

EN 303 471 V0.0.2 (2017-01)



**Energy efficiency measurement method and KPIs  
of Network Functions Virtualization (NFV) applications  
in ICT networks**

**SKELETON DRAFT 2**

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Reference

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Keywords

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 56 server) which are, or may be, or may become, essential to the present document.

## 57 Foreword

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

59 **The present document is**

60

National transposition dates	
Date of adoption of this EN:	1 October 2014
Date of latest announcement of this EN (doa):	31 January 2015
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 July 2015
Date of withdrawal of any conflicting National Standard (dow):	31 July 2015

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## 64 Modal verbs terminology

65 In the present document "shall", "shall not", "should", "should not", "may", "need not", "will", "will not", "can" and  
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67 provisions).

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## 70 Introduction

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

73 The present document extends the Objective KPIs of EN 305 200-2-2 (fixed access), EN 305-200-2-3 (mobile access)  
74 and EN 3050 200-2-4 (cable access networks) to assess the impact of NFV when applied to those networks as described  
75 in ETSI GS 003 [i.1].

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## 76 1 Scope

77 The present document specifies the method and metrics to determine the energy efficiency of Network Functions  
78 Virtualization (NFV) applications.

79 The present document extends the Objective KPIs of EN 305 200-2-2 (fixed access) and EN 305-200-2-3 (mobile  
80 access) when NFV is applied and to define the "boundaries" of such NFV implementations.

81 KPIs are also defined to determine the performances, in terms of energy efficiency, for the NFV applications..

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## 82 2 References

83 References are either specific (identified by date of publication and/or edition number or version number) or  
84 non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the  
85 referenced document (including any amendments) applies.

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89 their long term validity.

### 90 2.1 Normative references

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

92 EXAMPLE:

93 [1] ETSI EN 301 025-3: "<Title>".

94 EDITORS NOTE: during the development of the document see **xxxxxx**

### 95 2.2 Informative references

96 The following referenced documents are not necessary for the application of the present document but they assist the  
97 user with regard to a particular subject area.

98 [i.1] ETSI GS NFV 003: Network Functions Virtualisation (NFV); Terminology for Main Concepts in  
99 NFV

100 EDITORS NOTE: during the development of the document see xxxxxx

## 101 3 Definitions, symbols and abbreviations

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

### 104 3.1 Definitions

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

106 **base station (BS):** network distribution node (NDN) which serves one **or more** cells of a mobile access network [**from**  
 107 **EN 305 200-2-3**]

108 **customer premises (CP):** ??

109 **fibre node (FN):** [**from EN 305 200-2-4**]

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

111 NOTE: a combination of Information Technology Equipment and Network Telecommunications Equipment

112 **ICT site:** site containing structures or group of structures dedicated to the accommodation, interconnection and  
 113 operation of ICT equipment together with all the facilities and infrastructures for power distribution and environmental  
 114 control together with the necessary levels of resilience and security required to provide the desired service availability

115 **Information Technology Equipment (ITE):** equipment providing data storage, processing and transport services for  
 116 subsequent distribution by network telecommunications equipment (NTE)

117 **local head-end (HE):** [**from EN 305 200-2-4**]

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

120 **master head-end (HE):** [**from EN 305 200-2-4**]

121 **network data centre (NDC):** data centre embedded within the core network

122 NOTE: a network data centre of a cable access network may be termed a master head-end

123 **network distribution node (NDN):** grouping of NTE equipment within the boundaries of an access network providing  
 124 distribution of service from an operator site (OS)

125 NOTE: where all the network telecommunications equipment (NTE) at a given location is under common governance, any supporting infrastructure  
 126 for power distribution and environmental control together with the necessary levels of resilience and security required to provide the desired service  
 127 availability is included as part of the NDN

128 **network functions virtualisation (NFV):** principle of separating network functions from the hardware they run on by  
 129 using virtual hardware abstraction

130 **network functions virtualisation infrastructure (NFVI):** totality of all hardware and software components which  
 131 build up the environment in which VNFs are deployed

132 **network function virtualisation infrastructure (NFVI-Node) node:** physical device[s] deployed and managed as a  
 133 single entity, providing the NFVI Functions required to support the execution environment for virtualised network  
 134 functions

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

137 **network user interface (NUI):** [**from EN 305 200-2-4**]

138 **operator site (OS):** premises accommodating network telecommunications equipment (NTE) providing direct  
 139 connection to the core and access networks and which may also accommodate information technology equipment (ITE)

140 NOTE 1 to entry: an operator site that is only connected to the core network is considered as a network data centre

141 NOTE 2 to entry: an operator site of a cable access network may be termed a local head-end

142 **repeater:** device with two RF ports, both of which are intended to be connected to antennas, which is capable of  
 143 receiving, amplifying and transmitting simultaneously in one direction a signal in a BSS transmit band and in the other  
 144 direction a signal in the corresponding BSS receive band  
 145 [SOURCE: ETSI EN 301 489-50]

146 **terminal equipment (TE):** [??]

147 **user equipment (UE):** [from EN 305 200-2-3]

148 EDITORS NOTE: during the development of the document see xxxxxx

## 149 3.2 Symbols

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

151	$\Delta t$	the maximum time variation between measurement points of the different Objective KPIs within a
152		given Global KPI
153	$k$	assessment period index
154	$data\_volume_{NFVI}$	volume of data transported to and from the NFVI during an assessment period
155	$EC_{NFVI}$	energy consumption of NFVI during an assessment period
156	$KPI_{EE-transfer}$	KPI of NFVI energy efficiency based on data volume
157	$T_{KPI}$	period of time over which $KPI_{EE-transfer}$ is assessed
158	$T_{REPEAT}$	the time between which the KPI are assessed to determine relevant trend information
159		

