

ETSI ES 205 200-1 V1.1.1 (2013-05)



**Access, Terminals, Transmission and Multiplexing (ATTM);
Energy management;
Global KPIs;
Operational infrastructures;
Part 1: General requirements**

ReferenceDES/ATTM-02018

Keywordsperformance, power

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Foreword

This ETSI Standard (ES) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

The present document is part 1 of a multi-part deliverable covering operational energy management and sustainability of broadband deployment as identified below:

Part 1: "General requirements";

Parts 2: "Specific requirements".

NOTE 1: Additional documents are in development by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM) which include:

ES 205 200-1-1: "Access, Terminals, Transmission and Multiplexing; Guidance; Energy management; Global KPIs: Guidance";

ES 205 200-2-2: "Access, Terminals, Transmission and Multiplexing; Energy management; Global KPIs: Operational infrastructures: Fixed (excluding cable) access networks";

ES 205 200-3: "Access, Terminals, Transmission and Multiplexing; Energy management; Global KPIs: Monitoring of sustainability".

NOTE 2: A further document is under consideration ETSI Technical Committee CABLE to address "cable access networks (ES 205 200-2-4)".

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 actors implement effective general engineering of fixed and mobile broadband networks and sites provisioning, managing or using those networks (i.e. operator sites, operator data centres and customer data centres) in order to respond to critical issues of energy consumption while proposing essential solutions to true broadband deployment. To guide this process, it is essential that metrics are defined, termed Global Key Performance Indicators (KPI_{EM}) that enable energy usage to be managed more effectively.

The ES 205 200 series of standards comprises:

- ES 205 200-1: a generic requirements document addressing Global KPIs for operational infrastructures;

NOTE: Global KPIs do not address design/operation of components or subsystems of broadband deployment networks.

- a sub-series ES 205 200-2 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);
 - ES 205 200-2-1: Data centres;
 - ES 205 200-2-3: Mobile access networks.

These documents do not define KPI limits or targets (which is outside the scope of the ES 205 200 series of standards).

These documents will accelerate:

- 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.

Within the present document:

- clause 4 explains the context underlying the need for the development of Global KPIs for energy efficiency and introduces the Objective KPIs upon which the Global KPIs are founded;
- clause 5 outlines the role of the Objective KPIs that are used throughout the ES 205 200-2 series;
- clause 6 describes the general requirements that are applied to all KPIs defined within the ES 205 200-2 series;
- clause 7 provides a mapping of the operational infrastructures addressed by the ES 205 200-2 series to those described in the ESO response to the European Commission Mandate M/462 [i.1];
- clause 8 summarizes the applicability of the Global and Objective KPIs defined in the ES 205 200-2 series;
- Annex A discusses the roles of different types of Key Performance Indicators i.e. Technical, Objective and Global in relation to the overall energy management concepts of the present document.

1 Scope

The present document describes the energy management landscape of the operational infrastructures of broadband deployment addressed by the ES 205 200 series of documents, their inter-relationship and boundaries.

The present document specifies the following aspects for Global Key Performance Indicators (KPI_{EM}) in relation to energy management for the operational infrastructures of broadband deployment:

- common objectives in relation to:
 - energy consumption;
 - task efficiency;
 - energy re-use;
 - renewable energy;
- general requirements for all KPIs specified in the ES 205 200-2 series in relation to:
 - infrastructure scalability;
 - infrastructure evolution;
 - formulae and definitions of terms;
 - measurement points and procedures;
- the use of KPIs.

2 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 reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://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.

2.1 Normative references

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

Not applicable.

2.2 Informative references

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] EC Mandate M/462: "Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of Information and Communication Technologies".
- [i.2] European Commission DG JRC Code of Conduct for Data Centre Energy Efficiency.
- [i.3] European Commission DG JRC Code of Conduct on Energy Consumption of Broadband Equipment.

