



**Integrated broadband cable
telecommunication networks (CABLE);
Energy management;
Global KPIs;
Operational infrastructures;
Part 2: Specific requirements;
Sub-part 4: Cable Access Networks**

ETSI STANDARD PREVIEW
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<https://standards.etsi.org/standards-search/8ccd38ed-6031-4222-8770-551501000000/ETSI-205-200-2-4->

Reference

DES/CABLE-00005

Keywords

CABLE, energy efficiency

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 final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Integrated broadband cable telecommunication networks (CABLE), and is now submitted for the ETSI standards Membership Approval Procedure.

The present document is part 2, sub-part 4 of a multi-part deliverable covering operational energy management and sustainability of broadband deployment, as identified below:

Part 1: "General requirements";

Part 2: "Specific requirements":

Sub-part 1: "Data centres";

Sub-part 2: "Fixed (excluding cable) access networks";

Sub-part 3: "Mobile access networks";

Sub-part 4: "Cable Access Networks";

Part 3: "Monitoring of sustainability".

Modal verbs terminology

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Introduction

Energy costs rise steadily, 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 (*KPIs*) that enable energy usage to be managed more effectively.

The ETSI ES 205 200 series comprises:

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

NOTE 1: Global KPIs do not address design/operation of components or subsystems of broadband deployment networks.

- sub-series ETSI ES 205 200-2: definition of the Global KPIs and energy management targets for specific operational networks and sites including descriptions on how the Global KPIs are to be applied (which may be used to support future regulatory objectives):
 - ETSI ES 205 200-2-1 [i.12]: applies to data centres;
 - ETSI ES 205 200-2-2 [i.13]: applies to fixed broadband access networks (excluding Cable Access Networks);
 - ETSI ES 205 200-2-3 [i.14]: applies to mobile access networks;
 - **ETSI ES 205 200-2-4 (the present document): applies to broadband Cable Access Networks.**

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

These documents will accelerate:

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

Within the present document:

- Clause 4 provides a short explanation of a fixed broadband Cable Access Network's hybrid fiber coax (HFC) architecture in terms of the systems it comprises and the boundaries that apply and defines several formulae relating the objective and global KPIs to such a network.
- Clause 5 describes KPIs in terms of parameters applying to the Cable Access Network (CAN) and the inter-relationship between the technical, objective and global KPIs. The global energy performance KPI (KPI_{EP}) is expressed in terms of the data volume transmitted by the CAN in MB and the energy consumed in kWh. The clause relates the task efficiency of the HFC distribution network equipment and the overall energy performance KPI_{EP} .
- Clause 6 maps the objective KPIs defined in ETSI ES 205 200-1 to the broadband Cable Access Network.
- Clause 7 gives a mathematical definition of the KPIs, with equations, calculations and use case examples.

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1 Scope

The present document specifies Global Key Performance Indicators (KPIs) in terms of the performance of the fixed broadband Cable Access Network (CAN). The KPIs are expressed in terms of transmitted data volume in relation to the energy consumed by the distribution network between the in-home subscriber termination and network headend. The KPIs are taking into account the predominantly deployed HFC access network topologies by European cable network operators.

The present document addresses the objectives 1 to 4 as set out in ETSI ES 205 200-1 [1] to encourage:

- reduction in energy consumption;
- improvements in task efficiency;
- extension of energy re-use;
- application of renewable energy.

The definition of the Global KPIs is in accordance with requirements of ETSI ES 205 200-1 [1] in relation to:

- infrastructure scalability;
- infrastructure evolution;
- formulae and definition of terms;
- measurement points and procedures.

The present document refers to and introduces the Global KPI 'Energy Performance' in accordance with requirements of ETSI ES 205 200-1 [1] in relation to the above objectives.

With services trending towards exclusive use of digital transmission technologies, the present document considers only the network KPIs relevant for the support of digital services.

The contribution of all in-home equipment connecting to the customer premises network interface unit (NIU) such as the cable modem (CM), gateway (GW) and settop box (STB) to energy consumption as well as any other customer premises equipment connected to the in-home network are out of scope of the present document. The present document only considers components of the access network for the purpose of defining and measuring energy consumption key performance indicators.

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 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.

