

# Enhancements for ISO 37120 "Sustainable cities and communities" from smart city concept

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## Abstract

Smart cities are characterized as urban places that have information and communication technology mechanisms with an efficient management of resource's use and more citizen participation. In addition, sustainability is a key objective for the smart city implementation. Due to this, some researchers are adopting the expression "smart sustainable cities". Researches are showing the need to use indicators to evaluate if they get their objectives (performance measurement), directing public intervention and new investments, in a continuous improving process. Indicators also are used by cities' comparisons and good examples replying (respecting singularities of each city). The standard ISO 37120:2018 – Sustainable cities and communities - Indicators for city services and quality of life – helps governments and communities suggesting a hundred indicators that could be used by sustainability evaluation, creating a county system measurement, but it hasn't some specific indicators about particular smart city characteristics. Then, through a bibliographic review, a search was made for previous researches that could be used as a reference with complementary smart cities indicators systems, in order to complement the ISO's standard. Researches considered by this review have a holistic cities view, i.e. discussing about all systems and subsystems (transportation, urban infrastructure, ICT, water and sewage, energy, waste, and others). As a result, indicators systems were obtained with ordinal qualitative variables and quantitative. It's possible to perceive similarity in some variables from different systems but having different weights. There are some indicators overlapping ISO ones. In the end of this research, they're suggested two enhancements: (1) some of these indicators for an ISO increase and (2) modify overlapping ISO indicators with smart cities concept.

**Keywords:** Smart cities, ISO 37120, Smart Sustainable Cities, Indicators, Performance measurement.

## 1. Introduction

The International Organization for Standardization (ISO) defines sustainable development as the way of development with the environmental, social and economic needs of the present are considered in parallel of future generation needs (International Organization for Standardization, 2016). This development is an answer for urban problems such as population expansion, traffic congestion and environmental pollution, for example, that are growing (Pan, et al., 2017).

According to British Standards Institution (BSI), *smart cities* are urban places that have human, physical and digital systems effectively integrated in the built environment. This characteristic brings some benefits like a sustainable, prosperous and inclusive future for its citizens (British Standards Institution, Department for Business Innovation & Skills, 2014a) and justify the synonym *smart sustainable cities* (Hara, et al., 2016).

The expression *smart cities* hasn't a rigid meaning, once that changes over time. Reviewing scientific production in the last ten years (integrative bibliometric review), there are articles emphasizing a lot of benefits, and others criticizing the excessive focus on technology. However, when the city has a better data management, it's possible to get holistic solutions involving the different urban systems (Abreu & Marchiori, 2018).

To get all of these benefits, it's important monitoring the city performance, including temporal analysis. Information and indicators can contribute in city-to-city comparisons, support integrated policy and decision making. In addition, there is a possibility of identifying pitfalls and opportunities. (Strzelecka, et al., 2016).

A world reference in creation of indicators systems about sustainability communities is the standard ISO 37120 - *Sustainable cities and communities - Indicators for city services and quality of life* (Eremia, et al., 2017). It was created using the principles of sustainable development presented in the standard ISO 37101 - *Sustainable development in communities - Management system for sustainable development - Requirements with guidance for use* (International Organization for Standardization, 2016, 2018a).

The ISO 37120 has a hundred indicators for measuring sustainability, but there aren't specific proposed indicators for smart cities characteristics (British Standards Institution. Department for Business Innovation & Skills., 2015). The aim of this research is to get complementary smart cities indicators systems, contributing to the ISO 37120 through a bibliographic narrative review, as an enhancement of this standard.

