

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

L.1440

(10/2015)

SERIES L: ENVIRONMENT AND ICTS, CLIMATE
CHANGE, E-WASTE, ENERGY EFFICIENCY;
CONSTRUCTION, INSTALLATION AND PROTECTION
OF CABLES AND OTHER ELEMENTS OF OUTSIDE
PLANT

Methodology for environmental impact assessment of information and communication technologies at city level

Recommendation ITU-T L.1440



International
Telecommunication
Union

Document Sharing Hub

Recommendation ITU-T L.1440

Methodology for environmental impact assessment of information and communication technologies at city level

Summary

Recommendation ITU-T L.1440 gives general guidance on city-level environmental assessments related to information and communication technologies (ICT) and provides a description of the methodologies to be used for the assessment of the environmental impact of ICT in cities.

In this first edition of this Recommendation, the assessment is limited to energy consumption and greenhouse gas (GHG) emissions.

This Recommendation is divided into two parts.

- 1) Part I relates to the first order effects from the use of ICT goods and networks in a city's organizations and households.
- 2) Part II relates to the first and second order effects from ICT projects and services applied in the city.

This Recommendation provides specific guidance on setting city boundaries, preparing and performing the assessment of ICT-related GHG emissions and energy consumption at city level.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.1440	2015-10-23	5	11.1002/1000/12431

Keywords

Cities, energy consumption, environmental impact, GHG, greenhouse gas emissions, households, ICT, Information communication technologies, public administration.

* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/11830-en>.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

© ITU 2016

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

Table of Contents

	Page
1 Scope.....	1
2 References.....	1
3 Definitions	2
3.1 Terms defined elsewhere:.....	2
3.2 Terms defined in this Recommendation.....	2
4 Abbreviations and acronyms	3
5 Conventions	4
6 Guidance on how to use this Recommendation.....	4
7 General principles for impact assessment of ICT in cities	5
7.1 General	5
7.2 Boundaries.....	6
7.3 Cut-off	8
7.4 Allocation	8
7.5 Data quality and assessment.....	9
7.6 Interpretation of results.....	9
7.7 Emission factors	10
8 Guidance for the assessment of other impacts of ICT at city level	10
8.1 Inventory of other effects	10
8.2 Inventory of drivers and barriers for ICT projects and services.....	11
9 Preparing a report on the environmental impact of ICT in cities	12
9.1 General	12
9.2 Reporting of assessments based on Part I.....	13
9.3 Reporting of Part II.....	13
10 Part I: First order effects from the use of ICT goods and networks in a city's organizations and households	14
10.1 General description.....	14
10.2 First order effect at city level of ICT goods and networks in households.....	14
10.3 First order impact at city level of ICT goods and networks in organizations.....	15
11 Part II: Methodological guidance for the assessment of the second order effect of ICT projects and services at city level	16
11.1 General description.....	16
11.2 Environmental impact of ICT projects at city level	17
11.3 Environmental impact of ICT services at city level	19
11.4 Guidance for estimating the impact of ICT projects or ICT services based on pilot implementations or experiences made by pilots or other cities	20

Appendix I – Example of the assessment of the first order effect of ICT goods and networks in households at a city level	22
I.1 Tier 1 assessment example	22
I.2 Tier 2 Assessment example	27
I.3 Reporting	31
Appendix II – Example of the assessments of first order effect of ICT goods and networks in organizations at a city level.....	34
II.1 Tier 1 assessment example	34
II.2 Tier 2 assessment.....	39
II.3 Reporting	44
Appendix III – Examples on how to apply this Recommendation to an ICT project at city level.....	47
Appendix IV – Example on how to apply this Recommendation to an ICT service at city level.....	51
Appendix V – Example regarding how to estimate effects of ICT projects or ICT services based on pilots or experiences made by other cities.....	55
Appendix VI – Example of combined results for households and organizations	60
Appendix VII – Example of allocation of the impact of a data centre	62
Bibliography.....	64

Introduction

Cities, which are home to half the world's population, are growing rapidly and consume over two-thirds of the world's energy and account for more than 70 per cent of global CO₂ emissions. Nonetheless, cities are of the right scale and structure to deal with the challenges they face. As centres of cultural, political and economic leadership, cities can act on climate change, implementing bold steps to reduce greenhouse gas emissions so that others may follow. Due to this, the concept of smart sustainable cities (SSCs) is increasingly in focus.

Although the use of information and communication technologies (ICT) could reduce the environmental impact of cities, the deployment of ICT itself will consume increasing amounts of energy and resources. The positive as well as the negative impact of ICT has to be taken into account when assessing its impact.

The environmental impact of ICT in cities is the result of three orders of effects: The first order effect of ICT goods and networks in cities is related to their raw materials acquisition, production, use and end-of-life treatment. The impact of the whole life cycle is considered, both for goods, networks and services.

The second order effect refers to the environmental impact due to the use of ICT in other products or sectors in order to reduce their greenhouse gas (GHG) emissions or energy consumption. ICT can improve sustainability of urban infrastructure such as airports, harbours, buildings, public administration, sports venues, transport, street lighting, water management and security systems. ICT can also drive towards dematerialization and enhance optimization of other technologies, such as increasing the efficiency of power supply (e.g., to optimize smart grids).

Other effects of ICT in cities are systematic effects related to citizens' behaviours and behavioural changes, but also to structural changes linked to the use of ICT. In particular, so called rebound effects are included among other effects. Rebound effects refer to efficiency gains being offset by increased consumption.