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

- [1] ETSI ES 205 200-1 (V1.2.1): "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Global KPIs; Operational infrastructures; Part 1: General requirements".

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 reference 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] EC Mandate M/462 (May 2010): "Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of Information and Communication Technologies to enable efficient energy use in fixed and mobile information and communication networks".

[i.2] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products ("Ecodesign Directive").

NOTE: Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:285:0010:0035:en:PDF>.

[i.3] Commission Regulation (EC) No 1275/2008 of 17 December 2008 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment.

NOTE: Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:339:0045:0052:en:PDF>.

[i.4] Commission Regulation (EC) No 801/2013 of 22 August 2013 amending Regulation (EC) No 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to ecodesign requirements for televisions.

NOTE: Available at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:225:0001:0012:en:PDF>.

[i.5] Code of Conduct on Energy Consumption of Broadband Equipment - Version 5. European Commission, DG JRC, December 2013.

[i.6] ETSI EN 300 429 (V1.2.1): "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems".

[i.7] ETSI EN 302 878 (parts 1 to 5 - V1.1.1): "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems".

NOTE: Part 1: General; DOCSIS 3.0.
Part 2: Physical Layer; DOCSIS 3.0.
Part 3: Downstream Radio Frequency Interface; DOCSIS 3.0.
Part 4: MAC and Upper Layer Protocols; DOCSIS 3.0.
Part 5: Security Services; DOCSIS 3.0.

[i.8] ETSI TR 101 546 (V1.1.1): "Access, Terminals, Transmission and Multiplexing (ATTM); Integrated Broadband Cable and Television Networks; Converged Cable Access Platform Architecture".

[i.9] ETSI TR 102 881 (V1.1.1): "Access, Terminals, Transmission and Multiplexing (ATTM); Cable Network Handbook".

[i.10] ETSI TR 105 174-6 (V1.1.1): "CABLE; Broadband Deployment and Energy Management; Part 6: Cable Access Networks".

[i.11] CM-SP-EQAM-VSI-I01 (July 2011): "Edge QAM Video Stream Interface Specification. CableLabs".

- [i.12] ETSI ES 205 200-2-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Global KPIs; Operational infrastructures; Part 2: Specific requirements; Sub-part 1: Data centres".
- [i.13] ETSI ES 205 200-2-2: "Access, Terminals, Transmission and Multiplexing; Energy management; Global KPIs; Operational infrastructures: Fixed (excluding cable) access networks;".
- [i.14] ETSI ES 205 200-2-3: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Global KPIs; Operational infrastructures; Part 2: Specific requirements; Sub-part 3: Mobile access networks".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

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

EdgeQAM: head-end or hub device that receives packets of digital video or data from the operator network, re-packetizes the video or data into an MPEG transport stream and digitally modulates that transport stream onto a downstream RF carrier using QAM

energy consumption: total consumption of electrical 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

Hybrid Fibre Coax (HFC): broadband telecommunications network that combines optical fibre, coaxial cable and active and passive electronic components

information technology equipment: equipment providing data storage, processing and transport services for subsequent distribution by network telecommunications equipment

network telecommunications equipment: 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 and/or network telecommunications equipment together with the power supply and environmental control systems necessary to ensure provision of service

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:

BR_{ANA}	average data rate of an analog channel on the system in Mbps
BR_{CH}	data rate of an RF channel in Mbps

