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| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group TSG SA;  Study on Energy Efficiency as a service criteria  (Release 19) | |
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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document provides stage 1 use cases and potential 5G requirements on the following aspects regarding enhancements to Energy Efficiency of 5G network and application service enabler aspects:

- Defining and supporting energy efficiency criteria as part of communication service to user and application services;

- Supporting information exposure of systematic energy consumption or level of energy efficiency to vertical customers;

- Gap analysis between the identified potential requirements and existing 5GS requirements or functionalities;

- Potential requirements on security, charging and privacy aspects.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] ETSI ES 201 554: "Environmental Engineering (EE); Measurement method for Energy efficiency of Mobile Core network and Radio Access Control equipment".

[3] ETSI ES 203 228: "Environmental Engineering (EE); Assessment of mobile network energy efficiency".

[4] GSMA Intelligence: "Going green: benchmarking the energy efficiency of mobile", June 2021.

[5] 3GPP TR 21.866: "Study on Energy Efficiency Aspects of 3GPP Standards".

[6] 3GPP TS 28.310: "Management and orchestration; Energy efficiency of 5G".

[7] 3GPP TR 28.813: "Management and orchestration; Study on new aspects of Energy Efficiency (EE) for 5G".

[8] 3GPP TR 38.864: "Study on network energy savings for NR ".

[9] ETSI ES 202 336‑1: "Environmental Engineering (EE); Monitoring and control interface for infrastructure equipment (power, cooling and building environment systems used in telecommunication networks); Part 1: Generic Interface".

[10] 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".

[11] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".

[12] 3GPP TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)".

[13] 3GPP TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".

[14] Void

[15] 3GPP TS 22.261: "Service requirements for the 5G system".

[16] 3GPP TS 22.115: "Service aspects; Charging and billing"

[17] 3GPP TS 23.503: "Policy and charging control framework for the 5G System (5GS); Stage 2"

[18] 3GPP TS 32.299: " Telecommunication management; Charging management; Diameter charging applications".

[19] NGMN: "NGMN Energy Efficiency White Paper, Phase 2", Dec 2022.

[20] GSMA: "5G energy efficiencies: green is the new black, Nov 2020".

[21] Renewable Energy Certificates (RECs): <https://www.epa.gov/green-power-markets/renewable-energy-certificates-recs>

[22] ETSI EN 303 472: "Environmental Engineering (EE); Energy Efficiency measurement methodology and metrics for RAN equipment".

[23] ETSI GS OEU 020 (v1.1.1): "Operational energy Efficiency for Users (OEU); Carbon equivalent Intensity measurement; Operational infrastructures; Global KPIs; Global KPIs for ICT Sites".

[24] Methodological standard for the environmental assessment for Internet Service Provision (ISP), February 2023, <https://librairie.ademe.fr/cadic/7695/pcr_internet_services_provision__english_version.pdf>. Accessed April 29th, 2023

[25] 3GPP TR 28.829: "Study on network and service operations for energy utilities"

[26] 3GPP TR 28.913: "Study on new aspects of EE for 5G networks phase 2"

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**energy state:** state of a cell, a network element and/or a network function with respect to energy, e.g. (not) energy saving states, which are defined in TS 28.310 [6].

**energy charging rate**: a means of determining the energy consumption consequence (use of energy credit) associated with charging events.

NOTE 1: The rate listed above is a charging rate, completely distinct and unrelated to the 'Maximum Energy Consumption Rate' as discussed in 5.1.

**energy credit**: a quantity of credit associated with the subscriber that can be used for credit control by the 5G system.

**maximum energy credit limit**: a policy establishing an upper bound on the quantity of energy used by the 5G system to provide services provided to a specific subscriber.

**carbon emissions:** kilograms of equivalent carbon dioxide emitted (kg of CO2 equivalent)

**carbon intensity:** quantity of CO2 equivalent emission per unit of final energy consumption for an operational period of use [23]

**renewable energy**: energy from renewable sources 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

NOTE 2: This definition was taken from [22].

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

AS Application Server

DV Data Volume

EC Energy Consumption

EE Energy Efficiency

# 4 Overview

Climate change and global energy shortage are issues that requires international cooperation and coordinated solutions at all levels, many regions and countries have published related policies and requirements to control carbon release and promote energy efficiency. These policies have made energy efficiency a strategic priority for many telecom operators around the world. Energy efficiency has been considered in many standard groups and specifications.

The existing studies concentrate more on how to satisfy user experience and try to achieve energy efficiency at the same time and achieve energy efficiency within the network, so the requirements, use cases and solutions are basically within the network itself. Verticals and customers have no approach for energy efficiency related information from the network.

Introducing energy efficiency as a service will allow users to have the choice to select proper energy efficiency criteria as well as other network performance parameters when they need them, which may include:

- Define and support energy efficiency criteria as part of communication service to user and application services.

- Provide information exposure on systematic energy consumption or level of energy efficiency to vertical customers.

Such as in satellite and terrestrial convenience scenario, for some regions where both satellite and terrestrial coverage exist, energy saving could be taken as a dimension while providing the communication service, users or operators could have the choice to find out a best way in satisfying both user experience and energy efficiency. From another perspective, the network could also react to different energy consumption modes of applications or adjust network resources.

Both aspects above need more interactions between applications and networks on energy consumption status. It is worth considering how to deliver services with energy efficiency as service criteria, associated with verticals’ preferences, and how to support the policy of handling energy as part of a subscription.

# 5 Use cases

## 5.1 Use case on energy consumption as a performance criteria for best effort communication

### 5.1.1 Description

Currently energy consumption and efficiency can be monitored and considered through O&M and network operation, but not as a service performance criterion, as for example bit rate, latency or availability. Guidance from SA to all working groups in states:

*"The EE-specific efforts so far undertaken e.g., in SA5 have aimed mostly at improving the energy efficiency by impacting the operations of the system. As we now are starting to specify the 5G-Advanced features, TSG SA kindly requests the recipient WGs and TSGs to consider EE even more as a guiding principle when developing new solutions and evolving the 3GPP systems specification, in addition to the other established principles of 3GPP system design.*

*TSG SA clarifies that in addition to EE, other system level criteria shall continue to be met (i.e. the energy efficiency aspects of a solution defined in 3GPP is not to be interpreted to take priority or to be alternative to security, privacy, complexity etc. and to meeting the requirements and performance targets of the specific feature(s) the solution addresses)."*

There is an important type of traffic where energy efficiency policy, for example a *maximum amount of energy to be utilized* could be applied without conflict with this guidance. Best effort traffic is a type of traffic that is provided as a service to customers *everything else being equal*. Of course, security, privacy and complexity principles will not be sacrificed, but there is no conflict between a service policy that constrains performance (e.g. latency, throughput, even availability) on the basis of energy consumption and a best effort service, since there are no guarantees in the case of best effort traffic. We can say that best effort traffic is not associated with QoS policy service performance level criteria.

Today the 5G system works to support services efficiently, though does not take into account energy consumption at the service level. The use case explores a particular opportunity to identify this information and use it to make more efficient use of all network resources without sacrificing service quality. In particular, information gathered through O&M, and in the future possibly from the network (see 5.1.5 which identifies a gap and opportunity), can be leveraged to make it possible to employ energy consumption information as part of service delivery.

In the following use case, the possibility of using energy consumption as a new service criterion for this less constrained type of mobile telecommunication service is explored.

A large-scale logistics company L has deployed a large number of communicating components. These are integrated into vehicles, palettes, facilities, etc. Essentially, IoT terminals enable remote tracking and monitoring functions. The information gathered is relevant, but not constrained with respect to latency. In fact, eventual delivery (e.g. after hours or even a full day) of communication is entirely acceptable for L. The MNO M offers a 'green service' which limits the rate of energy utilized for communication over a particular time interval (e.g. per day) and this service is appropriate for L, whose overall corporate goals are also served by 'green service,' as they strive to operate with energy efficiency.

### 5.1.2 Pre-conditions

L deploys many UEs with associated 'green service' subscriptions from M. These subscriptions policies include the following criteria:

- Best Effort Service (service that is not associated with QoS policy service performance level criteria)

- Energy Constraints applied to service delivery

### 5.1.3 Service flows

1. The fleet of trucks belonging to L leave the logistic center located in the middle of the uninhabited region hundreds of kilometers northeast of the major city Erehwon. There are many devices located in this fleet. The trucks and their contents comprise a physically dense group of UEs, all communicating periodically with the network. This 'massive IoT' group leaves the coverage of the logistics center. The network coverage over the road through the uninhabited region is very sparse.

2. As the trucks proceed into extreme low coverage, the energy utilized to communicate with the IoT devices increases. This energy consumption increase is monitored by the 5G network and can be aggregated, e.g. at the slice level.

3. The 'green service' policy for the service provided to L includes a maximum energy consumption rate. At a certain point the IoT communication of the fleet exceed*s* this maximum energy consumption rate.

4. The policy indicates that latency can be traded off with energy consumption for service to L; the communication service is delay tolerant in this condition. As the energy consumption rate has exceeded the maximum, the latency is increased to enforce this policy. In effect, L's fleet receives very limited service, with high latency, even for a limited period of time, no service at all.

NOTE: This use case does not describe how latency is increased, but does assume that this increase will result in a reduction of energy consumption. It is possible to reduce energy consumption by offering less service.

The use case description does not define how operator M offers the 'green service'. One possibility is that the maximum energy consumption policy applies to all services for the subscription of a device deployed by L with operator M. This simple policy may not be appropriate if the UEs deployed by L use different kinds of services at different times. In this case, the policy would apply to specific services (service flows, etc.) A requirement at the service flow level is not pursued in this use case.

A further option is that specific network slices apply a 'green service' policy to all services communicating by means of that slice.

The use case does not describe how energy consumption is determined. There is related work in SA5 and RAN3 to determine energy consumption. If energy consumption cannot be determined at the granularity, e.g. of a specific service or network slice or even the aggregate energy consumption of a subscriber, it is still possible to identify the total energy consumption of different elements in the 5G network. It is therefore possible, at least in principle, to divide the total energy by the number of served sessions, subscribers, etc. 'Average consumption' of a node or cell or slice, etc. is a course unit of measurement, and does not reflect the true energy consumption at the finer granularity, though it still can be a useful metric.

Though an averaging approach could be useful to count the total amount of energy used to attribute to each subscriber, this approach is not enough to measure the rate of energy consumption as described in this use case. For this, there would have to be finer granularity energy reporting than 'per node' or 'per cell.' Though this is not yet supported in the 5G network.

### 5.1.4 Post-conditions

The IoT devices in the fleet belonging to L are able to communicate with varying latency, depending on the energy consumption required to serve the devices. When the UEs are in poor coverage, they communicate seldom, when under good coverage, they can communicate more frequently.

