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Sustainable cities and communities — Indicators for city services and quality of life

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Preface

This Standard was prepared by the Standards Australia Committee JT-001, Strategic Advisory Committee.

The objective of this Standard is to define and establish methodologies for a set of indicators to steer and measure the performance of city services and quality of life. It follows the principles set out in AS ISO 37101 and can be used in conjunction with AS ISO 37101 and other strategic frameworks.

This document is applicable to any city, municipality or local government that undertakes to measure its performance in a comparable and verifiable manner, irrespective of size and location.

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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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.

This document was prepared by Technical Committee ISO/TC 268, *Sustainable cities and communities*.

This second edition cancels and replaces the first edition (ISO 37120:2014), which has been technically revised.

In the development of this document, ISO Guide 82 has been taken into account in addressing sustainability issues.

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

Cities need indicators to measure their performance. Existing indicators at the local level are often not standardized, consistent, or comparable over time or across cities. This document is focused on city services and quality of life as a contribution to the sustainability of the city.

As part of a new series of International Standards being developed for a holistic and integrated approach to sustainable development, that includes indicators for city services and quality of life, indicators for smart cities and indicators for resilient cities, this set of standardized indicators provides a uniform approach to what is measured, and how that measurement is to be undertaken. As a list, it does not provide a value judgement, threshold or target numerical value for the indicators.

Conformance with this document does not confer a status in this regard. A city which conforms to this document in regards to measurement of indicators for city services and quality of life may only claim conformance to that effect.

These indicators can be used to track and monitor progress on city performance. In order to achieve sustainable development, the whole city system needs to be taken into consideration. Planning for future needs should take into consideration current use and efficiency of resources in order to better plan for tomorrow.

The indicators and associated test methods in this document have been developed in order to help cities:

a) measure performance management of city services and quality of life over time;

b) learn from one another by allowing comparison across a wide range of performance measures; and,

c) support policy development and priority setting.

NOTE It is acknowledged that cities might not have direct influence or control over factors governing some of these indicators, but the reporting is important for meaningful comparison and provides a general indication of service delivery and quality of life within a city.

The indicators in this document have been selected to make reporting as simple and inexpensive as possible, and therefore reflect an initial platform for reporting. Further development of indicators to support smartness (ISO 37122[1)]) and resilience (ISO 37123[2)]) in cities is ongoing in TC 268. This document also includes a third category of indicators – profile indicators – that are recommended to provide basic statistics and background information to help cities conduct peer comparisons. Additional profile indicators are listed in Annex D.

Maintaining, enhancing and accelerating progress towards improved city services and quality of life is also fundamental to the definitions of both smart cities and resilient cities. This document is intended to be implemented in conjunction with ISO 37122 and ISO 37123 to measure progress towards smart cities and resilient cities, respectively. The relationship between the family of standards is presented in Figure 1.

1) Under preparation. Stage at the time of publication: ISO/DIS 37122:2018.

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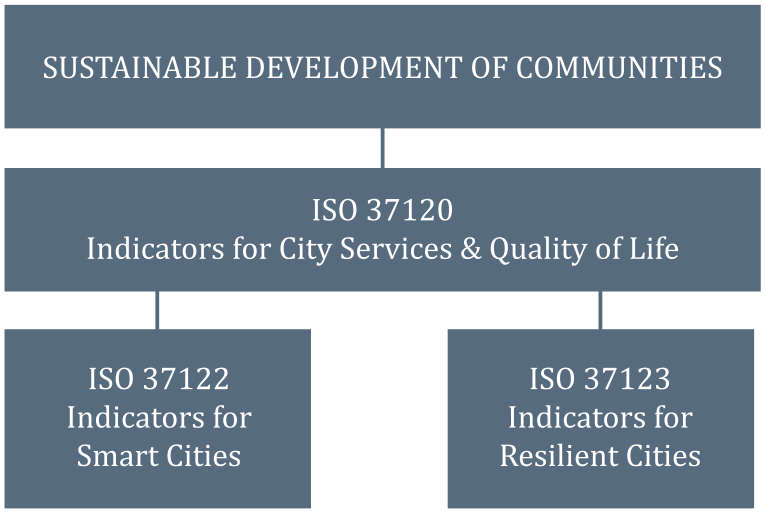

Figure 1 — Sustainable development of communities — Relationship between the family of city indicators standards

The indicators are structured around themes. Recognizing the differences in resources and capabilities of cities worldwide, the overall set of indicators for city performance has been divided into "core" indicators (those implementing this document shall follow) and "supporting" indicators (those implementing this document should follow). Both core and supporting indicators are listed in Annex A, Table A.1.

In this document, the following verbal forms are used:

— "shall" indicates a requirement;

— "should" indicates a recommendation;

— "may" indicates a permission;

— "can" indicates a possibility or a capability.

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Sustainable cities and communities — Indicators for city services and quality of life

1 Scope

This document defines and establishes methodologies for a set of indicators to steer and measure the performance of city services and quality of life. It follows the principles set out in ISO 37101 and can be used in conjunction with ISO 37101 and other strategic frameworks.

This document is applicable to any city, municipality or local government that undertakes to measure its performance in a comparable and verifiable manner, irrespective of size and location.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content can be used in conjunction with this document. For dated references, only the edition cited applies. For undated 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 1996-2, *Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 37101 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

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

3.1
city
municipality
local government
urban community falling under a specific administrative boundary

3.2
city population
number of residents living in a particular city or municipality, typically determined by census every 5 or 10 years

Note 1 to entry: Census populations exclude temporary residents but include residents temporarily absent.

3.3
community
group of people with an arrangement of responsibilities, activities and relationships

Note 1 to entry: In many, but not all, contexts, a community has a defined geographical boundary.

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

[SOURCE: ISO 37101:2016, 3.4, ISO/TS 37151:2015, 3.1]

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3.4
indicator
quantitative, qualitative or descriptive measure

[SOURCE: ISO 15392:2008, 3.14, modified – Note 1 to entry added.]

Note 1 to entry: There are three types of indicators in this document:

a) core indicators: indicators that are required to demonstrate performance in the delivery of city services and quality of life.

b) supporting indicators: indicators that are recommended to demonstrate performance in the delivery of city services and quality of life. These indicators can be selected according to city objectives.

c) profile indicators: indicators that are recommended to provide basic statistics and background information to help cities determine which cities are of interest for peer comparisons. Profile indicators are used as an informative reference.

3.5
full-time enrolment
enrolment in an education programme whose intended study load amounts to at least 75 % of the normal full-time annual study load

[SOURCE: UNESCO, 2011]

3.6
labour force
workforce
all employable persons within a specified geographic area

Note 1 to entry: This typically includes all working-age adults between the ages of 15 and 64, but the specific age will vary by country.

3.7
natural hazard
geological or meteorological phenomena that can cause damage to physical infrastructure or loss of life in cities

3.8
part-time enrolment
enrolment in school for at least every half-day in a week over the entire school year or equivalent on a weekly basis

EXAMPLE A student is counted as enrolled part-time if he/she is enrolled in school for every half-day in a week, but is not counted as enrolled if he/she is only enrolled for 0,25 of a day.

