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Environmental Engineering (EE);
Energy Efficiency measurement methodology and metrics for Network Function Virtualisation (NFV)

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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Environmental Engineering (EE).

National transposition dates	
Date of adoption of this EN:	1 January 2019
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Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 October 2019
Date of withdrawal of any conflicting National Standard (dow):	31 October 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

The present document specifies the method and metrics to determine the energy efficiency of operational Network Function Virtualisation (NFV) applications and their associated infrastructure.

Any such implementation of NFV within the access network served is addressed by the general engineering and associated energy management KPIs of the access network itself as described in ETSI EN 305 200-2-2 [i.2], ETSI EN 305 200-2-3 [i.3] and ETSI GR NFV 001 [i.4].

1 Scope

The present document specifies the method and metrics to determine the energy efficiency of operational Network Function Virtualisation (NFV) applications and their associated infrastructure when that infrastructure is implemented outside the boundaries of the access fixed, cable and mobile networks which they serve.

The present document:

- Extends the Objective KPIs of ETSI EN 305 200-2-2 [i.2] (fixed access networks) and ETSI EN 305 200-2-3 [i.3] (mobile access networks) to assess the impact of NFV when applied to those networks as described in ETSI GR NFV 001 [i.4].
- Does not consider any assessment of energy saved by the implementation of NFV as there can be no time-stamped comparison of an operational infrastructure from which functions have been removed to a virtualized environment.

NOTE: In an ICT network (e.g. a fixed access network) comprising many Network Distribution Nodes (NDNs) with different loading levels it is not clear that there will always be an energy consumption benefit - the more relevant benefit being network and operational flexibility (such as reduced maintenance or increased reliability).

The present document:

- Does not address the operational energy efficiency of specific Information Technology Equipment (ITE) such as servers which may provide NFV facilities. Other ETSI EN documents (e.g. ETSI EN 303 470 [i.1]) have been prepared to address such factors.
- Does not specify any assessment of the overall effectiveness of an NFV implementation although it contains information in an informative annex regarding the technical milestones that would be required for this to be addressed in a future revision of the present document.

The KPIs specified are primarily intended for trend analysis - not to enable comparison between individual implementations of NFV unless the conditions of operation are "similar".

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/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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

[1] ETSI ES 202 336-12: "Environmental Engineering (EE); Monitoring and control interface for infrastructure equipment (power, cooling and building environment systems used in telecommunication networks); Part 12: ICT equipment power, energy and environmental parameters monitoring information model".

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 303 470: "Environmental Engineering (EE); Energy Efficiency measurement methodology and metrics for servers".

[i.2] 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.3] 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.4] ETSI GR NFV 001: "Network Functions Virtualisation (NFV); Use Cases".

[i.5] ETSI GS NFV 003: "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".

[i.6] ETSI GS NFV-TST 008: "Network Functions Virtualisation (NFV) Release 2; Testing; NFVI Compute and Network Metrics Specification".

[i.7] ISO/IEC 17788: "Information technology -- Cloud computing -- Overview and vocabulary".

[i.8] Mandate 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".

[i.9] CEN-CENELEC-ETSI (12-2011): "Framework Document for ESO Response to EU Mandate M/462".

NOTE: Available at https://portal.etsi.org/Portals/0/TBpages/ee/Docs/ESO%20response%20to%20M462%20phase%201%20.pdf.

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Base Station (BS): radio access network component which serves one or more radio cells and interfaces the user terminal (through air interface) and a wireless network infrastructure

Base Station (BS) site: Network Distribution Node (NDN) which accommodates a Base Station (BS)

Cloud Service Customer (CSC): entity responsible for operation of a network services for cloud service users to consume

NOTE: Source: ISO/IEC 17788 [i.7] modified.

Cloud Service Provider (CSP): entity which makes cloud services available

NOTE: Source: ISO/IEC 17788 [i.7] modified.

cloud service user: end user, or applications operating on their behalf, using cloud services

NOTE: Source: ISO/IEC 17788 [i.7] modified.

core network: functional elements (that is equipment and infrastructure) that enable communication between Operator Sites (OSs) or equivalent ICT sites

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

energy efficiency: relation between the useful output (telecom service, etc.) and energy consumption

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

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)

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: An NDC of a cable access network may be termed a master head-end.

