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Moving to Smart Cities Through the Standard Indicators ISO 37120

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INTRODUCTION

As calculated half of the world's population lived in the cities, In Europe 73.6 % of the European Union's inhabitants live in the urban areas. It is expected that this 58.2 % of the world and 75.8 % of the European population will be living in urban areas by 2025, and sustainable urbanization has become a key policy point to administrations across the world (Colldahl et al., 2013). One of the challenges faced by the cities is to ensure good living conditions for the people and at the same time achieve appropriate economic results. To effectively provide better services and increase quality of life of citizens smart cities operate on the basis of integrated and interconnected systems. Currently, cities all over the world introduce a holistic "smart city" approach to make them sustainable, efficient, and more attractive to people's live and business initiative development to support economic growth. The "smart city" concept is now evolving in major cities of the world.

The international standards bodies proposed the standards relevant to smart cities. However, the standards should have some structure to be able to connect different areas of live and identify the interactions between them in the smart city. To aid in this search the standards are needed, which can be mapped and linked various properties of "smart city" model (Allam and Newman, 2018; Jing et al., 2019). There are many definitions for smart cities focusing on various aspects ranging from infrastructure to the living conditions of citizens (Albino et al. 2015). International Telecommunication Union established useful definition (ITU, 2015): "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects". According to this definition smart city is not just a city that introducing or using the new technologies but it is a complex ecosystem containing many stakeholders

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including citizens, city authorities, local companies and industry, community groups, etc.

Recently established the ISO standards for smart cities aim to help them measure their sustainability and answer for the question: how can cities adapt and establish to provide adequate resources and a sustainable future.

The aim of this paper is to present international standards for smart cities and to show how obtaining ISO 37120 certification helps in the achievement of assumptions of smart city. In this article the current and most important standards focusing on smart city sector and organizations issuing them are presented.

KEY INTERNATIONAL STANDARDS ON SMART CITIES

International standards enable cities to achieve appropriate technical, environmental and social indicators that have a significant impact on the infrastructure, safety, and life of residents.

International Electrotechnical Commission (IEC), International Organization for Standardization (ISO) and International Telecommunication Union (ITU) established the World Smart City partnership. This partnership organizes each year World Smart City Forum (WSCF). The Forum aims to create uniform rules, standards of good practices, and intensify cooperation for development of “smart city” approach.

The International Organization for Standardization (ISO) is an instrumental body supporting and developing for smart cities. The definition of “smart city” according to ISO Smart Cities Strategic Advisory Group is as follow: “Smart City is one that dramatically increases the pace at which it improves its social, economic and environmental (sustainability) outcomes, responding to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, how it applies collaborative leadership methods, how it works across disciplines and city systems, and how it uses data information and modern technologies in order to transform services and quality of life for those in and involved with the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of other or degradation of the natural environment” (ISO/TMB, 2015).

The ISO Technical Committee 268 (Sustainable cities and communities) was established the work on standardization in the field of sustainable development of cities and communities. The role of this technical committee is: development of requirements, frameworks, guidance and supporting techniques and tools related to the achievement of sustainable development considering sustainability, smartness and resilience, to help all cities and communities from both rural and urban areas become more sustainable.

The committee comprises of 3 working groups but only two are strictly related to idea of smart cities, e.g. working group 1 – system management ISO 37101

and working group 2 – city indicators which are the keys smart cities standards developed by ISO TC268.

The standards should be used in the evaluation of smart cities because (ISO/TMB, 2015):

- Standards facilitate the connection of structures from different suppliers. Interconnection in cities (both physically and virtually) can only be achieved by standardized interfaces using the same harmonized technical rules that are described in standards.
- The use of international standards also facilitates the maintenance and repair of city infrastructure. Spare parts can be bought from anywhere at more competitive prices.
- Standards give many solutions – companies use Standards to build the electrical and electronic components, devices or systems which support smooth and integrated smart city development.
- Standards facilitate the development of strictly defined solutions that are adapted to specific conditions of the city.
- Standards describe good practice and clearly and exactly explain what needs to be used and applied.
- They also highlight what needs to be specified in procurement processes to ensure goods and services supplied are fit for purpose.

There are three main levels (BSI, 2014) of standards relating to smart cities: strategic, process and technical with each playing an important role in evaluation of smart cities (Figure 1 and 2).

