



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

Reference

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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
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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Integrated broadband cable telecommunication networks (CABLE).

The present document is part 4, sub-part 4 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";

Part 3: "ICT sites";

Part 4: "Design assessments";

Sub-part 4: "Cable Access Networks".

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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 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 Global Key Performance Indicators of the ETSI EN 305 200 [i.4] series address operational infrastructures and do not consider design/operation of components of broadband deployment networks.

The ETSI EN 305 200 series of standards [i.4] comprises:

- ETSI EN 305 200-1 [i.5]: 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 [i.6]: ICT sites;
 - ETSI EN 305 200-2-2 [i.7]: Fixed broadband access networks;

NOTE: Excluding cable access networks.

- ETSI EN 305 200-2-3 [i.8]: 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 [i.9] including ETSI EN 305 200-3-1 [i.10] that defines particular implementations of Global KPIs within ICT sites based on the requirements of ETSI EN 305 200-2-1 [i.6], 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, the present document, 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.11] 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 requirements for a Global KPI for energy management (KPI_{EM}) and its underpinning Objective KPI for energy consumption for cable access networks of broadband deployment employing DOCSIS 3.0 and/or DOCSIS 3.1. The requirements are mapped to the general requirements of ETSI EN 305 200-1 [i.5].

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1 Scope

The present document specifies the requirements for a Global KPI for energy management (designated KPI_{EP}) and its underpinning Objective KPI for energy consumption addressing the following objectives for the cable operator access networks of broadband deployment:

- energy consumption;
- renewable energy.

The requirements are mapped to the concepts of ETSI EN 305 200-1 [i.5].

Energy management of cable access networks comprises a number of independent layers. The present document addresses performance of infrastructures that supports the normal function of hosted ICT equipment within the cable access network (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. final energy required 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 cable access networks employing DOCSIS 3.0 and/or DOCSIS 3.1 together with inclusions/exclusions of different energy sources;
- clause 5 specifies the requirements for measurement, calculation, classification and reporting of KPI_{EP} .

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.

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

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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] 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.2] 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.3] 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.4] ETSI EN 305 200 series: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs".

- [i.5] ETSI EN 305 200-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 1: General requirements".

- [i.6] ETSI EN 305 200-2-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 2: Specific requirements; Sub-part 1: ICT Sites".

- [i.7] 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.8] 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.9] ETSI EN 305 200-3 series: "Access, Terminals, Transmission and Multiplexing (ATTM); Energy management; Operational infrastructures; Global KPIs; Part 3: ICT Sites".

- [i.10] 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.11] ISO 50001: "Energy management systems - Requirements with guidance for use".

- [i.12] ETSI EN 302 878-1: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 1: General; DOCSIS 3.0".

- [i.13] ETSI EN 302 878-2: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 2: Physical Layer; DOCSIS 3.0".

- [i.14] ETSI EN 302 878-3: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 3: Downstream Radio Frequency Interface; DOCSIS 3.0".

- [i.15] ETSI EN 302 878-4: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 4: MAC and Upper Layer Protocols; DOCSIS 3.0".

- [i.16] ETSI EN 302 878-5: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 5: Security Services; DOCSIS 3.0".

- [i.17] ETSI TS 103 311-1: "Integrated broadband cable telecommunication networks (CABLE); Fourth Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 1: General; DOCSIS® 3.1".
- [i.18] ETSI TS 103 311-2: "Integrated broadband cable telecommunication networks (CABLE); Fourth Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 2: Physical Layer; DOCSIS® 3.1".
- [i.19] ETSI TS 103 311-3: "Integrated broadband cable telecommunication networks (CABLE); Fourth Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 3: MAC and Upper Layer Protocols Interface; DOCSIS® 3.1".
- [i.20] M/462 Standardisation mandate addressed to CEN, CENELEC and ETSI in the field of ICT to enable efficient energy use in fixed and mobile information and communication 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: access network provided by cable operators comprising optical fibre and metallic cabling providing direct connection to customer premises

Customer Premises (CP): any location which is the sole responsibility of the customer

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

Fibre Node (FN): device which performs a media conversion between an optical fibre cable link and a coaxial cable link in a cable access network

global KPI: KPI, combining two or more Objective KPIs, which reflects the overall energy management performance of an operational infrastructure

Head-End (HE): facility for receiving television signals for processing and distribution over a cable access network

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

NOTE: A combination of Information Technology Equipment and Network Telecommunications Equipment.

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 Distribution Node (NDN): grouping of Network Telecommunications Equipment (NTE) equipment within the boundaries of an access network providing distribution of service from an Operator Site (OS)

NOTE: Where all the Network Telecommunications Equipment (NTE) at a given location is under common governance, any supporting infrastructure for power distribution and environmental control together with the necessary levels of resilience and security required to provide the desired service availability is included as part of the NDN.

