v4

Variant of [RAN93e-R18Prep-13] Network energy savings Version 0.0.4

RAN

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Title: Moderator's summary for discussion [RAN93e-R18Prep-13] Network energy savings

Agenda item: 9.0.1

Document for: Discussion and decision

1 Introduction

Proposals on network energy savings were provided to the 3GPP RAN Rel-18 workshop in June 2021. Network energy savings was subsequently identified as a topic for further email discussions in RWS-210659 [1]:

13. Network energy savings

- KPIs and evaluation methodology, focus areas and potential solutions

Deadline and NWM organization are based on the guidelines provided by the RAN Chair in RP-211639. As per guidance RWS-210659 of the RAN Chair the discussion in this thread should be based on the RWS submissions.

The aim is to converge on a set of areas with a reasonable scope as a "high-level description" – where "high-level description" herein is not a "draft SID/WID" but is something like a single slide with a set of bullets. In other words, it can be viewed as a skeleton of the possible objectives with some high-level notes.

Please avoid any input like "We support / we do not support" as this is no "number counting" driven discussion, but focus on tangible commercial interests (near & longer terms).

This email discussion will start by collecting general views as well as comments on KPIs, evaluation methodology, and focus areas. It is not the goal of this email discussion to discuss potential solutions. Views will also be requested (in a later round) on the potential impact on SA/CT, and on the leading WG and secondary WGs.

2 Initial phase

2.1 General comments

Companies are invited to provide general comments on the topic of network energy savings in the context of Rel-18.

Feedback Form 1: General comments on network energy savings

1 – Nokia France

Network energy efficiency is essential for both environmental sustainability and OpEx reduction.

2 – Nokia France

Network energy efficiency should be a criterion for selection of solutions across all Rel-18 features (where relevant), not isolated to a single item. (sorry for split posting!)

3 – Telia Company AB

Telia Company agrees with Nokia view and we see that energy efficiency, NW sustainability and operational cost reduction targets should be the key criteria for all 3GPP Release 18 solutions and proposed work items.

4 – VODAFONE Group Plc

•Improved Energy Efficiency is important for at least:

–Reduction in greenhouse gas emissions

–Reduction in energy costs

•Our current studies show that the majority of energy is consumed at the base station site

•Within the base station site, the majority of power is consumed by the “remote radio head” transmission path

–This situation is likely to get worse as more frequency bands are added to existing sites.

•Current techniques for energy saving include dynamically powering down under utilised frequency bands on multi-band sites

–Fairly effective but crude -> optimisations and alternatives are likely to exist!

–Maintenance of coverage for LTE and 2G will remain important for IoT devices

•**Proposal**: **in Rel18, 3GPP should study techniques for base station energy efficiency improvements, including those that permit maintenance of LTE coverage while delivering NR (e.g. using DSS)**

5 – CATT

The network energy saving had been studied in LTE Rel-10 with the conclusion of network energy saving techniques through network implementation. Additional network energy saving technique of small cell ON/OFF had been specified in LTE 12. The standard specific solution of network energy saving would provide higher benefit in network energy saving and UE experience in network access

6 – MediaTek Inc.

Network power saving should include both network nodes (gNBs/TRPs/IABs) and UEs for achieving the best network-wise energy efficiency. The evaluation methodology and power saving adaptation designs should take into account both network nodes and UEs.

7 – Ericsson LM

Agree with above companies that network energy savings are important from an environmental and OPEX perspective

8 – Verizon UK Ltd

Agree with all above - network power saving is one of the high priorities issues for us. We think only by implementation is not enough. We are looking for better resutls based on likely UE involvement. We also agree with Vodafone that this should cover the DSS case with LTE.

9 – InterDigital Belgium. LLC

Agree with above. Improving network energy efficiency is beneficial for reducing operational costs and environmental impact. Initiating SI focused on this topic can help ensure that potential solutions are given due consideration.

10 – Futurewei Technologies

Network energy saving is crucial for sustainability and cost saving. Study (and then specification) of standards features to enable network energy saving while maintain good network performance and user experience should be a key item in R18.

11 – China Telecom Corporation Ltd.

We think NR network energy saving can be a study item leaded by RAN1 because we need to develop the evaluation methodology and evaluate the energy saving effect and performance impact to select the proper network energy saving solutions, similar to UE power saving. RAN2 can be the secondary WG because RAN1 energy saving solutions may have RAN2 impact such as signalling aspects, and RAN2 may study UE assistance information as potential focus area, which attracts many companies' attention. RAN3 is also the possible secondary WG because intra-network signalling enhancement are mentioned by some companies in the last R18 workshop.

Regarding possible SA/CT impact, we think the energy efficiency metric for RAN may have SA impact since SA5 is working on the overall energy efficiency metric.

12 – Motorola Mobility UK Ltd.

Energy efficient network operation may be one of key aspects to enable dense deployments to satisfy coverage and capacity KPIs. Rel-18 NR can provide more optimized solutions to improve network energy efficiency on top of existing implementation-based solutions.

13 – Guangdong OPPO Mobile Telecom.

OPPO

For network energy, it is reasonable to consider for OPEX of operator. To identify the benifit of candidated scheme, we should consider:

1. Overall power saving saving gain of gNB side.

2. Power comsumption for UE side should be keepin in the same level. Lower UE performance impact.

We don't want to see the energy consumption simply move to UE side.

14 – Apple Benelux B.V.

Agree with Vodafone and other companies that network energy efficiency is important and 3GPP should study in Rel-18 ways for gNB entry efficiency improvements

15 – Spreadtrum Communications

Spreadtrum Network energy saving has benefits on carbon neutrality and OpEx reduction. It is our desire to investigate the alignment and harmonization b/w gNB and UE to save the whole network power consumption. Also, we share the view from some UE vendors that we should pay attention to not introduce the power consumption increase at UE side.

