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Smart community infrastructures — Principles and requirements for performance metrics

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee SDS/2, Smart and sustainable cities and communities.

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

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International Standard

ISO 37151

Smart community infrastructures — Principles and requirements for performance metrics

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

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Foreword

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

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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.

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— 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.

Layers	Example of functions
Community services	education, healthcare, public safety and security, tourism, etc.
Community facilities	residences, commercial buildings, office buildings, factories, hospitals, schools, recreation facilities, etc.
Community infrastructures	energy, water, transportation, waste, ICT, etc.

Contribution

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.

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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".]

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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]

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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.

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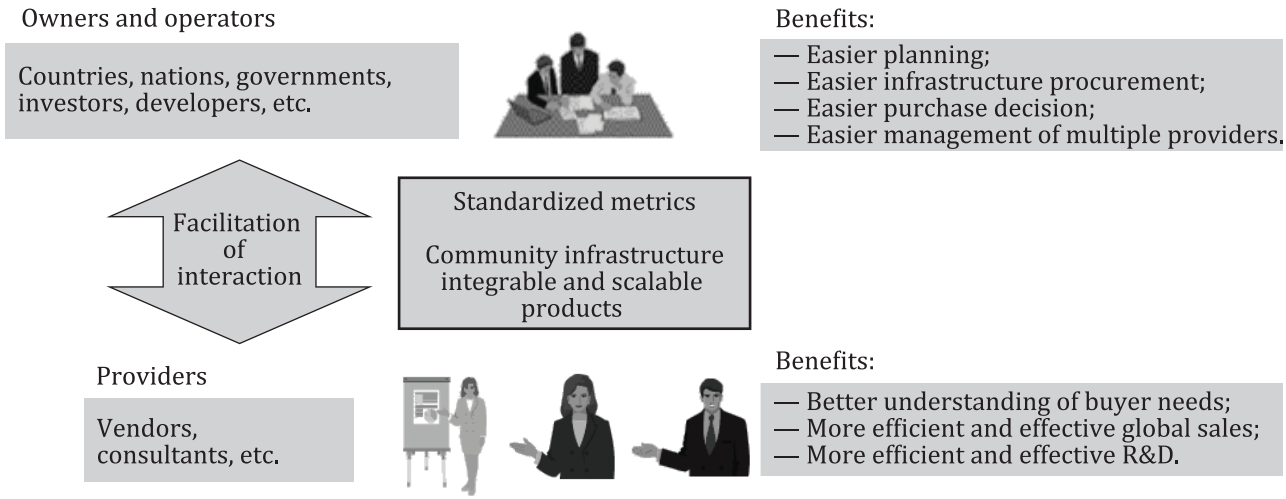

SOURCE ISO/TR 37150:2014, modified.

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

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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.

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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.

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— 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.

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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.

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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).

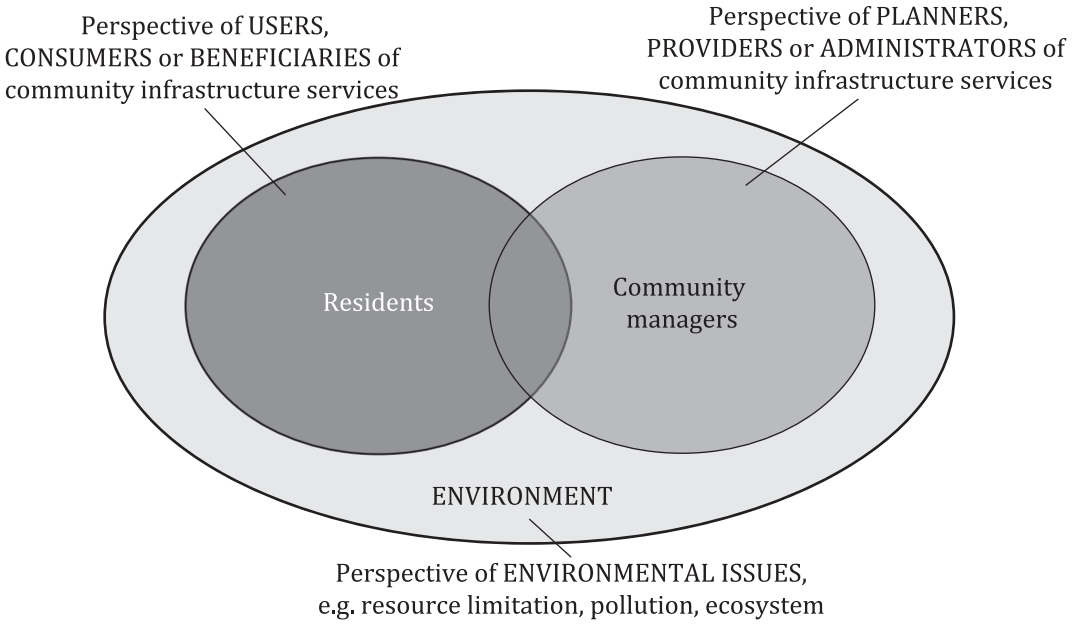

Figure 3 — Example of a model of multiple perspectives

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.

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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.

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