## 160 3.3 Abbreviations

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

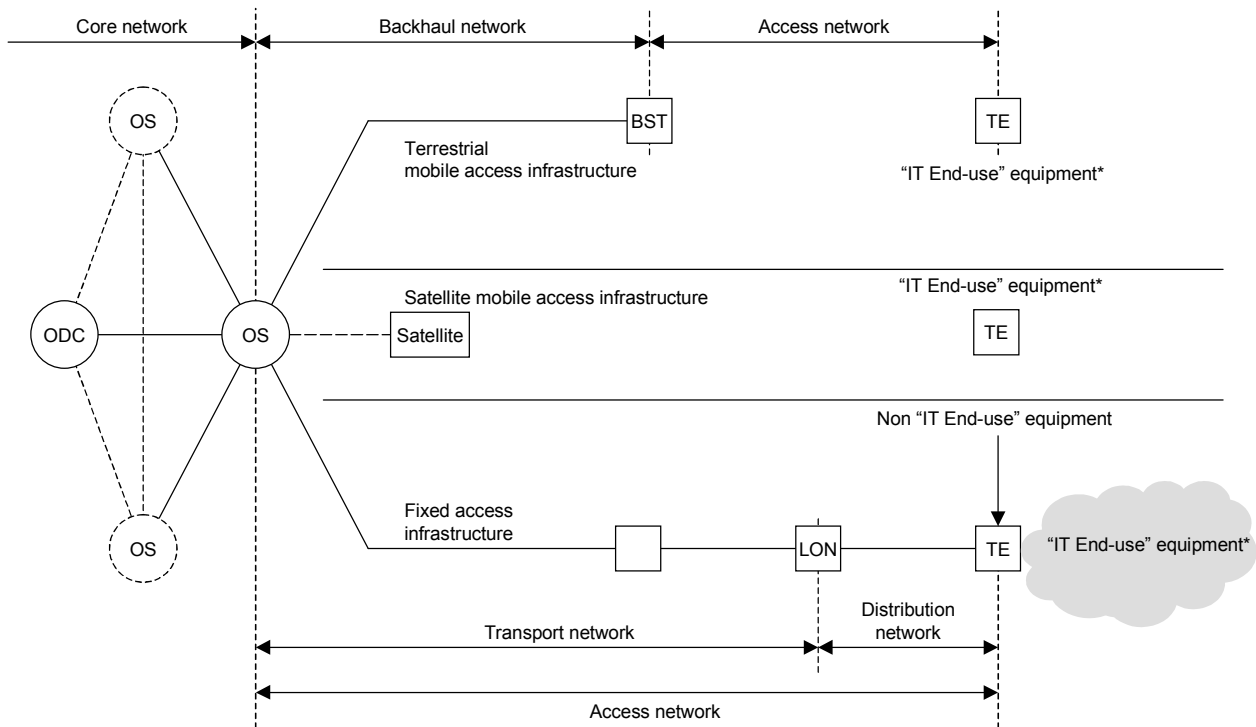
162	FN	Fibre Node
163	HE	Head-End
164	LOC	Last Operator Connection Point
165	ICT	Information and Communications Technology
166	ITE	Information Technology Equipment
167	NDC	Network Data Centre
168	NFV	Network Function Virtualisation
169	NFVI	Network Function Virtualisation Infrastructure
170	NFVI-Node	Network Function Virtualisation Infrastructure Node
171	NTE	Network Telecommunications Equipment
172	NUI	Network User Interface
173	OS	Operator Site
174	TE	Terminal Equipment
175	UE	User Equipment

176  
 177 EDITORS NOTE: during the development of the document see xxxxxx

## 178 4 NFV configurations

### 179 4.1 Access networks

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



\* out of scope of Mandate M/462

184

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

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

189 Within the fixed access networks in Figure 2, the term NDN is employed to describe a variety of aggregations of NTE  
190 at locations between the OS and the CP.

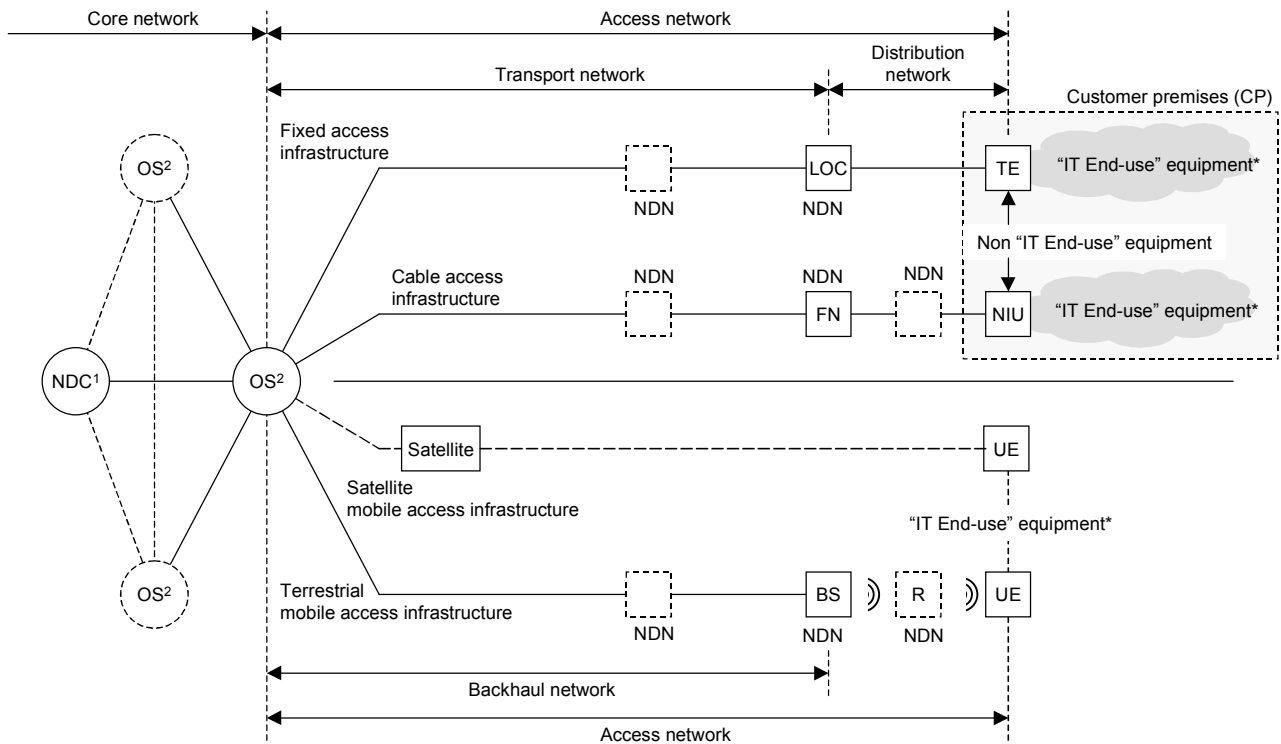
191 The principal changes for mobile access networks are that network distribution nodes (NDNs) are shown and the base  
192 station (BS) and repeater (R) are shown as specific examples of NDNs. Also user equipment (UE) has replaced  
193 terminal equipment (TE).

194 Within the mobile access network in Figure 2, the term NDN is employed to describe a variety of aggregations of NTE  
195 at locations between the operator site (OS) and the UE.

196 The principal changes for cable access networks are that customer premises (CP) and network distribution nodes  
197 (NDNs) are shown and the network interface unit (NIU) replaces the terminal equipment (TE).

198 Within the cable access network in Figure 2, the term NDN is employed to describe a variety of aggregations of NTE at  
199 locations between the local head-end (HE) and the NUI.





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

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

\* out of scope of Mandate M/462

200

201

**Figure 2 - Updated schematic of fixed and mobile communication networks**

202 For all access networks, the operator data centres (ODC) have been replaced by a network data centre (NDC) and  
 203 certain NDNs are shown within dashed boxes to indicate that they are:

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

## 206 4.2 Network Functional Virtualisation (NFV)

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

209 The network functions that may be virtualised include:

- 210 • xxx;  
 211 • yyy.

212 The centralisation of network functions within the hardware resources of a NFVI, comprising information technology  
 213 equipment (ITE) that is either general purpose or application-specific to those functions, results in potential reduction of  
 214 energy consumption (as one of many possible operational advantages). The NFV infrastructure (NFVI) may be  
 215 accommodated within the OS or NDC under the common governance with the access network to which the functions  
 216 apply or in 3<sup>rd</sup> party ICT sites or CP.

