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Part 2: Specific requirements
Sub-part 2: Fixed broadband access networks

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Contents

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Foreword

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

The present document is part 2, sub-part 2 of a multi-part deliverable covering lifecycle resource management of broadband deployment as identified below:

EN 305 200 series: **Energy management: Operational infrastructures: Global KPIs**

EN 305 200-1: General requirements

EN 305 200-2 series: **Specific requirements**

Sub part 1: ICT sites

Sub part 2: Fixed broadband access networks

Sub part 3: Mobile broadband access networks

Sub part 4: Cable access networks

EN 305 200-3: ICT sites

Sub part 1: DCEM

National transposition dates	
Date of adoption of this EN:	1 October 2014
Date of latest announcement of this EN (doa):	31 January 2015
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Date of withdrawal of any conflicting National Standard (dow):	31 July 2015

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).

"must" and "must not" are NOT allowed in ETSI deliverables except when used in direct citation.

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 EN 305 200 series address operational infrastructures and do not consider design/operation of components of broadband deployment networks.

The EN 305 200 series of standards comprises:

- EN 305 200-1: a generic requirements document addressing Global KPIs for operational infrastructures;
- a sub-series 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);
    - EN 305 200-2-1: ICT sites;
    - EN 305 200-2-2: Fixed broadband access networks;
      NOTE: excluding cable access networks (see EN 305 200-2-4)
    - EN 305 200-2-3: Mobile broadband access networks;
    - EN 305 200-2-4: Cable operator access networks.

  The documents do not define weightings of Objective KPIs or targets or limits for Global KPIs. Where relevant such information is provided in a related ETSI ES in the ES 205 200-2 series.
- a sub-series EN 305 200-3 that defines particular implementations of Global KPIs within ICT sites based on the requirements of EN 305 200-2-1, 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 documents do not define weightings of Objective KPIs or targets or limits for Global KPIs. Where relevant such information is provided in a related ETSI ES in the ES 205 200-3 series.

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.

The present document specifies the requirements for a Global KPI for energy management (KPI_{EM}) and their underpinning Objective KPIs for the fixed access networks (FANs) of broadband deployment. The requirements are mapped to the general requirements of EN 305 200-1.

1 Scope

The present document specifies the requirements for a Global KPI for energy management (KPI_{EM}) and their underpinning Objective KPIs addressing the following objectives for the fixed access networks (FANs) of broadband deployment;

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

The requirements are mapped to the general requirements of EN 305 200-1.

Energy management of fixed access networks comprises a number of independent layers. This document addresses performance of infrastructures that supports the normal function of hosted ICT equipment within the fixed 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 itemised outcome) or overlay layers (e.g. final energy required per itemised outcome).

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

Within the present document:

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

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 referenced 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.

[1] ETSI EN 305 200-1: Energy management: Operational infrastructures: Global KPIs - Part 1: General requirements.

[2] ETSI ES 205 200-2-2: ??

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] ETSI EN 305 174-4-1: Broadband deployment and life cycle resource management - Part 4: Access networks - Sub-part1: Fixed access networks

[i.2] ETSI EN 305 200-2-1: Energy management: Operational infrastructures: Global KPIs - Part 2: Specific requirements - Sub-part 1: ICT sites

[i.3] ETSI EN 305 200-3 series: Energy management: Operational infrastructures: Global KPIs - Part 3: ICT sites

[i.4] European Commission DG JRC Code of Conduct on Energy Consumption of Broadband Equipment

3 Definitions, symbols and abbreviations

*Definitions and abbreviations extracted from ETSI deliverables can be useful when drafting documents and can be consulted via the **Terms and Definitions Interactive Database (TEDDI) (http://webapp.etsi.org/Teddi/).***

3.1 Definitions

For the purposes of the present document, the terms and definitions given in EN 305 200-1 and the following apply:

customer premises (CP): ??

last operators connection point (LOC): interface to the fixed access transport networks of one or more operators from which cabling is routed to a customer network

network data centre (NDC): data centre embedded within the core network
NOTE: a network data centre of a cable access network may be termed a master head-end

network distribution node (NDN): grouping of 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

operator site (OS): premises accommodating network telecommunications equipment (NTE) providing direct connection to the core and access networks and which may also accommodate information technology equipment (ITE)
NOTE 1 to entry: an operator site that is only connected to the core network is considered as a network data centre
NOTE 2 to entry: an operator site of a cable access network may be termed a local head-end