[i.4] ISO Guide 82: "Guide for addressing sustainability in standards".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

customer data centre: data centre connected to the access network

data centre: structure, or group of structures, dedicated to the centralized accommodation, interconnection and operation of information technology and network telecommunications equipment providing data storage, processing and transport services 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

energy consumption: total consumption of energy by an operational infrastructure

energy management: combination of reduced energy consumption and increased task efficiency, 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

fixed access network: functional elements that enable wired (including optical fibre) communications to customer equipment

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

mobile access network: functional elements that enable wireless communications to customer equipment

Network Telecommunications Equipment (NTE): equipment dedicated to providing direct 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 (KPI_{EM})

operational infrastructure: combination of information technology equipment (ITE) and/or network telecommunications equipment (NTE) together with the power supply and environmental control systems necessary to ensure provision of service

operator data centre: data centre embedded within the core network

operator site: premises accommodating network telecommunications equipment providing direct connection to the core and access networks and which may also accommodate information technology equipment

renewable energy: energy produced from dedicated generation systems using resources that are naturally replenished

task efficiency: 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 Key Performance Indicators within a given Global Key Performance Indicator
KPI_{EM}	Global Key Performance Indicator of energy management
KPI_{EC}	Objective Key Performance Indicator of energy consumption
KPI_{TE}	Objective Key Performance Indicator of task efficiency
KPI_{REN}	Objective Key Performance Indicator of renewable energy usage

KPI_{REUSE}	Objective Key Performance Indicator of energy re-use
T_{KPI}	period of time over which Objective KPIs are assessed
T_{REPEAT}	the minimum time between which the Objective KPIs can be assessed to determine relevant trend information
W_{EC}	weighting factor applied to KPI_{EC}
W_{TE}	weighting factor applied to KPI_{TE}
W_{REN}	weighting factor applied to KPI_{REN}
W_{REUSE}	weighting factor applied to KPI_{REUSE}

3.3 Abbreviations

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

ITE	Information Technology Equipment
KPI	Key Performance Indicator
NTE	Network Telecommunications Equipment
ODC	Operator Data Centre
OS	Operator Site

4 Context

The Global Key Performance Indicators (KPI) for energy management (KPI_{EM}) specified in the ES 205 200 series of standards shall reflect and encourage:

Objective 1: a reduction in energy consumption;

NOTE: Other sustainability issues are not considered within ES 205 200-1 or ES 205 200-2.

Objective 2: improvements in task efficiency (although the meaning of task efficiency may depend on the particular operational infrastructure);

Objective 3: the re-use of energy;

Objective 4: the contribution of renewable energy.

While objectives 1 and 2 are in the foreground of the development of all Global KPIs, the relative priority given to the objectives 3 and 4 above may differ depending on the opportunities available to the particular operational infrastructure.

Figure 1 shows the combination and inter-relation of the four objective KPIs in the production of the KPI_{EE} for an operational infrastructure.

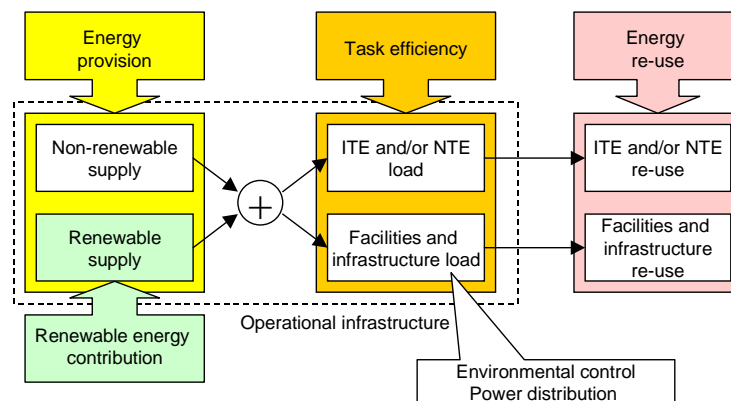


Figure 1: Schematic of foundations of Global KPIs

For each of the operational infrastructures considered within the ES 205 200-2 series of documents, there may be more than one KPI_{EM} but each KPI_{EM} reflects a combination of the four separate objective KPIs:

- energy consumption (KPI_{EC});
- task efficiency (KPI_{TE});
- re-use of energy (KPI_{REUSE});
- use of renewable energy (KPI_{REN}).

