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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Integrated broadband cable telecommunication networks (CABLE).

The present document is part 6 of a multi-part deliverable. Full details of the entire series can be found in part 1 [i.1].

Modal verbs terminology

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Introduction

The increasing interaction between the different elements of the Information Communication Technology (ICT) sector (hardware, middleware, software and services) supports the concept of convergence in which:

- multi-service packages can be delivered over a common infrastructure;
- a variety of infrastructures is able to deliver these packages;
- a single multi-service-package may be delivered over different infrastructures.

As a result of this convergence, the development of new services, applications and content has resulted in an increased demand for bandwidth, reliability, quality and performance, with a consequent increase in the demand for energy which has implications for cost and, in some cases, availability. It is therefore important to maximize the energy efficiency of all the network elements necessary to deliver the required services.

New technologies and infrastructure strategies are expected to enable operators to decrease the energy consumption, for a given level of service, of their existing and future infrastructures thus decreasing their costs. This requires a common understanding among market participants that only standards can produce.

The present document analyses the work on fixed broadband cable access networks whilst details of each of the other parts of the document set can be found in Part 1 [i.1]. It offers a contribution to the required standardization process by establishing an initial basis for determining the main energy consuming elements of the operators' broadband cable access network and defining indicators to measure their energy consumption and performance in terms of the work done by the network to transfer a volume of data.

Clearly the energy efficiencies of Operator Sites, Data Centres, the Core Networks and Customer Network Infrastructures are also important in maximizing the end-to-end energy efficiency of broadband communications and these issues will be covered in other parts of the document set. However, Access Networks differ from the other network components in that they are likely to include a very large number of locations each consuming a relatively low amount of energy. Not only do such small installations tend to be inefficient in their power utilization but when multiplied by their number, their total energy usage becomes considerable. Thus any energy saving which can be achieved becomes significant when the number of sites is taken into account.

The present document provides a basis for defining network key performance indicators as a bench mark that may assist network developers to measure energy metrics with progressive state of art., designs with the aim to reduce the overall energy consumption of the network. When complete, the documents will contain information to present principle metrics and approaches to calculate the broadband cable access network infrastructure energy performance. Innovative cable access architectures describe how these progress the broadband cable access network towards energy efficient infrastructures whilst continuing to meet year by year ever increasing demand for consumer multimedia services, voice, video and data.

Cable Operators across Europe and North America are defining metrics to measure the energy performance of their access network. In North America, the U.S. based SCTE [i.19] is in the process of defining the CAN in terms of energy consumption and metrics.

Through the cooperation agreement between ETSI TC CABLE and SCTE EMS-004 group [i.19], development of energy efficiency infrastructures for the broadband cable access network are expected to be defined along with metrics to support improvement measures in the energy consumption. Collaboration between the two organizations would ensure consistency and alignment as well as encourage sharing of information to optimize resources for standardization.

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1 Scope

The present document describes the cable access network, and progressive network access architectures that reduce the network energy consumption and the metrics required to benchmark the network and its components to support and enable the proper implementation of services, applications and content on an energy efficient infrastructure and describe measures that may improve the energy efficiency of cable access networks.

Within the present document:

- clause 4 presents the schematic for cable access network infrastructures, the evolution of the network architectures to meet consumer capacity demand and bandwidth growth and the main components of the cable access network energy consuming elements;
- clause 5 presents measurement key performance indicators to baseline and measure network energy performance;
- clause 6 explains power consumption metrics of the CAN;
- clause 7 describes and gives consideration to power metrics of field deployed access network elements;
- clause 8 describes the electrical powering of the CAN components and the distributed usage of the electrical power. This clause explains ways to improve the power consumption and benchmarking the HFC CAN plant;
- clause 9 considers the calculations to measure the data throughput of a CAN.

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.

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2.2 Informative references

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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] ETSI TR 105 174-1-1: "Access and Terminals (AT); Relationship between installations, cabling and communications systems; Standardization work published and in development; Part 1: Overview, common and generic aspects; Sub-part 1: Generalities, common view of the set of documents".

[i.2] ETSI TR 102 881 (V1.1.1): "Access, Terminals, Transmission and Multiplexing (ATTM); Cable Network Handbook".

[i.3] 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.4] ETSI TR 101 546: "Access, Terminals, Transmission and Multiplexing (ATTM); Integrated broadband Cable and Television Networks; Converged Cable Access Platform Architecture".

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

[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 TS 103 311 (all parts) (V1.1.1): "Integrated broadband cable telecommunication networks (CABLE); Fourth Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems".

[i.8] 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. European Commission, DG Enterprise and Industry".

[i.9] Coroama, Vlad C., Lorenz M. Hilty, Ernst Heiri, and Frank M. Horn. 2013. "The Direct Energy Demand of Internet Data Flows." Journal of Industrial Ecology, n/a-n/a. doi:10.1111/jiec.12048.

[i.10] Chan, Chien A., André F. Gygax, Elaine Wong, Christopher A. Leckie, Ampalavanapillai Nirmalathas, and Daniel C. Kilper. 2013. "Methodologies for Assessing the Use-Phase Power Consumption and Greenhouse Gas Emissions of Telecommunications Network Services." Environmental Science & Technology 47 (1): 485-92. doi:10.1021/es303384y.