16 – Beijing Xiaomi Mobile Software

Network energy savings is beneficial to operators, the study is necessary. In the same time, the minimum UE power consumption and performance impact should be considered as a baseline.

17 – Qualcomm Incorporated

In our view, network energy saving is important for operational cost reduction, and environmental sustainability. Rel-18 should have a dedicated item to investigate and standardize solutions to enable network energy saving, while also considering the impact on the UE's power consumption.

18 – RadiSys

We agree with other companies that Network energy savings is needed for Opex reduction and to reduce carbon footprint. We also think this is a much needed SI for mmW small cell equipment. Rel18 should have a separate SI to analyse possible solutions and impacts.

19 – TELECOM ITALIA S.p.A.

We agree with the other companies this is a key topic for Rel 18.

We must focus on short term objectives (to be part of a Work Item) and studies to be hopefully finalized in Rel 18, but looking to longer term aspects.

We fully share the point raised by Mediatek and others:

Network power saving should include both network nodes (gNBs/TRPs/IABs) and UEs for achieving the best network-wise energy efficiency

The KPIs adopted need to provide an holistic view of the effects of features. As such, any new Work Item / Study Item should provide an assessment on energy efficiency (improve/decrease/neutral). Just to make an example, increasing the channelization in RedCap UEs is likely to have a major impact on network densification and therefore on carbon footprint.

The evaluation has to be done by considering the system, not the single element. In particular, system evaluations should be carried out by considering a cluster of cells, not a gNB in isolation (and of course the impact of UEs)

20 – vivo Communication Technology

Network energy saving is one useful aspect for future evolution of the network. We support to study the related solutions. As stated by CATT, similar studies in UMTS and LTE have been finalized.

On the other hand, UE backward compatibility is also important for consideration. The new solutions for network energy saving which have less impact / complexity / power consumption to UE side is taken first priority for consideration.

21 – SoftBank Corp.

We also see the strong need for network energy saving. In our past experience, improvement on the power consumption on network side has a negative impact to UE side, and vise versa. We fully agree with MediaTek and other companies that finding good balance between UE and network is quite important.

22 – Samsung Electronics Co.

We agree to the importance of NR network energy efficiency.

We also see Nokia's point, i.e., Network energy efficiency should be taken as an overall criterion for all Rel-18 features rather than an isolated item

23 – Intel K.K.

Agree with above comments on the need for a study item focusing on Network energy savings. Impact to UE power consumption and throughput/latency should also be considered for any proposed solutions.

24 – China Mobile Com. Corporation

Network energy savings is essential for operators' OPEX control and also environment-friendly. 5G network has been widely deployed since 2019, with the increasing number of 5G gNBs, it is urgent for operators to reduce network energy consumption. Considering that R18 enhancement will be applied no earlier than 2024, we strongly propose the network energy savings can be an independent study item followed by a WI lead by RAN1 in Rel-18.

25 – KDDI Corporation

we are very interested in this topic and also believe the solutions will reduce the OPEX and keep NW sustainability. Taking into account the future use of small cell operation, Rel-18 will be a good start to study this topic.

26 – Orange

Network energy saving is essential to operators. We agree with Nokia that better consideration should be made on the impact of features on energy consumption. Besides we believe that further specification work is required to reach finer granularity on managing the switch off of transmitter elements in the base station (e.g. at beam level) and finer granularity to monitor the energy efficiency of each network element.

27 – Deutsche Telekom AG

For us as operator it is of utmost importance to support meeting the UN Sustainable Development Goals 2030 (SDG2030). In addition, the power consumption of RAN nodes have a very strong impact on the OPEX of mobile radio networks. Therefore, energy efficiency and energy saving opportunities are basic requirements to be considered for all features to be introduced by 3GPP in 5G-A both on the network and on UE side.

For the NW infrastructure, operators need tools that allow dynamic handling/provisioning of radio resources in different load situations and also allow tradeoffs between energy saving and possible loss of coverage, capacity and/or performance for customers. Ideally, those tools should be embedded in a NW automation framework incl. AI/ML approaches.

28 – Fujitsu Limited

Agree with above companies, network energy saving is important for OPEX reduction and sustainable growth.

29 – BBC

We are keen to see a realistic and standardised methodology for the measurement and modelling of power consumption in networks to help operators to reduce their impact. In addition, as a content provider, the BBC would like the ability to better understand the impact of our content being consumed over these networks to also drive down our impact.

30 – HUAWEI TECHNOLOGIES Co. Ltd.

We also think that network energy efficiency is very important and it is worthwhile to do some enhancements in Rel-18. In our understanding, a dedicated SI is needed for this study. Firstly, a dedicated SI is needed to establish some fundamental thing for evaluating the performance from network energy efficiency perspective, e.g. network power consumption model. Secondly, it is worthwhile to study some dedicate solutions to improve the network energy efficiency while minimizing the impact on spectral efficiency and/or user experience. Thirdly, the target scenario for network energy saving may not be exactly the same as other Rel-18 SI/WI. For example, it is expected that the main gain on potential network energy saving is mainly for network idle state and light load case, while other Rel-18 features may mainly target for high load case to improve the spectral efficiency. Of course, it would be good if all other Rel-18 features can take network energy efficiency into account when applicable also, though it is not clear yet how to apply this network energy efficiency criterion here and there, it may depend on the detailed features.

31 – ZTE Corporation

We also agree that the network energy saving is important for the development of a sustainable and green comminication system, and also reduction of the operation cost. Therefore, we think the study and specificiation of solutions to network energy saving in Rel-18 is essential. In genral, we also think that the network energy saving requires the involvement of RAN1, RAN2, and RAN3 for a comprehensive study.

