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Sustainable cities and communities — Indicators for smart cities

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National foreword

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Sustainable cities and communities — Indicators for smart cities

Villes et communautés territoriales durables — Indicateurs pour les villes intelligentes

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

The committee responsible for this document is ISO/TC 268, *Sustainable cities and communities*.

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.

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Introduction

The indicators detailed in ISO 37120 have quickly become the international reference point for sustainable cities. ISO/TC 268/WG2 experts have identified the need for additional indicators for smart cities.

This document complements ISO 37120 and establishes indicators with definitions and methodologies to measure and consider aspects and practices that dramatically increase the pace at which cities improve their social, economic and environmental sustainability outcomes.

This document, when used in conjunction with ISO 37120, helps cities to identify indicators for applying city management systems such as ISO 37101 and to implement smart city policies, programmes and projects to:

— respond to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how they engage society;

— apply collaborative leadership methods, work across disciplines and city systems;

— use data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors);

— provide a better life environment where smart policies, practices and technology are put to the service of citizens;

— achieve their sustainability and environmental goals in a more innovative way;

— identify the need for and benefits of smart infrastructure;

— facilitate innovation and growth;

— build a dynamic and innovative economy ready for the challenges of tomorrow.

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Sustainable cities and communities — Indicators for smart cities

1 Scope

This document specifies and establishes definitions and methodologies for a set of indicators for smart cities.

As accelerating improvements in city services and quality of life is fundamental to the definition of a smart city, this document, in conjunction with ISO 37120, is intended to provide a complete set of indicators to measure progress towards a smart city. This is represented in Figure 1.

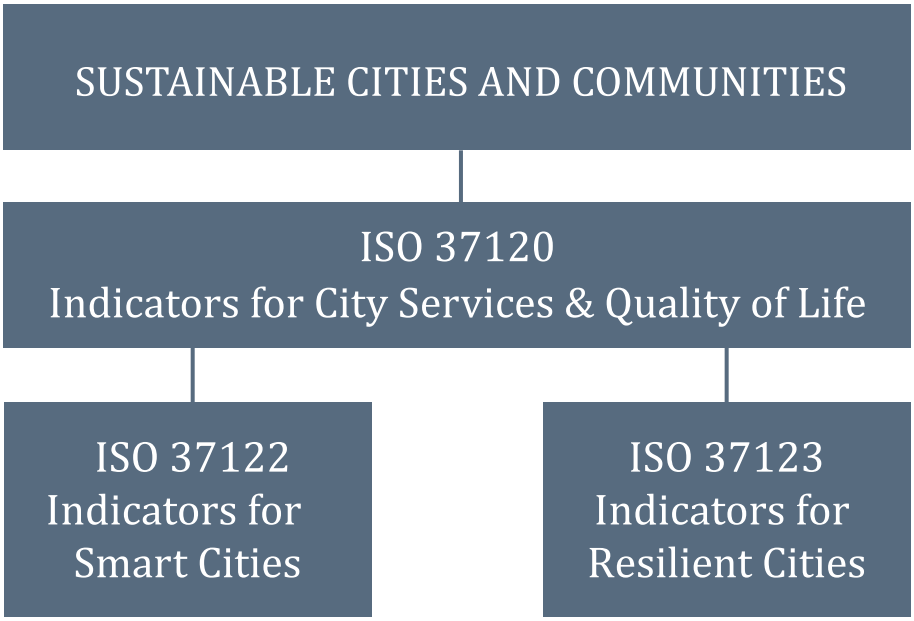

Figure 1 — Sustainable development of communities — Relationship between the family of city indicators standards

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For updated references, the latest edition of the referenced document (including any amendments) applies.

ISO 37101, *Sustainable development in communities — Management system for sustainable development — Requirements with guidance for use*

ISO 37120, *Sustainable cities and communities — Indicators for city services and quality of life*

3 Terms and definitions for cities

For this document, the terms and definitions in ISO 37101 and ISO 37120 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

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

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

3.1
gigajoule
measure of the energy that is equivalent to 1 billion joules (J), where 1 J is the amount of energy required to send an electrical current of one ampere through a resistance of one ohm for one second

Note 1 to entry: One gigajoule (GJ) is equivalent to 277,8 kilowatt hours (kWh)

3.2
per 100 000 population
for every 100 000 of the city's population

Note 1 to entry: The choice of 100 000 population was made to enable cities of different sizes to compare results with each other relatively easily and effectively. It should be noted that in some countries the statistic per 1 000 capita is collected and a slight mathematical adjustment might be necessary to reflect this difference to obtain an accurate comparison. The measure of per 1 000 population might be a more applicable measure for small cities.

3.3
public building
government-owned or leased building that functions as a municipal and administrative office, library, recreation centre, hospital, school, fire station or police station

Note 1 to entry: Ownership of buildings (public or private) is variously defined according to region and political system. The restrictive definition used here permits global comparability across cities.

3.4
smart city
city that increases the pace at which it provides social, economic and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without unfair disadvantage of others or degradation of the natural environment

Note 1 to entry: A smart city also faces the challenge of respecting planetary boundaries and taking into account the limitations these boundaries impose.

Note 2 to entry: There are numerous definitions of a smart city; however, the definition that is used within TC268 is the official one agreed to by the ISO Technical Management Board.

3.5
biosolid
mixture of water and solids separated from various types of water as a result of natural or artificial processes

4 City indicators

This document is designed to assist cities in steering and assessing the performance management of city services as well as quality of life. It considers sustainability as its general principle and "smart city" as a guiding concept in the development of cities. Indicators shall be reported on an annual basis. Depending on their objectives in term of smartness, cities will choose the appropriate set of indicators from this document to be reported.

