
		Stability	— service available time	— same as on the left	— same as on the left
	Accessibility	Capability of being accessed and used by a wide range of people	— number of available languages for telephone services	— number of available languages for Internet service	— number of available languages for ICT services
	Affordability	Service price	a) price of telephone equipment b) price of communication	a) price of data service b) price of personal computer (PC), server c) Internet fee	— price of ICT system and service
	Safety and security	Safety	a) harmless conscious design of mobile phone b) green label	a) harmless design of PC server and storage system b) green label	— harmless design of ICT system
		Cyber security and data privacy		— data and data centre (DC) security — systems security engineering capability maturity model (SSE-CMM) (ISO/IEC 21827)	
		Physical security		— level of ID check function and personal authentication — physical security of DC	

[a] a) Natural Resource efficiency of ICT service; b) Natural Resource efficiency by using ICT service; c) Maintenance of forest resources by introduction of paperless office service.

[b] a) Amount of pollutant emission from ICT service; b) Contribution to reducing amount of pollutant emission.

[c] Contribution to reducing negative impact on green space and increasing green space.

[d] Contribution to reducing negative impact on surface run-off and drainage.

[e] a) Contribution to reducing negative impact on human and public health; b) Contribution to agricultural productivity.

Table A.6 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures		
			ICT		
			Telecommunication	Computing platform	ICT services
	Quality of service	Service capacity	a) number of admissible users, number of online users b) bandwidth of output c) success rate of wireless network access d) download speed by FTP e) capacity of user number	a) number of admissible users b) of online users c) transmission rate (speed) server computing rate d) access time for storage e) capacity of user number	— capacity of ICT service user number
		Easy procedure to understand and use			
		Proper invoicing			
		Community infrastructure-specific qualities	a) quality of telecommunications b) signal/noise ratio c) noise level of telecommunications	a) response time b) transmission rate (speed) c) SV computing rate d) access time for storage	
		Provision of information	— sharing information about the situation of telephone service	— sharing information about the situation of ICT, data on ICT in an emergency and back up situation	— sharing information about the situation of ICT service

[a] a) Natural Resource efficiency of ICT service; b) Natural Resource efficiency by using ICT service; c) Maintenance of forest resources by introduction of paperless office service.

[b] a) Amount of pollutant emission from ICT service; b) Contribution to reducing amount of pollutant emission.

[c] Contribution to reducing negative impact on green space and increasing green space.

[d] Contribution to reducing negative impact on surface run-off and drainage.

[e] a) Contribution to reducing negative impact on human and public health; b) Contribution to agricultural productivity.

Table A.6 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures		
			ICT		
			Telecommunication	Computing platform	ICT services
Community managers	Operational efficiency	Interoperability	— available distance for telecommunications from community	— available distance for internet from community	— available distance for ICT service from community
		Appropriate size of facilities	— size of telecommunication system	— size of PC system, server system, and DC	— size of ICT service system
		Flexibility for the size of demands	— expandability of user	— expandability of Internet user	— expandability of user
		Operational efficiency	— operational efficiency of telecommunication system	— operational efficiency of server system, DC	— operational efficiency of ICT service
	Economic efficiency	Total life-cycle cost	— total life cycle cost of telecommunication system	— total life cycle cost of PC, server system, DC	— total life cycle cost of ICT service
		Investment efficiency	— cost performance for services	— same as on the left	— same as on the left
	Performance information availability	Customer communication	— number of kinds of information for customer	— same as on the left	— number of kinds of information for customer
	Maintainability	Appropriateness of maintenance	a) level of maintenance b) time and cost for maintenance	— same as on the left	— same as on the left
		Efficiency of maintenance			
	Resilience	Robustness		— level of robustness of DC	
		Redundancy	— level of redundancy	— same as on the left	— same as on the left
		Substitutability	— level of substitutability	— same as on the left	— same as on the left
		Swiftness of recovery	— swiftness of recovery — time to arrive at the site	— same as on the left	— same as on the left

[a] a) Natural Resource efficiency of ICT service; b) Natural Resource efficiency by using ICT service; c) Maintenance of forest resources by introduction of paperless office service.