32 – CEWiT

Network energy saving is essential in Rel-18 for green revolution of wireless communication considering environmental impact by high power transmissions. Also, It is also needed for energy cost reduction and to deal with variations in energy consumption introduced by new technologies. The impact of Network energy saving on the user performance should be considered.

33 – LG Uplus

We think all aspects for this important item are covered from companies above where we want to emphasize especially following points :

- In terms of consideration/evaluation for energy efficiency, overall assessment for system is required.
- Balance/consideration/impact between NW and UE should be taken into account.
- Regarding the consideration of energy efficiency over all Rel-18 items, conceptually agreeable, but seems difficult where in practical how and what to do for each item.

34 – Panasonic Corporation

We agree the need to study network power saving considering the environmental impacts. The trade with UE power consumption and the system efficiency should be taken into account. Multiple carriers transmission base station should take into account.

35 – China Unicom

We think network energy saving is very important to reduce the OPEX, especially for 5G network. We are supportive to have a R18 WI/SI on network energy saving. It is proposed to study and evaluate the potential solution to minimize network energy consumption, as well as impact on spectral efficiency and user experience.

2.2 Proposals

Companies are invited to provide views on KPIs and network energy consumption modelling.

Feedback Form 2: Comments on KPIs and network energy consumption modelling

1 – Nokia France

A straightforward network power model should be adopted from existing work, e.g.: "A Flexible and Futureproof Power Model for Cellular Base Stations," B. Debaillie, C. Desset, and F. Louagie, IMEC, in IEEE 81st VTC Spring 2015 (https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7145603)

Developing such models from scratch takes significant effort and time; hence adoption of an existing model is recommended in order to avoid delay to network energy considerations in other WIs.

Reference parameters for the model should be identified. (The above model has already been referenced in Rel-17 work, and is likely to be sufficiently flexible to be used as-is, with potential adjustment of parameters where identified as necessary.)

This model could be applied in other WIs impacting network energy efficiency, and in any subsequent study of specific network energy efficiency techniques.

2 – MediaTek Inc.

Fundamental KPIs should be energy efficiency per bit in unit of **Joule per bit**. Alternatively, we can define **average power consumption per link for gNB and jointly investigate it with average UE power consumption**.

Energy consumption modelling can reuse/extend UE power consumption model framework, as in Appendix of TR38.840, where fundamental operations (power states) are defined and assigned with agreed power values. There also define different levels of sleep powers and minimum time gaps to realize the respective sleep types. Regarding the TX power scaling for serving multiple UEs, it can also be defined as part of power scaling.

3 – Ericsson LM

For KPIs and evaluation methodology, we see the following needs study:

- Determine reference configuration(s).
- Identify main functionalities and their associated relative energy consumption, e.g.

- Idle: digital parts, beamforming, receive L1/L2 processing, reception, etc.
- PA: PDCCH, SSB, TRS/CSI-RS, SI, PDSCH transmissions, etc.

- Identify potential sleep states and the associated transition times e.g., Micro, Light, Deep, MIMO sleep modes.
- Identify KPIs related to NW energy consumption evaluation

4 – InterDigital Belgium. LLC

Similar view as Ericsson that the identification of KPIs should be part of the Study. Reuse of existing models can be considered.

5 – Futurewei Technologies

Need KPIs that enable evaluating the relative power consumption savings from various techniques while assess the network and UE performance.

It is desirable to have a more generic and not overly complicated model of network energy consumption that can apply to different implementation and various scenarios.

Suggest to separate UE power saving study from network energy consumption work to be more focused.

6 – China Telecom Corporation Ltd.

KPIs

The energy efficiency(EE) metric has been defined in 3GPP TS 38.913 and ITU-T M.2083 as an important KPI for NR. And it can also be used as the KPI for network energy saving. The EE of a single gNB can be expressed as $EE=V/E$

Where V is the indicator of the network performance in a period of time, e.g. throughput, coverage, E is the energy consumption in a period of time. For the throughput indicator, the EE can be in bits/Joule; for the coverage indicator, the metric can be in m2/Joule. The EE of the global network should be load related. The model defined in 3GPP TS 38.913 for the global EE can be a start point.

Network energy consumption model

The energy consumption should include at least three parts:

- The energy consumption of sleep mode
- The energy consumption of transition: the lower power level of the sleep mode, the longer time for transition.
- The energy consumption of active mode with data transmission/reception, which includes the energy consumption of RF and circuit. The power of RF can be impacted by multiple factors such as spatial domain factor/frequency domain factor/power domain factor.

  Further details can be found in our contribution later.

7 – CATT

The network power model is much straight forward since network control the DL Tx/UL Rx and associated power consumption. The UE power model defined in TR38.840 could be used as the starting point for the power model of network component.

8 – Motorola Mobility UK Ltd.

KPIs need to address energy consumption (Joule/bit), spectral efficiency (bps/Hz), and RAN-level latency aspects. We think it is important to guarantee qualities of user experiences (e.g. average UE throughput, latency) while improving network energy efficiency.

To model network energy consumption, it would be useful to define different sleep modes for different types of base stations and to come up with energy consumption estimates for the defined sleep modes and state transitions.

9 – Guangdong OPPO Mobile Telecom.

OPPO

We see the KPI of NW size could be the overall power saving percentage of network(cellular modeling)

Another KPI should be UE side power consumption change and performance impact.

10 – Apple Benelux B.V.

3GPP should identify KPIs to optimize, network elements that would benefit the most of such energy efficiency KPI optimizations and the methods to improve network energy efficiency in accordance with identified KPIs. While doing so, it is important to control the impact of such network energy efficiency optimizations on UE power and performance.

