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Foreword

This draft European Standard (EN) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI standards EN Approval Procedure.

The present document is part 2, sub-part 1 of a multi-part deliverable covering Global Key Performance Indicators for energy management of operational broadband deployment infrastructures as identified below:

Part 1: "General requirements";

Part 2: "Specific requirements";

Sub-part 1: "ICT sites";

Sub-part 2: "Fixed broadband access networks";

Sub-part 3: "Mobile broadband access networks";

Part 3-1: "ICT sites; Sub-part 1: DCEM";

Part 4-4: "Design assessments; Sub-part 4: Cable Access Networks".

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
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Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

Energy costs continue to rise, a trend that will continue in the future, while broadband penetration is introducing new active equipment to the network architecture. In this context, and to reflect other environmental aspects of sustainability, it is vital that the main telecommunication operators implement effective general engineering of fixed and mobile broadband networks and sites provisioning, managing or using those networks (i.e. ICT sites) in order to respond to critical issues of energy consumption while proposing essential solutions to broadband deployment. To guide this process, it is essential that metrics are defined, termed Global Key Performance Indicators (KPIs), that enable energy usage to be managed more effectively.

The Global Key Performance Indicators specified in the ETSI EN 305 200 [i.11] series address operational infrastructures and do not consider design or operation of individual components comprising those infrastructures.

The ETSI EN 305 200 [i.11] series of standards comprises:

- ETSI EN 305 200-1 [i.12] a generic requirements document addressing Global KPIs for operational infrastructures;
- a sub-series ETSI EN 305 200-2 that defines the Global KPIs, and drives energy management targets, for specific operational networks and sites and which describes how the Global KPIs are to be applied (which may be used to support future regulatory objectives):
  - ETSI EN 305 200-2-1 ((the present document) which replaces the earlier ETSI ES 205 200-2-1): ICT sites;
  - ETSI EN 305 200-2-2 [i.13]: Fixed broadband access networks;

  NOTE: Excluding cable access networks.

  - ETSI EN 305 200-2-3 [i.14]: Mobile broadband access networks.

  The standards do not define weightings of Objective KPIs or targets or limits for Global KPIs but may contain information on values that have been used by certain organizations.
- a sub-series ETSI EN 305 200-3 including ETSI EN 305 200-3-1 [i.15] that defines particular implementations of Global KPIs within ICT sites based on the requirements of the present document, and which may define levels of performance to simplify and provide clearer understanding of Global KPIs allowing the evaluation of performance of energy use management in ICT sites.

  The standards do not define weightings of Objective KPIs or targets or limits for Global KPIs but may contain information on values that have been used by certain organizations.
- a sub-series ETSI EN 305 200-4 including ETSI EN 305 200-4-4 [i.16] that defines design assessments of Global KPIs, and drives energy management targets, for specific operational networks and sites and which describes how the Global KPIs are to be applied (which may be used to support future regulatory objectives).

These standards may be considered to be a contribution to the application of ISO 50001 [i.17] in relation to the development of policy for the continuous improvement of energy management and will accelerate:

- the availability of operational infrastructure architectures and network implementations that use energy more efficiently;
- the definition and attainment objectives for other environmental aspects of sustainability for operational broadband networks.

The present document specifies the requirement for a Global KPI for energy management (KPI_{EM}) and its underpinning Objective KPIs for the ICT sites of broadband deployment. The requirements are mapped to the general requirements of ETSI EN 305 200-1 [i.12].

1 Scope

The present document specifies the requirements for a Global KPI for energy management (KPI_{EM}) and its underpinning Objective KPIs addressing the following objectives for the ICT sites of broadband deployment:

- energy consumption;
- task effectiveness;
- energy reuse;
- renewable energy.

The requirements are mapped to the general requirements of ETSI EN 305 200-1 [i.12].

Energy management of ICT sites comprises a number of independent layers. The present document addresses performance of infrastructures that supports the normal function of hosted ICT equipment (e.g. power distribution, environmental control, security and safety). The present document does not address other layers such as performance of ICT equipment itself, performance of usage of available processing power, and layers related to final service delivered (e.g. processing power required per itemized outcome) or overlay layers (e.g. energy consumption per itemized outcome).

The environmental impact and management of different energy sources are outside the scope of the present document.

Within the present document:

- clause 4 describes the energy parameters for ICT sites together with inclusions/exclusions of different energy contributions;
- clause 5 specifies the requirements for measurement, calculation, classification and reporting of KPI_{EM}.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] CEN EN 1434 series: "Heat meters".

[2] CENELEC EN 50600-2-2: "Information technology - Data centre facilities and infrastructures - Part 2-2: Power distribution".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings.

[i.2] CENELEC CLC/TR 50600-99-1: "Information technology; Data centre facilities and infrastructures; Part 99-1: Recommended practices for energy management".

[i.3] CENELEC EN 50600-1: "Information technology; Data centre facilities and infrastructures; Part 1: General concepts".

[i.4] CENELEC EN 50600-2-3: "Information technology; Data centre facilities and infrastructures; Part 2-3: Environmental control".

[i.5] CENELEC EN 50600-2-4: "Information technology; Data centre facilities and infrastructures - Part 2-4: Telecommunications infrastructure".

[i.6] CENELEC EN 50600-4-2: "Information technology; Data centre facilities and infrastructures; Part 4-2: Power usage effectiveness".

[i.7] CENELEC EN 50600-4-3: "Information technology; Data centre facilities and infrastructures; Part 4-3: Renewable energy factor".

[i.8] CENELEC EN 50600-4-6: "Information technology; Data centre facilities and infrastructures; Part 4-6: Energy reuse factor".

[i.9] ETSI ES 203 228: "Environmental Engineering (EE); Assessment of mobile network energy efficiency".

[i.10] ETSI EN 305 174-2: "Access, Terminals, Transmission and Multiplexing (ATTM); Broadband Deployment and Lifecycle Resource Management; Part 2: ICT Sites".

[i.11] ETSI EN 305 200 series: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs".

[i.12] ETSI EN 305 200-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 1: General requirements".

[i.13] ETSI EN 305 200-2-2: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 2: Specific requirements; Sub-part 2: Fixed broadband access networks".

[i.14] ETSI EN 305 200-2-3: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 2: Specific requirements; Sub-part 3: Mobile broadband access networks".

[i.15] ETSI EN 305 200-3-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 3: ICT sites; Sub-part 1: DCEM".

[i.16] ETSI EN 305 200-4-4: "Integrated broadband cable telecommunication networks (CABLE); Energy management; Operational infrastructures; Global KPIs; Part 4: Design assessments; Sub-part 4: Cable access networks".

[i.17] ISO 50001: "Energy management systems - Requirements with guidance for use".

[i.18] ISO/IEC 30134: "Information technology -- Data centres -- Key performance indicators".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

energy consumption: total consumption of energy by an operational infrastructure

energy management: combination of reduced energy consumption and increased task effectiveness, re-use of energy and use of renewable energy

energy re-use: transfer or conversion of energy (typically in the form of heat) produced by the operational infrastructure to do other work

ICT equipment: equipment providing data storage, processing and transport services

NOTE: A combination of information technology equipment and network telecommunications equipment.