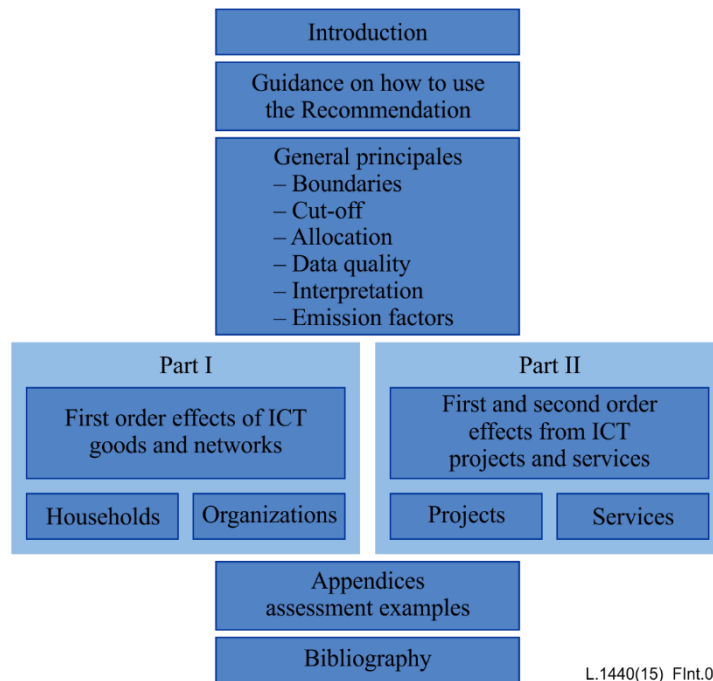
NOTE 1 – This Recommendation uses both the terms "effects" and "impacts" where impact denotes the quantification of the effect.

NOTE 2 – In this Recommendation, energy consumption refers to the secondary energy used. GHG emissions also include the emissions related to energy generation and distribution. Furthermore, GHG emissions are included for assessment in ITU-T L.1410.

A number of methodologies have been developed in order to assess the environmental impact of cities. However, this Recommendation provides specific guidance on the assessment of the overall environmental impact of ICT at city level, as well as guidance on the assessment of city-level ICT projects and services.

This Recommendation is structured as follows: the initial clauses contain the general principles. Part I relates to the first order effects of the use of ICT goods and networks in a city's organizations and households and Part II relates to the first and second order effects of ICT projects and services applied in the city. Both parts are based on the existing ITU-T L.14xx-series of Recommendations (ITU-T L.1410, ITU-T L.1420 and ITU-T L.1430). In addition, examples are provided in the appendices.

Figure Int.0.1 shows an overview of the structure of this Recommendation. Part I is contained in clause 10 and Part II is contained in clause 11.



L.1440(15)_Fint.0.1

Figure Int.0.1 – Overview of the structure of Recommendation ITU-T L.1440

Although this Recommendation focuses on assessing the impact of ICT in cities, it is advisable that cities consider the first order impact of ICT in relation to the overall impact of ICT, in order to ensure that a balanced approach is adopted when tackling climate change and that ICT first order impact is co-optimized with its potential ability to enable GHG emissions reductions.

Recommendation ITU-T L.1440

Methodology for environmental impact assessment of information and communication technologies at city level

1 Scope

Based on other ITU-T L.14xx-series of Recommendations, this Recommendation aims at providing guidance for the assessment of ICT-related greenhouse gas (GHG) emissions and energy consumption at city level. This Recommendation provides a framework for the quantitative assessment at city level of first and second order effects of ICT. It also gives some guidance on how to qualitatively assess other effects.

More specifically, this Recommendation can be used to assess the first order effects of the use of ICT in organizations and households, as well as its first and second order effects when applied to different industrial sectors such as transport, buildings, utilities and waste management.

For the second order effects, it is not expected that the overall second order effects of all ICT at city level is assessed. Rather, this Recommendation provides guidance on how to assess the second order impact of one or more ICT projects or ICT services at the scale of the city.

This Recommendation, in line with [ITU-T L.1400], is focused on energy consumption and GHG emissions.

This Recommendation is intended for city authorities, policy-makers, environment and ICT experts and the industry and planning authorities, and can be used to guide the assessment of ICT-related GHG emissions and energy consumption at a city level.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T L.1400] Recommendation ITU-T L.1400 (2011), *Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies*.
- [ITU-T L.1410] Recommendation ITU-T L.1410 (2014), *Methodology for environmental life cycle assessments of information and communication technology goods, networks and services*.
- [ITU-T L.1420] Recommendation ITU-T L.1420 (2012), *Methodology for energy consumption and greenhouse gas emissions impact assessment of information and communication technologies in organizations*.
- [ITU-T L.1430] Recommendation ITU-T L.1430 (2013), *Methodology for assessment of the environmental impact of information and communication technology greenhouse gas and energy projects*.

3 Definitions

3.1 Terms defined elsewhere:

This Recommendation uses the following terms defined elsewhere:

3.1.1 ICT energy project [ITU-T L.1430]: An ICT project that is designed to reduce energy consumption or enhance generation or storage of energy.

3.1.2 ICT goods [ITU-T L.1410]: Tangible goods deriving from or making use of technologies devoted to or concerned with:

- the acquisition, storage, manipulation (including transformation), management, movement, control, display, switching, interchange, transmission or reception of a diversity of data;
- the development and use of the hardware, software, and procedures associated with this delivery; and
- the representation, transfer, interpretation, and processing of data among persons, places, and machines, noting that the meaning assigned to the data is preserved during these operations.