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[i.12] Coroama, Vlad C., and Lorenz M. Hilty. 2014. "Assessing Internet Energy Intensity: A Review of Methods and Results." Environmental Impact Assessment Review 45 (February): 63-68. doi:10.1016/j.eiar.2013.12.004.

[i.13] Malmodin, Jens, Dag Lundén, Åsa Moberg, Greger Andersson, and Mikael Nilsson. 2014a. "Life Cycle Assessment of ICT." Journal of Industrial Ecology, May, n/a-n/a. doi:10.1111/jiec.12145.

[i.14] Schien, Daniel, Vlad C. Coroama, Lorenz M. Hilty, and Chris Preist. 2015. "The Energy Intensity of the Internet: Edge and Core Networks." In ICT Innovations for Sustainability, edited by Lorenz M. Hilty and Bernard Aebischer, 157-70. Advances in Intelligent Systems and Computing 310. Springer International Publishing.

NOTE: Available at http://link.springer.com/chapter/10.1007/978-3-319-09228-7_9.

[i.15] Coroama, Vlad C., Daniel Schien, Chris Preist, and Lorenz M. Hilty. 2015: "The Energy Intensity of the Internet: Home and Access Networks." In ICT Innovations for Sustainability, edited by Lorenz M. Hilty and Bernard Aebischer, 137-55. Advances in Intelligent Systems and Computing 310. Springer International Publishing.

NOTE: Available at http://link.springer.com/chapter/10.1007/978-3-319-09228-7_8.

[i.16] ETSI ES 205 200-2-4: "Integrated broadband cable telecommunication networks (CABLE); Energy management; Global KPIs; Operational infrastructures; Part 2: specific requirements; Sub-part 4: Cable Access Networks".

[i.17] 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.18] "Harmonizing Global Metrics for Data Centers Energy Efficiency, Global Taskforce Reaches Agreement Regarding Data Center Productivity," Green Grid, March 13, 2014.

NOTE: Available at http://www.thegreengrid.org/Global/Content/Regulatory-Activities/HarmonizingGlobalMetricsForDataCenterEnergyEfficiency_DCeP.

[i.19] Society of Cable Telecommunication Engineers (SCTE).

NOTE: Available at http://www.scte.org/.

3 Definitions, symbols and abbreviations

3.1 Definitions

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

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

fixed Cable Access Network: functional elements that enable wired (including optical fibre) communications to customer equipment

Hybrid Fibre Coax: 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

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

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
dB	decibel - a unit used to measure the intensity of the power level of an electrical signal by comparing it with a given level on a logarithmic scale
dBµV	decibel relative to one microvolt
dBmV	decibels relative to one millivolt
Gb	unit of Gigabyte (10^9 Byte)
GB	unit of Gigabyte (10^9 Byte)
KPI_{EP}	Global Key Performance Indicator of energy performance
KPI_{CMTSDS}	Key Performance Indicator metric for downstream CMTS ports
KPI_{CMTSUS}	Key Performance Indicator metric for upstream CMTS ports
KPI_{CMTS}	Key Performance Indicator metric for CMTS
KPI_{EQAM}	Key Performance Indicator metric for EQAM
KPI_{TXSA}	Key Performance Indicator metric for stand-alone optical transmitter
KPI_{CWDA}	Key Performance Indicator metric for CWDM based technology optical transmitter
KPI_{TXRX}	Key Performance Indicator metric for stand-alone optical receiver
KPI_{FN}	Key Performance Indicator metric for fibre node

KPI_{RFAMP}	Key Performance Indicator metric for RF Amplifier
KPI_{ANTOT}	Key Performance Indicator metric for the complete access network i.e. the total access network
KPI_{RFAMP}	Key Performance Indicator metric for RF Amplifier
$KPI_{EP\_broadcast}$	Key Performance Indicator energy performance metric for broadcast data transmission
kWh	kilowatt hours
m	unit of measurement of length in meters
REF_{HE}	Reference point at the cable headend
REF_{NIU}	Reference point at the network interface unit

3.3 Abbreviations

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

AC	Alternating Current
ANA	Autonomic Network Architecture
CAN	Cable Access Network
CATV	Cable Television
CCAP	Converged Cable Access Platform
CMTS	Cable Modem Termination System
CM	Cable Modem
CPE	Customer Premises Equipment
CWDM	Course wavelength division multiplexing
DC	Direct Current
DEMUX	De-multiplexer
DEPI	Downstream External-PHY Interface
DOCSIS	Data over Cable Service Interface Specification
DTV	Digital Television
DPI	Deep Packet Insertion
DS	Downstream
DSL	Digital Subscriber Line
DVB-C	Digital Video Broadcast- Cable
EdgeQAM	Edge Quadrature Amplitude Modulator
EMS	Energy Management Subcommittee
EUI	Energy Unit Intensity
GW	Gateway
Fwd	Forward
HD	High Definition
HE	Headend
HFC	Hybrid Fibre Coax
HVAC	heating, ventilating, and air conditioning
ICT	Information Technology Equipment
IP	Internet Protocol
KPI	Key Performance Indicator
OFDM	Orthogonal Frequency Division Multiplexing
OS	Operator Site
OSP	Outside Plant
PBX	Private Branch Exchange
PC	Personal Computer
POS	Point of Sale
PS	Power Supply or Power Source
PUE	Power Usage Effectiveness
M-CMTS	Modular Cable Modem Termination System
MUX	Multiplexer
N+0	Node plus no amplifier
N+1	Node plus one amplifier
NC	Narrowcast
PHY	Physical
QAM	Quadrature Amplitude Modulator
Ret	Return
RF	Radio Frequency
ROI	Return on Investment
SC-QAM	Single Carrier-Quadrature Amplitude Modulation