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

NOTE: Where all the 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

NOTE: Source: ETSI GS NFV 003 [i.5].

Network Functions Virtualisation Infrastructure (NFVI): totality of all hardware and software components which build up the environment in which VNFs are deployed

NOTE: Source: ETSI GS NFV 003 [i.5] modified.

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 direct connection to, core and/or access networks

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 OS that is only connected to the core network is considered as a Network Data Centre (NDC).

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

Repeater (R): device with two RF ports, both of which are intended to be connected to antennas, which is capable of receiving, amplifying and transmitting simultaneously in one direction a signal in a base station's transmit band and in the other direction a signal in the corresponding base station's receive band

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

User Equipment (UE): device allowing user access to the services provided by the mobile access network

NOTE: Examples of user equipment include a mobile phone, tablet, data modem and connected devices such as meter or actuator.

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
$data\_volume_{NFVI}$	volume of data transported to and from the NFVI during an assessment period
EC_{NFVI}	energy consumption of NFVI during an assessment period
$KPI_{EE\text{-}transfer}$	KPI of NFVI energy efficiency based on data volume
T_{KPI}	period of time over which $KPI_{EE\text{-}transfer}$ is assessed
T_{REPEAT}	the time between which the KPI are assessed to determine relevant trend information

3.3 Abbreviations

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

BS	Base Station
CP	Customer Premises
CSC	Cloud Service Customer
CSP	Cloud Service Provider
FN	Fibre Node
HE	Head-End
ICT	Information and Communications Technology
ITE	Information Technology Equipment
KPI	Key Performance Indicator
LOC	Last Operator Connection point
LON	Last Operator Node
NDC	Network Data Centre
NDN	Network Distribution Node
NFV	Network Functions Virtualisation
NFVI	Network Functions Virtualisation Infrastructure
NIU	Network Interface Unit
NTE	Network Telecommunications Equipment
ODC	Operator Data Centre
OS	Operator Site
R	Repeater
TE	Terminal Equipment
UE	User Equipment

4 Network Function Virtualisation (NFV) configurations

4.1 Access network

Figure 1 shows schematics of the following access networks:

- fixed access network;
- cable access network;
- terrestrial and satellite mobile access networks.

Figure 1 has been updated since the original schematic included in the initial response [i.9] to the Mandate M/462 [i.8]. The original schematic and details of the changes are listed in annex A.