[b] a) Amount of pollutant emission from ICT service; b) Contribution to reducing amount of pollutant emission.

[c] Contribution to reducing negative impact on green space and increasing green space.

[d] Contribution to reducing negative impact on surface run-off and drainage.

[e] a) Contribution to reducing negative impact on human and public health; b) Contribution to agricultural productivity.

Table A.6 *(continued)*

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures		
			ICT		
			Telecommunication	Computing platform	ICT services
Environment	Circularity	Efficiency of energy consumption	— energy efficiency of telecommunication system	— energy efficiency of PC, SV, storage, network and DC; power usage effectiveness (PUE); data centre performance per energy	a) energy efficiency of ICT service b) energy efficiency by using ICT service
		Efficiency of natural resources consumption	— resource efficiency of telecommunication system	— resource efficiency of PC, server, storage, network and DC	— [a]
		Net amount of waste	— level of reduce, reuse and recycle (3R) of telecommunication system	— level of 3R of PC, server, storage, network and DC	— level of 3R of ICT service; contribution to reduce net amount of waste
	Mitigation of climate change	Amount of greenhouse gas (GHG) emission	— GHG emission of life-cycle of telecommunication system	— GHG emission of life-cycle of server, storage, network and DC	a) GHG emission of life-cycle of ICT service b) contribution to reducing GHG emission
	Prevention of pollution	Amount of pollutant emission	— amount of pollutant — label	— same as on the left	— [b]
		Level of sensory nuisance	— level of noise	— same as on the left	— same as on the left
	Conservation of ecosystems	Amount of green space	— level of impact on green space	— level of impact on green space	— [c]
		Control of surface run-off and drainage	— level of impact on surface run-off and drainage	— same as on the left	— [d]
		Contribution to human and public health	— level of impact on human and public heath	— same as on the left	— [e]

[a] a) Natural Resource efficiency of ICT service; b) Natural Resource efficiency by using ICT service; c) Maintenance of forest resources by introduction of paperless office service.

[b] a) Amount of pollutant emission from ICT service; b) Contribution to reducing amount of pollutant emission.

[c] Contribution to reducing negative impact on green space and increasing green space.

[d] Contribution to reducing negative impact on surface run-off and drainage.

[e] a) Contribution to reducing negative impact on human and public health; b) Contribution to agricultural productivity.

A.5 Examples of applicability to existing key performance indicators for water and waste (Contribution by France)

Table A.7 — Examples of applicability to existing key performance indicators for water and waste (France)

Perspectives	The category of needs	Performance characteristics	Metrics	
			Water	Waste
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage	— average annual hours of water service interruption per household (%)	
		Areal coverage		
		Population coverage	— percentage of city population with potable supply service (%) — percentage of city population with sanitation service (%) — percentage of city waste water that has received no treatment (%)	— percentage of residential city population with regular solid waste collection (%)
		Stability		
	Accessibility	Capability of being accessed and used by a wide range of people	— existence of pricing policy for potable water dedicated to low income population (Yes/No) — existence of pricing policy for sanitation dedicated to low income population (Yes/No)	
	Affordability	Service price		
	Safety and security	Safety		
		Cyber security and data privacy		
		Physical security		
	Quality of service	Service capacity		
		Easy procedure to understand and use		
		Proper invoicing		