3.2 Symbols

For the purposes of the present document, the symbols given in EN 305 200-1 and the following apply:

E_{REUSE}	reused energy
E_{REN}	renewable energy
s	downstream split from ICT site

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in EN 305 200-1 and the following apply:

CP	customer premises
FAN	fixed access network
FTTB	Fibre-to-the-Building
FTTC	Fibre-to-the-last operator Connection point, Cabinet or kerb (Curb)
FTTH	Fibre-to-the-Home
LOC	last operator connection point
NDN	network distribution node
NTP	network termination point
OS	operator site
TE	terminal equipment
TRX	transceiver

4 Energy management of fixed access networks (FANs)

4.1 General

4.1.1 Fixed broadband access networks (FANs)

The ESO submission of June 2011 to the European Commission in response to Mandate M/462 (dealing with "efficient energy use in fixed and mobile information and communication networks") used Figure 1 as an overall schematic to describe with fixed and mobile networks of broadband deployment. Since that time the schematic has been subject to change and is replaced by Figure 2.

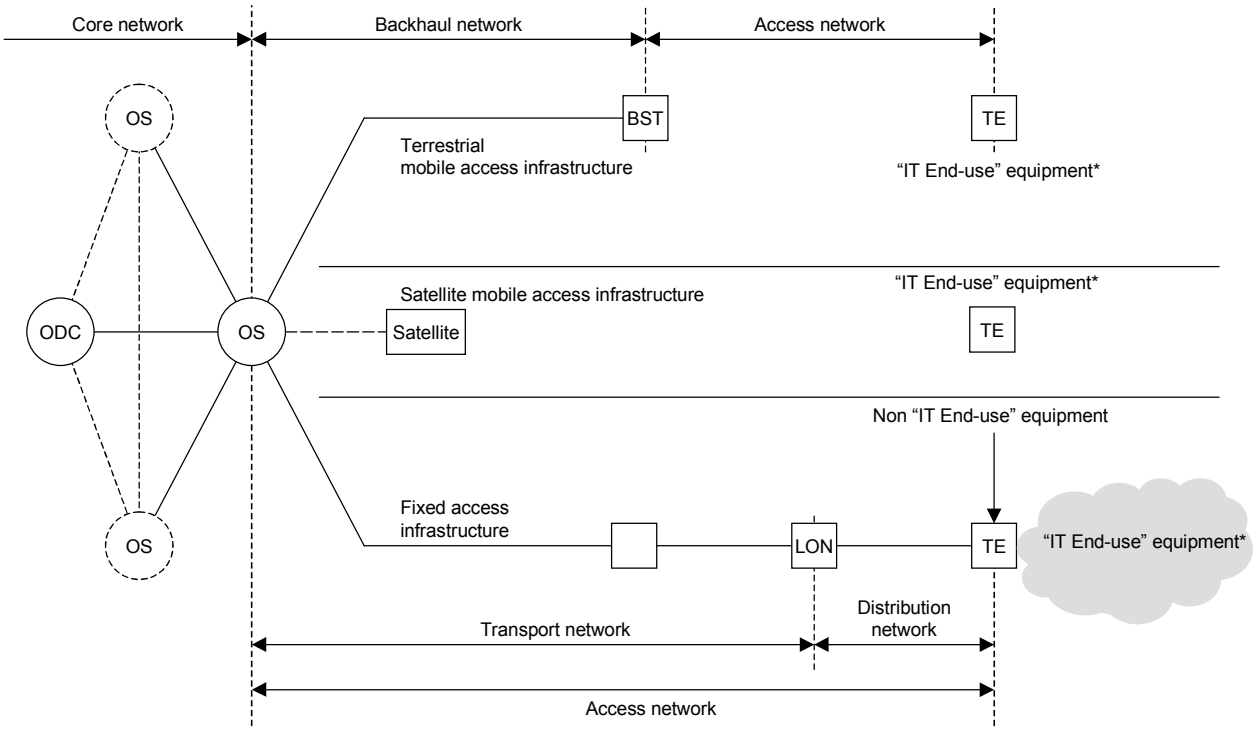


Figure 1 - Schematic of fixed and mobile communication networks (June 2011)

The principal changes for FANs are that customer premises (CP) have been included, network distribution nodes (NDNs) are shown and the last operator node (LON) has been replaced by the last operator connection point (LOC), which is a specific example of an NDN.