3.9
primary education
elementary school
education that is considered to be the first stage of "basic education"

Note 1 to entry: Primary education typically covers six years of full-time schooling with the legal age of entrance normally being not younger than 5 years or older than 7 years. Primary education typically lasts until ages 10–12. Primary education refers to children aged 5–12 years or 1st grade through to 5th or 6th grade, as defined by local education systems.

[SOURCE: UNESCO Institute for Statistics, UOE data collection on education systems, 10.1]

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3.10
secondary education
education that is considered to be the second stage of basic education and marks the end of compulsory education where it exists

Note 1 to entry: Students usually enter between the ages of 10 and 13 (age 12 being the most common). Secondary education usually ends 12 or 13 years after the beginning of primary education (or around age 18). However, this can range from 11 to 14 years after beginning school (or around age 17 to 20). Secondary education also refers to 6th grade (or 7th grade) to 12th grade, as defined by local education systems.

3.11
tertiary education
education provided by universities and other higher education institutions following secondary education

3.12
hazardous waste
waste that is potentially harmful to human beings, property or the environment

[SOURCE: ISO 18113-1:2009, 3.22, modified – Examples and Notes removed.]

3.13
solid waste
non-soluble, discarded solid materials, including sewage sludge, municipal garbage, industrial wastes, agricultural refuse, demolition wastes and mining residues

3.14
vascular plant
tracheophyte
plant that can internally transport water and food

3.15
per 100 000 population
in 100 000 of the city's population

Note 1 to entry: The choice of 100 000 population was made to permit cities of different sizes to be able 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 may 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.

3.16
United States dollar
USD
national currency for the United States of America

Note 1 to entry: It is a benchmark currency and is used in many countries worldwide. To make the conversion from USD to local currency, use the rates posted by the US Federal Reserve Bank: https://www.newyorkfed.org/markets/foreignex.html. Make note of the rate and date of conversion.

3.17
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.

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4 City indicators

This document is designed to assist cities in steering and assessing the performance management of city services and all service provisions, as well as quality of life. It considers sustainability as its general principle, and smartness and resilience as guiding concepts in the development of cities. All indicators shall be compiled on an annual basis. If census data are used, the year of census shall be reported. The year of population data shall also be reported.

Those implementing this document shall report on all core indicators listed in Clauses 5 to 23 of this document.

The core indicators described in this document are considered essential for steering and assessing the performance management of city services and quality of life.

Depending on the objectives, cities should also report on the supporting indicators given in Clauses 5 to 23 of this document.

The core, supporting and profile indicators are classified into themes according to the different sectors and services provided by a city. The classification structure is used solely to denote the services and area of application of each type of indicator when reported on by a city. This classification of themes has no hierarchical significance and is organized alphabetically. For each indicator, the correspondence with the issues of ISO 37101 is noted [for consistency with Annex B, Table B.1, and with the United Nations Sustainable Development Goals (SDGs) (Annex C)].

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

Indicators under each theme, where possible, were selected and paired on the basis of input and outcome indicators for further contextual analysis.

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

Users may 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);

— since some indicators are indirectly linked to sustainability, there is a need to consider the resource efficiency of a city;

— indicators can be grouped together for analysis when taking into consideration holistic characteristics of a city; and

— this set of indicators may be complemented by other indicator sets in order to have a more comprehensive, holistic approach to analysis on sustainability.

Furthermore, it is also important to acknowledge potential antagonistic effects of the outcome of particular indicators, either positive or negative, when analysing results. For example, the number of automobiles per capita will potentially result in increased levels of greenhouse gas emissions.

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5 Economy

5.1 City's unemployment rate (core indicator)

5.1.1 General

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

NOTE 1 The unemployment rate is considered one of the most informative labour market indicators reflecting the general performance of the labour market and the health of the economy as a whole. It is used to measure a city's unutilized labour supply and track business cycles. When economic growth is strong, unemployment rates tend to be low and when the economy is stagnating or in recession, unemployment rates tend to be higher.

NOTE 2 This indicator reflects "Living together, interdependence and mutuality" and "Economy and sustainable production and consumption" issues as defined in ISO 37101. It can allow an evaluation of the contribution to "Social cohesion", "Well-being", "Attractiveness" and "Resilience" purposes of the city as defined in ISO 37101.

5.1.2 Core indicator requirements

A city's unemployment rate shall be calculated as the number of working-age primary residents who during the survey reference period were not in paid employment or self-employment, but available for work and seeking work (numerator) divided by the total labour force (denominator). The result shall be multiplied by 100 and expressed as a percentage.

Unemployment shall refer to individuals without work, actively seeking work in a recent period (past four weeks) and currently available for work. Persons who did not look for work but have a future labour market stake (arrangements for a future job start) are counted as unemployed (International Labour Organization). Discouraged workers or hidden unemployed shall refer to persons who are not actively seeking work because they believe the prospects of finding it are extremely poor or they have restricted labour mobility, face discrimination and/or structural, social and cultural barriers. They are not counted as part of the labour force, and are therefore not considered to be unemployed. Not actively seeking work shall refer to people who have not taken active steps to seek work (e.g. job searches, interviews, informational meetings) during a specified recent period (usually the past four weeks).

Labour force shall refer to the sum of the total persons employed and unemployed who are legally eligible to work and who are primary residents of the city.

For cities that cannot report unemployment at the city level, the reporting level should be indicated.

NOTE 1 If data are categorized by gender, cities are encouraged to specify the respective unemployment rates for males and females during reporting of the overall unemployment rate

NOTE 2 The social responsibility core subjects of human rights and labour practices from ISO 26000 can be considered, and are particularly useful in regards to child labour.

NOTE 3 The International Labour Organization (ILO) Fundamental Principles and Rights at Work (FPRW) include the elimination of child labour alongside the right to freedom of association and collective bargaining, elimination of forced labour, and the elimination of discrimination in employment or occupation. These fundamental principles and rights at work are mutually interdependent. Violation of one category of rights at work often has an adverse impact on the respect and realization of the others. Vice versa, recognition, promotion and implementation of one category of rights can have a beneficial impact on the respect and realization of the others.

Over the years the international community has developed a framework of International Standards which seek to protect children from child labour, in particular the two important ILO Conventions on the subject and more generally the UN Convention on the Rights of the Child[45]. Although some progress is being made in reducing child labour, in too many cases the rights contained in these International Standards are still not fully applied in practice and enforced. Users of this document are encouraged to keep these principles in mind.

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5.2 Assessed value of commercial and industrial properties as a percentage of total assessed value of all properties (supporting indicator)

5.2.1 General

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

NOTE 1 Assessed value of commercial and industrial properties as a percentage of total assessed value of all properties provides an understanding of the mix of assessed values of properties as well as the stability of the assessed base. A downward trend in the proportion of commercial and industrial assessed values could indicate an eroding economic base. Overreliance on residential assessed values can impact affordability.

NOTE 2 This indicator reflects "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.

5.2.2 Supporting indicator requirements

The assessed value of commercial and industrial properties as a percentage of total assessed value of all properties shall be expressed as the total assessed value of commercial and industrial properties (numerator) divided by the total assessed value of all properties (denominator). The result shall then be multiplied by 100 and expressed as a percentage.

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

NOTE 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.

5.3 Percentage of persons in full-time employment (supporting indicator)

5.3.1 General

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

NOTE 1 The persons living in the city in full-time employment is an indicator of the economic health of the city and the success of city economic policy.