11 – Spreadtrum Communications

Spreadtrum

KPI

To address both NW side and UE side power consumption, we recommend that one KPI is the power saving gain of gNB like that done in UE power saving, and another KPI is the power consumption of UE which cannot be increased, e.g. over a threshold.

network energy consumption modelling

The level of the power model should be discussed. For example, the power model in UE power saving study is abstract sufficiently, which is based on power consumption unit per slot. Can we follow such simple methodology?

In UE power saving, the power model for reception is constructed. For NW energy saving, can the power model be focused on transmission? In this way, we can easily achieve the harmonization b/w gNB transmission and UE reception.

12 – Beijing Xiaomi Mobile Software

The KPIs for network energy consumption modelling should take UE power consumption impact into account, both idle mode and connected mode should be modelling in parallel.

13 – Qualcomm Incorporated

For network energy consumption modeling and methodology:

- It is desired to reuse and extend the available models, such as 3GPP UE power consumption model, or the well-known models (like Nokia's reference) found in the literature
- PA efficiency should be added to the model to scale the PA consumption (as opposed to it being fixed)

- A model for the PA efficiency number could be discussed linking PAPR, back-off and linearity requirements to PA efficiency (as opposed to having these parameters fixed)
- Different types of network nodes (such as different base station classes, and IAB-nodes) should be supported.
- Different sleep states and their associated power consumption values and transition times should be supported.

For the KPI, we should at least use “Joule per bit”.

14 – vivo Communication Technology

Network power model is important. Similar approach as used in TR38.840 could be used as the starting point for the power model of network component.

15 – TELECOM ITALIA S.p.A.

The assessment should be done in a holistic manner, considering not only a single gNB, but system performance and evaluating e.g. the impact on energy efficiency if some feature require network densification (e.g. poor TRP/TRS UE performance).

Proposal 1: provide KPIs based on system performance, non isolated gNBs

Proposal 2: include an holistic energy efficiency KPI in every Work Item

From technical aspects, we suggest (in addition to the topic mentioned above) to specify/improve in a Rel 18 Work Items aspects such as DL power control, radiation pattern shaping (to focus the power where needed), subframe switchoff, SON/MDT aspects to identify traffic patterns

Proposal 3: approve a ”short term” Work Item focusing on ”low hanging fruits” (power states, radiation pattern shaping, SON/MDT, DL power control, subframe switchoff, ...)

16 – RadiSys

3GPP should define KPIs to calculate network energy consumption. Green rating of networks shall be introduced based on the KPIs by operators.

17 – Samsung Electronics Co.

TR38.913 (KPI) and TR38.840 (reference configuration, power consumption model) could be a starting point.

18 – Intel K.K.

Agree with CATT above that power consumption model developed as part of Rel16 UE Power Saving SI (i.e., TR 38.840) can be used as starting point. In particular, model should take into account energy consumption in different sleep modes, transitions between different states, energy consumption in active mode. Both DL and UL activity should be taken into account.

19 – China Mobile Com. Corporation

The evaluation of network energy saving should include two aspects, namely the network energy consumption gain and the system performance loss.

The evaluation of network energy consumption gain can be realized by the comparison of absolute energy consumption or the comparison of relative energy consumption. For absolute energy consumption comparison, KPI of network energy efficiency (in bit per Joule) can be studied and defined. For relative energy

consumption comparison, reference configurations for power consumption needs to be defined, and then based on the power model, energy-saving gain of various solutions can be compared.

The system performance loss is measured by user throughput. The aim of Rel-18 network energy savings is to build a balance between network energy consumption and network performance/UE experience.The final choice of energy-saving schemes should be those with better energy-saving gains and limited user throughput loss.

20 – China Mobile Com. Corporation

Update of above comments.

KPIs:

The evaluation of network energy saving should include two aspects, namely the network energy consumption gain and the system performance loss.

The evaluation of network energy consumption gain can be realized by the comparison of absolute energy consumption or the comparison of relative energy consumption. For absolute energy consumption comparison, KPI of network energy efficiency (in bit per Joule) can be studied and defined. For relative energy consumption comparison, reference configurations for power consumption needs to be defined, and then based on the power model, energy-saving gain of various solutions can be compared.

The system performance loss is measured by user throughput. The aim of Rel-18 network energy savings is to build a balance between network energy consumption and network performance/UE experience.The final choice of energy-saving schemes should be those with better energy-saving gains and limited user throughput loss.

Network energy consumption modelling:

We think the Rel-18 network energy consumption modelling can take the UE power saving model as the baseline, which including the following parts:

l Network sleep mode: The network sleep mode is when network doesn't need to transmit or receive and can turn off some or all component devices. Different sleep modes, e.g., deep sleep, light sleep and micro sleep and the energy consumption value for each mode can be further studied in SI phase.

l Network active mode: The active mode is when network transmit or receive signal normally. Furthermore, the network active mode can be divided into network transmission mode and network reception mode, since the energy consumption can be different, e.g., PA only works in network transmission mode. The energy consumption value of each mode and the scaling factors for active mode such as spatial domain/frequency domain/power domain that affect active mode power consumption can be studied during the SI phase.

l Network mode transition: This part is to evaluate the transition time and energy consumption between the switch of different network sleep/active modes.

21 – Orange

Network energy saving is essential to operators. We agree with Nokia that better consideration should be made on the impact of features on energy consumption. Besides we believe that further specification work is required to reach finer granularity on managing the switch off of transmitter elements in the base station (e.g. at beam level) and finer granularity to monitor the energy efficiency of each network element.

22 – KDDI Corporation

We think Ericsson's suggestion on the KPI identification is needed

23 – Telia Company AB

We agree with proposals (1&2&3) from TIM. Potentially there could also be a document to capture the summary of release 18 WIDs total energy efficiency and network energy savings. Maybe RAN level WID.