Within the FAN in Figure 2, the term NDN is employed to describe a variety of aggregations of NTE at locations between the OS and the CP. The diagram shows certain NDNs within dashed boxes to indicate that they are:

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

4.1.2 Fixed broadband access (FAN) technologies

The present document addresses energy management in FANs comprising the technologies shown in Figure 3. For single tenant premises (subscribers), the FAN technologies support are copper local loop, fibre to the last operator connection point (FTTC) - also known as fibre to the cabinet or kerb - and fibre to the home (FTTH). For multi-tenant premises the additional option of fibre to the building is also included.

In the most general sense, the operator sites (OS) and NDNs contain NTE of multiple access technologies. The totality of a FAN under the governance of a given operator takes into account all NTE (in terms of both energy consumption and data volumes).

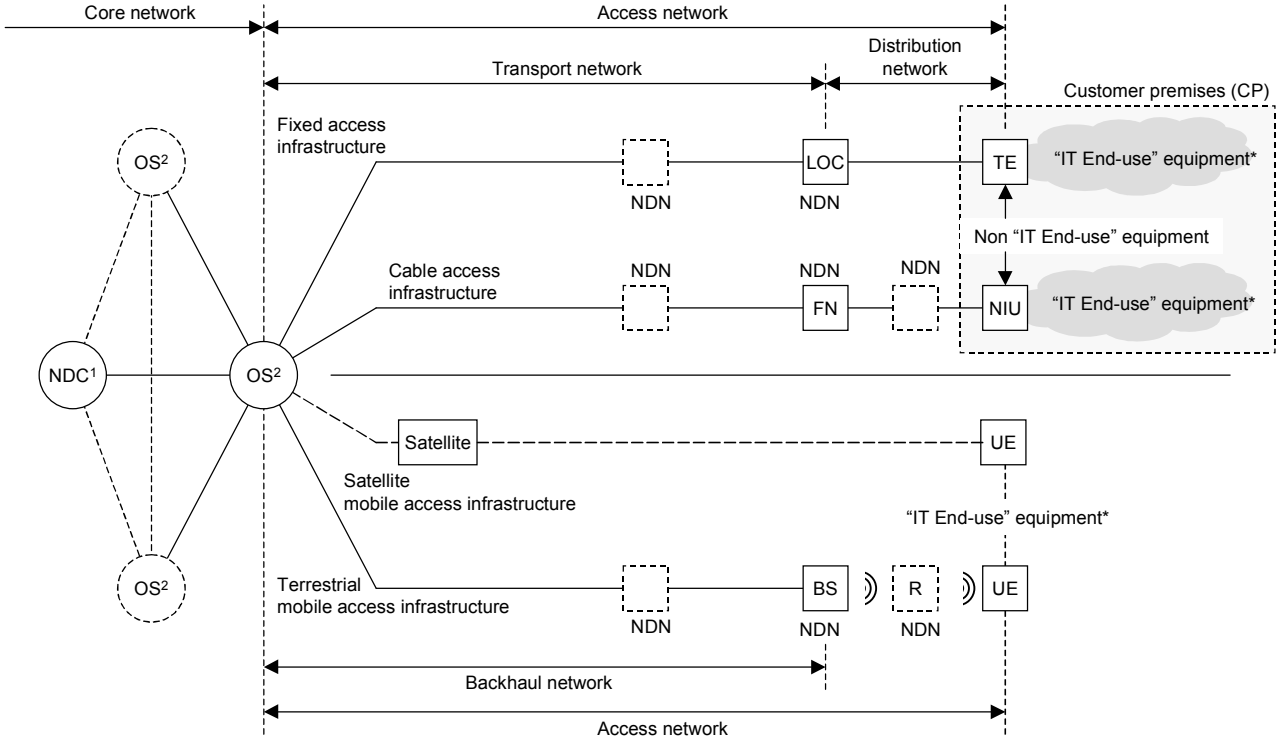
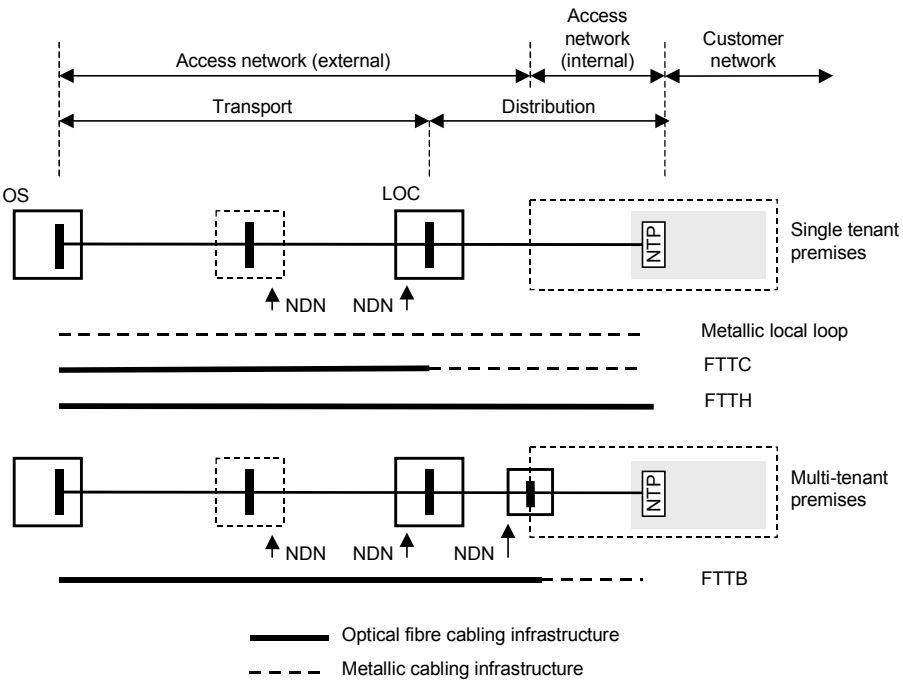