The total energy consumption of M's network has reduced while still providing adequate service to customer L.

It is important to emphasize that there has been no trade-off between 'energy efficiency' and 'service quality.' Customer L received what was necessary while using less energy precisely because the energy consumption was taken into account in the service delivery.

### 5.1.5 Existing feature partly or fully covering use case functionality

The 5G network can monitor energy consumption. The existing energy consumption monitoring is done at an O&M level, per network node, per cell and per slice. The number of UEs per network node, cell and slice are also known. Please see Annex A for an overview of existing energy efficiency standardization, which includes the determining energy consumption for use in calculating energy efficiency.

The 5G network can enforce performance criteria, as described in TS 22.261, 6.7 [15]. Most of the enforcement requirements refer to prioritization, but policies that result in other enforcement are possible too, e.g. gating, charging, credit control, restrictions with respect to maximum allowed resources, etc.

Gap: there is currently no means for the 5G network to determine the per subscriber or per network slice service flow energy consumption. This information is not included in network data analytic services.

### 5.1.6 Potential new requirements needed to support the use case

[PR.5.1.6-1] Subject to operator’s policy, the 5G network shall support subscription policies that define a maximum energy consumption rate for services without QoS criteria (also termed "best effort" services.)

NOTE 1: The granularity of the subscription policies can either apply to the subscriber (all services), or to particular services. This requirement's applicability is limited to UEs that *only* support services without QoS criteria.

[PR.5.1.6-2] Subject to operator’s policy, the 5G network shall support enforcement of subscription policies that define a maximum energy consumption rate for services without associated QoS criteria (also termed "best effort" services.)

[PR.5.1.6-3] The 5G network shall support a means to define maximum energy consumption rate with specific granularities:

a) subscriber granularity (considering all services of the 5G network for the subscriber);

b) network slice granularity.

NOTE 2: The energy consumption of the UE is out of scope of this requirement.

[PR.5.1.6-4] Subject to operator's policy, the 5G network shall support energy consumption monitoring at per network slice and per subscriber granularity.

NOTE 3: Energy consumption monitoring as described in the preceding requirement is done by means of averaging or applying a statistical model. The requirement does not imply that some form of 'real time' monitoring is required.

## 5.2 Use case on supporting different energy-related SLAs in industrial campus

### 5.2.1 Description

Industrial campuses are very typical scenarios of edge computing and local traffic offload. Dedicated network facilities are usually deployed near the campus for lower latency and local data protection. This brings a problem that these network facilities are used only for the campus, so while the manufacturing load is light or during vacation, these network facilities will be in very light load or even no load. Under this scenario, the energy consumption of these network facilities will be unnecessary.

### 5.2.2 Pre-conditions

Factory F, a smart manufacturing factory locates in a remote area outside the city. Factory F requires low latency in AGV transporting services and local data processing using computing vision to support image comparison for fault detection in circuit boards. Factory F has an agreement with Operator T on the communication service with certain SLA. As the manufacturing activity is not consistent, Operator T provides a replaceable SLA which can be used during off-peak time. This replaceable SLA can reduce energy consumption by changing the energy state of network functions used locally (e.g. to “energy saving” state), and the action can be activated either by pre-configured policy or by notification from Factory F.

### 5.2.3 Service flows

1. Operator T provides a dedicate set of UPF and MEC platform for factory F. Factory F is an environmental conscious enterprise that cares about energy saving (and efficiency) along its whole industrial chain.

2. When the manufacturing load of Factory F reaches a certain threshold (lower or higher), which is evaluated by Factory F, a notification will be sent to Operator T.

3. Operator T will change the energy state of the dedicated network functions accordingly to energy saving, based on the pre-agreed policy with Factory F.

4. After one year of this kind of usage, the charging information of the communication service will consider the actual usage time of the different energy states.

### 5.2.4 Post-conditions

Manufacturing of Factory F will be not affected, while energy consumption of the communication service could be saved by dynamically changing energy states of network functions, and the expenses of the communication service will be lower to encourage this kind of environmental-friendly action.

### 5.2.5 Existing features partly or fully covering the use case functionality

In TS 28.310 [6], there are existing requirements to switch off edge UPFs during off-peak hours:

***REQ-SOUPF-FUN-1:*** *The management service producer responsible for energy saving should have the capability allowing its authorized consumer to collect the traffic load performance measurements of its edge UPFs.*

***REQ-SOUPF-FUN-2:*** *The management service producer responsible for energy saving should have the capability allowing its authorized consumer to administratively prohibit selected edge UPFs from performing services for its users, either with immediate effect or only when no more users are using these UPFs.*

### 5.2.6 Potential new requirements needed to support the use case

[PR.5.2.6-1] The 5G system shall support different energy states of network elements and network functions.

[PR.5.2.6-2] The 5G system shall support dynamic changes of energy states of network elements and network functions, based on pre-configured policy with authorised 3rd party.

NOTE 1: Pre-configured policy may include: the time of changing energy states, which energy state map to which level of load, etc.

[PR.5.2.6-3] The 5G system shall support different charging mechanisms based on the different energy states of network elements and network functions.

## 5.3 Use case on energy consumption exposure considering possible deployment scenarios

### 5.3.1 Description

When considering Energy as a service or network performance criteria, it is necessary to consider different 5G network deployment scenarios, e.g. for RAN network with dual connectivity, RAN network with CU-DU deployment, RAN sharing, etc. That means whatever the deployment scenario, the energy consumption of the 5G network which relates to the industry customer is expected to be acquired and exposed to the authorized third parties.

### 5.3.2 Pre-conditions

The network operator A deploys 5G network “N” to serve industry customers C and D.

In the 5G network “N”, some of the gNBs can support dual-connectivity. In order to achieve more flexible deployment and reduce the cost, operator A also deploys a large number of DUs in some hotspot area, each DU is for covering a certain area. For customer C, dual-connectivity is utilized, while for customer D, multiple DUs have been configured.

Industry customers C and D have also subscribed the “Green Energy Moni” value-added service from network operator A, thus they can access energy consumption information corresponding to their respective network functions from a web application provided by Operator A.

### 5.3.3 Service flows

1. The 5G network “N” of operator A acquires the energy consumption information of related 5G network functions serving customers C and D.

2. Customer C asks the “Green Energy Moni” of Operator A to provide the network energy consumption information associated with the 5G network functions serving it via dual-connectivity deployment.

3. Operator A provides the network energy consumption information to customer C.

4. Customer D asks the “Green Energy Moni” of Operator A to provide the network energy consumption information associated with the 5G network functions serving it via DU deployment.

5. Operator A provides the network energy consumption information to customer D.

### 5.3.4 Post-conditions

Customers C and D can get the energy consumption information of the network functions serving them, independently from NG-RAN deployment scenarios.

### 5.3.5 Existing features partly or fully covering the use case functionality

None.

### 5.3.6 Potential new requirements needed to support the use case

[PR.5.3.6-1] Subject to operator’s policy and consent by the vertical customer, the 5G system shall be able to acquire energy consumption information of the network functions serving the customer, independently from NG-RAN deployment scenarios, and expose this information to the customer and authorized third parties.

## 5.4 Use case on energy efficiency information exposure under NPN RAN sharing

### 5.4.1 Description

In the practice of 5G NPN deployment, in order to save time and cost, RAN sharing (i.e. NG-RAN is shared by any combination of PLMNs and NPNs) is a common deployment scenario for vertical industries. The customers will concern about the energy efficiency of their communication service especially in RAN sharing cases. Thus, it is reasonable for 5G system to acquire and expose the energy efficiency information of the customer including when it is served by RAN sharing network.

### 5.4.2 Pre-conditions

The 5G network operator A deploys local NPN “N1” network in factories for customer C which is sharing resource of operator A’s PLMN “R”.

Customer C has subscribed the “Green energy Moni” value-added service for its NPN “N1” from network operator A, thus it can access energy efficiency information corresponding to the “N1” network from a web application provided by Operator A.

### 5.4.3 Service flows

1. The 5G network of operator A acquires the energy efficiency information of the NPN ”N1” and PLMN “R”.

2. Customer C asks the “Green Energy Moni” of Operator A to provide the energy efficiency information of its network “N1”.

3. The operator A acquires and provides energy efficiency information of the network “N1” to customer C.

### 5.4.4 Post-conditions

Customer C can get the energy efficiency information of its network “N1”.

### 5.4.5 Existing features partly or fully covering the use case functionality

TS 28.554 [12] already defines EE, EC and DV-related KPIs and use cases to acquire and calculate energy-efficiency at various levels within the 5G system.

### 5.4.6 Potential new requirements needed to support the use case

[PR.5.4.6-1] Subject to operator’s policy and consent by the customer of NPN, the 5G system shall be able to acquire energy efficiency information of the NPN, including the shared network function(s) which is (are) serving the NPN, and expose this information to the NPN customer and authorized third parties.

## 5.5 Use case on service energy monitoring by an application server

### 5.5.1 Description

In this scenario, a service provider monitors events resulting from energy consumption policy triggers in the 5G system. These triggers correspond to monitoring policy in the 5G system as well as energy enforcement policies.



Figure 5.5-1: Monitoring of Energy Events by the 5G network for an AS

In Figure 5.5.1, the application server AS obtains information corresponding to the energy consequences of a UE 'A' served by the 5G network.

This use case will provide a description of a scenario in which the service provider (who operates an application server) cares about energy consumption in the 5G system as a result of the service to UE A. This could be for 3 reasons:

- the service provider needs to show they are saving energy;

- the service has an associated energy cost, and the service provider wants to reduce it. This is analogous to the use of industrial or consumer electronics when energy rates are lower, and also as an incentive to operate more efficiently;

- the service provider recognizes that there are policies that limit energy use (such as aggregate energy use of a slice) and controls the overall use of the service to operate within those constraints.

The use case introduces five new concepts related to new energy events and energy event monitoring:

a) the ability for the network operator to create a 'maximum energy credit' policy, after which services are gated;

b) the ability for the network operator to inform an AS of the 'maximum energy credit expired' event;

c) the ability for the 5G system to calculate 'energy credit' use;

d) the ability to monitor and provide to the AS the use of 'energy credits' (or other energy 'quantum');

e) the support a new policy that establishes the energy consequence for charging control - either charging for use of energy or establishing an 'energy credit limit' for enforcement by the 5G system.

### 5.5.2 Pre-conditions

The UE "A" has a subscription that enables it to make use of 'best effort communication subject to energy constraints' policy for communication. This class of communication was introduced in clause 5.1.

The application service provider of "AS" is capable monitoring service aspects of the 3GPP system, e.g. through network exposure of information as described in TS 22.261 [15] for QoS monitoring or TS 22.115 [16] related to credit limit policy and control.