24 – Deutsche Telekom AG

With respect to energy efficiency metrics we can rely on existing definitions made by ITU, ETSI or SA5.

Dependent on 5G-A features under consideration single link evaluations may be sufficient in exceptional cases, but usually system level simulation evaluations under different load and traffic type scenarios have to be considered. Furthermore, there is a need for a tradeoff analysis between energy saving potential of certain features and the related loss in customer performance (throughput, latency, …) or coverage taking into account also impacts of transition phases for gNB PA/cell wake-up or sleep modes.

Reference scenarios have initially to be defined that allow the evaluation of feature impacts on energy consumption and performance.

25 – Fujitsu Limited

Not only energy consumption but also spectral efficiency and coverage need to be considered. We agree that KPI identification is also a part of the SI.

26 – HUAWEI TECHNOLOGIES Co. Ltd.

For the network energy consumption modelling, it is preferred to define a **reference network energy consumption model** as what is done in UE power saving. That is, there is no need to align the absolute power values of different base stations from different vendors but only develop a simplified energy consumption model with reference power levels (e.g. reference power unit) when operating in different states with different key parameters.

The **study on the reference network energy consumption model** can focus on the following aspects:

- Define reference configuration(s), e.g. FR1/FR2, Macro/Pico, the number of Rx/Tx chains, BW, etc.
- Define power level of different sleep modes (e.g. Micro/Light/Deep sleep mode) for network idle state with no data transmission/reception, including the associated transition time and the transition energy
- Define power level for network active state with data transmission/reception, considering key parameters such as the number of active CCs, the number of active TRX chains, the RB occupation and the transmit power scaling factors, etc.

As to the KPIs, in our understanding it seems sufficient to define some evaluation metrics to reflect both the gain from energy saving perspective and the impact on system performance / user experience, details as shown in our reply below for evaluation methodology. The motivation to introduce other energy efficiency KPI (e.g., bit/J or bps/W) for RAN study on network energy saving is not clear to us, maybe proponents can explain more on the motivation first.

27 – ZTE Corporation

To model the NW energy consumption, the UE power consumption model in TR38.840 can be taken as a reference. Herein, the following aspects need to be considered:

(1) a refenrence configuration, includling the number of RX/TX antenna, the number of RBs, the number of carriers, etc

(2) Possible sleep modes, and corresponding time/energy required by sleep mode transition

(3) Power consumed by differenet states, such as data transmission/reception(PDSCH, PUSCH,PDCCH, PUCCH), reference signal transmission/ reception(SSB, CSI-RS, SRS), etc.

(4) Scaling rules if the configuration of transmission/reception is updated in relative to the reference configuration.

The KPIs capable of reflecting the NW energy saving benefits can be considered.

28 – LG Uplus

Regarding KPI/modeling, we agree with the companies mentioned that it can be started from well-known references like ITU-T and 3GPP works before.

Companies are invited to provide views on evaluation methodology and scenarios

Feedback Form 3: Comments on evaluation methodology and scenarios

1 – VODAFONE Group Plc

DSS operation should be included in the evaluation where the topic is relevant for the IoT coverage bands (e.g. sub 2 GHz bands).

2 – MediaTek Inc.

Evaluation should be based on **system-level simulations**, covering at least **urban micro** and **rural macro** cell cases. Whether advanced network nodes, TRPs and/or IABs, are included can be discussed further.

3 – Ericsson LM

See comment above

4 – InterDigital Belgium. LLC

Determining applicable deployment scenarios should be part of the Study. The scenarios can include typical deployments used today as well as more advanced types of deployments expected to be used more frequently in the future.

5 – Futurewei Technologies

Need to focus the scope. For example, we can start with FR1 and not including IAB.

Scenarios at least include various loads, CA combination (intra- and inter-), FDD (with moderate number of antennas) and TDD (with large number of antennas)

6 – China Telecom Corporation Ltd.

Evaluation methodology

The appropriate system models reflecting the realistic network should be studied and developed, e.g. the scenario coverage/capacity limited, the proper traffic/model.

The system level simulation (SLS) can be used for evaluation. Since the frequency/spatial/power factor can all impact the evaluation results, the reference configuration should be defined for the evaluation, e.g. the number of TRX/beam, the periodicity of SSB/RMSI, the multiplex of SSB.

Scenario

Since the downlink transmission mainly influence the energy consumption according to our test results, we suggest to focus on the downlink scenario first. Besides, since the energy consumption of RRU is more dynamic and more potential to be reduced, the potential solutions on RRU energy saving can be considered first.

7 – CATT

The reference system configuration and operation scenarios need to be identified in order to evaluate the potential power saving techniques for network energy saving.

8 – Motorola Mobility UK Ltd.

Considering that a major source of power consumption in NR is massive MIMO based multi-beam operation, FR2 and FR1 with massive MIMO (e.g. 3.5 GHz bands) can be prioritized.

9 – Guangdong OPPO Mobile Telecom.

OPPO

Methodology. Network power model should be introduced based on exsiting ones.

UE side can reused the power model defined in Rel-16.

10 – Spreadtrum Communications

Spreadtrum

Evaluation methodology

Like methodology in UE power saving, SLS and simple numerical analysis and evaluation can be used. ”Power budget” may be used like the link budget to easily align companies’ view. In the ”power bugdet”, each modules/component of gNB transmitter/receiver has a power consumption unit.

Scenarios

Macro/micro cell deployment is the most important scenarios. Small cell deployment is the second priority.

11 – Beijing Xiaomi Mobile Software

FR1 DL transmission might be a start point for evaluation.

12 – Qualcomm Incorporated

Please see above our answers in Feedback Form 2.