3.1.3 ICT greenhouse gas (GHG) project [ITU-T L.1430]: An ICT project that is designed to reduce GHG emissions or increase GHG removals.

3.1.4 ICT network [ITU-T L.1410]: Set of nodes and links that provide physical or over the air information and communication connections between two or more defined points.

EXAMPLE: Wireless network, fixed network, local area network (LAN), home network and server network, access networks, core networks, cloud computing networks.

3.1.5 ICT organization [ITU-T L.1420]: An ICT organization is an organization, the core activity of which is directly related to the design, production, promotion, sales or maintenance of ICT goods, networks or services.

3.1.6 ICT project [ITU-T L.1430]: A set of activities intended to implement a specific task that uses mainly ICT goods, networks and services. The task may consist of undertaking one or more ICT project activities with the ICT goods, networks and services.

3.1.7 ICT service (application) [ITU-T L.1410]: Use of ICT goods and/or networks to provide value to one or more users.

EXAMPLE: Teleconferencing, teleworking, e-ticketing, e-learning, e-healthcare, smart transport and logistics, procurement systems, supply chain management systems, music/film distribution over Internet or voice over IP, machine-to-machine systems.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 assessment boundary: The assessment boundary defines what to assess and considers the project boundaries, services boundaries, city boundaries and system boundaries applicable to the assessment.

3.2.2 city: Any municipality incorporating one or several governments or planning authorities, which has defined geographical boundaries.

3.2.3 city boundaries: City boundaries denote the geographical boundaries of the city, city area or city district which is to be assessed.

3.2.4 first order effect of ICT at city level: The city level impact created by the physical existence of ICT and the processes involved, e.g., GHG emissions, e-waste, use of hazardous substances and use of scarce, non-renewable resources.

NOTE – Based on [ITU-T L.1410].

3.2.5 other effects of ICT at city level: Effects of ICT at city level that are not first or second order effects; other effects can be related to changes of behaviour, of social, working or living habits and can include, e.g., rebound effects.

NOTE – Based on [ITU-T L.1410].

3.2.6 project boundaries: The project boundaries identifies the geographical boundaries of the project deployment and the ICT goods and networks that are part of the GHG and Energy ICT project.

3.2.7 second order effect of ICT at city level: The city level impacts and opportunities created by the use and application of ICT projects and services. This includes environmental load reduction effects which can be either actual or potential.

NOTE – Based on [ITU-T L.1410].

3.2.8 service boundaries: The service boundaries identifies the geographical boundaries of the service deployment and the ICT goods and networks that are part of the ICT service.

3.2.9 tier 1 assessment: An assessment of the impact of ICT where only the energy consumption and GHG emissions of the use phase of ICT are assessed.

NOTE – "energy consumption" refers to the secondary energy use in the use stage; "GHG emissions" due to this energy consumption also includes the emissions related to energy production.

3.2.10 tier 2 assessment: An assessment of the impact of ICT where the impacts of the energy consumption and GHG emissions for the whole life cycle of ICT are assessed, including those occurring outside city boundaries.

NOTE – "energy consumption" refers to the secondary energy use in the use stage; "GHG emissions" due to this energy consumption also include the emissions related to energy production.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AMI	Advanced Metering Infrastructure
EoL	End-of-Life
EoLT	End-of-Life Treatment
GHG	Greenhouse Gas
GNS	Goods, Networks and Services
GWP	Global Warming Potential
ICT	Information and Communication Technology
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Inventory Assessment
LTE	Long Term Evolution
PC	Personal Computer
RAN	Radio Access Network
SME	Small and Medium-sized Enterprises
SSC	Smart Sustainable City

5 Conventions

In the present Recommendation PC refers to a desktop personal computer while laptop refers to a laptop personal computer.

6 Guidance on how to use this Recommendation

This clause describes the intended use of this Recommendation.

Table 1 summarizes the different use cases for this Recommendation:

Table 1 – Overview of use cases for this Recommendation

	Type of assessment	Scope	Purpose
Part I (See clause 10)	Assessment of ICT related first order impacts of households (Tier 1 and 2)	ICT first order effects: ICT in households of the city	Understand the first order effects of the ICT used by households within the city boundaries. Such results can serve as an input for assessments according to Part II of the methodology, or serve as a tool for the city stakeholders to monitor the impact of ICT used within the city boundaries.
	Assessment of ICT-related first order impacts of organizations (Tier 1 and 2)	ICT first order effects: ICT in organizations of the city	Understand the first order effects of the ICT of the organizations of the city. Such results can serve as a reference for assessments according to Part II of the methodology, or serve as a tool for the city stakeholders to monitor the impact of ICT used within the city boundaries.
Part II (See clause 11)	Assessment of an ICT project's first and second order impacts (Tier 1 and 2)	ICT first and second order effects: One or more ICT projects with city level impact	Understand the first and second order effects of one or more ICT project(s). Such results can give a projection on how planned ICT projects will impact on the reduction of the GHG emissions and energy consumption of the city. Such assessments can also be used to monitor the impact of the actual project.
	Assessment of an ICT service's first and second order impacts	ICT first and second order effects: One or more ICT services with city level impact	Understand the first and second order effects of one or more ICT service(s). Such results can give a projection on how planned ICT services will impact on the reduction of the GHG emissions and energy consumption of the city. Such assessments can also be used to monitor the impact of the actual service.
	Assessment of the expected impact of an ICT project or ICT service based on the experiences	ICT first and second order effects: One or more ICT projects or ICT services with city level impact	Understand how assessment results of one city or a pilot project may be used to understand how an ICT project or service would impact another city.

