ITU-T Study Group "Environment and Climate Change"

Methodologies for assessment of environmental impacts of ICT

Jean-Manuel Canet, Orange Business Services
Rapporteur, Question on methodologies 18/5

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ITU, The UN agency responsible for ICTs
193 Member States and more than 700 Sector Members

Co-operations include on methodologies :

United Nations Framework Convention on Climate Change

Organisation internationale de normalisation

GeSI GLOBAL e-SUSTAINABILITY INITIATIVE

ETSI World Class Standards

The Greenhouse Gas Protocol Initiative
The foundation for sound and sustainable climate strategies

IEC

Question on methodologies (18/5) :

3 recommendations published
3 recommendations under preparation

- L.1400 Overview and general principles, available on the ITU-T website
- L.1410 Environmental impact of ICT goods, networks and services available on the ITU-T website
- L.1420 Environmental impact of ICT in organisations available on the ITU-T website

- L.1430 Environmental impact of ICT projects (consent expected in 2012)
- L.1440 Environmental impact of ICT in countries (consent expected in 2012- 2013)
- L.1450 Environmental impact of ICT in cities (consent expected in 2012-2013)

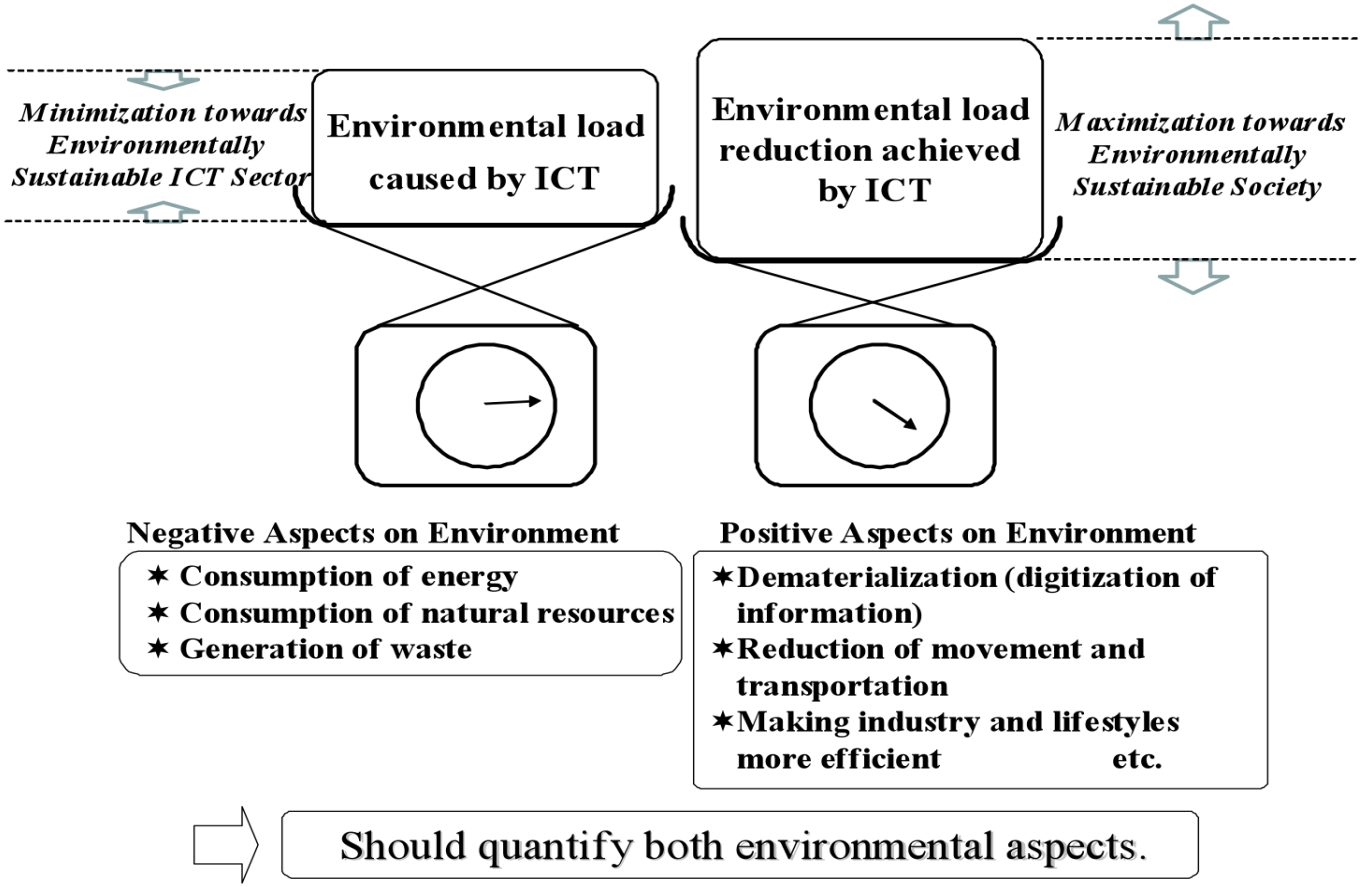
L.1400 Overview and general principles

L.1400 purpose

The Recommendation ITU-T L.1400 presents general principles on assessing the environmental impact of information and communication technologies (ICT) and outlines the different methodologies that are being developed:

- Assessment of the environmental impact of ICT goods, networks, and services
- Assessment of the environmental impact of ICT in organizations
- Assessment of the environmental impact of ICT projects
- Assessment of the environmental impact of ICT in cities
- Assessment of the environmental impact of ICT in countries or group of countries.

Environmental aspects of ICT



Possible reduction effects by using ICT

Categories	Effects
Consumption of materials	By reducing material consumption (dematerialization), the environmental load related to goods production and disposal as well as waste generation can be reduced.
Power consumption/energy use	By enhancing the efficiency of power and energy use to reduce consumption, the environmental load related to power generation, power transmission, etc. can be reduced.
Movement of people	By reducing the movement of people, the environmental load required for transportation can be reduced.
Movement of materials	By reducing the movement of materials, the environmental load required for transportation can be reduced.
Improved efficiency of office space	By using office space efficiently, power consumption for lighting, air conditioning, etc. can be reduced, thus reducing environmental load.
Storage of goods	By reducing storage space of goods, power consumption for lighting, air conditioning, etc. can be reduced, thus reducing environmental load.
Improved work efficiency	By enhancing work efficiency, the environmental load can be reduced.
Waste	By reducing waste emissions, the environmental load required for environmental preservation as well as for waste disposal can be reduced.
NOTE – This list of categories is not exhaustive. The metrics relative to environmental load reduction are different according to the categories of environmental impacts.	

Environmental impacts categories

The following categories of environmental impacts are commonly assessed:

- Global warming potential or greenhouse gas (GHG) emissions
- Energy consumption
- Raw material depletion
- Water depletion
- Ozone depletion
- Air toxic emissions
- Photochemical ozone creation
- Air acidification
- Water eutrophication
- Water toxic emissions
- Hazardous waste generation

Energy consumption and GHG emissions

The series of ITU-T Recommendations on methodology focus, for their first versions, on both energy consumption and greenhouse gas emissions.