Network Interface Unit (NIU): principal device within customer premises allowing user access to the services provided by the cable access network

Network Telecommunications Equipment (NTE): equipment between 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

renewable energy: energy from renewable sources such 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

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI EN 305 200-1 [i.5] and the following apply:

D_{NIU}	<i>data_volume</i> - summation of upstream (US) and downstream (DS) data transmitted during the assessment period for $KPI_{EC,NIU}$
GB/kWh	GigaBytes per kiloWatt hour
$KPI_{EC,NIU}$	Objective KPI of energy consumption
KPI_{EM}	Global KPI of energy management
KPI_{EP}	Global KPI of energy performance
KPI_{REN}	Objective KPI of renewable energy usage
Mb/s	MegaBits per second
MB/s	MegaBytes per second
MB/kWh	MegaBytes per kiloWatt hour

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 305 200-1 [i.5] and the following apply:

ANA	ANALog
CCAP	Converged Cable Access Platform
CMTS	Cable Modem Termination System
CP	Customer Premises
CPE	Customer Premises Equipment
DCEM	Data processing and Communications Energy Management
DOCSIS	Data-Over-Cable Service Interface Specifications
DS	DownStream
DVB-C	Digital Video Broadcasting - Cable
EC	European Commission
EQAM	Edge Quadrature Amplitude Modulation
FN	Fibre Node
HD	High Definition
HE	Head-End
HFC	Hybrid Fibre Coaxial
ICT	Information and Communications Technology
IP	Internet Protocol
ISO	International Standards Organization
ITE	Information Technology Equipment
KPI	Key Performance Indicator
MAC	Media Access Control
NDC	Network Data Centre
NDN	Network Distribution Node
NIU	Network Interface Unit
NTE	Network Telecommunications Equipment
NUI	Network User Interface
OFDM	Orthogonal Frequency-Division Multiplexing
OS	Operator Site
PHY	PHYSical
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying

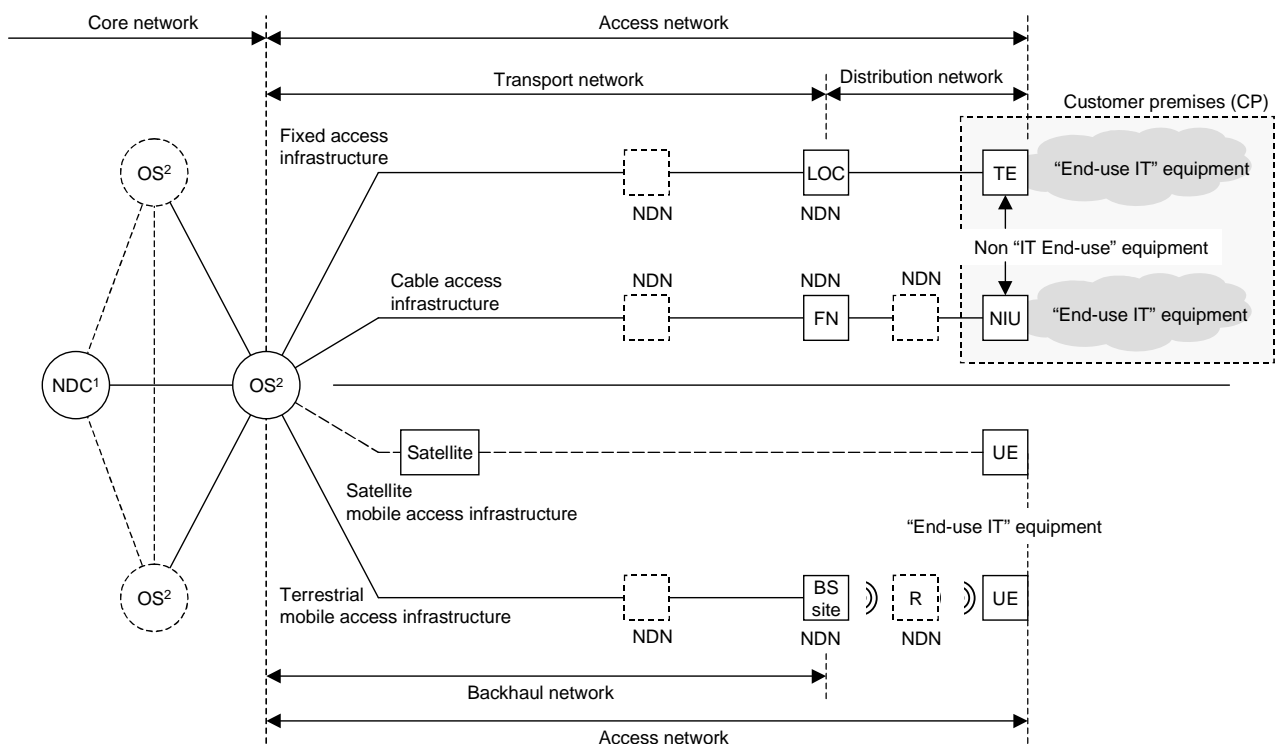
RF	Radio Frequency
SD	Standard Definition
TE	Terminal Equipment
US	UpStream

4 Energy management of cable access networks

4.1 General

4.1.1 Cable access networks

The network schematic used in the present document is shown in Figure 1. This has been updated since the original schematic included in the initial response to the Mandate M/462 [i.20]. The original schematic and details of the changes are listed in annex A.