For cities that cannot report employment at the city level, the reporting level should be indicated.

NOTE 2 This indicator reflects "living together, interdependence and mutuality" and "economy and sustainable production and consumption" issues as defined in ISO 37101. It can allow an evaluation of the contribution to "social cohesion", "well-being", "attractiveness" and "resilience" purposes of the city as defined in ISO 37101.

5.3.2 Supporting indicator requirements

The percentage of persons in full-time employment shall be calculated as the number of persons in full-time employment (numerator) divided by the total labour force (denominator). The result shall then be multiplied by 100 and expressed as a percentage.

The number of persons residing in the city in full-time employment shall include residents who are self-employed and shall only include those who work a minimum of 35 h a week in one job and who are of legal working age (International Labour Organization).

NOTE Employment is a formal labour market concept which is often complicated in developing countries with a large informal sector of the city economy.

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5.4 Youth unemployment rate (supporting indicator)

5.4.1 General

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

NOTE 1 The unemployment rate is probably the best-known and most used labour market performance indicator. Youth unemployment rate is a key indicator for quantifying and analysing the current labour market trends and challenges of young people, being considered as more sensitive to market changes. Youth unemployment can have damaging effects on individuals, communities, economies and society at large. Unemployed or underemployed youths are less able to contribute effectively to community and national development and have fewer opportunities to exercise their rights as citizens.

NOTE 2 This indicator reflects "living together, interdependence and mutuality", "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 "social cohesion", "well-being", "attractiveness" and "resilience" purposes of the city as defined in ISO 37101.

5.4.2 Supporting indicator requirements

The youth unemployment rate shall be calculated as the total number of a city's unemployed youth (numerator) divided by the city's youth labour force (denominator). The result shall be multiplied by 100 and expressed as a percentage.

Unemployed youth shall refer to individuals above the legal working age and under 24 years of age who are without work, actively seeking work in a recent period (past four weeks) and currently available for work (registered students are not counted). Youths who did not look for work but have a future labour market stake (arrangements for a future job start) are counted as unemployed (International Labour Organization, http://youthstatistics.org/). Discouraged workers or hidden unemployed shall not be counted as part of the labour force, and are therefore not considered to be unemployed. Not actively seeking work shall refer to people who have not taken active steps to seek work (e.g. job searches, interviews, informational meetings) during a specified recent period (usually the past four weeks).

Youth labour force shall refer to all persons above the legal working age and under 24 years of age who are either employed or unemployed over a specified reference period.

NOTE Countries vary somewhat in their operational definitions of youth; in particular, the lower age limit for young people is usually determined by the minimum age for leaving school, where this exists.

For cities that cannot report unemployment rates at municipal level, the reporting level should be indicated.

5.5 Number of businesses per 100 000 population (supporting indicator)

5.5.1 General

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

NOTE 1 The number of businesses per 100 000 can inform a city's level of economic activity and economic performance. It provides one indication of the overall business climate in a jurisdiction, and attitudes towards entrepreneurship. Strong entrepreneurial activity is closely associated with a dynamic and growing economy. The number of businesses is also used to inform competitiveness of a city.

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 "attractiveness" purpose of the city as defined in ISO 37101.

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5.5.2 Supporting indicator requirements

The number of businesses per 100 000 population shall be calculated as the total number of businesses in a city (numerator) divided by one 100 000th of the city's total population (denominator). The result shall be expressed as the number of businesses per 100 000 population.

Businesses shall refer to companies or enterprises. The enterprise is the smallest combination of legal unit, that is, an organizational unit producing goods or services. Business can either be categorized as simple (one operating entity) or complex (multiple operating entities).

5.5.3 Data sources

Cities should consult a business registry to obtain data on the number of businesses.

5.6 Number of new patents per 100 000 population per year (supporting indicator)

5.6.1 General

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

NOTE 1 The number of patents issued to persons or corporations of a city is an indicator of commercial and technological innovation.

NOTE 2 This indicator reflects the "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 the "attractiveness" purpose of the city as defined in ISO 37101.

5.6.2 Supporting indicator requirements

The number of new patents per 100 000 population per year shall be calculated as the total number of new patents issued to persons and corporations of the city (numerator) divided by one 100 000th of the city's total population (denominator). The result shall be expressed as the number of patents registered per 100 000 population.

5.6.3 Data sources

As patents are generally issued by the national government, cities will be reliant on another level of government to provide this information on an annual city-by-city basis.

Data should be obtained from Government patent offices, which maintain records of all patents registered to persons and corporations across their jurisdiction.

5.7 Annual number of visitor stays (overnight) per 100 000 population (supporting indicator)

5.7.1 General

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

NOTE 1 This indicator measures the number of people visiting a city for leisure, business or other purposes, and the importance of tourism to the local economy.

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 "attractiveness" purpose of the city as defined in ISO 37101.

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5.7.2 Supporting indicator requirements

The annual number of visitor stays (overnight) per 100 000 population shall be calculated as the sum of overnight visitor stays (numerator) divided by one 100 000th of the city's total population (denominator). The result shall be expressed as the annual number of visitor stays (overnight) per 100 000 population.

Visitor stays shall refer to paid, per person nightly accommodation at hotels, hostels, vacation centres, rented houses/cottages and campsites. Overnight stays with family or friends, or in private houses or cottages, are not included.

NOTE Two people staying in one hotel room for one night is counted as two overnight stays.

5.7.3 Data sources

Data should be gathered from the best available data sources pertaining to visitor arrivals and paid accommodation in a city. These can include statistics taken from tourism boards and from hotel and lodging associations.

5.8 Commercial air connectivity (number of non-stop commercial air destinations) (supporting indicator)

5.8.1 General

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

NOTE 1 The diversity of non-stop commercial airline destinations is indicative of a city's connectivity to the rest of the nation and the world. Cities with high commercial air connectivity typically have more robust economies and are able to provide a higher level of service to residents. Although commercial air is one demonstration of connectivity, other modes such as rail can also measure connectivity and could be considered a more sustainable alternative to air travel.

NOTE 2 This indicator reflects the "mobility," "community infrastructures" and "economy and sustainable production and consumption" issues 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.

5.8.2 Supporting indicator requirements

Commercial air connectivity shall be calculated as the sum of all non-stop commercial (i.e. scheduled) flights departing from all airports serving the city.

Airports serving the city shall include all airports within a 2-h travel distance from the subject city (e.g. Paris could count flights departing from Charles de Gaulle and Orly airports). Connecting flights shall be excluded because travel is theoretically possible between any two cities in the world, given an unlimited number of connections.

5.8.3 Data sources

Commercial air destination lists should be obtained from airport operators, passenger airport facility planners, and/or federal aviation agencies. Web resources including airline websites and the Official Airline Guide (OAG) may also be used.

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5.9 Economy profile indicators

5.9.1 Average household income (USD) (profile indicator)

5.9.1.1 General

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

NOTE Household income measures the combined incomes of the people in a particular household. An average of household income in a city can indicate the monetary well-being of residents within the city.

5.9.1.2 Profile indicator requirements

The average household income shall be calculated as the sum of total income received during the calendar year by all households within city boundaries (numerator) divided by the total number of households within city boundaries (denominator). The result shall be expressed as the average household income in USD.

Household income shall include income earned by all household members who are 15 years of age or older.