This selection has been carried out in the context of two key concern areas:

- Oil production peak: an important number of experts consider that we are approaching a peak or rather a wavy plateau in the world's conventional oil production. After this period, which could start before 2020, the world's conventional oil production will decrease. It is expected that the price of energy will rise and security of supply will get harder in that context.
- Climate Change due to human activities: the IPCC (Intergovernmental Panel on Climate Change) considers that the impact of anthropogenic greenhouse gas on the Earth's climate change is very likely.

General principles to follow (1/2)

- Assessment of environmental impacts should be performed on a full life-cycle perspective for goods, networks and services
- Boundaries should be selected, quoted, documented and made available for verification
- Quantification methodologies should be selected, quoted, documented and made available for verification

General principles to follow (2/2)

- Reliable data should be researched. Used data should be quoted, documented and made available for verification
- Bias and uncertainties should be documented and reduced as far as it is practicable
- It should be noted that results of assessments may vary significantly depending upon the selection of boundaries, the quantification methodologies selected and data used

L.1410 Goods, Networks and Services

ITU-T L.1410 Goods, Networks and Services

1. What is it ? What is it for?
2. Steps to follow in Part I
3. Steps to follow in Part II
4. Part I Step by Step
5. Part II Step by Step

L.1410 : What is it? What is it for?

- It is a Recommendation that complements ISO 14040 and ISO 14044 and provides guidance on how to assess environmental impacts of ICT Goods, Networks and Services
  - It has been built with a large number of representatives from the ICT sector and governments. It has been built to be consistent with EC/JRC, ETSI, IEC and GHG Protocol ICT supplement initiatives
- There are 2 Parts in the Recommendation:
  - ICT Lifecycle assessment: framework and guidance,
  - Comparative analysis between ICT and baseline scenario : framework and guidance
- The 2 Parts describe clear steps to follow in order to assess environmental impacts over the entire life cycle
  - This will help identify what are the major activities and life cycle stages impacting the environment, design and prepare action plans and prioritize actions
  - This will help identify risks, save costs and develop new opportunities

- ISO has standardized the Life Cycle Assessment methodology with the publication in 2006 of 2 documents
  - ISO 14040 “Environmental management- Life cycle assessment- Principles and framework”
  - ISO 14044 ”Environmental management- Life –cycle assessment- Requirements and guidelines”

Organisation internationale de normalisation

Life Cycle assessment (LCA)

- Environmental Life Cycle Assessment is a system analytical method by which the environmental effects can be estimated.
- Takes a “cradle to grave” approach where life cycle stages are included

Benefits of an LCA approach

- To provide an assessment of the environmental impact of a product system as a basis for improving it
- To understand the relative importance of different life cycle stages /activities - where to put best efforts for improvement
- To monitor performance improvements over time

Limitations of LCA

"*LCA addresses potential environmental impact:*

LCA does not predict absolute or precise environmental impacts due to the relative expression of potential impacts to a reference unit, the integration of environmental data over space and time, the inherent uncertainty in modeling environmental impacts, and the fact that some possible environmental impacts are clearly future impacts"

ISO 14040: 2006 Section 4.3

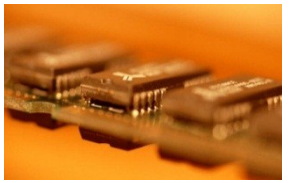
The Effects of ICT on Environmental Sustainability

First Order (direct result of its existence)

GHG Emission

Waste

Hazardous Substances



Use of Scarce, Nonrenewable Resources

Second Order (from application)

Travel Substitution

Transportation Optimization

E-Business

Environmental Control Systems

Third Order long-term, socio-economic structural changes

Energy Intensity

GHG Intensity

Transportation Intensity

Material Intensity

ICT represents a 2 Edged sword

The Bad News:
ICT Accounts for Approximately

3%

of Global CO_2 Emissions

VS

The Good news:
ICT has the potential to reduce emissions in other sectors by

15%

Smart buildings, Smart metering, Smart Motor systems, Smart Logistics plus Dematerialisation of Transport

ICT LCA Challenges

- Complexity
- Hardware, software, networks and services
- Rapidly changing product specifications, and service offerings
- Multitude of components and subcomponents
- Long, complex and dynamically changing supply chains that span the globe
- Multitude of suppliers
- Second-order effects

Data availability and data quality

L.1410
Environmental impact of ICT goods, networks and services
Part I: What are the steps to follow?

- General requirements
- Goal and scope definition
- Functional unit definition
- System boundaries definition
- Cut-off rules
- Data quality requirements
- Life Cycle Inventory
  - Data collection
  - Data calculation
  - Allocation procedure
- Life Cycle impact assessment
- Life cycle interpretation
- Reporting

L.1410 Part I

Key definitions

ICT Goods

- The tangible products deriving from or making use of technologies devoted to or concerned with
- (a) the study and application of data and the processing thereof; *i.e.,* the automatic acquisition, storage, manipulation (including transformation), management, movement, control, display, switching, interchange, transmission or reception of a diversity of data;
- (b) the development and use of the hardware, software, and procedures associated with this delivery; and
- (c) the representation, transfer, interpretation, and processing of data among persons, places, and machines, noting that the meaning assigned to the data must be preserved during these operations.
- Examples are mobile phone, PC, laptop, router, base station

L.1410 Part I

Key definitions

ICT Networks

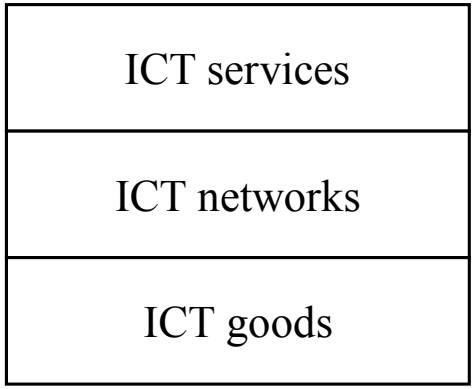
- A set of nodes and links that provide physical or over the air information and communication connections between two or more defined points.
- Examples are wireless network, fixed network, local area network (LAN), home network and server network, access networks, core networks, cloud computing networks.

ICT Services

- The combination of ICT goods and ICT networks.
- An ICT service is produced in one or more nodes of the network and provided to users or other ICT systems over the ICT network.
- Examples of services are 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.

L.1410 Part I

- Relationship between methodologies of LCA for ICT Good Networks and services



- ICT Networks are composed of ICT goods and ICT services utilize ICT networks: ICT Goods are the basis for the methodologies for ICT networks and ICT services.