Table 1 – Overview of use cases for this Recommendation

	Type of assessment	Scope	Purpose
	encountered in other cities		

Acknowledging that a city level assessment may be very challenging, both Tier 1 and Tier 2 assessments are described in this Recommendation for some of the use cases above as indicated in Table 1.

At the Tier 1 level, the assessment of the impact of ICT is limited to the operation of ICT in the use stage. A Tier 2 assessment is a more comprehensive assessment that provides more information about the impacts by including the full life cycle. It should be noted that Tier 2 level assessments often include impacts of activities occurring outside city boundaries.

The practitioner shall identify the most suitable approach in line with the scope and purpose of the assessment. Any intermediate level between Tier 1 and Tier 2 can be defined, provided that assumptions are transparently stated. As an example, Tier 1 may be combined with coarse estimates of other life cycle stages based on secondary data reflecting reference values from published sources.

A Tier 2 assessment should be preferred when possible for more representative results and stable conclusions. In both cases uncertainty analysis should be performed.

As an example, for a laptop or mobile phone, the production stage often represents a large portion of the life cycle impacts and an analysis of results based on only the use stage may therefore give the wrong conclusions from an environmental point of view. In the case where Tier 1 is adopted as a starting point it is recommended to prepare a plan to go all the way to Tier 2.

The tier concept is illustrated in Figure 6-1.

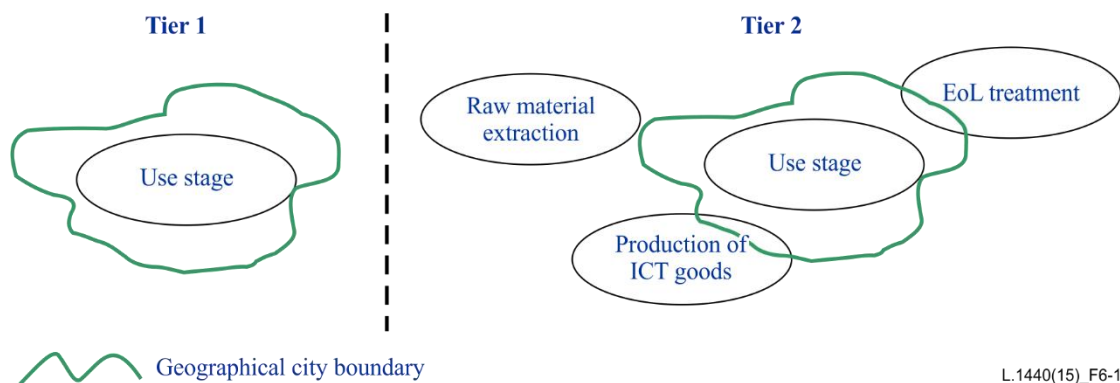


Figure 6-1 – The tier concept

NOTE – For both Tier 1 and Tier 2 assessments, all the emissions related to the energy supply shall be included even if the energy source is located outside the city boundaries.

7 General principles for impact assessment of ICT in cities

7.1 General

This Recommendation follows the guidelines of [ITU-T L.1400] for the environmental impact assessment of ICT, requiring that boundaries and a methodology are defined, that reliable data are used and that bias and uncertainty are addressed.

Practitioners shall strive for the assessments to be relevant, complete, accurate, consistent and transparent.

The practitioner shall adopt and document a consistent approach for all parts of the assessment. When combining the results of different parts of an assessment, the practitioner shall ensure that principles for data collection, data quality, boundary setting and cut-off, are consistent and documented in order to ensure that the best possible assessment quality is ensured.

7.2 Boundaries

Boundaries are defined to allow identifying what is "in" and what is "out" of the scope of the assessment of this Recommendation.

7.2.1 City boundaries

For all kinds of city level assessments, the city boundaries shall be identified, i.e., the geographical boundaries for a city, a part of a city or a city region, for which the ICT assessment shall be performed.

It is recommended that city boundaries identified and used for an overall city GHG emissions assessment are reused when performing an assessment of ICT-related emissions according to this Recommendation, especially for Part I (see clause 10).

7.2.2 Assessment boundaries

For the city level assessment, boundaries at different levels apply and need to be specified for the assessment boundaries to be well-defined.

Assessment boundaries shall be well defined in order to avoid the accounting of activities not directly concerning the city and to avoid double accounting.

7.2.2.1 Assessment boundaries for Part 1

The assessment boundaries define the entities of the city that are taken into consideration in the assessment: which households and organizations are included. Furthermore, it defines which ICT goods and networks to consider and to what extent.

To define the assessment boundaries for a city level assessment according to Part I the following steps apply:

- 1 Identify the geographical boundaries of the city, city area or city region to be assessed (see clause 7.2.1).
- 2 Identify the households and/or organizations¹ located within those boundaries.
- 3 For these organizations and households, define the ICT goods and networks to include in the assessment, based on Annex A of [ITU-T L.1420] (this is referred to as operational boundaries in [ITU-T L.1420]).
- 4 For appointed ICT goods and networks, define the system boundaries to apply in accordance with clause 7.2.4 of [ITU-T L.1420] and the level of assessment chosen (Tier 1 or Tier 2). The system boundaries shall define the unit processes that should be taken into

¹ The Part I examples in this Recommendation are based on a statistical approach. If the assessment involves data collection from organizations the practitioner would also have to consider the boundaries between the organizations in order to ensure a consistent reporting approach to avoid double counting and gaps, i.e., the reporting should in this case be based on either operational control or ownership as further outlined in [ITU-T L.1420].

account in the assessment of ICT goods and networks². Further guidance on system boundaries is given in [ITU-T L.1410].