For data interpretation purposes, cities shall take into consideration contextual analysis when interpreting results. The local institutional environment can affect the capacity to apply indicators. In some cases, services can be delivered by the private sector or the community itself.

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The list of indicators is based on the following criteria:

— Completeness: indicators should measure and balance all relevant aspects for evaluation of the smart city.

— Technology neutral: not favouring one technology over another, existing or future.

— Simplicity: indicators can be expressed and presented in an understandable and clear way.

— Validity: indicators are an accurate reflection of the facts and data that can be collected using scientific techniques.

— Verifiability: indicators are verifiable and reproducible. Methodologies are rigorous enough to give certainty to the level of implementation of the criteria.

— Availability: quality data are available, or it is feasible to initiate a secure and reliable monitoring process that will make them available in the future.

When interpreting the results of a particular service area, it is important to review the results of multiple types of indicators across themes; focusing on a single indicator can lead to a distorted or incomplete conclusion. Elements of aspiration should also be taken into consideration in the analysis.

Users can also consider the following aspects which shall be clearly stated in the report and justified: indicators can be aggregated to larger administrative areas (e.g. region, metropolitan area); indicators can be grouped for analysis when taking into consideration the holistic characteristics of a city; and, this set of indicators can be complemented by other indicator sets in order to have a more comprehensive holistic approach for the analysis of smart and sustainable cities.

Furthermore, it is also important to acknowledge potential antagonistic effects of the outcome of particular indicators, either positive or negative, when analysing results.

Data sources can vary depending on the cities and can be different from the ones indicated in this document. However, data shall be verifiable, auditable, trustworthy and justified. Cities might not have access to all data required for indicators within this document as the services are performed by a third party. However, it is still important for cities to obtain this data. An important component of smart cities is the role of public/private partnerships and this collaboration, including sharing of data, should be encouraged.

Cities using this document shall report at least 50 % of the indicators in this document as it is meant to be used in conjunction with ISO 37120. “Smart cities” is a relatively new and evolving concept that cities worldwide are addressing and it is important that cities report progressively more indicators in this document over time.

Moreover, for each indicator, the correspondence with the issues of ISO 37101 is noted [for consistency with Annex A and with the United Nations Sustainable Development Goals (SDGs) (Annex B)].

5 Economy

5.1 Percentage of service contracts providing city services which contain an open data policy

5.1.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 An open data policy demontrates a city's commitment to better manage business information throughout the information lifecycle. Identifying and making data accessible helps to ensure that the public is informed and engaged through a transparent, accountable and accessible government.

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NOTE 2 This indicator reflects the "Governance, empowerment and engagement", "Innovation creativity and research" and "Economy and sustainable production and consumption" issues as defined in ISO 37101. It can allow an evaluation of the contribution to "Attractiveness" and "Responsible resource use" purpose of the city as defined in ISO 37101.

5.1.2 Indicator requirements

The percentage of service contracts providing city services which contain an open data policy shall be calculated as the total number of service contracts providing city services which contain an open data policy (numerator) divided by the total number of service contracts in the city (denominator). The result shall then be multiplied by 100 and expressed as the percentage of service contracts providing city services which have an open data policy.

Open data policy shall refer to data that are to be provided to and used by the city which can be analysed and open to the public, including residents and non-residents of the city.

Service contracts shall refer to agreements with businesses providing city services.

City services shall refer to services provided by the city and typically cover the following areas: utilities, garbage and recycling; public safety; fire department; roads and traffic; recreation; construction; bylaws, violations and enforcement; permits and licences; planning; building; policies, projects and initiatives; rentals and catering of city buildings; water, wastewater and sewers; and property taxes and utilities.

5.1.3 Data sources

Data from service contracts should be sourced from relevant city departments, or market research companies and survey companies.

5.1.4 Data interpretation

A higher percentage of service contracts providing city services which have data openly available leads to greater transparency of city service performance and a technologically forward community. This allows people to review the data and performance of businesses contracted by the city to complete city services that are not normally covered by performance measurements published by the city.

5.2 Survival rate of new businesses per 100 000 population

5.2.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 New businesses make a positive contribution to local economies, and start-up activity can signal a city's economic potential. New businesses can potentially contribute a substantial number of new jobs to the economy and tend to have faster employment growth rates, especially those in innovation-driven/technologically focused enterprises, such as computer or software development.

NOTE 2 This indicator reflects the "Economy and sustainable production and consumption" and "Innovation, creativity and research" issues as defined in ISO 37101. It can allow an evaluation of the contribution to the "Attractiveness" and "Resilience" purpose of the city as defined in ISO 37101.

5.2.2 Indicator requirements

The survival rate of new businesses per 100 000 population shall be calculated as the survival rate of new businesses in the city (numerator) divided by 1/100 000 of the city's total population (denominator). The result shall be expressed as the survival rate of new businesses per 100 000 population.

Survival rate shall refer to those new businesses which have been created during the last two years, registered in the city and still operating during the last year (numerator) divided by the total number

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of new businesses which have been created during the last two years and registered in the city (denominator).

Businesses shall refer to companies or enterprises in the city.

These businesses can be considered to have innovative business processes and/or products. Cities reporting on this indicator shall specify the sectors and categories of innovative businesses that are included in this calculation. The enterprise is the smallest combination of legal unit, which is an organisational unit producing goods or services. Business can either be categorised as simple (one operating entity) or complex (multiple operating entities) as stated in ISO 37120:2018, 5.5.2. An innovative business refers to a business that is implementing new ideas, creating dynamic products or improving existing services in any industry.

5.2.3 Data sources

Data on new businesses should be obtained through relevant city departments or ministries that oversee the approval of new business licenses or new registrations of businesses.