13 – vivo Communication Technology

System level simulation (monte carlo) is needed. UE power consumption is also provided as supplementary results for considering the impact to UE side.

14 – TELECOM ITALIA S.p.A.

as indicated before:

The assessment should be done in a holistic manner, considering not only a single gNB, but system performance and evaluating e.g. the impact on energy efficiency if some feature require network densification (e.g. poor TRP/TRS UE performance).

Proposal 1: provide KPIs based on system performance, non isolated gNBs

Proposal 2: include an holistic energy efficiency KPI in every Work Item

15 – Samsung Electronics Co.

the target scenario includes both FR1 and FR2 with reference to LTE.

16 – Intel K.K.

We think SLS evaluations are needed, and one or more reference configurations can be identified. Possible scenarios could include dense urban deployment, CA, multi-TRP, FR1/FR2 with large number of antennas etc.

17 – China Mobile Com. Corporation

Evaluation methodology: System-level evaluation (SLS) can be used in Rel-18 network energy savings to evaluate the absolute or relative power saving gain of each candidate network energy saving methods, and the user throughput performance compared to baseline configuration. The final choice of energy-saving schemes should be those with better energy-saving gains and limited user throughput loss.

In addition, different UE traffic models and network traffic loads should also be considered in the SLS evaluation to reflect realistic network.

Scenarios:

Frequency range: the target frequency range can focus on FR1 since its large scale deployment.

Deployment scenarios: Both Macro and hot spot deployment scenarios can be studied.

18 – KDDI Corporation

We share the similar view as Futurewei, DSS might also need to be considered

19 – Fujitsu Limited

Both FR1 and FR2 need to be studied.

20 – Deutsche Telekom AG

We see system level simulations as an appropriate tool for the evaluation of energy saving potentials of 5G-A features and to derive the tradeoff w.r.t. potential performance losses dependent on different load and traffic type scenarios.

Scenarios should initially focus on macro cell deployments (at least in urban and rural environments) with usage of FR1 bands including especially Massive MIMO TDD deployments around 3.5 GHz for at least urban environment. Joint usage of bands by LTE and NR via DSS, as proposed by several companies, should also be incorporated.

21 – HUAWEI TECHNOLOGIES Co. Ltd.

As to the KPI/metric for evaluation, as described in the above question, it needs to use some **evaluation metrics to reflect both the gain on energy saving and the impact on system performance / user experience**. To reflect the gain on energy saving, the number of reference power units saved by some power-saving solutions can be considered. To reflect the impact on system performance / user experience, the detailed metric may depend on the detailed use case/scenario to evaluate, e.g. *UPT* of data transmission can be used to reflect impact on user experience, and possibly *coverage* of common channel/signal for some potential enhancements.

As to the scenarios to evaluate, we should focus on the case when the network is idle or the traffic load is light. As to high load, it is not the main target scenario to achieve energy saving.

In addition, it is expected that at least system-level simulation should be involved and the corresponding assumptions should be set also. Most of the assumptions can be discussed during the study phase. One new key issue to mention here is that we may need some new traffic model for the study of network energy saving. In the case when the network is nearly idle or the traffic load is small, the number of active UEs is often small and the packet size for a large part of data transmission would be small. This may be different from some existing simulation assumptions used before for other topics.

22 – ZTE Corporation

See our comments above.

Furthermore, similar with Rel-16 UE power saving study, we think both system level simulation and numerical simulation can be considered in the evaluation of NW energy saving.

23 – LG Uplus

We agree to the view that the evaluation should be system-level.
Also the general scenario for most operators should be considered which is FR1 EN-DC + TDD + massive MIMO in urban as Deutsche Telekom mentioned.

Companies are invited to provide views on the potential focus areas (e.g. which parts of the RAN to study)

Feedback Form 4: Comments on potential focus areas

1 – Nokia France

Specific network energy saving proposals with standards impact should be considered under relevant topics, e.g. multi-antenna related proposals under MIMO.

2 – VODAFONE Group Plc

DSS operation should be included where the topic is relevant for the IoT coverage bands (e.g. sub 2 GHz bands).

3 – MediaTek Inc.

In addition to scenario-based or semi-static power saving adaptations, dynamic and joint adaptation for network nodes and UEs should be investigated to maximally exploit all possible power saving opportunities. For the focus areas for L1 part of power saving techniques, we can focus on the **techniques for power saving in data inactivity durations as well as those in data activity durations**. Specifically, the following can be considered:

- Study network-wise power saving techniques for the time durations without data activity
  - Study **joint network node and UE power saving adaptations** in time, frequency, spatial and power domains
  - Study **gNB wake-up mechanism** for balanced network power saving and UE service/coverage requirements
- Study **techniques for improving PA efficiencies of gNB and UE slides** for the time durations with data activity

For higher-layer enhancements, the following include two potential focus areas:

- Study **UE assistance information** for joint network and UE power saving
- Study **network node coordination** for network power saving

4 – Ericsson LM

We see the following areas to be looked at:

- Network energy saving techniques in spatial domain
  - e.g. Dynamic TX/RX port adaptation including port ON/OFF, CSI-RS enhancements.
- Network energy saving techniques in time domain
  - e.g., Identify techniques which can enable micro/light/deep sleep including micro TX OFF.
  - Wake-up signal(WUS) mechanism for gNB, broadcast signal periodicity adaptation.
- Network energy saving techniques in frequency domain
  - CA/DC adaptation using additional information such as UE assistance information.
- UE assistance information helping network energy saving
  - e.g., UE traffic type, priority, time criticality, expected volume, coverage, mobility status, location, etc.
- Intra-Network assistance information helping network energy saving
  - e.g., UE population, context, coverage, etc.