Figure 2 - Updated schematic of fixed and mobile communication networks



NOTE 1: dotted line indicates metallic (balanced or coaxial) cabling

Figure 3 - Fixed access network implementations

4.1.3 Energy consumption

It should be noted that optical fibre and metallic cabling infrastructures shown in Figure 3 refer to the telecommunications transmission media. Telecommunications transmission energy loss (indirect consumption) in the cabling of the FAN is assumed to be negligible.

Some of the FAN technologies require the use of active equipment at the NDNs shown in Figure 3.

In some cases, the site accommodating the NDN may also require power to provide environmental control for the NTE together with other infrastructures to provide the necessary levels of resilience and security required to provide the desired service availability. Where all the network telecommunications equipment (NTE) at a given NDN location is under common governance, the supporting infrastructures are included as part of the NDN In other case, the energy consumption of the NDN is restricted to that of the NTE.

Separate elements within the telecommunications cabling may be used to distribute power to a NDN from the OS or from other NDNs. In such cases, the energy loss (indirect consumption) in the cabling of the FAN may be non-negligible and shall be taken into account within the energy consumption of the FAN by including the relevant consumption at the source.

As shown in Figure 4, energy management within the FAN addresses energy consumption at an overall level to the OS and NDNs from both non-renewable and renewable sources. This supports the use of renewable energy which is locally generated or is supplied to the OS and NDN(s) via a contribution within the utility (grid) from other sites under common governance with the FAN.

Renewable energy content generated at the OS and NDNs or supplied to those locations the grid (utility) is subject to the same considerations as for ICT sites (see EN 305 200-2-1 and 5.1.2.4).