217 The NFV process removes energy consumption of NTE equipment at the OS and NDNs of the fixed, mobile and cable  
 218 access networks and relocates consumption to the NFVI. This would initially appear to result in improvement in the  
 219 KPIs for energy management defined in EN 305 200-2-2, EN 305 0200-2-3 and EN 305 200-2-4. However, those  
 220 standards requires the hardware resources of the NFVI to be accommodated in such a manner to allow its energy  
 221 consumption to be measured (as is required by this standard also) and included in any assessment of the KPI of the  
 222 access network.

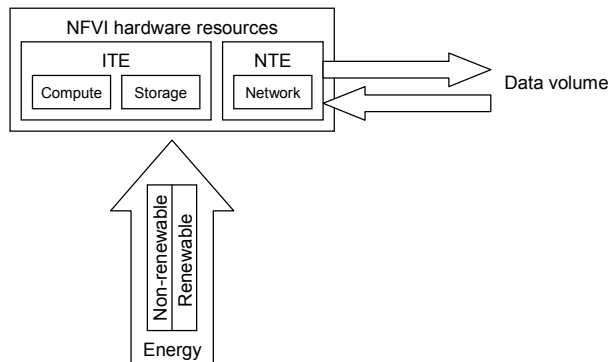
223 This document does not address the operational energy efficiency of specific ITE such as servers which may provide  
 224 NFV facilities. Other ETSI EN documents (e.g. EN 303 470) have been prepared to address such factors.

## 225 5 NFV KPIs for energy efficiency

### 226 5.1 Energy efficiency based on data transfer ( $KPI_{EE-transfer}$ )

227  $KPI_{EE-transfer}$  is a measure of the data volume transferred to and from the NFVI per unit of energy consumed by the  
228 NFVI.

229 The determination of the effectiveness of such NFVI in effecting a reduction of energy consumption depend upon  
230 knowledge of the energy consumption of the NFVI and data volume transmitted and received by the network  
231 telecommunications equipment associated (NTE) with the NFVI.



232

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Figure 3 - Schematic of  $KPI_{EE-transfer}$

## 234 6 Measurement conditions

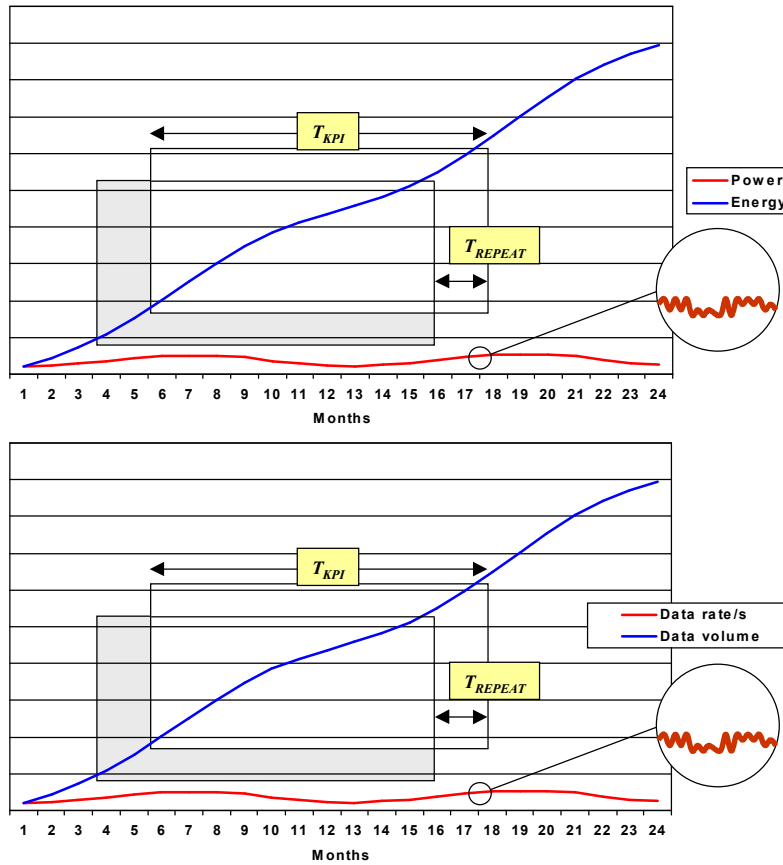
### 235 6.1 General requirements

#### 236 6.1.1 Measurement period

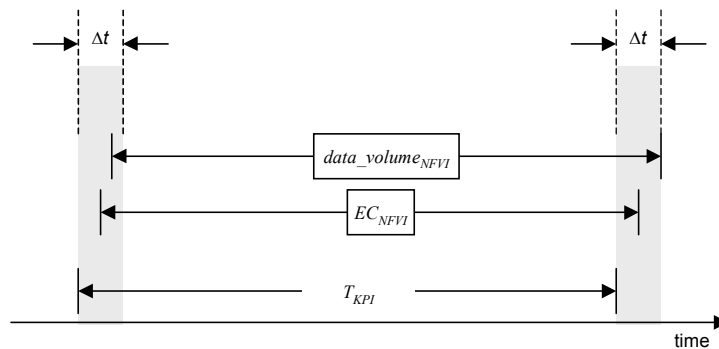
237 The energy consumption and data volume used to produce a value for a  $KPI_{KE-transfer}$  shall be measured as consumption  
238 or transfer of energy and data during a defined and common time period  $T_{KPI}$ .

239 The measurement techniques or processes used for each parameter may not allow simultaneous commencement or  
240 completion of an assessment period. A time-spread parameter  $\Delta t$  is provided to allow such conditions. This is shown  
241 schematically in Figure 4.

242 In order to obtain useful trend information the assessment periods should overlap. This is shown schematically in  
243 Figure 4. The time interval between which the parameters shall be re-assessed is defined as  $T_{REPEAT}$ , which is bounded  
244 by a minimum (typically equal to  $\Delta t$ ) and a maximum value. To provide the required trend profile and assessment  
245 period overlap, the maximum value of  $T_{REPEAT}$  shall be lower than  $T_{KPI}$ .



246



247

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Figure 4 - Schematic showing application of  $T_{KPI}$ ,  $T_{REPEAT}$  and  $\Delta t$

249 **6.1.2 Detailed treatment**

250 Figure 5 and the following text provides a detailed mathematical treatment of the content of clause ???.

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

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

254 The above concepts may be applied to a mean of the relevant time periods applied to  $EC_{NFVI}$  and  $data\_volume_{NFVI}$ . As  
 255 shown in Figure 5, each measurement may start and finish at a slightly different time.