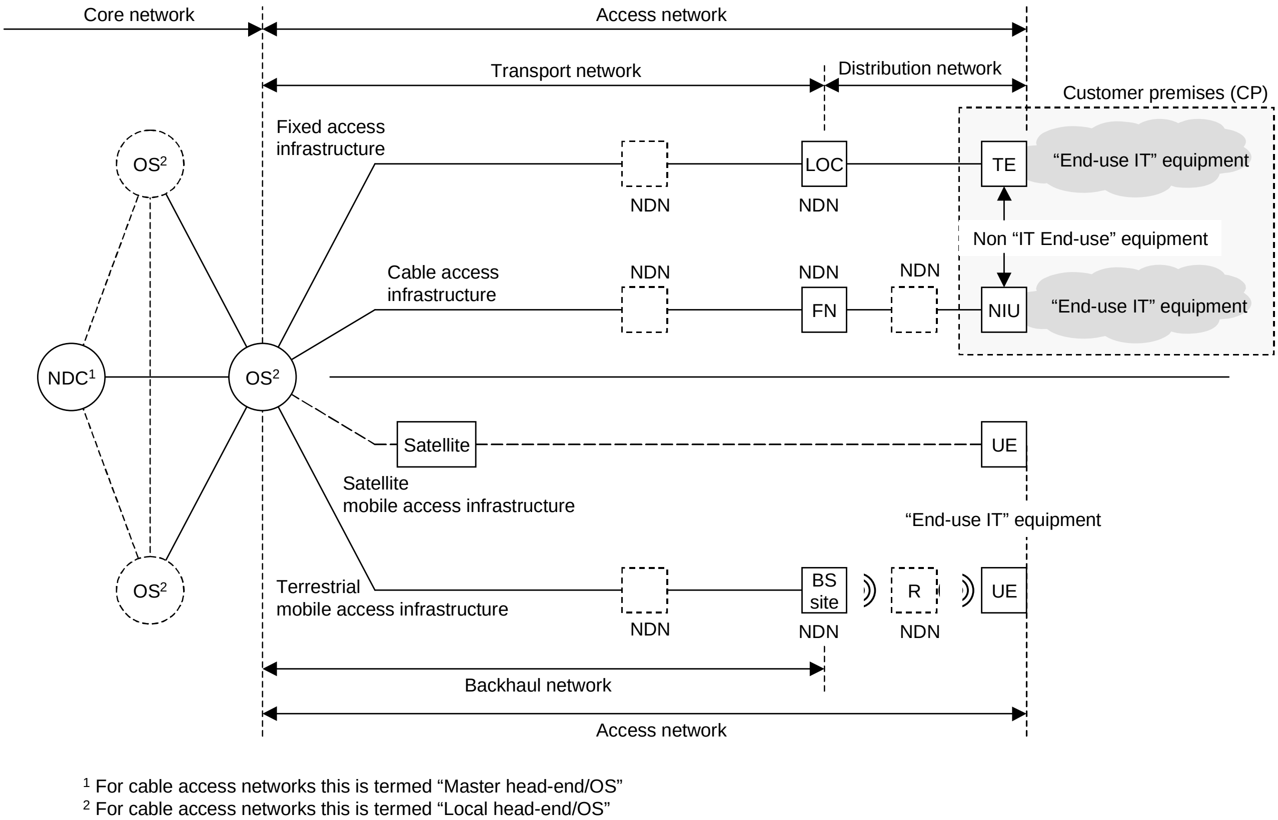

Figure 1: Updated schematic of fixed and mobile access networks

It is necessary to distinguish between the access provider, who is responsible for the design, operation and maintenance of the access network, and the service provider that provides the service carried to the subscriber by the access network. These two entities may be different. A given access network may support multiple service providers.

The Network Functions Virtualisation Infrastructure (NFVI) may be accommodated within a Network Data Centre (NDC), Operator Site (OS) or NDN under the common governance with the access network to which the functions apply or in 3rd party ICT sites or Customer Premises (CP).The roles within the NFV ecosystem are further designated as Cloud Service Provider (CSP) and Cloud Service Customer (CSC). In the context of the present document CSP will be concerned with the energy efficiency of the NFVI, while the CSC will be concerned with the energy efficiency of the NFV.

Figure 1 shows certain Network Distribution Nodes (NDNs) within dashed boxes to indicate that they are:

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

4.2 NFV and energy consumption

The virtualisation of network functions of fixed, mobile and cable access networks may provide an opportunity for improved energy management of those networks.

Use cases of NFV are described in ETSI GR NFV 001 [i.4].

The centralization of network functions within the hardware resources of an NFVI, comprising Information Technology Equipment (ITE) that is either general purpose or application-specific to those functions, results in potential reduction of energy consumption (as one of many possible operational advantages). However, in a given access network comprising many NDNs with different loading levels it is not clear that there will always be an energy consumption benefit - the more relevant benefit being network flexibility.

The NFV process removes energy consumption of NTE equipment at the OS and NDNs of the fixed and mobile access networks and relocates consumption to the NFVI. This would initially appear to result in improvement in the KPIs for energy management defined in ETSI EN 305 200-2-2 [i.2] and ETSI EN 305 200-2-3 [i.3].

However, ETSI EN 305 200-2-2 [i.2] and ETSI EN 305 200-2-3 [i.3] require the hardware resources of the NFVI to be accommodated in such a manner to allow its energy consumption to be measured (as is also required by the present document) and included in any assessment of the KPI of the access network.

5 NFV KPIs for energy efficiency

5.1 Energy efficiency based on data transfer ($KPI_{EE\text{-}transfer}$)

5.1.1 General

The present document specifies two variants of $KPI_{EE\text{-}transfer}$ ($KPI_{EE\text{-}bit\_transfer}$ and $KPI_{EE\text{-}packet\_transfer}$) which are measures of the data volume transferred to and from the NFVI per unit of energy consumed by the NFVI as shown schematically in Figure 2.

The determination of the effectiveness of such NFVI in effecting a reduction of energy consumption depend upon knowledge of the energy consumption of the NFVI and data volume transmitted and received by the NTE with the NFVI.