¹ For cable access networks this is termed "Master head-end/OS"

² For cable access networks this is termed "Local head-end/OS"

Figure 1: Updated schematic of fixed and mobile communication networks

The cable access network is now shown separately from the fixed access network. Within the cable access network, the term Network Distribution Node (NDN) is employed to describe a variety of aggregations of Network Telecommunications Equipment (NTE) at locations between the local head-end (HE) and the Network Interface Unit (NIU), which has replaced the Terminal Equipment (TE). The Fibre Node (FN) is shown as specific example of an NDN. The other change for cable access networks is that Customer Premises (CP) is shown.

Figure 1 shows certain NDNs within dashed boxes to indicate that they are:

- optional;
- not restricted in number to the configurations shown.

4.1.2 Cable access network technologies

4.1.2.1 General

The present document addresses energy management in cable access networks comprising the cabling infrastructure technologies shown in Figure 2. It is a mixture of optical fibre and metallic cabling described as hybrid (optical) fibre coaxial (HFC) networks where the NIU is a 75 ohm coaxial interface.

In the most general sense, the Head-End (HE) and NDNs may contain NTE of multiple access technologies. The totality of a cable access network under the governance of a given operator takes into account all NTE (in terms of both data volumes and energy consumption).

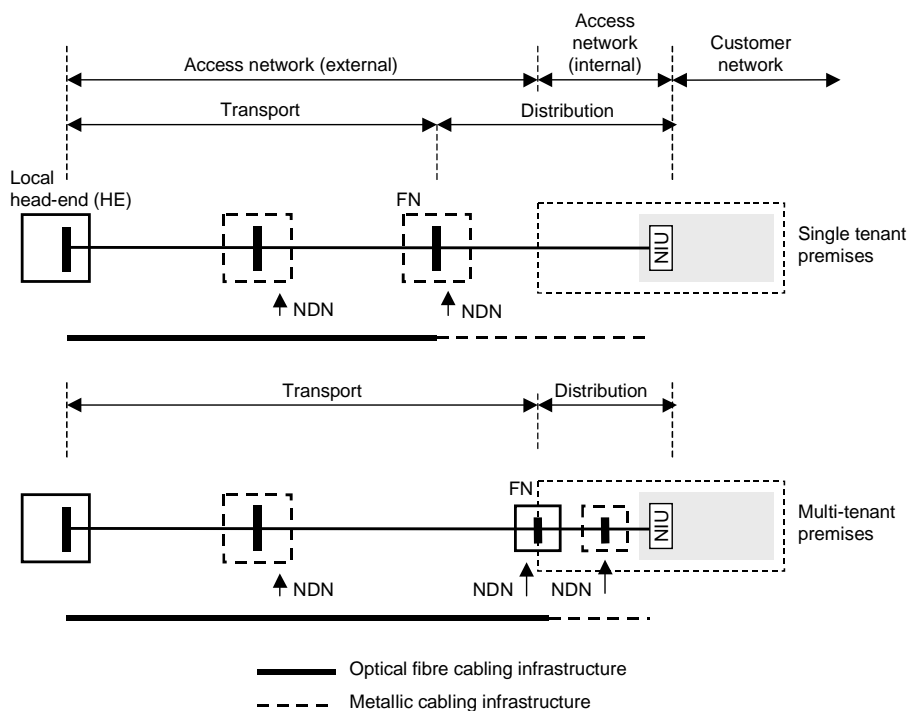


Figure 2: Schematic of cable access network technologies

4.1.2.2 DOCSIS 3.0

Standards related to DOCSIS 3.0 are listed in clause 4.3.1.1.

The HE accommodates NTE such as CMTS, EdgeQAM (EQAM) and CCAP as referred to in the ETSI Cable Handbook [i.6].

The NDNs comprises a variety of:

- active equipment including amplifiers and fibre nodes (FN) together with power supplies;
- passive equipment including taps and couplers.

4.1.2.3 DOCSIS 3.1

Cable access network operators across Europe and North America are evolving their implementation of HE equipment with new technologies that increase the available upstream (US) and downstream (DS) bandwidth in accordance with DOCSIS 3.1 (standards related to DOCSIS 3.1 are listed in clause 4.3.1.2). This technology evolution of DOCSIS maximizes the spectral efficiency, bits per hertz, of the transmitted information to the limits of the Shannon theorem such that a greater amount of information can be transferred for a much less than proportional increase of power consumption.

Orthogonal Frequency-Division Multiplexing (OFDM) subcarriers can be bonded inside a block spectrum that can be up to 200 MHz wide. DOCSIS 3.1 enables capacities of at least 10 Gb/s DS and 1 Gb/s US using 4096 QAM.

The NDNs comprise a variety of:

- active equipment including amplifiers and fibre nodes (FN) together with power supplies;
- passive equipment including taps and couplers.

In order to maximize on the highest possible DS and US capacity, within the relevant components of the NDN part of the HFC network, the active equipment is engineered to operate at the higher frequencies e.g. to 1,2 GHz. In addition, the DS and US frequency split would be optimized.

DOCSIS 3.1 is backward compatible with DOCSIS 3.0 such that both technologies can reside in the deployed access network and combinations of channel bonded scenarios are possible.

The technology is still in an early stage from a deployment perspective with cable access network operators implementing different roadmaps for migrating from DOCSIS 3.0 to DOCSIS 3.1 deployment.