5 – InterDigital Belgium. LLC

Suggest to focus on network energy saving techniques for both “data active” and “data inactive” cases. For each considered technique, UE assistance information and network coordination should also be studied as suggested by Mediatek and Ericsson above.

6 – Futurewei Technologies

Work on different level power saving schemes are needed including network node level, carrier level, signal level, and antenna/panel level.

Study is needed on the tradeoff of energy consumption and network/UE performance.

Work on standard impacts such as UE assistance information and network signaling to the UE and over network interfaces.

7 – China Telecom Corporation Ltd.

1. Network energy saving enhancement techniques in spatial domain (e.g. efficient dynamic TRX/panel/beam on-off)

We tested the TRX switch-off method in realistic network, and according to the test results, by switch off the TRX from 64T to 32T, the energy consumption can be reduced effectively, especially for medium load network. However, The cell throughput descends about 15%-20%, which can be further enhanced.

enhancement.

2. Network energy saving enhancement techniques in time domain (e.g. efficient dynamic symbol switch-off, longer periodicity of common signals/channels)

According to the test results, by switch-off the symbols, the energy consumption can be reduced effectively for low load network with nearly no impact on performance. The performance can be further compensated with the dynamic adjustment of PRB number.

3. Network energy saving enhancement techniques in power domain(e.g. improving PA power efficiency in gNB, dynamic adjust the PSD)

Reducing the transmission power by half, the energy consumption can be saved according to our test results. And the strategy has nearly no impact on the coverage and throughput. However, in the current realistic network, the power adjustment can only be achieve by reboot the network. So we proposed to enhance the energy consumption from the power domain.

4. Network energy saving enhancement techniques in frequency domain (e.g. efficient multi-carrier adaptation, efficient TX/RX bandwidth adjustment)

This solution can combined with the time/power domain solutions to reduce the impact on performance

5. UE assistance information (e.g. UE traffic characteristic information which reflects UE traffic distribution/UE traffic volume change in the time/space domain, uplink wake-up signal)

UE assistance information report is a possible approach to accurate and flexible network energy saving management including.

6. Enhanced intra-network information exchange (e.g. Intra-network information exchange to support transmission power adjustment coordination, beam level operation coordination, energy saving mode extension)

NR R15 only specified the signalling of cell switch-off/re-activation via Xn/X2 interface, similar to LTE. Enhanced intra-network information exchange is a possible way to fine-grained energy saving operation coordination.

8 – Motorola Mobility UK Ltd.

Rel-18 study may need to focus on how to optimize transmission of broadcast signals/channels under multi-beam based cell operation for energy saving, without degrading user experiences in terms of mobility, latency, and throughput.

We think at least the following areas should be studied for Rel-18.

- gNB/TRP/beam dormancy and efficient offloading
- Adaptive transmission of periodic/broadcast signal/channel
- Impact on legacy UEs and UE power consumptions

9 – Guangdong OPPO Mobile Telecom.

OPPO

We can study the solutions for RS, Control channels, Data Channel, Phy procedure and elvaluations.

10 – Apple Benelux B.V.

We support studying network energy enhancements in spatial, time, frequency and power domain as suggested by other companies.

Furthermore, the study should focus on network interfaces enhancements to support those (RAN3); SA5 involvement (for OAM aspects) is likely to be needed too.

11 – Spreadtrum Communications

Spreadtrum

In our view, the effective way to save gNB power consumption is to shut down transmission/reception power in some cases. However, different from UE, the transition energy from sleeping to wakeup is very large, considering the massive MIMO characteristic. We may focus on the scenarios where gNB can sleep for a long time. As well, we should distinguish the baseline coverage scenario and capacity improvement scenario.

12 – Beijing Xiaomi Mobile Software

1 Typical scenarios and evaluation methods

2 Inter-gNB/Network enhancement

3 On DL control and data signal/channels

4 In time/freq/spatial… domains

13 – Qualcomm Incorporated

Optimize Tx On mode: processing for improving PA power efficiency

- Solutions on the Tx and/or the Rx side to compensate for possible PA non-linearities and increase in the in-band and/or out-of-band distortions
- PAPR reduction solutions to facilitate higher efficiency transmission
- Fixed or dynamic out-of-band emissions control method, e.g., allowing usage of the reduced back-off transmission and signal shaping while controlling out-of-band emissions

Support flexible, dynamic, and granular network energy saving techniques, including

- Optimizations and proper configuration of periodic/broadcast signals (SSBs/SI/paging)
- Granular network energy saving (compared to the coarse legacy cell activation/deactivation) in time, frequency, and spatial domain
- Support required coordination (including exchange of assistance information) on the network-side as well as coordination with the UE.

14 – vivo Communication Technology

UL based cell on/off

It is observed that network energy saving could be achieved by shutting down some of cells. In this way, one of potential areas could be dynamic (not very frequent) power on/off for some of cells. For example, cells could be on-demand power on when UL signal is detected, while UEs need to send UL signal periodically. Then, the cell which cannot detect UL signal could be power-off to save energy.

15 – RadiSys

We can study Inter/Intra network co-ordination, AI/ML based traffic prediction for network power reduction and UE assistance information for Network energy savings

16 – TELECOM ITALIA S.p.A.

From technical aspects, we suggest (in addition to the topic mentioned above) to specify/improve in a Rel 18 Work Items aspects such as DL power control, radiation pattern shaping (to focus the power where needed), subframe switchoff, SON/MDT aspects to identify traffic patterns

17 – Samsung Electronics Co.

Keep in mind the performance trade-off from network energy saving

18 – Intel K.K.

