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**Access, Terminals, Transmission and Multiplexing (ATTM);
Energy management; Operational infrastructures; Global KPIs;
Part 2: Specific requirements;
Sub-part 2: Fixed broadband access networks**

Reference
REN/ATTM-006

Keywords
broadband, energy management, ICT,
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Foreword

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

The present document is part 2, sub-part 2 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";

    Sub-part 1:   "ICT Sites";

    Sub-part 2:   "Fixed broadband access networks";

    Sub-part 3:   "Mobile broadband access networks";

Part 3:   "ICT Sites";

Part 4:   "Design assessments".

National transposition dates	
Date of adoption of this EN:	23 July 2018
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Date of withdrawal of any conflicting National Standard (dow):	30 April 2019

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 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.1] series address operational infrastructures and do not consider design or operation of individual components comprising those infrastructures.

The ETSI EN 305 200 [i.1] series of standards comprises:

- ETSI EN 305 200-1 [i.2]: 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.3]: ICT Sites;

    - ETSI EN 305 200-2-2: Fixed broadband access networks;

  NOTE: Excluding cable access networks.

    - ETSI EN 305 200-2-3 [i.4]: 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.5] including ETSI EN 305 200-3-1 [i.6] that defines particular implementations of Global KPIs within ICT sites based on the requirements of ETSI EN 305 200-2-1 [i.3], 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 [i.7] 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.8] 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 their underpinning Objective KPIs for the fixed access networks (FANs) of broadband deployment. The requirements are mapped to the general requirements of ETSI EN 305 200-1 [i.2].

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 effectiveness;

- renewable energy.

The requirements are mapped to the general requirements of ETSI EN 305 200-1 [i.2].

Energy management of fixed 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 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 itemized outcome) or overlay layers (e.g. energy consumption 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 FANs together with inclusions/exclusions of different energy contributions;

- clause 5 specifies the requirements for measurement, calculation, classification and reporting of *KPI$_{EM}$*.

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.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

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

Not applicable.

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

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

[i.3]   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.4]   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.5]   ETSI EN 305 200-3 series: "Energy management: Operational infrastructures: Global KPIs - Part 3: ICT Sites".

[i.6]   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.7]   ETSI EN 305 200-4-4: "Integrated broadband cable telecommunication networks (CABLE); Energy management; Operational infrastructures; Global KPIs; Part 4: Design assessments; Sub-part 4: Cable Access Networks".

[i.8]   ISO 50001: "Energy management systems - Requirements with guidance for use".

[i.9]   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:

access network: functional elements (that is equipment and infrastructure) that enable communication between an Operator Site (OS) and a customer network

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

fixed (broadband) access network: access network provided by telecommunications operators comprising optical fibre and metallic cabling providing direct connection to customer premises

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

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)

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

mobile access network: telecommunications network in which the access to the network (connection between user equipment and network) is implemented over the air interface

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.

Network Functions Virtualisation (NFV): principle of separating network functions from the hardware they run on by using virtual hardware abstraction

Network Telecommunications Equipment (NTE): equipment between the boundaries of, and dedicated to providing connection to, core and/or access networks

Network Termination Point (NTP): physical point(s) at which a subscriber is provided with access to the operator network (this may be co-located with an external network test interface)

objective KPI: KPI assessing one of the objectives of operational energy performance which is subsequently used to define a Global KPI for energy management

operational infrastructure: combination of ICT equipment together with the power supply and environmental control systems necessary to ensure provision of service

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: An Operator Site that is only connected to the core network is considered as a network data centre.

   NOTE 2: An Operator Site of a cable access network may be termed a local head-end.

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

task effectiveness: measure of the work done (as a result of design and/or operational procedures) for a given amount of energy consumed

Terminal Equipment (TE): principal device within customer premises allowing user access to the services provided by the fixed access network

3.2   Symbols

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

Δt	The maximum time variation between measurement points of the different Objective KPIs within a given Global KPI
k	Assessment period index
C_{LOC}	Energy consumption of a LOC
C_{NDN}	Energy consumption of an NDN
C_{OS}	Energy consumption of an OS

KPI_{EC}	Objective KPI of energy consumption
$KPI_{EC\text{-}power}$	Objective KPI of energy consumption if any OS, NDN or LOC measurements are based on power rather than energy
KPI_{EM}	Global KPI of energy management
KPI_{REN}	Objective KPI of renewable energy usage
KPI_{TE}	Objective KPI of task effectiveness
R_{LOC}	Renewable energy consumption of a LOC
R_{NDN}	Renewable energy consumption of an NDN
R_{OS}	Renewable energy consumption of an OS
T_{KPI}	Period of time over which Objective KPIs are assessed
T_{REPEAT}	The time between which the Objective and Global KPIs are assessed to determine relevant trend information