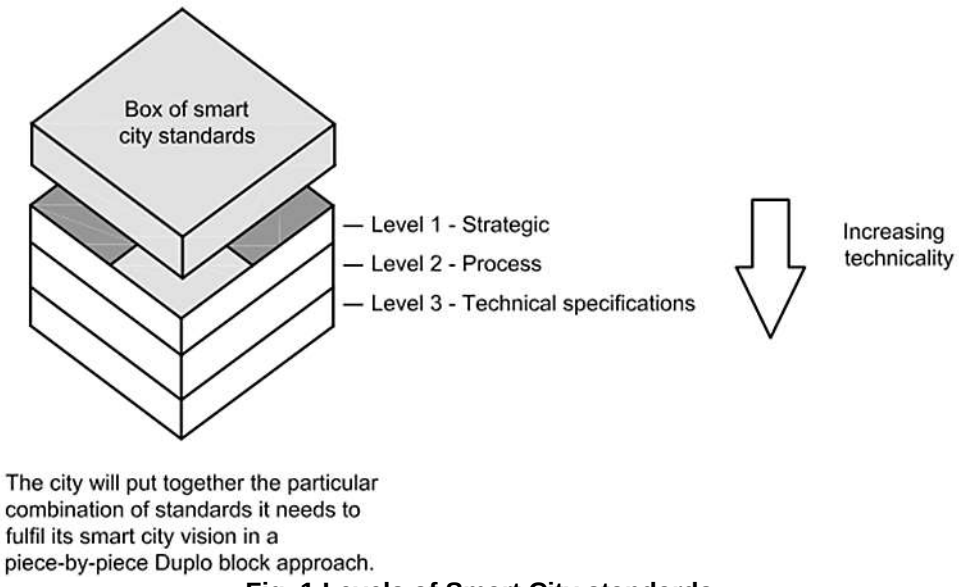

Fig. 1 Levels of Smart City standards

Source: (BSI, 2014)

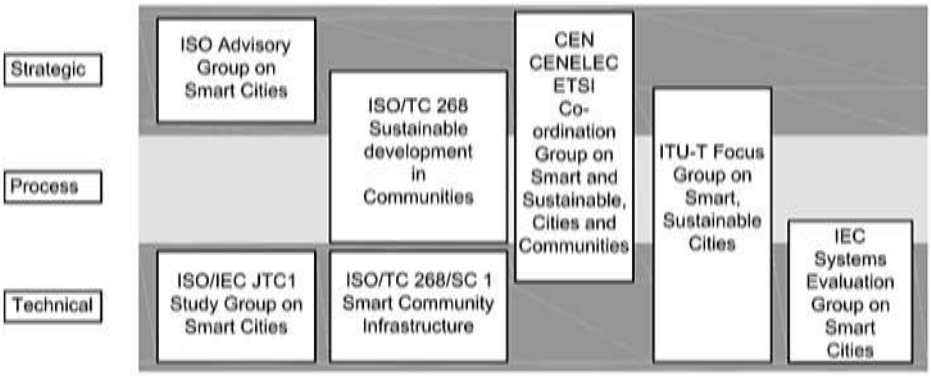

Fig. 2 The BSI Framework for Smart City Standards activities
Source: (BSI, 2014)

Level 1 – Strategic level: standards provide guidance to government leadership and other bodies how to establish and develop smart cities strategy. They include guidance of identifying priorities, how to develop and implement of roadmap and how to monitor and evaluate progress along the roadmap.
Level 2 – Process level: standards cover good practice in procuring and managing of projects realized in smart cities, including guidance with the appropriate financing packages. The standards offer best practices and associated guidelines.
Level 3 – Technical level: standards describe the practical requirements for products and services to ensure that they achieve the results and they meet the objectives.
Strategic-level standards (level 1) are dedicated to government leadership, while process-level standards (level 2) and technical specifications are related to management. The selection of smart cities standards to three groups is listed in the ITU page (ITU).
The ISO standards on sustainable cities were developed by the working group "City indicators" of the committee "Sustainable cities and communities".
The family of standards for smart cities is shown in Figure 3. This family consists of 4 basic standards: ISO 37101, ISO 37120, ISO 37122 and ISO 37123.
Implementation of ISO 37101:2016 standard is useful because (Panos, 2018; Da Silva de Santana et al., 2018):

- help to establish consensus on sustainable development within communities;
- improve the sustainability, smartness and resilience of strategies and other activities performed under the direct consultations of communities;
- evolve and develop multidisciplinary approaches, including life cycle values and total costing;
- support synergies between several entities through a holistic approach;
- increase the efficiency and attractiveness of communities.