ICT equipment load: total requirement for power by a set of Information Technology Equipment (ITE) and/or Network Telecommunications Equipment (NTE)

ICT site: site containing structures or group of structures dedicated to the accommodation, interconnection and operation of ICT equipment together with all the facilities and infrastructures for power distribution and environmental control together with the necessary levels of resilience and security required to provide the desired service availability

Information Technology Equipment (ITE): equipment providing data storage, processing and transport services for subsequent distribution by Network Telecommunications Equipment (NTE)

Network Data Centre (NDC): data centre embedded within the core network

NOTE: A network data centre of a cable access network may be termed a 'master headend'.

Network Telecommunications Equipment (NTE): equipment within the boundaries of, and dedicated to providing connection to, core and/or access networks

objective KPI: KPI assessing one of the objectives of operational energy performance which is subsequently used to define a Global KPI for energy management

operational infrastructure: combination of ICT equipment together with the power supply and environmental control systems necessary to ensure provision of service

Operator Site (OS): premises accommodating Network Telecommunications Equipment (NTE) providing direct connection to the core and access networks and which may also accommodate Information Technology Equipment (ITE)

NOTE 1: An operator site that is only connected to the core network is considered as a network data centre.

NOTE 2: An operator site of a cable access network may be termed a local head-end.

renewable energy: energy produced from dedicated generation systems using resources that are naturally replenished and for which the energy required for production does not exceed 10 % of the energy produced

NOTE: Directive 2010/31/EU [i.1] defines "energy from renewable sources" as energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

task effectiveness: measure of the work done (as a result of design and/or operational procedures) for a given amount of energy consumed

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Δt	the maximum time variation between measurement points of the different Objective KPIs within a given Global KPI
k	assessment period index
KPI_{EC}	objective KPI of energy consumption
KPI_{EM}	global KPI of energy management
KPI_{REN}	objective KPI of renewable energy usage
KPI_{REUSE}	objective KPI of energy re-use
KPI_{TE}	objective KPI of task effectiveness
T_{KPI}	period of time over which Global KPIs are assessed to determine relevant trend information
W_{EC}	weighting factor applied to KPI_{EC}
W_L	weighting factor within KPI_{REUSE}
W_{REN}	weighting factor applied to KPI_{REN}
W_{REUSE}	weighting factor applied to KPI_{REUSE}
W_{TE}	weighting factor applied to KPI_{TE}

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ATTM	Access, Terminals, Transmission and Multiplexing
CEN	European Committee for Normalization
CENELEC	European Committee for Electrotechnical Standardization
CHP	Combined Heat and Power
CLC	CENELEC
CLC/TR	CENELEC Technical Report
DCEM	Data processing and Communications Energy Management
DG JRC	Directorate General (of the European Commission) Joint Research Centre
EC	European Commission
ICT	Information Communications Technology
IEC	International Electrotechnical Committee
ISO	International Standards Organization
ITE	Information Technology Equipment
KPI	Key Performance Indicator
NDC	Network Data Centre
NTE	Network Telecommunications Equipment
OS	Operator Site
PDU	Power Distribution Unit
UPS	Uninterruptible Power Supply

4 Energy management of ICT sites

4.1 General

4.1.1 Measured energy

The energy referred to in Figure 2, Figure 3 and elsewhere in the present document may be referred to as "final energy" and excludes losses from production or transmission to the measurement boundary.

4.1.2 Dedicated ICT sites

The ICT sites addressed by the present document are Operator Sites (OSs) and Network Data Centres (NDCs). It should be noted that an OS that is only connected to the core network is considered to be an NDC.

With reference to the schematic in Figure 1:

- an NDC accommodates a mixture of information technology equipment (ITE) and network telecommunication equipment (NTE);
- an OS will also accommodate a mixture of ITE and NTE - where the NTE may provide connections to connections to core, fixed access, terrestrial mobile access and satellite mobile access network infrastructures;
- the present document does not differentiate between ITE and NTE and the generic term ICT equipment is used.

The design and configuration of ICT sites vary depending on their function and overall availability objectives. CENELEC EN 50600-2 ([2], [i.4] and [i.5]) standards provide requirements for the facilities and infrastructures that may be required. The primary task of the ICT site is the effective function of the ICT equipment which, in turn, defines requirements for the power distribution, environmental control, security and telecommunications cabling infrastructures and the other control and support facilities necessary for the maintenance of that function. This is shown schematically in Figure 1.

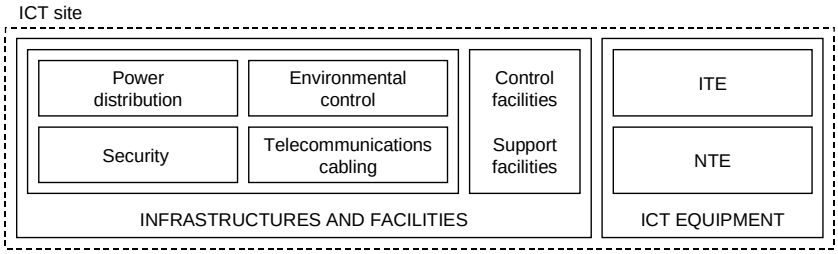

Figure 1: Schematic of the functional elements of an ICT site

For a dedicated ICT site, the energy management Objective KPIs of the ICT site take into account:

- the energy consumption of the ICT site (from both renewable and non-renewable sources);
- the task effectiveness of the ICT site (i.e. a measure of the consumption by the ICT equipment versus that of the infrastructure and facilities);
- the possibility of the re-use of waste energy from the ICT site.

As a result, it is required to be able to measure the energy transfer at points 1, 2, 3 and 4 as shown schematically in Figure 2.

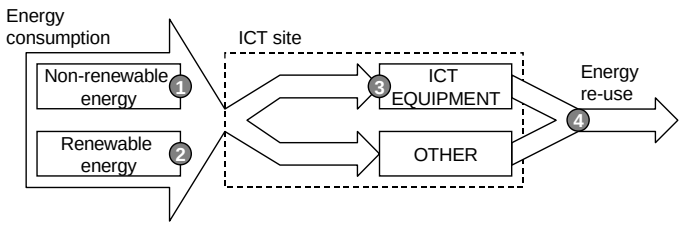

Figure 2: Schematic of energy measurement of a dedicated ICT site

4.1.3 Mixed-use ICT sites

For mixed-use premises accommodating an ICT site, the energy management Objective KPIs are those of the ICT site as described in clause 4.1.2. As a result, it is required to be able to measure the energy transfer at points A, B and C as shown in Figure 3 in addition to point 3 of Figure 2.

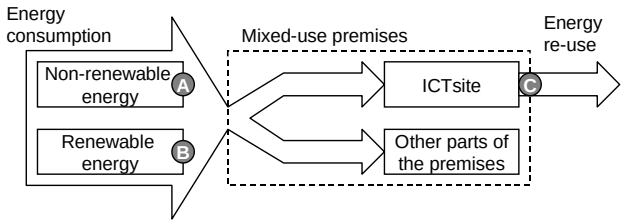

Figure 3: Schematic of energy measurement of a mixed-use ICT site

4.1.4 Groups of ICT sites

The Global KPI (KPI_{EM}) of clause 5.1.1 and the underpinning Objective KPIs of clause 5.5.2 may be applied to individual ICT sites, whether in dedicated or mixed-use premises, or to groups of ICT sites under common governance.

The selection of ICT sites to be included in groups shall reflect a common purpose, i.e. groups of OSs or groups of NDCs. The use of standard ETSI ES 203 228 [i.9] may help to determine such ICT sites.