256

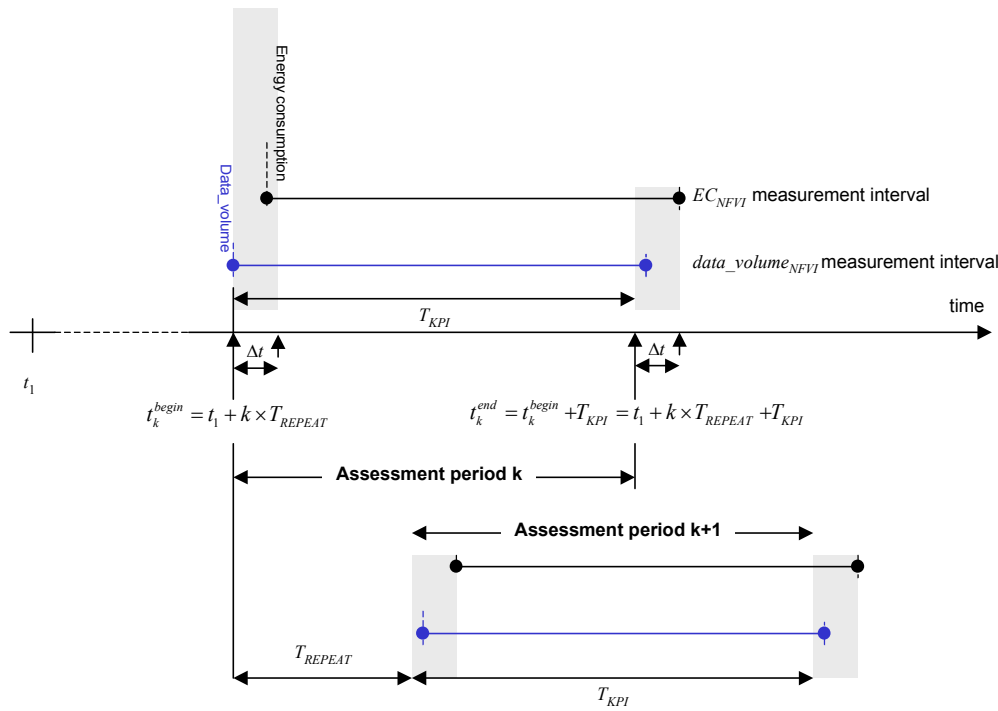


Figure 5 - Mathematical treatment of assessment timing

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

- 261 • each NFVI be subject to different environmental conditions which will affect the energy consumption required to
- 262 maintain the desired conditions for effective and long-term operation of the ICT equipment accommodated at those
- 263 locations;
- 264 • those environmental conditions may vary over time in a random manner due to their location and the construction
- 265 of the structure housing the NFVI.

266 Shorter measurement periods may be applied where seasonal climate variations are sufficiently small to enable the

267 measurement period to exhibit the equivalence to the default measurement period. In such cases, the period shall be

268 based upon the minimum period required to reflect annualised data throughput based on historical traffic patterns for the

269 access network for which the functions are being virtualised.

270 The NFVI and the network functions being virtualised shall not change during the measurement period. In case of

271 change a new measurement period shall be initiated. The period shall exclude any time during which engineering trials

272 of energy efficiency measures are employed on a temporary basis.

273 In addition:

- 274 •  $T_{REPEAT}$  shall be between one week and one calendar month;
- 275 •  $\Delta t$  shall be 7 days - by ensuring that the maximum variation is maintained with the required value of 7 days
- 276 whereas  $T_{KPI}$  is one year, the impact on the accuracy of the resulting KPI will be minimal. If improved accuracy is
- 277 required, or if  $T_{KPI}$  is reduced substantially from the default value, the value of  $\Delta t$  may be reduced.

## 278 6.2 Renewable energy

279 The use of renewable energy is embedded within  $EC_{NFVI}$ . The energy supplied to the NFVI may meet all its energy

280 needs from local, renewable (like solar or wind energy) sources on a continuous basis.

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

- 282 a) sources dedicated to and directly serving the NFVI;
- 283 b) sources from which it is conveyed by the utility (grid) serving the NFVI;

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

285 the NFVI.

286 NOTE 2: This does not, as yet, take into consideration any proportion of renewable electricity in the mix of production of utility supplies  
 287 certified as "green" (e.g. based on the carbon footprint of the energy source) by electricity suppliers or in accordance with  
 288 nationally recognised schemes.

289 In the case of (b), the renewable energy in  $EC_{NFVI}$  is counted as renewable energy at the recipient site provided that the  
 290 energy produced is not considered in the public mix and there is no feed-in contract. The portion of such energy  
 291 allocated to the (which) ICT site added to other ICT site consumptions shall not exceed the overall energy consumption  
 292 by the ICT site.

293 The loss produced by the utility (grid) shall be included at the recipient ICT site(s). If losses are not otherwise  
 294 specified, a default loss of 10 % shall be used.

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

## 296 6.3 Measurement and test equipment

297 The measurement of the energy consumption shall be performed by either measuring the power supply voltage and true  
 298 effective current in parallel and calculate the resulting energy consumption (applicable only for DC) or with a wattmeter  
 299 (applicable for both AC and DC). The measurements can be performed by a variety of measurement equipment,  
 300 including power clamps, or power supplies with in-built power measurement capability.

301 All measurement equipment shall be calibrated and shall have data output interface in order to allow long term data  
 302 recording and calculation of the complete energy consumption over a dedicated time.

303 The measurement equipment shall comply with following attributes:

- 304 • Input power:
  - 305 - Resolution:  $\leq 10$  mA;  $\leq 100$  mV;  $\leq 100$  mW;
  - 306 - DC current:  $\pm 1\%$ ;
  - 307 - DC voltage:  $\pm 1\%$ ;
  - 308 - AC power:  $\pm 1\%$ :
    - 309 ▪ an available current crest factor of 5 or more;
    - 310 ▪ the test instrument shall have a bandwidth of at least 1 kHz;
- 311 NOTE: Additional information on accuracy can be found in EN 62018 [Error! Reference source not found.].
- 312 • RF output power:  $\pm 0,4$ dB.

313 If the power consumption measurements are done remotely via built-in measurement equipment they shall fulfil the  
 314 requirements specified in ES 202 336-12 [1].

---

## 315 7 Measurement methods

### 316 7.1 Measurement method for $KPI_{EE-transfer}$

#### 317 7.1.1 Definition of data volume

318 The actual throughput (total data volume) shall be measured based on the number of downlink (DL) data volume sent  
 319 to the user equipments (UEs). Peak and average throughput shall be measured and reported as well as BS utilisation  
 320 data.

#### 321 7.1.2 Formulae

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

325  $KPI_{EM}$  is defined mathematically as:

326 
$$KPI_{EE\_transfer} = \frac{data\_volume_{NFVI}}{EC_{NFVI}}, \text{ subject to a minimum value of 0.}$$

327 This is shown schematically in Figure 6.

328 **Figure 6 - Schematic of  $KPI_{EM}$  calculation and drivers**  
329

### 330 7.1.2.1 Definition of terms

331  $data\_volume_{NFVI} =$  ??during the KPI assessment period  $k$  (in the interval  $t_k^{begin}$  to  $t_k^{end}$ ) as described in detail in Annex  
332 A

333  $EC_{NFVI} =$  ?? during the KPI assessment period  $k$  (in the interval  $t_k^{begin}$  to  $t_k^{end}$ ) as described in detail in Annex  
334 A

### 335 7.1.2.2 Clarity

### 336 7.1.2.3 Criteria

---

## 337 8 Measurement report

338

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339 **Annex A: Items for consideration**

340 **A.1 Real-time measurements**

341 Measurements and methodology Indicating load on NFVI

342 **A.2.1 ???????**

343

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344 Other annexes (as required)

345

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346 History

<b>Document history</b>		
<Version>	<Date>	<Milestone>
V0.0.1	22/09/2016	Skeleton
V0.0.2	01/01/2017	Skeleton draft 2

347



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 53 server) which are, or may be, or may become, essential to the present document.