5.3 Percentage of the labour force employed in occupations in the information and communications technology (ICT) sector

5.3.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 The information and communications technology (ICT) sector is a combination of manufacturing and services industries that capture, transmit and display data and information electronically[8]. With the rapid development of ICT and the mainstreaming of ICT into everyday life, the link between ICT technologies and human development has never been more evident. ICT has long been recognized as a key enabler for bridging the digital divide and achieving the three dimensions of sustainable development – economic growth, environmental balance and social inclusion – as well as promoting innovation in society[7]. Thus, having a labour force to develop the ICT sector will help to drive economic growth, augment labour productivity and enhance international competitiveness via innovative ICT development, including by the wider use of ICT products and services across the economy and society.

NOTE 2 This indicator reflects “Innovation creativity and research”, “Education and capacity building” and “Economy and sustainable production and consumption” issues as defined in ISO 37101. It can allow an evaluation of the contribution to “Attractiveness” and “Resilience” purposes of the city as defined in ISO 37101.

5.3.2 Indicator requirements

The percentage of the labour force employed in occupations in the ICT sector shall be calculated as the number of city residents in the labour force employed in occupations in the ICT sector (numerator) divided by the city’s total labour force (denominator). The result shall then be multiplied by 100 and expressed as the percentage of the labour force employed in occupations in the ICT sector.

The ICT sector shall refer to a combination of manufacturing and services industries that capture, transmit and display data and information electronically. For manufacturing industries, the products of a candidate industry must be intended to fulfil the function of information processing and communication including transmission and display, and must use electronic processing to detect, measure and/or record physical phenomena or control a physical process. For services industries, the products of a candidate industry must be intended to enable the function of information processing and communication by electronic means[8].

More specifically, the ICT sector shall refer to the United Nations Statistics Division’s International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4 (https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf) section J (Information and communication) in its entirety, and those subsections of section C (Manufacturing) that align with ICT manufacturing

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industries stated above, such as sections 26 (Manufacture of computer, electronic and optical products) and 27 (Manufacture of electrical equipment).

The labour force shall refer to, as defined by the International Labour Organization (ILO), the sum of persons in employment plus persons in unemployment who are legally eligible to work. Thus, working age shall refer to all persons who are the same age or older than the legal working age in the jurisdiction of reference. This indicator shall exclude child labour, which is labour completed by persons 14 years of age or younger.

5.3.3 Data sources

Data on employment by industry should be obtained through labour force surveys or city employment assessments administered by local, regional or national authorities/statistical bodies, or a Ministry or Department of Labour Employment.

5.4 Percentage of the labour force employed in occupations in the education and research and development sectors

5.4.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 As cities and communities strengthen their focus on the development of their knowledge economy, the role of education and research and development industries is all the more important in the development of human capital. These industries play a critical role in economic development, promoting innovative thought processes to enhance existing products or services or to develop new products and services. Also, the education sector includes those employed in all levels of the educational system, ensuring that citizens have access to education and receive effective services. Thus, the labour force employed in these two industries aids in the development or enhancement of products and services, in addition to ensuring that citizens receive high-quality education to become actively involved in the knowledge economy.

NOTE 2 This indicator reflects "Innovation, creativity and research" and "Economy and sustainable production and consumption" issues as defined in ISO 37101. It can allow an evaluation of the contribution to "Attractiveness" and "Resilience" purposes of the city as defined in ISO 37101.

5.4.2 Indicator requirements

The percentage of the labour force employed in occupations in the education and research and development sectors shall be calculated as the number of city residents in the labour force employed in occupations in the education and research and development sectors (numerator) divided by the city's total labour force (denominator). The result shall then be multiplied by 100 and expressed as the percentage of the labour force employed in occupations in the education and research and development sectors.

Cities shall refer to the United Nations Statistics Division's International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4 (https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf) when defining the education and research and development sectors.

The education sector shall refer to organisations primarily engaged in providing instruction and training in a wide variety of subjects. Instruction and training are provided by specialized establishments, such as schools, colleges, universities and training centres. Cities shall refer to any organisations that fall within section P of the ISIC, Rev.4, which is divided into the following subsections: 851 (Pre-primary and primary education), 852 (Secondary education), 853 (Higher education), 854 (Other education) and 855 (Educational support activities).

The research and development section shall refer to organisations primarily engaged in conducting original investigation, undertaken on a systematic basis to gain new knowledge (research), and in the application of research findings or other scientific knowledge for the creation of new or significantly improved products or processes (experimental development). Cities shall refer to organisations that

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fall within Division 72 – Scientific research and development of section M – Professional, scientific and technical activities of the ISIC, Rev.4[6].

The numerator of this indicator shall be calculated as the sum of the total number of persons employed in occupations in these two sectors, education and research and development.

The labour force shall refer to, as defined by the ILO, the sum of persons in employment plus persons in unemployment who are legally eligible to work. Thus, working age shall refer to all persons who are the same age or older than the legal working age in the jurisdiction of reference. This indicator shall exclude child labour, which is labour completed by persons 14 years of age or younger.

5.4.3 Data sources

Data on employment by industry should be obtained through labour force surveys or city employment assessments administered by local, regional or national authorities/statistical bodies, or a Ministry or Department of Labour Employment.

6 Education

6.1 Percentage of city population with professional proficiency in more than one language

6.1.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Foreign language skills are indicative of a diverse, employable workforce. They also suggest highly successful educational programming.

NOTE 2 This indicator reflects the “Education and capacity building” issue as defined in ISO 37101. It can allow an evaluation of the contribution to the “Social cohesion”, “Well-being”, “Attractiveness” and “Resilience” purpose of the city as defined in ISO 37101.

6.1.2 Indicator requirements

The percentage of city population with professional proficiency in more than one language shall be calculated as the total number of people who are able to communicate in more than one foreign language with professional proficiency (numerator) divided by the city’s total population (denominator). The result shall then be multiplied by 100 and expressed as the percentage of city population with professional proficiency in more than one language.