- a) For Tier 1 assessments, the system boundaries include only the use stage of ICT goods and networks.
- b) For Tier 2 assessments, all life cycle unit processes including raw materials acquisition, production, use and end-of-life treatment (EoLT) apply.

NOTE – Ultimately, the practitioner would perform or have access to [ITU-T L.1410] compatible life cycle assessments (LCAs) for all included categories of ICT goods. If available, such data takes precedence over other data. In practice, other secondary data sources (including studies by ICT vendors and academia) may be used. The data and its quality need to be described as transparently as possible.

NOTE – In case the practitioner performs a full LCA study of a specific ICT good (rather than reusing results from previous studies) the different activities composing the life cycle of an ICT good as defined in [ITU-T L.1410] should be identified and taken into account. All of the activities that are part of an ICT good have their own contribution to its overall environmental impact.

7.2.2.2 Assessment boundaries for Part II

To define the assessment boundaries for a city level assessment of an ICT project or service according to Part II (clause 11) the following steps apply:

- 1 Identify the geographical boundaries of the city, city area or city region to be assessed (same as for Part I).
- 2 Define how the ICT project or ICT service is adopted within these boundaries and the corresponding use of ICT goods and networks needed to implement the project or service. Identify also the expected or actual second order effects of the project or service.
- 3 Define the reference scenario based on the selected geographical boundaries.
- 4 For both the ICT scenario and the reference scenario define the system boundaries to apply in accordance with [ITU-T L.1410] (for ICT services) and [ITU-T L.1430] (for ICT projects). For ICT projects indicate also the chosen level of assessment (Tier 1 or Tier 2).
 - a) For Tier 1 assessments, the system boundaries include only the use stage unit processes of ICT goods and networks.
 - b) For Tier 2 assessments, all life cycle unit processes including raw materials acquisition, production, use and end-of-life treatment apply.
 - c) For second order effects, the system boundaries of the reference product system also need to be defined as outlined in Part II of [ITU-T L.1410].

Further guidance on system boundaries of ICT goods is given in [ITU-T L.1410].

NOTE 1 – Ultimately, the practitioner would perform or have access to [ITU-T L.1410] compatible LCAs for all included categories of ICT goods. If available such data takes precedence over other data. In practice, other secondary data sources (including studies by ICT vendors and academia) may be used. The data and its quality need to be described as transparently as possible.

NOTE 2 – In case the practitioner performs a full LCA study of a specific ICT good (rather than reusing results from previous studies) the different activities composing the life cycle of an ICT good as defined in [ITU-T L.1410] should be identified and taken into account. All of the activities that are part of an ICT good have their own contribution to its overall environmental impact.

² As a Part I assessment may often reuse published LCA results the input data may not fully align with [ITU-T L.1410]; it may also not have enough documentation to see to what extent it does. If available, [ITU-T L.1410] compliant data takes precedence.

When assessing the impact of an ICT project or service, it is recommended that the geographical assessment boundaries equal the city boundaries applied for Part I if possible, so that the ICT project or service impact may be related to the first order impact of ICT in households and organizations

Particularly for the assessment of second order effects, the ICT project or service and the reference scenario shall address the same geographical boundaries and time span.

7.2.3 Time boundaries

When assessing the ICT-related GHG emissions of a city in accordance with Part I, the recommended assessment period is one year.

For consistency, it is recommended that the assessment of the first order impact of ICT in households and in organizations, including the public administration, refers to the same year.

When assessing the GHG emissions related to the outcome of an ICT project or a service, the assessment timeframe depends on the duration of the project or on the lifetime of the service. However, it is recommended that results are presented as yearly values consistently with the overall timeframe of the assessment of the impact of ICT at city level.

7.3 Cut-off

Any cut-off shall follow the rules of [ITU-T L.1420] for the assessment of the first order impact of ICT at city level (Part I, see clause 10) and of [ITU-T L.1430] and [ITU-T L.1410] for the assessment of the second order impact of ICT at city level (Part II, see clause 11).

In particular, if the practitioner carries out an assessment at Tier 1 level, only unit processes of the use stage of ICT goods and networks are considered. Within this stage the practitioner shall document and justify the cut-offs.

For the Tier 2 level of assessment of all life cycle stages of all ICT goods and networks shall be considered. Accordingly, any cut-off applied with respect to life cycle emissions shall be justified and documented.

If the number of organizations within the city boundaries is too large, it might be preferable to establish the assessment gradually and proceed in different phases and some priority criteria can be set to initially restrict the assessment to, e.g., large organizations, organizations with large environmental impacts or organizations with a large presence of ICT. If so, the priority criteria shall be documented and motivated.

Any cut-off applied, shall be described and justified.

7.4 Allocation

If an ICT good is used by a household, but owned by an organization the impact shall be allocated to the household.

ICT goods and networks serving users both inside and outside the city boundaries shall be allocated according to the following:

- For Part I (clause 10), impact from ICT goods and networks located within the city boundaries and used inside and outside city boundaries shall be fully allocated to the city. Impact from ICT goods and networks located outside the city, but used by the city shall not be allocated to the city.

For example consider a data centre (or another ICT network good) located within the city boundaries but mainly used by households and organizations outside the city boundaries. In this case, the assessing city shall take into account all its impacts. In contrast, a data centre located

outside the city boundaries but used by the citizens is not allocated to the city. For a more detailed approach refer to Appendix VII.