ISO 37120: Sustainable cities and communities – Indicators for city services and quality of life. They are key measurements for evaluating a city's service delivery and quality of life. This document defines and establishes methodologies for a

set of indicators to monitor and measure the performance of city services and quality of life. It can be applied in conjunction with ISO 37101 and ISO 37123 as presented in Figure 3. Any city, municipality or local government can applicable this document independently from size and location.

Fig. 3 The relationship between ISO standards establishing smart city assessment indicators

Source: (Huovila et al., 2019)

ISO 37122: Sustainable cities and communities – Indicators for smart cities provides indicators for smart cities. This document was published in 2018. ISO 37122 defines not only indicators but also presents methods and practices that can change significant cities to their social, economic and environmental sustainability. In this document definitions and methodologies for a set of indicators for smart cities are specified and established.

In the opinion of Bernard Gindroz, Chair of ISO/TC 268, Sustainable cities and communities the ISO technical committee, when ISO 37122 will be used in conjunction with ISO 37101 and ISO 37120, this standard helps cities implement and develop smart city projects (ISO/TC 268).

ISO 37122 is complemented by ISO 37123, Sustainable cities and communities – Indicators for resilient cities This standard on resilient cities was published in 2019. In this document definitions and methodologies for a set of indicators on resilience in cities are defined and established. This document is also applicable to any city, municipality or local government independently from size and location and can be implemented in combined with ISO 37120. Also this document follows the principles described in ISO 37101 and can be used in conjunction with this and other strategic frameworks.

Together, the ISO standards form a set of standardized indicators that provide a uniform approach to develop and monitor the progress of cities towards “smart city” concept. The standards also provide guidance to cities on how to assess their performance towards the global roadmap for a more sustainable world.

These standards have been developed with sustainability as a guiding principle and therefore can be used in conjunction to provide a holistic approach to urban sustainability (Huovilaa et al. 2019).

PRACTICAL APPLICATION OF THE INDICATORS IN ISO 37120:2014 STANDARD – WCCD ORGANIZATION

ISO 37120 standard was published for the first time in 2014 and it specified 17 heads, 46 standardized Core, 54 Supporting and 35 profile indicators that provide a uniform approach to what is measured, and how that measurement is to be undertaken – Figure 4.

Fig. 4 Groups of indicators in ISO 37120:2014 standard

Source: (Panos, 2018)

Table 1 presents detailed indicators from ISO 37120 standard divided into groups as well as basic and auxiliary indicators. In 2018, 28 new indicators were updated and added, removal of 24 old ones and slight modification to 10 indicators.

Table 1 City services and quality of life indicators ISO 37120:2014

Groups	Core indicator	Supporting indicator
Economy	City's unemployment rate Assessed value of commercial and industrial properties as a percentage of total assessed value of all properties Percentage of city population living in poverty	Percentage of persons in fulltime employment Youth unemployment rate Number of businesses per 100000 population Number of new patents per 100000 population per year
Education	Percentage of female school-aged population enrolled in school	Percentage of male school-aged population enrolled in school

	Percentage of students completing primary education Percentage of students completing secondary education Primary education student/ teacher ratio	Percentage of school-aged population enrolled in school Number of higher education degrees per 100000 population
Energy	Total residential electrical Energy use per capita (kWh/ year) Percentage of city population with authorized electrical service Energy consumption of public buildings per year (kWh/m²) Percentage of total energy derived from renewable sources, as a share of the city's total energy consumption	Total electrical energy use per capita (kWh/year) Average number of electrical Interruptions per customer per year Average length of electrical interruptions (in hours)
Environment	Fine Particulate Matter (PM2.5) concentration Particulate Matter (PM10) concentration Greenhouse gas emissions measured in tonnes per capita	NO_2 (nitrogen dioxide) concentration SO_2 (sulphur dioxide) concentration O_3 (ozone) concentration Noise pollution Percentage change in number of native species
Finance	Debt service ratio (debt service expenditure as a percentage of a municipality's own-source revenue)	Capital spending as a percentage of total expenditures Own-source revenue as a percentage of total revenues Tax collected as percentage of tax billed
Fire and emergency response	Number of firefighters per 100000 population Number of fire related deaths per 100000 population Number of natural disaster related deaths per 100000 population	Number of volunteer and part time firefighters per 100000 population. Response time for emergency response services from initial call Response time for fire department from initial call
Governance	Voter participation in last municipal election (as a percentage of eligible voters) Women as a percentage of total elected to city-level office	Percentage of women employed in the city government workforce Number of convictions for corruption and or bribery by city officials per 100000 population