3.3 Abbreviations

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

BS	Base Station
BST	Base Station
CP	Customer Premises
DCEM	Data processing and Communications Energy Management
FAN	Fixed Access Network
FN	Fibre Node
FTTB	Fibre-To-The-Building
FTTC	Fibre-To-The-last operator Connection point, Cabinet or kerb (Curb)
FTTH	Fibre-To-The-Home
ICT	Information and Communications Technology
ISO	International Standards Organization
ITE	Information Technology Equipment
KPI	Key Performance Indicator
LL	Leased Line
LOC	Last Operator Connection point
LON	Last Operator Node
NDC	Network Data Centre
NDN	Network Distribution Node
NFV	Network Function Virtualisation
NIU	Network Interface Unit
NTE	Network Telecommunications Equipment
NTP	Network Termination Point
ODC	Operator Data Centre
OS	Operator Site
R	Repeater
TE	Terminal Equipment
UE	User Equipment

4 Energy management of fixed access networks (FANs)

4.1 General

4.1.1 Fixed (broadband) access networks (FANs)

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.9]. The original schematic and details of the changes are listed in annex A.
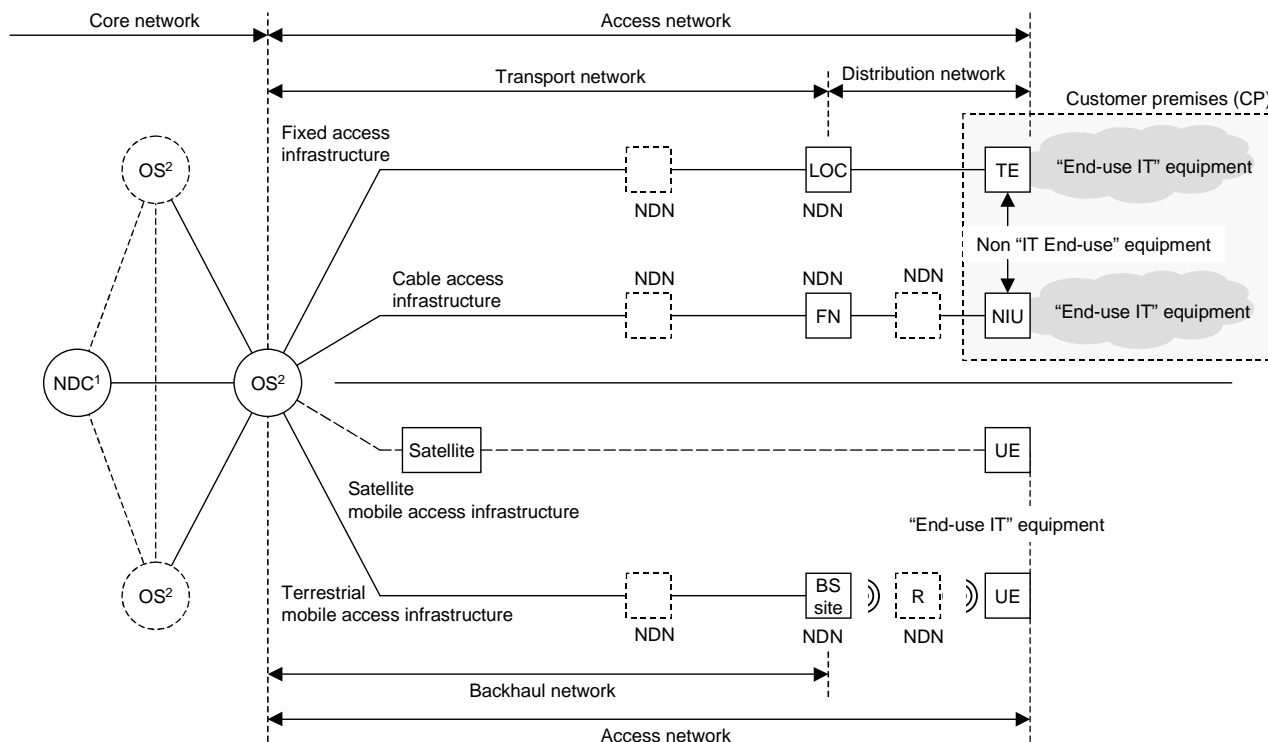
¹ For cable access networks this is termed "Master head-end/OS"
² For cable access networks this is termed "Local head-end/OS"

Figure 1: Updated schematic of fixed and mobile communication networks

Within the fixed access network (FAN), the term Network Distribution Node (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) in the Customer Premises (CP).

The Last Operator Connection point (LOC) is shown as a specific example of an NDN and is the closest NDN containing NTE to a CP.

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

- optional;

- not restricted in number to the configurations shown.

The architectures of the FAN and cable access network of are very similar and could comprise common materials. The difference lies primarily in the naming of the elements. As a result, cable access networks are addressed in ETSI documents separate from those of FANs.

4.1.2   Fixed access network (FAN) implementations

The present document addresses energy management in FANs comprising a number of services using the delivery technologies shown in Figure 2. For single and multi-tenant CP, the FAN technologies supported are copper local loop, optical fibre to the LOC (sometimes known as FTTC - also known as fibre to the cabinet or kerb) and optical fibre to the home (FTTH). For multi-tenant premises the additional option of optical fibre to the building is also included.

In the most general sense, the OS and NDNs contain NTE to support multiple services using multiple delivery technologies.