4.1.3 Energy consumption

Some of the cable access network technologies require the use of active equipment both at the local HE and at the NDNs distributors shown in Figure 3.

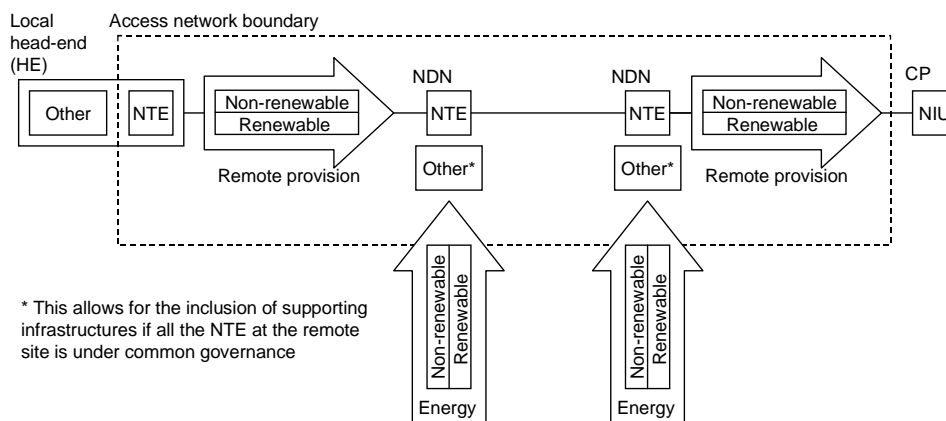


Figure 3: Schematic of cable access network energy consumption

At the HE, the energy consumed within the cable access network is that supplied to the NTE. The energy consumed by the NTE at a NDN may be supplied by grid (utility) supplies or by local generation. The NIU is powered by an NDN.

Renewable energy content generated at the HE or supplied to the HE by the grid (utility) is subject to the same considerations as for ICT sites of ETSI EN 305 200-2-1 [i.6] and as described in clause 5.1.2.4.

Renewable energy content generated at an NDN or supplied to the NDNs, by the grid (utility) or from a HE, is subject to the same considerations as for ICT sites of ETSI EN 305 200-2-1 [i.6] and as described in clause 5.1.2.4.

Sites accommodating NDNs may also contain supporting infrastructures including those for environmental control and security.

Where energy is supplied to an NDN from a HE or other NDN using an interconnecting cable then the consumption is that at the source (i.e. including any dissipation in the interconnecting cable).

As shown in Figure 3, NDNs may be associated with locally generated energy generation which exceeds the demands of the NDN at that location. This energy may be provided to other facilities and infrastructures which are independent from the access network. The KPI_{EP} of the present document takes no account of any such excess provision.

With regard to energy re-use, the NDNs of the present document are not considered to be of material effect.

Requirements or recommendations in relation to the improvement of the energy consumption of the NTE (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 are described in a number of documents (see clause 4.3).

4.1.4 Data volume

4.1.4.1 General

Cable access networks of the present document support the transmission of:

- broadcast signals i.e. data streams which are delivered independent of whether the end user equipment is connected - as is the energy required to deliver the signal over the cable access network;
- DS data signals;
- US data signals.

In order to compare data volumes of services delivered via broadcast and services delivered via unicast IP signals, the transported broadcast data shall be adjusted to the effective volume of broadcast data "consumed" by the end users.

Broadcast video is carried using three different types of channels, standard definition (SD), high definition (HD) and analog (ANA) channels.

Broadcast video data is defined as consumed if at least one CP device connected to the NUI is either displaying or recording the video content. To calculate this, the following three assumptions are required:

- types of channels delivered to customers (SD, HD and ANA);
- average bit rates for delivering those channels (typical values for each channel are described in clause 5.5.3);
- amount of viewing/recording (i.e. "consumption") time for the each type of channels - appropriate data should be drawn either from regional or national sources or from operators' own data.

NOTE: The average television usage is generally measured by surveys of national statistic offices, ministries of telecommunication or similar institutions. These consumption patterns vary from region to region and are expected to change considerably over time.

4.1.4.2 DOCSIS 3.0

Standards related to DOCSIS 3.0 are listed in clause 4.3.1.1.

DS and US broadband data is similarly transmitted on an HFC cable access network as an RF signal using Quadrature Amplitude Modulation (QAM).

Where broadband data is delivered:

- the DS data rates are detailed in Table B.1 - in Europe the commonly used channel width is 8 MHz;
- the US data rates are detailed in Table B.2 using 1,6 MHz, 3,2 MHz and 6,4 MHz channels as appropriate.

As with power, the first choice for data source for DS and US data is via measurement.

4.1.4.3 DOCSIS 3.1

Standards related to DOCSIS 3.1 are listed in clause 4.3.1.2.

DS and US broadband data is similarly transmitted on an HFC cable access network as an RF signal.

For DS, DOCSIS 3.1 deploys OFDM aggregating 24 x 8 MHz channels grouped in 192 MHz bands, with 4096 QAM modulation rate to deliver 10 GHz data rate (QAM). The DS frequency range starts from 258 MHz to 1 218 MHz.