L.1410 Part I

Key definitions

- **Functional unit [ISO 14040]**
  quantified performance of a product system for use as a reference unit
- **Product system [ISO 14040]**
  collection of unit processes with elementary and product flows, performing one or more defined functions, and which models the life cycle of a product
- **Operating life time**
  The duration of the actual use period (active and non active periods) for the first user
- **Comparative analysis**

  analysis aiming to compare two different product systems based on the same functional unit

L.1410 Part I

Key definitions

- **Primary data**
  quantified value of a unit process or an activity within the product system obtained from a direct measurement or a calculation based on direct measurements at its original data source
- **Secondary data**
  quantified value of a unit process or an activity within the product system obtained from sources other than direct measurements at its original source
- **Process-sum approach**

  method using facility-level data describing processes in terms of the inputs of materials and energy, outputs of products and waste, and emissions

L.1410 Part I

- **General Requirements**
  When assessing environmental impact of ICT, the requirements of [ISO 14040] and [ISO 14044] shall be applied

- **Goal and scope definition**

  In accordance with [ISO 14040], the goal of an LCA states:

  - the intended application;
  - the reasons for carrying out the study;
  - the intended audience, i.e. those to whom the results of the study are intended to be communicated; and
  - whether the results are intended to be used in comparative assertions intended to be disclosed to the public.

L.1410 Part I

General Requirements

- By definition, LCA considers the full life cycle, i.e. no life cycle stages should be excluded *a priori*. However, if a life cycle stage is found to have a limited impact on the results and conclusions of an LCA, the corresponding life cycle stage or items in the life cycle stage may be excluded in accordance with applicable rules for cut off.
- This Recommendation also could apply to studies not covering the full life cycle. In that case, please refer to A.1.2 in [ISO 14040] Annex A.

Environmental impact of ICT goods, networks and services Part I

- **Functional unit definition**

  Shall be chosen in accordance with goal and scope of the LCA

- Example for a laptop

  The function experienced by a user of an (offline) laptop is the ability to handle documents, use multimedia etc. The corresponding functional unit could then be usage of laptop applications, ten hours per week during an operational lifetime (e.g. 4 years). The corresponding reference flow is defined as one laptop sales package.

- **A well defined functional unit considers the following aspects :**

  - The **magnitude** of the function or service
  - The **duration** or operating lifetime of that function or service
  - The expected level of **quality**

L.1410 Part I

- **Functional unit definitions, ICT goods**

The following functional unit should be used:

- Annual ICT goods use (per one year of ICT good use) or
- Total ICT good use per lifetime of ICT good.

For ICT goods, additional more specific functional units may also be considered when the result is presented, e.g. the time during which one uses a phone and the number of e-mails sent.

- **Example : Mobile phone**
  The function of overall usage of a mobile phone is studied cradle-to-grave. The mobile phone provides several sub-functions, e.g. phone calls, text messages, e-mails, use of internet, camera and music player, but in this case the aggregated use of the phone is the focus. The function is thus the provision of smart phone capabilities. The functional unit is then “the use of a model X smartphone during an operating lifetime of 3 years”.

L.1410 Part I

- **Functional unit definitions, ICT networks**

ICT networks can be seen as a system composed of different types of ICT goods.

The following functional unit should be applied for ICT networks used during at least one year:

- Annual Network use

Additionally, other more specific functional units may be applied as well, based on the scope and purpose of the LCA, for instance: annual network use per phone line, per amount of users, or per transmitted data, or per coverage area (if applicable).

- Example : A mobile telecommunication system has a large number of different functions working on different system levels. From an end-user customer point of view the basic function of a mobile communication system is to be able to communicate. The basic functionality of a mobile communication system is thus the possibility to communicate with speech and data “anywhere, anytime” The functional unit is “one year of operation of a mobile communication system”.

L.1410 Part I

- **Functional unit definitions, ICT services**

The following functional unit should be applied:

- Annual service use.

Corresponding realistic use scenarios shall be defined.

Additionally, other more specific functional units may be applied as well, based on the scope and purpose of the LCA, e.g. per one hour or per Gigabit.

System boundaries

- The system boundaries defines the unit processes across the life cycle of the studied ICT goods, networks and services that are to be assessed in terms of data collection and calculation of environmental load from energy consumption and GHG emissions.
- The selection of the system boundary shall be consistent with the goal of the study.

System boundaries (continued)

- The following eight checklist items should be considered in the system boundary setting to identify activities associated with the ICT GNS life cycle for which data will be collected. These checklist items may then also be used to structure data and reporting but other structures are also possible.
- The intention of the eight checklist items above is to ensure that all relevant impacts are considered for all life cycle stages when defining the impact from a product system viewpoint. Table 1 illustrates the relationships between the checklist items and the life cycle stages. However, the purpose of Table 1 is to check whether all relevant items for data collection are included, it may not be part of the overall assessment reporting.

System boundaries (continued) : Table 1

Life Cycle stage/ Category	*Raw material acquisition*	*Production*	*Use*	*EoLT*
ICT hardware				
ICT software				
Consumables and other supportive products				
Site infrastructure				
Transport (Movement of goods)				
Travel (Movement of people)				
Storage of goods				
Working environment				

Lifetime

- Operating lifetime is critical for the interpretation of the results of the LCA and shall be reported when presenting LCA results. Assumptions related to lifetime of ICT Goods shall be clearly described in the reporting.
- Operating lifetime can only be defined for goods. In general the lifetime of an ICT network cannot be defined as a network lifetime with one start date and one end date, instead the network is continuously built out, upgraded etc. and the associated operating lifetimes are therefore the lifetimes of the individual nodes. The same is valid for ICT services.
- Operating lifetime should be based on available information on actual goods use(e.g. statistics for similar goods, networks and services or information on commercial lifetime) and should model real operating lifetime as closely as possible.
- If information on actual use of goods, networks and services cannot be found, economical statistics may be used to estimate operating lifetime, e.g. depreciation time. If the LCA is used to estimate historic environmental impact, actual use time may be available and can then be used. In most cases actual operating lifetime is not available and estimates are needed.