### 5.5.3 Service flows

1. The application service provider of AS has an energy policy related to the service for the subscription related to UE "A". As a result, AS requests to monitor 'Energy Use', which is a kind of usage monitoring supported by the 5G system. The monitoring policy has an established 'threshold' for the 5G system to notify the AS.

In addition, the AS requests to monitor 'Out of Energy Credit' events.

2. The 5G system provides service to UE A according to a 'best effort communication subject to energy constraints' policy, where the policy charges for energy use and also imposes an 'energy credit' limit, after which the UE A subscription is 'gated' (receives no further services from the 5G system until more 'energy credit is available).

3. UE A proceeds to use services of the 5G system, especially data communication. As it does so, the charging system is triggered and generates records. The 3GPP charging system uses a means to identify how much credit is used and whether a credit limit is exceeded. The 3GPP charging system in this use case also uses a means of calculating energy credits on the basis of charging events. That is, there is a 'rating policy' used to multiply a 'charging event' by an 'energy consumption' unit.

NOTE 1: The actual amount of energy corresponding to an 'energy unit' used in energy credit control is out of scope of this use case. A mobile network operator can develop a model by which they analyze the total energy needed to provide services and assign fractions of these to each event triggered in the charging system.

4. When the total 'energy units' exceed the reporting threshold according to the energy monitoring policy, the 5G system exposes this energy consumption information to AS.

NOTE 2: Monitoring of energy consumption could be done by other means than 'energy units' corresponding to the same units as the credit limit. This could be useful for the third party. However, only by exposing units that result in charging or gating enforcement by the network operator can the third party determine the consequences of their use of services and potentially change their use of those services, e.g. to communicate sparingly, to communicate more efficiently (e.g. at times in less energy use is reported per 'byte', etc. of communication, as calculated by the third party based on their own measurements and the monitoring reports of the 5G system.)

5. When the total 'energy units' exceed the energy credit limit, this results in the 5G system exposing this event to the AS. The AS could take some action to restore energy credit, but this is out of scope of the use case.

### 5.5.4 Post-conditions

The UE A's energy consumption can be monitored by AS. The AS can alter their activity (e.g. communicate less intensely or less frequently) to remain within their expectation - be it to keep the charging per energy consumption to their expectation, or to avoid exhausting A's energy credit limit.

The MNO is able to create and enforce policies that attach consequences to energy consumption. This can lead to energy efficient behaviour on the part of service providers which is both in their interest and the interest of the MNO.

### 5.5.5 Existing feature partly or fully covering use case functionality

The 5G system provides support for credit limits [16, clause 8.2] and for performance monitoring [15]. There are a number of other events that are exposed by the 5G system to third parties by the Policy and charging control framework by the 5G System [17]. These events and their triggers, which are not detailed in stage 1, allow for usage monitoring to be exposed to a third party in specific circumstances, e.g. sponsored connectivity. The scenario in this use case is similar to sponsored connectivity, as the application service provider is a directly concerned party that seeks to operate successfully in an efficient manner, as there are charging and even gating consequences as the UE communicates with AS.

Note that the existing usage monitoring and reporting for sponsored connectivity is not sufficient to support this use case because these do not in any way take into account the *energy consequence* of the service. Only traffic volume and time-based monitoring are supported today. Other chargeable events (and therefore significant from an energy perspective) are not captured by usage monitoring as supported in the 5G system.

### 5.5.6 Potential new requirements needed to support the use case

[PR.5.5.6-1] Subject to operator’s policy, the 5G system shall support subscription policies that define a maximum energy credit limit for services.

[PR.5.5.6-2] Subject to operator’s policy, the 5G system shall support subscription policies that support a means to associate energy consumption units with charging records.

[PR.5.5.6-3] Subject to operator’s policy, the 5G system shall support a means to expose energy consumption to authorized third parties for services, such that the energy consumption information clearly identifies the 'approaching' enforcement of an energy credit limit.

[PR.5.5.6-4] Subject to operator’s policy, the 5G system shall support a mechanism to perform energy consumption credit limit control for services.

NOTE 1: The result of the credit control is not specified by this requirement. Examples include gating, increased charging rates, etc.

NOTE 2: Credit control [18] compares against a credit control limit. In this use case, charging events are assigned a corresponding energy consumption and this is compared against a policy of energy credit limit. The use case assumes it is possible that there is a new policy to limit energy consumption allowed.

## 5.6 Use case on supporting service-level energy efficiency analysis for verticals

### 5.6.1 Description

Company A is located in an industrial campus. There are three internal applications used by employees for daily work which are based on two network slices. App A is for internal communication. App B is for production control. App C is for office automation. A and C are running on one slice, while B running on a separate slice. The data of these three applications are all dealt with a locally deployed UPF in this campus. The operator provides the additional service of exposing energy consumption of locally deployed UPF. Company A find that energy consumption of the UPF become higher recently, but cannot find out the cause, hope that 5G system can help to analysis which users or application are abnormal.

5G system analysis the data volume on this UPF and energy consumption of each app periodically.

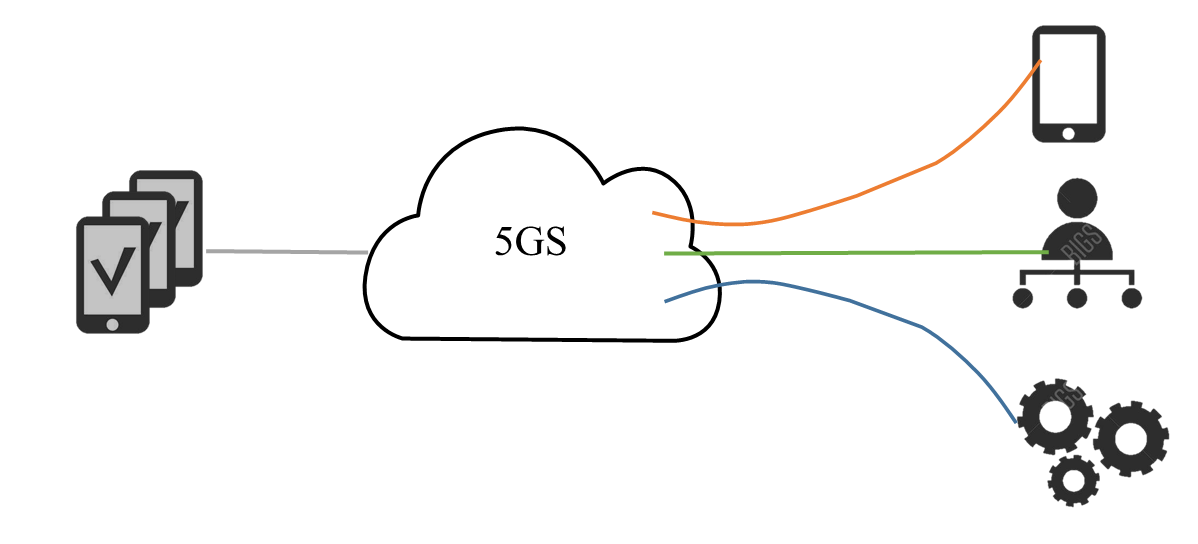


Figure 5.6-1: Supporting service-level energy efficiency analysis for verticals

### 5.6.2 Pre-conditions

5G system support energy consumption analysis based on data volume and energy consumption of network functions, which can be done by UPF.

### 5.6.3 Service flows

1.Company A finds abnormal energy consumption on the local network entity and request 5G system to report data usage of app A, B and C in past 3 days.

2.5G system analyses data volume and energy consumption of each app in every 2 hours.

3.5G system report shows that app B has a large data usage during 3am-5am every day.

4.Company A finds that app B has an abnormal setting which lead to system update repeatedly and large energy consumption.

### 5.6.4 Post-conditions

Company A located the abnormal app and machine. They reset the setting and fix the problem.

### 5.6.5 Existing features partly or fully covering the use case functionality

Requirements for DV measurement control and Power, Energy and Environmental (PEE) measurement has been defined to support for 5G NF measurement control.

In SA5 TS 28.554 [12], clause 6.7.3.3 Network Slice Energy Consumption are introduced.

In SA2, quota for PDU sessions per network slice and user numbers are already defined.

### 5.6.6 Potential new requirements needed to support the use case

[PR.5.6.6-1] The 5G system shall support energy consumption measurement of network functions and exposure to authorised 3rd party.

NOTE : The granularity of energy consumption measurement could vary according to different situations, for example, when several services share a same network slice, etc. Energy utilization monitoring as described in the preceding requirement is done by means of averaging or applying a statistical model. The requirement does not imply that some form of 'real time' monitoring is required.

## 5.7 Use case on energy consumption information exposure considering QoS

### 5.7.1 Description

Quality of service (QoS) refer to the network measurement of the overall performance about a communication service for the user. This network performance statistic can be e.g, packet loss, data rate, transmission delay, jitter, etc. When provide the energy as a service or a network performance criteria, e.g. in clause 5.2, the industrial park customer can be provided different energy-related SLAs under different energy states of network by operator, it is reasonable that not only the energy consumption information of the network or network functions but also the associated network performance statistic information are collected and exposed together to the customers or authorized third parties which will help customers to achieve more visible network service under different energy states of network functions.

The network performance statistic information can be pre-configured by the customer , authorized third parties or by Operator to be associated with the network functions energy usage information. The network performance statistic information can be packet loss, data rate, transmission delay, jitter, etc. which can be collected and calculated the average value based on 5QI refer TS28.554.

### 5.7.2 Pre-conditions

The network Operator deploys 5G NPN network in industrial park to provide energy as a service “GreenPark” for the industry park customer M. The “GreenPark” service can provide high data rate communication service and higher reliability service either. The industry customer M has subscribed the high data rate service with SLA “H”. The network Operator also provides a replaceable SLA “E2H” which can be used during off-peak working time. This replaceable SLA can reduce energy consumption by changing the energy state of a cell, a network element and/or a network function belong to the 5G NPN (e.g. to “energy saving” state), and the action can be activated either by pre-configured policy or by notification from customer M.

### 5.7.3 Service flows

1. Customer M asks the “GreenPark” Operator to provide the “GreenPark” energy consumption information and its communication services network performance statistic information (e.g. the data rate , packet delay and packet loss) per hour during the working time (e.g. from 9am to 5pm) in the industrial park.

2. The operator acquires the energy consumption information of the 5G NPN serving customer M every hour.

3. At the same time, operator collects the network performance statistic information (e.g. average data rate , average packet delay and average packet loss) from the 5G NPN serving customer M every hour.

4. The operator provides the energy consumption information of the 5G NPN serving the customer M and the network performance statistic information from the 5G NPN e.g. the average data rate, average packet delay and average packet loss during the working time in the industrial park.