NOTE – Due to the ways data centres are used by users from many different locations and the high number of data centres accessed from one city, other allocation principles would be too complicated.

- For Part II (clause 11), impact from ICT goods and networks serving users inside and outside the city boundaries shall be allocated to the ICT service or project to the extent applicable to the ICT project or ICT service (proportional to parameters such as use time or amount of data). [ITU-T L.1410] gives detailed guidance on allocation.

7.5 Data quality and assessment

The practitioner shall ensure consistency in data collection, calculation and reporting.

In general, cities should use the most accurate and complete sets of data in order to perform the assessments.

The assessment of the impact of ICT at city level refers to [ITU-T L.1410], [ITU-T L.1420] and [ITU-T L.1430] respectively. Each of these Recommendations provides guidance on the quality of the input data and assessments, thus data quality requirements of [ITU-T L.1410], [ITU-T L.1420] and [ITU-T L.1430] apply. In addition, these Recommendations provide the principles for collection and reporting of data which shall be followed.

NOTE 1 – The most recent data is preferred due to the fast change of technologies.

NOTE 2 – If no [ITU-T L.1410] compatible data is available for Tier 2 assessments the breakdown of the life cycle stages may differ among goods, which could cause some difficulties when calculating and presenting results. How this is solved should be described in a transparent manner.

NOTE 3 – Data compliant with [ITU-T L.1410] take precedence over other data.

7.6 Interpretation of results

At city level, the practitioner shall adopt and document a consistent approach to perform the uncertainty analysis for all the assessments, including the assessment of ICT goods and networks for households and organizations and assessments of ICT projects and services.

The guidance for uncertainty analysis of related Recommendations applies as follows:

- [ITU-T L.1420] for Part I (clause 10) (for households and organizations);
- [ITU-T L.1430] for Part II (clause 11) (for projects);
- [ITU-T L.1410] for Part II (clause 11) (for services).

In addition, the interpretation phase should include a sensitivity analysis on the most relevant inputs, outputs, methodologies, allocations and scenarios, particularly addressing the boundary setting and choice of assessment approach (Tier 1 or Tier 2), in order to interpret the results.

The emission factors used demand special attention. As an example a city may assess its ICT impacts related to households and organizations based on Part I on a yearly basis. Between two years the emission factor used may change. If so, the practitioner must make sure to analyse to what extent changes in GHG emission level is due to the change in emission factor (reflecting mainly the changes in impacts of the energy supply system or new data) – and to what extent it actually reflects a change in the adoption or energy consumption of the ICT goods and networks.

For Part I, in some cases, an increase in impacts from ICT organizations within the city boundaries may correspond to a decrease in the impact in a wider region. As an example, a city may build a highly efficient data centre that replaces a number of less efficient data centres located outside the city boundaries. In this case the ICT-related GHG emissions of the cities' organizations may increase, but the overall GHG emissions may decrease. For further details refer to Appendix VII.

7.7 Emission factors

When selecting emission factors for the calculation of GHG emissions under this Recommendation the following guidance shall be followed:

Emission factors used should be the most up to date from publicly available sources. Where emission factors are sourced from non-public sources, or are not the most up to date ones, a justification for their use shall be provided.

For all life cycle stages, representative energy mixes are preferred in accordance with the goal and scope of the assessment.

For the use stage, the emission factor should reflect the energy mix of the city as closely as possible while also taking into account distribution and transport losses from electricity generation. When known, location-specific data on energy mixes for a given locality or region gives the most accurate results. In particular, the following emission factors shall be used for the energy consumed during the use phase:

- city-specific emission factors if available;
- country emission factors otherwise.

Consequently, cities that purchase or generate electricity from sources that are more sustainable than the national sources (like wind or solar power) may use emissions factors for these. Choice of emission factors should be transparently described and motivated.

NOTE – Different emission factors for electricity may or may not consider the energy supply and distribution. As complete emission factors as possible should be used and the comprehensiveness of those shall be transparently reported. Due to this, the most recent emission factors available may not be the preferred choice or may need to be complemented.

The specific global warming potential (GWP) values used shall be those taken from the latest UN IPCC reports. For further guidance see Appendix XI of [ITU-T L.1410].

8 Guidance for the assessment of other impacts of ICT at city level

Other impacts of ICT include those related to the behaviour and behavioural changes of citizens, but also to structural changes.

For Part I and Part II, among the other effects, particularly the rebound effect is of interest, i.e., there is a tendency that reduction in environmental impacts from increased efficiency is offset by increased consumption. The quantification of such effects is in most cases very challenging and could not be standardized at this stage. However, to understand the risks related to rebound and try to minimize them it is important when rolling out an ICT project or service to reduce or avoid the offset of its positive effects. Therefore, this Recommendation provides guidance for a subjective but systematic, qualitative assessment of other effects.

For Part II assessments, drivers and barriers for an ICT project or service will also impact its use, and thereby its potential positive second order effects. This Recommendation therefore provides similar guidance for those as for the rebound effect.

8.1 Inventory of other effects

To evaluate the other effects the following procedure may be applied:

- Try to identify, analyse and describe the potential other effects related to the assessed ICT service or project and what the potential effect would be, how and where it would occur and within what time frame. Do this for the following categories:
 - **Induction:**
when an ICT application stimulates increased use of a product or service.