The totality of a FAN under the governance of a given operator takes into account all NTE in terms of energy consumption (both non-renewable and renewable) and task effectiveness.
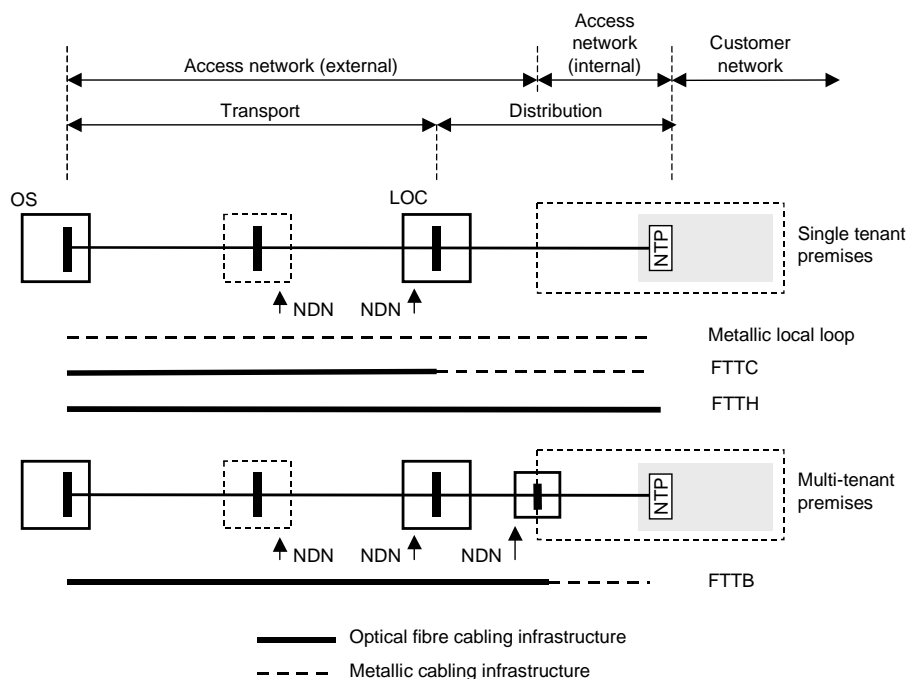
NOTE: Dotted line indicates metallic (balanced or coaxial) cabling.

Figure 2: Fixed access network implementations

4.1.3   Measured energy

The energy referred to in Figure 3 and elsewhere in the present document may be referred to as "final energy" and excludes losses from production or transmission to the measurement boundary.

4.1.4   Energy consumption

It should be noted that optical fibre and metallic cabling infrastructures shown in Figure 2 refer to the telecommunications transmission media.

The present document specifies a Global KPI, KPI_{EM}, by the separate presentation of two Objective KPIs, both of which rely on a measurement of the total energy consumption of the FAN.

The relevant energy consumption at an OS is that of the NTE directly connected to the FAN.

NOTE: All other energy consumption of the OS is addressed by the KPIs of ETSI EN 305 200-2-1 [i.3] and the ETSI EN 305 200-3 series [i.5].

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. Where the supporting infrastructures are shared by NTE of multiple operators, the apportionment of energy consumption of the shared infrastructure is for further study.

Some of the FAN services and technologies require the use of active equipment at the NDNs shown in Figure 2. In some cases the OS may power the NDN and an NDN may power other equipment downstream towards and at the CP.

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.

The boundaries of energy (both non-renewable and renewable) consumption are shown in Figure 3.

The boundary includes:

- at each OS, the energy consumption of NTE dedicated to each FAN service;

- at each NDN, the locally provided energy consumption of NTE dedicated to each FAN service;

- at each NDN, the energy consumption resulting from any power provision made from an upstream NDN;

- at each NDN, the energy consumption used 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;

- at each LOC, the energy consumption resulting from any power provision made to the CP.

The energy consumed is described as non-renewable or renewable. This supports the use of renewable energy which is generated on-site at the OS and NDN(s) 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 clause 5.1.2.4).

It is also recognized that in some cases the energy consumption of NTE at the LOC (and other NDNs) may be supplied from the CP (termed reverse powering). The treatment of energy consumption in these cases is for further study.
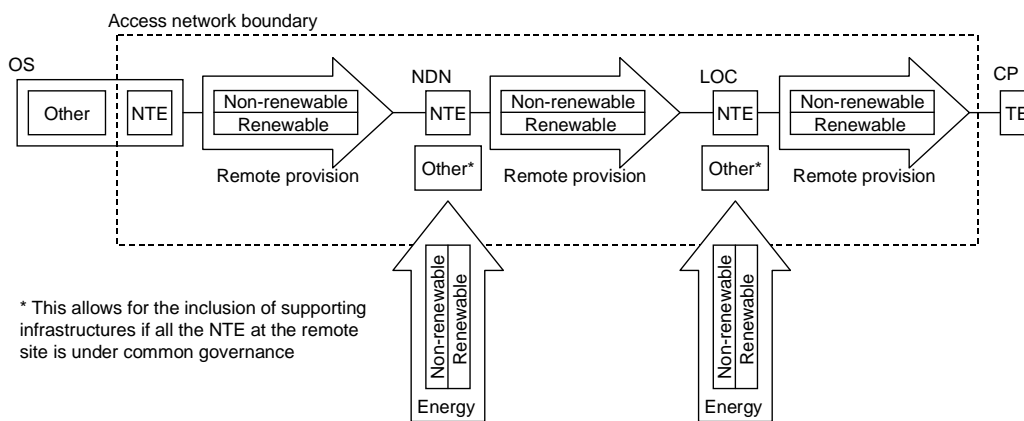
Figure 3: Schematic of FAN energy consumption