The KPI_{EM} may either:

- be a single-valued parameter based upon a specified function comprising each of the objective KPIs in a form as shown below:

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

or

- require each of the four Objective KPIs to be met on an agreed basis (as shown schematically in Figure 2).

The approach taken, the relative priority and definition of each Objective KPI may differ between each operational infrastructure considered.

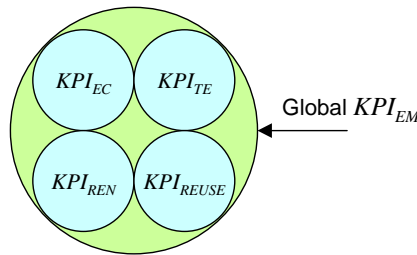


Figure 2: Schematic of combinations of KPI within KPI_{EM}

5 Objective KPIs of ES 205 200-2 series

5.1 Energy consumption

The reduction in the energy consumption required to provide a given level of service is a primary objective of this series of standards.

This objective shall be clearly identified within the KPI for each operational infrastructure which specifically addresses energy consumption (KPI_{EC}).

5.2 Task efficiency

An improvement in task efficiency is a primary objective of this series of standards.

This objective shall be clearly identified within the KPI for each operational infrastructure which specifically addresses task efficiency (KPI_{TE}).

5.3 Energy re-use

The re-use of energy is a secondary objective of this series of standards.

Where applicable, this objective shall be clearly identified within the KPI for each operational infrastructure which specifically addresses re-use of energy (KPI_{REUSE}). However, its application is subject to the following conditions:

- "non-use" is better than "re-use" and therefore the application of KPI_{REUSE} (see Figure 1) within KPI_{EM} will reflect a preference for energy consumption reduction rather than re-use;
- any KPI_{REUSE} shall reflect a preference for re-use of energy in the form of heat generated from by ITE/NTE rather than from poorly designed facilities and infrastructures.

5.4 Renewable energy

The use of energy from renewable sources is a secondary objective of this series of standards.

Where applicable, this objective shall be clearly identified within the KPI for each operational infrastructure which specifically addresses use of renewable energy (KPI_{REN}). However, its application is subject to the following condition:

- even if all energy is renewable the KPI_{EM} shall be formulated to encourage the application of the other KPIs.

6 General requirements for Objective and Global KPIs

6.1 Scale

Operational infrastructures vary dramatically in terms of scale (i.e. the maximum design service implementation).

KPIs shall be valid for all "scales" of an operational infrastructure although this may be achieved by the Global KPI addressing a grouping of operational infrastructures of different scales.

6.2 Evolution

Operational infrastructures:

- generally do not go from "zero" to full utilization on Day One;
- tend to feature power demands that grow from Day One, moving towards the maximum design load at which point strategic changes may take place (such as the procurement of more efficient information technology equipment and/or network telecommunications equipment) which will reduce the load before once again beginning to grow again towards the maximum design load.

KPIs shall be valid for all "states of evolution" of an operational infrastructure.

6.3 Formulae

Each KPI shall be defined in clear and unambiguous mathematical terms.

Where the KPI_{EM} of an operational infrastructure is defined as a combination of the objective KPIs, weighting factors shall be applied which reflect the priority given to each objective KPI which results in a formula of following general type:

$$KPI_{EM} = f(W_{EC} \times KPI_{EC}, W_{TE} \times KPI_{TE}, W_{REUSE} \times KPI_{REUSE}, W_{REN} \times KPI_{REN})$$

The relevant weighting factors W_{EC} , W_{TE} , W_{REUSE} and W_{REN} will differ between each type of operational infrastructure considered. The documents in the ES 205 200-2 series shall define default values for the weighting factors but alternative values could be applied by third parties, including regulatory or legislative bodies. Similarly the default values provided may be modified over a period of time.

6.4 Definition of terms

Each KPI shall clearly define all terms relevant to its application.

6.5 Measurement points and procedures

6.5.1 Overview

Each KPIs shall be based upon parameters that are measurable in an unambiguous manner. The measurement points and procedures shall be included for each KPI.