- **Direct economic rebound:**
when the increased efficiency in providing some products/services affects the price which leads to increased consumption of those products/services.
- **Indirect economic rebound:**
when the efficiency savings from specific good/services is spent on other goods/services.
- **Time rebound:**
when time savings are used in a way that increases emissions (may be direct or indirect).
- **Space rebound:**
when space savings are used in a way that increases emissions (may be direct or indirect).
- **Learning in production and consumption:**
when ICT is developing the production-consumption system and facilitates informed customer decisions, e.g., with respect to environmental impact (this effect is often positive).

Potential effects related to learning are happening through the ability of ICT to enhance knowledge-sharing, and transparency throughout the production supply chain, to offer consumers increased transparency regarding production conditions or to improve the coordination between producers and consumers.
- **Scale effects:**
scale effect is when large-scale production has less environmental impacts than small-scale production.
- **Changed practices (behaviours and routines):**
transforming the everyday practice of people due to using ICT devices and services in a way that either increases or decreases emissions (additional to intended changes).
- **Transformational impact:**
when changes in technology leads to changes in consumer preferences, alter social institutions and the organization of production.
- Once the other effects have been identified they could be categorized with respect to importance, probability and addressability based on qualified guesstimates.
- If possible, identify countermeasures and analyse the ability of such measures to prevent the negative other effects from occurring or to reduce their impact.

8.2 Inventory of drivers and barriers for ICT projects and services

To evaluate the drivers and barriers for an ICT service or project the following procedure may be applied:

- Identify the stakeholders of the ICT service or project for the relevant categories such as:
 - end users;
 - ICT providers and vendors;
 - investors;
 - policy makers;
 - society.
- Use the following categories to try to identify the drivers and barriers related to the assessed ICT service or project and map them to different stakeholder categories and to different phases of the project or service (e.g., planning, execution, deployment and operation).
 - economic obstacles/incentives;

- business obstacles/incentives;
- structural obstacles/incentives;
- social obstacles/incentives;
- attitudes and behaviours.
- Once the drivers and barriers have been identified they could be categorized with respect to importance, probability and addressability.
- If possible, identify countermeasures against the barriers and supporting measures for the drivers to support that the full potential of positive second order effects is utilised.

9 Preparing a report on the environmental impact of ICT in cities

9.1 General

Reporting is an important step in ensuring accountability for the cities implementing this methodology. This clause specifies the reporting requirement and examples are provided in Appendices I and II.

If the city decides to assess both first and second order effects, the impact of ICT representing the first order effects of ICT in organizations and households (Part 1, see clause 10), and the enabling effect of ICT corresponding to the first and second order effects of selected ICT projects and services (Part II, see clause 11), shall be reported separately.

For Part I (clause 10), the reporting shall follow the guidelines stated in clause 9 of [ITU-T L.1410] and the contributions related to the life cycle stages: raw material acquisition, production, use and end-of-life treatment, shall be stated. It is also recommended that a breakdown into households, ICT organizations, non-ICT organizations and public administration is made.

For Part II (clause 11), in the case of ICT projects, reporting shall follow the guidelines stated in clause 13 of [ITU-T L.1430] for ICT GHG and energy projects. In the case of ICT services, reporting shall follow the guidelines stated in clause I.3.4 of [ITU-T L.1410].

For all assessments of ICT at a city level, the following information shall be included in the report:

- contact information;
- goal and scope of the study;
- type of assessment (i.e., the approach chosen, Tier 1 or Tier 2);
- a compliance statement with reference to this Recommendation and any deviations clearly stated;
- period for which the report is valid and frequency of the reporting;
- identification and justification of boundaries and timeframe chosen;
- identification and justification of cut-offs;
- identification of possible double counting situations;
- a description of the data collection method and quality with respect to energy data, GHG activity data and emission factors (how, where, when, why);
- emission factors used: the report shall include, for each reporting year, a list of the emission factors used and their origin and what they represent (e.g., the year they represent, to what extent the energy distribution and supply chain was included);
- other data, justifications and explanations as stated throughout this report.

9.2 Reporting of assessments based on Part I

When reporting the results of the assessment, households, ICT organizations, non-ICT organizations and public administrations should be reported separately.

Based on the relevant parts of the previous ITU-T L.14xx series of Recommendations, in particular [ITU-T L.1410], and in addition to what is listed in clause 9.1, the Part I (clause 10) report shall also contain:

- The results of the assessment:
 - energy consumption and GHG emissions of the use stage for Tier 1 assessments;
 - energy consumption and life cycle GHG emissions for Tier 2 assessments.
- The interpretation of the results and the outcome of the uncertainty analysis for energy consumption and GHG emissions.

Moreover, the following information shall be recorded by the city:

- organizations and/or households taken into account. Any exclusion of organizations and/or households within the city boundaries shall be documented and justified;
- number of people working in each organization and/or number of people living in the households;
- the data sources.

9.3 Reporting of Part II

9.3.1 Reporting the first and second order effects of an ICT project

The reporting of the first and second order effects of ICT projects at a city level shall consider the reporting as outlined in clause 12 of [ITU-T L.1430] and it shall include the following:

- information about any GHG programme to which the ICT project belongs;
- general market conditions, national regulations, requests of intended users, or internal policies, applicable to the ICT goods, networks or services incorporated in the project activities;
- short description of the ICT project;
- adoption of the ICT project, its use and effects;
- geographic boundaries of the ICT project, indicating whether the project involves activities or effects in more than one city. If so, also describe allocation between those cities involved;
- the operational lifetime of the ICT project;
- statement describing whether the GHG and energy assertions exist and have been validated and/or verified, including the type of validation or verification and level of assurance achieved;
- description of the project activity and the selected baseline scenarios;
- results covering the impacts of the project activities and the estimated baseline scenario;
- the interpretation of the results and the outcome of the uncertainty analysis for energy consumption and GHG emissions;
- monitoring plan.