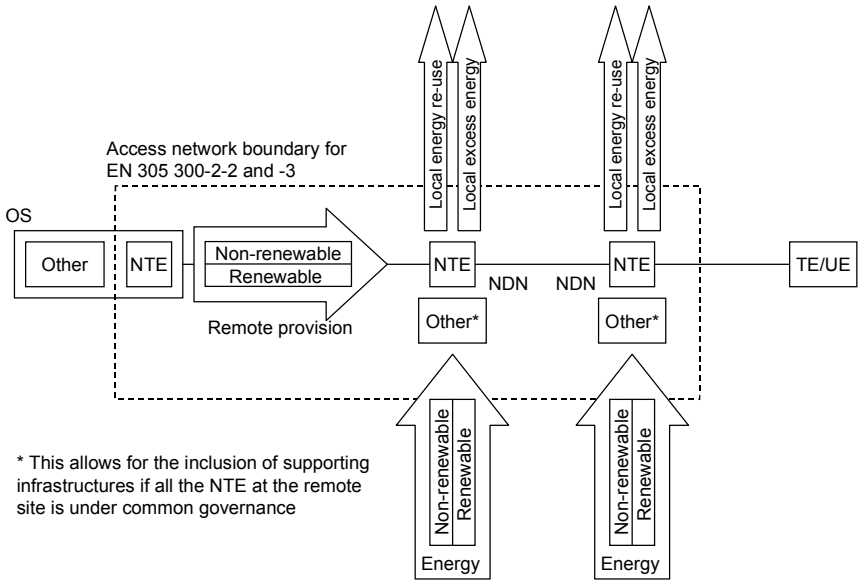


Figure 4 - Schematic of FAN profile-based energy management

As shown in Figure 4, NDNs may be associated with locally generated energy generation which exceeds the demands of the NDNs at that location. This energy may be provided to other facilities and infrastructures which are independent from the access network. The KPI_{EM} of the present document take no account of any such excess provision.

The re-use of energy at an operator site (OS) is addressed in the Objective KPIs of ICT sites (see EN 305 200-2-1 [i.2] and EN 305 200 series [i.3]).

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

Equipment providing NFV functionality is accommodated outside the boundaries of the access network then its energy consumption
shall be included in the overall energy consumption of the specific access network technology

4.1.4 Data volume

The data volume of a given FAN technology is the summation of upstream and downstream data (bit/s) at the transceiver (TRX) devices of the OS.

4.2 Related standards

For further study.

5 Global KPI (KPI_{EM}) for fixed access networks (FANs)

5.1 General

5.1.1 Global KPI (KPI_{EM}) for fixed access networks (FANs)

In accordance with EN 305 200-1, KPI_{EM} for FANs has the form:

$$KPI_{EM} = f\left(KPI_{EC}, data\_volume\right)$$

where:

KPI_{EC} = Objective KPI for energy consumption (see 5.1.2.1);
data_volume summation of upstream and downstream data transmitted during the assessment period for KPI_{EC}

5.1.2 Objective KPIs

5.1.2.1 Energy consumption (KPI_{EC})

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} is relevant to each FAN 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 FAN technology model, the KPI_{EC} may be improved by local actions within the OS 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.

Objectives for energy consumption of NTE within OS are included in the European Commission DG JRC Code of Conduct on Energy Consumption of Broadband Equipment [i.2]. Similar equipment will also be found in NDNs.

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. The KPI_{REN} is embedded within KPI_{EC}.

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

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

a) sources dedicated to and directly serving an OS or NDN;
b) sources from which it is conveyed by the utility (grid) serving an OS or NDN defined for the application of the KPI_{EM};

NOTE 1: these sources may be an OS, NDN or a generator and shall be under common governance with the FAN it serves.
NOTE 2: This does not, as yet, take into consideration any proportion of renewable electricity in the mix of production of utility supplies certified as "green" (e.g. based on the carbon footprint of the energy source) by electricity suppliers or in accordance with nationally recognised schemes.

In the case of (b), the renewable energy (E_{REN}) in KPI_{EC} is counted as renewable energy at the recipient site provided that the energy produced is not considered in the public mix and there is no feed-in contract. The portion of such energy allocated to the (which) ICT site or NDN added to other ICT site or NDN consumptions shall not exceed the overall energy consumption by the ICT site or NDN.

The loss produced by the utility (grid) shall be included at the recipient ICT site(s) or NDNs. If losses are not otherwise specified, a default loss of 10 % shall be used.
NOTE: a power source producing 100 kW is assumed to deliver 90 kW to recipient ICT sites.

5.2 Scale

KPI_{EM} is expressed with units of bits/W.

The dominant factor in the calculation of KPI_{EM} is the data volume served by the Objective KPI for energy consumption (KPI_{EC}).

The value of KPI_{EC} is mitigated by any energy contribution from renewable sources (KPI_{REN}).

5.3 Evolution

The use of a profile-based approach shall take into account various stages of network growth and utilisation.

5.4 Definition of boundaries

5.5 Formulae

5.5.1 Global KPI (KPI_{EM}) for fixed access networks (FANs)

5.5.1.1 General

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

KPI_{EM} is defined mathematically as:

$$KPI_{EM} = W \times \sum_{t=1}^{t=T} \frac{data\_volume_t}{KPI_{EC_t}}$$, subject to a minimum value of 0.

This is shown schematically in Figure 5.