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## 54 Foreword

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

56 **The present document is**

57

National transposition dates	
Date of adoption of this EN:	1 October 2014
Date of latest announcement of this EN (doa):	31 January 2015
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 July 2015
Date of withdrawal of any conflicting National Standard (dow):	31 July 2015

58

59

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## 61 Modal verbs terminology

62 In the present document "shall", "shall not", "should", "should not", "may", "need not", "will", "will not", "can" and  
63 "cannot" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of  
64 provisions).

65  
66 "must" and "must not" are NOT allowed in ETSI deliverables except when used in direct citation.

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## 67 Introduction

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

70 The present document extends the Objective KPIs of EN 305 200-2-2 (fixed access networks) [i.1], EN 305-200-2-3  
71 [i.2] (mobile access networks) and EN 305 200-2-4 [i.3] (cable access networks) to assess the impact of NFV when  
72 applied to those networks as described in ETSI GS 003 [i.4].

---

## 73 1 Scope

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

76 The present document extends the Objective KPIs of EN 305 200-2-2 (fixed access networks) [i.1], EN 305-200-2-3  
77 [i.2] (mobile access networks) and EN 305 200-2-4 [i.3] (cable access networks) to assess the impact of NFV when  
78 applied to those networks as described in ETSI GS 003 [i.4].

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## 79 2 References

80 References are either specific (identified by date of publication and/or edition number or version number) or  
81 non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the  
82 referenced document (including any amendments) applies.

83 Referenced documents which are not found to be publicly available in the expected location might be found at  
84 <http://docbox.etsi.org/Reference>.

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

### 87 2.1 Normative references

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

89 EXAMPLE:

90 [1] ETSI EN 301 025-3: "<Title>".

91 EDITORS NOTE: during the development of the document see **xxxxxx**

### 92 2.2 Informative references

93 The following referenced documents are not necessary for the application of the present document but they assist the  
94 user with regard to a particular subject area.

95 [i.1] ETSI EN 305 200-2-2: Energy management: Operational infrastructures: Global KPIs - Part 2:  
96 Specific requirements - Sub-part 2: Fixed access networks

97	[i.2]	ETSI EN 305 200-2-3: Energy management: Operational infrastructures: Global KPIs - Part 2:
98		Specific requirements - Sub-part 3: Mobile access networks
99	[i.3]	ETSI EN 305 200-2-4: Energy management: Operational infrastructures: Global KPIs - Part 2:
100		Specific requirements - Sub-part 4: Cable access networks
101	[i.1]	ETSI GS NFV 003: Network Functions Virtualisation (NFV); Terminology for Main Concepts in
102		NFV
103	EDITORS NOTE: during the development of the document see <b>xxxxxx</b>	

## 104 3 Definitions, symbols and abbreviations

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

### 107 3.1 Definitions

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

109 **base station (BS):** network distribution node (NDN) which serves one **or more** cells of a mobile access network [**from**  
 110 **EN 305 200-2-3**]

111 **customer premises (CP):** ??

112 **fibre node (FN):** [**from EN 305 200-2-4**]

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

114 NOTE: a combination of Information Technology Equipment and Network Telecommunications Equipment

115 **ICT site:** site containing structures or group of structures dedicated to the accommodation, interconnection and  
 116 operation of ICT equipment together with all the facilities and infrastructures for power distribution and environmental  
 117 control together with the necessary levels of resilience and security required to provide the desired service availability

118 **Information Technology Equipment (ITE):** equipment providing data storage, processing and transport services for  
 119 subsequent distribution by network telecommunications equipment (NTE)

120 **local head-end (HE):** [**from EN 305 200-2-4**]

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

123 **master head-end (HE):** [**from EN 305 200-2-4**]

124 **network data centre (NDC):** data centre embedded within the core network

125 NOTE: a network data centre of a cable access network may be termed a master head-end

126 **network distribution node (NDN):** grouping of NTE equipment within the boundaries of an access network providing  
 127 distribution of service from an operator site (OS)

128 NOTE: where all the network telecommunications equipment (NTE) at a given location is under common governance, any supporting infrastructure  
 129 for power distribution and environmental control together with the necessary levels of resilience and security required to provide the desired service  
 130 availability is included as part of the NDN

131 **network functions virtualisation (NFV):** principle of separating network functions from the hardware they run on by  
 132 using virtual hardware abstraction

133 **network functions virtualisation infrastructure (NFVI):** totality of all hardware and software components which  
 134 build up the environment in which VNFs are deployed

135 **network function virtualisation infrastructure (NFVI-Node) node:** physical device[s] deployed and managed as a  
 136 single entity, providing the NFVI Functions required to support the execution environment for virtualised network  
 137 functions

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

140 **network user interface (NUI):** [from EN 305 200-2-4]

141 **operator site (OS):** premises accommodating network telecommunications equipment (NTE) providing direct  
 142 connection to the core and access networks and which may also accommodate information technology equipment (ITE)

143 NOTE 1 to entry: an operator site that is only connected to the core network is considered as a network data centre

144 NOTE 2 to entry: an operator site of a cable access network may be termed a local head-end

145 **repeater:** device with two RF ports, both of which are intended to be connected to antennas, which is capable of  
 146 receiving, amplifying and transmitting simultaneously in one direction a signal in a BSS transmit band and in the other  
 147 direction a signal in the corresponding BSS receive band

148 [SOURCE: ETSI EN 301 489-50]

149 **terminal equipment (TE):** [??]

150 **user equipment (UE):** [from EN 305 200-2-3]

151 EDITORS NOTE: during the development of the document see xxxxxx

## 152 3.2 Symbols

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

154	$\Delta t$	the maximum time variation between measurement points of the different Objective KPIs within a
155		given Global KPI
156	$k$	assessment period index
157	$data\_volume_{NFVI}$	volume of data transported to and from the NFVI during an assessment period
158	$EC_{NFVI}$	energy consumption of NFVI during an assessment period
159	$KPI_{EE-transfer}$	KPI of NFVI energy efficiency based on data volume
160	$T_{KPI}$	period of time over which $KPI_{EE-transfer}$ is assessed
161	$T_{REPEAT}$	the time between which the KPI are assessed to determine relevant trend information
162		