5. According to the pre-configured policy with customer M, the Operator changes the energy state of the 5G network functions of the 5G NPN serving customer M for energy saving. The operator continues to acquire the energy usage information and collects the network performance statistic information from the 5G NPN under new energy state and provides this information together to the customer M.

### 5.7.4 Post-conditions

Customers M can get the not only the energy consumption information but also the average data rate, average packet delay and average packet loss from 5G NPN during the working time and off-peak working time.

### 5.7.5 Existing features partly or fully covering the use case functionality

The QoS monitoring requirements have been specified in the TS22.261 section 6.23. But it has not any consideration on energy consumption. Some related requirements are listed below:

*The 5G system shall be able to provide real time QoS parameters and events information to an authorized application/network entity.*

*NOTE 2: The QoS parameters to be monitored and reported can include latency (e.g. UL/DL or round trip), jitter, and packet loss rate.*

*The 5G system shall support different levels of granularity for QoS monitoring (e.g. per flow or set of flows)*

*The 5G system shall support an update/refresh rate for real time QoS monitoring with a specified value (e.g., at least one update per second)*

In TR 28.829 [25], there are solutions of collect network information of energy utility via OA&M.

In TR28.913 [26], section 4.6, the key issue is to add reliability KPI into the URLLC network slice energy efficiency formula. In this key issue, the energy efficiency is calculated in the 3GPP domain, the related information is not exposed together to external.

### 5.7.6 Potential new requirements needed to support the use case

[PR.5.7.6-1] Subject to Operator policy and consent by the customer, the 5G system shall be able to, collect and expose to the authorized third party, through same update rate e.g. hourly or daily, the energy consumption information for the network functions serving the customer, together with the network performance statistic information for the services provided by that network functions.

NOTE: The network performance statistic information could be the data rate, packet delay and packet loss, etc.

[PR.5.7.6-2] Subject to Operator policy, the 5G system shall provide means for the trusted 3rd party, to configure which network performance statistic information (e.g. the data rate, packet delay and packet loss) for the communication service provided to the customer, needs to be exposed along with the energy consumption information of the network functions serving the customer.

## 5.8 Use case on Application energy efficiency monitoring

### 5.8.1 Description

Next generation mobile communication systems are expected to accommodate more demanding services, e.g., XR, AI/ML which will require much energy consumption at the device side as well as the network side. The impact on devices and the network to support these services will be huge and sometimes unpredictable.

When Operator A is deploying a communication service to meet the application service requirements (e.g. gaming app requirements), the customer (e.g. service provider or vertical) needs to make sure that the application service doesn’t consume significant energy for the end users as well as for the data network side.

Possible high energy consumption or low energy efficiency of the application service can lead to an application layer adaptation at the service provider’s domain to deal with this. An example of application layer adaptation would be to trigger the adaptation of the service level due to high expected energy consumption for the given application in a certain service area (e.g. edge service area).

The Application service Energy Efficiency (AEE) can be monitored and predicted at the 5GS and can be exposed as a monitoring event to the Service Provider to allow an application layer action. Such monitoring may relate to whether the AEE is sustainable for a given service area and time of the day, or can be provided when the energy consumption for the application service is reaching the upper bound (upper bound can be set based on the SLA). The monitoring result can be exposed either periodically or event-based (e.g. when upper threshold is reached as defined in Energy-related KPIs) subject to the application service provider’s requirement (based on the SLA).

### 5.8.2 Pre-conditions

The service provider X wants to deploy an application service (e.g., gaming service) in a given service area and for a target number of users, where the service is expected to be communicated via 5G network “N” of the 5GS of operator A. The application service may have different service levels, which may be different KPIs associated with the service, and can correspond e.g., to different levels of automation or video quality targets.

The service provider X subscribes to the operator A for the “App EnergyEff Moni” feature with the requested service level(s) to monitor whether the application service is energy-efficient when using 5G system of operator A for the given service level(s).

The operator A and service provider X have agreed on certain energy efficiency target for the application service and optionally for given service levels.

### 5.8.3 Service flows

1. Service provider X asks the “App EnergyEff Moni” of Operator A to provide the predicted application service energy efficiency information for App Service #1 and one or more service modes for a given service area and time of the day.

2. The 5G system of operator A acquires the energy consumption information of related 5G system functions serving the App Service #1 of service provider X. Such information can be derived per application service and can include statistical data related to the application service energy consumption within a given service area.

Then, the 5G system of operator A calculates or predicts the AEE for the application service #1 and optionally the service mode X, based on the acquired energy consumption information.

3. Operator A exposes the calculates or predicted AEE for the application service #1 (and optionally the service mode X) to the Service Provider X.

4. Service Provider X configures or adapts the application service parameters based on the Operator A feedback. Such adaptation of the application service parameters can be for instance the application server re-location to an edge data network to enhance the energy efficiency for the application.

### 5.8.4 Post-conditions

Service provider X can get the energy related statistics or predictions for the application service #1, independently from NG-RAN deployment scenarios, and this can help either adapting the application service parameters (e.g. service levels, application relocation) or configuring the application service in an energy-efficient manner.

### 5.8.5 Existing features partly or fully covering the use case functionality

EE TS 28.310 specifies the work in 3GPP related to energy efficiency. It specifies use cases relating to energy efficiency such as switching off edges UPFs for low-latency communication in certain geographical areas when no user is actively using them. Based on the scenarios the document presents requirements to be considered to support energy efficiency. The main requirements among them are requirements related to Power, Energy and Environmental measurements as well as requirements concerning energy saving.

This use case uses the existing 3GPP features as input for the application-level energy efficiency prediction, without providing an overlapping capability. In particular, the energy monitoring and optimization tasks in OAM cannot consider per application / session energy monitoring/predictions, and are limited to the energy calculation and monitoring per managed element (e.g. NG-RAN, UPF, slice...).

### 5.8.6 Potential new requirements needed to support the use case

[PR.5.8.6-1] Based on operator policy and service agreement between the operator and application service provider, the 5G system shall be able to derive energy efficiency information for one or more application services, and expose energy efficiency information notifications to the application service provider.

NOTE : The granularity of energy efficiency information notifications could vary according to different situations, for example, application service energy consumption can be acquired based on means of averaging or applying a statistical model for the energy consumed by the application sessions within the application service in the service area, etc.

[PR.5.8.6-2] Based on operator policy and service agreement between the operator and application service provider, the 5G system shall be able to provide means to predict the energy efficiency per application service, and expose the predictive energy efficiency information to the application service provider.

[PR.5.8.6-3] Based on operator policy and service agreement between the operator and application service provider, the 5G system shall enable the application service provider to subscribe, update, and unsubscribe for energy efficiency information notifications.

## 5.9 Use case on renewable energy consumption information exposure

### 5.9.1 Description

According to a recent GSMA report [20], all major operators have set up targets to reduce carbon intensity from 50% to 70% in next couple of years with the ultimate goal of achieving net-zero emissions. Though 5G NR offers improved energy-efficiency, new 5G use cases and the wider adoption of 5G NR will result in an increased number of sites and antennas, which may offset these gains if left unmitigated.

To address this, cut down on emissions and increase network efficiency, operators have an interest in powering their network using renewable energy sources to reduce emissions and enhance network efficiency. It is also important for operators to understand and track the proportion of energy consumed in their networks that is sourced from renewable sources, which can be made available to customers and authorized third parties.

### 5.9.2 Pre-conditions

The network operator R has deployed a 5G network "N" and is promoting its services as "Green Energy". This is due to the fact that 60% (this could be any % number, 60% is just provided as an example) of the energy required for network operations is sourced from renewable resources. The government is providing tax credits to companies using renewable energy, and R provides its customers with information about the proportion of renewable energy utilized and renewable energy certificates (RECs) [21], if applicable.

Company X, which places a high value on environmental sustainability, has subscribed to R’s Green Energy services requesting for minimum ratio of renewable energy used for the communication service. R provides X with a dedicated slice (or NPN) guaranteeing this minimum ratio. R provides periodic reporting information regarding the percentage of renewable energy utilized. As a result, X is eligible to receive tax credits from the government for its purchase of renewable energy.

### 5.9.3 Service flows

1. Customer X subscribes to the ‘Green Energy’ service for its warehouse, provided by operator R.

2. The warehouse is served by a limited “X” number of base stations and the core network could be hosted in a central cloud location that is powered by renewable energy.

3. Operator R provides a dedicated network slice that utilizes a minimum 80% renewable energy for customer X’s NPN at their warehouse. The 5G system will not actively monitor the dedicated resources for energy consumption.

4. Operator R periodically calculates statistics about the ratio of renewable energy utilization of the network elements used within the customer X’s dedicated slice (or NPN).

5. Customer X receives periodic report every month regarding the ratio of renewable energy consumption from Operator R.

6. Operator R supplies customer X with the requested information.

7. Customer X can advertise that it is committed to a “Green Energy” and is using 80% renewable energy for the dedicated communications service at its warehouse. Additionally, Customer X can also claim tax credits from the government.

### 5.9.4 Post-conditions

Customer X can get a dedicated network slice or NPN utilizing a minimum ratio of renewable energy used by the network serving its warehouse.

Customer X receives a periodic report on the ratio of renewable energy used by the network serving its warehouse.

### 5.9.5 Existing features partly or fully covering the use case functionality

None.

### 5.9.6 Potential new requirements needed to support the use case

[PR.5.9.6-1] Subject to operator’s policy, the 5G system shall enable the operation of a dedicated network above a minimum ratio of renewable energy as requested by an authorized 3rd party.

NOTE 1: This requirement does not imply that the 5G system will actively monitor the dedicated resources.

[PR.5.9.6-2] Subject to operator’s policy, the 5G system shall be able to provide to a 3rd party the reporting of the ratio of renewable energy used to provide dedicated communication service to the 3rd party on periodic basis.

NOTE 2: The reporting period could be set, e.g., on monthly or yearly basis.

## 5.10 Use case on supporting carbon-aware communication service

### 5.10.1 Description

Global warming caused by excessive emissions of GHG (Green House Gas, e.g., carbon dioxide) due to human activity (e.g., burning fossil fuels for electricity generation) is the main driver to climate change, which poses a significant threat to society and the environment. To achieve carbon neutrality, it is important to reduce the GHG incl. carbon emissions in the first place rather than offset them later. Recent advancements in communication capabilities of networks (e.g., 5GS) enables a wide range of services (e.g., AR/XR). However, the rising demand for communication services in turn triggers a rising demand for energy and a greater risk of an even higher resulting GHG footprint. 3GPP plays a crucial role in the ICT sector to enable the deployment of these technologies on a global scale and therefore must also play a central role in enabling a sustainable future.