## 2. The standard ISO 37120

The standard ISO 37120:2018 is the second version, revised from the 2014 edition. According to International Organization for Standardization, their standards are reviewed in a period of five years (International Organization for Standardization, 2014). The *Table 1* has a brief set of characteristics of this standard:

*Table 1: ISO 37120 characteristics (International Organization for Standardization, 2018b, 2018c, Associação Brasileira de Normas Técnicas, 2017)*

<b>Importance</b>	In cities, there are seventy percent of global GDP and fifty-three percent of world’s population. In the year 2050, is estimated that urban population will be seventy percent. Because of this, is important to do effective management and evidence-based policies considering an aim of sustainable future and development.
<b>Schematic themes</b>	<ul style="list-style-type: none"> <li>• <i>Economy.</i></li> <li>• <i>Education.</i></li> <li>• <i>Energy.</i></li> <li>• <i>Environment and climate change.</i></li> <li>• <i>Recreation.</i></li> <li>• <i>Safety.</i></li> <li>• <i>Solid waste.</i></li> <li>• <i>Sport and culture.</i></li> <li>• <i>Reporting and record maintenance.</i></li> <li>• <i>Finance.</i></li> <li>• <i>Governance.</i></li> <li>• <i>Health.</i></li> <li>• <i>Housing</i></li> <li>• <i>Population and Social Condition</i></li> <li>• <i>Transportation.</i></li> <li>• <i>Urban/local agriculture and food security.</i></li> <li>• <i>Urban planning.</i></li> <li>• <i>Wastewater.</i></li> <li>• <i>Water.</i></li> <li>• <i>Telecommunication.</i></li> </ul>
<b>Way of measuring telecommunications</b>	It’s considered indicators that measure mobile connection and internet access by this standard, with a rate from a basis of hundred thousand inhabitants.
<b>Users</b>	The international standard ISO 37120 could be used by stakeholders involved in municipality or region government.
<b>Indicators</b>	There are a hundred indicators (qualitative and quantitative). These ones are all suggested for a selection and adoption considering local necessities.
<b>Benchmarking</b>	There aren’t optimal values for these indicators. Then, it’s important considering an equal method of measurement for create comparisons over time and city-to-city.

The main idea of this standard is summarized by the Table 1. However, the ISO 37120:2018 could be expanded with indicators that encompass smart city concept. The link between smart cities and sustainable cities is reinforced by a lot of studies (such as Hara et al., 2016), justifying the expansion.

### 3. Method

This paper uses a narrative review in search engines or other standards (article review). According to Silva & Menezes (2005), this one is a research classified as: qualitative (involves information, not numeric data), exploratory and bibliographic. The *Figure 1* has the research framework:

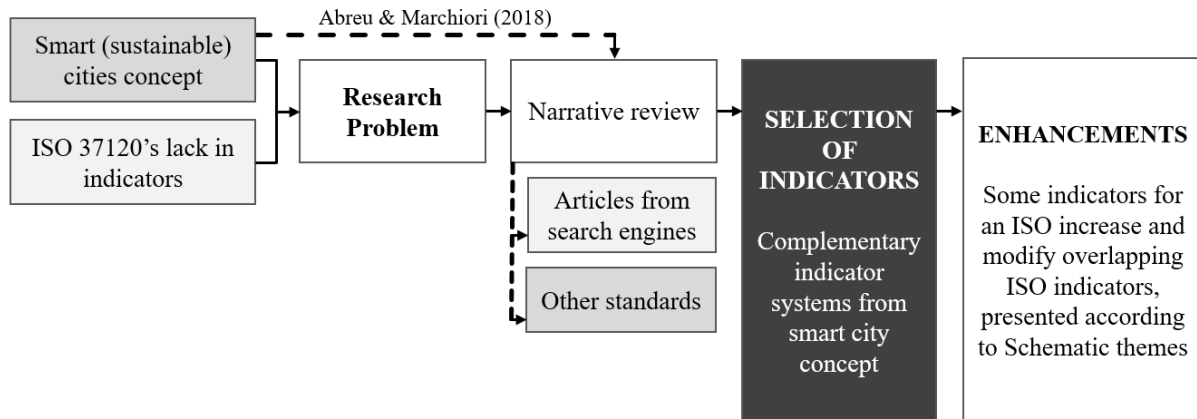


Figure 1: Method (Authors, 2018)

### 3.1 Definition of Smart City concept

There isn't a consensus about smart city concept (Eremia, et al., 2017). Trying to compare different conclusions from researches with this matter, Abreu & Marchiori (2018) did an integrative bibliometric review in search engines (ASCE Library, Scopus and EBSCO host) using the method *SystematicSearchFlow (SSF)* proposed by Ferenhof & Fernandes (2016). This paper considered the result from this integrative review as the concept of smart city.