For US, DOCSIS 3.1 deploys OFDM access. The US frequency range is from 5 MHz to 204 MHz.

The maximum DS and US data rates achievable are dependent on many factors not only the QAM scheme and bandwidth but also on the bonding scheme and number of bits per carrier. It also depends on the sharing of the frequency raster between DOCSIS 3.0 and 3.1.

4.2 Application of KPI_{EP}

The present document specifies the calculation of KPI_{EP} for a given design of cable access network. The KPI differs from those of other ETSI EN 305 200 series [i.4] since it is based on design assumptions (although certain measurements of operational data may be included).

KPI_{EP} has units of MB/kWh (or GB/kWh) and as such is not assessed or measured over an extended assessment period and take no account of environmental changes that may affect energy consumption.

In contradiction to the principles of ETSI EN 305 200-1 [i.5], KPI_{EP} does allow comparison of different cable access networks because the KPI is based a detailed calculation using values of energy performance and assumptions of subscriber usage of the services provided. However, in order to make sense of any comparison the reporting of the KPI requires the values used in the calculation to be reported also.

However, KPI_{EP} does not reflect changes in NTE utilization, network design or data volumes unless they are included in a re-calculation. Therefore trend information is not provided automatically.

4.3 Related standards and regulations

4.3.1 Standards

4.3.1.1 DOCSIS 3.0

- ETSI EN 302 878-1 (V1.1.1) (11-2011) [i.12]: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 1: General; DOCSIS 3.0".
- ETSI EN 302 878-2 (V1.1.1) (11-2011) [i.13]: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 2: Physical Layer; DOCSIS 3.0".
- ETSI EN 302 878-3 (V1.1.1) (11-2011) [i.14]: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 3: Downstream Radio Frequency Interface; DOCSIS 3.0".
- ETSI EN 302 878-4 (V1.1.1) (11-2011) [i.15]: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 4: MAC and Upper Layer Protocols; DOCSIS 3.0".
- ETSI EN 302 878-5 (V1.1.1) (11-2011) [i.16]: "Access, Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 5: Security Services; DOCSIS 3.0".

4.3.1.2 DOCSIS 3.1

DOCSIS 3.1 builds upon the earlier DOCSIS 3.0 standards of clause 4.3.1.1, leveraging the existing media access control (MAC) and physical (PHY) layers, but with the addition of a new PHY layer designed to improve spectrum efficiency with updates to the MAC and management to support the new PHY layer.

- ETSI TS 103 311-1 (V1.1.1) (02-2017) [i.17]: "Integrated broadband cable telecommunication networks (CABLE); Fourth Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 1: General; DOCSIS® 3.1".
- ETSI TS 103 311-2 (V1.1.1) (02-2017) [i.18]: "Integrated broadband cable telecommunication networks (CABLE); Fourth Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 2: Physical Layer; DOCSIS® 3.1".
- ETSI TS 103 311-3 (V1.1.1) (02-2017) [i.19]: "Integrated broadband cable telecommunication networks (CABLE); Fourth Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 3: MAC and Upper Layer Protocols Interface; DOCSIS® 3.1".

4.3.2 Regulation

Energy consumption improvement targets have also been defined under the European Commission's Ecodesign Directive 2009/125/EC [i.3] for improving the environmental performance of energy related products (ERPs) through ecodesign measures.

The so-called "network standby" Commission Regulation 801/2013 [i.1] which amends Commission Regulation 1275/2008 [i.2] is used to manage reduction in the energy consumption of CPE ERPs during periods when communication data is not being consumed as determined by the network functions.

5 Global KPI (KPI_{EP}) for cable access networks

5.1 General

5.1.1 Global KPI (KPI_{EP}) for cable access networks

The KPI_{EM} of ETSI EN 305 200-1 [i.5] for cable access networks is designated KPI_{EP} and has the form:

$$KPI_{EM} = KPI_{EP} = f(KPI_{EC,NIU}, data_volume)$$

where:

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

$data_volume$ = Summation of upstream (US) and downstream (DS) data transmitted during the assessment period for $KPI_{EC,NIU}$.

The approach to the assessment of the KPI_{EM} is a calculation based on operational concepts. This does not truly reflect operational conditions where parameters are measured over a specified period but is based upon cable access network design assumptions.

As a result the KPI_{EM} is re-designated KPI_{EP} . It represents the data volume delivered and received from the NIU for a given energy consumption of the cable access networked apportioned to support that data volume to NIU.

5.1.2 Objective KPIs

5.1.2.1 Energy consumption ($KPI_{EC,NIU}$)

A reduction in the energy consumption required to provide a given level of service is a primary objective of the present document.

The value of $KPI_{EC,NIU}$ is relevant to each cable access network technology solution.

Unless otherwise specified, the applicable energy consumption is that of the NTE and takes no account of any additional loads required to maintain the effective operation of the NTE.

For a given cable access network technology model, the $KPI_{EC,NIU}$ may be improved by local actions within individual HE and NDNs by the use of NTE with reduced energy consumption.

Requirements or recommendations in relation to the improvement of the energy consumption of the NTE and support infrastructures are not within the scope of the present document (see clause 4).