The adoption of alternative sustainable sources of energy incl. renewable energy (e.g., solar, wind, hydropower, geothermy) and nuclear power could help offset the GHG footprint of energy generation based on fossil fuels, even though their corresponding environmental impact also need to be considered. From an ICT standpoint and, 3GPP system in particular, the energy used by network nodes can be from varied energy with different related levels of environmental impact incl. GHG emissions. Due to the highly variable and unpredictable nature of renewable energy sources (Mother Nature’s dictate), the average GHG emissions per consumed energy unit varies substantially by time and location. Hence, it is critical to take temporal and spatial dimensions of energy sources into account to provide communication services not only for a better traceability of the energy sources used but in turn for enabling a more sustainable energy use.

In the following use case, telecom operator provides the estimation of carbon emissions for the services.

Note that ADEME, the French Agency for Ecological Transition, has introduced a methodological standard for the environmental assessment of digital services. [24] According to this standard, “internet service providers and telecoms operators (physical and virtual) for fixed and mobile networks must inform their subscribers of the amount of data consumed and indicate the equivalent in greenhouse gas emissions.” The objective is to communicate on a monthly bill the carbon impact of a subscriber using the mobile network of operator 1 in <Month YEAR> with a consumption of <DV> GB is: <X> g CO2 eq.

### 5.10.2 Pre-conditions

Eva uses her XR device during the commute. This XR device receives 5G service from the mobile network operator A.

The 5G system operated by operator A is powered by both of renewable energy (e.g., solar energy) and non-renewable energy (e.g., coal).

Carbon intensity, defined as the quantity of CO2 equivalent emission per unit of final energy consumption for an operational period of use (e.g., gCO2 per kW·h), is used to estimate the amount of carbon emissions incurred by the 5G system operations. Such carbon intensity information can be collected from a third party.

The operator A offers a “carbon-aware communication service” which provides the estimated carbon emissions of communication services. The estimation is based on the subscriber’s data volume, the operator’s energy consumption and the carbon intensity of network. The estimated carbon emissions information is exposed to the service provider B. Users can acquire the estimated carbon emissions from the service provider B.

Eva loves our planet, so she prefers to know how her requested services produce carbon emissions.

### 5.10.3 Service flows

1. Eva subscribes the communication service provided by operator A.
2. During the commute between the home and the workplace, Eva wears her XR device and enjoys the immersive entertainment via 5G system operated by operator A.
3. During the service time, the 5G system incurs carbon emissions due to the energy consumption.
4. The operator A collects the carbon intensity information of energy consumption from an authorized third party.
5. By "carbon-aware communication service”, the operator A calculates the estimated carbon emissions for the service and exposes the estimated carbon emissions result to the service provider B.
6. From the service provider B, Eva can know the estimation of carbon emissions for her requested service from the operator A.

### 5.10.4 Post-conditions

Eva can enjoy low-carbon XR entertainment with the awareness of its environmental impacts.

### 5.10.5 Existing features partly or fully covering the use case functionality

None.

### 5.10.6 Potential new requirements needed to support the use case

[PR.5.10.6-1] Subject to user consent, operator policy and regulatory requirements, the 5G system shall be able to provide a mechanism to expose to the authorized third parties the energy efficiency information (e.g., including the estimated carbon emissions) related to a subscriber based on the subscriber’s data volume over a specific period of time, the operator’s energy consumption, and the carbon intensity of operator’s network.

NOTE 1: The carbon intensity of operator’s network can be provided by an authorized third party and can vary based on locations.

NOTE 2: The granularity of reporting (e.g., per month) is not discussed in this study.

## 5.11 Use case on Temporarily pooling coverage layers over a geographical area for energy saving

### 5.11.1 Description

One of the strategies to save energy within mobile networks is to shut down some RAN nodes at times of low usage. Eventually only one coverage layer would be used. Thus, there is a potential for further gain to be exploited by pooling the coverage layer on a local basis among operators at times of low usage.

Agreements could be put in place between operators so that in the low load periods (e.g., night time) only one of multiple mobile networks may be active in an area and will provide coverage to the subscribers of all networks, whereas the other networks can apply cell shutdown to obtain network energy savings.

Alternatively, based on risks of power outage nationwide/regionwide, regulators could ask operators to “optimize” their coverage e.g., shutdown some overlapping coverage areas during peak hours and/or in regional areas, whilst still guaranteeing minimum coverage/service (in particular emergency calls).

This can also apply between NPN operators and/or with PLMN operators.

### 5.11.2 Pre-conditions

- OP1 and OP2 are two PLMN operators.

- There is an overlap coverage between OP1 and OP2, which both provide mobile services to their subscribers on various bands.

- There are mutual agreements between OP1 and OP2 allowing them to provide services to the subscribers of the other network, in case it is not active in an area for low load. They define e.g. on a daily basis or specific locations a time when the coverage pooling starts and ends, and can include other parameters like preferred bands etc.

- OP3 operates an NPN dedicated to a factory around its campus, which is mainly used for IIoT purposes, but also for employees.

- There is a business agreement between the OP1 and OP3, i.e. OP3 users can be served by OP1 network (but not the other way around) based on certain conditions. At night, OP3 shuts down its network when the machines are off, as the little remaining traffic is generated by some employees staying late or overnight. The agreement requests OP1 to provide access to OP3 UEs during the night hours for this type of traffic.

- UE 1 belongs to OP1. UE 2 belongs to OP2. UE 3 belongs to OP3.

### 5.11.3 Service flows

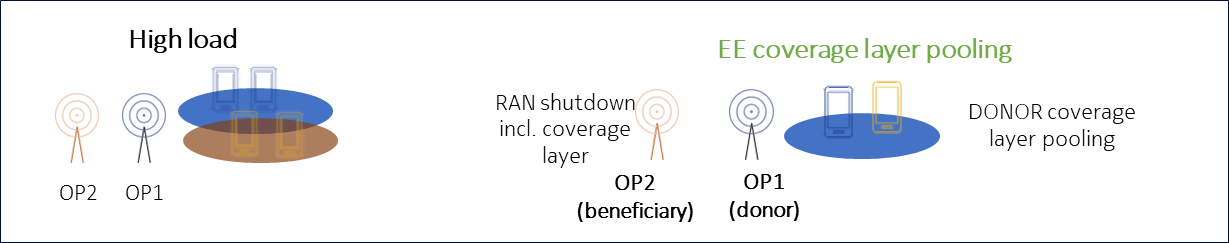


Figure 5.11-1: Basic service scenario of coverage layer pooling for energy saving

1) At 8PM, OP3 (“beneficiary” network) starts informing its currently served UEs within a specific area that it will shut down its network and request them to move to OP1 (“donor” network). It can also indicate the time when it will resume connectivity (e.g. 8AM).

2) OP1 accepts OP3’s UEs onto its network based on “EE-based coverage layer pooling” reason (it wouldn’t have without agreement).

3) Once OP3 detects no UE is served anymore on its network, it shuts down its network

4) On the next morning at 8AM, OP3 powers up its network again in that area

5) OP3 UEs return to OP3

6) OP1 stop serving OP3 UEs.

Furthermore, as this is an industrial campus area, traffic for OP2 is low this Saturday (only OP3 factory is working). Based on its EE KPIs in that area and according to the agreement with OP1, OP2 decides to shut down its cells until Monday morning 6AM with the same mechanism. OP1 starts serving OP2 UEs under its own network during this time. In this case the decision is dynamic and not only based on fixed times, but on other conditions, within the agreed conditions between operators (e.g., anytime during weekends).

### 5.11.4 Post-conditions

After OP2 and OP3 have shut down their networks, their subscribers can still be served via OP1.

OP2 subscribers under “EE-based coverage layer pooling” are not charged differently when served by OP1 network, with respect to when they are under OP2 network coverage. OP2 may be charged by OP1 as per their company agreement, e.g. based on a flat cost, per subscriber, data volume, duration etc.

OP3 may also be charged by OP1 as per their company agreement.

### 5.11.5 Existing feature partly or fully covering use case functionality

Network sharing is an existing technique used to save resources across operators (see TS 22.261, cl 6.21), which could be leveraged for “coverage layer pooling” for energy saving purposes.

However, current network sharing agreements are mainly on a permanent basis with little flexibility in time and space. Indirect network sharing is a promising technique that can be considered for this use case.

Minimization of Service Interruption (MINT) as defined in TS 22.261, cl 6.31 in another existing feature, which has specified that “*UEs can obtain service in the event of a disaster, if there are PLMN operators prepared to offer service. The minimization of service interruption is constrained to a particular time and place. To reduce the impact to the 5G System and EPS of supporting Disaster Roaming, the potential congestion resulting from an influx or outflux of Disaster Inbound Roamers is taken into account.*”. Requirements exist, e.g., “*to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list*”.

Disaster roaming is further specified in clauses 4.4.3.3.1 and 3.10 of TS 23.122.

However, this use case is not related to disaster condition. Furthermore, differently from disaster roaming, there may be no detection of failure of home PLMN by the UE, and the pooling (i.e., roaming) duration may be known in advance.

### 5.11.6 Potential new requirements needed to support the use case

[PR.5.11.6-1] Subject to regulatory requirements and operators’ policies, the 5G system shall support temporary pooling of coverage layers of multiple operators on a single operator within a geographical area.

NOTE 1: policies may include predefined times/locations, energy consumption/efficiency thresholds, preferred bands etc.

[PR.5.11.6-2] Subject to regulatory requirements and operators’ policies, the 5G system shall enable an operator providing coverage layer pooling to serve UEs of other operators.

[PR.5.11.6-3] Subject to operators’ policies, the 5G system shall enable a UE to display the subscriber’s home operator network name during coverage layer pooling, even when this UE is served by another operator.

[PR.5.11.6-4] The 5G system shall be able to support collection of charging information associated with a UE served using coverage layer pooling.

Editor’s Note: The term “coverage layer pooling” used in the above requirements may be further clarified, renamed or defined.

## 5.12 Use case on supporting communication service with best-effort renewable energy usage

### 5.12.1 Description

Climate change caused by excessive emissions of GHG (Green House Gas, e.g., carbon dioxide) due to human activity (e.g., burning fossil fuels for electricity generation) is the main driver to climate change, which poses a significant threat to society and the environment. Toward the goal of carbon neutrality, it is important to reduce the GHG incl. carbon emissions in the first place rather than offset them later. Recent advancements in cellular technologies (e.g., 5GS) that enable a wide range of applications has led to an explosive growth of service demands in networks. ICT sector is expected to account for 20% of the global energy consumption by 2040. 3GPP plays a crucial role in the ICT sector to enable the deployment of these technologies on a global scale and therefore must also play a central role in enabling a sustainable future.