As shown in Figure 3, NDNs may be associated with energy generated on-site 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 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.

If equipment providing network function virtualisation (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. If such equipment supports multiple access networks then the consumption relevant to the FAN under consideration shall be included. If this is not possible then it shall be reported that the consumption measured excludes any NFV activity.

4.1.5 Task Effectiveness

Task effectiveness is a measure of the data volumes (both upstream and downstream data (bits)) as a function of the energy consumption (Wh).

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)

KPI_{EM} for FANs separately describes the task effectiveness and the renewable energy performance of an entire FAN for a specific service or a collection of services.

KPI_{EM} is a combination of two separate KPIs as follows:

   1)   the Objective KPI for task effectiveness expressed as KPI_{TE} (see clause 5.1.2.2);

   2)   the Objective KPI for renewable energy contribution expressed as KPI_{REN} (see clause 5.1.2.4);

and both of these Objective KPIs incorporate a third Objective KPIs for energy consumption expressed as KPI_{EC} (see clause 5.1.2.1).

The Global KPI, KPI_{EM}, presented as its two Objective KPIs, KPI_{TE} and KPI_{REN}, is primarily intended for trend analysis - not to enable comparison between FANs. An increase in either KPI_{TE} or KPI_{REN} represents an improvement in energy management of the network - although individual improvements of KPI_{TE} and KPI_{REN} are not comparable.

5.1.2   Objective KPIs

5.1.2.1   Energy consumption (KPI_{EC})

5.1.2.1.1   General

The present document supports the reduction in the energy consumption required to provide a given level of service as a primary objective.

KPI_{EC} may be improved by local actions within the OS and NDNs by one or more of the following:

   •   the use of NTE with reduced energy consumption;

   •   the replacement of NTE platforms with more modern and more energy efficient solutions;

   •   the use of NTEs that have lower demand on supporting infrastructures within the NDNs and LOCs.

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.

It is desirable that the actual energy consumption of all relevant NTE equipment is measured and used to calculate the KPI. However, in situations where direct measurement of the consumption is not possible, the rated consumption of the equipment may be used. This latter approach will result in a generally higher value of KPI_{EC}. This will encourage the implementation of methodologies to enable the direct measurements to be made.

5.1.2.2   Task effectiveness (KPI_{TE})

5.1.2.2.1   General

The present document supports the improvement in task effectiveness as a primary objective.

KPI_{TE} is a measure of the data volume transported across the FAN (at the interface to echo) per unit of energy consumed by the entire FAN.

An improvement of KPI_{TE} reflects a reduction of the overall energy consumption required to deliver a given data volume (which is noted by a reduction in KPI_{EC}) and/or in increase in the data volume provided for a given level of energy consumption.

An increase in the task effectiveness is a primary objective of the present document. KPI_{TE} is a measure of the data volume transported across the FAN per unit of energy consumed by the entire network.

The ideal measurement of data volume is that at the NTE directly connected to the FAN at the OS. However, not all such NTE may be able to report that information. In such cases an alternative may employed. This is discussed in clause 5.6.1.1.2.

5.1.2.3 Energy re-use (KPI_{REUSE})

Not applicable in the present document.

5.1.2.4 Renewable energy (KPI_{REN})

The present document supports the use of renewable energy as a primary objective.

KPI_{REN} is the ratio of energy consumption from renewable sources to the total energy consumption of clause 5.1.2.1. It is a dimensionless number.

Only the sources contributing to KPI_{EC} will be taken into account, whether dedicated or shared.

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

a)   sources dedicated to and directly serving an NDN or LOC;

b)   sources under common governance with the NDNs and LOCs they serve and from which it is conveyed by the utility (grid) serving a NDNs and LOCs in the group defined for the application of the KPI_{EM}.

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 NDNor LOCas 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 NDN or LOC added to other NDN or LOC consumptions shall not exceed the overall energy consumption by the NDN.

5.2 Scale

The Global KPI, KPI_{EM}, is presented as a combination of the two Objective KPIs, KPI_{TE} and KPI_{REN}.

KPI_{TE} is expressed with units of bits/Wh and KPI_{REN} is expressed as a percentage. Both Objective KPIs include the Objective KPI_{EC} but do not indicate its value.

This approach allows:

- the energy impact of all scales of FAN to be assessed but not compared between FANs of different operators;

- regulatory objectives to be applied to FANs which have the greatest individual energy impact.