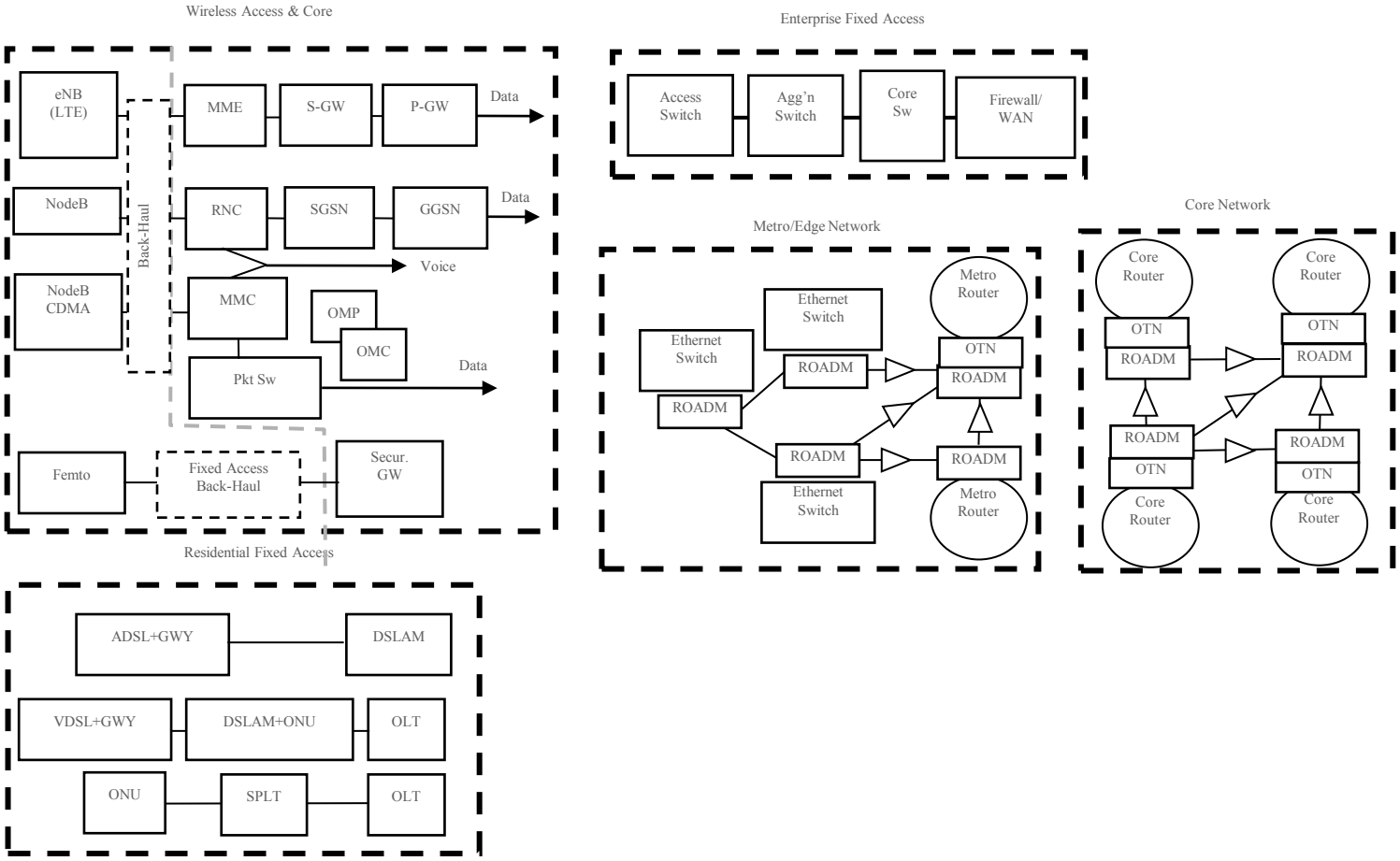
ICT Product system

- The ICT GNS product system to be assessed shall be clearly described as well as relevant functions and characteristics.
- ICT Goods : For the ICT good under study applicable types of parts, as well as amounts of these, shall be defined.
  - In-depth information about the product composition is required before setting the system boundary of the product. Often, bill of material (BOM) data (where parts information including weight and material composition is listed) is necessary to understand the full product composition. Table D.1 in Annex D provide generic information about the composition of the ICT goods.

ICT product system (continued)

- ICT network : An ICT network is ICT based infrastructure which offers the possibility to transfer voice and/or data between different access points, usually referred to as nodes, and further on to the end–users (e.g. represented by a mobile phone or a PC)
  - Annex E details the most frequently adopted ICT networks in use today**.** However, the Recommendation is not restricted to these networks but will also apply when assessing any existing or future networks.
- ICT services : For the ICT service under study applicable types of ICT network elements and infrastructure, as well as amounts of these, shall be defined.

ICT product system : networks



Life cycle stages

- The following four high-level life cycle stages apply to ICT GNS and shall be assessed in accordance with goal and scope :
  - Raw material acquisition
  - Production
  - Use
  - End of Life Treatment
- If all these life cycle stages have not been assessed, this should be stated when reporting.
- It is important that the GHG emissions and energy consumption arising from the transport processes both within and between each life cycle stage are considered in the assessment.

Life cycle stages (continued)

- Annex F defines the detailed life cycle stages which further defines the system boundary and which are to be considered when assessing the life cycle impact of ICT GNS. In particular, it is important to cover all processes whose relevance is marked as high in that table. The study report should transparently show and justify whenever processes marked with high relevance are not taken into account.
- Throughout the life cycle some processes reoccur several times, e.g. unit processes associated with the life cycle impact of electricity use, transports and travel. These processes are referred to as generic processes and are further described in Annex C.
- Appendix I gives additional information on the different stages and on the interfaces between the processes.

Annex F : Specific ICT unit processes that should be considered if applicable

Tag	Life cycle stage	Unit process	Class and Relevance: High/Medium/Low		
			ICT Good	ICT Network	ICT Service
A	***Raw Material Acquisition***				
A1	Raw material extraction		High	High	High
A2	Raw material processing		High	High	High
B	***Production***				
B1	Goods production				
B1.1		Parts production (for further details refer to Annex D Part types and Appendix I)	High	High	High
B1.2		Assembly	High	High	High
B1.3		ICT manufacturer support activities	Medium	Medium	Medium

Annex F (continued)

B2	Support goods production				
B2.1		Support goods manufacturing*	Medium (High if Support goods is included in the Scope)	High	High
B3	Construction of the ICT specific Site		Medium	High	High
C	***Use***				
C1	Goods use		High	High	High
C2	Support goods use		Medium (High if Support goods is included in the Scope)	High	High
C3	Operator activities*		Medium	High	High
C4	Service provider activities		Not applicable	Medium	High

Annex F (continued)

D	***End of Life Treatment***				
D1	Preparation of ICT goods for Re-use		High	High	High
D2	ICT specific EoLT		High	High	High
D2.1		Storage/Disassembly/Dismantling/ Shredding	High	High	High
D2.2		Recycling	High	High	High
D3	Other EoLT		High	High	High

Annex C : Generic unit processes and their importance.

Part	Generic process categories	Unit processes (for each category)	Product flow unit	Important issues
G1. Transport & Travel	Road Air Ship Train	High: Direct (during transport) emissions &Fuel supply chain Medium: Vehicle production & Infrastructure production	tonne×km, kg×km, Ctonne×km	Chargeable weight = Ctonne×km (function that also considers volume or density)
G2. Electricity	Div. country, regional and producer electricity mixes	High: Fuel supply chain, Direct emissions (during electricity production) Medium: power plant production, dam production, grid production, nuclear waste treatment	kWh	
G.3 Fuels	Oil Diesel Petrol Jet—fuel LPG LNG Coal Gas	High: Fuel supply chain: Extraction and Production Distribution (transports) and emissions related to the incineration of the fuel is connected to a unit process or "site LCI model".	mass, volume, energy content	

Annex C : Generic unit processes and their importance (continued)

G4. Other energy	District heating (hot water) District heating (steam) District cooling (cold water) as electricity	High: Fuel supply chain, Direct emissions during energy/electricity production Medium: Power plant construction, Infrastructure production	kWh	Electricity is also a energy source or district heating/cooling production
G5. Raw material acquisition		High: Extraction Processing	mass, volume	
G6. End–of–life treatment	See Annex G			
G7.Raw material recycling	Metal recycling	High: Smelting, refining		Other material should be considered

Aggregated impacts at network and service level

- The aggregated impact of an ICT network equals the sum of impact from the different goods constituting the ICT network. When aggregating results, data should be based on equivalent assumptions or use scenarios.
- To calculate the impact of an ICT service, it is generally necessary to assess the ICT network, as outlined in previous section, and if necessary (i.e., in a multi–service situation) allocate an appropriate amount of this impact to the ICT service under study.