All the objective KPIs are based on measurements of energy consumption and shall be assessed over a defined period of time (T_{KPI}). All objective KPIs relevant to a given assessment of KPI_{EM} shall be measured over a period not exceeding a specified time Δt . The maximum time between measurements (T_{REPEAT}) defines the time interval between which objective KPIs shall be re-assessed to determine relevant trend information. This is shown schematically in Figure 3.

The documents in the ES 205 200-2 series shall define default values for T_{KPI} , T_{REPEAT} and Δt for each objective KPI. Use of alternative values of T_{KPI} and T_{REPEAT} for each objective KPI is discussed in clause 8.

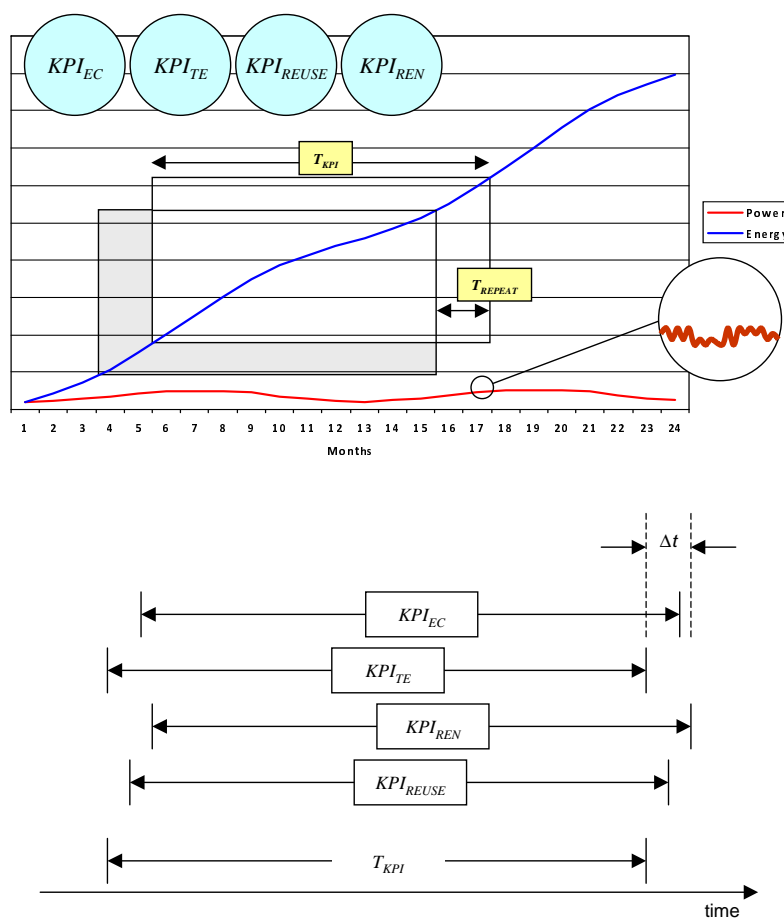


Figure 3: Schematic showing application of T_{KPI} , T_{REPEAT} and Δt

6.5.2 Detailed treatment

Figure 4 and the following text provides a detailed mathematical treatment of the content of clause 6.5.1.

The beginning of overall assessment period k is described as t_{k-1}^{begin} . The first assessment period, when $k=1$ is defined as $t_{k-1}^{begin} = t_0$. The end of an overall assessment period k is described as $t_{k-1}^{end} = t_{k-1}^{begin} + T_{KPI}$. The first assessment period, when $k=1$ is therefore $t_{k-1}^{end} = t_0 + T_{KPI}$.

Any subsequent assessment period, $k+1$, shall begin at least T_{REPEAT} following the beginning of assessment period k .

The measurement techniques or processes used of reach Objective KPI may not allow simultaneous commencement or completion of an assessment period. A time-spread parameter Δt is provided to allow such conditions which is typically defined equally either side of the t_{k-1}^{begin} and t_{k-1}^{end} leading to boundaries $\pm \Delta t_{max}$.