To make the conversion from local currency, cities should use the rates posted by the US Federal Reserve Bank: https://www.newyorkfed.org/markets/foreignex.html. Cities should also make note of the rate and date of conversion.

5.9.2 Annual inflation rate based on the average of the past five years (profile indicator)

5.9.2.1 General

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

NOTE Inflation is the general increase in price of goods and services in an economy. An increase in prices might result in reduced purchasing power per unity of money. The Consumer Price Index (CPI) is one of the simplest and most frequently used statistics to calculate inflation rates. The formula to calculate inflation rate for a 1-year period is $[(B - A) / A] \times 100$, where B is the current CPI value and A is the CPI value from 1 year ago.

5.9.2.2 Profile indicator requirements

The annual inflation rate based on the average of the past five years shall be calculated as the sum of the rate of inflation of the preceding five years (numerator) divided by five (denominator). The result shall be expressed as a percentage.

For cities that cannot report annual inflation rate at the city or municipal level, the reporting level should be indicated.

5.9.3 City product per capita (USD) (profile indicator)

5.9.3.1 General

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

NOTE City product per capita is the same concept as gross national product but applied to a city or municipality only. It provides indication of city economic development, employment and investment. Moreover, it provides better indication of international trade than other more traditional measures such as gross domestic product.

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5.9.3.2 Profile indicator requirements

The annual city product shall be calculated using one of two methods:

Method A consists of taking the national product in each industry sector (SITC standard industry classification) and then multiplying it by the differential wage rates at the city level, for each industry sector. This method is used when employment by industry sector is known.

Method B consists of using the city household income figures and by multiplying the ratio of gross national product (GNP) to total household income at the national level. This method assumes that the ratio of the GNP to the household income is the same at the city and national level. So far, this method has been used in most of the UN habitat city indicator reports.

Method A is considered preferable. However, the method used in calculating the city product should be clearly noted in the result reported.

The city product should then be converted into US dollars and divided by the current population of the city to give a per capita figure, expressed in US dollars. To make the conversion from local currency, cities should use the rates posted by the US Federal Reserve Bank: https://www.newyorkfed.org/markets/foreignex.html. Cities should also make note of the rate and date of conversion.

City product is difficult to calculate. If cities do not have ready estimates of city product based on own methodologies or established industry norms, then Method A or B should be used. Note that these methods provide estimates of city product, not exact values.

5.9.3.3 Data sources

Data for this indicator are available from the agency of each national government charged with the responsibility of collecting gross national product data. Data can also be available from the offices of city managers or finance offices of the city if a city is already calculating city product within the city government.

6 Education

6.1 Percentage of female school-aged population enrolled in schools (core indicator)

6.1.1 General

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

NOTE 1 Education is one of the most important aspects of human development. This indicator addresses the issue of educational opportunity, by indicating how widespread formal education is in the city among school-aged population. Reporting on the differential enrolment by gender is consistent with the Sustainable Development Goals, Goal 5: Achieve Gender Equality and Empower all Women and Girls[22].

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", "Resilience" and "Well-being" purposes of the city as defined in ISO 37101.

6.1.2 Core indicator requirements

The percentage of female school-aged population enrolled in schools shall be calculated as the number of a city's female school-aged population enrolled at primary and secondary levels in public and private schools (numerator) divided by the total number of a city's female school-aged population (denominator). The result shall then be multiplied by 100 and expressed as a percentage.

The proportion of enrolment in public and private schools should be reported, and cities should note if private school data are included. In many cities, private schools are a significant component of

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education in the city. Private schools shall be recognized as providing real, bona fide education; many ministries or departments of education have a program that recognizes such schools. Enrolment in religious schools and home schools should be included if they are recognized.

One part-time enrolment of a half-day or more shall be counted as a full-time enrolment.

If the geographies of school districts and the city are different, best judgement should be used to relate enrolment data to the city boundaries.

NOTE Primary education is considered to be the first stage of basic education. It typically covers six years of full-time schooling with the legal age of entrance normally being not younger than 5 years or older than 7 years. Primary education refers to children aged 5–12 years or 1st grade through to 5th or 6th grade, as defined by local education systems. Secondary education is considered to be the second stage of basic education and marks the end of compulsory education where it exists. Secondary students usually enter between the ages of 10 and 13. Secondary education usually ends approximately 12 or 13 years after the beginning of primary education (or around age 18). Secondary education also refers to 6th grade (or 7th grade) to 12th grade, as defined by local education systems.

6.1.3 Data sources

Data on school enrolment should be obtained from local school boards, or the relevant Ministry or Department of Education. If enrolment data from these sources are not available, then data for enrolment from surveys or censuses may be used.

6.2 Percentage of students completing primary education: survival rate (core indicator)

6.2.1 General

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

NOTE 1 Survival rate measures the holding power and internal efficiency of an education system. Survival rate to the fifth grade of primary education is of particular interest since this is commonly considered as a prerequisite for sustainable literacy. This indicator is often used as an assessment of Sustainable Development Goals, Goal 4: Quality Education[22].

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”, “Resilience” and “Well-being” purposes of the city as defined in ISO 37101.

6.2.2 Core indicator requirements

The percentage of students completing primary education (survival rate) shall be calculated as the total number of a city’s students belonging to a school-cohort who complete the final grade of primary education (numerator) divided by the total number of a city’s students belonging to a school cohort, i.e. those originally enrolled in the first grade of primary education (denominator). The result shall then be multiplied by 100 and expressed as a percentage.

The survival rate of primary education shall refer to the percentage of a cohort of students enrolled in the first grade of primary education who reached the final grade of primary education. If data are categorized by public and private education sectors, cities are encouraged to specify the respective survival rates for those sectors during reporting of the overall survival rate.

NOTE 1 This indicator measures students belonging to a school cohort who have reached each successive grade of primary education without failing or moving to another jurisdiction.

NOTE 2 This methodology is adapted from UNESCO Education Indicator Technical Guidelines[4].

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EXAMPLE If the city reporting year is 2012 and primary education lasts five years, the percentage of students who entered primary education in 2006 and reached the final grade of primary education in 2011 would be reported.

NOTE 3 Since the calculation of this indicator is based on student-flow rates, the reliability of the survival rate depends on the consistency of data on enrolment and repeaters (those who repeat one or more grades) in terms of coverage over time.

6.2.3 Data sources

Data on school enrolment is usually recorded by the Ministry or Department of Education or local school boards. In some cities survival rates will only be readily available for public school systems. However, since private schools are a significant component of education in many cities, private schools shall be recognized as providing real, bona fide education and since many ministries or departments of education have a program that recognizes such schools, both private and public school data should be included in this calculation.

6.3 Percentage of students completing secondary education: survival rate (core indicator)

6.3.1 General

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

NOTE 1 Survival rate measures the holding power and internal efficiency of an education system.

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", "Resilience" and "Well-being" purposes of the city as defined in ISO 37101.

6.3.2 Core indicator requirements

The percentage of students completing secondary education (survival rate) shall be calculated as the total number of a city's students belonging to a school cohort who complete the final grade of secondary education (numerator) divided by the total number of a city's students belonging to a school cohort, i.e. those originally enrolled in the first grade of secondary education (denominator). The result shall then be multiplied by 100 and expressed as a percentage.

Survival rates for the private education sector should be reported, if known. The user of this document shall note if private school data are included.