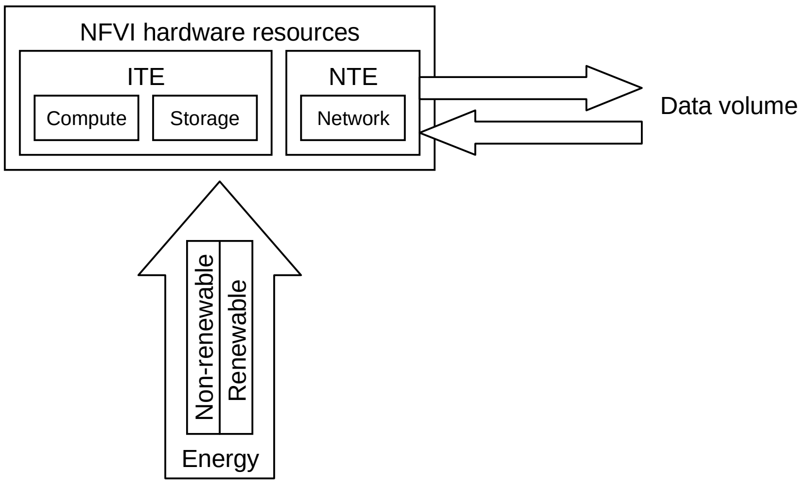

Figure 2: Schematic of $KPI_{EE\text{-}transfer}$

$KPI_{EE\text{-}bit\_transfer}$ and $KPI_{EE\text{-}packet\_transfer}$ do not take account of:

- the energy consumption involved in the transport of the data to and from the NFVI beyond the physical interface of Figure 2;

- the energy consumption of any processing of the data (e.g. routing, etc.) beyond the physical interface of Figure 2.

5.1.2 Data volume measured in bits

$KPI_{EE\text{-}bit\_transfer}$ is based on the data volume defined by the arithmetic sum of Layer 2 payload content of the number of successfully transmitted and received bits.

NOTE: This is founded on the Network-02 metric described in ETSI GS NFV-TST 008 [i.6].

5.1.3 Data volume measured in packets

$KPI_{EE\text{-}packet\_transfer}$ is based on the data volume defined by the arithmetic sum of successfully transmitted and received packets.

NOTE: This is founded on the Network-01 metric described in ETSI GS NFV-TST 008 [i.6].

5.2 NFV effectiveness

The approach of clause 5.1 does not assess the "effectiveness" of the NFV functions. The necessary milestones to achieve this are described in annex B.

6 Measurement conditions

6.1 General requirements

6.1.1 Measurement period

The energy consumption and data volume used to produce a value for the variant of $KPI_{EE\text{-}transfer}$ shall be measured as consumption or transfer of energy and data during a defined and common time period T_{KPI}.

If the NFVI supports multiple access networks then the consumption relevant to each access network shall be separately measurable if it is to be included with the access network KPIs of ETSI EN 305 200-2-2 [i.2] and ETSI EN 305 200-2-3 [i.3].

The measurement techniques or processes used for each parameter may not allow simultaneous commencement or completion of an assessment period. A time-spread parameter Δt is provided to allow such conditions. This is shown schematically in Figure 3.