Figure 4 shows each Objective KPI starting at a slightly different time. In general therefore:

- the commencement of assessment period k is $t_{k-1}^{begin} = t_0 + (k-1) \times T_{REPEAT}$
- the end of assessment period k is $t_{k-1}^{end} = t_0 + (k-1) \times T_{REPEAT} + T_{KPI}$
- each Objective KPI for period k , is

$$KPI_{xx}^{(k)} = KPI_{xx}(t_k) = KPI_{xx}(t_0 + ((k-1) \times T_{REPEAT}) + T_{KPI} + \Delta t_{xx})$$

In order to ensure appropriate relevance for the comparative assessments:

- $-\Delta t_{max} \leq \Delta t_{xx} \leq +\Delta t_{max}$;
- $\Delta t_{max} \ll T_{REPEAT}$.

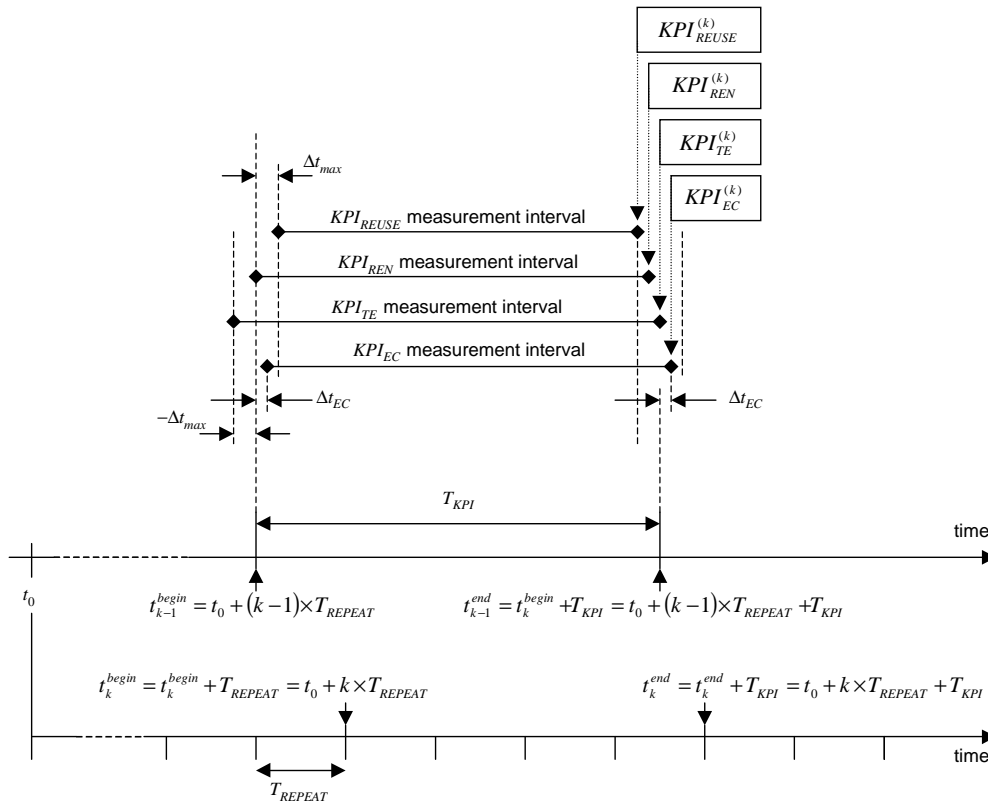


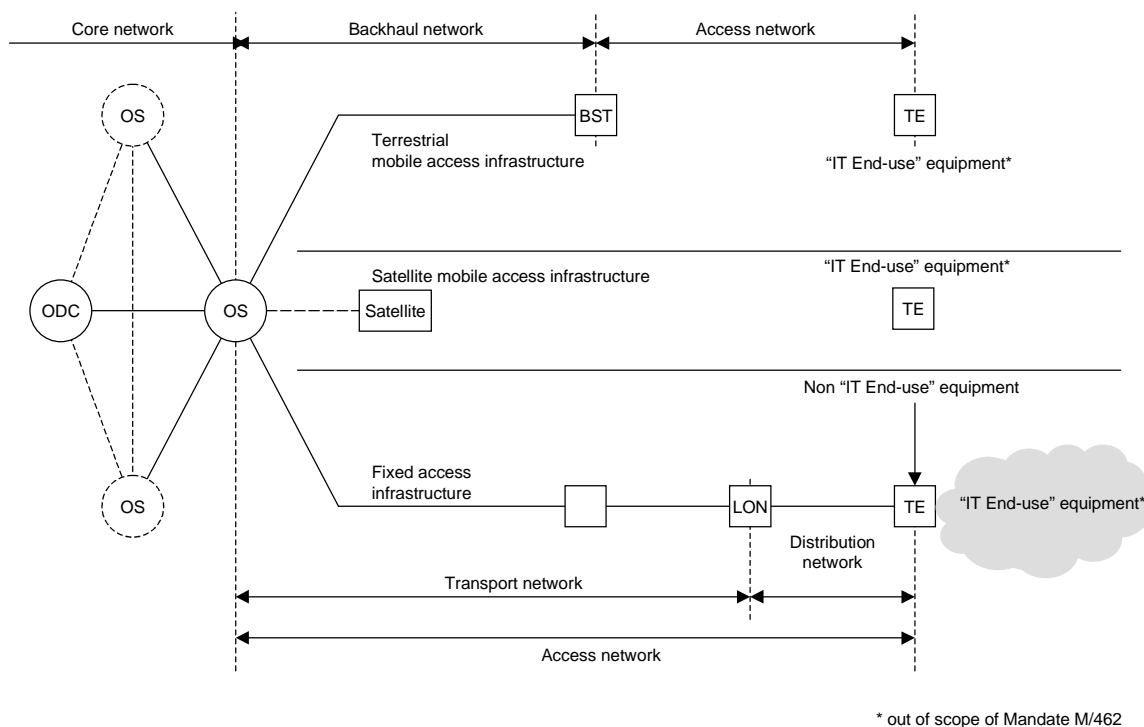
Figure 4: Mathematical treatment of assessment timing

6.6 Criteria

Each KPIs shall clearly define strict criteria for inclusions/exclusions with the formulae.

7 System approach

Figure 5 shows the schematic of the operational infrastructures of broadband deployment as contained with the ESO response to the EC Mandate M/462 [i.1].



NOTE: Not all the terms and abbreviations of Figure 5 are included in clause 3 of the present document.

Figure 5: Schematic of core network together with fixed and mobile access infrastructures

For the purposes of Global KPIs defined by this series of documents, the boundaries of the subsystems within Figure 5 have to be modified as follows:

- for ES 205 200-2-1, all operators data centres and operator sites are assessed as complete entities;
- for ES 205 200-2-3, mobile access networks defined as all mobile access network equipment outside operator sites.

8 The use of KPIs

It should be noted that the application of the above documents is not restricted to infrastructures of broadband deployment. Where applicable, the specific scope and field of application of each document includes a broader range of infrastructures within the ICT domain.