SCTE	Society of Cable Telecommunication Engineers
SD	Standards Definition
SG	Signalling Group
STB	Set Top Box
TV	Television
US	Upstream
U.S	United States
VOD	Video on Demand
IT	Information Technology
LDPC	Low Density Parity Check
MAC	Medium Access Control
MPEG	Motion Pictures Experts Group
VA	Volt-Ampere (unit of apparent power)

4 Cable Access Network Infrastructure

4.1 Classical network, generic reference model

The HFC Cable Network is as described by ETSI Cable Handbook [i.2]. Figure 1 presents a schematic of a generic cable access network infrastructure.

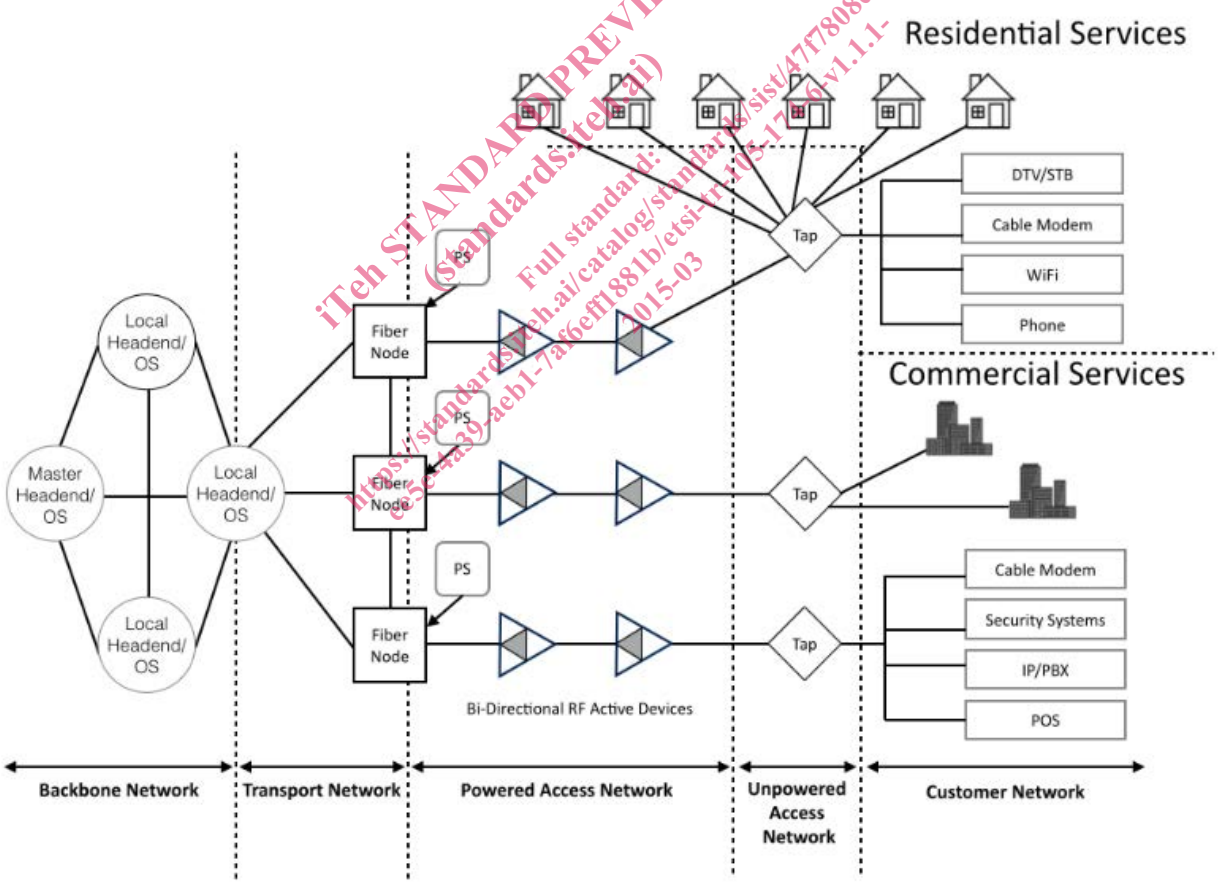

Figure 1: Schematic of HFC classical 'fixed' cable network infrastructures