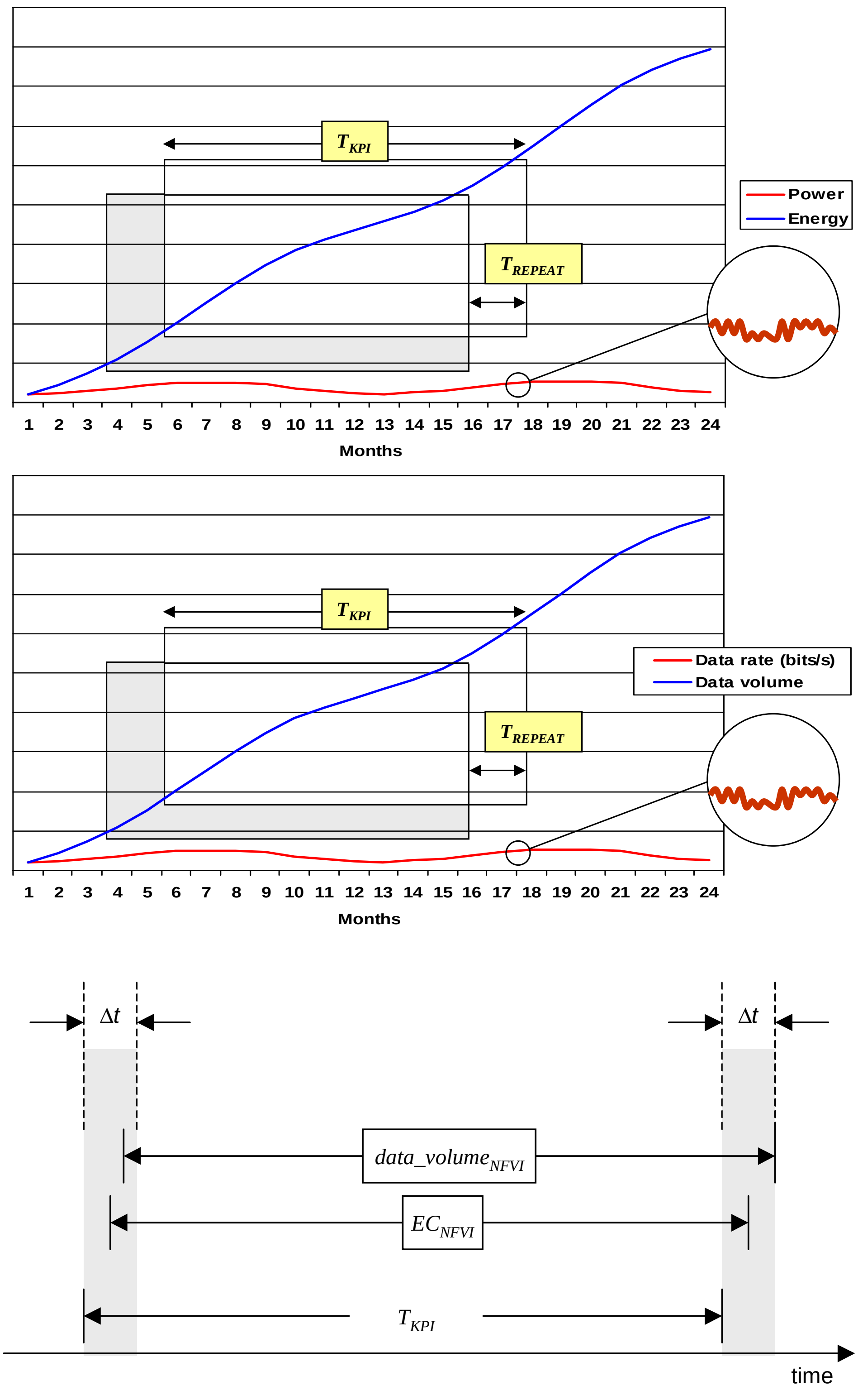

Figure 3: Schematic showing application of T_{KPI}, T_{REPEAT} and Δt

In order to obtain useful trend information the assessment periods should overlap. This is shown schematically in Figure 3. The time interval between which the parameters shall be re-assessed is defined as T_{REPEAT} which is bounded by a minimum (typically equal to Δt) and a maximum value. To provide the required trend profile and assessment period overlap, the maximum value of T_{REPEAT} shall be lower than T_{KPI}.

6.1.2 Detailed treatment of assessment periods

Figure 4 and the following text provides a detailed treatment of the content of clause 6.1.1.

The beginning of overall assessment period k is described as t_k^{begin}. The end of an overall assessment period k is described as $t_k^{end} = t_k^{begin} + T_{KPI}$.

Any subsequent assessment period, $k+1$, shall begin after a period T_{REPEAT} following t_k^{begin}.

The above concepts may be applied to a mean of the relevant time periods applied to EC_{NFVI}, $data\_volume(bit)_{NFVI}$ and $data\_volume(packet)_{NFVI}$. As shown in Figure 4**,** each measurement may start and finish at a slightly different time.