To reduce the carbon footprint, telecom operators are utilizing more renewable energy (e.g., solar, wind) that does not release carbon dioxide when producing electricity. The energy used by network can be from varied energy with different related levels of environmental impact incl. GHG emissions. Due to the highly variable and unpredictable nature of renewable energy sources, the supply of renewable energy varies substantially by time and location.

In the following use case, telecom operator provides communication service considering the supply of renewable energy, in which operator utilizes renewable energy sources in a best-effort manner while ensuring the QoS levels of services to be met.

### 5.12.2 Pre-conditions

Eva has video calls with her family during the commute. She receives 5G service from the mobile network operator A.

The 5G system operated by operator A is powered by both of renewable energy (e.g., solar energy) and non-renewable energy (e.g., coal). The ratio of renewable energy is determined as the ratio of the power that is used from renewable energy sources as a percentage of total power usage in a given time unit. Calculation of ratio of renewable energy is done by means of averaging or applying a statistical model.

The operator A offers a “green communication service option” for which the supply of renewable energy is additionally considered during the provision of the services to users. If the green communication service option is determined to be enabled by the operator A, the operator A utilizes renewable energy sources in a best-effort manner while ensuring the QoS levels of services still be met.

The operator A monitors the supply of renewables in 5GS and the network operates on different ratios of renewable energy over time. The operator may also report to user the statistics of ratio of renewable energy for providing the requested communication service.

Eva loves our planet, so she subscribes the green communication service option which utilize as much renewable energy as possible without sacrificing the quality of serve for her video calls.

NOTE: This green service ensures that QoS level criteria continues to be met (i.e., there is no trade-off between energy efficiency and service quality) since the usage of renewable energy is just a best effort attempt.

### 5.12.3 Service flows

1. During the commute, Eva has video calls with her family via the 5G system operated by operator A.
2. Eva subscribes the green communication service option provided by operator A, which ensures the QoS level of service to be met and utilize renewable energy sources in a best-effort manner.
3. The operator A monitors the supply of renewables for its 5G system, which varies substantially by time and/or location due to the highly variable and unpredictable nature of renewable energy sources.
4. During early morning, the operator A is able to provide communication service to Eva with 40% of ratio of renewable energy since solar power is plentiful and most of users don’t use services.
5. During the busy evening, many users request communication services at the same time, so the operator A is only able to provide communication service to Eva with 20% of ratio of renewable energy since the required energy consumption for network operation becomes more and the solar energy supply is decreasing.
6. Periodically, the operator reports to Eva the ratio of renewable energy for providing her communication service.
7. By "green communication service option” provided by operator A, the service requested by Eva use renewables as much as possible and Eva is still satisfied with the quality of video calls.

### 5.12.4 Post-conditions

Eva can enjoy video calls with the satisfied quality of service while reducing her carbon footprint.

### 5.12.5 Existing features partly or fully covering the use case functionality

None.

### 5.12.6 Potential new requirements needed to support the use case

[PR.5.12.6-1] Subject to user consent and operator’s policy, the 5G system shall be able to expose to a subscriber the ratio of renewable energy used for the subscriber’s dedicated communication service on periodic basis.

[PR.5.12.6-2] The 5G system shall be able to collect charging information associated with a subscribed service based on the ratio of renewable energy used for providing the service.

NOTE: Calculation of ratio of renewable energy as described in the preceding requirements is done by means of averaging or applying a statistical model. The requirements do not imply that some form of 'real time' monitoring is required.

## 5.13 Use case on energy as service criteria for 5G environment adaptation

### 5.13.1 Description

It is becoming more important and challenging for operators and cloud/data service providers to reduce carbon emissions while providing for the best-in-class with optimal service plans to end-users. Many operators including cloud/data service providers run their services on top of multiple virtualized infrastructure environments with different hardware/software having various energy consumptions.

Often, operators are unaware of their own individual network functions’ power consumption or requirements, and how they behave with 5GS procedures for end-to-end service quality. Thus, operators should be able to measure and control their network functions with energy-based requirements.

In addition, individual network functions should be able to process, register, discover, select, load (re)balance and overload-control based on their current or predicted energy consumption. This would allow operators to fully control and optimize energy consumption internally, and/or based on various service plans for verticals and end-users. For example, using a ‘dynamic energy saving plan’ in mind, during a non-busy hour, the operator should be able to provide a service with a limited number of features, smaller capacity and/or relaxed SLA.

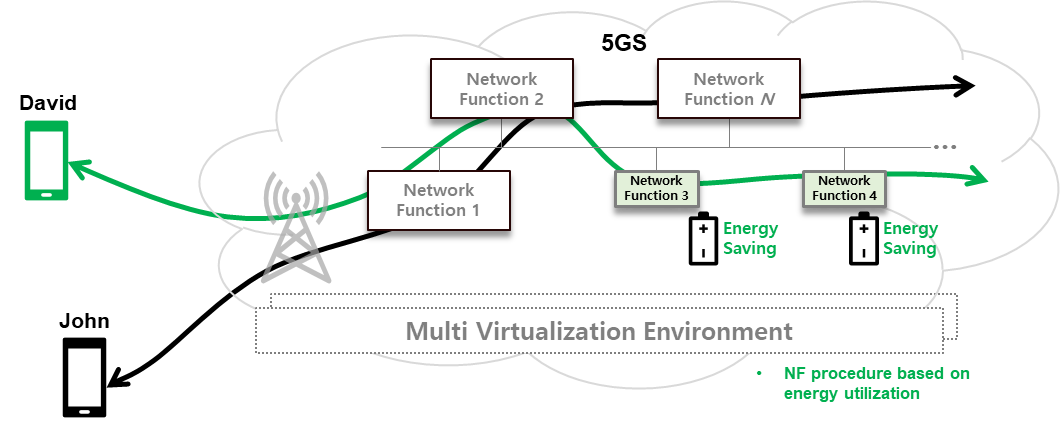


Figure 5.13-1: energy as service criteria for 5G environment adaptation

### 5.13.2 Pre-conditions

5G system supports individual network functions monitoring of energy consumption.

It also supports for registration, discovery, selection, load-(re)balance and overload-control of individual network functions based on their energy consumption.

### 5.13.3 Service flows

1. David and John are subscribed to operator A with different service plans.

2. During operator’s A 5G service time over the 24 hours, depending on the number of subscribers and various service plans, the individual or groups of network functions are adapted, migrated and/or scaled based on their energy-efficiency requirements and plans.

3. Operator A has the ability to set their individual network functions to operate (e.g., for UE registration, NF selection, etc.) based on their current or predicted energy consumption.

4. By regularly measuring energy consumption of the individual network functions, operator A has the ability to fully optimize their energy savings whilst also maintaining a high service quality along with the time-of-the day. Based on how their network functions behave with energy-saving characteristics and controls, they can provide means to coordinate the operation of individual network functions to target global optimization of energy consumption within the 5G network.

### 5.13.4 Post-conditions

David is satisfied and enjoys his lower pricing plan with the awareness of carbon emission.

Operator A is also satisfied because it has the ability to manage (e.g., load balance) its network functions and adapt their procedures based on energy-saving characteristics.

### 5.13.5 Existing features partly or fully covering the use case functionality

None.

### 5.13.6 Potential new requirements needed to support the use case

[PR.5.13.6.1] Subject to operator policy and regulatory requirements, the 5G system shall be able to provide a mechanism for one or more network functions to operate based on energy consumption to meet various end-user’s service requirements.

[PR.5.13.6.2] Subject to operator policy and regulatory requirements, the 5G system shall be able to provide means to coordinate the operation of individual network functions to target optimization of energy consumption within the 5G network.

## 5.14 Use case on reducing GHG footprint of Application Services

### 5.14.1 Description

Global warming caused by excessive emissions of GHG (e.g., carbon dioxide) due to human activity (e.g., burning fossil fuels for electricity generation) is the main driver to climate change, which poses a significant threat to society and the environment. To achieve carbon neutrality, it is important to reduce the GHG incl. carbon emissions in the first place rather than offset them later. Recent advancements in communication and computing capabilities of networks (e.g., 5GS, cloud services) enables offloading tasks to networked and distributed computing nodes (e.g., edge computing, cloud computing) for a wide range of services. However, the rising demand for such services in turn triggers a rising demand for energy and a greater risk of an even higher resulting GHG footprint. 3GPP plays a crucial role in the ICT sector to enable the deployment of these technologies on a global scale and therefore must also play a central role in enabling a sustainable future.

The adoption of alternative sustainable sources of energy incl. renewable energy (e.g., solar, wind, hydropower, geothermy) could help offset the GHG footprint of energy generation based on fossil fuels, even though their corresponding environmental impact also need to be considered. From an ICT standpoint and, 3GPP system in particular, the energy used by computing nodes in networks can be from varied energy with different related levels of environmental impact incl. GHG emissions. Due to the highly variable and unpredictable nature of renewable energy sources, the supply of renewable energy varies substantially by time and location. Hence, it is critical to take temporal and spatial dimensions of energy sources into account to accomplish compute tasks not only for a better traceability of the energy sources used but in turn for enabling a more sustainable energy use to achieve those tasks.

Up until now usually a system is designed to finish compute tasks as soon as possible (high throughput) and indicate results to the requester as soon as possible (low latency). However, some compute tasks have flexibility in both when and where they are executed, i.e., such type of workload could be executed in any computing node and tolerate some delays if the workload gets completed within certain given deadline. For example, some of AI/ML training, simulation, and video processing tasks might not require a quick response, which would allow flexibility to delay the execution of the related workloads in a computing node until, e.g., the utilized energy is deemed satisfactory in terms of GHG emissions. Such flexibility further allows to route workloads to a computing node using the (most) sustainable energy sources at that moment. As part of service, 3GPP system is able to execute compute tasks in a sustainable way by leveraging such flexibility.

In addition, consuming the renewable energy immediately when they are available, instead of storing them for the future use (e.g., in a big battery system), can also bring some economic benefits to operators or service providers, because this can reduce the cost and investment for scaling the energy storage system needed by the overall system.

In the following use case, by considering the temporal and spatial information of sustainable energy source and availability, the possibility of reduction of the GHG footprint for application services is explored.

### 5.14.2 Pre-conditions

The operator A provides the computing services through the computing nodes owned by itself or other third-party companies via certain Service Level Agreement (SLA), which execute the compute tasks (e.g., offloaded by users). Each computing node is powered by renewable energy (e.g., solar energy), non-renewable energy (e.g., coal) or both. The highly variable nature of renewable energy sources makes the resulting GHG emissions by each computing node varies considerably by time and location. The high cost of large-scale energy storage system (e.g., battery system) also brings the incentive to the operator to consume the renewable energy immediately when it is produced (e.g., to reduce the cost for building the needed battery system). The ratio of renewable energy measures the ratio of the power that is used from renewable energy sources as a percentage of total power usage in a given time unit.