A value for the Global KPI (KPI_{EM}) of clause 5.1.1 is only valid if all the Objective KPIs are applied to the same group of ICT sites.

4.2 Related standards

The definition of an ICT site in the present document (see clause 3.1) is a modification of a common definition of data centres applied in standards prepared by ISO/IEC JTC1 SC39 (ISO/IEC 30134 [i.18] series), CENELEC TC215 (CENELEC EN 50600 series) and that published in data centre landscaping documents produced by the CEN/CENELEC/ETSI Coordination Group on Green Data Centres.

This reflects the similarity between NDC and OS infrastructures. As indicated in clause 4.1, the present document does not differentiate between NDC and OS infrastructures.

CENELEC TC215 has published standards in the CENELEC EN 50600 series generally entitled "Information technology; Data centre facilities and infrastructures". These standards address the design, operation, management and resource management of data centres including:

- General:
  - CENELEC EN 50600-1: General concepts [i.3];
- Design:
  - CENELEC EN 50600-2-2: Power supply and distribution [2];
  - CENELEC EN 50600-2-3: Environmental control [i.4];
  - CENELEC EN 50600-2-4: Telecommunications cabling infrastructure [i.5] .

CENELEC EN 50600-1 [i.3] uses the design solutions of CENELEC EN 50600-2-2 [2], CENELEC EN 50600-2-3 [i.4] and CENELEC EN 50600-2-4 [i.5] to define an overall Availability Class for a data centre.

Examples of design concepts of the Availability Class for each infrastructure are shown in Table 1.

Table 1: Implementation of Availability Class

Availability Class	Class 1	Class 2	Class 3	Class 4
Availability	**Low**	**Medium**	**High**	**Very high**
Power supply infrastructure (see CENELEC EN 50600-2-2 [2])	Single source	Redundant source - Single path to primary distribution equipment	Redundant source - Multiple paths to primary distribution equipment	Multiple source - Multiple paths to primary distribution equipment
Power distribution infrastructure (see CENELEC EN 50600-2-2 [2])	Single path	Single path - redundancy of components	Redundant path	Redundant path - fault tolerant except during maintenance via redundancy of components
Environmental control infrastructure (see CENELEC EN 50600-2-3 [i.4])	Single system	Single system with redundant devices	Multi-path Concurrent repair/operate solution	Multi-path Concurrent repair/operate and fault tolerant solution
Telecommunications cabling infrastructure (see CENELEC EN 50600-2-4 [i.5])	Single-path using direct connections or fixed infrastructure with single access network connection	Single-path using fixed infrastructure with multiple access network connections	Multi-path using fixed infrastructure with diverse pathways with multiple access network connections	Multi-path using fixed infrastructure with diverse pathways and redundant distribution zones and multiple access network connections

The increasingly complexity of the higher classes for each infrastructure generally involves more equipment which consumes energy.

In addition, CENELEC EN 50600-2-2 [2] and CENELEC EN 50600-2-3 [i.4] specify requirements for energy efficiency enablement which define locations for the measurement of energy consumption and related parameters.

In addition, CENELEC EN 50600-4 series ([i.6] to [i.8]) standards specify resource management KPIs (and are, in many cases, the European implementation of ISO/IEC 30134 [i.18] standards) which are useful in the development of ETSI the present document and ETSI EN 305 200-3-1 [i.15].

5 Global KPI (KPI_{EM}) for ICT sites

5.1 General

5.1.1 Global KPI (KPI_{EM}) for ICT sites

In accordance with ETSI EN 305 200-1 [i.12], KPI_{EM} for ICT sites has the form:

$$KPI_{EM} = f\left(KPI_{EC}, KPI_{TE}, KPI_{REUSE}, KPI_{REN}\right)$$

where:

KPI_{EC} = Objective KPI for energy consumption (see clause 5.1.2.1);

KPI_{TE} = Objective KPI for task effectiveness (see clause 5.1.2.2);

KPI_{REUSE} = Objective KPI for energy re-use (see clause 5.1.2.3);

KPI_{REN} = Objective KPI for renewable energy (see clause 5.1.2.4).

NOTE 1: KPI_{EC} approximates to E_{DC} in CENELEC EN 50600-4-2 [i.6], CENELEC EN 50600-4-3 [i.7] and CENELEC EN 50600-4-6 [i.8] although boundary conditions may differ.

NOTE 2: KPI_{TE} approximates to power usage effectiveness of CENELEC EN 50600-4-2 [i.6], although boundary conditions may differ.

NOTE 3: KPI_{REN} approximates to renewable energy factor in CENELEC EN 50600-4-3 [i.7], although boundary conditions may differ.

NOTE 4: KPI_{REUSE} approximates to energy reuse factor in CENELEC EN 50600-4-6 [i.8], although boundary conditions may differ.

KPI_{EM} is applicable to ICT sites, regardless of:

- the Availability Class of their infrastructures as outlined in Table 1;
- the business model of the data centre (such as operator, enterprise, co-location service or co-host service);

NOTE 5: General purpose data centres (DCs) may be subject to the application of Objective and Global KPIs of the present document and of those in the ETSI EN 305 200-3 [i.15] series.

- the type, quantity and relative proportions of ITE and NTE within the totality of ICT equipment;
- climatic conditions to which the ICT site is subjected during an annual period.

5.1.2 Objective KPIs

5.1.2.1 Energy consumption (KPI_{EC})

The present document supports the reduction in the energy consumption required to provide a given level of service as a primary objective.

The KPI_{EC} may be improved by local actions within individual ICT sites and/or global actions applied to the group under common governance.

Requirements or recommendations in relation to the improvement of the energy consumption of the ICT equipment and support infrastructures are not within the scope of the present document. Requirements and recommendations for practices enabling reductions in energy consumption of operational data centres which may be applied to all ICT sites are described in a number of documents including:

- ETSI EN 305 174-2 [i.10];
- CLC/TR 50600-99-1 [i.2].

5.1.2.2 Task effectiveness (KPI_{TE})

The present document supports the improvement in task effectiveness as a primary objective.

KPI_{TE} is the ratio of the total energy consumption of the ICT site to the energy consumption of the ICT equipment in the ICT site. KPI_{TE} is dimensionless and has the following properties:

- $KPI_{TE} \geq 1$;
- $KPI_{TE} = 1$ is an ideal value.

In an ICT site, an improvement of the KPI for task effectiveness (KPI_{TE}) reflects a reduction of the overall energy consumption required to both power a given ICT equipment load and to support (e.g. cool) the equipment associated with that load over a given period of time.

It should be noted that the work done by the load is not a basis for the KPI_{TE} due to the wide variety of operations performed by the ICT equipment in ICT sites.

5.1.2.3 Energy re-use (KPI_{REUSE})

The present document supports the re-use of energy as a secondary objective.

KPI_{REUSE} is the ratio of re-used energy by facilities, external to the ICT site, to the total energy consumption of the ICT site. Thermal energy can be reused in different forms, liquid or gas (air). KPI_{REUSE} shall be measurable and quantifiable. It is a dimensionless number.

The KPI_{REUSE} shall reflect:

- a preference for energy consumption reduction rather than re-use;
- a preference for re-use of energy in the form of heat generated by the ICT equipment rather than from poorly designed facilities and infrastructures.