5.3 Utilization and evolution

The Global KPI, KPI_{EM}, is presented as a combination of the two Objective KPIs, KPI_{TE} and KPI_{REN}.

KPI_{TE} is expressed with units of bits/Wh and KPI_{REN} is expressed as a percentage. Both Objective KPIs include the Objective KPI_{EC} but are not impacted its value.

KPI_{TE} is applicable from early stages, when both energy consumption and data volumes may be lower than the design objective, although KPI_{TE} may be poorer than that of a fully utilized FAN, to a more complete utilization stage when KPI_{TE} should match the design goals.

KPI_{REN} is applicable to all stages of network development.

This approach encourages:

- the re-engineering of the supporting infrastructures (e.g. power distribution and environmental control systems) in older legacy FANs which tend to exhibit low KPI_{TE} values;

- the optimization of NTE loads by selection, configuration and utilization of equipment and management systems.

5.4   Definition of boundaries

See clause 4.1.4.

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 sites provides all the primary functions of the sites (i.e. NTE load, environmental control, etc.). If the supply of energy of any of the loads is provided by other supplies not included in KPI_{EC} then KPI_{EM} cannot be assessed.

KPI_{EM} is defined mathematically as:

$$KPI_{TE} = \frac{data\_volume}{KPI_{EC}} \text{ in conjunction with } KPI_{REN}$$

5.5.1.2   Definition of terms

$data\_volume =$ Total volume of data delivered over the FAN (see clause 5.6.1.2.1 for assessment options)

$KPI_{EC} =$ Objective KPI of energy consumption (see clause 5.6.1.1.2 for options based on measurement procedures)

$KPI_{REN} =$ Objective KPI of renewable energy consumption for all services

$KPI_{TE} =$ Objective KPI of task effectiveness for all services

5.5.1.3   Clarity

KPI_{EC}, KPI_{REN} and KPI_{TE} meet the requirements of ETSI EN 305 200-1 [i.2].

5.5.1.4   Criteria

KPI_{EM} is based on the Objective KPIs which shall meet the requirements listed below.

In accordance with the terminology of clause 5.6 of ETSI EN 305 200-1 [i.2]:

- the Objective KPIs shall be measured on a FAN over the same period of time (T_{KPI}) subject to the allowed variation (Δt);

- the default value of T_{KPI} shall be 365 days because:

    - each OS, NDN and LOC 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 and LOC;

- other values of T_{KPI} may be applied (subject to a minimum of 7 days) where:

    - seasonal climate variations are sufficiently small to enable the measurement period to exhibit the equivalence to the default measurement period;

    - the period is able to reflect annualized data volume based on historical traffic patterns for the FAN.

In addition:

- T_{REPEAT} shall be between one week and one calendar month;

- Δt shall be less than 2 % of T_{KPI}.

The period shall exclude any time during which engineering trails of energy efficiency measures are employed on a temporary basis.

The values of T_{KPI}, T_{REPEAT} and Δt applied to the Objective KPIs are also applicable to *data_volume*.

5.5.2 Objective KPIs for fixed access networks (FANs)

5.5.2.1 Energy consumption (KPI_{EC})

5.5.2.1.1 Formula

$$KPI_{EC} = \sum_{x=1}^{N} C_{OS_x} + \sum_{y=1}^{M} C_{NDN_y} + \sum_{z=1}^{Q} C_{LOC_z}$$

5.5.2.1.2 Definitions of terms

$x =$	index of OS
$y =$	index of NDN sites
$z =$	index of LOC sites
$N =$	total number of OS
$M =$	total number of NDN sites
$Q =$	total number of LOC sites
$C_{OS_x} =$	energy consumption of all the FAN NTE at OS$_i$
$C_{NDN_y} =$	energy consumption of all the FAN NTE at NDN$_j$ supplied from the utility, from upstream sources or generated on-site
$C_{LOC_z} =$	energy consumption of all the FAN NTE at LOC$_z$ supplied from the utility, from upstream sources or generated on-site

NOTE: C_{NDN} and C_{LOC} includes the energy consumption of the supporting infrastructure at NDNs and LOCs where all the NTE is under common governance.

5.5.2.1.3   Clarity

See clause 5.5.1.3.

5.5.2.1.4   Criteria

Where all the network telecommunications equipment (NTE) at a given NDN or LOC location (i.e. excluding the OS) is under common governance, the supporting infrastructures (such as cooling, power distribution, surveillance systems, access control, flood and fire detection, fire extinguishing system and lighting) are included as part of the NDN or LOC. In other cases, the energy consumption of the NDN or LOC is restricted to that of the NTE. Where the supporting infrastructures are shared by NTE of multiple operators, the apportionment of energy consumption of the shared infrastructure is for further study.

Each OS and NDN shall operate at its design level of service availability during the period of assessment. This includes any circumstances during which fault conditions exist and alternative sources are used (e.g. testing, online standby duty).