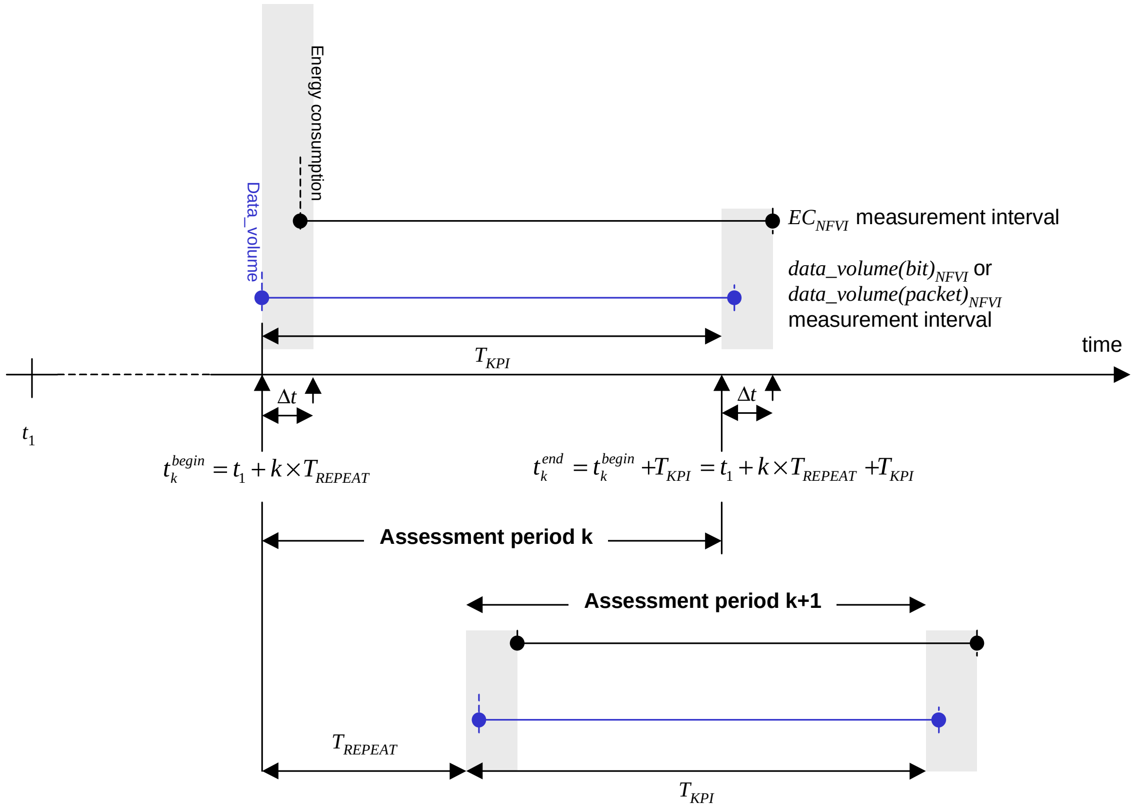

Figure 4: Detailed treatment of assessment timing

The default measurement period for T_{KPI} shall be 365 days. This is because:

- each NFVI 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 ICT equipment 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 NFVI.

Shorter measurement periods (subject to a minimum of 7 days) may be applied 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 access network for which the functions are being virtualized.

The NFVI and the network functions being virtualized shall not change during the measurement period. In case of change, a new measurement period shall be initiated. The period shall exclude any time during which engineering trials of energy efficiency measures are employed on a temporary basis.

In addition, and independent of the value of T_{KPI}:

- T_{REPEAT} shall be between one week and one calendar month;
- Δt shall be less than 2 % of T_{KPI}.

6.2 Renewable energy

The use of renewable energy is embedded within EC_{NFVI}. The energy supplied to the NFVI may meet all its energy needs from local, renewable (like solar or wind energy) sources on a continuous basis.

EC_{NFVI} takes account of renewable energy that is produced by:

a) sources dedicated to and directly serving the NFVI;

b) sources from which it is conveyed by the utility (grid) serving the NFVI.

NOTE 1: These sources may be an OS, NDC, NDN or a generator and may be under common governance with the access network served by the NFVI.

In the case of (b):

- the renewable energy shall not be included within EC_{NFVI} of the recipient site if it 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 2: 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 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;
- the loss produced by the utility (grid) shall be included at the recipient ICT site(s) and if losses are not otherwise specified, a default loss of 10 % shall be used.

NOTE 3: A power source producing 100 kW is assumed to deliver 90 kW to recipient ICT sites.

6.3 Measurement and test equipment

Power and energy consumption measurement methods and accuracy shall meet the requirements of ETSI ES 202 336-12 [1].