A foreign language shall refer to a language spoken with professional proficiency other than one of the official languages of the country in which the city is located. For example, the official language in the United States of America (USA) is English, so a city resident speaking a language other than English at a professional proficiency is counted as a foreign language in the USA. In the case of a country with more than one official language, such as Canada with two designated official languages (English and French), when a person can speak two official languages at professional proficiency level, one official language shall be included in the count of foreign languages and the other language shall be excluded from the count of foreign languages. For example, if a person in Canada speaks both English and French, they would have one foreign language and be counted in the numerator of this indicator. Similarly, if a Canadian speaks only English (only one of the official languages) but also has professional proficiency in Spanish, for example, then that person would be counted as having professional proficiency in more than one language.

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Professional proficiency shall refer to the following level of competence:

— able to speak the language with sufficient structural accuracy, vocabulary and cohesiveness in discourse to participate effectively in most formal and informal conversations on practical, social and professional topics;

— understanding is essentially complete;

— can discuss with fluency and ease abstract issues and special fields of competence and interest;

— can support opinions and hypothesize;

— can provide a structured argument that is clear and well organized;

— while the influence of the speaker's first language can be noticed (in pronunciation, grammar and vocabulary), there should not be any patterned errors, and errors should never distract the listener or interfere with communication.

For reference, the above definition of professional proficiency corresponds to level C1 of the Common European Framework of Reference for Languages: Learning, Teaching, Assessment.

6.1.3 Data sources

Data on foreign languages spoken by the city population should be sourced using census data, or local, regional or national surveys pertaining to languages spoken.

6.1.4 Data interpretation

A high percentage of residents who can communicate in more than one foreign language indicates that the city has a well-educated and diverse population that can handle interactions that extend beyond national borders. Globalization, economic growth in developing economies and improved transport infrastructure have resulted in a considerable shift in world trading patterns and a higher proportion of the world's population being able to visit other countries, whether for business, pleasure or other reasons.

Foreign language skills have the potential to increase one's mobility, employability and personal development.

6.2 Number of computers, laptops, tablets or other digital learning devices available per 1 000 students

6.2.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Computer literacy is an essential aspect of professional employability in many sectors, and it allows an alternative form of civic engagement for citizens. The increase in accessibility of electronic devices for students, as well as the exposure to computers, laptops, tablets or other digital learning devices, can enhance a student's computer literacy. It also allows citizens to access a broader array of information, empowering people in all walks of life to seek, evaluate, use and create information effectively to achieve personal, social, occupational and educational goals.

NOTE 2 This indicator reflects the "Education and capacity building" issue as defined in ISO 37101. It can allow an evaluation of the contribution to the "Attractiveness" purpose of the city as defined in ISO 37101.

6.2.2 Indicator requirements

The number of computers, laptops, tablets or other digital learning devices available per 1 000 students shall be calculated as the total number of computers, laptops, tablets or other digital learning devices

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with Internet access available to primary and secondary school students attending primary and secondary school in the city (numerator) divided by 1/1 000 of the city's total primary and secondary school population (denominator). The result shall be expressed as the number of computers, laptops, tablets or other digital learning devices available per 1 000 students.

Only school owned/provided computers, laptops, tablets or other digital learning devices shall be counted.

Primary school students shall refer to students enrolled in primary education as defined in ISO 37120: 2018, Clause 3.

Secondary school students shall refer to students enrolled in secondary education as defined in ISO 37120: 2018, Clause 3.

The number of computers, laptops, tablets or other digital learning devices available per 1 000 students shall be reported separately for both primary and secondary school students in the table below.

	Number of computers, laptops, tablets or other digital learning devices	**Number of computers, laptops, tablets or other digital learning devices per 1 000 students**
Primary students		
Secondary students		
Total students (primary and secondary)		

6.2.3 Data sources

Data on the number of electronic devices with Internet access should be sourced from local school boards, or a Ministry or Department of Education.

6.2.4 Data interpretation

While computer literature can benefit secondary school students, there are debates concerning the positive impact of the availability of digital devices and technology for primary school students.

Sufficiently fast broadband as defined in 18.1 can also be taken into consideration for analysis of this indicator. When the percentage of city population having sufficiently fast broadband is low, the benefit of accessibility to computers, laptops, tablets or other digital learning devices may be limited. Sufficiently fast broadband shall refer to a network capable of speeds of at least 256 kbit/s in both directions, uploading and downloading. This speed is sufficient for Internet surfing and emails. Sufficient broadband corresponds to basic broadband.

6.3 Number of science, technology, engineering and mathematics (STEM) higher education degrees per 100 000 population

6.3.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Receiving higher education provides individuals with a foundation for meaningful participation in the labour force and helps reduce poverty and inequality. This pillar of human development is widely recognized as the main avenue for social mobility. All disciplines taught by higher education institutions benefit society in some way, such as science, technology, engineering and mathematics (STEM) disciplines, which are critical to the technological development and innovation of a city. STEM education helps to create critical thinkers, increase science literacy, and enable the next generation of innovators. Furthermore, STEM is important because science pervades every part of our lives, and the need for STEM degree holders is increasing with the growing demand for innovators of products and processes that will help sustain and promote economic growth.

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NOTE 2 This indicator reflects the "Education and capacity building" and "Innovation, creativity and research" issues as defined in ISO 37101. It can allow an evaluation of the contribution to "Resilience" and "Attractiveness" purposes of the city as defined in ISO 37101.

6.3.2 Indicator requirements

The number of STEM higher education degrees per 100 000 population shall be calculated as the number of people holding higher education degrees with a specialization or major in a discipline within a STEM subject (numerator) divided by 1/100 000 of the city's total population (denominator). The result shall be expressed as the number of STEM higher education degrees per 100 000 population.