The objective of the ES 205 200-2 series of documents is to define KPIs that can be applied to all operational infrastructures of a given type. However this does not mean that all infrastructures of that type are intended to, or are able to, operate within a common limits for the KPI.

For example, operational infrastructures required to deliver high reliability (based on resilience of support infrastructures such as power distribution and environmental control) will tend to exhibit higher values of KPI_{EM} .

Similarly, operational infrastructures of a given type but serving a different function (business models or primary technology employed) cannot be directly compared - although it is recognized that technology evolution may exhibit lower values of KPI_{EM} .

KPI_{EM} metrics are generally used in order to indicate trends within a particular implementation of a given type of operational infrastructure and to indicate improvements achieved across the four objectives identified in clause 4.

In order to obtain true trend analysis for KPI_{EM} , the assessment period T_{KPI} is typically one year in order to take full account of climatic variations on the four objective KPIs. However, general engineering changes to an operational infrastructure (new equipment or modified operating procedures) may use much shorter values of T_{KPI} (e.g. based on days or weeks) to determine improvements in one or more of the objective KPIs.

Annex A (informative): Concepts: Energy management, sustainability and Key Performance Indicators

A.1 Energy management and sustainability concepts

ISO Guide 82 [i.4], entitled "*Guide for addressing sustainability in standards*", defines sustainability as "state of the global system, which includes environmental, social and economic subsystems, in which the needs of the present are met without compromising the ability of future generations to meet their own needs".