7 Measurement methods

7.1 Measurement method for $KPI_{EE\text{-}bit\_transfer}$ and $KPI_{EE\text{-}packet\_transfer}$

7.1.1 Definition of data volume

The actual throughput (total data volume) is the arithmetic sum of data transmitted and received across the physical interface(s) analysed and shall be measured based on the data volumes either as the amount in bits or number of packets as described in clauses 5.1.2 and 5.1.3 respectively.

7.1.2 Formulae

An assessment of $KPI_{KE\_transfer}$ requires that the energy supplied to the NFVI provides all the primary functions of the network (i.e. NTE load, environmental control, etc.).

$KPI_{EE\text{-}bit\_transfer}$ is defined mathematically as:

$$KPI_{EE-bit\_transfer} = \frac{data\_volume(bit)_{NFVI}}{EC_{NFVI}}$$, subject to a minimum value of 0.

$KPI_{EE\text{-}packet\_transfer}$ is defined mathematically as:

$$KPI_{EE-packet\_transfer} = \frac{data\_volume(packet)_{NFVI}}{EC_{NFVI}}$$, subject to a minimum value of 0.

7.1.3 Definition of terms

$data\_volume(bit)_{NFVI}$ = number of bits (or 8-bit bytes) within the Layer 2 payload successfully transmitted and received across the physical interface of the NFVI during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 6.1

$data\_volume(packet)_{NFVI}$ = number of packets successfully transmitted and received across the physical interface of the NFVI during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 6.1

EC_{NFVI} = energy consumption of the NFVI during the KPI assessment period k (in the interval t_k^{begin} to t_k^{end}) as described in detail in clause 6.1

NOTE: This measurement excludes the allowable renewable energy content described in clause 5.1.

8 Measurement report

The following shall be reported for the equipment for which the $KPI_{EE\_transfer}$ has been determined:

- a clear and unambiguous description of the NFVI;
- the reported value of $KPI_{EE\text{-}bit\_transfer}$ and/or $KPI_{EE\text{-}packet\_transfer}$;
- T_{KPI};
- T_{REPEAT};
- Δt.

Annex A (informative): History of network schematics

The response of the European Standards Organizations (December 2011) [i.9] to the European Commission in response to Mandate M/462 [i.8] (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.

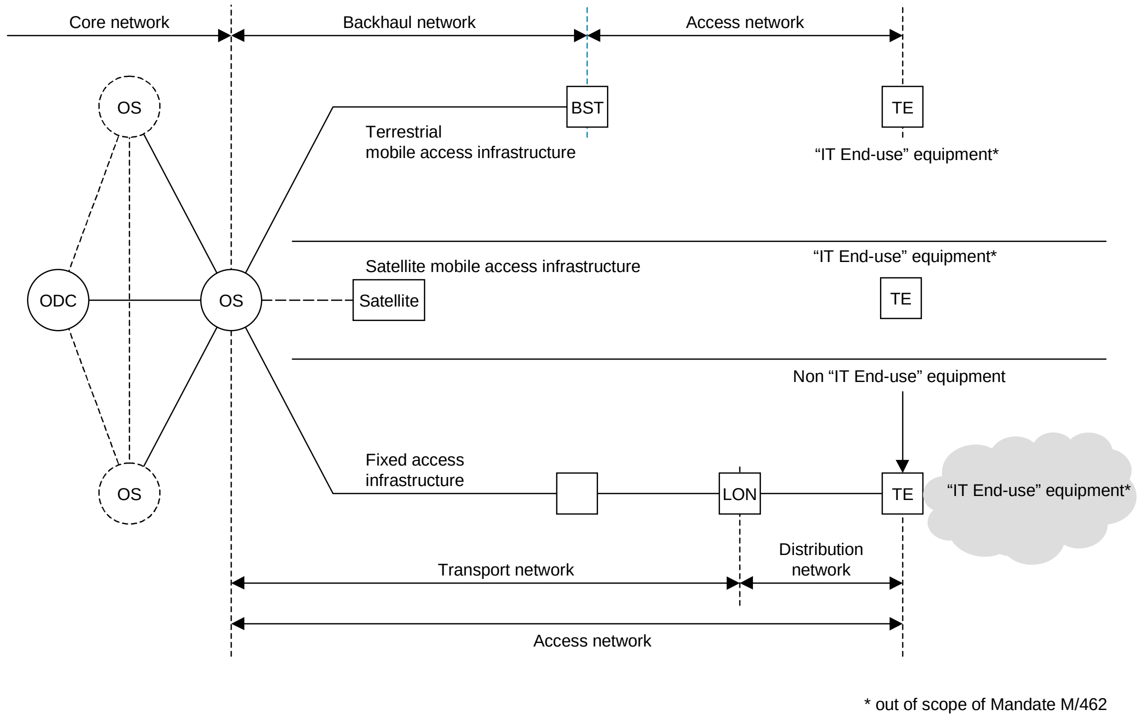

Figure A.1: Schematic of fixed and mobile communication networks (June 2011)

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 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 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 the CP is shown.