Cut off rules

Cut-off in LCA is defined as the process for exclusion of input and output flows associated with unit processes from the product system. Several cut-off criteria exist and are further outlined below.

By invoking cut-off, the assessment can be simplified by excluding processes that will not significantly change the overall conclusions of the study, as long as the intended application is met.

Cut-off of processes or input/output data within the system boundaries however requires careful consideration and should be avoided. A recommended alternative to cut–off is often to model unavailable data based on known data.

Data quality requirements

In LCA context data refers to activity data, emission factors and in some cases direct GHG emissions. Primary data are preferred to secondary data. In addition data which is more specific with respect to time (age) geography and technology takes precedence over data that is less specific. This is particularly so for ICT GNS due to the fast technology evolution and the growth in network traffic.

Life cycle inventory (LCI)

- Inventory analysis involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system.
- Data for inclusion in the inventory is collected for each unit process within the previously defined system boundary
- The collected data is then used to quantify the inputs and outputs of a unit process
- Transparency as to how the data is collected is recommended
- A process sum approach is generally the preferred option for evaluating the environmental load.
  - However, a hybrid approach may be applied where both process sum and Economic Input Output (EIO) are used for the assessment so as to overcome these barriers. In these cases the approach used should be fully documented and all assumptions made fully disclosed.

Life cycle inventory (LCI)

Allocation - a challenging issue in LCA

- During the boundary setting phase practitioners may identify unit processes that have multiple products as input or outputs
- Data collected on emissions and removals need to be shared between the studied product and the other products in the life cycle
- As a principle emissions and removals shall be allocated in a manner that accurately reflects the studied products contribution to the common processes emissions

Life cycle impact assessment (LCIA)

- For LCIA the requirements according to [ISO 14044] clause 4.4 apply.
- The life cycle impact assessment (LCIA) aims to describe and indicate the impact of the environmental loads quantified in the inventory analysis. LCIA is a stepwise aggregation of the information given by the life cycle inventory (LCI) results.
- The LCIA aims to evaluate the significance of potential environmental impacts using the LCI results. In general, this process involves associating inventory data with specific environmental impact categories and category indicators, thereby attempting to understand these impacts.
- The most recent global warming characterization factors from the Intergovernmental Panel on Climate Change (IPCC) [b- IPCC] for each GHG should be used and the timeframe should be 100 years.

Life Cycle Interpretation

Interpretation is the phase of LCA in which the findings from the life cycle inventory (LCI) analysis and the life cycle impact assessment (LCIA) are considered together. The interpretation comprises several elements:

- identification of the significant issues based on the results of the LCI and LCIA phases of LCA;
- an assessment that considers completeness, sensitivity and consistency checks;
- conclusions, limitations, and recommendations.

Reporting

- Reporting shall be performed in accordance with ISO 14044. In the case of reporting a public GHG inventory report, the key accounting principles (relevance, accuracy, completeness, consistency, and transparency) shall be met.
- the report shall include the following information :

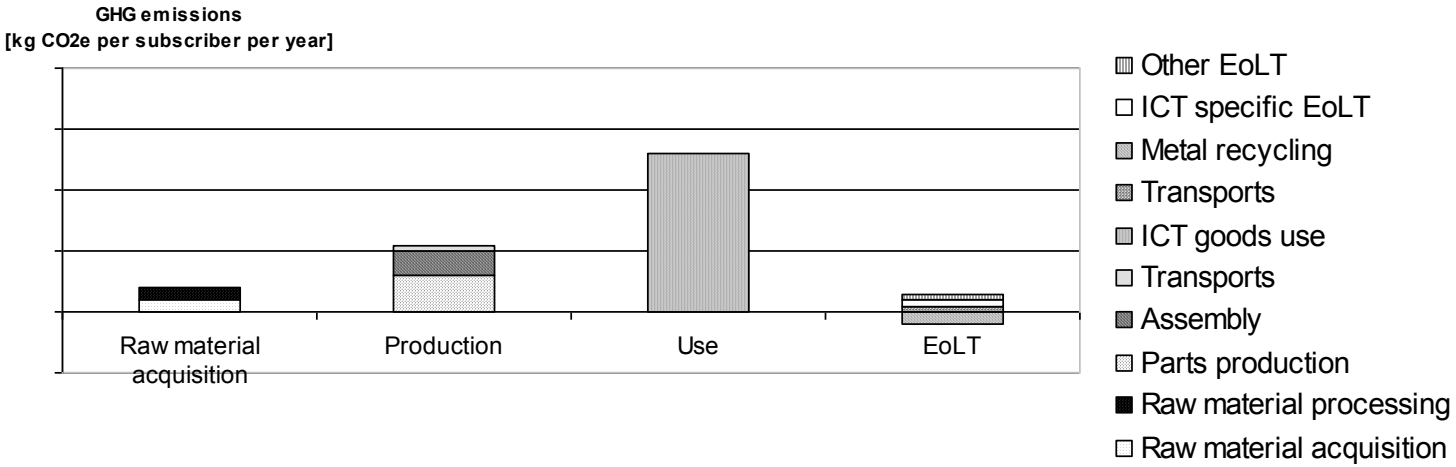
- Contact information;
- Studied GNS product system name and description;
- Type of inventory (i.e. final product cradle-to-grave or intermediate product cradle-to-gate inventory);
- Goals of the study;

Reporting (continued)