The documents in the ES 205 200 series do not specifically address any social and economic aspects of sustainability but do focus on the environmental issues in relation to the operational performance of infrastructures of deployed broadband.

The documents in the ES 205 200 series adopt the position that the environmental viability aspects of sustainability comprise:

- those elements that relate directly to energy consumption and its outcomes within the locale of the broadband deployment infrastructures;
- other environmental elements relating to the wider impact of energy generation (e.g. greenhouse gas, carbon), consumption of other resources (e.g. water), and issues such as life cycle assessment.

It is common for equipment suppliers to define the energy efficiency of their products either in terms of the total energy consumed by a device or improvements in the performance of a specific task or outcome for a given energy input. Within the ES 205 200 series, these are considered, separately, as improvements in "energy consumption" and "task efficiency" respectively.

By comparison, operators and legislators are more interested in the performance of complete systems at an operational level taking into account global management aspects. As a result they apply a wider view of energy management that combines energy consumption and task efficiency with more general objectives such as the re-use of waste heat and the use of renewable energy.

For example both the EU Codes of Conduct on Data Centres Energy Efficiency [i.2] and Energy Consumption of Broadband Equipment [i.3] are actually targeted to reduce energy consumption by increasing task efficiency (i.e. not by reducing service levels) but includes re-use of waste heat as one of its best practices to achieve this goal.

While it is self-evident that if less energy is consumed by an operational infrastructure then the environmental impact of that infrastructure will be reduced, it is equally important to consider:

- the task efficiency of the operation for which that energy is consumed;
- while not wishing to encourage poor task efficiency, some benefit can be seen if waste energy, typically in the form of heat, is able to be re-used - substituting, to some degree, for other utility grid energy, the replacement of utility grid supplies by locally generated energy from renewable sources.

These four aspects: energy consumption, task efficiency, re-use of waste heat and the contribution of locally generated energy from renewable sources are considered to work in concert, albeit to different degrees for different infrastructures - and in the ES 205 200 series are considered as key objectives for which Objective KPIs are specified and for from which a Global KPI is produced which reflects energy efficiency of operational systems - meeting the needs of operators and legislators alike.

The imperatives placed on the different elements may vary from time to time - regulators specifically encouraging local generation of energy from renewable sources but then shifting focus on to other areas.

A.2 The status of Key Performance Indicators (KPIs)

A.2.1 Technical KPIs

At the most basic level, individual components or sub-assemblies can be designed to have improved task efficiency i.e. less energy is consumed for a given output or task. Such components or sub-assemblies may be inherently more efficient in the way in which they use energy under specific operating conditions but are essentially unable to manage that consumption. An example of such a product would be a power supply unit which may be more efficient under higher load conditions.

More complex products may contain hardware and/or software which automatically reduces energy consumption under specific operating conditions by putting certain functions into "idle" state if not required. This is distinctly different than that of a single task component or sub-assembly detailed above.

Technical KPIs can be applied to both of the above by assessing energy consumption for a number of specific operating conditions and also across a combination of such operating conditions. Assuming those operating conditions reflect the probable operating environment for the component, sub-assembly or product, a customer may make valued judgements in relation to the appropriateness of the Technical KPI.

For example, two products that have equal "combined" Technical KPIs, may be more efficient under very specific conditions. For example, a design of power supply that is more task efficient under high load conditions may be inappropriate for users who plan to predominantly operate under low load conditions (and vice versa).

A higher level of task efficiency management is also possible where groups of products are managed to reduce energy consumption by either allocating loads in such a way that the group is operating at maximum task efficiency and/or by putting individual products within the group into an "idle" mode. Examples of such managed solutions are seen in data centre software plug-ins (such as those developed under the Fit4Green and GAMES projects funded by the European Commission) and in documents developed by ETSI TC EE. Once again, the value of such approaches can be validated by the establishment of Technical KPIs which can be applied to both of the above by assessing energy consumption of a defined group of products for a number of specific operating conditions and also across a combination of such operating conditions.

Figure A.1 provides a schematic in relation to energy-related KPIs. The left-hand side of that schematic relates to the Technical KPIs of the design and engineering phase for components, sub-assemblies, products and systems.