5.5.2.2   Task Effectiveness (KPI_{TE})

5.5.2.2.1   Formula

$$KPI_{TE} = \frac{\sum_{i=1}^{N} data\_volume_i}{KPI_{EC}}$$

5.5.2.2.2   Definitions of terms

$i =$ index of OS

$N =$ total number of OS

$data\_volume_i =$ total data volume (downstream and upstream) at OS_i

5.5.2.2.3   Clarity

See clause 5.5.1.3.

5.5.2.2.4   Criteria

Measurement criteria for KPI_{EC} are specified in clause 5.5.2.1.4.

Measurement criteria for $data\_volume_i$ comprise two options as follows:

- the preferred option is the total volume (measured) of data transmitted and received at the ports of the NTE connected to the FAN at OS_i;

- the alternative option is a combination of measured at the connection to the core network at OS_i together with estimated data volumes associated with data internal to the FAN at OS_i. See annex B for information regarding estimation of data volumes.

Two options are provided due to the fact that a FAN served by an OS may simultaneously comprise a number of different network transmission technologies. While many of the newer technologies allow data volumes to be accurately records, some of the older technologies do not.

Therefore as technology migration occurs the preferred option will become dominant in the determination of $data\_volume_i$.

The reporting of KPI_{TE} (see clause 5.7) shall include the measurement criteria applied.

5.5.2.3 Renewable energy (KPI_{REN})

5.5.2.3.1 Formula

$$KPI_{REN} = \frac{\sum\limits_{x=1}^{N} C_{OS_x} \times R_{OS_x} + \sum\limits_{y=1}^{M} C_{NDN_y} \times R_{NDN_y} + \sum\limits_{z=1}^{Q} C_{LOC_z} \times R_{LOC_z}}{KPI_{EC}}$$

5.5.2.3.2 Definitions of terms

$x =$ index of OS

$y =$ index of NDN sites

$z =$ index of LOC sites

$N =$ total number of OS

$M =$ total number of NDN sites

$Q =$ total number of LOC sites

$C_{OS_x} =$ energy consumption of all the FAN NTE at OS_x

$C_{NDN_y} =$ energy consumption of all the FAN NTE at NDN_y supplied from the utility, from upstream sources or generated on-site

$C_{LOC_z} =$ energy consumption of all the FAN NTE at LOC_z supplied from the utility, from upstream sources or generated on-site

$R_{OS_x} =$ ratio of renewable energy generated on-site at OS_x

$R_{NDN_y} =$ ratio of renewable energy generated on-site at NDN_y

$R_{LOC_z} =$ ratio of renewable energy generated on-site at LOC_z

5.5.2.3.3 Clarity

See clause 5.5.1.3.

5.5.2.3.4 Criteria

Measurement criteria for KPI_{EC} and the renewable content of each element of KPI_{EC} are specified in clause 5.5.2.1.4.

5.6 Measurement points and procedures

5.6.1 Objective KPIs for FANs

5.6.1.1 Energy consumption (KPI_{EC})

5.6.1.1.1 Measurement points

Measurement points are as follows:

- C_{OS} shall be measured at the input to the NTE at each OS.

- C_{NDN} shall be measured at the input to each NDN (including the consumption of the supporting infrastructure where appropriate).

- C_{LOC} shall be measured at the input to each LOC (including the consumption of the supporting infrastructure where appropriate).

5.6.1.1.2   Measurement procedures

C for each OS, NDN and LOC is defined as the energy consumption recorded by all relevant meters (utility and local sources) over the specified time period used to assess KPI_{EM} (i.e. T_{KPI} subject to the allowed variation Δt specified in clause 5.5.1.4).

Measurements shall be made in Wh.

Where energy consumed by the OS, NDN and LOC is provided by a utility then the value reported by that utility may be used. However, if the reported value is based upon extrapolation of a statistical sample then in order for the KPIs to provide a valid basis for trend analysis:

- it is necessary to maintain the basis of such procedures during the periods of assessment;

- any changes in that process shall be recorded since they may invalidate the trend analysis that includes the time at which the change is made.

The present document recommends the measurement of energy consumption. An alternative approximation using regular power measurements is allowed but the inclusion of any such measurement within the KPI requires the resulting KPI be designated as $KPI_{EC\text{-}power}$.

The reporting of KPI_{TE} (see clause 5.7) shall include the measurement criteria applied.

5.6.1.2   Task effectiveness (KPI_{TE})

5.6.1.2.1   Measurement points

Measurement points for KPI_{EC} are specified in clause 5.6.1.1.1.

Measurement points for *data_volume* are shown in Figure 4.

The preferred option for the measurement of *data_volume* are identified at points "1" in Figure 4.