Figure 5 - Schematic of KPI_{EM} calculation and drivers

5.5.1.2 Definition of terms

$data\_volume_t$ = summation of upstream and downstream data at the TRX of the NTE at the OS during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 5.6 of EN 305 200-1

$KPI_{EC,\,t}$ = Objective KPI for energy consumption for FAN technology t

t = FAN technology index

W = weighting of the profile applied (see clause 5.6)

5.5.1.3 Clarity

5.5.1.4 Criteria

5.5.2 Objective KPIs for fixed access networks (FANs)

5.5.2.1 Energy consumption (KPI_{EC})

5.5.2.1.1 Formula

$$KPI_{EC_t} = \sum_{i=1}^{N} C_n - E_{REN_n}$$

5.5.2.1.2 Definitions of terms

n = index of OS or NDN sites (OS = 1, LOC = N)

N = total number of OS and NDN sites

C_n = energy consumption of the NTE at site n

$E_{REN,\,n}$ = renewable energy content for the NTE at site n

5.5.2.1.3 Clarity

5.5.2.1.4 Criteria

5.5.3 Data_volume (*data_volume*)

5.5.3.1 Genral

5.5.3.2 Formula

5.5.3.3 Definitions of terms

5.5.3.4 Clarity

5.5.3.5 Criteria

5.6 Application of profiles

5.6.1 Universal consumption measurement

The most advantageous methodology for the determination of $KPI_{EC,\,t}$ is to measure the performance of every OS and NDN for an assessment period equivalent to a year. This is because:

- each part of the FAN may be subject to different environmental conditions which will affect the energy consumption required to maintain the desired conditions for effective and long-term operation of the NTE accommodated at those locations;
- those environmental conditions may vary over time in a random manner due to their location and the construction of the structure housing the NDN.

Shorter assessment periods may be applied where seasonal climate variations are sufficiently small to enable the assessment period to exhibit the equivalence to the default assessment period. In such cases, the period shall be based upon the minimum period required to reflect annualised data volumes based on historical traffic patterns for the FAN.

The FAN configuration shall not change during the assessment period. In case of change a new assessment period shall be initiated. The assessment period shall exclude any time during which engineering trails of energy efficiency measures are employed on a temporary basis.

The value of *W* for this approach is 1.

5.6.2 Statistic-based extension of consumption measurement

Where it is not viable to define the "real time" energy consumption and renewable energy utilisation at individual OS and NDNs across an entire FAN then it is possible to effect a "design" value for the network in relation to KPI_{EC} it is not appropriate to consider such values as truly operational.

Text required to explain the approach.

See Annex A.

The value of *W* for this approach is that found in ES 205 200-2-2.

5.6.3 Profile-based extension of consumption assessment

Where it is not viable to define the "real time" energy consumption and renewable energy utilisation at individual OS and NDNs across an entire FAN then it is possible to effect a "design" value for the network in relation to KPI_{EC} it is not appropriate to consider such values as truly operational.

The use of design models for each FAN technology coupled with load profiles is one way around this problem and can provide values of KPI_{EC} which can be used to meet the requirements of EN 305 200-1, clause 6, which states:

> *The objective of the EN 305 200 documents is to define Global KPIs for energy management that can be applied to all operational infrastructures of a given type .....*
>
> *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 a Global KPI for energy management.*
>
> *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 recognised that technology evolution may exhibit lower values of a Global KPI for energy management.*
>
> *Objective and Global KPIs 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.*

Text required to explain the approach.

See Annex B.

The value of *W* for this approach is that found in ES 205 200-2-2.

5.7 Reporting

Annex A: Statistical approach

A.1 «xx»

A.1.1 «yyy»

Annex B: Profile-based approach - Example

		Overall percentage	Overall percentage	Overall percentage
		30	30	40
		Load		
Overall percentage	Operational condition	Low	Medium	High
35	A	10,5 %	10,5 %	14,0 %
35	B	10,5 %	10,5 %	14,0 %
30	C	9,0 %	9,0 %	12,0 %