A.2.2 Objective KPIs

The Objective KPIs described in the documents of the ES 205 200-2 series relate to specific elements of energy management described in Figure A.1 for operational infrastructures under the control of operators as follows:

- energy consumption: the total consumption of energy by an operational infrastructure;
- task efficiency: a measure of the work done (as a result of design and/or operational procedures) for a given amount of energy consumed;
- energy re-use: transfer or conversion of energy (typically in the form of heat) produced by the operational infrastructure to do other work;
- renewable energy: energy produced from dedicated generation systems using resources that are naturally replenished.

The procurement of products and systems based upon their Technical KPIs for energy consumption and/or task efficiency underpins the relevant Objective KPIs. However, the ES 205 200-2 series documents define requirements for the measurement of those Objective KPIs for operational infrastructures, i.e. taking into account the real operating conditions over a defined period of time.

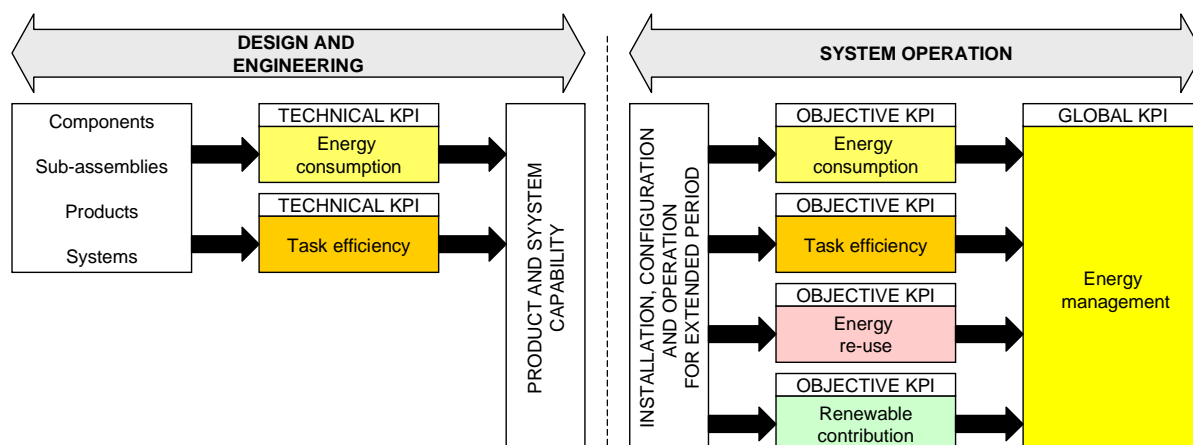


Figure A.1: The relationship of energy-related Technical, Objective and Global KPIs

The performance of products and systems, of proven Technical KPIs performance, may exhibit different energy consumption and task efficiency characteristics when subjected to actual operating conditions which lie outside those of the Technical KPIs applied to those products and systems at the design and engineering stages and, equally importantly, when subjected to user configuration and controls which may undermine the sophisticated systems available.

The right-hand side of the schematic in Figure A.1 relates to the Objective KPIs of complete infrastructures in the operational phase.

A.2.3 Global KPIs

The Objective KPIs, of which task efficiency is only one, are combined using a formula appropriate to the specific operational infrastructure to produce a Global operational KPI which reflects the overall performance of the operational infrastructures against wider energy management targets which may be self-imposed by the operators or externally applied by legislators.

Global KPIs provide a wider view of a users commitment to strategic energy management practices than the Objective KPIs. For example a user is not supporting overall energy goals by achieving class-leading provision of local renewable energy if their overall energy consumption is based upon equipment with very poor task efficiency.

A.2.4 Summary

Operational Global and Objective KPIs are fundamentally different to the Technical KPIs applied to products and systems at the design and engineering stages. The former are used to monitor and drive user behaviour whereas the latter are substantial indications of potential operational performance.

It is therefore important to support, but differentiate, the role of the Technical KPIs from the Objective and Global operational KPIs.

History

Document history		
V1.1.0	March 2013	Membership Approval Procedure MV 20130524: 2013-03-25 to 2013-05-24
V1.1.1	May 2013	Publication