NOTE: Computing node is the resource to execute compute tasks belong to service provider, e.g., computing node can be a Server node hosted by an Edge Computing Service Provider (ECSP) based on PLMN operator service agreement. Alternatively, ECSP and the PLMN operator can be part of the same organization.

Eva is an AI engineer who needs to train some AI/ML models for her research work. Eva has collected all the needed data (e.g., the images of cats and dogs) during the weekdays. To train this model, the required dataset must be sent to a computing node, and the node will train the specified model (e.g., a dog/cat classifier) over this dataset. Eva needs to get the training result at the beginning of workday next week. Her compute tasks for AI/ML model training are offloaded to the system owned by the operator A for execution.

The operator A offers a “green compute and communication service” which can decide when and where the offloaded tasks are computed to reduce the overall GHG footprint of the system. This green compute and communication service requires tolerated deadline of compute task specified by the user, i.e., the quality of experience is not degraded as long as the compute task is finished within the given deadline. Eva loves our planet, so she is using this service for reducing the GHG footprint of her research work.

### 5.14.3 Service flows

1. Eva subscribes the green compute and communication service to save our planet.
2. Eva indicates to the operator A that the compute task needs to be finished before the next workday (8:00 AM on Monday).
3. Eva offloads the compute task of AI/ML model training to the system owned by the operator A before she left the office (7:00 PM on Friday) in New York.
4. In the operator A’s system, the "computing node NY" (i.e., the computing farm located in New York) is the closest computing resource to the Eva’s workplace. Traditionally the "computing node NY" is selected to execute Eva’s task immediately; however, there is no solar power in New York at this moment (i.e., the ratio of renewable energy is low).
5. If Eva’s AI/ML model is trained by the "computing node NY", it will result in some GHG emissions to the air which is not friendly to the environment.
6. Fortunately, the "green compute and communication service" has two alternative options for the execution of Eva’s compute task based on the ratio of renewable energy reported by the "computing node NY" and another node "computing node LA" located in Los Angeles:
   * [Option 1: Greener Location] The "computing node LA" located in Los Angeles (is on 4:00 PM) having abundant solar energy at that moment (i.e., the ratio of renewable energy is high). The dataset can be sent to "computing node LA" and the results are sent back to Eva after the completion. Since the execution will not last over one day, the system can adopt this option even if it requires more time for the communications.
   * [Option 2: Greener Time] The "computing node NY" will have plentiful solar energy during the period of 9:00 AM – 4:00 PM every day. The training executed during the daytime of the weekend will not generate any GHG emissions. Since the task can be finished before the next workday, the system can adopt this option to schedule the training to be executed during the weekend.

In addition, by consuming the renewable energy immediately when it is produced, the operator can reduce the scale of its renewable energy storage system and reduce the overall cost.

1. By adopting the either option provided by "green compute and communication" service, the execution of AI model training requested by Eva can be nearly carbon-free and Eva still obtains the desired training result before the deadline.

### 5.14.4 Post-conditions

Eva’s AI/ML model training is finished before the targeted deadline while protecting our beautiful planet.

Operator A reduces the scale of its renewable energy storage system and reduce the overall cost.

### 5.14.5 Existing features partly or fully covering the use case functionality

None.

### 5.14.6 Potential new requirements needed to support the use case

[PR.5.14.6-1] Subject to operator’s policy and agreement between an application service provider and operator, the 5G system shall support a mechanism for the application service provider (including edge computing service provider) to provide to the 5G system the current or predicted ratio of renewable energy used for providing application services on periodic basis.

[PR.5.14.6-2] Subject to user consent and operator policy, the 5G system shall provide a mechanism to support the selection of an application server (including edge application server) based on the ratio of renewable energy for providing application services.

NOTE: An application server (including edge application server) can be a server node hosted by an Edge Computing Service Provider (ECSP) based on PLMN operator service agreement. Alternatively, ECSP and the PLMN operator can be part of the same organization.

## 5.15 Use case on supporting communication service with carbon-aware service requirements

### 5.15.1 Description

Climate change caused by excessive emissions of GHG (Green House Gas, e.g., carbon dioxide) due to human activity (e.g., burning fossil fuels for electricity generation) is the main driver to climate change, which poses a significant threat to society and the environment. Toward the goal of carbon neutrality, it is important to reduce the GHG incl. carbon emissions in the first place rather than offset them later. Recent advancements in cellular technologies (e.g., 5GS) that enable a wide range of applications has led to an explosive growth of service demands in networks. ICT sector is expected to account for 20% of the global energy consumption by 2040. 3GPP plays a crucial role in the ICT sector to enable the deployment of these technologies on a global scale and therefore must also play a central role in enabling a sustainable future.

One key approach for telecom operators to reduce their carbon footprint is utilizing more renewable energy (e.g., solar, wind) that does not release carbon dioxide when producing electricity. The energy used by network can be from varied energy with different related levels of environmental impact incl. GHG emissions. Due to the highly variable and unpredictable nature of renewable energy sources, the supply of renewable energy varies substantially by time and location.

In the following use case, telecom operator provides communication service with carbon-aware requirements considering the ratio of renewable energy and the subscriber’s preferences.

### 5.15.2 Pre-conditions

Eva watches videos during the commute. She receives 5G service from the mobile network operator A.

The 5G system operated by operator A is powered by both of renewable energy (e.g., solar energy) and non-renewable energy (e.g., coal). The ratio of renewable energy measures the ratio of the power that is used from renewable energy sources as a percentage of total power usage in a given time unit. Calculation of ratio of renewable energy is done by means of averaging or applying a statistical model.

The operator A offers a “green communication service option”, in which the service has adaptable QoS levels considering the ratio of renewable energy and the subscriber’s preferences, e.g., the operator A can provide a communication service with bit rate of 30Mbps and low ratio of renewable energy, which can be adapted to the service with bit rate is 10Mbps when high ratio of renewable energy is more desirable to the subscriber.

The operator A monitors the supply of renewables for its 5G system and adjust the operation of communication services. Following the pre-agreed QoS requirements with a subscriber, the operator A adjusts the communication services based on the supply of renewable energy.

Eva loves our planet, so she subscribes the optional green communication service. Therefore, the operator can determine to use a higher latency but greener network function entities (e.g., located in a faraway but powered by 80%+ renewable energy large scale computing/communication center) to provide services to Eva.

NOTE: This green service ensures that QoS level criteria continues to be met (i.e., there is no trade-off between energy efficiency and service quality) since all the adapted QoS levels are satisfied by the subscriber based on the pre-agreement.

### 5.15.3 Service flows

1. During the commute between the home and the workplace, Eva watches videos via 5GS operated by operator A.
2. Eva subscribes the green communication service option provided by operator A. Following the pre-agreed QoS requirements with Eva, the operator A adjusts the communication services based on the supply of renewable energy. That is, Eva is satisfied with all the adapted QoS levels based on this agreement when watching videos.
3. The operator A monitors the supply of renewables for its 5GS, i.e., the ratio of renewable energy (i.e., the ratio of the power that is used from renewable energy sources as a percentage of total power usage).
4. During the daytime, since solar power of a remote computing/communication center is plentiful, Eva gets video streaming with bit rate of 10Mbps, and the service provided by operator A has 40% for the ratio of renewable energy.
5. During the busy evening time, since the supply of solar power is decreasing, Eva gets video streaming with bit rate of 25Mbps, and the service provided by operator A has 10% for the ratio of renewable energy.
6. By "green communication service option” provided by operator A, the service requested by Eva use renewable as much as possible and Eva is still satisfied with the video content.

### 5.15.4 Post-conditions

Eva can enjoy communication service with the satisfied quality of service while protecting our beautiful planet.

### 5.15.5 Existing features partly or fully covering the use case functionality

None.

### 5.15.6 Potential new requirements needed to support the use case

[PR.5.15.6-1] Subject to user consent and operator policy, the 5G system shall be able to provide means to adapt a communication service to fulfil the subscriber’s preference concerning the ratio of renewable energy used for providing the service.

NOTE: Calculation of ratio of renewable energy as described in the preceding requirement is done by means of averaging or applying a statistical model. The requirement does not imply that some form of 'real time' monitoring is required.

# 6 Consolidated potential requirements

## 6.1 Energy consumption as service criteria

This subclause contains the requirements related to energy consumption as service criteria and supporting energy credit limit for specific service.

Table 6.1-1 – Consolidated requirements on energy consumption as service criteria

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.1-1 | Subject to operator’s policy, the 5G system shall support subscription policies and means to enforce the policy that define a maximum energy consumption rate for services without QoS criteria.  NOTE x: The granularity of the subscription policies can either apply to the subscriber (all services), or to particular services. | PR 5.1.6-1, PR 5.1.6-2 | merge |
| CPR 6.1-2 | The 5G network shall support a means to define maximum energy consumption rate with specific granularities (which include subscriber granularity, network slice granularity). | PR 5.1.6-3 |  |
| CPR 6.1-3 | Subject to operator’s policy, the 5G system shall support subscription policies that define a maximum energy credit limit for services.  NOTE x: The definition of subscription is in TS 21.905. | P.R 5.5.6-1 | Definition of subscription is in TS 21905  **maximum energy credit limit:** a policy establishing an upper bound on the quantity of energy used by the 5G system to provide services provided to a specific subscriber.(clause 3.1) |
| CPR 6.1-4 | Subject to operator’s policy, the 5G system shall support a means to associate energy consumption with charging information based on subscription policies. | P.R 5.5.6-2 | Charging aspect |
| CPR 6.1-5 | Subject to operator’s policy, the 5G system shall support a mechanism to perform energy consumption credit limit control for services.  NOTE x: The result of the credit control is not specified by this requirement.  NOTE x: Credit control [18] compares against a credit control limit. It is assumed charging events are assigned a corresponding energy consumption and this is compared against a policy of energy credit limit. It is assumed there can be a new policy to limit energy consumption allowed. | P.R 5.5.6-4 |  |

## 6.2 Different energy states of network elements and network functions

This subclause contains the requirements related to different energy states of network elements and network functions and dynamic changes.

Table 6.2-1 – Consolidated Requirements on different energy states of network elements and network functions

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.2-1 | The 5G system shall support different energy states of network elements and network functions. | PR 5.2.6-1 |  |
| CPR 6.2-2 | 5G system shall support dynamic changes of energy states of network elements and network functions.  NOTE x: This requirement also include the condition when providing network elements or functions to an authorised 3rd party, the dynamic changes can be based on pre-configured policy (the time of changing energy states, which energy state map to which level of load, etc.) | PR 5.2.6-2 |  |
| CPR 6.2-3 | The 5G system shall support different charging mechanisms based on the different energy states of network elements and network functions. | PR 5.2.6-3 | Charging aspect |
| NOTE x: These requirements assume it is possible that there is new energy states of network elements and network functions. | | | |

## 6.3 Monitoring and measurement related to energy efficiency

This subclause contains the requirements of monitoring and measurement related to energy efficiency .