5.1.2.2 Task efficiency (KPI_{TE})

Not applicable in the present document.

5.1.2.3 Energy re-use (KPI_{REUSE})

Not applicable in the present document.

5.1.2.4 Renewable energy (KPI_{REN})

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

As the value of $KPI_{EC,NIU}$ is calculated from assumptions regarding the design, construction and utilization of the cable access network, any consideration of KPI_{REN} is embedded within $KPI_{EC,NIU}$. The power supply (and thereby energy consumption) parameters of clause 5.5.2 shall include the "design values" of renewable energy supply.

An HE or NDN may meet all its energy needs from local, renewable (like solar or wind energy) sources on a continuous basis.

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_{EP} .

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_{EP} is expressed with units of MB/kWh Or GB/kWh and is a measure of data volume per unit of energy consumption delivered to an NIU.

As the value is calculated from assumptions regarding the design, construction and utilization of the cable access network, it is independent of scale since those assumptions shall reflect the scale employed.

5.3 Evolution

KPI_{EP} is expressed with units of MB/kWh Or GB/kWh and is a measure of data volume per unit of energy consumption delivered to an NIU.

As the value is calculated from assumptions regarding the design, construction and utilization of the cable access network, it is independent of scale since those assumptions shall reflect the current state of evolution of the network.

5.4 Definition of boundaries

The boundaries of energy consumption with the cable access network are defined in Figure 3.

5.5 Formulae

5.5.1 Global KPI (KPI_{EP}) for cable access networks

5.5.1.1 General

$$KPI_{EP} = \frac{D_{NIU}}{KPI_{EC,NIU}}$$

5.5.1.2 Definition of terms

D_{NIU} = data volume per NIU per hour (presented in MB/h)

$KPI_{EC,NIU}$ = Objective KPI for energy consumption per NIU (presented in kWh)

5.5.2 Objective KPIs for cable access networks

5.5.2.1 Energy consumption ($KPI_{EC,NIU}$) for DOCSIS 3.0

5.5.2.1.1 Formula

$$KPI_{EC,NIU} = P_{NIU} = P_{HENIU} + P_{PSNIU}, \text{ expressed in kWh per NIU}$$

where:

$$P_{HENIU} = \frac{P_{CMTS}}{C_{CMTS}} + \frac{P_{EQAM}}{C_{FAC}} + \frac{P_{RX}}{C_{RX}} + \frac{P_{TX}}{C_{TX}} \text{ and } P_{PSNIU} = \frac{P_{PS}}{C_{PS}}$$

5.5.2.1.2 Definitions of terms

C_{CMTS} = number of NIU connections fed by the CMTS

C_{FAC} = number of NIU connections fed by HE broadcast equipment

C_{PS} =	number of NIU connections to the network fed by the power supply
C_{RX} =	average number of NIU connections fed by a HE optical receiver
C_{TX} =	average number of NIU connections fed by a HE optical transmitter
P_{CMTS} =	total CMTS power
P_{EQAM} =	total power of all EQAMs required to provide broadcast feed
P_{HENIU} =	power in the HE needed to provide network signal between the HE and NIU (the sum of the individual HE power elements)
P_{PS} =	total power supply power
P_{PSNIU} =	total access network power per NIU connection
P_{RX} =	total power required to power a single HE optical receiver
P_{TX} =	total power required to power a single HE optical transmitter

5.5.2.2 Energy consumption ($KPI_{EC,NIU}$) for DOCSIS 3.1

5.5.2.2.1 Formula

See clause 5.5.2.1.1.

5.5.3 Data_volume ($data_volume$)

5.5.3.1 General

See clause 4.1.4 for details of data transmission.

5.5.3.2 Data_volume (D_{NIU}) for DOCSIS 3.0

5.5.3.2.1 General

The data volume (D_{NIU}) for DOCSIS 3.0 is the total of average broadcast data consumed together with the DS and US data transmitted using the RF channels expressed as Mb/ per hour per NIU.

5.5.3.2.2 Formula

$$D_{NIU} = D_{BCEFF} + D_{DS} + D_{US}$$

where:

$$D_{BCEFF} = \frac{\left((BR_{SD} \times t_{SD}) + (BR_{HD} \times t_{HD}) + (BR_{ANA} \times t_{ANA}) \right)}{bpB} \times \frac{3600}{1440}$$

$$D_{DS} = \frac{k_{DS} \times N_{CHDS} \times BR_{CHDS}}{bpB \times C_{DS}} \times 3600$$

$$D_{US} = \frac{k_{US} \times N_{CHUS} \times BR_{CHUS}}{bpB \times C_{US}} \times 3600$$