9.3.2 Reporting the first and second order effects of ICT services

The reporting of the first and second order impacts of ICT services at a city level shall consider the reporting as outlined in clause 13 of [ITU-T L.1410] and it shall include the following:

- short description of the ICT service and its use and effects;
- adoption of the ICT service;
- geographic boundaries of the ICT service, indicating whether the service involves activities or effects in more than one city, and if so, the allocation between those cities involved;
- description of the baseline scenario;
- results covering the impacts of the ICT services and the selected baseline scenario;
- the interpretation of the results and the outcome of the uncertainty analysis for energy consumption and GHG emissions.

10 Part I: First order effects from the use of ICT goods and networks in a city's organizations and households

10.1 General description

Within the city, households and organizations, including the public administration, are identified as the main users of ICT for which the environmental impact of ICT can be assessed.

Thus, Part I aims at the assessment of the first order impacts of the ICT goods and networks used in households and organizations, public or private, ICT or non-ICT, within the city's boundaries.

The practitioner shall apply the non-ICT organizations' approach outlined in clause 7 of [ITU-T L.1420] for all the assessed main ICT users (households, organizations, including the ICT organizations and the public administration). If possible, data should be structured into the categories of households, ICT organizations, non-ICT organizations and Public Administration to enable that these are reported separately.

Building on [ITU-T L.1420], the present clause describes the steps to apply to assess the first order impacts of the ICT goods and networks used in a city. Although not specifically written for cities it is understood that [ITU-T L.1420] can be used also to estimate or follow-up on the impact of ICT in households and organizations at a city level. This Recommendation gives guidance on how the methodology should be applied.

Two different assessment approaches are considered in this clause: the Tier 1 assessment allowing for a simplified application of the methodology, and the Tier 2 assessment corresponding to a more complete evaluation as further outlined in clause 6.

NOTE – As a starting point, the assessment could be partial, for a reduced area of the city or a limited category of households or organizations. This should then be clarified and a roadmap should be provided towards the full assessment.

10.2 First order effect at city level of ICT goods and networks in households

This clause describes the assessment method to be applied for households. The practitioner shall apply clause 7 of [ITU-T L.1420], by considering all the households in the city as part of an organization. An example of a household assessment is available in Appendix I.

10.2.1 Boundaries

10.2.1.1 Identification of city boundaries and households

As discussed in to clause 7.2, the city boundaries shall be identified as well as the households to be included in the assessment together with any selection criteria used.

10.2.1.2 Identification of ICT goods and networks in households

The practitioner shall then define the ICT goods and networks present in the households as further outlined in 10.2.2. Any exclusion of ICT goods and networks shall be documented and justified.

Furthermore, the system boundaries should be outlined based on the assessment approach (Tier 1 or Tier 2) and the guidance given in [ITU-T L.1410].

Associated consumables, software and the impact of operation and maintenance activities may be excluded from the assessment.

10.2.2 Data collection and assessment

In accordance with [ITU-T L.1420] the environmental impact of the ICT goods and networks present in households shall be assessed according to the city boundaries. The data needed for the assessment of the impact of ICT, such as, the number of ICT goods and networks used per household, their use patterns and their energy consumption, may be collected with different approaches. The practitioner shall describe and document the data collection approach adopted as well as the data sources selected. For example, cities may use data collected from a sample of the households to model the average ICT usage of households, or they may rely on any other consistent data collection approach, including the use of secondary data. Alternative data collection approaches for user profiles include surveys, sampling and extrapolation, metering or census statistics.

In particular, the practitioner may rely on publicly available data for the embodied life cycle stages.

At a Tier 1 level of assessment only the use stage of ICT goods and networks shall be considered, whereas at a Tier 2 level the overall impact of ICT goods and networks, including all stages of the life cycle assessment, shall be considered.

NOTE – For each ICT good, the time of use in different modes (e.g., operation, idle state, deep sleep and off) is relevant for assessing the impact of the use stage. It is recommended to take into consideration the various modes of use. However, some simplifications could be made and then need to be transparently described.

It could also be practical to gather the ICT data collected into categories that reflects the use profiles. For a Tier 1 assessment, broad categories of ICT goods could be considered (information technologies, fixed communication technology, mobile communication technology, etc.) which could be associated with simple use profiles (for example a fixed percentage of time in operation/idle/deep sleep/off modes for each ICT categories).

10.3 First order impact at city level of ICT goods and networks in organizations

This clause describes the assessment method to be applied for organizations. To assess the impact of ICT used by organizations, clause 7 of [ITU-T L.1420] applies and should be used for both ICT and non-ICT organizations and for public as well as private organizations, as it is further described in this clause.

NOTE – As the intention of the city level assessment is not to assess the overall impact of ICT organizations but the use of ICT in any kind of organization, clause 8 of [ITU-T L.1420] does not apply.

The assessment and the documentation should distinguish between ICT organizations, non-ICT organizations and public administrations.

An assessment example for organizations is available in Appendix II.

10.3.1 Boundaries

10.3.1.1 Identification of city boundaries and organizations

As referenced in clauses 7.3 and 7.4 of [ITU-T L.1420], the city boundaries as well as the organizations to be assessed shall be identified and the selection criteria used shall be documented together with information about the included organizations reflecting the granularity of the