STEM higher education degrees shall refer to higher education degrees specializing in subjects within the fields of science, technology, engineering and mathematics, and is intended to capture a broad field of education and employment opportunities, beyond the more narrow fields of science and mathematics. STEM programmes of study are typically classified based upon several occupational clusters: computer science and technology; mathematical sciences; digital music and digital arts, engineering and surveying; and natural, physical and life sciences.

This indicator shall only include people who comprise the city's total population, and shall not include temporary residents or international students.

Higher education shall refer to the definition of tertiary education stated within ISO 37120: 2018, Clause 3.

6.3.3 Data sources

Data on higher education degrees by subject should be sourced from local tertiary/postsecondary degree-, diploma- or certificate-granting institutions, or the relevant Ministry or Department of Education, if available. If higher education data from these sources are not available, data from surveys or censuses can be used.

6.3.4 Data interpretation

This indicator provides an overview of the skill set of the population. These data can also have an impact on surrounding cities because the population with STEM degrees can work in those cities or, in other contexts, may force lower educated people to move to surrounding cities, creating intellectual ghettos in the city. Although only STEM disciplines are considered for this indicator, social science and other disciplines are also important for the city's labour force and can contribute to the smartness of the city.

7 Energy

7.1 Percentage of electrical and thermal energy produced from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources, as a share of the city's total energy mix for a given year

7.1.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Waste heat is an endogenous energy resource of every city. Waste heat can be obtained from wastewater and solid waste treatment plants or any other industrial processes, as well as from the tertiary and transport sectors (e.g. heat rejected from data centres or the subway ventilation).

Wastewater is a renewable resource that conveys thermal and chemical energy. In some instances, wastewater is found to contain nearly five times the amount of energy needed to process and treat the wastewater. It is important for cities to recognize the potential of wastewater as a sustainable energy source and utilize wastewater in their energy source mix.

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Furthermore, wastewater treatment plants use considerable amounts of energy and create greenhouse gas emissions, but they also have the potential to be sources of renewable energy for cities. Wastewater treatment plants can use sewage to generate energy on site, where this energy can then be used to help operate the wastewater treatment plants, thereby reducing a wastewater treatment plant's operating costs, energy consumption and greenhouse gas emissions.

While reduction, recycling and composting can do their part to mitigate the environmental impacts of municipal solid waste, not all types of materials can be practically and economically recycled in an environmentally beneficial manner. This leftover solid waste can therefore present an opportunity to recover energy, using new and possibly cleaner technologies.

Waste heat can be categorised into high enthalpy and low enthalpy. While high enthalpy waste heat allows the production of electricity, low enthalpy heat can be used directly for heating (and even cooling) of buildings, typically through district heating and cooling networks.

NOTE 2 This indicator reflects the "Economy and sustainable production and consumption" and "Community infrastructures" issues as defined in ISO 37101. It can allow an evaluation of the contribution to the "Responsible resource use" purpose of the city as defined in ISO 37101.

7.1.2 Indicator requirements

The percentage of electrical and thermal energy produced from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources as a share of the city's total energy mix for a given year shall be calculated as the total amount of electrical and thermal energy expressed in GJ produced from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources (numerator) divided by the city's total end-use energy demand in the same units as the numerator (GJ). The result shall then be multiplied by 100 and expressed as a percentage of electrical and thermal energy produced from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources as a share of the city's total energy mix for a given year.

The term energy mix refers to the combination of the various primary energy sources used to meet energy needs in a given geographic region.

Where possible, data from wastewater treatment, solid waste and other liquid waste treatment and other waste heat resources shall be included and listed individually. This shall include on-site use of recovered electrical and thermal energy at the wastewater/waste facilities and off-site use by external parties.

	Thermal energy (% of the total energy mix)	**Electrical energy (% of the total energy mix)**	**Total energy (% of the total energy mix)**
Wastewater resource			
Solid waste treatment			
Other liquid waste treatment			
Other waste heat sources			
Total (%)			

Waste heat shall be considered as all residual thermal energy generated in the city which is not used, as well as potential chemical energy sources that are not valued as energy.

Wastewater shall refer to the physical, chemical and biological processes used to remove, reduce or neutralize contaminants from wastewater before discharging it into a water body. Wastewater treatment can include primary, secondary or tertiary treatment, or wastewater treatment of higher standard.

Solid waste treatment shall refer to the physical, chemical and biological processes used to remove, reduce or neutralize contaminants from solid waste before recycling, recovery or final disposal.

Other liquid waste shall refer to liquid waste such as fasts, oil or grease that are sources of energy.

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7.1.3 Data sources

Data on the amount of electrical and thermal energy produced from waste water treatment, solid waste and other liquid waste treatment and other waste heat resources should be sourced from city departments or ministries that oversee such matters, as well as from regulators and local utility providers.

7.2 Electrical and thermal energy (GJ) produced from wastewater treatment per capita per year

7.2.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Wastewater is a renewable resource that conveys thermal and chemical energy. In some instances, wastewater is found to contain nearly five times the amount of energy needed to process and treat the wastewater. It is important for cities to recognize the potential of wastewater as a sustainable energy source and utilize wastewater in their energy source mix.

Furthermore, wastewater treatment plants use considerable amounts of energy and create greenhouse gas emissions, but they also have the potential to be sources of renewable energy for cities. Wastewater treatment plants can use sewage to generate energy on site, where this energy can then be used to help operate the wastewater treatment plants, thereby reducing a wastewater treatment plant's operating costs, energy consumption and greenhouse gas emissions.

NOTE 2 This indicator reflects the "Economy and sustainable production and consumption" and "Community infrastructures" issues as defined in ISO 37101. It can allow an evaluation of the contribution to the "Responsible resource use" purpose of the city as defined in ISO 37101.