In all cases "non-use" is better than "re-use".

All energy input to a ICT site is converted into heat. Possible initiatives to for re-use the heat produced by the ICT equipment in ICT sites include:

- heating of water;
- heating of facilities within the ICT site (e.g. pre-heating of diesel generators);
- heating of other premises (commercial or residential).

The KPI for energy re-use (KPI_{REUSE}):

- provides the main incentive to the re-use of heat up to the quantity produced by the ICT equipment load;
- provides a lower incentive to the re-use of heat from the technical environment including, but not limited to, cooling, power distribution, security systems, safety systems and lighting.

KPI_{REUSE} can only be assessed and included in subsequent calculation and presentation of KPI_{EM} if the energy re-used is measurable at the intended point of delivery i.e. any losses in the delivery system shall not be included.

5.1.2.4 Renewable energy (KPI_{REN})

The present document supports the use of renewable energy as a secondary objective.

KPI_{REN} is the ratio of energy consumption from renewable sources to the total energy consumption of the ICT site. It is a dimensionless number.

Only the sources contributing to KPI_{EC} will be taken into account, whether dedicated or shared.

KPI_{REN} takes account of renewable energy that is produced by:

a) sources dedicated to and directly serving an ICT site;

b) sources (an ICT site or generator) under common governance with the ICT site(s) they serve and from which it is conveyed by the utility (grid) serving an ICT site or ICT sites in the group defined for the application of the KPI_{EM}.

In the case of b):

- the renewable energy shall not be included within KPI_{REN} of the recipient site if it is already included in the proportion of "green" energy within the energy mix of the utility (grid) supplied to the ICT site as defined in European standards or other international schemes;

NOTE: Any proportion in the mix of utility electricity supplies certified as "renewable " (e.g. based on the carbon footprint of the energy source) by electricity suppliers or in accordance with nationally recognized schemes is not recognized by the present document.

- the portion of such energy allocated to the recipient ICT site added to other ICT site consumptions shall not exceed the overall energy consumption by the ICT site.

5.2 Scale

KPI_{EM} is expressed with units of MWh.

The dominant factor in the calculation of KPI_{EM} is the Objective KPI for energy consumption (KPI_{EC}). Large ICT sites that are fully utilized will naturally have higher values of KPI_{EC}.

The value of KPI_{EC} is mitigated by the weighted subtraction of any valid energy re-use (KPI_{REUSE}) and any energy contribution from locally generated renewable sources (KPI_{REN}).

This modified consumption value is multiplied by the Objective KPI for task effectiveness (KPI_{TE}) which increases the value of the KPI_{EM} in direct proportion to the lack of task effectiveness i.e. ICT sites with poor task effectiveness will be adversely affected.

This approach allows:

- the energy impact of all scales of ICT sites to be assessed but not compared;
- regulatory objectives to be applied to groups of ICT sites which have the greatest individual energy impact.

5.3 Utilization and evolution

A given ICT site is able to be assessed throughout its operational life.

KPI_{EM} is applicable from early stages, whenKPI_{EC} is low and KPI_{TE} may be higher than the design objective (i.e. task effectiveness may be poorer than that of a fully utilized ICT site), to a more complete utilization stage when KPI_{TE} should match the design goals and KPI_{EC} is higher.

However, for ICT sites with higher values of KPI_{TE}, KPI_{EM} will only reduce if reductions of ICT equipment load are supported by reductions in non-ICT equipment load consumption.

This approach encourages the:

- re-engineering of the supporting infrastructures (e.g. power distribution and environmental control systems) in older legacy ICT sites which tend to exhibit high KPI_{TE} values;
- optimization of ICT equipment loads by selection, configuration and utilization of equipment and management systems.

5.4 Definition of boundaries

5.4.1 General

The ICT site(s) under consideration shall be viewed as a system with boundaries through which energy dedicated to the ICT site(s) flows.

Two forms of flow can be used to operate an ICT site:

- electrical energy providing function to the:
  - ICT equipment;
  - environmental control systems supporting the function of the ICT equipment;
  - other facilities and infrastructure of the ICT site;

- thermal energy in the form of:
  - heat from a source: energy flows from the source into the ICT site which can be used for cooling and, in rare cases, for producing electricity;
  - heat discharge: energy flows from the ICT site to a heat discharge system for cooling purposes.

Energy in either form shall not be counted twice.

5.4.2 Flows of electrical energy

Figure 4 shows a schematic in relation to the electrical energy input to the ICT site.

Sources include:

- delivered electricity supply (e.g. utility);
- dedicated local generation of electricity (via conversion of fuels and/or local heat sources).

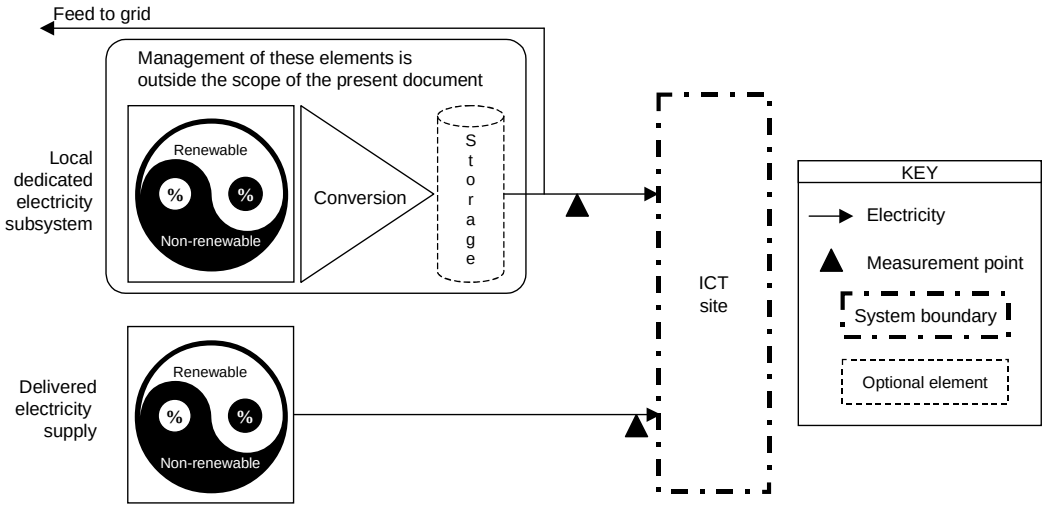

Figure 4: Electrical energy flows

When an electricity generating subsystem is dedicated to the ICT site (e.g. a combination of power generators and energy storage), the electrical energy flow from the subsystem is taken into consideration at output of the subsystem to an ICT site. Other flows of electrical energy from the subsystem (e.g. feed to grid) are not taken into consideration.

Delivered electricity is taken into account at its delivery point to the ICT site.

5.4.3 Flows of thermal energy

5.4.3.1 ICT site cooling (heat discharge systems)

Figure 5 shows a schematic describing the thermal energy exchange with the heat discharge systems for the ICT site.

Heat discharge systems include:

- air and/or water providing cooling;
- public or district heat collection networks;
- local dedicated cooling subsystems such as adsorption chillers powered by locally generated heat including that of combined heat and power (CHP) systems.