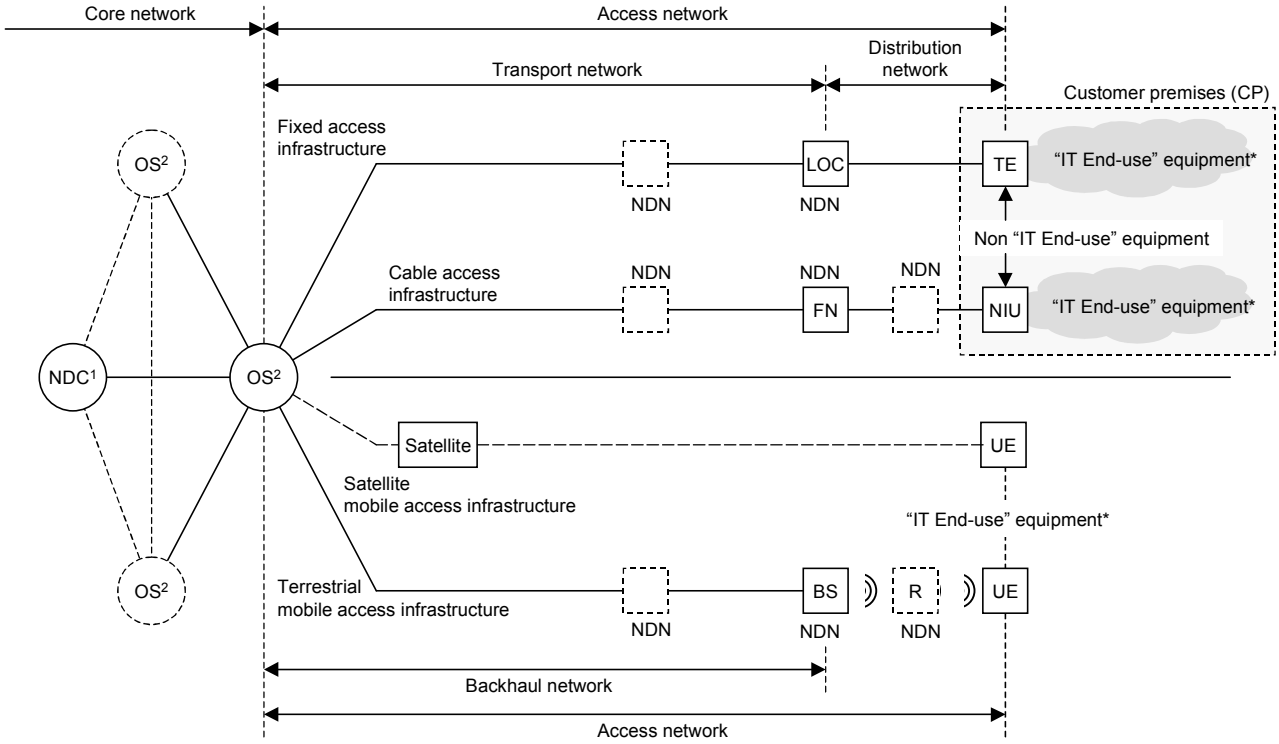
OPERATION CONDITION A

		Parameter A	Parameter B	Parameter C
		20	50	30
		Load		
Overall percentage	Parameter	Low	Medium	High
25	X	5,0 %	12,5 %	7,5 %
50	Y	10,0 %	25,0 %	15,0 %
25	Z	5,0 %	12,5 %	7.5 %

Annex X: Temporary

X.1 Mapping to Mandate M/462

Figure X.1 shows the schematic of the operational infrastructures of broadband deployment as contained with the ESO response to the EC Mandate M/462 with including modifications relevant to the present document.



[1] For cable access networks this is termed "Master head-end/OS"
[2] For cable access networks this is termed "Local head-end/OS"

* out of scope of Mandate M/462

Figure B.1 - Operational infrastructures of Mandate M/462

Figure X.1 is consistent with the Optical Access Networks Architectures defined in Recommendation ITU-T G.992.5 [i.x], Recommendation ITU-T G.984 [i.x], Recommendation ITU-T G.987 [i.x] and Recommendation ITU-T G.989 [i.x]);