7.2.2 Indicator requirements

The electrical and thermal energy (GJ) produced from wastewater treatment per capita per year shall be calculated as the total amount of electrical and thermal energy expressed in GJ produced from wastewater treatment in the city (numerator) divided by the city's total population (denominator). The result shall be expressed as the amount of electrical and thermal energy in GJ produced from wastewater treatment per capita for a given year.

This shall include the on-site use of recovered electrical and thermal energy at the wastewater facilities and off-site use by external parties.

Wastewater treatment shall refer to the physical, chemical and biological processes used to remove, reduce or neutralize contaminants from wastewater before discharging into a water body. Wastewater treatment can include primary, secondary or tertiary wastewater treatment, or wastewater treatment of a higher standard.

7.2.3 Data sources

Data on the amount of electrical and thermal energy produced from wastewater treatment should be sourced from city departments or ministries that oversee such matters, as well as from regulators and local utility providers.

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7.3 Electrical and thermal energy (GJ) produced from solid waste or other liquid waste treatment per capita per year

7.3.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 While reduction, recycling and composting can do their part to mitigate the environmental impacts of municipal solid waste, not all types of materials can be practically and economically recycled in an environmentally beneficial manner. This leftover solid waste might therefore present an opportunity to recover energy, using new and possibly cleaner technologies. Other liquid waste such as fats, oils and grease are also a source of energy.

NOTE 2 This indicator reflects the "Economy and sustainable production and consumption" and "Community infrastructures" issue as defined in ISO 37101. It can allow an evaluation of the contribution to the "Responsible resource use" purpose of the city as defined in ISO 37101.

7.3.2 Indicator requirements

The electrical and thermal energy (GJ) produced from solid waste or other liquid waste treatment per capita per year shall be calculated as the total amount of electrical and thermal energy expressed in GJ produced from solid waste and other liquid waste treatment in the city (numerator) divided by the city's total population (denominator). The result shall be expressed as the amount of electrical and thermal energy in GJ per capita for a given year.

This shall include the on-site use of recovered electrical and thermal energy at the solid waste facilities and off-site use by external parties.

This also includes other liquid waste such as fats, oil or grease.

7.3.3 Data sources

Data on the amount of electrical and thermal energy produced from solid waste and other liquid waste treatment should be sourced from city departments or ministries that oversee such matters, as well as from regulators and local utility providers.

7.4 Percentage of the city's electricity that is produced using decentralised electricity production systems

7.4.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 A primary benefit of a more decentralised energy system is the potential for a more reliable electricity system and higher-quality power supply (with the appropriate supporting systems in place). A decentralised electricity production system can be defined as locating electricity production closer to the site of consumption, such as locating electricity production facilities within a city rather than sourcing electricity from a regional electricity production facility that is most likely distant from a city. Although a relatively new approach for the power industry and utility providers, a decentralised system can potentially lead to more optimal use of renewable energy sources, which in turn can reduce fossil fuel use and increase the energy efficiency and sustainability of a region. Therefore, tracking the amount of decentralised electricity production can be used to assess a region's potential for utilizing renewable energy sources and expanding access to clean energy services, such as combined heat and power, that might not otherwise have been available due to the distance from centralised electricity production facilities. The opportunity for combined heat and power is important – but this generally has to be included in the design of these systems and is difficult to install retroactively.

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NOTE 2 Besides the environmental issues of decentralised electricity production mentioned before, i.e. adoption of renewable energy sources and reduction of primary energy usage, decentralised electricity production can also be advantageous for the resilience of the electrical grid of the city, particularly during a crisis event such as a large storm.

NOTE 3 This indicator reflects the "Economy and sustainable production and consumption" and "Community infrastructures" issues as defined in ISO 37101. It can allow an evaluation of the contribution to the "Responsible resource use" and "Resilience" purpose of the city as defined in ISO 37101.

7.4.2 Indicator requirements

The percentage of the city's electricity that is produced using decentralised electricity production systems shall be calculated as the amount of electricity produced by decentralised electricity production systems/facilities in GJ (numerator) divided by the total amount of electricity consumed in the city in the same units as the numerator (GJ) – this includes electricity produced by both centralised and decentralised electricity production facilities (denominator). The result shall be multiplied by 100 and expressed as the percentage of the city's electricity that is produced using decentralised electricity production systems.

Decentralised electricity, also referred to as distributed electricity production, shall refer to electricity production at or near the point of use, irrespective of size, technology, or fuel used – both off-grid and on-grid. Also, decentralised electricity production refers to the wide range of technologies that include wind turbines or plants, photovoltaic (solar) panels, micro-turbines and modular internal combustion engines.

7.4.3 Data sources

Data on the amount of electricity produced by both centralised and decentralised electricity production systems/facilities should be sourced from local utilities, and relevant city departments or ministries that oversee energy production. It can be acceptable to use estimates based on energy audits performed on sample sites to address the electricity production that is immediately used as auto-consumption, which sometimes is not communicated to the electrical utilities.

7.4.4 Data interpretation

If one plant produces 100 % of the city's electricity, this is not considered to be decentralised and the indicator therefore equals 0 %.

7.5 Storage capacity of the city's energy grid per total city energy consumption

7.5.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 The peak energy demand is a less spoken vector that increases energy costs and limits the penetration of renewables. Smart grids will accommodate energy storage (typically electrical and thermal storage, but also "clean" fuels such as hydrogen) to reduce demand peaks and transfer energy usage to periods of intermittent renewable energy production. Efficient storage capacity is essential to balance the supply and demand for energy in a region, and it can be achieved by several strategies:

— electricity storage, onsite or nearby, including chemical storage such as hydrogen;

— electrical storage of electrical vehicles (excluding hybrid vehicles);

— thermal storage (e.g. heat and cold storage in nearby district heating and cooling schemes);

— geothermal energy storage (e.g. some heat pump/chiller-driven district heating and cooling schemes);

— thermal mass of buildings considered onsite thermal storage if associated with predictive heat consumption algorithms that allow the reduction of heat and cold peak demand from district heating and cooling schemes;

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— other ways of storing renewable energy such as fuels cells, if conveniently justified, including onsite energy storage.