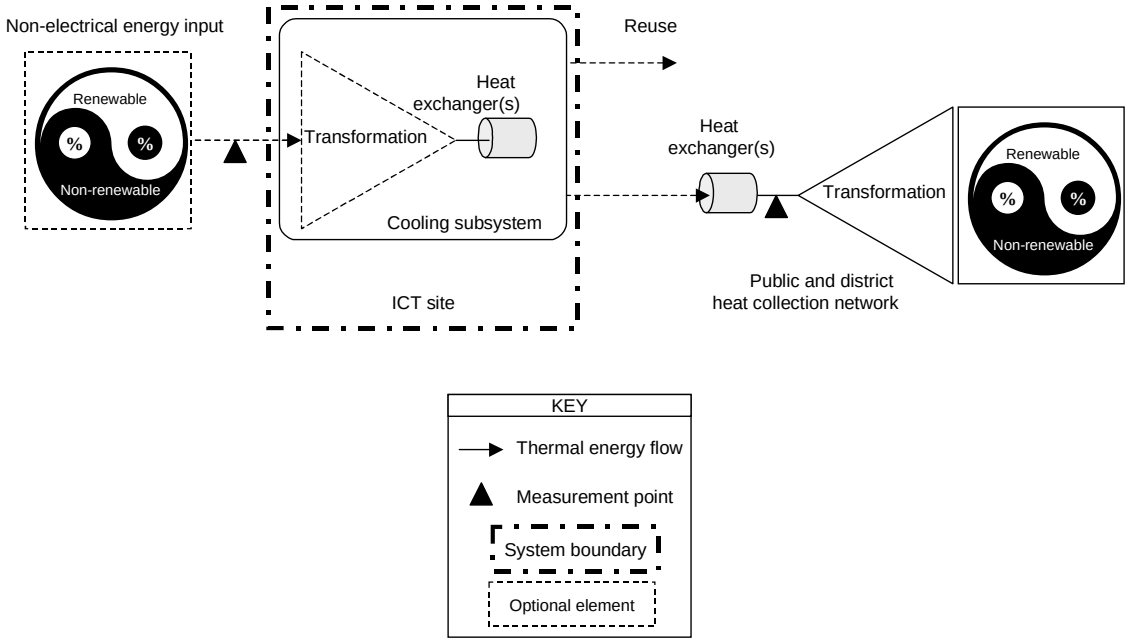

Figure 5: Energy flows for heat sinks

All energy flows required to operate heat discharge systems and not already accounted for in clauses 5.4.2 and 5.4.3.2 shall be taken into account as described in clause 5.4.4.

5.4.3.2 Heat distribution networks

Heat from public or district distribution networks shall be taken into account at ICT site input.

5.4.4 Inclusion in Objective KPIs

In order for Objective KPIs to be calculated, all forms of energy flow including those used only under fault conditions shall be metered as, or converted to, MWh.

All electrical energy flows as defined in clause 5.4.2 shall be allocated to KPI_{EC}. When direct measurement is not possible, the calculations of clause 5.6.1.1.1 shall be applied.

Cooling resulting from use of natural resources (e.g. air, water, heat) and waste heat including CHP shall not be allocated to KPI_{EC}. All other thermal flows as defined in clause 5.4.3 shall be allocated to KPI_{EC}. When direct measurement is not possible for cooling, an estimate shall be calculated using a fixed factor applied to heat extracted (see clause 5.6.1.1.1).

The following thermal flows shall not be allocated to KPI_{EC}:

- between heat exchangers and natural resources (e.g. air, water, heat);
- between heat exchangers waste heat including CHP.

Heat discharge flows to public or district networks shall not be taken into account for KPI_{REUSE}.

5.5 Formulae

5.5.1 Global KPI (KPI_{EM}) for ICT sites

5.5.1.1 General

An assessment of KPI_{EM} requires that the energy supplied to the ICT site provides all the primary functions of the ICT site (i.e. ICT equipment load, environmental control etc.). If the supply of energy of any of the non-ICT equipment loads is provided by other supplies not included in KPI_{EC}, then KPI_{EM} cannot be assessed.

KPI_{EM} is defined mathematically as:

$$KPI_{EM} = KPI_{TE} \times KPI_{EC} \times \left(1 - W_{REUSE} \times KPI_{REUSE}\right) \times \left(1 - W_{REN} \times KPI_{REN}\right)$$, subject to a minimum value of 0.

This is shown schematically in Figure 6.

The contributions of energy re-use and the use of renewable energy are subject to weighting. Clause 5.5.1.5.1 and clause 5.5.1.5.2 provide guidance on the range of weighting values for W_{REUSE} and W_{REN} respectively. In order to evaluate trend analysis, the weightings applied shall be consistent for the period covered by the analysis.

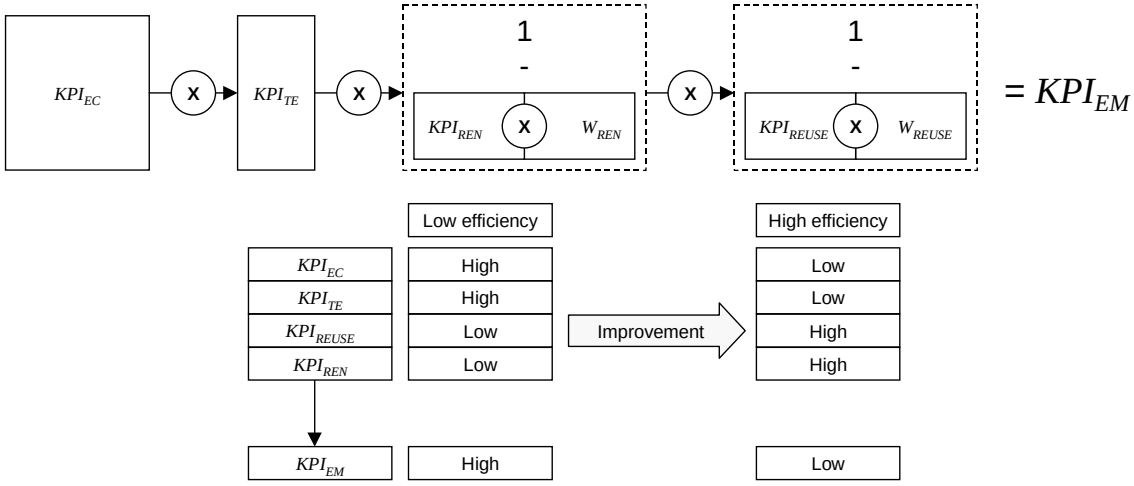

Figure 6: Schematic of KPI_{EM} calculation and drivers

5.5.1.2 Definition of terms

See clause 3.2.

5.5.1.3 Clarity

KPI_{EM} meets the requirements of ETSI EN 305 200-1 [i.12].

5.5.1.4 Criteria

KPI_{EM} is based on Objective KPIs which shall meet the requirements listed below.

In accordance with the terminology of clause 5.6 of ETSI EN 305 200-1 [i.12]:

- the Objective KPIs shall be measured on a single ICT site (or a common group of ICT sites) over the same period of time (T_{KPI}) subject to the allowed variation (Δt);
- the default value of T_{KPI} shall be 365 days (in order to take account of the climatic variations that will be experienced by the operational infrastructure);

- T_{REPEAT} shall be between one week and one calendar month;
- the maximum time difference in the periods of assessment, Δt, of the objective KPIs shall be 7 days - by ensuring that the maximum variation is maintained with the required value of 7 days whereas T_{KPI} is one year, the impact on the accuracy of the resulting Objective KPIs will be minimal. If improved accuracy is required, the actual value of Δt shall be reduced.