Table 6.3-1 –Consolidated Requirements on monitoring and measurement related to energy efficiency

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.3-1 | Subject to operator's policy, the 5G network shall support energy consumption monitoring at per network slice and per subscriber granularity.  NOTE x: Energy consumption monitoring as described in the preceding requirement is done by means of averaging or applying a statistical model. The requirement does not imply that some form of 'real time' monitoring is required. | PR 5.1.6-4 |  |
| CPR 6.3-2 | Subject to operator’s policy and agreement with 3rd party, the 5G system shall be able to acquire energy consumption information of the network functions serving this 3rd party, independently from NG-RAN deployment scenarios. | PR.5.3.6-1 |  |
| CPR 6.3-3 | Subject to operator’s policy and agreement with 3rd party, the 5G system shall be able to acquire energy consumption information of the NPN serving this 3rd party, including the shared network function(s) which is (are) serving the NPN. | PR.5.4.6-1 |  |
| CPR 6.3-4 | Subject to operator’s policy and agreement with 3rd party, the 5G system shall be able to acquire the ratio of renewable energy used to provide dedicated communication service to this 3rd party on periodic basis.  NOTE x: The reporting period could be set, e.g., on monthly or yearly basis. | PR.5.9.6-2 |  |
| CPR 6.3-5 | Subject to user consent, operator policy and regulatory requirements, the 5G system shall be able to acquire the energy efficiency information (e.g., including the estimated carbon emissions) related to a subscriber based on the subscriber’s data volume over a specific period of time, the operator’s network energy consumption, and the carbon intensity of operator’s network.  NOTE x: The carbon intensity of operator’s network can be provided by an authorized third party and can vary based on locations.  NOTE x: The granularity of reporting (e.g., per month) is not discussed in this work. | PR 5.10.6-1 |  |

## 6.4 Information exposure related to energy consumption

This subclause contains the requirements related to information exposure related to energy consumption.

Table 6.4-1 – Consolidated Requirements on information exposure related to Energy Usage

| CPR # | Consolidated Potential Requirement | Original PR # | Comment |
| --- | --- | --- | --- |
| CPR 6.4-1 | Subject to operator’s policy and agreement with 3rd party, the 5G system shall be able to expose energy consumption information of the network functions serving this 3rd party, independently from NG-RAN deployment scenarios to authorized 3rd parties. | PR.5.3.6-1 |  |
| CPR 6.4-2 | Subject to operator’s policy and agreement with 3rd party, the 5G system shall be able to expose energy consumption information of the NPN serving this 3rd party, including the shared network function(s) which is (are) serving the NPN to authorized 3rd parties. | PR.5.4.6-1 |  |
| CPR 6.4-3 | Subject to operator’s policy, the 5G system shall support a means to expose energy consumption to authorized third parties for services, including energy consumption information related to the condition of energy credit limit (e.g. when the energy consumption is reaching the energy credit limit). | P.R 5.5.6-3 |  |
| CPR 6.4-4 | Subject to operator’s policy and agreement with 3rd party, the 5G system shall be able to provide to authorised 3rd parties the reporting of the ratio of renewable energy used to provide dedicated communication service to this 3rd party on periodic basis.  NOTE x: The reporting period could be set, e.g., on monthly or yearly basis. | PR.5.9.6-2 |  |
| CPR 6.4-5 | Subject to user consent, operator policy and regulatory requirements, the 5G system shall be able to provide a mechanism to expose to the authorized third parties the energy efficiency information (e.g., including the estimated carbon emissions) related to a subscriber based on the subscriber’s data volume over a specific period of time, the operator’s network energy consumption, and the carbon intensity of operator’s network.  NOTE x: The carbon intensity of operator’s network can be provided by an authorized third party and can vary based on locations.  NOTE x: The granularity of reporting (e.g., per month) is not discussed in this work. | PR 5.10.6-1 |  |

# 7 Conclusion and recommendations

Editor's Note: to be provided.

Annex A: Existing energy efficiency standardisation

## A.1 Overview of existing energy efficiency standardisation

In ETSI, GSMA and 3GPP, there were many reports, studies, specifications related to energy efficiency. And now there are also ongoing 3GPP R18 studies on energy efficiency in both SA5 and RAN.

In ETSI, existing specifications cover several aspects of energy efficiency, which include energy efficiency metrics and measurement methods for mobile core equipment, metrics and methods to measure energy performance of Mobile Radio Access Networks, measurement and monitoring of power, energy and environmental parameters for ICT equipment in telecommunications. [2] [3]

GSMA has done lots of work in assessing energy consumption in different fields within a communication system. In "Going green: benchmarking the energy efficiency of mobile", GSMA states that 73% of the energy of the participating operators is consumed in the radio access network (RAN). The network core (13%), owned data centres (9%) and other operations (5%) account for the rest. [4] The statistics show that energy efficiency is an end-to-end issue.

In 3GPP, energy efficiency has been studied in SA, SA5 and RAN. SA have studied system requirements and principles and provided an Energy Efficiency Control Framework. [5] SA5 has specified concepts, use cases, requirements and solutions for energy efficiency assessment and optimization for energy saving, as well as Energy Efficiency (EE) KPIs. [6] [7] RAN EE study has concentrated on the definition of network energy consumption models, evaluation methodology and KPIs, also studied and identified techniques on the gNB and UE sides to improve network energy savings in terms of both BS transmission and reception. [8]

## A.2 Energy efficiency KPIs

3GPP Energy Efficiency KPI definitions are under SA5 (Telecom Management) responsibility. They are based on measurements collected on RAN or CN network elements / network functions via OA&M. The KPI calculation is a generalisation of the work in ETSI TC EE. Figure A.2-1 below shows the KPI derivation with notes to the source specifications.

Performance Measurements

(TS 28.552, 3GPP SA5)

Energy Consumption Measurements a.k.a. PEE parameters (Power, Energy and Environmental)

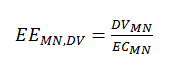
(TS 28.552, TS 28.554, 3GPP SA5, based on input from ETSI ES 203 336-12)

3GPP generic EE KPI =

is a generalisation of

O&M Collection Method

(TS28.550, TS 28.532, 3GPP SA5)



Defined in ETSI TC EE 203 228

Figure A.2-1: KPI derivation and sources

## A.3 Summary of existing energy efficiency standards

Table A.2-1 below shows the standards relevant to the present document with a synopsis taken from the Scope clause of the standard.

Table A.3-2: List of EE specifications

|  |  |  |  |
| --- | --- | --- | --- |
| **SDO** | **Group** | **Standard** | **Summary** |
| 3GPP | SA | TR 21.866: "Study on Energy Efficiency Aspects of 3GPP Standards" [5] | Identifies and studies the key issues and the potential solutions in defining Energy Efficiency Key Performance Indicators and the Energy Efficiency optimization operations in existing and future 3GPP networks. |
| 3GPP | SA5 | TS28.310: "Management and orchestration; Energy efficiency of 5G" [6] | Specifies concepts, use cases, requirements and solutions for the energy efficiency assessment and optimization for energy saving of 5G networks. |
| 3GPP | SA5 | TS28.552: "Management and orchestration; 5G performance measurements" [11] | Specifies the performance measurements for 5G networks including network slicing.  Performance measurements for NG-RAN are defined in this document, and some L2 measurement definitions are inherited from TS 38.314.  The performance measurements for 5GC are all defined in this document. Related KPIs associated with those measurements are defined in TS 28.554 [12]. |
| 3GPP | SA5 | TS28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)" [12] | Specifies end-to-end Key Performance Indicators (KPIs) for the 5G network and network slicing |
| 3GPP | SA5 | TS28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)" [13] | Specifies the Generic network resource information that can be communicated for telecommunication network management purposes, including management data about energy efficiency |
| 3GPP | SA5 | TR28.813: "Management and orchestration; Study on new aspects of Energy Efficiency (EE) for 5G" [7] | Investigates the opportunities for defining new Energy Efficiency (EE) KPIs and new Energy Saving (ES) solutions. |
| 3GPP | RAN1 | TR 38.864: "Study on network energy savings for NR" [8] | Investigates network energy consumption modelling, techniques for network energy saving, evaluation of gains and impact. |
| ETSI | TC EE | ETSI ES 203 228: "Environmental Engineering (EE); Assessment of mobile network energy efficiency" [3] | Defines the topology and level of analysis to assess the energy efficiency of mobile networks (excluding terminal) |
| ETSI | TC EE | ETSI ES 202 336-1: "Environmental Engineering (EE); Monitoring and Control Interface for Infrastructure Equipment (Power, Cooling and Building Environment Systems used in Telecommunication Networks) Part 1: Generic Interface" [9] | Defines monitoring and control of Infrastructure Environment i.e. power, cooling and building environment systems for telecommunication centres and access network locations. |
| ETSI | TC EE | 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" [10] | Defines measurement and monitoring of power, energy and environmental parameters for ICT equipment in telecommunications or datacenter or customer premises |

Annex B:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-08 | SA1#99-e | S1-222412 |  |  |  | TR skeleton | 0.0.0 |
| 2022-08 | SA1#99-e |  |  |  |  | Inclusion of approved pCRs from SA1 #99e: S1-222413: S1-222414: S1-222415: S1-222416 | 0.1.0 |
| 2022-11 | SA1#100 |  |  |  |  | Inclusion of approved pCRs from SA1 #100: S1-223431: S1-223654: S1-223656: S1-223657: S1-223658 | 0.2.0 |
| 2023-02 | SA1#101 |  |  |  |  | Inclusion of approved pCRs from SA1 #101: S1-230061: S1-230418: S1-230445: S1-230589: S1-230680: S1-230685: S1-230790: S1-230791: S1-230792: S1-230793 | 0.3.0 |
| 2023-03 | SA#99 | SP-230226 |  |  |  | MCC clean-up presentation to SA#99 | 1.0.0 |
| 2023-05 | SA1#102 |  |  |  |  | Inclusion of approved pCRs from SA1 #102: S1-231179: S1-231180: S1-231277: S1-231531: S1-231532: S1-231533: S1-231540: S1-231543: S1-231550: S1-231552: S1-231553: S1-231770: S1-231771: S1-231772 | 1.1.0 |
| 2023-06 | SA#100 | SP-230519 |  |  |  | MCC clean-up for approval by SA#100 | 2.0.0 |
| 2023-06 | SA#100 | SP-230519 |  |  |  | Raised to v.19.0.0 by MCC following approval by SA#100 | 19.0.0 |