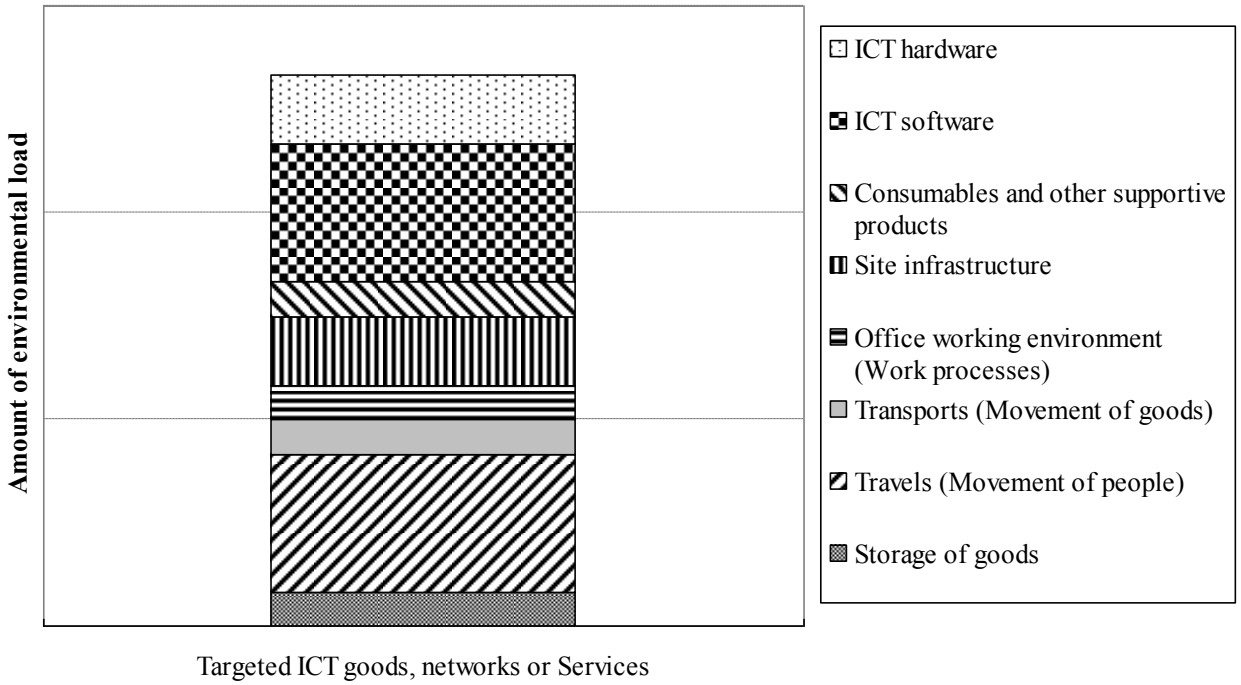
The reporting of results shall include:

- Total GHG emissions reported as amount of CO2e per functional unit for ICT good, network and service that have been assessed;
- Percentage for each life cycle stage contributing to the total results;
- Electricity (with use stage separated from the other stages)
- Primary energy
- Fuels
- Value and sources of emission factors for CO2 and CO2e, and Global Warming Potential (GWP) metric used in the report.
- Other data, justifications and explanations as stated throughout this report

Reporting : example



Reporting : example



ITU-T L. 1410 GNS Part II

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Comparative analysis between ICT and a Reference product System (baseline scenario): Framework and Guidance

Environmental impact of ICT goods, networks and services
Part II : What are the steps to follow?

- General requirements
- Goal and scope definition
- Functional unit in the case of comparison
- System boundaries definition
- Cut-off rules
- Data quality requirements
- Life Cycle Inventory
- Life Cycle impact assessment
- Life cycle interpretation
- Reporting

N.b. For Part 2 which is a comparative analysis between an ICT system and a reference product system the above steps need to be carried out on BOTH the ICT system and the reference product system

ITU-T L. 1410 GNS Part II

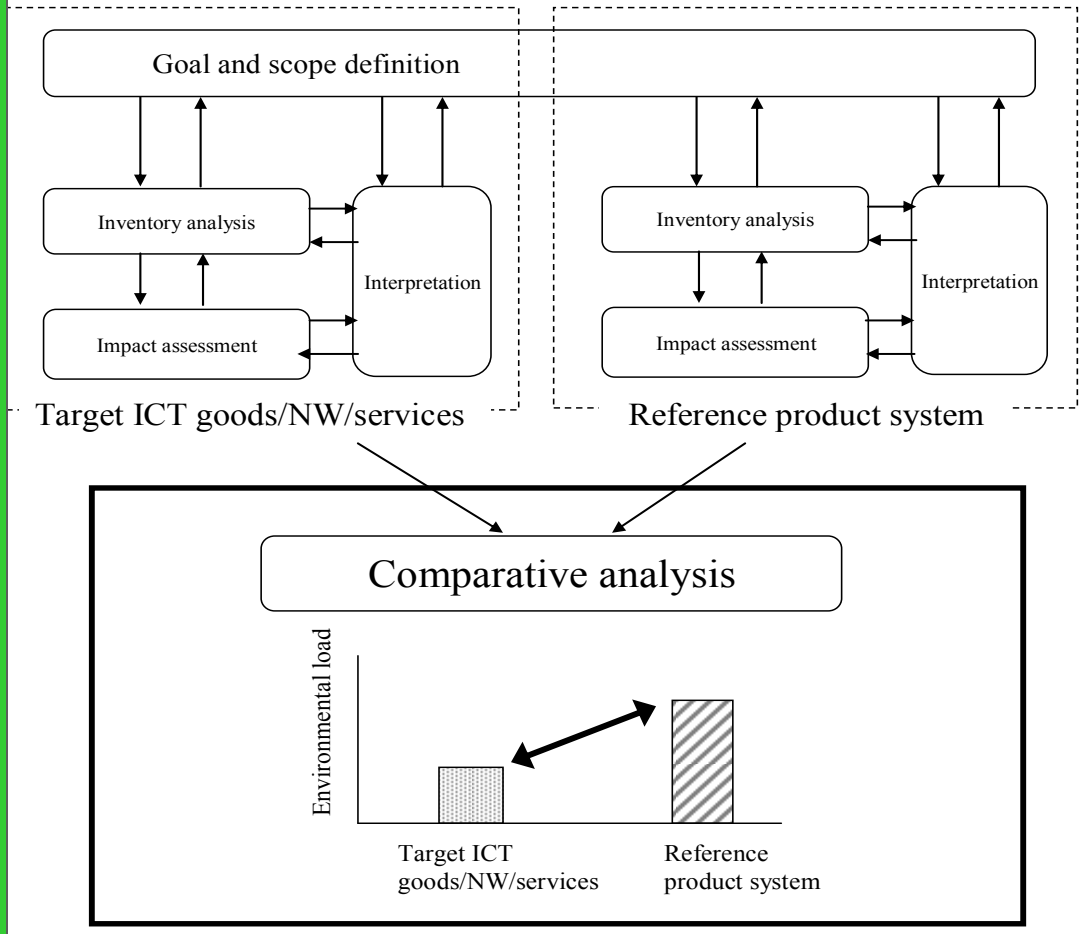
- There are two target systems for comparative analysis

1. Comparison between a reference product system and an ICT service
   i.e. travelling to a face to face meeting (flight, train, car, hotel stays) vs the use of a Video conferencing service
2. Comparison between two ICT goods or two ICT networks or two ICT services

- **Key principle: Systems must be compared using the same functional unit and equivalent methodological considerations, such as system boundary, data quality, allocation procedures and cut off rules (if applied)**

- In a comparative analysis what one is seeking to capture is the difference between the two systems rather than the magnitude of both

ITU-T L. 1410 GNS Part II



Procedures of comparisons between systems (comparative analysis)

As indicated above the assessment procedure contains several steps:

- Definition of goal, functional unit and scenarios;
- Definition of system boundaries for each product system;
- Life Cycle Inventory including data collection for each product system;
- Life Cycle Impact Assessment for each product system;
- Life Cycle Interpretation including comparison.

Comparative assessment of a reference product system and an System of ICT GNS.