5.5.1.5 Weighting factors

5.5.1.5.1 Energy re-use (W_{REUSE})

In accordance with clause 5.1.2.3, the contribution of energy re-use to the reduction of KPI_{EM} shall not undermine efforts to reduce energy consumption. As a result, the value of W_{REUSE} shall encourage "non-use rather than re-use" as required in clause 5.1.2.3.

The general application of this weighting factor requires $0 \leq W_{REUSE} \leq 1$.

Annex A provides details on weighting values employed by certain industry organizations. Other weightings may be used to meet specific objective needs provided that they fall within the above range and their application is in accordance with clause 5.5.1.1.

5.5.1.5.2 Renewable energy (W_{REN})

In accordance with ETSI EN 305 200-1 [i.12], the application of KPI_{REN} shall not undermine efforts to reduce energy consumption. If all energy was generated locally from renewable sources and W_{REN} = 1,0, KPI_{EM} would be zero - independent of total consumption or task effectiveness. This situation, although obviously extreme, would be undesirable since if so much energy were available from locally generated renewable sources it should not be "wasted" by profligate energy consumption or poor task effectiveness within the infrastructures of broadband deployment.

The general application of this weighting factor requires $0 \leq W_{REN} \leq 1$.

Annex A provides details on weighting values employed by certain industry organizations. Other weightings may be used to meet specific objective needs provided that they fall within the above range and their application is in accordance with clause 5.5.1.1.

5.5.2 Objective KPIs for ICT sites

5.5.2.1 Energy consumption (KPI_{EC})

5.5.2.1.1 Formula

KPI_{EC} for assessment period k is defined mathematically as:

$$KPI_{EC}^{(k)} = \sum_{n=1}^{N} C_n^{(k)}$$

where:

$$C_n^{(k)} = \sum_{s=1}^{S_n} (1 + MP_{s,n}^{(EC)}) \times C_{s,n}^{(k)}$$

5.5.2.1.2 Definitions of terms

n = ICT site number (if the assessment is applied to a common set of ICT sites).

N = total number of ICT sites (if the assessment is applied to a common set of ICT sites).

$C_n^{(k)}$ = total energy consumption by ICT site n during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

$C_{s,n}^{(k)}$ = total energy consumption for energy source s in the ICT site n during the KPI period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

s = energy source number.

S_n = total number of separate energy sources of the ICT site n including those provided only during fault conditions.

$MP_{s,n}^{(EC)}$ = measurement penalty for energy source s at ICT site n which takes account of the means by which energy consumption measurement is obtained (see clause 5.6.1.1.1).

5.5.2.1.3 Clarity

KPI_{EC} meets the requirements of ETSI EN 305 200-1 [i.12].

5.5.2.1.4 Criteria

Each ICT site shall operate at its design level of service availability during the period of assessment. This includes any circumstances during which fault conditions exist and alternative sources are used (e.g. testing, online standby duty).

All the energy required to maintain the ICT site at its design level of service availability, such as cooling, power distribution, surveillance systems, access control, flood and fire detection, fire extinguishing system and lighting shall be included in any measurements of $C_{s,n}^{(k)}$.

All other energy consumption within the boundaries of the ICT site but not necessary to deliver the design level of service availability (such as office facilities) are out of the scope and shall not be included in any measurements of $C_{s,n}^{(k)}$.

5.5.2.2 Task effectiveness (KPI_{TE})

5.5.2.2.1 Formula

KPI_{TE} for assessment period k is defined mathematically as:

$$KPI_{TE}^{(k)} = \frac{\sum_{n=1}^{N} C_n^{(k)}}{\sum_{n=1}^{N} L_n^{(k)}}$$

where:

$$L_n^{(k)} = \sum_{j=1}^{J_n} \left[L_{j,n}^{(k)} \times (1 - MP_{j,n}^{(TE)}) \right]$$

5.5.2.2.2 Definitions of terms

n = ICT site number (if the assessment is applied to a common set of ICT sites).

N = total number of ICT sites (if the assessment is applied to a common set of ICT sites).

$C_n^{(k)}$ = total energy consumption of ICT site n during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

$L_n^{(k)}$ = total energy consumed by ICT equipment load in ICT site n during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

j = ICT equipment load measurement point number.

J_n = total number of measurement points of ICT equipment load in ICT site n.

$L_{j,n}^{(k)}$ = energy consumed by ICT equipment load at the measurement point j in ICT site n.

$MP_{j,n}^{(TE)}$ = measurement penalty for ICT equipment load measurement point j in ICT site n (see clause 5.6.1.2.1).

5.5.2.2.3 Clarity

KPI_{TE} meets the requirements of ETSI EN 305 200-1 [i.12].

5.5.2.2.4 Criteria

Measurement criteria for $C_n^{(k)}$ are specified in clause 5.5.2.1.4.

All the ICT equipment shall be taken into account in the measurement of $L_{j,n}^{(k)}$. The energy consumption of other equipment such as rack cooling systems, room air handling units and office utilities shall not be included in $L_{j,n}^{(k)}$.

5.5.2.3 Energy re-use (KPI_{REUSE})

5.5.2.3.1 Formula

KPI_{REUSE} can only be assessed and included in subsequent calculation and presentation of KPI_{EM} if the energy re-used is measurable at the intended point of delivery i.e. any losses in the delivery system shall not be included.

KPI_{REUSE} for assessment period k is defined mathematically as:

$$KPI_{REUSE}^{(k)} = \frac{\sum_{n=1}^{N}\left\{\min\left\{RU_n^{(k)}, L_n^{(k)}\right\} + W_L \times \max\left\{0, RU_n^{(k)} - L_n^{(k)}\right\}\right\}}{\sum_{n=1}^{N} C_n^{(k)}}$$

This is shown schematically in Figure 7.

The ratio of re-used energy for the portion that is above the load energy is subject to weighting. Clause 5.5.2.3.4 provides guidance on the range of weighting values that may be applied. In order to evaluate trend analysis, the weightings applied shall be consistent for the period covered by the analysis.

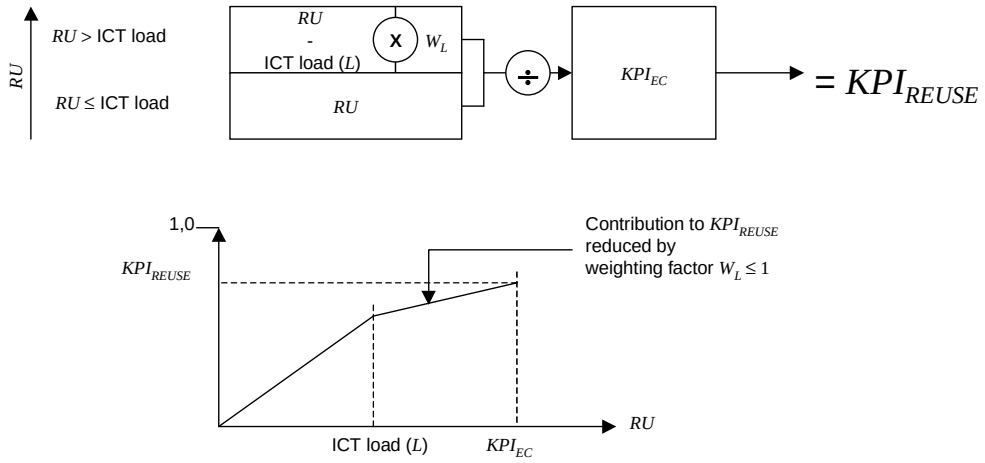

Figure 7: Schematic of energy re-use KPI

5.5.2.3.2 Definitions of terms

n = ICT site number (if the assessment is applied to a common set of ICT sites).