		Citizens' representation: number of local officials elected to office per 100000 population Number of registered voters as a percentage of the voting age population
Health	Average life expectancy Number of in-patient hospital beds per 100000 population Number of physicians per 100000 population Under age five mortality per 1000 live births	Number of nursing and midwifery personnel per 100000 population Number of mental health practitioners per 100000 population Suicide rate per 100000 population
Recreation		Square meters of public indoor recreation space per capita Square metreō of public outdoor recreation space per capita
Safety	Number of police officers per 100000 population Number of homicides per 100000 population	Crimes against property per 100000 Response time for police department from initial call Violent crime rate per 100000 population
Shelter	Percentage of city population living in slums	Number of homeless per 100000 population Percentage of households that exist without registered legal titles
Solid waste	Percentage of city population with regular solid waste collection (residential) Total collected municipal solid waste per capita Percentage of the city's solid waste that is recycled	Percentage of the city's solid Waste that is disposed of in a sanitary landfill Percentage of the city's solid waste that is disposed of in an incinerator Percentage of the city's solid waste that is burned openly Percentage of the city's solid waste that is disposed of in an open dump Percentage of the city's solid waste that is disposed of by other means Hazardous waste generation per capita Percentage of city's hazardous waste that is recycled

Telecommunication and innovation	Number of internet connections per 100000 population Number of cell phone connections per 100000 population	Number of landline phone connections per 100000 population
Transportation	Kilometers of high capacity public transport system per 100000 population Kilometers of light passenger public transport system per 100000 population Annual number of public transport trips per capita Number of personal automobiles per capita	Percentage of commuters using a travel mode other than a personal vehicle Number of two-wheel motorized vehicles per capita Kilometers of bicycle paths and lanes per 100000 population Transportation fatalities per 100000 population Commercial air connectivity (number of non-stop commercial air destinations)
Urban planning	Green area (hectares) per 100000 population	Annual number of trees planted per 100000 population Areal size of informal settlements as a per cent of city area Jobs/housing ratio
Wastewater	Percentage of city population served by wastewater collection Percentage of the city's wastewater that has received no treatment Percentage of the city's wastewater receiving primary treatment Percentage of the city's wastewater receiving secondary treatment Percentage of the city's wastewater receiving tertiary treatment	
Water and sanitation	Percentage of city population with potable water supply service Percentage of city population with sustainable access to an improved water source Percentage of population with access to improved sanitation	Total water consumption per capita (liters/day) Average annual hours of water service interruptions per household Percentage of water loss (unaccounted for water)

	Total domestic water consumption per capita (liters/day)	

Source: (ISO 37120:2014)

WCCD (World Council on City Data) has developed the first and so far the only international Global Cities RegistryTM (WCCD) for ISO 37120 in 2014, on which cities from all over the world can compare based on the indicators contained in Table 1.

WCCD is a world leader in collecting standardized data, helping to create smart, sustainable and thriving cities. The WCCD hosts a network of innovative cities committed to improving services and quality of life with open city data and provides a consistent and comprehensive platform for standardized urban metrics. The WCCD is a global hub for creative learning partnerships across cities, international organizations, corporate partners, and academia to further innovation, envision alternative futures, and build better and more liveable cities (WCCD).

With the data contained in database, city authorities can answer the question: How prosperous is my city? by comparing with other cities around the world. Any city that holds an ISO 37120 certificate obtained by WCCD can use this virtual open data platform to report its achievements on the basis of indicators and compare with other cities in different areas. This provides an opportunity for self-assessment and development towards a smart city.