Life cycle interpretation

- Life cycle interpretation Results of a comparative analysis between reference product system and systems of ICT GNS can be obtained by calculating the difference in environmental impact between the reference product system and the systems of ICT GNS. The difference is termed secondary effect.
  Equation (1) shows the calculation formula:

$$EI_{difference,I} = EI_{reference,I} - EI_{ICT\ GNS}$$

  Where,
  EI = environmental impact,
  I = ith comparison category
  $EI_{difference,I}$ = ith secondary effect,
  $EI_{reference,I}$ = ith EI of the reference product system,
  $EI_{ICT\ service,i}$ = ith EI of the systems of ICT GNS.

- Summing up $EI_{difference,I}$ over i gives total $EI_{difference}$ or the secondary effect of the systems of ICT GNS over the reference product system.

- Equation (2) shows the formula for calculating secondary effect.

$$Total\ EI_{difference} = \sum EI_{difference,I}$$

Comparison categories

Comparison category and its secondary effects

Comparison categories	Second order effects
Consumption of goods	By reducing goods consumption (paper, etc.), EI related to goods can be reduced.
Energy consumption	By enhancing the efficiency of power and energy use, EI related to power. can be reduced.
Movement of people	By reducing the movement of people, EI required for transportation can be reduced.
Movement and storage of goods	By reducing the movement of goods, EI required for transportation can be reduced.
Improved work efficiency	By using office space efficiently, power consumption for lighting, air conditioning, etc. can be reduced, thus reducing EI
Waste	By reducing waste emissions, EI for waste disposal etc. can be reduced.

Reporting

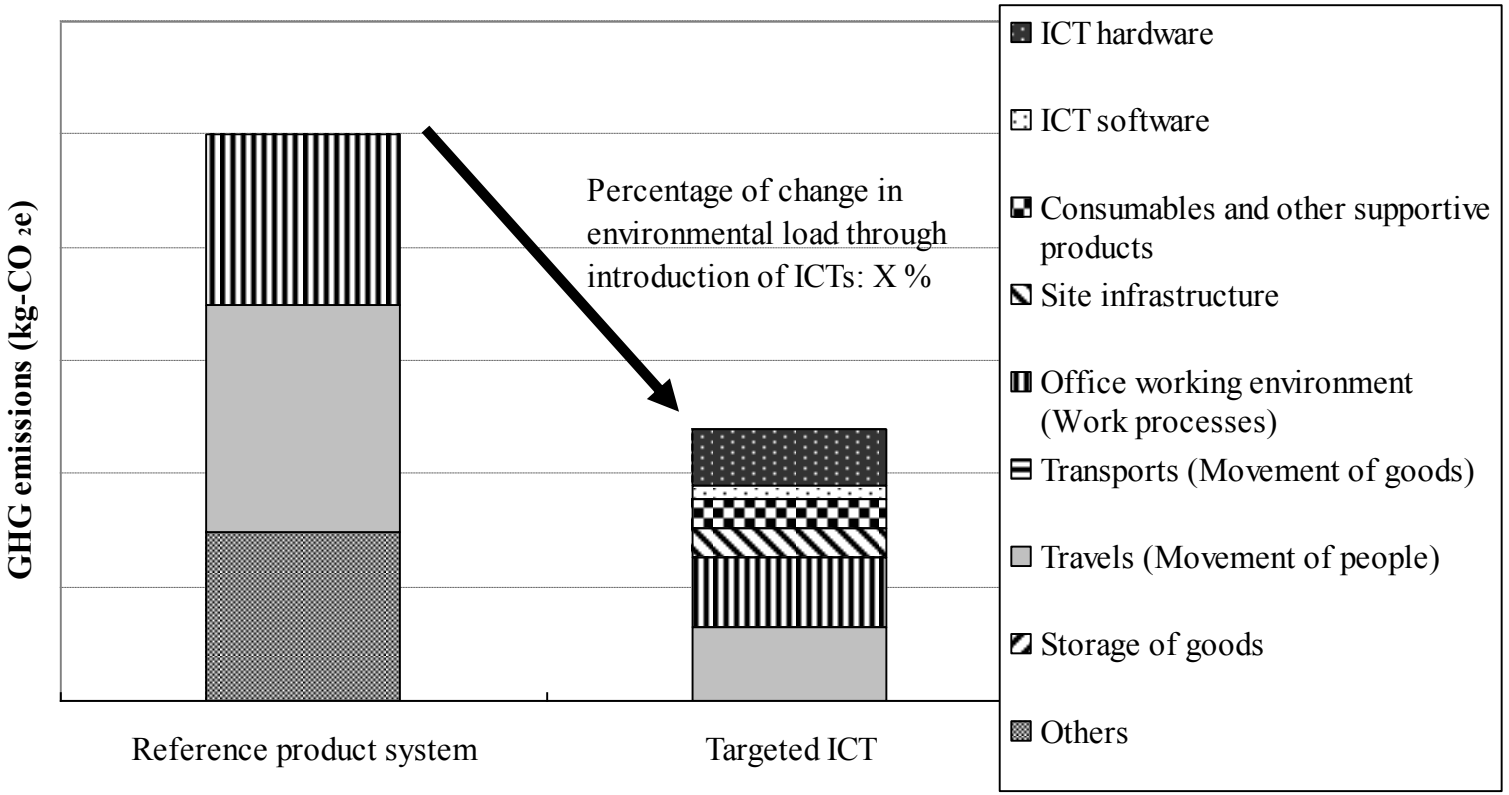
In addition to general reporting rules outlined in Part I, clause I.3, the following specific consideration applies for the comparative assessment.

- When the result of a comparative analysis between an ICT system and a reference product system (another ICT system or a non-ICT system) is reported as an environmental impact assessment, the environmental impact should detail the life cycle stages. It may be detailed according to checklist items if assessed in LCA of ICT GNS product system, in accordance with the goal and scope of the LCA.

- Any cut-off made during a study shall be clearly stated in the study report, e.g. the exclusion of life cycle processes which are considered insignificant should be justified.