## 163 3.3 Abbreviations

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

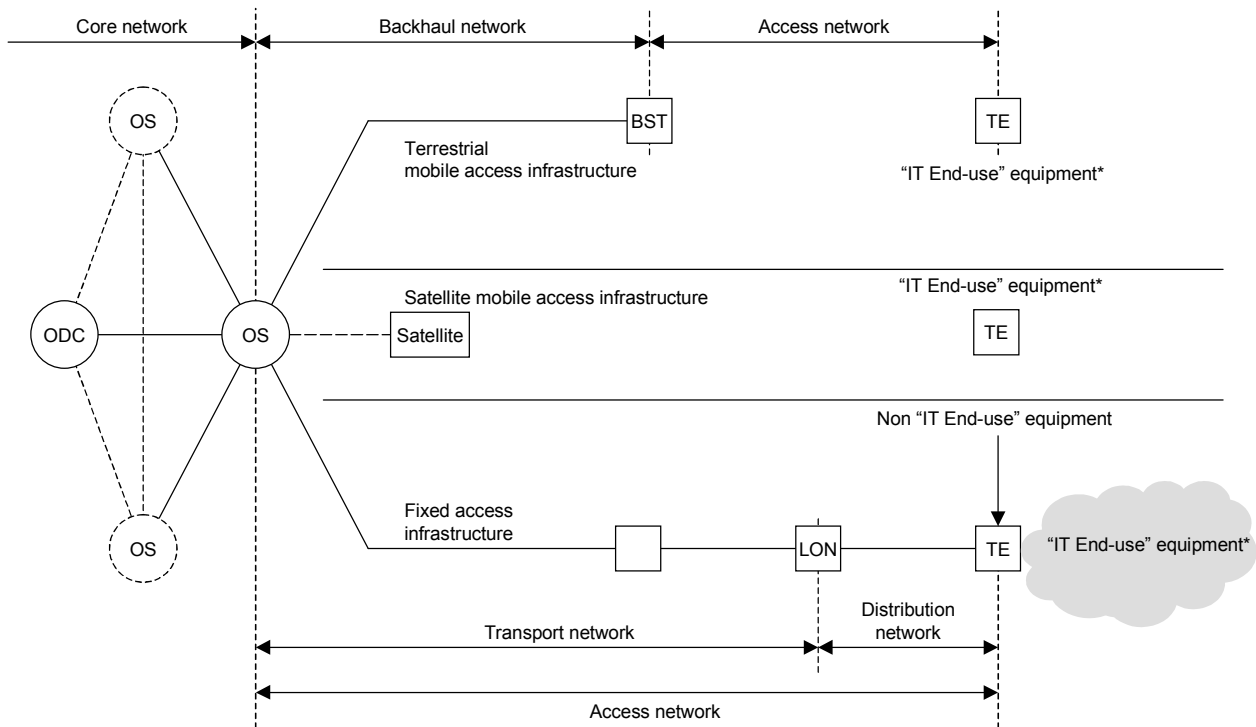
165	FN	Fibre Node
166	HE	Head-End
167	LOC	Last Operator Connection Point
168	ICT	Information and Communications Technology
169	ITE	Information Technology Equipment
170	NDC	Network Data Centre
171	NFV	Network Function Virtualisation
172	NFVI	Network Function Virtualisation Infrastructure
173	NFVI-Node	Network Function Virtualisation Infrastructure Node
174	NTE	Network Telecommunications Equipment
175	NUI	Network User Interface
176	OS	Operator Site
177	TE	Terminal Equipment
178	UE	User Equipment
179		

180 EDITORS NOTE: during the development of the document see xxxxxx

## 181 4 NFV configurations

### 182 4.1 Access networks

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



\* out of scope of Mandate M/462

187

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

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

192 Within the fixed access networks in Figure 2, the term NDN is employed to describe a variety of aggregations of NTE  
193 at locations between the OS and the CP.

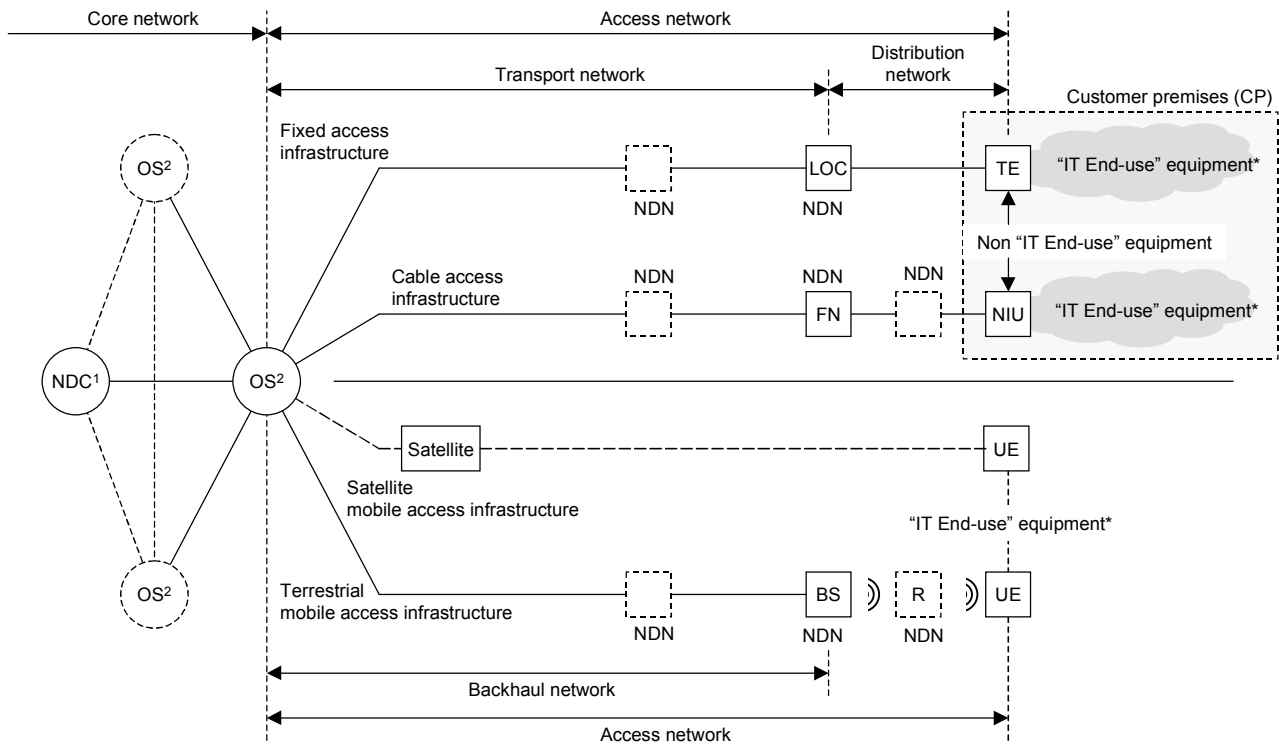
194 The principal changes for mobile access networks are that network distribution nodes (NDNs) are shown and the base  
195 station (BS) and repeater (R) are shown as specific examples of NDNs. Also user equipment (UE) has replaced  
196 terminal equipment (TE).

197 Within the mobile access network in Figure 2, the term NDN is employed to describe a variety of aggregations of NTE  
198 at locations between the operator site (OS) and the UE.

199 The principal changes for cable access networks are that customer premises (CP) and network distribution nodes  
200 (NDNs) are shown and the network interface unit (NIU) replaces the terminal equipment (TE).

201 Within the cable access network in Figure 2, the term NDN is employed to describe a variety of aggregations of NTE at  
202 locations between the local head-end (HE) and the NUI.





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

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

\* out of scope of Mandate M/462

203

204

**Figure 2 - Updated schematic of fixed and mobile communication networks**

205 For all access networks, the operator data centres (ODC) have been replaced by a network data centre (NDC) and  
 206 certain NDNs are shown within dashed boxes to indicate that they are:

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

## 209 4.2 Network Functional Virtualisation (NFV)

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

212 The network functions that may be virtualised include:

- 213 • xxx;  
 214 • yyy.