The alternative option for the measurement of *data_volume* are identified at points "2" in Figure 4 subject to the additional elements of *data_volume* detailed in annex B.
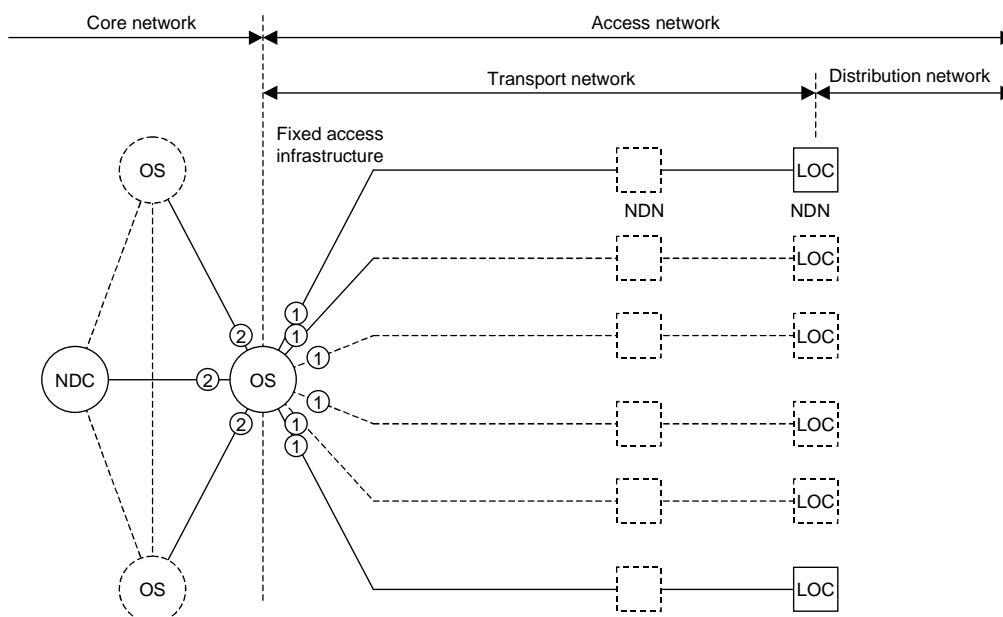
Figure 4: Schematic of measurements points for *data_volume*

5.6.1.2.2 Measurement procedures

Measurement procedures for KPI_{EC} are specified in clause 5.6.1.1.2.

Measurement procedures for *data_volume* via the counters relevant to the measurement points.

data_volume shall be measured over the specified time period used to assess KPI_{EM} (i.e. T_{KPI} subject to the allowed variation Δt specified in clause 5.5.1.4) and measurements shall be made in bits.

5.6.1.3 Renewable energy (KPI_{REN})

5.6.1.3.1 Measurement points

Measurement points for KPI_{EC} are specified in clause 5.6.1.1.1.

R_{OS} is the ratio of on-site generated renewable energy to the total energy consumption of each OS as defined in ETSI EN 305 200-2-1 [i.3].

R_{NDN} is the ratio of on-site generated renewable energy to the total energy consumption of each NDN.

R_{LOC} is the ratio of on-site generated renewable energy to the total energy consumption of each LOC.

5.6.1.3.2 Measurement procedures

Measurement procedures for KPI_{EC} are specified in clause 5.6.1.1.2.

R_{OS}, R_{NDN} and R_{LOC} shall be calculated from measurement taken over the specified time period used to assess KPI_{EM} (i.e. T_{KPI} subject to the allowed variation Δt specified in clause 5.5.1.4).

R_{OS}, R_{NDN} and R_{LOC} are expressed as a dimensionless value.

5.7 Reporting

The following shall be reported for the entire FAN for which the KPI_{EM} has been determined:

- KPI_{TE} (stating the option applied for the assessment of data volume);

- KPI_{REN};

- T_{KPI};

- T_{REPEAT};

- Δt.

In addition, in view of the two options for the assessment of energy consumption the KPI_{EC} shall be reported as either:

- KPI_{EC} or

- $KPI_{EC\text{-}power}$.