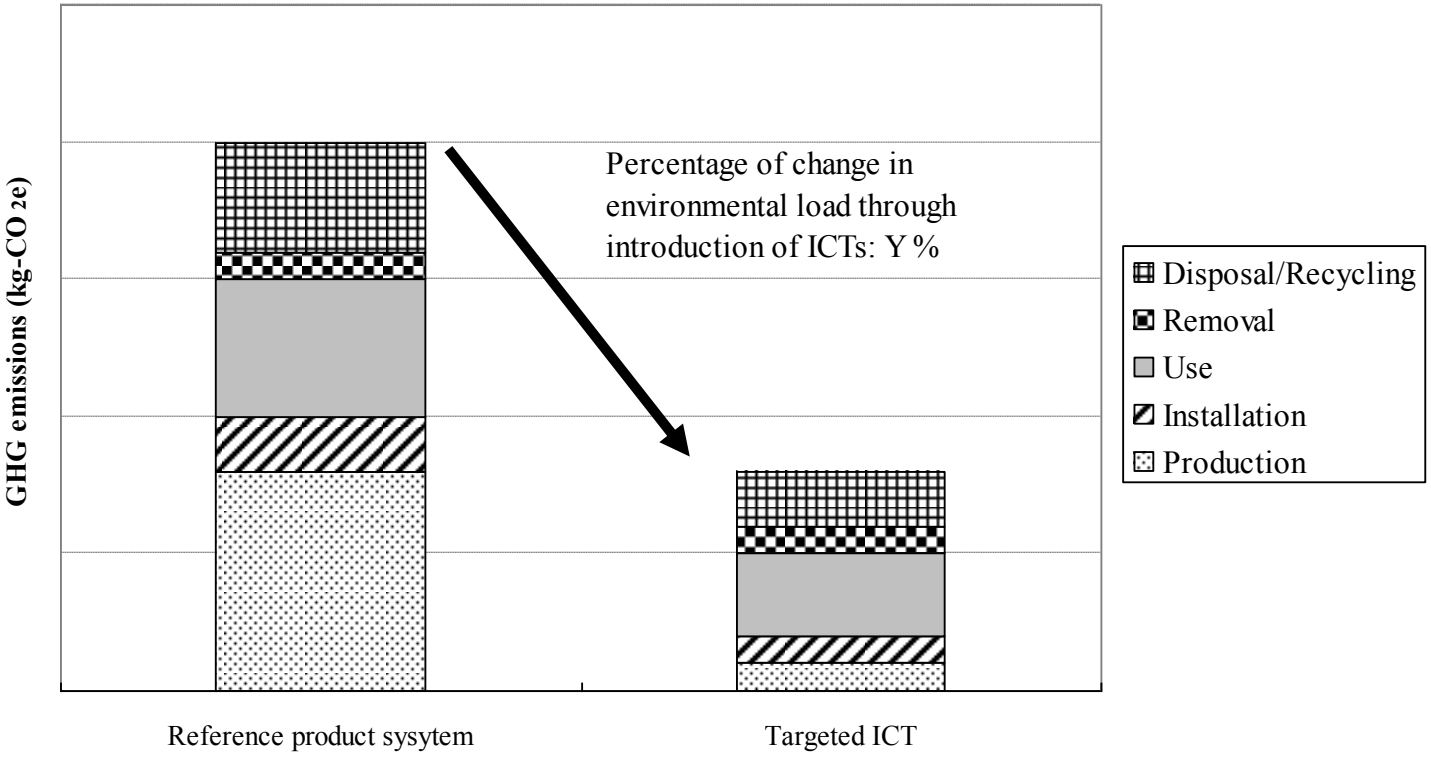
- The results may either been given as absolute amounts or as relative difference between the systems. Thus, instead of reporting the calculated absolute amount of environmental impact, a relative difference (possibly in percentage) between the impact from the ICT system and the impact from the reference product system may be presented.

ITU-T L. 1410 GNS Part II : example of reporting



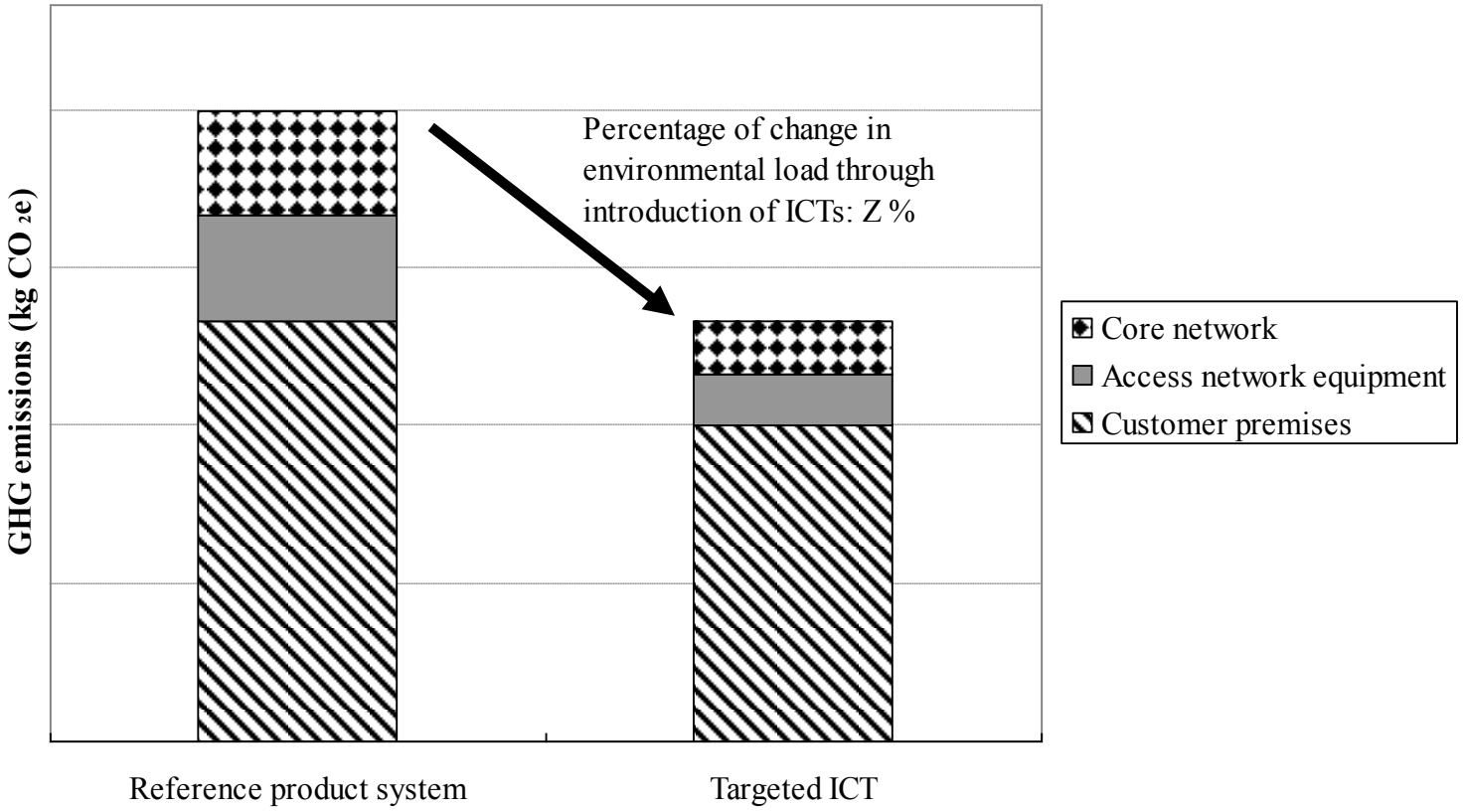
Example of comparative evaluation between ICT and reference product system

ITU-T L. 1410 GNS Part II, example of reporting



Example of comparative evaluation between ICT and reference product system with categories of life cycle stages.

ITU-T L. 1410 GNS Part II : example of reporting



Example of comparative evaluation between ICT and reference technology with categories of communication equipment.

Thank you for your attention !