215 The centralisation of network functions within the hardware resources of a NFVI, comprising information technology  
 216 equipment (ITE) that is either general purpose or application-specific to those functions, results in potential reduction of  
 217 energy consumption (as one of many possible operational advantages). The NFV infrastructure (NFVI) may be  
 218 accommodated within the OS or NDC under the common governance with the access network to which the functions  
 219 apply or in 3<sup>rd</sup> party ICT sites or CP.

220 The NFV process removes energy consumption of NTE equipment at the OS and NDNs of the fixed, mobile and cable  
 221 access networks and relocates consumption to the NFVI. This would initially appear to result in improvement in the  
 222 KPIs for energy management defined in EN 305 200-2-2, EN 305 0200-2-3 and EN 305 200-2-4. However, those  
 223 standards requires the hardware resources of the NFVI to be accommodated in such a manner to allow its energy  
 224 consumption to be measured (as is required by this standard also) and included in any assessment of the KPI of the  
 225 access network.

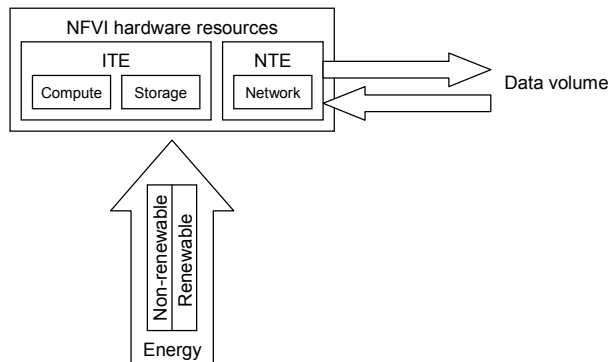
226 This document does not address the operational energy efficiency of specific ITE such as servers which may provide  
 227 NFV facilities. Other ETSI EN documents (e.g. EN 303 470) have been prepared to address such factors.

## 228 5 NFV KPIs for energy efficiency

### 229 5.1 Energy efficiency based on data transfer ( $KPI_{EE-transfer}$ )

230  $KPI_{EE-transfer}$  is a measure of the data volume transferred to and from the NFVI per unit of energy consumed by the NFVI  
 231 as shown schematically in Figure 3

232 The determination of the effectiveness of such NFVI in effecting a reduction of energy consumption depend upon  
 233 knowledge of the energy consumption of the NFVI and data volume transmitted and received by the network  
 234 telecommunications equipment associated (NTE) with the NFVI.



235

236

Figure 3 - Schematic of  $KPI_{EE-transfer}$

## 237 6 Measurement conditions

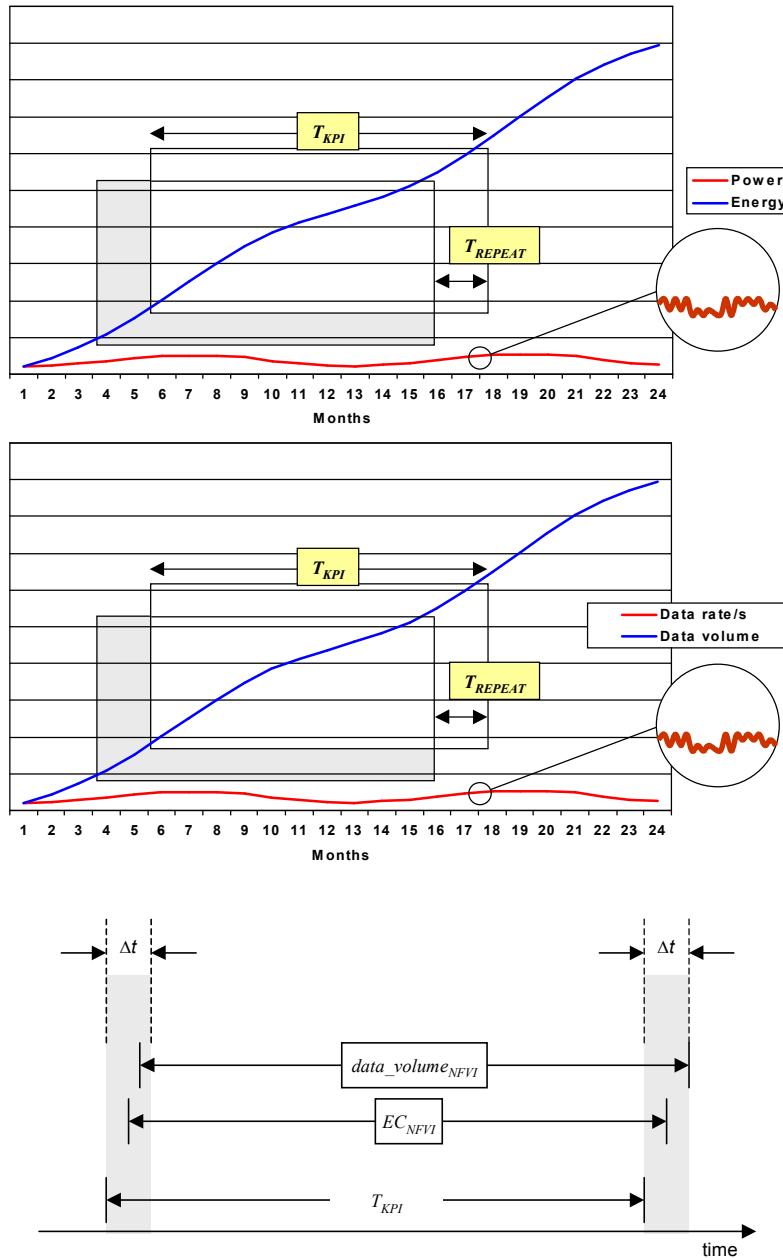
### 238 6.1 General requirements

#### 239 6.1.1 Measurement period

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

242 The measurement techniques or processes used for each parameter may not allow simultaneous commencement or  
 243 completion of an assessment period. A time-spread parameter  $\Delta t$  is provided to allow such conditions. This is shown  
 244 schematically in Figure 4.

245 In order to obtain useful trend information the assessment periods should overlap. This is shown schematically in  
 246 Figure 4. The time interval between which the parameters shall be re-assessed is defined as  $T_{REPEAT}$ , which is bounded  
 247 by a minimum (typically equal to  $\Delta t$ ) and a maximum value. To provide the required trend profile and assessment  
 248 period overlap, the maximum value of  $T_{REPEAT}$  shall be lower than  $T_{KPI}$ .



249

250

251

Figure 4 - Schematic showing application of  $T_{KPI}$ ,  $T_{REPEAT}$  and  $\Delta t$

### 252 6.1.2 Detailed treatment

253 Figure 5 and the following text provides a detailed mathematical treatment of the content of sub-clause 6.1.1.

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

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

257 The above concepts may be applied to a mean of the relevant time periods applied to  $EC_{NFVI}$  and  $data\_volume_{NFVI}$ . As  
 258 shown in Figure 5, each measurement may start and finish at a slightly different time.