BR_{HD}	average data rate of an HD channel on the system in Mbps
BR_{SD}	average data rate of an SD channel on the system in Mbps
C_{CMTS}	number of NIU connections fed by CMTS
C_{DS}	number of NIU connections fed by Downstream transport channels
C_{FAC}	number of NIU connections fed by HE broadcast equipment
C_{PS}	number of NIU connections to network PS feeds
C_{RX}	number of NIU connections fed by HE optical receiver on average
C_{TX}	number of NIU connections fed by HE optical transmitter on average
C_{US}	number of NIU connections fed by Upstream transport channels
D	volume of data transferred in MB
D_{BCEFF}	volume of broadcast data effectively transferred per NIU connection in MB
D_{BCTOT}	total volume of broadcast data transferred in MB
D_{DS}	volume of Downstream data transferred per NIU connection in MB
D_{NIU}	total volume of data transferred per NIU connection in MB
D_{US}	volume of Upstream data transferred per NIU connection in MB
E	energy consumed in kWh
k	weighing factor dependant on the type of communication, e.g. video, data, voice
k_{DS}	downstream channel utilisation co-efficient
k_{US}	upstream channel utilisation co-efficient
KPI_{EC}	Objective Key Performance Indicator of energy consumption
KPI_{EM}	Global Key Performance Indicator of energy management
KPI_{EP}	Global Key Performance Indicator of energy performance
KPI_{NP}	Global Key Performance Indicator of network performance
KPI_{REN}	Objective Key Performance Indicator of renewable energy usage
KPI_{REUSE}	Objective Key Performance Indicator of energy re-use
KPI_{TE}	Objective Key Performance Indicator of task efficiency
kWh	unit of Kilowatthour
L	distribution path between HE and NIU
$Mbps$	unit of Megabit per second
MB	unit of Megabyte (10^6 Byte)
N_{CH}	number of RF channels carried between REF_{HE} and REF_{NIU}
N_{DS}	number of Downstream channels carried between REF_{HE} and REF_{NIU}
N_{US}	number Upstream channels carried between REF_{HE} and REF_{NIU}
P_{CMTS}	total CMTS power
P_{CNIU}	CMTS power per NIU connection
P_{EQNIU}	EQAM power per NIU connection
P_{EQAM}	total power of all EQAMs required to provide broadcast feed
P_f	performance factor
P_{HENIU}	HE power per NIU connection
P_{NIU}	total power per NIU connection
P_{PS}	total power supply power
P_{PSNIU}	power supply power per NIU connection
P_{RX}	total power required to operate single HE optical receiver
P_{RXNIU}	optical receiver power per NIU connection
P_{TX}	total power required to power single HE optical transmitter
P_{TXNIU}	optical transmitter power per NIU connection
REF_{HE}	Reference point at the cable headend
REF_{NIU}	Reference point at the network interface unit
t	period of time over which KPIs are assessed
t_{ANA}	average time in minutes a customer watches analogue channels each hour
t_{HD}	average time in minutes a customer watches HD channels each hour
t_{SD}	average time in minutes a customer watches SD channels each hour
TE_{FA}	task efficiency of the final amplifier
TE_{FN}	task efficiency of the fibre node
TE_{GA}	task efficiency of the group amplifier
TE_{HE}	task efficiency of headend PHY equipment
TE_{NIU}	task efficiency of the network interface unit
TE_{PS}	task efficiency of the power supply
VAC	unit of Volt with alternating current
W	factor dependant on technology, architecture and design, e.g. modulation scheme, integrated HE, fibre deep

3.3 Abbreviations

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

AMP	Amplifier
BST	Base Station Transmitter
CAN	Cable Access Network
CCAP	Converged Cable Access Platform
CM	Cable Modem
CMTS	Cable Modem Termination System
CPE	Customer Premises Equipment
DOCSIS	Data over Cable Service Interface Specification
DS	Downstream
DSL	Digital Subscriber Line
DTV	Digital Television
DVB-C	Digital Video Broadcast- Cable
EC	Energy Consumption
EC	European Commission
EM	Energy Management
EP	Energy Performance
EQAM	Edge Quadrature Amplitude Modulator
ERP	Energy Related Products
ESO	European Standards Organisation
FA	Final Amplifier
FAC	Facility
FN	Fibre Node
GA	Group Amplifier
GW	Gateway
HD	High Definition (digital video channel)
HE	Head End
HFC	Hybrid Fiber Coax
HSD	High Speed Data
IP	Internet Protocol
IP/PBX	Internet Protocol/ Public Branch Exchange
IT	Information Technology
KPI	Key Performance Indicator
LCR	Inductance, Capacitance, Resistance
LON	Local Operating Network
MAC	Media Access Control layer
MPEG	Motion Pictures Experts Group
NIU	Network Interface Unit
NP	Network Performance
ODC	Operator Data Centre
OS	Operator Site
OSP	Outside Plant
PF	Power Feed
PHY	Physical layer
POS	Point of Sale
PS	Power Source or Power Supply
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase-Shift Keying
REN	RENewable Energy
REUSE	Energy RE-USE
RF	Radio Frequency
SC-QAM	Single Carrier-Quadrature Amplitude Modulation
SD	Standard Definition (digital video channel)
STB	Settop Box
TE	Task Efficiency (in the rest of the document)
TE	Terminal Equipment (in architecture figures)
TV	Television
US	Upstream