The concept obtained by these authors has the holistic view indicated from many authors. For example, Fernández-Güell, et al. (2016) affirmed that cities are complex systems – are adaptive and aren't deterministic predictable. Cities are more complex than the sum of their parts. Smart cities (or *smart sustainable cities*) are the future of our cities according lots of researches in urban deployment. In the next years, will be possible two movements: creation and adaptation from existing cities to smart cities, as an answer for problems that is getting worse together the growing world population. Considering the triple bottom line of sustainability, *environmental* and *economic* spheres get increase benefits with the better use of natural resources and work/economic opportunities. *Social* sphere needs solutions over the urban systems optimization from a big technology infrastructure (Li & Liu, 2013).

Considering only the better use of natural resources, the smart metering helps to produce knowledge in use of urban systems such as water and energy. This knowledge is used in estimation's consumption adjustment, because initial versions of master plans could have superestimation in water end uses and its related demand of energy. In the other side, consumers have more information and could be use these resources in a better way (Siddiqi & Weck, 2013).

One key-word of smart city is *communication* because it requires constant dissemination of information. This characteristic includes intercommunication of resources, energy, information systems and between monitoring equipment and control of services and participation. The management of the different systems that are parts of a city should be interconnected as a tool of development. Urban design, democracy, participation, ICT and telecommunication are all elements of the new strategic vision for smart cities (Zubizarreta, et al., 2016).

### 3.2 ISO 37120's analysis

The standard ISO 37120:2014 was analyzed by the authors that observed sustainability indicators, but not viewed the relation between smart cities and sustainability expressed in proposed indexes. This

characteristic is corroborated by British Standards Institution. Department for Business Innovation & Skills (2015). In July, was published the second edition, ISO 37120:2018<sup>1</sup> presents adjustments like the remotion of the proposed indicator of landfone access, justified by the trend of mobile phone use, for example, but is still verified there aren't specific indicators with the smart city concept, being an opportunity of enhancement.

### 3.3 Review of indicators for smart city systems

To get appropriate indicators for smart cities characteristics, a search was made using the string "smart cit\*" in the following databases: ASCE, Scopus, EBSCO Host and DOAJ. After the abstract and title reading, seven publications of approximately four hundred were selected:

- **Rad, et al., 2017:** Indicators are presented considering the different systems and a Likert scale with (0; 0,5 and 1) as the weights. There are twelve categories: U-citizens, U-policy, U-home, U-environment, U-power network, U-water network, U-transportation, U-health, U-security, U-economy and U-education.
- **Wu, et al., 2016:** This system was improved three times, reducing the number of indicators for an easy adoption. There are four indicators in each dimension: environment & construction, governance & public service, economy & industries, informatization and innovative human resource.
- **Marsal-Llacuna & López-Ibáñez, 2014:** There is a proposed a time-use method. The indicators measurement is the time spend in weekly activities compared with the use of urban space (considering the city studied or neighborhood). The finality is contributing in smart city master plan reviews of land use classes.
- **Pantazis, et al., 2017:** There is an overall KPI named S<sup>2</sup>I<sup>2</sup> (Smart sustainable islands index) is composed of five dimensions (ICT & economy, Resource sustainability, infrastructure, Quality of life and Society) with sub-dimensions (indicators).
- **Garau & Pavan, 2018:** The I<sub>SUQ</sub> (Indicator of Smart Urban Quality) is the sum of six indicators (use and fruition, health and wellbeing, appearance, safety and security, management, environment) composed by sub-indicators. The best category of I<sub>SUQ</sub> sum is since seven hundred to the maximum score of seven hundred sixty points (excellent quality).
- **Hara, et al., 2016:** This system has four layers of indicators. The first layer has the triple bottom line with the satisfaction dimension. From first to third layers the unit is monetary value, but the fourth layer is measured with percentage, weight, time and other units).
- **Strzelecka, et al., 2016:** This article shows the City Amberprint Indicators. There are better focus on telecommunications, with eight related indicators.