Table A.7 *(continued)*

Perspectives	The category of needs	Performance characteristics	Metrics	
			Water	Waste
		Community infrastructure-specific qualities	— percentage of city population with sustainable access to an improved water resource (%) — percentage of population for whom a quality class could be calculated (%) — percentage of population supplied with excellent of high-quality water (%) — percentage of city population with access to an improved sanitation (%) — percentage of city wastewater receiving primary treatment (%) — percentage of city wastewater receiving secondary treatment (%) — percentage of city wastewater receiving tertiary treatment (%)	— percentage of solid waste that is disposed of in a sanitary landfill (%) — percentage of solid waste that is disposed of in an incinerator (%) — percentage of solid waste that is burned in open air (%) — percentage of solid waste that is disposed of in an open dump (%)
		Provision of information		
Community managers	Operational efficiency	Interoperability		
		Appropriate size of facilities		
		Flexibility for the size of demands		
		Operational efficiency	— waste water treatment efficiency in terms of BOD5 (BOD5 reduction/day/capita) — waste water treatment efficiency in terms of COD (COD reduction/day/capita) — potable water losses from water distribution networks (m^3/km/day) — potable water distribution network efficiency (%) — quantity of sludge treated/quantity of BOD5 treated	
	Economic efficiency	Total life-cycle cost		
		Investment efficiency		
	Maintainability	Appropriateness of maintenance		
		Efficiency of maintenance		

Table A.7 *(continued)*

Perspectives	The category of needs	Performance characteristics	Metrics	
			Water	Waste
	Resilience	Robustness		
		Redundancy		
		Substitutability		
		Swiftness of recovery		
Environment	Resources efficiency	Efficiency of energy consumption	— energy consumption per volume of potable water produced and distributed (kWh/m^3) — energy consumption per volume of waste water collected and treated (kWh/m^3) — energy efficiency of water treatment plants (kWh/gBOD5 treated)	— heat production per ton of solid waste (kWh/t) — electricity production per ton of solid waste (kWh/t)
		Efficiency of water consumption	— total domestic water consumption per capita (litres/day) — total water consumption per capita (litres/day) — water impact index (m^3 WIIX equivalent/day/capita)	
		Efficiency of raw materials consumption	— share of sludge produced by waste water treatment plants used in agriculture (%)	— percentage of city solid waste that is recycled (%) — rate of materials recovery (%) — percentage of packaging that is recycled (%) — percentage of organic waste that is recycled (%) — percentage of construction waste that is recycled (%) — percentage of city hazardous waste that is recycled (%)
		Amount of waste	— total waste water production per capita (litres/day)	— total collected municipal solid waste per capita (kg/capita/year)
			— share of waste water reused after treatment (%)	— hazardous waste generation (kg/capita/year)
				— share of separate solid waste collection (%)

Table A.7 *(continued)*

Perspectives	The category of needs	Performance characteristics	Metrics	
			Water	Waste
	Climate change	Amount of green-house gas (GHG) emission	— CO_2 emission per volume of potable water distributed [g(CO_2eq)/m^3] — CO_2 emission per volume of waste water treated [g(CO_2eq)/m^3] — renewable energy used for the potable water production and distribution (%) — renewable energy used for the waste water treatment plants (%)	— CO_2 emission per ton of collected municipal waste [g (CO_2eq)/t] — CO_2 emission per ton of treated municipal waste [g(CO_2eq)/t] — methane capture rate at landfill sites (% of methane capture)
	Pollution	Amount of pollutant emission		— emission of dusts from waste collection (g/t) — emission of dusts from waste incineration (g/t) — emission of SOX from waste incineration (g/t) — emission of NOX from waste incineration (g/t)
		Level of sensory nuisance		
	Biodiversity	Amount of green space		
		Habitat conservation or creation	— ecosystem an biodiversity preservation of well field (Yes/No)	
		Control of surface run-off and drainage		
		Contribution to human and public health		

A.6 Examples of existing key performance indicators for water (Contribution by Spain)

Table A.8 — Examples of existing key performance indicators for water (Spain)

Step a) Perspectives	Step b) The category of needs (minimum)	Step c) Performance characteristics (examples)	Step d) Examples of existing metrics/key performance indicators for specific types of community infrastructures	
			Water	Formula
Residents (end-users, beneficiaries, consumers)	Availability	Temporal coverage		
		Areal coverage		
		Population coverage		