N = total number of ICT sites (if the assessment is applied to a common set of ICT sites).

$C_n^{(k)}$ = total energy consumption of ICT site n during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

$L_n^{(k)}$ = total energy consumed by ICT equipment load in ICT site n during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

$RU_n^{(k)}$ = total energy re-used from ICT site n during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

W_L = ratio of re-used energy taken into account for the portion that is above the load energy, if any.

min (x,y) = the smaller of x and y.

max (x,y) = the larger of x and y.

5.5.2.3.3 Clarity

KPI_{REUSE} meets the requirements of ETSI EN 305 200-1 [i.12].

5.5.2.3.4 Criteria

Measurement criteria for $C_n^{(k)}$ are specified in clause 5.5.2.1.4.

Measurement criteria for $L_n^{(k)}$ are specified in clause 5.5.2.2.4.

Re-use of waste heat from power generators shall not be allocated to KPI_{REUSE}.

W_L is applied to the re-use of waste heat from the supporting infrastructures such as power distribution and environmental control.

The general application of this weighting factor requires $0 \leq W_L \leq 1$.

Annex A provides details on weighting values employed by certain industry organizations. Other weightings may be used to meet specific objective needs provide that they fall within the above range and their application is in accordance with clause 5.5.2.3.1.

Organizations that wish to apply the requirements of the present document using a different value of W_L in line with their short, medium or long term objectives do not conform to the present document. However, those organizations are subject to the criteria requirements of clause 5.5.1.4 in relation to the application of weighting factors.

5.5.2.4 Renewable energy (KPI_{REN})

5.5.2.4.1 Formula

KPI_{REN} for assessment period k is defined mathematically as:

$$KPI_{REN}^{(k)} = \frac{\sum_{n=1}^{N} REN_n^{(k)}}{\sum_{n=1}^{N} C_n^{(k)}}$$

5.5.2.4.2 Definitions of terms

n = ICT site number (if the assessment is applied to a common set of ICT sites).

N = total number of ICT sites (if the assessment is applied to a common set of ICT sites).

$C_n^{(k)}$ = total energy consumption of ICT site n during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

$REN_n^{(k)}$ = energy input (MWh) from renewable sources in accordance with clause 5.1.2.4 to ICT site n during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of ETSI EN 305 200-1 [i.12].

5.5.2.4.3 Clarity

KPI_{REN} meets the requirements of ETSI EN 305 200-1 [i.12].

5.5.2.4.4 Criteria

Measurement criteria for $C_n^{(k)}$ are specified in clause 5.5.2.1.4.

5.6 Measurement points and procedures

5.6.1 Objective KPIs for ICT sites

5.6.1.1 Energy consumption (KPI_{EC})

5.6.1.1.1 Measurement points

Requirements for the measurement of the energy consumption parameters for ICT sites are specified in CENELEC EN 50600-2-2 [2]. The present document applies this approach to all ICT sites.

Figure 8 provides additional detail relevant to the present document.

The treatment of energy sources shall be as specified in clause 5.4.

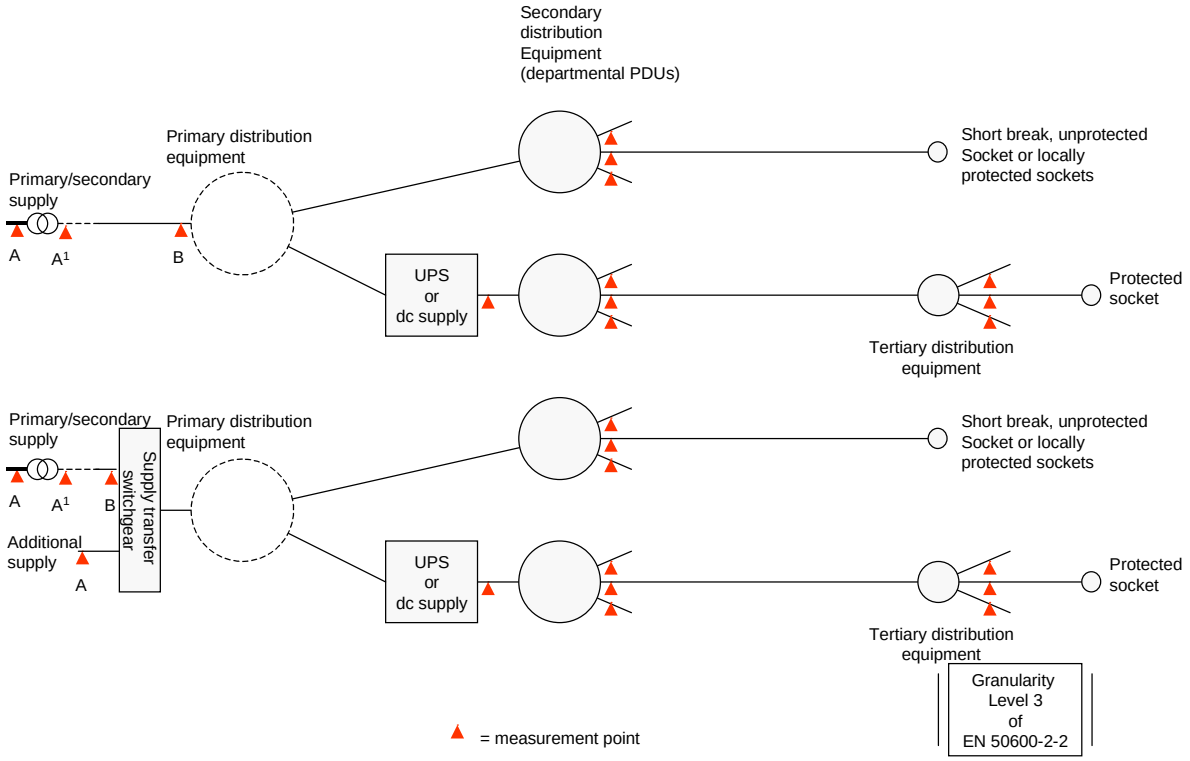

Figure 8: Measurement points for energy consumption

The consumption $C_{s,n}^{(k)}$ from energy sources (including those provided only during fault conditions)shall be determined as described below.

Electrical energy from delivered supply(s):

- the consumption $C_{s,n}^{(k)}$ shall be measured as MWh at the input to the transformer (points A in Figure 6) in which case $MP_{s,n}^{(EC)}$= 0;
- where this is not possible:
  - $C_{s,n}^{(k)}$ may be measured at the output of the transformer (points A^1 in Figure 8) and $MP_{s,n}^{(EC)}$= 0,015 (i.e. 1,5 % of additional penalty);
  - $C_{s,n}^{(k)}$ may be measured at the input to the switchgear in the primary distribution equipment or at the input to the supply transfer switch (if present) of the ICT site (points B in Figure 8) and $MP_{s,n}^{(EC)}$ = 0,02 (i.e. 2 % of additional penalty).