Annex A (informative):
History of network schematics

The response of the European Standards Organisations (June 2011) to the European Commission in response to Mandate M/462 [i.9] (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.
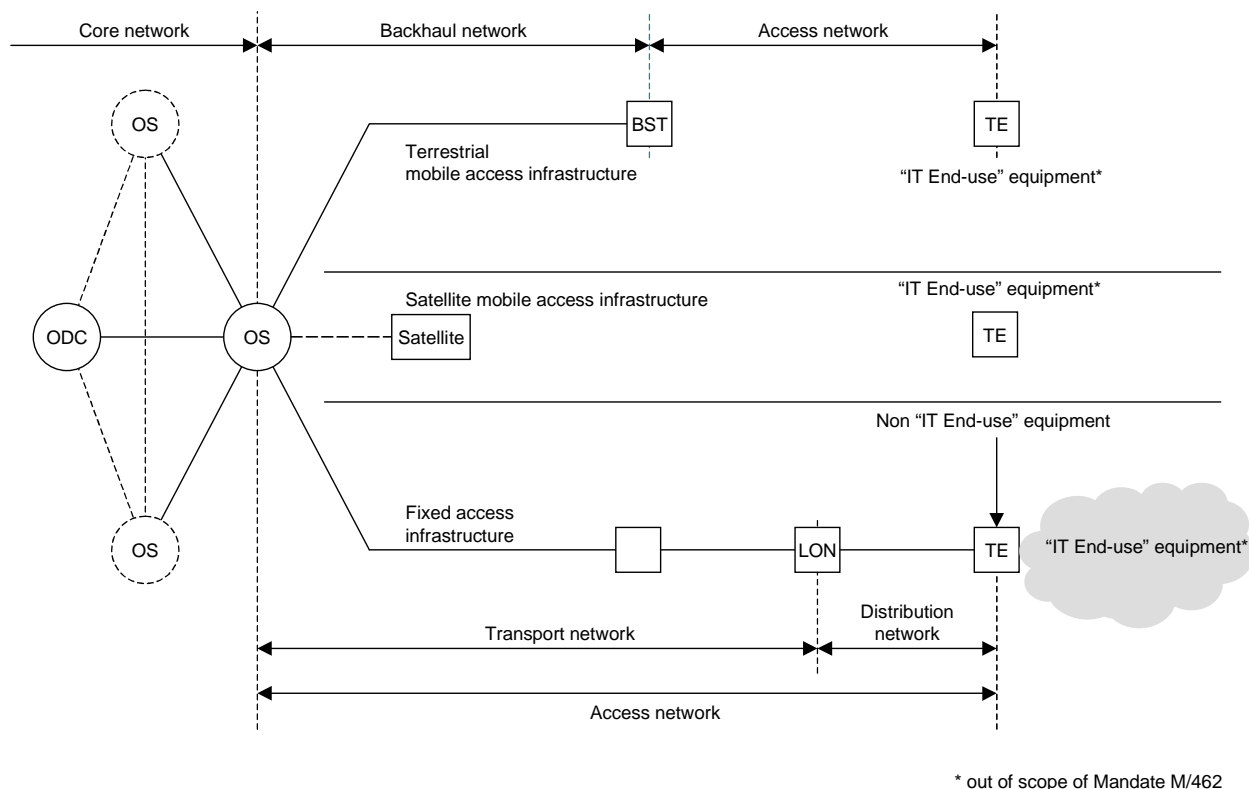

Figure A.1: Schematic of fixed and mobile communication networks (June 2011)

See clause 4.1.1 for the changes to the schematic for FANs.

Within the mobile access network, the term NDN is employed to describe a variety of aggregations of NTE at locations between the OS and the User Equipment (UE), which has replaced the TE. The Base Station (BS) site and Repeater (R) are shown as specific examples of NDNs.

Within the satellite network UE has replaced TE.

Within the cable access network, the term NDN is employed to describe a variety of aggregations of NTE at locations between the local Head-End (HE) and the Network Interface Unit (NIU), which has replaced the 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.

For all access networks, the Operator Data Centres (ODC) have been replaced by a Network Data Centre (NDC).

Annex B (normative):
Estimating data volumes

The alternative option for assessment of data volumes uses measurements of core network throughput as described in clause 5.6.1.2.1 plus an assessment of data not counted within that measurement.

This annex details the additional information required.

These estimates shall be made over the specified time period used to assess KPI_{EM} (i.e. T_{KPI} subject to the allowed variation Δt specified in clause 5.5.1.4 and measurements shall be made in bits).

Telephony traffic

The following calls are included:

- local fixed calls (same metropolitan district);

- national fixed calls;

- international fixed calls;

- fixed to mobile calls;

- calls related to the Carrier Selection (CS) and Carrier Pre-Selection (CPS) services.

The total minutes are then transformed in Gbit through the following formula:

$$Traffic_{voice} = 77 \left[\text{kbits/s}\right] \times 60 \left[\text{s/minutes}\right] \times CALL_{\text{million minutes}}$$

where:

$Traffic_{voice}=$ data volume equivalent (Gbit) of total call time of the FAN served by each OS

$CALL_{million\ minutes} =$ total call time (in millions of minutes) over the FAN served by each OS

   NOTE 1: The "77 [kbit/s]" value comprises 64 kbit/s (the call) + 13 kbit/s (the signalling and framing overhead).

Data traffic

In addition to the total data measured at the NTE ports connected to the core network at a given OS, an estimate is made of the traffic that circulates within the FAN connected to that OS but does not pass on the core network.

Leased lines traffic

There are two main types of Leased Line (LL) services:

- LL services dedicated to other operators;

- residential LL services (dedicated to private customers and other companies).

Only the residential LL services are of interest since the other element is already included in the data traffic.

The actual data volume of the residential LL connections is unknown requiring an estimate to be made.

The following formula is used to calculate the annual traffic:

$$Traffic_{LL} = 0,05 \times T_{KPI} \times \sum_i \left(K_i \times LL_i\right)$$

where:

$Traffic_{LL} =$ data volume estimate (Gbit) of the residential LL connections of the FAN served by each OS operating a nominal data rate K (Gbit/s)

$i =$ index of LL connection data rate

K =   nominal speed of the LL connections (Gbit/s)

LL =   number of LL connections operating at nominal speed K

NOTE 2: The value 0,05 is a "utilization factor" and is considered a typical value found in data connections where the actual data transmitted is a small fraction of the channel capacity.

History

Document history		
V1.1.1	May 2018	Publication as ETSI ES 205 200-2-2
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