NOTE 1 This indicator measures students belonging to a school cohort who have reached each successive grade of secondary education without failing or moving to another jurisdiction.

NOTE 2 This methodology is adapted from UNESCO Education Indicator Technical Guidelines[4].

EXAMPLE If the city reporting year is 2012 and secondary education lasts seven years, the percentage of students who entered secondary education in 2004 and reached the final grade of secondary education in 2011 would be reported.

6.3.3 Data sources

Since the calculation of this indicator is based on student-flow rates, the reliability of the survival rate depends on the consistency of data on enrolment and repeaters (those who repeat one or more grades) in terms of coverage over time and across grades.

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In most cities, survival rates will only be readily available for public school systems. However, since private schools are a significant component of education in many cities, private schools shall be recognized as providing real, bona fide education and since many ministries or departments of education have a program that recognizes such schools, both private and public school data should be included in this calculation.

NOTE Data on school enrolment are usually recorded by the Ministry or Department of Education or by local school boards.

6.4 Primary education student–teacher ratio (core indicator)

6.4.1 General

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

NOTE 1 The student–teacher ratio is an indicator of the adequacy of teacher availability and can be related to the strength and quality of an education system.

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 "Responsible resource use" purpose of the city as defined in ISO 37101.

6.4.2 Core indicator requirements

The primary education student–teacher ratio shall be expressed as the number of enrolled primary school students (numerator) divided by the number of full-time equivalent (FTE) primary school classroom teachers (denominator). The result shall be expressed as the number of students per teacher and represent the primary education student–teacher ratio.

Private educational facilities shall not be included in the student–teacher ratio. The number of teachers and students shall be reported as the average per school year.

One part-time student enrolment shall be counted as one full-time enrolment; in other words a student who attends school for half a day should be counted as a full-time enrolment. If a city reports FTE enrolment (where two half-day students equals one full student enrolment), this shall be noted.

The number of classroom teachers and other instructional staff (e.g. teachers' aides, guidance counsellors) shall not include administrators or other non-teaching staff. Kindergarten or pre-school teachers and staff shall not be included.

The number of teachers shall be counted in time increments according to local school practices and number of days worked. For example, a teacher working one day per week should be counted as 0.2 teachers, and a teacher working three days per week should be counted as 0.6 teachers, if the number of days worked is usually 5 days.

6.4.3 Data sources

The number of FTE primary school classroom teachers and the number of enrolled primary school students should be collected from the local public school system or Ministry of Education.

6.4.4 Data interpretation

The student–teacher ratio reflects teacher workload and the availability of teachers' services to their students. The lower the student–teacher ratio, the higher the availability of teacher services to students. The student–teacher ratio has implications not only for the cost of education, but also for the quality. Higher educational attainment is correlated with a lower student–teacher ratio.

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6.5 Percentage of school-aged population enrolled in schools (supporting indicator)

6.5.1 General

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

NOTE 1 Education is one of the most important aspects of human development. This indicator addresses the issue of educational opportunity by indicating how widespread formal education is in the city among the school-age population.

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", "Resilience" and "Well-being" purposes of the city as defined in ISO 37101.

6.5.2 Supporting indicator requirements

The percentage of school-aged population enrolled in schools shall be calculated as the number of a city's school-aged population enrolled in primary and secondary levels in public and private schools (numerator) divided by the total number of the city's school-aged population (denominator). The result shall then be multiplied by 100 and expressed as a percentage.

Enrolment in public and private schools should be reported, and cities should note in the comment section if private school data are included. In many cities, private schools are a significant component of education in the city. Private schools shall be recognized as providing real, bona fide education; many ministries or departments of education have a program that recognizes such schools. Enrolment in religious schools and home schools should be included if they are recognized.

Part-time enrolment of a half-day or more shall be counted as a full-time enrolment.

If the geographies of school districts and the city are different, best judgement should be used to relate enrolment data to the city boundaries.

6.6 Number of higher education degrees per 100 000 population (supporting indicator)

6.6.1 General

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

NOTE 1 Education is a major component of well-being and is an indicator of economic development and quality of life. A city's population that holds higher education degrees signals a well-educated workforce across a city's population that helps to drive economic development. Higher education degrees provide individuals with a foundation for meaningful participation in the labour force.

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 "Social Cohesion", "Resilience", "Attractiveness" and "Well-being" purposes of the city as defined in ISO 37101.

6.6.2 Supporting indicator requirements

The number of higher education degrees per 100 000 population shall be calculated as the number of people holding higher education (tertiary education) degrees (numerator) divided by one 100 000th of the city's total population. The result shall be expressed as the number of higher degrees per 100 000 population.

Higher education shall refer to forms of tertiary learning beyond those of secondary level. Higher education is offered through universities, colleges, institutes, academies, seminaries and trade schools that grant academic degrees and/or professional certifications.

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6.6.3 Data sources

Data on the number of people holding higher education degrees should be available from census and household surveys.

7 Energy

7.1 Total end-use energy consumption per capita (GJ/year) (core indicator)

7.1.1 General

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

NOTE 1 An understanding of how much energy is currently being consumed can help cities to effectively manage the generation, consumption and conservation of energy. This process can be aided further with an understanding of what types of energy are used by end-use sector.

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.

7.1.2 Core indicator requirements

Total end-use energy consumption per capita shall be calculated as the total end-use energy consumed[3)] by a city in gigajoules (numerator) divided by the total population of the city (denominator). The result shall be expressed as the total end-use energy consumed per capita in gigajoules per year.

Heating and cooling degree days as reported in 7.8.1 and 7.8.2 should be considered in order to allow for comparison between years and across regions.

Table 1 — Total end-use energy consumption by type and by sector

	Electricity	Coal	Fuel oil	Natural gas/ propane/ butane/ LPG	Gasoline	Diesel	Biomass	Biofuels	Other	Total
Residential										
Commercial										
Industrial										
Transportation										
Other sector										
TOTAL										

"Other sector" includes sectors such as agriculture that are not explicitly stated. As a minimum, all sectors shall be reported with total needs.

NOTE Commercial can also be referred to as tertiary/service sector ranging from commerce to administration (public buildings), financial and real estate activities, services to business, personal services, education, health and social services.

Where possible, the energy mix and data from each sector for thermal (e.g. heating of buildings) and electrical energy use should be included and listed as additional information. See Table 1.

3) The inputs used to provide the sum of total end-use energy usage should include a breakdown of the fuel type by end-use sector. Categories of fuel types include electricity, coal, fuel oil, natural gas, gasoline, diesel, biomass, biofuels and other. Once the energy mix is provided, the usage of energy consumption should be further divided by end-use sector. End-use sectors include residential, commercial, industrial, transportation and other. Total energy consumption should include thermal, motive and electrical energy for all sectors.

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7.1.3 Data sources

Data should be gathered from electricity and fuel distributors. Electricity consumption statistics are typically collected in categories of residential, industrial, transportation, commercial and other sector.

7.2 Percentage of total end-use energy derived from renewable sources (core indicator)

7.2.1 General

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

NOTE 1 The promotion of renewable energy sources is a high priority for sustainable development, for reasons such as the security and diversification of energy supply and for environmental protection.

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" and "Resilience" purposes of the city as defined in ISO 37101.