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

Annex B (informative): Milestones for NFV effectiveness

B.1 Introduction

NFV effectiveness is based on several factors:

- existence of excess capacity or capability;
- the ability to re-provision fixed hardware resources while maintaining services to the remaining activities sharing the same resources - enabling unassigned equipment to be placed in a low power (energy consumption mode);
- ability to scale such that elements of the pool can be treated equally.

Effectiveness of Virtualisation functions can be measured by the reduction of dedicated resources provisioned while being able to service the peak capacity or load from any one source. This means being able to perform logical to physical load shifts, while maintaining data and operational boundaries in logical form. Conversely, if peak provisioning and actual use is well correlated (e.g. little overhead), virtualized functions will demonstrate little to no energy benefit.

B.2 Assessment

For assessments, one should:

- determine if:
  - excess capacity or network capabilities are available (or needed in a redundancy case);
  - assessments can be conducted per logical location assessment (effectiveness at one logical location in the network);
  - there exists a common workload that replicates a typical consumption in the network;
  - establish a fixed size of the network for common comparison - one may wish to consider all other parts of the network as equal capability and compatible capabilities, but the assessment should be conducted modelled with at least node+1 (i.e. including another point for effective round trip transactions, full-duplex);
- define network activity to conducted that is representative of the typical transactions:
  - virtualized function and its proportion in typical transactions;
  - benchmark end to end transaction including encryption and database modification;
  - include bit failure rates and effective transactions;
- compare inactive power of dedicated equipment vs. overhead:
  - utilization comparison;
  - load impact changes;
  - IP address reassignments and data isolation;
  - do NOT assume time load shifts if these are not feasible and use peak load periods to develop "available" capacity assumptions:
    - ▪ unlike computing, network demands are not easily shifted and do not normally segregate batch mode transactions that are not time sensitive;

    - for a virtualized network, switching to a new VLAN is a feature to use when load exceeds a specific port or set of ports;
    - re-provisioning may, however, need to be scheduled or platooned - as such the time and sequence of events should be included in the assessment scenario for the virtualized function case.

For the evaluation of scalability and impact, the following steps can be employed:

- define scaling capacity scenario: bandwidth, number of ports, bandwidth per port, redundancy for failover;
- deployed power assessment of dedicated equipment vs. consolidated (virtualized functions + overhead):
    - provision based on peak load provisioning;
    - ensure virtualized functions are assumed operating at the same time as peak demand;
    - dedicated resources imply that peak demand will be supported on all ports, including any fail-over ports attached to a separate line (including failover and reassignment time for failover case);
- use multiple transactions (e.g. benchmarking cycles) to maximize the peak load assessments.

When developing the assessment scenario, the NFV activity should include:

- energy to re-provision;
- data transfer and transaction;
- energy not available to other provisioned activities.

The baseline to compare against is:

- dedicated device energy for transaction;
- inactive power (based on 50 % load).

B.3 Comparisons

To conduct the comparison:

- benchmark complete set of transactions that emulates the load expectations in scenarios above;
- benchmark standard communication activity and provisioning (e.g. boot, reboot if needed);
- compare energy expenditures (deployed power) in the dedicated provisioning and NFV enabled provisioned cases:
    - worst case loading;
    - fail-over case (if provisioned);
    - typical loading;
    - low loading (include platooning scenario, if NFV is configured to allow that to occur).

Although a single metric is not available today, the comparison provides sufficient information as to the effectiveness of the NFV function as deployed in scale. Monitoring utilization, response time and power levels could be used in combination with the offline assessment parameters to determine the energy effectiveness realized by NFV application.

History

Document history		
V1.0.0	October 2018	EN Approval Procedure AP 20190101: 2018-10-03 to 2019-01-01
V1.1.1	January 2019	Publication