5.5.3.2.3 Definitions of terms

bpB	=	bits per Byte
BR_{CHDS}	=	DS data rate of an RF channel (Mb/s)
BR_{CHUS}	=	US data rate of an RF channel (Mb/s)
BR_{ANA}	=	average data rate of an analog channel on the system (Mb/s)
		$BR_{ANA} = BR_{SD}$ as analog channels deliver something similar to an SD quality signal to subscribers
BR_{HD}	=	average data rate of an HD channel on the system (Mb/s) - typical values in the range 12 - 13 Mb/s
BR_{SD}	=	average data rate of an SD channel on the system (Mb/s) - typical values in the range 3 - 5 Mb/s
C_{DS}	=	number of NIU connections fed by DS transport channels
C_{US}	=	number of NIU connections fed by US transport channels
D_{BCEFF}	=	effective volume of broadcast video data per NIU (MB/hour)
D_{DS}	=	broadband DS data transmitted (MB/hour)
D_{US}	=	broadband US data transmitted (MB/hour)
k_{DS}	=	DS channel utilization co-efficient
k_{US}	=	US channel utilization co-efficient
N_{CHDS}	=	number of DS RF channels per NIU
N_{CHUS}	=	number of US RF channels per NIU
t_{ANA}	=	average time receiving analog channels at NIU (minutes per day)
t_{HD}	=	average time receiving HD at NIU (minutes per day)
t_{SD}	=	average time receiving SD at NIU (minutes per day)

5.5.3.3 Data_volume (D_{NIU}) for DOCSIS 3.1

5.5.3.3.1 General

The data volume for DOCSIS 3.0 is the total of average broadcast data consumed together with the DS and US data transmitted using the RF channels expressed as Mb/ per hour per NIU.

5.5.3.3.2 Formula

See clause 5.5.2.1.1.

5.6 Reporting

The following shall be reported for only the access part of the cable operators network for which the KPI_{EM} has been determined:

- KPI_{EP} (presented as MB/kWh);
- D_{NIU} ;
- $KPI_{EC,NIU}$;
- a clear statement of the boundaries of the cable operators network for which the KPI_{EM} has been determined;
- the date on which, and the period over which, the assessment was made.

Annex A (informative): History of network schematics

The response of the European Standards Organizations (June 2011) to the European Commission in response to Mandate M/462 [i.20] (dealing with "efficient energy use in fixed and mobile information and communication networks") used Figure A.1 as an overall schematic to describe the fixed and mobile networks for the delivery of broadband services. Since that time the schematic has been subject to change and is replaced by Figure 1.

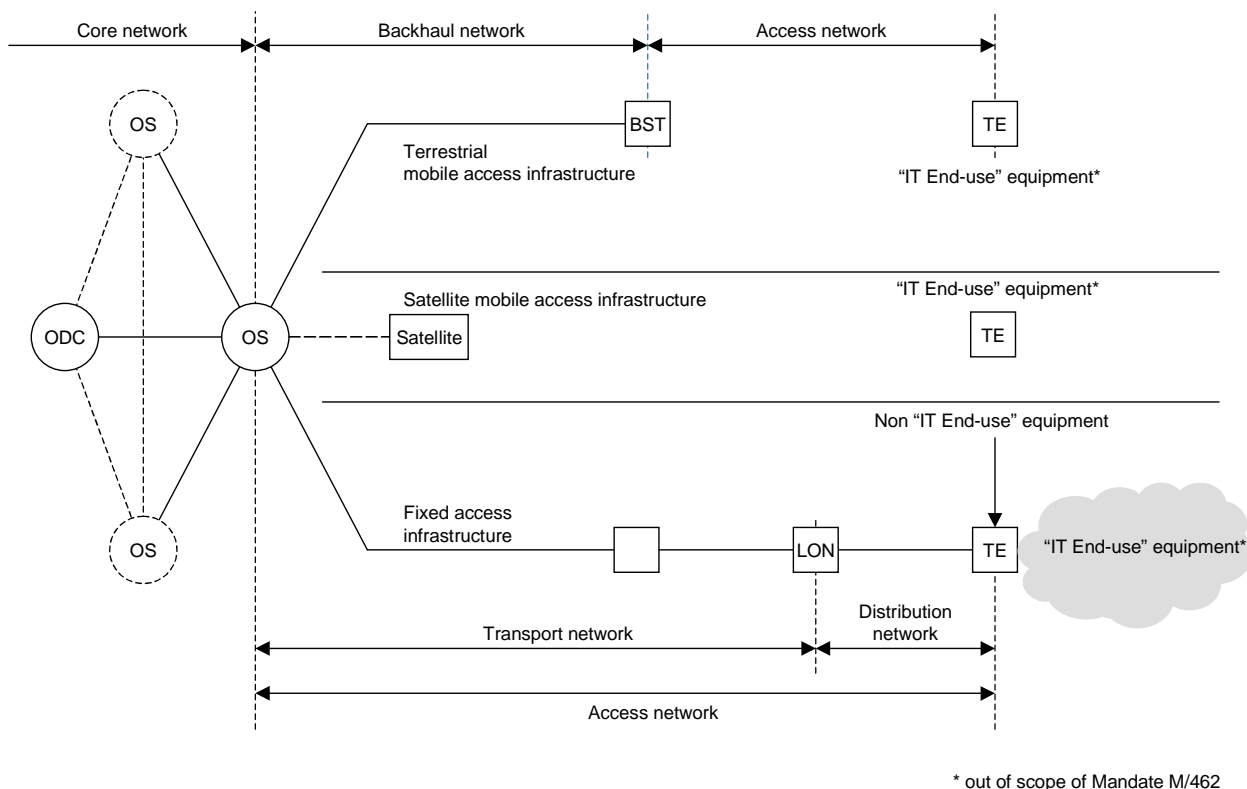


Figure A.1: Schematic of fixed and mobile communication networks (June 2011)

Within the fixed access network, the term NDN is employed to describe a variety of aggregations of Network Telecommunications Equipment (NTE) at locations between the Operator Site (OS) and the Terminal Equipment (TE). The Last Operator Connection Point (LOC) is shown as a specific example of an NDN and has replaced the Last Operator Node (LON). The other change for fixed access networks is that Customer Premises (CP) is shown.