7.2.2 Core indicator requirements

The percentage of total end-use energy derived from renewable sources shall be calculated as the total consumption of end-use energy generated from renewable sources divided by total end-use energy consumption. The result shall then be multiplied by 100 and expressed as a percentage.

Renewable energy sources should include geothermal, solar, wind, hydro, tide and wave energy, combustibles and biofuels such as biomass.

Total renewable energy consumption shall include both thermal energy and electrical energy from all sectors including residential, transport, service/trade and industrial. Where possible, data from each sector for both thermal and electrical energy use shall be included and listed individually.

	Thermal energy	**Electrical energy**
Total renewable energy consumption		

7.2.3 Data sources

Data are available from local utility providers, city energy or environment offices, and from various international sources such as the International Energy Agency (IEA) and the World Bank.

7.2.4 Data interpretation

End-use energy from renewable sources shall include both combustible and non-combustible renewables. Non-combustible renewable electricity sources include geothermal, solar, wind, hydro, tide and wave energy. For geothermal energy, the energy quantity is the enthalpy of the geothermal heat entering the process. The combustible renewables and waste (CRW) consist of biomass (e.g. fuelwood, vegetal waste, ethanol) and animal products (animal materials/waste with sulphite lyes), municipal waste (waste produced by the residential, commercial and public service sectors that is collected by local authorities for disposal in a central location for the production of heat and/or power) and biogenic industrial waste.

The breakdown of end-use energy consumption by source, if these data are available (e.g. % derived from fossil fuel; % derived from nuclear; % derived from renewables), should be noted.

NOTE Data on particular renewable electricity sources for a number of developing countries might be a limitation.

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7.3 Percentage of city population with authorized electrical service (residential) (core indicator)

7.3.1 General

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

NOTE 1 The percentage of the city population with authorized connection to the electricity supply system (the electricity grid) is an indicator of lawful provision of a basic urban service, which is of particular relevance to cities in less developed regions of the world. Electrical service is a contributing indicator of sustainability, resilience and economic productivity.

NOTE 2 This indicator reflects the "Community infrastructures" issue as defined in ISO 37101. It can allow an evaluation of the contribution to the "Resilience", "Attractiveness" and "Well-being" purposes of the city as defined in ISO 37101.

7.3.2 Core indicator requirements

The percentage of the city population with authorized electrical service (residential) shall be calculated as the number of people in the city with authorized electrical service (numerator) divided by the total population of the city (denominator). The result shall then be multiplied by 100 and expressed as a percentage.

Authorized electrical service shall refer to a lawful connection to the electrical supply system.

The number of city households with authorized connections to the electricity supply system (often referred to as the electricity grid) shall be multiplied by the current average city household size to determine the number of people with authorized connection to the electricity supply system.

NOTE Most electricity supply authorities distinguish billing accounts to residential and non-residential establishments. Residential establishments in most cities equate to households (although in some condominiums, the body corporate holds the account for multiple households).

7.4 Number of gas distribution service connections per 100 000 population (residential) (core indicator)

7.4.1 General

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

NOTE 1 The number of gas distribution service connections is an indicator of a basic service provision in cities of cool climates or where there is a prevalence of gas appliance use.

NOTE 2 This indicator reflects the "Community infrastructures" issue as defined in ISO 37101. It can allow an evaluation of the contribution to the "Attractiveness" and "Well-being" purposes of the city as defined in ISO 37101.

7.4.2 Core indicator requirements

The number of gas distribution service connections per 100 000 population (residential) shall be calculated as the number of people in the city with connection to gas distribution services (numerator) divided by one 100 000th of the city's total population (denominator). The result shall be expressed as the number of gas distribution service connections per 100 000 population.

The number of city households with connections to the gas distribution supply system shall be multiplied by the current average city household size to determine the number of people with connection to the gas supply system.

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7.4.3 Data interpretation

Not all cities use gas distribution networks, and thus a reported low value of this indicator does not suggest inadequate service delivery.

7.5 Final energy consumption of public buildings per year (GJ/m^2) (core indicator)

7.5.1 General

Those implementing this document shall 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 consumption can create substantial savings and can enhance security of the energy supply. Reducing the energy consumption of a building can also reduce greenhouse gas emissions and its ecological footprint, which can help combat climate change and promote a low-carbon economy.

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.

7.5.2 Core indicator requirements

Final energy consumption of public buildings per year shall be calculated as the total end use of energy in public buildings (GJ) within a city (numerator) divided by total floor space of these buildings in square metres (m^2) (denominator). The result shall be expressed as the total final energy consumption of public buildings per year in gigajoules per square metre.

Energy consumption shall include both thermal and electrical energy consumption.

NOTE See 3.17.

7.6 Electricity consumption of public street lighting per kilometre of lighted street (kWh/year) (supporting indicator)

7.6.1 General

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

NOTE 1 Street lighting can comprise 15 % to 50 % of public electricity. Improving the efficiency of street lighting is also one of the most important and cost-effective steps that a city can take to improve energy efficiency. Improving the quality and efficiency of public street lighting has multiple co-benefits, including reduced maintenance costs, improved public safety and reduced crime rates, improved road and traffic safety, improved air quality, enhanced city attractiveness and community identity and increased economic productivity.

NOTE 2 This indicator reflects the "Economy and sustainable production and consumption" and "Community infrastructure" 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 Supporting indicator requirements

Electricity consumption of public street lighting shall be calculated as the total electricity consumption of public street lighting (numerator) divided by the total distance of streets where street lights are present (denominator). The result shall be expressed as electricity consumption of public street lighting in kilowatt hours per kilometre per year.

For the purposes of the standard, the street lighting should meet locally or nationally defined standards for illumination and/or the requirements set by the International Commission on Illumination, Technical Report CIE 115:2010, "Lighting of Roads for Motor and Pedestrian Traffic."

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7.7 Average annual hours of electrical service interruptions per household (supporting indicator)

7.7.1 General

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

NOTE 1 Average annual hours of electrical service interruptions helps to track and benchmark reliability performance in electric utility services and resource constraints.

NOTE 2 This indicator reflects the "Community infrastructure" issue as defined in ISO 37101. It can allow an evaluation of the contribution to the "Well-being", "Attractiveness" and "Resilience" purposes of the city as defined in ISO 37101.

7.7.2 Supporting indicator requirements

The average annual hours of electrical service interruptions per household shall be calculated by taking the total sum of hours of interruption multiplied by the number of households impacted (numerator) divided by the total number of households (denominator). The result shall be expressed as the average annual hours of electrical service interruptions per household.

It is normal to experience interruptions in service for a number of reasons including scheduled maintenance, equipment breakdown and power load shedding. To ensure valid comparisons between energy providers, major storms and weather events should be excluded due to their variability with geographic location.

NOTE This indicator is affected by the age, standard of maintenance and reliability of the infrastructure that constitutes electricity distribution and transmission. The ability of both the grid and its electricity transmission capacity to provide supply on demand and to cope with peak loads is also an important consideration.

7.7.3 Data interpretation

Cities with older infrastructure, intermittent power supply, war or civil unrest, or exposure to natural hazards will tend to experience more service interruptions.

7.8 Energy profile indicators

7.8.1 Heating degree days (profile indicator)

7.8.1.1 General

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

NOTE Degree days indicate the energy demands of buildings as a response to their local and regional climate. 'Heating' degree days is a measure of the space heating requirements of buildings, while "cooling" degree days is a measure of the space cooling requirements.