There are other standards about smart cities that were published. These ones and complementary references were reviewed:

- PD 8100:2015 – Smart cities overview – Guide (BSI Standards Publication).
- PD 8101:2014 – Smart cities – Guide to the role of the planning and development process (BSI Standards Publication).
- Smart Cities Stakeholder Platform – Integrated Action Plan – Report Process & Guidelines (European Commission).
- Orchestrating infrastructure for sustainable Smart Cities (IEC<sup>®</sup>).

This review doesn't result indicators systems except in International Eletrotecnical Commission

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<sup>1</sup> It was accessed using the International Organization for Standardization website and verified updates. The international standards from ISO are translated in countries around the world by the official entities for standardization. In Brazil, this entity is ABNT (*Associação Brasileira de Normas Técnicas* - Brazilian Association for Technic Standards), that translated and adjusted for the local actuality the standard ISO 37120:2014. Therefore, the previous version is still valid in Brazil (ABNT, 2017).

(2014). This white paper brings a guide to evaluate an implementation for a smart city compared to a normal city with a holistic concept. But, the majority part of the indicator system is useful by energy solutions, using Likert scale of one to five with qualitative descriptions for each score.

## 4. Results

After the review of indicator systems about smart cities and the parallel of ISO 37120:2018, a proposed set of suggested indexes for addition or complement is showed in the *Table 2*. With this suggestion, this standard stay could be used in normal cities, but it's possible to use it in smart cities too.

*Table 2a – Suggested indicators resulted by this review (produced by Authors, 2018)*

<b>Schematic themes of ISO 37120</b>	<b>Suggested indicators related: *(addition), ** (complement).</b>	<b>Reference</b>
<b>Education</b>	The ability to monitor student attendance through smart cards.*	Rad, et al., 2017
<b>Energy</b>	Integration into the existing urban energy system (facilities and infrastructures) of new smart cities solutions.*	International Eletrotecnical Commission, 2014
	Potential scale-up and replication of new smart cities solutions.*	International Eletrotecnical Commission, 2014
	The ability to have alternative energy suppliers, even at the house level.*	Rad, et al., 2017
<b>Safety</b>	The ability to provide early warning of disasters.*	Rad, et al., 2017
<b>Governance</b>	The existence of a central data warehouse for storing, retrieving and accessing data.*	Rad, et al., 2017
	Online openness of non-confidential governmental documents.*	Wu, et al., 2016, Pantazis, et al., 2017
	Online civic engagement participation.*	Pantazis, et al., 2017
	Information leakage rate.*	Hara, et al., 2016
<b>Health</b>	The existence of a comprehensive database about public health.*	Rad, et al., 2017
	The ability to remotely visit and control patients.*	Rad, et al., 2017
<b>Housing</b>	The ability to measure energy, gas, and water consumption by household appliances.*	Rad, et al., 2017
	The existence of smart devices and appliances (smart phone, smart mailbox, smart TV, smart floor, etc.).** - complementing the set "Housing profile indicators".	Rad, et al., 2017, Pantazis, et al., 2017
	The ability to share internet and entertainment content with other smart appliances and other smart homes. ** - complementing the set "Housing profile indicators".	Rad, et al., 2017

Table 2b – Suggested indicators resulted by this review (produced by Authors, 2018)

<b>Schematic themes of ISO 37120</b>	<b>Suggested indicators related: *(addition), ** (complement).</b>	<b>Reference</b>
<b>Population and social condition</b>	Services for people with disabilities.*	Garau & Pavan, 2018
<b>Urban planning</b>	Online openness of future city construction plan.*	Wu, et al., 2016
	Proportion between urban land use and urban time use.*	Marsal-Llacuna & López-Ibáñez, 2014
<b>Telecommunication</b>	Free Wi-Fi coverage in public space.*	Wu, et al., 2016
	ICT use in different areas (transport, waste management, energy utilities, water utilities, infrastructure investment).	Strzelecka, et al., 2016

The use in smart cities when are added indexes is justified, according to the bibliographic review, because in these cities:

- ICT technologies are used as tools to improve public services and efficiency. A indicators system about smart cities need to consider the presence of these technologies and, for a better relation between costs and benefits, to consider both in an analysis. Another important question is, considering a city that wish to change to a smart city, the implementation of smart technologies and integration with existing infrastructure, because there are a lot of problems and costs in remove all the existing facilities (almost impracticable).
- Telecommunication is not only measurable with mobile connection of internet, but with all kinds of connection, because web access is useful for all citizens and, in some countries around the world, the Wi-Fi connection is more used (or only used) as a way to get connection with the world wide web. Because of this fact, it's justified the indicator "Free Wi-Fi coverage in public space" proposed by Wu et al. (2016).
- The citizen participation in city decisions could to be facilitated with government transparent tools. There are researches about smart cities that shows the benefit of the use of these tools in transparency and public services improving quality and easiness.
- House infrastructure has more technology gadgets. These facilities are used with the aim of automate home tasks and exchange information between homes and public services. These public services get more information, with present validity and remove the delay and errors in periodic government census.
- Considering the public health service, the technology represents an opportunity of enhancement with health databases. This tool allows to improve attendance, including another health professionals in another cities or city districts that could do better services.
- It's important and could improve city management the use of information from smart sensors, but security needs to get attention, oppose information leakage.

The suggested indexes have characteristics about smart cities that the standard ISO 37120 doesn't contemplate in these original indexes. There isn't another standard produced by the International Organization for Standardization with specific indexes for smart cities, and the mentioned standard is considered the near standard of a smart sustainable city.

## 5. Conclusion

This paper has a review of indicators for smart cities performance measurement. It got its aim of obtain more indicators for a future ISO 37120 standard enhancement. This standard has a group of indicators for measuring sustainability in cities, but it's possible adding specific indicators considering smart sustainable cities characteristics.

The ISO 37120 has a suggestive group of indicators and there aren't optimal values. Now, it's possible to merge with another indicator systems (suggested as a result), but with indicators from smart sustainable cities concept incorporated, this standard could be more profound, useful for all kind of city.

Smart cities bring a promise of more sustainable places. Because of this aspect, there are overlap in some indicators in these systems and proposed indicators by ISO 37120, considered across the research development.

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## References

Abreu, J. P. M. d. & Marchiori, F. F., 2018. Definição do conceito e dos componentes de avaliação de uma smart city – uma revisão sistemática. *XVII Encontro Nacional de Tecnologia do Ambiente Construído*.

Associação Brasileira de Normas Técnicas, 2017. *ABNT NBR ISO 37120:2017 - Desenvolvimento sustentável de comunidades — Indicadores para serviços urbanos e qualidade de vida*. [Online] Available at: <http://www.abntcatalogo.com.br/norma.aspx?ID=366389> [Accessed 08 may 2018].

British Standards Institution, Department for Business Innovation and Skills, 2014. *PAS-180: Smart cities - vocabulary*. s.l.:BSI.

British Standards Institution, Department for Business Innovation and Skills, 2014. *Smart cities - Guide to the role of the planning and development process*. [Online] Available at: <https://www.bsigroup.com/en-GB/smart-cities/Smart-Cities-Standards-and-Publication/PD-8101-smart-cities-planning-guidelines> [Accessed 2018 may 2018].

British Standards Institution. Department for Business Innovation & Skills., 2015. *PD 8100 Smart city overview*. [Online] Available at: <https://www.bsigroup.com/en-GB/smart-cities/Smart-Cities-Standards-and-Publication/PD-8100-smart-cities-overview/> [Accessed 12 september 2018].

Eremia, M., Toma, L. & Sanduleac, M., 2017. The Smart City Concept in the 21 st Century. *Procedia Engineering*, pp. 12-19.