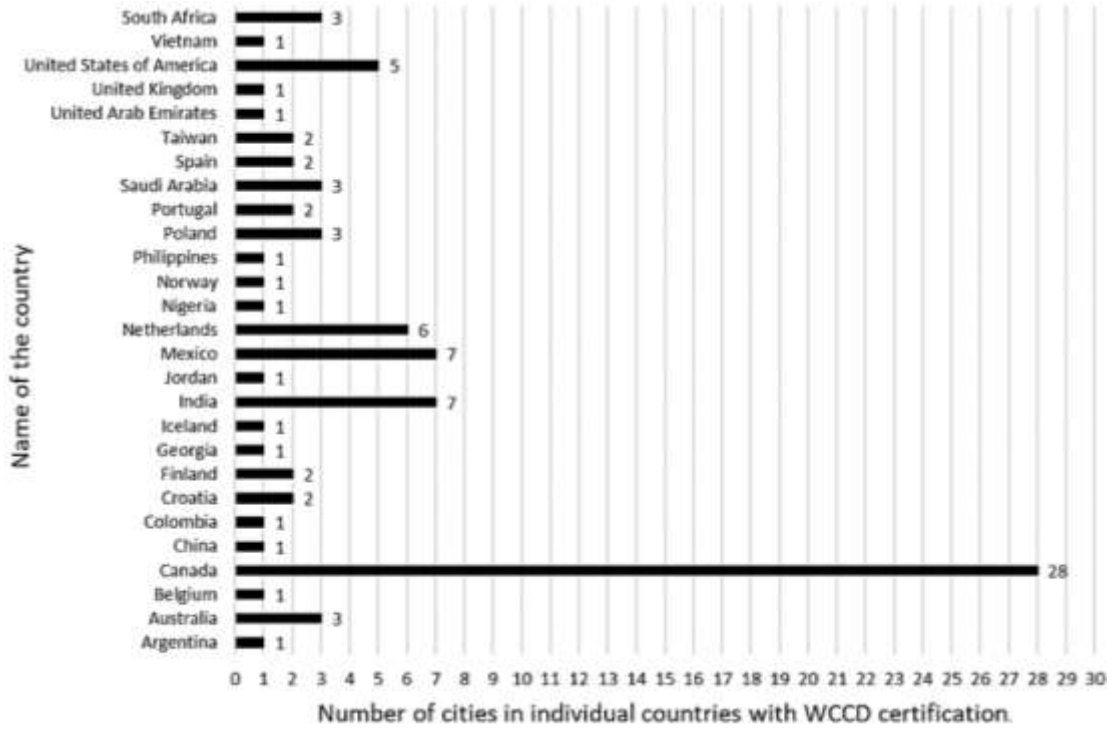

Fig. 5 The number of cities in individual countries that are certified in accordance with ISO 37120 and the WCCD certification system

Source: Own elaboration based on (WCCD)

The WCCD portal registers cities from all over the world. These are not only wealthy cities but also those that are in the development stage. Figure 5 shows the number of cities from individual countries. As can be seen Canada has 28 cities that hold ISO 37120 certification, while the UK has only 1 such city. It is worth noting that Poland has 3 such cities. These are Gdynia, Kielce and Warsaw.

AN EXAMPLE OF USING DATA FROM THE WCCD PORTAL TO COMPARE EUROPEAN CITIES ASPIRING TO BE SMART CITY

On the WCCD portal, it is possible to verify at what level individual cities from all over the world implement the indicators contained in ISO 37120:2014 standard. Since 2014, every year, the portal collects data of all cities that have obtained a certificate of the standard. Everyone interested can analyze the development trends of individual cities, as well as make a comparative analysis of different cities in terms of the indicators of their interest. Currently there are more than 1.2 million data combinations. Therefore, it is a source of extremely important information needed to verify the development of individual cities, but also different regions of the world or individual countries.

Figure 6 shows an exemplary comparison of 21 European cities in terms of renewable energy consumption (this is the primary indicator in the Energy Indicator group) against the size of population living in the individual city.

Fig. 6 Diagram of the relation of energy consumption obtained from renewable sources to the total number of the city' inhabitants. Europe region

Source: (WCCD)

All these cities have been certified by WCCD ISO 37120 in 2014-2018. The Figure shows axes of relationship: amount of energy from renewable sources to population. The size of the point next to individual city indicates the share of renewable sources in energy generation within the city. It can be seen that cities such as Oslo or Copenhagen have the largest share in the use of renewable energy. However, the size of city population is shown on a diagram on the axis

of ordinates. It can be seen that the largest city in Europe in this comparison – London, which is the furthest right point on the chart, has a very small point, which indicates that energy in this city is obtained from renewable sources to a small extent.