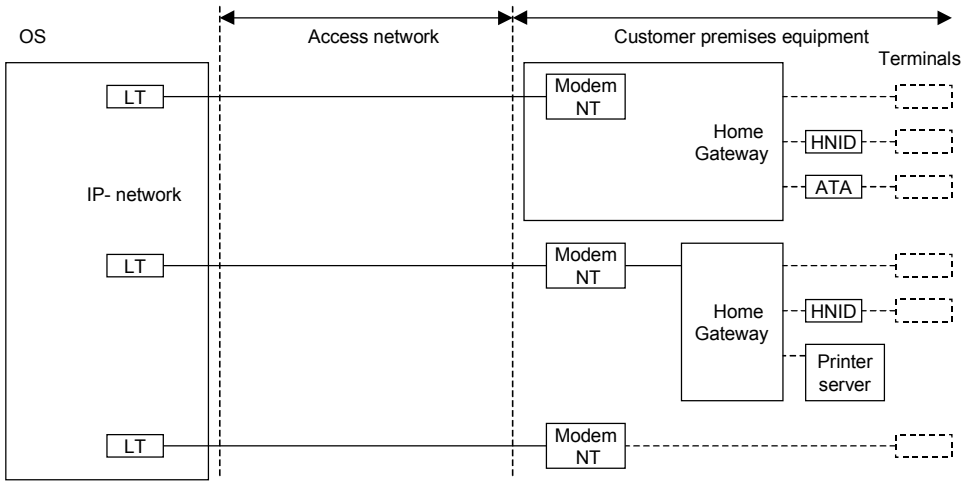
Figure X.1 shows a fixed access network (FAN) with network telecommunications equipment (NTE) at the operator site (OS). The FAN may be based on MSAN, DSLAM and OLT according to the access technology.

For the purposes of energy management, the FAN comprises NTE at all NDNs between, and including, the operator sites OS and the last operators connection point (LOC), as shown in Figure B.1. Thus:

- there can be a simple FAN comprising NTE only at the OS;
- there can be a complex FAN comprising NTE at the OS and one or more NDNs.

X.2 Topology

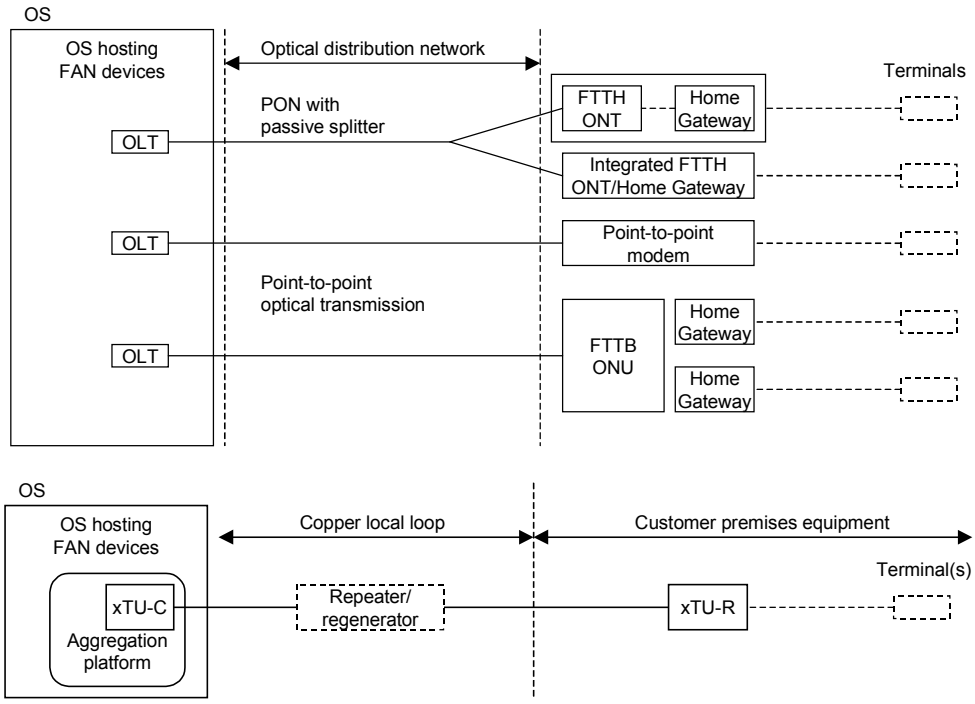
Figure X.2 describes the different possibilities of connections between the NTE at the OS, e.g the MSAN, and the customers (represented by terminals in the Figure X.2).



425

426 **Figure X.2 - Connection options between OS and customer premises**

427 The upper part of Figure X.3 is a schematic of optical access network configurations. The lower part of Figure X.3 is a
428 schematic of the configuration for DSL technologies, for A/VDSL but also for SHDSL [i.x] (Repeater-Regenerators are
429 mainly used on HDSL [i.x] and SHDSL links).



430

431

432 **Figure X.3 - Connection options between OS and customer premises**

Other annexes (as required)

History

Document history		
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V0.0.1	09/09/2016	Skeleton draft
V0.0.2	06/11/2016	Skeleton draft 2
V0.0.3	09/12/2016	Skeleton draft 2a
V0.0.4	28/12/2016	Skeleton draft 3