- Ferenhof, H. A. & Fernandes, R. F., 2016. Desmistificando a revisão de literatura como base para redação científica: método SSF. *Revista ACB*, august/november, 21(13), pp. 550-563.
- Fernández-Güell, J.-M., Collado-Lara, M. & Guzmán-Araña, S., 2016. Incorporating a systemic and foresight approach into smart city initiatives: the case of Spanish cities. *Journal of urban technology*, 23(3), pp. 43-67.
- Garau, C. & Pavan, V. M., 2018. Evaluating Urban Quality: Indicators and Assessment Tools for Smart Sustainable Cities. *Sustainability*, 25 february, Volume 10, pp. 1-18.
- Hara, M., Nagao, T., Hannoe, S. & Nakamura, J., 2016. New Key Performance Indicators for a Smart Sustainable City. *Sustainability*, 3 march, Volume 206.
- Hara, M., Nagao, T. & Nakamura, J., 2016. New Key Performance Indicators for a Smart Sustainable City. *Sustainability*, 3 march, Volume 8, pp. 1-19.
- International Eletrotecnical Commission, 2014. *International Standards and Conformity Assessment for all electrical, electronic and related technologies*. [Online]  
Available at: <http://www.iec.ch/whitepaper/smartcities/>  
[Accessed 08 may 2018].
- International Organization for Standardization, 2014. *ISO 37120:2014 - Sustainable development of communities -- Indicators for city services and quality of life*. [Online]  
Available at: <https://www.iso.org/standard/62436.html>  
[Accessed 13 september 2018].
- International Organization for Standardization, 2016. *ISO 37101 - Sustainable development in communities*. [Online]  
Available at: <https://www.iso.org/publication/PUB100394.html>  
[Accessed 12 september 2018].
- International Organization for Standardization, 2018a. *ISO 37120:2018. Sustainable cities and communities -- Indicators for city services and quality of life*. [Online]  
Available at: <https://www.iso.org/standard/68498.html>  
[Accessed 12 september 2018].
- International Organization for Standardization, 2018b. *ISO 37120 briefing note: the first ISO International Standard on city indicators*. [Online]  
Available at: <https://www.iso.org/standard/62436.html>  
[Accessed 13 september 2018].
- International Organization for Standardization, 2018c. *ISO 37120 - Sustainable development of communities - Indicators for city services and quality of life*. s.l.:s.n.
- Li, Y. & Liu, A., 2013. Analysis of the challenges and solutions of building a smart city. *ICCREM*.
- Marsal-Llacuna, M. L. & López-Ibáñez, M.-B., 2014. Smart Urban Planning: Designing Urban Land Use from Urban Time Use. *Journal of Urban Technology*, Volume 21, pp. 39-54.
- Pan, S., Sun, Y. & Cong, W., 2017. Research on the Evaluation of Smart City Development Level Based on “Galaxy” Model. *ICCREM*, pp. 380-391.
- Pantazis, D. N. et al., 2017. Smart Sustainable Islands VS Smart Sustainable Cities. *2nd International Conference on Smart Data and Smart Cities*, 4-6 october, pp. 45-53.
- Rad, T. G., Sadeghi-Niaraki, A., Abbasi, A. & Choi, S.-M., 2017. A methodological framework for assessment of ubiquitous cities using ANP and DEMATEL methods. *Sustainable Cities and Society*.
- Siddiqi, A. & Weck, O. L. d., 2013. Quantifying End-Use Energy Intensity of the Urban Water Cycle. *Journal of Infrastructure Systems*, 1 december, 19(4), pp. 474-485.

Silva, E. L. d. & Menezes, E. M., 2005. *Metodologia da pesquisa e elaboração da dissertação*. 4 ed. Florianópolis(Santa Catarina): UFSC.

Strzelecka, A. et al., 2016. Integrating water, waste, energy, transport and ICT aspects into the smart city concept. *18th Conference on Water Distribution System Analysis, WDSA 2016*, p. 609–616.

Wu, Z., Pan, Y., Ye, Q. & Kong, L., 2016. The City Intelligence Quotient (City IQ) Evaluation System: Conception and Evaluation. *Engineering*, pp. 196-211.

Zubizarreta, I., Seravalli, A. & Arrizabalaga, S., 2016. Smart city concept: what is and what it should be. *Journal of Urban Planning and Development*, 01 march, 142(1), p. 04015005.