Electrical energy from local dedicated generating subsystems:

- the consumption $C_{s,n}^{(k)}$ shall be measured as MWh at their output in which case $MP_{s,n}^{(EC)}$= 0;
- where this is not possible, then either:
  - $C_{s,n}^{(k)}$ may be measured at the at the input to the switchgear in the primary distribution equipment or input to the supply transfer switch of the ICT site (points B in Figure 8) and $MP_{s,n}^{(EC)}$= 0,02 (i.e. 2 % of additional penalty); or
  - where the generation is based on resource conversion, a conversion factor shall be applied to the resource consumed. In such cases the following values shall be applied:
    - diesel: 0,0099 MWh/l;

- gas: 0,0105 MWh/m^3;
- hydrogen: 0,0389 MWh/kg;
- bioethanol: 0,006 MWh/l.

Thermal energy from local dedicated generating subsystems:

- consumption $C_{s,n}^{(k)}$ from heat distribution networks shall be measured as MWh at the network delivery point using a calorie counter/integrator according to CEN EN 1434 [1] series, where the distribution network is considered a closed loop;
- heat injection into cold distribution networks shall be measured as MWh at the network delivery point using a calorie counter/integrator according to CEN EN 1434 [1] series, where the distribution network is considered a closed loop. The electrical energy required to sink that thermal energy into the cold distribution network shall be allocated to $C_{s,n}^{(k)}$ by dividing the measured value by a conversion factor of 2,5 and $MP_{s,n}^{(EC)}$= 0,08 (i.e. 8 % of additional penalty);

NOTE: Corresponding to a reference installation using chillers with air condensing.

- where local heat generators would be used the heat consumption shall be measured as MWh at the generator output using a calorie counter/integrator according to CEN EN 1434 [1] series.

5.6.1.1.2 Measurement procedures

$C_{s,n}^{(k)}$ for each ICT site is defined as the energy consumption (MWh) recorded by all meters (utility, grid) and local sources) over the specified time period used to assess KPI_{EM} (i.e. T_{KPI} between t_k^{begin} and t_k^{end} subject to the allowed variation (Δt) specified in clause 5.5.1.4).

5.6.1.2 Task effectiveness (KPI_{TE})

5.6.1.2.1 Measurement points

Measurement points for $C_n^{(k)}$are specified in clause 5.6.1.1.1.

Where practicable, $L_n^{(k)}$shall be the total of all measurements of energy consumption (MWh) measured at the socket(s) directly feeding the ICT equipment i.e. granularity Level 3 of CENELEC EN 50600-2-2 [2] as shown in Figure 8 in which case $MP_{j,n}^{(TE)} = 0$.

Alternatively, $L_{j,n}^{(k)}$may be measured at other points of measurement as follows:

- at the secondary distribution equipment shown in Figure 8 (also termed "departmental power distribution unit (PDU)" level) excluding (if any) feeds to non-ICT equipment loads, provided that the feeds of ICT equipment are separate from feeds to non-ICT equipment such as rack cooling systems;
- measurement may be made at the uninterruptible power supply (UPS) output provided that all the ICT equipment is fed by UPS and that the UPS only feeds such equipment.

The measurement of $L_n^{(k)}$ at the other points detailed above invokes a measurement penalty to reflect the additional waste heat in cabling between the measurement point and the ICT equipment as follows:

- for measurement at secondary distribution equipment shown in Figure 8: $MP_{j,n}^{(TE)} = 0,01$ (i.e. 1 % of additional penalty);
- for measurement at UPS output: $MP_{j,n}^{(TE)} = 0,02$ (i.e. 2 % of additional penalty).

5.6.1.2.2 Measurement procedures

Measurement procedures for $C_n^{(k)}$ are specified in clause 5.6.1.1.2.

$L_{j,n}^{(k)}$for each ICT site *n* and ICT equipment load measurement point *j* is defined as the difference in energy consumption (MWh) recorded by all meters serving the ICT equipment load over the specified time period used to assess KPI_{EM} (i.e. T_{KPI} between t_k^{begin} and t_k^{end} subject to the allowed variation (Δt) specified in clause 5.5.1.4).

It is recognized that the actual times of measurement of $C_n^{(k)}$ and $L_{j,n}^{(k)}$ may differ by the allowed variation (Δt).

5.6.1.3 Energy re-use (KPI_{REUSE})

5.6.1.3.1 Measurement points

Measurement points for $C_n^{(k)}$ are specified in clause 5.6.1.1.1.

Measurement points for $L_n^{(k)}$ are specified in clause 5.6.1.2.1.

Measurement points for $RU_n^{(k)}$ shall be at the intended point of delivery i.e. any losses in the delivery system shall not be included.

5.6.1.3.2 Measurement procedures

Measurement procedures for $C_n^{(k)}$ are specified in clause 5.6.1.1.2.

Measurement procedures for $L_n^{(k)}$ are specified in clause 5.6.1.2.2.

$RU_n^{(k)}$shall be measured in MWh.

5.6.1.4 Renewable energy (KPI_{REN})

5.6.1.4.1 Measurement points

Measurement points for $C_n^{(k)}$ are specified in clause 5.6.1.1.1.

Requirements for the measurement of $REN_n^{(k)}$ for each ICT site are specified in CENELEC EN 50600-2-2 [2] and as shown in Figure 8.

The treatment of energy sources shall be in accordance with clauses 5.4, 5.1.2.4 and 5.6.1.1.1).

5.6.1.4.2 Measurement procedures

Measurement procedures for $C_n^{(k)}$ are specified in clause 5.6.1.1.2.

$REN_n^{(k)}$ is defined as the difference in energy consumption (MWh) of all renewable energy meters recorded over the specified time period used to assess KPI_{EC} (i.e. T_{KPI} between t_k^{begin} and t_k^{end} subject to the allowed variation (Δt) specified in clause 5.5.1.4).

5.7 Classifications

None.

5.8 Reporting

The following shall be reported for each ICT site, or group of ICT sites, for which KPI_{EM} is determined:

- KPI_{EC};
- KPI_{TE};
- KPI_{REUSE},W_{REUSE} and W_L;
- KPI_{REN} and W_{REN}.

In accordance with clause 4.1.4, the KPI_{EM} may be applied to groups of ICT sites under common governance and with common purpose.

KPI_{EM} may be applied to sub-groups which are subject to common operating conditions. This allows the demonstration of the difference in performance resulting from sub-groups with different operating conditions.

Annex A (informative): Weighting values

A.1 General

This annex provides details of the weighting values for W_{REUSE}, W_L and W_{REN} employed by certain industry organizations.

A.2 Industry organizations

A.2.1 CRIP

CRIP is a French group of ICT users working together in order to share experience. It represents now more than 300 major French industries and governmental organizations. CRIP uses the values shown in Table A.1.

Table A.1: Weighting values used by CRIP

W_{REUSE}	W_L	W_{REN}
1,0	0,5	0,8

A.2.2 eG4U

eG4U is an European NGO of private and public ICT users (e.g. industries and cities).It proposes standards, KPIs and tools in order enforce at European level the sustainability in ICT energy management, ICT waste monitoring and ICT carbon footprint during all the whole life cycle of ICT resources. eG4U uses the values shown in Table A.2.

Table A.2: Weighting values used by eG4U

W_{REUSE}	W_L	W_{REN}
1,0	0,5	0,8

History

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