NOTE 2 This indicator reflects the "Economy and sustainable production and consumption" and "Community infrastructures" issues as defined in ISO 37101. It can allow an evaluation of the contribution to the "Responsible resource use" and "Resilience" purpose of the city as defined in ISO 37101.

7.5.2 Indicator requirements

Storage capacity of the city's energy grids per total city energy consumption shall be calculated as the total amount of energy that can be stored annually on the city's electrical grid and thermal grids (district heating and cooling schemes) in gigajoules (GJ) (numerator) divided by the city's total energy consumption (denominator). The result shall be expressed as the storage capacity of the city's energy grid per total city energy consumption.

Energy storage shall refer to the process of converting energy into a stored form that can later be converted back into energy when needed. Thus, storage capacity shall refer to the amount of energy capable of being stored.

For total end-use energy consumption refer to ISO 37120:2018, 7.1.

Where possible, specify and report the types of energy consumption used in the calculation. Also, if the energy storage facility is not within the city boundaries, the city should report the distance of the energy storage facility.

7.5.3 Data sources

Data for storage capacity should be sourced from relevant city departments or ministries that oversee the energy grid of the city, and local utilities that operate district heating and cooling schemes.

7.5.4 Data interpretation

Having energy storage capacity nearby or within city boundaries (close to the loads) reduces transmission losses and ensures a more reliable power supply. It also allows cities to better manage peaks in energy demand. If energy storage facilities are not located within city boundaries, the city shall report the distance to the energy storage facility.

7.6 Percentage of street lighting managed by a light performance management system

7.6.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Remotely managed light points contribute to higher energy efficiency and can be optimised and adapted to switch on and off and to dim in any area of the city. Also, remotely managed lights can potentially improve safety in the city, where any failure of a light point which leads to insufficiently illuminated streets can be immediately monitored and localized to ensure fast repair. Lastly, real energy consumption per light point can be measured and reported accurately with the light management system, to better monitor energy cost and CO_2 reduction schemes.

NOTE 2 This indicator reflects "Economy and sustainable production and consumption" and "Safety and security" issues as defined in ISO 37101. It can allow an evaluation of the contribution to the "Responsible resource use" purpose of the city as defined in ISO 37101.

7.6.2 Indicator requirements

The percentage of street lighting managed by a light performance management system shall be calculated as the number of light points that can be controlled by a light performance management system (numerator) divided by the number of total light points in the city (denominator). The results

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shall then be multiplied by 100 and expressed as the percentage of street lighting managed by a light performance management system.

Controlled by a light performance management system shall refer to the ability to monitor light points, set schedules for switching off/on and adjust light levels by dimming. This means a light point can be changed individually and remotely with an ICT-based system, which is connected via a communication network to the light points. This system shall also be able to accurately measure the electrical energy consumed by the light point and indicate via the ICT-based system to the operator any occurring failure affecting the light performance of the light point.

7.6.3 Data sources

Data on remote management of lighting should be sourced from city departments or ministries responsible for street lighting inventory and street light management.

7.7 Percentage of street lighting that has been refurbished and newly installed

7.7.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Street lighting can account for 15 % to 50 % of total electricity consumption of municipalities. Refurbishing city street lights and installing new lighting can help improve energy efficiency, thus reducing street lighting energy consumption. In addition, the recent market introduction of energy-efficient technologies for street lighting offers high-cost savings with comparatively short payback times. The annual energy and maintenance cost savings might then possibly cover the investment and capital costs.

NOTE 2 This indicator reflects the “Economy and sustainable production and consumption” issue as defined in ISO 37101. It can allow an evaluation of the contribution to the “Responsible resource use” purpose of the city as defined in ISO 37101.

7.7.2 Indicator requirements

The percentage of street lighting that has been refurbished and newly installed within the year shall be expressed as the number of refurbished and newly installed light points (numerator) within the year divided by the total number of light points (denominator). The result shall then be multiplied by 100 and expressed as the percentage of street lighting that has been refurbished and newly installed.

Where possible, cities shall report and indicate separately the percentage of street lighting that is refurbished and newly installed.

	Number of street lighting points	**Percentage of street lighting points**
Refurbished		
Newly installed		
Replaced		
Untreated		
Total number		

Refurbishment of existing street light systems, for example upgrading ballasts, shall refer to activities that aim not only to decrease energy consumption but also improve energy efficiency of the street lighting system. Newly installed as well as retrofitted street lighting for upgrading to high efficiency technologies shall be included.

A light point shall refer to any single source of public street lighting, such as a street light, light pole, lamppost, street lamp, light standard or lamp standard.

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7.7.3 Data interpretation

Cities should consider the lifecycle of the street lighting assets when replacing, refurbishing and installing street lighting. A street lighting lifecycle plan should be developed by cities to better assess the current state of lighting assets of a city and to identify what treatment/material/technology should be used for street lighting.

7.7.4 Data sources

Data on street lighting refurbishment and street lighting systems should be sourced from city departments or ministries responsible for street lighting inventory.

7.8 Percentage of public buildings requiring renovation/refurbishment

7.8.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Buildings are the largest energy consumers in most cities. Reduced and efficient energy use can create substantial savings and can enhance the stability of the energy supply. As such, buildings requiring renovation/refurbishment can hinder progress to reduce energy consumption, thus contributing more to climate change and other negative externalities.