4 System Definition and Boundaries

4.1 Cable Access Network

The present document considers the cable network operational infrastructure whereby the Global Key Performance Indicator on Energy Performance KPI_{EP} is used as the measure of the overall ability of the network to use electrical energy efficiently in its operation. KPI_{EP} is expressed as a function of the total number of bytes of data transferred across the HFC distribution network against the overall power consumed. The data volume transferred across the network is registered between the cable modem (CM) measured at the in-home Network Interface Unit (NIU) reference point REF_{NIU} and the headend equipment reference point REF_{HE} .

NOTE: The headend comprises data and video equipment. At the headend, the CMTS equipment supports data communications and the EdgeQAM equipment supports video communication. A CCAP headend equipment is a platform that converges both data and video communication. For the purpose of the present clause, the volume of transferred data is presented in terms of the CMTS (data communication service) but the generic formulae and equations defined are applicable to EdgeQAM and CCAP headend equipment using a weighting factor k_v and k_c to represent an equivalent data throughput for video and converged data/video communications.

Figure 1 illustrates Energy Performance as a Global Key Performance Indicator in terms of the broadband CAN structure and how it makes use of the individual network components, systems and sub-assemblies to consume energy when transferring data. This indicator enables network managers to better manage the network resources in order to reduce the overall energy consumption of the broadband Cable Access Network.

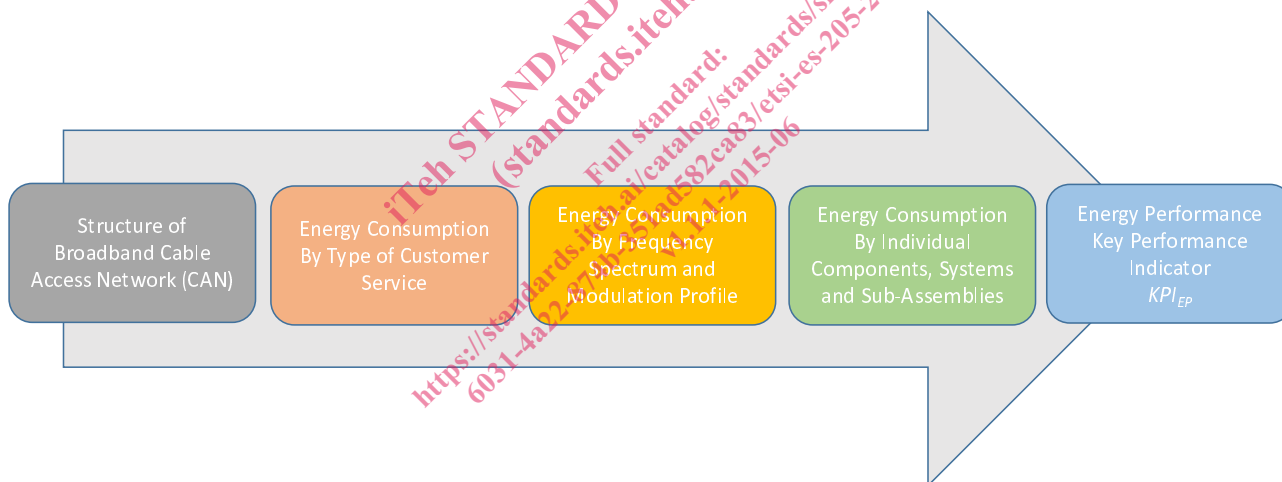


Figure 1: Illustration of Energy Performance as a Global Key Performance Indicator

A description of the Energy Performance KPI KPI_{EP} in relation to the definition of the Global Energy Management KPI KPI_{EM} and the Objective KPIs as defined in ETSI ES 205 200-1 [1] is given in clause 5.

Within an HFC distribution network, active components such as amplifiers, taps, couplers, fibre nodes and power distribution modules as well as passive elements such as taps, coaxial cable drops present the single value parameters in terms of each of their representative functions comprising the Objective KPIs.

Objective KPIs are:

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