259

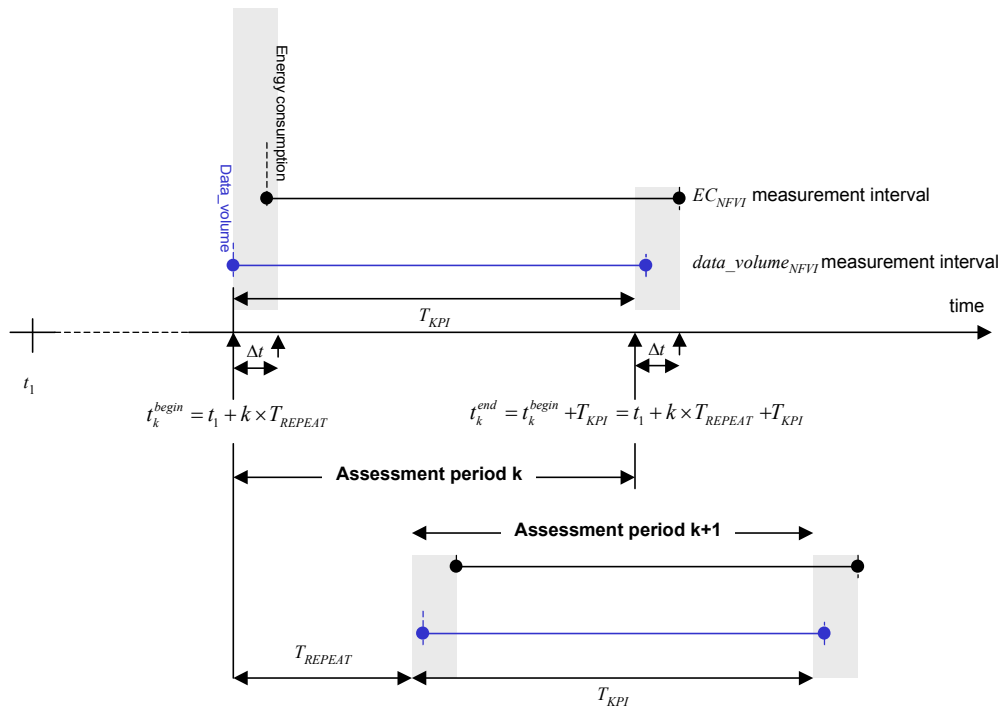


Figure 5 - Mathematical treatment of assessment timing

260

261

262

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

- 264 • each NFVI be subject to different environmental conditions which will affect the energy consumption required to
- 265 maintain the desired conditions for effective and long-term operation of the ICT equipment accommodated at those
- 266 locations;
- 267 • those environmental conditions may vary over time in a random manner due to their location and the construction
- 268 of the structure housing the NFVI.

269 Shorter measurement periods may be applied where seasonal climate variations are sufficiently small to enable the  
 270 measurement period to exhibit the equivalence to the default measurement period. In such cases, the period shall be  
 271 based upon the minimum period required to reflect annualised data throughput based on historical traffic patterns for the  
 272 access network for which the functions are being virtualised.

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

276 In addition:

- 277 •  $T_{REPEAT}$  shall be between one week and one calendar month;
- 278 •  $\Delta t$  shall be 7 days - by ensuring that the maximum variation is maintained with the required value of 7 days
- 279 whereas  $T_{KPI}$  is one year, the impact on the accuracy of the resulting KPI will be minimal. If improved accuracy is
- 280 required, or if  $T_{KPI}$  is reduced substantially from the default value, the value of  $\Delta t$  may be reduced.

## 281 6.2 Renewable energy

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

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

- 285 a) sources dedicated to and directly serving the NFVI;
- 286 b) sources from which it is conveyed by the utility (grid) serving the NFVI;

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

289 NOTE 2: This does not, as yet, take into consideration any proportion of renewable electricity in the mix of production of utility supplies  
 290 certified as "green" (e.g. based on the carbon footprint of the energy source) by electricity suppliers or in accordance with  
 291 nationally recognised schemes.

292 In the case of (b), the renewable energy in  $EC_{NFVI}$  is counted as renewable energy at the recipient site provided that the  
 293 energy produced is not considered in the public mix and there is no feed-in contract. The portion of such energy  
 294 allocated to the (which) ICT site added to other ICT site consumptions shall not exceed the overall energy consumption  
 295 by the ICT site.

296 The loss produced by the utility (grid) shall be included at the recipient ICT site(s). If losses are not otherwise  
 297 specified, a default loss of 10 % shall be used.

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

## 299 6.3 Measurement and test equipment

300 The measurement of the energy consumption shall be performed by either measuring the power supply voltage and true  
 301 effective current in parallel and calculate the resulting energy consumption (applicable only for DC) or with a wattmeter  
 302 (applicable for both AC and DC). The measurements can be performed by a variety of measurement equipment,  
 303 including power clamps, or power supplies with in-built power measurement capability.

304 All measurement equipment shall be calibrated and shall have data output interface in order to allow long term data  
 305 recording and calculation of the complete energy consumption over a dedicated time.

306 The measurement equipment shall comply with following attributes:

- 307 • Input power:
  - 308 - Resolution:  $\leq 10$  mA;  $\leq 100$  mV;  $\leq 100$  mW;
  - 309 - DC current:  $\pm 1\%$ ;
  - 310 - DC voltage:  $\pm 1\%$ ;
  - 311 - AC power:  $\pm 1\%$ :
    - 312 ▪ an available current crest factor of 5 or more;
    - 313 ▪ the test instrument shall have a bandwidth of at least 1 kHz;
- 314 NOTE: Additional information on accuracy can be found in EN 62018 [Error! Reference source not found.].
- 315 • RF output power:  $\pm 0,4$ dB.

316 If the power consumption measurements are done remotely via built-in measurement equipment they shall fulfil the  
 317 requirements specified in ES 202 336-12 [1].

---

## 318 7 Measurement methods

### 319 7.1 Measurement method for $KPI_{EE-transfer}$

#### 320 7.1.1 Definition of data volume

321 The actual throughput (total data volume) shall be measured based on the number of downlink (DL) data volume sent  
 322 to the user equipments (UEs). Peak and average throughput shall be measured and reported as well as BS utilisation  
 323 data.

#### 324 7.1.2 Formulae

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

328  $KPI_{EM}$  is defined mathematically as:

$$329 KPI_{EE\_transfer} = \frac{data\_volume_{NFVI}}{EC_{NFVI}}, \text{ subject to a minimum value of 0.}$$

330 7.1.2.1 Definition of terms

331  $data\_volume_{NFVI}$  = volume of data transported to and from the NFVI during the KPI assessment period  $k$  (in the  
332 interval  $t_k^{begin}$  to  $t_k^{end}$ ) as described in detail in sub-clause 6.1

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

335 NOTE: this measurement excludes the allowable renewable energy content described in sub-clause 5.1

336 7.1.2.2 Clarity

337 7.1.2.3 Criteria

---

338 **8 Measurement report**

339

---

340 **Annex A: Items for consideration**

341 **A.1 Real-time measurements**

342 Measurements and methodology Indicating load on NFVI

343 **A.2.1 ???????**

344

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345 Other annexes (as required)

346

---

347 **History**

<b>Document history</b>		
<Version>	<Date>	<Milestone>
V0.0.1	22/09/2016	Skeleton
V0.0.2	01/01/2017	Skeleton draft 2

348