NOTE 2 This indicator reflects the "Economy and sustainable production and consumption" and "Living and working environment" issues as defined in ISO 37101. It can allow an evaluation of the contribution to the "Attractiveness" and "Responsible resource use" purpose of the city as defined in ISO 37101.

7.8.2 Indicator requirements

The percentage of public buildings requiring renovation/refurbishment shall be calculated as the square metres of public buildings requiring renovation/refurbishment (numerator), divided by the total square metres of public buildings (denominator). The result shall then be multiplied by 100 and expressed as the percentage of public buildings requiring renovation/refurbishment.

Public building shall refer to a government-owned or leased building that functions as a municipal and administrative office, library, recreation centre, hospital, school, fire station or police station.

NOTE Ownership of buildings (public or private) is variously defined according to region and political system. The restrictive definition used here permits global comparability across cities.

Renovation/refurbishment shall refer to the remodelling, refashioning and general renovation of a building to gain better energy use, improvements to structural integrity and conformity to safety standards. Buildings requiring renovation/refurbishment shall be assessed by a city's audit and registration of buildings in need of renovation/refurbishment. Renovation and refurbishment of a building shall not include the demolition/removal and replacement of buildings, but does include buildings requiring renewal.

7.8.3 Data sources

Data on public buildings requiring renovation/refurbishment should be sourced from city ministries, departments or agencies that oversee the building and maintenance of buildings in the city.

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7.9 Percentage of buildings in the city with smart energy meters

7.9.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Smart energy meters record and display the consumption of energy in real time. Smart meter data can be sent to a central location wirelessly, thus providing energy providers with the means to understand how and when power is being used to better plan and conserve energy. Also, smart meter data help consumers better understand and monitor energy usage.

NOTE 2 This indicator reflects the "Community infrastructure" and "Economy and sustainable production and consumption" issues as defined in ISO 37101. It can allow an evaluation of the contribution to "Responsible resource use" and "Attractiveness" purpose of the city as defined in ISO 37101.

7.9.2 Indicator requirements

The percentage of buildings in the city with smart energy meters shall be calculated as the number of buildings in the city with smart energy meters (numerator) divided by the total number of buildings in the city (denominator). The result shall be multiplied by 100 and expressed as the percentage of buildings in the city with smart energy meters.

Data for public and commercial and industrial buildings shall be included and listed individually.

	Number of buildings in the city with smart energy meters	**Total number of buildings in the city**	**Percentage of buildings in the city with smart energy meters**
Public buildings			
Commercial and industrial buildings			

Public buildings shall refer to a government-owned or leased building that functions as a municipal and administrative office, library, recreation centre, hospital, school, fire station or police station.

NOTE 1 Ownership of buildings (public or private) is variously defined according to region and political system. The restrictive definition used here permits global comparability across cities.

Commercial and industrial buildings shall refer to those which have been designated by the city for commercial and industrial use.

NOTE 2 Property assessment methods might vary from one jurisdiction or country to another, including the market-oriented method, the profit-oriented method and the cost-oriented method.

Household buildings are not considered in this indicator.

For smart energy management at the household scale refer to indicator 12.1.

A smart energy meter shall refer to an energy meter that includes real-time digital displays or that is available through a real-time online application, so a customer can better understand their energy usage. Also, a smart energy meter can digitally send meter readings to an energy supplier for more accurate energy bills, and for better planning and conservation of energy by providers.

7.9.3 Data sources

Data on the number of buildings in the city with smart energy meter figures should be sourced from local or regional energy providers, or relevant city departments or ministries that have data on local smart energy meters.

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7.10 Number of electric vehicle charging stations per registered electric vehicle

7.10.1 General

Those implementing this document should report on this indicator in accordance with the following requirements.

NOTE 1 Unlike conventional vehicles that use gasoline or diesel-powered engines, electric vehicles (EVs) are powered by electricity from batteries. EVs therefore emit fewer greenhouse gases and tailpipe pollutants than conventional vehicles. EVs are also cheaper to operate because fuel costs are minimal or nil. However, with limited motor and battery capacity (meaning shorter travel range), electric cars need regular and convenient access to vehicle (i.e. battery) charging stations.

NOTE 2 This indicator reflects the "Health and care in the community", "Community infrastructure" and "Living and working environment" issues as defined in ISO 37101. It can allow an evaluation of the contribution to "Well-being" and "Attractiveness" and "Preservation and improvement of environment" purposes of the city as defined in ISO 37101.

7.10.2 Indicator requirements

The number of electric vehicle charging stations per registered electric vehicle shall be calculated as the total number of electric vehicle charging stations in the city (numerator) divided by the total number of registered electric vehicles in the city (denominator). The result shall be expressed as the number of electric vehicle charging stations per registered electric vehicle.

Electric vehicle shall refer to any means by which something or someone is carried or conveyed with an engine and wheels (including cars, buses, motorcycles and auto rickshaws, but not trains) and which runs fully or partially on a battery-powered electric motor. Electric vehicles, therefore, require "plugging in" to an electricity source to recharge their batteries. There are two types of electric vehicles:

1) "hybrid" vehicles that are powered from a gasoline or diesel engine as well as an electric motor;

2) "battery electric" vehicles that are powered exclusively from a battery and require no liquid fuels.

Charging station shall refer to publicly accessible equipment (also called "electric vehicle supply equipment" or EVSE) that supplies electric energy for recharging battery electric vehicles. Charging stations are often provided in municipal parking locations by electric utility companies or at retail shopping centres by private companies. Some charging stations have advanced features such as smart metering, cellular capability and network connectivity.

Registered vehicle shall refer to any vehicle that has been officially listed or recorded with a government authority and that displays a vehicle registration plate and/or a vehicle registration certificate.

7.10.3 Data sources

Data for this indicator should be obtained from municipal or state departments or ministries responsible for transportation and vehicle registration in the city.

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