Within the mobile access network, the term NDN is employed to describe a variety of aggregations of NTE at locations within the backhaul network (also known as transport network) between the OS and the Base Station (BS) site. The Base Station (BS) site and repeater (R) are shown as specific examples of NDNs.

Within the satellite network UE has replaced TE.

See clause 4.1.1 for the changes to the schematic for cable access networks.

For all access networks, the operator data centres (ODC) have been replaced by a network data centre (NDC).

Annex B (informative): DOCSIS 3.0 data rates (downstream/upstream)

Table B.1: Available data rates for a DVB-C system (in Mb/s)

Modulation	Bandwidth (MHz)				
	2	4	6	8	10
16QAM	6,41	12,82	19,23	25,64	32,05
32QAM	8,01	16,03	24,04	32,05	40,07
64QAM	9,62	19,23	28,85	38,47	48,08
128QAM	11,22	22,44	33,66	44,88	56,10
256QAM	12,82	25,64	38,47	51,29	64,11

Table B.2: Data rates for DOCSIS US channels (in Mb/s)

Modulation	Bandwidth (MHz)		
	1,6 MHz	3,2 MHz	6,4 MHz
QPSK	2,56	5,12	7,68
16QAM	5,12	10,24	20,48
32QAM	6,40	12,80	25,60
64QAM	7,68	15,36	30,72
128QAM	8,96	17,92	35,84

Annex C (informative): DOCSIS 3.0 Use Case Sample Calculation of KPI_{EP}

The example of this annex does not infer energy performance values for an actual operators cable access network. To determine the KPI_{EP} of an actual cable operator's access network the values and assumptions would need to be specified for a dimensioned portion of the actual cable access network architecture in the same way as described in the example given in this annex and applying the equations from relevant sub-clause of clause 5 to give an indication of the energy performance of the specified portion of the cable access network.

This annex presents a DOCSIS 3.0 use case example to illustrate the use of the equations from clauses 5.5.2.1 and 5.5.3.2 to calculate the energy performance of the network. The following assumptions are made for the data throughput as:

- each broadcast channel is 8 MHz wide, using 256QAM;
- DS DOCSIS 3.0 uses 4×8 MHz 256QAM:
 - Table B.1 indicates a data rate of 51,29 MB/s;
 - channel feeds 960 subscribers.
- US DOCSIS 3.0 uses 3×64 MHz 16QAM:
 - Table B.2 indicates a data rate of 20,48 MB/s;
 - channel feeds 240 subscribers.

Table C.1 provides an example of calculations based on the data volume assumptions listed above.

Table C.1: Example of DOCSIS 3.0 calculation of KPI_{EP}

Energy consumption parameters (see clause 5.5.2)		Data volume parameters (see clause 5.5.3)	
C_{CMTS}	5 000	bpB	8
C_{FAC}	15 000	BR_{CHDS}	51,3 MB/s
C_{PS}	250	BR_{CHUS}	20,48 Mb/s
C_{RX}	240	BR_{ANA}	5,13 Mb/s
C_{TX}	960	BR_{HD}	12,82 Mb/s
P_{CMTS}	1 000 W	BR_{SD}	5,13 Mb/s
P_{EQAM}	1 500 W	C_{DS}	960
P_{PS}	1 271 W	C_{US}	240
P_{RX}	12 W	k_{DS}	0,25
P_{TX}	16 W	k_{US}	0,75
$P_{HENIU} = \frac{1000}{5000} + \frac{1500}{15000} + \frac{12}{240} + \frac{16}{960} = 0,37 \text{ W ,}$ $P_{PSNIU} = \frac{1271}{250} = 5,08 \text{ W}$ <p style="text-align: center;">and</p> $KPI_{EC,NIU} = 0,00545 \text{ W}$		N_{CHDS}	4
		N_{CHUS}	3
		t_{ANA}	10
		t_{HD}	103
		t_{SD}	31
		$D_{BCEFF} = \frac{((5,13 \times 31) + (12,82 \times 103) + (5,13 \times 10))}{8} \times \frac{3600}{1440} = 478,37 \text{ MB/h ,}$ $D_{DS} = \frac{0,75 \times 4 \times 51,29}{8 \times 960} \times 3600 = 72,13 \text{ MB/h ,}$ $D_{US} = \frac{0,25 \times 3 \times 20,48}{8 \times 240} \times 3600 = 28,8 \text{ MB/h ,}$ <p style="text-align: center;">and</p> $D_{NIU} = 579,30 \text{ MB/h}$	
$KPI_{EP} = \frac{579,28}{0,00545} = 106,290 \text{ MB/kWh}$			

History

Document history		
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