It is worthwhile to take a look at the Polish cities here. Figure 7 shows a comparison of the basic indicator from the Energy 7.4 Percentage of total energy derived from renewable sources, as a share of the city's total energy consumption between the cities of Warsaw, Kielce and Gdynia. The rectangle shows how this indicator is shaped for individual cities. It can be seen that the size of the dark bar is the largest in the city of Kielce and is almost invisible for Warsaw. This means that Kielce obtains energy for its households to a much greater extent from renewable sources (it is 19th out of 57 cities in the ranking) than Gdynia (27/57) or Warsaw (49/57).

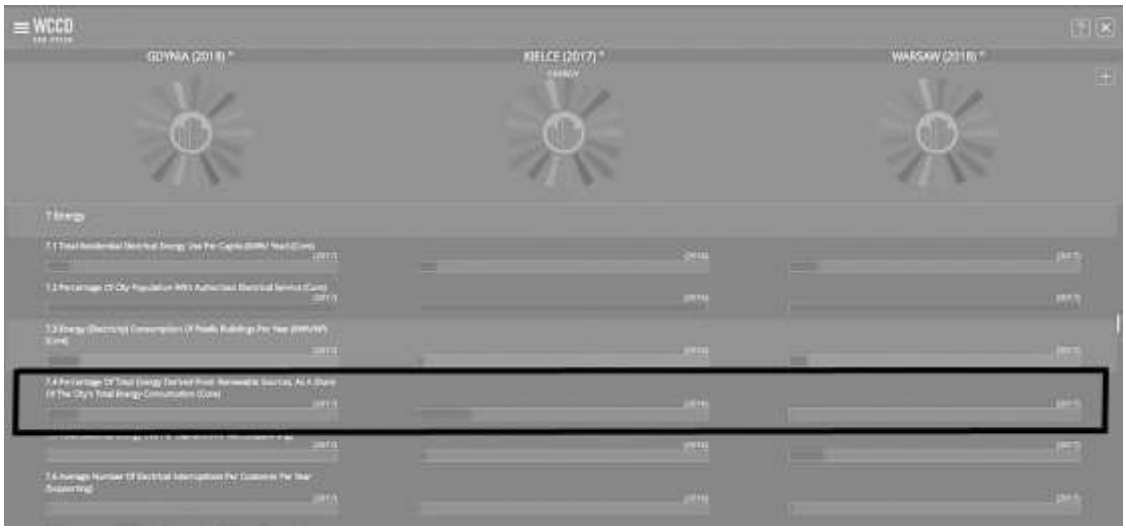

Fig. 7 Comparison of indicators from the Energy group between Polish cities on the WCCD portal

Source: (WCCD)

The WCCD portal offers a wide range of comparison possibilities. As more and more cities become members of the group on the WCCD portal, thus providing data on their sustainability levels, there will be an increased possibility to set trends, relationships between individual indicators or predict future performance values. This will give those who govern cities an instrument that will support them in making decisions about the directions of their cities to be smart cities.

CONCLUSION

Standards can provide a range of benefits to cities and the industries that support them. Diverse standards are available to support smart cities activities. By enabling systems to work together, standards stimulate innovation, making it easier for cities to procure reliable and cost-effective systems to meet their needs.

WCCD organization through its portal has given city authorities certified to ISO 37120 a tool that allows them to verify their goals in the pursuit of a smart city and the possibility to compare in many aspects and in different areas with cities from all over the world in order to improve and promote themselves.

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Abstract: In this article the current and most important standards focusing on smart city sector and organizations issuing them were presented. The standard-setting family for smart cities consists of four basic standards: ISO 37101, ISO 37120, ISO 37122 and ISO 37123. The paper also presents the indicators on the basis of which a city can apply for a certificate of ISO 37120 standard and presents the possibilities of a register of different cities from all over the world in the Global Cities RegistryTM, developed by WCCD (World Council on City Data). Thanks to the data contained in the database, city authorities can answer the question: How prosperous is my city? and compare with other cities from around the world. As an example of the use of WCCD data, a comparison of 21 European cities in terms of the amount of renewable energy consumption in relation to the size of population living in the city has been presented.

Keywords: smart city, ISO 37120 standard, WCCD Organization, smart city indicators