7.8.1.2 Profile indicator requirements

Heating degree days shall be calculated by subtracting the mean daily air temperature from the standard baseline air temperature, and then summed for each day of the year to meet an annual total. If the temperature difference is a negative number, it shall be omitted from the calculation. The result shall be expressed as heating degree days.

Base temperature standards vary by country. For example, in the United States the base figure is 65 °F while in the UK it is 15,5 °C. Reporting cities shall provide base temperature standards as additional information.

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Those implementing this document shall use the method and base temperature given in the specific standard for their country.

Cities should describe the location of the temperature measurements to convey the local representativeness of the reported values (e.g. airport, city centre).

7.8.2 Cooling degree days (profile indicator)

7.8.2.1 General

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

NOTE Degree days indicate the energy demands of buildings as a response to their local and regional climate. "Heating" degree days is a measure of the space heating requirements of buildings, while "cooling" degree days is a measure of the space cooling requirements.

7.8.2.2 Profile indicator requirements

Cooling degree days shall be calculated by subtracting the mean daily air temperature from the standard baseline air temperature, and then summed for each day of the year to meet an annual total. If the temperature difference is a negative number, it shall be omitted from the calculation. The result shall be expressed as cooling degree days.

Base temperature standards vary by country. For example, in the United States the base figure is 65 °F while in the UK it is 15,5 °C. Reporting cities shall provide base temperature standards as additional information.

Those implementing this document shall use the method and base temperature given in the specific standard for their country.

Cities should describe the location of the temperature measurements to convey the local representativeness of the reported values (e.g. airport, city centre).

8 Environment and climate change

8.1 Fine particulate matter (PM2.5) concentration (core indicator)

8.1.1 General

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

NOTE 1 Fine particulate matter can cause major health problems in cities. According to the WHO, any concentration of particulate matter (PM) is harmful to human health. PM is carcinogenic and harms the circulatory system as well as the respiratory system. As with many other air pollutants, there is a connection with questions of environmental justice, since underprivileged citizens can often suffer from stronger exposure. The evidence on PM and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations in both developed and developing countries. The range of health effects is broad, but predominantly associated with the respiratory and cardiovascular systems.

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

8.1.2 Core indicator requirements

Fine particulate matter (PM2.5) concentration shall be calculated as the total mass of collected particles that are 2,5 μm or less in diameter (numerator) divided by the volume of air sampled in standard

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cubic metres (μg/m^3) (denominator). The result shall be expressed as the concentration of PM2.5 in micrograms per standard cubic metre (μg/m^3).

The method for measurement shall involve the use of an air sampler which draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM2.5 size range. The 24-h (daily) measurements of PM2.5 concentrations are forwarded to a database where yearly summaries for each monitoring station are computed.

NOTE Since data for PM2.5 are not readily available, levels are often calculated on the basis of PM10 emission and this is reported as a separate indicator.

Cities should describe the location of each monitoring station to convey the local representativeness of the measured values (e.g. airport, city centre, industrial park). Ideally, multiple station locations should be used to determine a spatial average for the city.

8.2 Particulate matter (PM10) concentration (core indicator)

8.2.1 General

Those implementing this document shall report on this indicator (unless reporting on PM2.5 under 8.1) in accordance with the following requirements.

NOTE 1 The evidence on airborne PM and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations in both developed and developing countries. PM poses a health concern because it can be inhaled and accumulate in the respiratory system.

People with heart or lung disease, older adults and children are considered at greater risk to particle pollution. Long-term exposures (annual mean) to particles, such as those experienced by people living for many years in areas with high particle levels, have been associated with problems such as reduced lung function, the development of chronic bronchitis and even premature death. Short-term exposures (24 h) to particles can aggravate lung diseases, causing asthma attacks and acute bronchitis, and may also increase susceptibility to respiratory infections. High particle pollution in major cities have major negative impacts on economic/business growth due to a decline in foreign investors. According to the World Health Organization[12], air pollution is estimated to cause approximately 2 million premature deaths worldwide per year. In many cities, the average levels of PM10 exceed 70 μg per cubic metre (μg/m^3).

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

8.2.2 Core indicator requirements

Particulate matter (PM10) concentration shall be calculated as the total mass of collected particles in micrograms in the PM10 size range (numerator) divided by the volume of air sampled in standard cubic metres (denominator). The result shall be expressed as the concentration of PM10 in micrograms per standard cubic metre (μg/m^3).

The method for measurement shall involve the use of an air sampler which draws ambient air at a constant flow rate into a specially shaped inlet where the suspended particulate matter is inertially separated into one or more size fractions within the PM10 size range. "Respirable particulate matter" or PM10 particles are defined as greater than 2,5 μm and less than or equal to 10 μm in diameter. The 24-h

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(daily) measurements of PM10 concentrations are forwarded to a database where yearly summaries for each monitoring station are computed.

NOTE Particulate matter is a mixture of microscopic solids and liquid droplets suspended in air. These particulates are made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, soil or dust particles, and allergens (such as fragments of pollen or mould spores). Coarse particles are greater than 2,5 µm and less than or equal to 10 µm in diameter and are defined as "respirable particulate matter" or PM10. Sources of coarse particles include crushing or grinding operations, and dust from paved or unpaved roads.

Cities should describe the location of each monitoring station to convey the local representativeness of the measured values (e.g. airport, city centre, industrial park). Ideally, multiple station locations should be used to determine a spatial average for the city.

8.3 Greenhouse gas emissions measured in tonnes per capita (core indicator)

8.3.1 General

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

NOTE 1 The greenhouse gas emissions from all activities within the city are an indicator of the adverse contribution the city is making to climate change.

NOTE 2 This indicator reflects the "Biodiversity and Ecosystem Services" and "Economy and sustainable production and consumption" issues as defined in ISO 37101. It can allow an evaluation of the contribution to the "Preservation and improvement of environment" purpose of the city as defined in ISO 37101.

8.3.2 Core indicator requirements

The greenhouse gas emissions measured in tonnes per capita shall be measured as the total amount of greenhouse gases in tonnes (equivalent carbon dioxide units) generated over a calendar year by all activities within the city, including indirect emissions outside city boundaries (numerator) divided by the current population of the city (denominator). The result shall be expressed as the total greenhouse gas emissions per capita in tonnes.

The total aggregate tonnage (expressed as equivalent carbon dioxide units of greenhouse gas) of greenhouse gas emissions shall be calculated for all activities within the city for the preceding 12 months.

The Global Protocol for Community-Scale GHG Emissions (GPC), (2012 Accounting and Reporting Standard) refers to a multi-stakeholder consensus-based protocol for developing internationally recognized and accepted community-scale greenhouse gas accounting and reporting. This protocol defines the basic emissions sources and categories within sectors for a community-scale GHG inventory, in order to standardize GHG inventories between communities and within a community over time. The protocol provides accounting methodologies and step-by-step guidance on data collection, quantification and reporting recommendations for each source of emissions.

Both emissions sources and sector categorizations reflect the unique nature of cities and their primary emissions sources. These include emissions from: 1) stationary units, 2) mobile units, 3) waste and 4) industrial process and product use sectors. For further specifications, refer to the full GPC methodology. Local governments shall be expected to provide information (i.e. quantified emissions) for each of these emission sources.

In order to address the issue of inter-city sources of emissions that transcend more than one jurisdictional body, the GPC integrates the GHG Protocol Scope definitions, as follows:

Scope 2 emissions: energy-related indirect emissions that occur as a consequence of consumption of grid-supplied electricity, heating and/or cooling, within the community's geopolitical boundary.

Scope 3 emissions: all other indirect emissions that occur as a result of activities within the community's geopolitical boundary.

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For step-by-step guidance on data and accounting collection, see Section 3 of the GPC. http://www.ghgprotocol.org/sites/default/files/ghgp/standards/GHGP_GPC_0.pdf

NOTE Greenhouse gases (GHGs) are gases in the atmosphere that absorb infrared radiation that would otherwise escape to space, thereby contributing to rising surface temperatures. There are six major GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). The warming potential for these gases varies from several years to decades to centuries.

Users can also consult the ISO 14064 series[82–84] on *Greenhouse Gases* for further guidance.

8.4 Percentage of areas designated for natural protection (supporting indicator)

8.4.1 General

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

NOTE 1 Natural areas play an important role in conserving biodiversity and maintaining ecological processes and natural cycles which serve to benefit the natural and human environment. Natural areas also serve as potential economic hubs by drawing in recreational users into and around the area.

NOTE 2 A protected area is a clearly defined geographical space, recognized, dedicated and managed through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services (International Union for Conservation of Nature).

NOTE 3 This indicator reflects the "Biodiversity and Ecosystem Services" issue as defined in ISO 37101. It can allow an evaluation of the contribution to the "Preservation and improvement of environment" purpose of the city as defined in ISO 37101.

8.4.2 Supporting indicator requirements

The percentage of areas designated for natural protection shall be calculated as the total land area of designated natural protection and/or biodiversity (numerator) divided by the total land area of the city (denominator). The result shall be multiplied by 100 and expressed as a percentage.

Areas designated for natural protection and/or biodiversity shall refer to areas under municipal, communal, natural and/or local protection/biodiversity schemes.

8.5 NO_2 (nitrogen dioxide) concentration (supporting indicator)

8.5.1 General

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

NOTE 1 NO_2 (nitrogen dioxide) is a major air pollutant, which can have significant impacts on human health and the environment. NO_2 contributes to the formation of photochemical smog and at raised levels can increase the likelihood of respiratory problems. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis. Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. NO_2 chemically transforms into nitric acid and contributes to acid rain. Nitric acid can corrode metals, fade fabrics and degrade rubber. When deposited, it can also contribute to lake acidification and can damage trees and crops, resulting in substantial losses.

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

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8.5.2 Supporting indicator requirements

NO_2 concentration shall be calculated as the sum of daily concentrations for a whole year (numerator) divided by 365 days (denominator). The result shall be expressed as the annual average for daily NO_2 concentration in μg/m^3.

The daily concentrations shall be determined by averaging the hourly concentrations throughout a 24-h period from all monitoring stations within the city.

Cities should describe the location of each monitoring station to convey the local representativeness of the measured values (e.g. airport, city centre, industrial park). Ideally, multiple station locations should be used to determine a spatial average for the city.

Users of this document should also note the frequency of NO_2 exposures. Peak exposure is determined by calculating the number of times the hourly mean exceeded 200 μg/m^3 of NO_2 in a calendar year. Long-term exposure is determined by calculating the number of times the daily mean exceeded 40 μg/m^3 of NO_2 in a calendar year.

8.5.3 Data sources

Hourly average concentrations are measured by monitoring equipment and reported to an air quality monitoring authority (e.g. City Environment Office, National Environment Office).

8.6 SO_2 (sulfur dioxide) concentration (supporting indicator)

8.6.1 General

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

NOTE 1 SO_2 (sulfur dioxide) is a major air pollutant, which can have significant impacts on human health and the environment. Health effects caused by exposure to high levels of SO_2 include breathing problems, respiratory illness, changes in the lung's defences, and worsening respiratory and cardiovascular disease. People with asthma or chronic lung or heart disease are the most sensitive to SO_2. It also damages trees and crops. SO_2, along with nitrogen oxides, are the main precursors of acid rain. This contributes to the acidification of lakes and streams, accelerated corrosion of buildings, reduced visibility and deforestation. SO_2 also causes formation of microscopic acid aerosols, which have serious health implications as well as contributing to climate change.

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

8.6.2 Supporting indicator requirements

SO_2 concentration shall be calculated as the sum of daily concentrations for the whole year (numerator) divided by 365 days (denominator). The result shall be expressed as the annual average for daily SO_2 concentration in μg/m^3.

The daily concentration shall be determined by averaging the hourly concentrations throughout a 24-h period from all monitoring stations within the city.

Users of this document should also note the frequency of SO_2 exposures. Peak exposure is determined by calculating the number of times the 10-min mean exceeded 500 μg/m^3 of SO_2 in a calendar year. Long-term exposure is determined by calculating the number of times the daily mean exceeded 20 μg/m^3 of SO_2 in a calendar year.

Cities should describe the location of each monitoring station to convey the local representativeness of the measured values (e.g. airport, city centre, industrial park). Ideally, multiple station locations should be used to determine a spatial average for the city.

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8.6.3 Data sources

Hourly average concentrations are measured by monitoring equipment and reported to an air quality monitoring authority (e.g. City Environment Office, National Environment Office).

8.7 O_3 (ozone) concentration (supporting indicator)

8.7.1 General

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

NOTE 1 High concentrations of ozone in the ambient air are harmful for humans as well as plants. High concentrations of ozone can irritate the respiratory system and are linked to asthma, bronchitis and heart attacks. The elderly are especially vulnerable. There are links being made to ozone concentration and environmental justice, in particular with reference to underprivileged social groups with higher exposure and vulnerability.

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

8.7.2 Supporting indicator requirements

O_3 (ozone) concentration shall be calculated as the sum of daily concentrations for the whole year (numerator) divided by 365 days (denominator). The result shall be expressed as the annual average for daily O_3 (ozone) concentration in $\mu g/m^3$.

O_3 is normally monitored at 8-h intervals. To determine the 24-h average daily concentration, the three 8-h concentrations shall be determined and averaged over a 24-h period at all monitoring stations within the city's boundaries.

Cities should describe the location of each monitoring station to convey the local representativeness of the measured values (e.g. airport, city centre, industrial park). Ideally, multiple station locations should be used to determine a spatial average for the city.

Long-term exposure shall be determined by the number of days when the daily average concentration over an 8-h exposure exceeds 100 $\mu g/m^3$. Long-term exposure should be noted.

8.8 Noise pollution (supporting indicator)

8.8.1 General

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

NOTE 1 Prolonged exposure to noise can lead to significant health effects, both physical and mental.

NOTE 2 This indicator reflects the "Living & working environment" and "Health and care in the community" issues as defined in ISO 37101[36]. It can allow an evaluation of the contribution to the "Preservation and improvement of environment" and "Well-being" purposes of the city as defined in ISO 37101.

8.8.2 Supporting indicator requirements

Noise pollution shall be calculated by assessing the population exposed to noise pollution (the numerator), divided by the total population of the city (denominator). The result shall then be multiplied by 100 and expressed as the percentage of the population affected by noise pollution.

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