Since periodic broadcast transmissions control how long network could stay in a certain sleep mode, some enhancement and adaptation in this regard can be studied. Moreover, dynamic adaptation of Tx/Rx antenna ports, TRP/beam on/off, adaptation of CA, UE assistance information can be considered.

19 – KDDI Corporation

We think Ericcon's comments covers most of the area, we would like to add

another 2 areas □DSS □Secondary cell which is operated under TDD

20 – China Mobile Com. Corporation

The potential network energy saving areas can consider the following:

1. Network energy saving in spatial domain [RAN1]:

   - dynamic TX/RX on/off
   - dynamic RS port adaption
   - potential CSI measurement/report enhancement

2. Network energy saving in time domain [RAN1/2]:

   - dynamic network on/off to enable different sleep modes
     - wake up signal design
   - periodic RS transmission adaptation, e.g., SSB/SIB/paging periodicity adaptation, partial beams on/off of SSB/SIB/paging

3. Network energy saving in frequency domain [RAN2]:

   - power efficient CA/DC operation, e.g., reduce SIB/paging transmission in non-anchor carriers in overlapping deployment scenario

4. Network energy saving in power domain [RAN1]:

   - dynamic transmit power level adjustment

5. UE assistance information [RAN2]:

- UE's traffic, location, preference configuration, etc.

6. Inter-node assistance information [RAN3]:

- exchange the configuration or information of TX/RX number, periodic RS periodicity/beams, power, energy saving mode, etc.

21 – Fujitsu Limited

CA/DC adaptation, UE assistance information for network enerygy saving can be considered.

22 – Deutsche Telekom AG

We share the same view as Ericsson, China Telecom, and China Mobile on the different aspects on energy saving in network infrastructure domains (spatial, time, frequency, power) and the incorporation of UE assistance and inter-RAN node assistance information (with the latter both for aggregated and disaggregated nodes).

23 – ZTE Corporation

The cell is de-activated for NW energy saving in the legacy scheme, which has more impact on system performance. Therefore, more dynamic and fine granularity schemes are preferred to achieve a better tradeoff between NW energy saving and system performance. The study of network energy saving techniques includes

1.gNB transmission/receiving antenna or beam adaption [RAN1, RAN2]

2.Extension of the periodicity of "always-on" or common signal/channel, such as SSB [RAN1, RAN2]

3.UE assistance information [RAN2].

For example, UE can report information such as mobility, or traffic pattern to assist NW energy saving.

4. Network coordination for network energy saving[RAN3].

For example, exchange of the adaptation or other information is needed to support the network energy saving.

Other NW energy saving techniques in frequency/power domain can be also considered.

24 – HUAWEI TECHNOLOGIES Co. Ltd.

The study of network energy saving should focus on two scenarios, i.e., the case in which the network is idle with no data transmission/reception (first case) and the case in which the traffic load is light (second case). For the first case, we think it is important to optimize the transmission of common signals/channels to reduce the number of active symbols and thus enabling the base station in inactive state with more duration, especially for FR2 in which case a lot of symbols must be turned on for beam training. For FR1 case, efficient transmission of common channel/signal together with efficient multi-carrier operation can be considered to avoid/reduce the impact on legacy UEs, e.g. some of the carriers can still operate as normal with the existing common channel/signal while other carriers can operate with simplified common channel/signal as in our paper RWS-210447. For the second case, we think the power saving can be achieved by adjusting the transmission strategies in time domain, spatial domain, frequency domain and power domain, and the adjusting can be in a dynamic manner. For dynamic adjusting, the key issue is to enable accurate link adaption when the transmission parameters in time/spatial/frequency/power domain changes dynamically, and thus some CSI enhancements are needed.

In addition, for FR2, on-demand beamforming with suitable beam width and active analog chains can be considered also. For mmWave, the transmission pathloss is large and hence a lot of antennas are exploited

to form a narrow beam for signal transmission. This large amount of antennas used for beamforming incurs a large power consumption, and hence it is of great significance to enable on-demand beamforming with suitable beam width and active analog chains to achieve power savings.

In a word, we think the study of network energy saving can focus on the following areas:

- o Network energy saving techniques in spatial domain
  - e.g. dynamic TRX port/beam/panel on-off
- o Network energy saving techniques in time domain
  - e.g. efficient transmission of common signals/channels
- o Network energy saving techniques in frequency domain
  - e.g. efficient multi-carrier adaptation using additional information/signaling from UE, adjust TX/RX bandwidth
- o Network energy saving techniques in power domain,
  - e.g. dynamic adjustment of transmit power level

Detailed solutions for the above focus areas needs to be studied in the study item, e.g. CSI enhancements to enable efficient dynamic TRX port/panel on-off and CSI enhancements to enable dynamic adjustment of transmit power level

25 – CEWiT

We suggest to study on coordination between network and UE power saving schemes, UE assistance information for network power saving, network transmission adaptation based on channel condition/traffic etc, n/w power saving schemes based on time/frequency/spatial/power domain as suggested by other companies. The focus should be on both FR1 and FR2.

26 – CATT

During the study of network energy saving in LTE and HSPA, the gNB power saving would come from the ON/OFF of transmission/receiving chain in time and antenna domain as well as the bandwidth reduction of RF processing. Most of them could be performed by network implementation. However, the standard specific solution of network operation in achieving network power consumption reduction would not only accomplish the network energy saving gain but also UE power saving gain as well.

The most important target of network energy saving is the transparency to legacy UEs.

3 Intermediate phase

The moderator's summary of the initial phase is provided below. In the intermediate phase, companies are asked to provide their views on the proposals provided by other companies in the initial phase, using the questions provided below by the moderator.

Summary of general comments

All responding companies emphasized the importance of network energy savings for environmental sustainability, to reduce environmental impact (greenhouse gas emissions) and for operational cost savings. A

majority of companies proposed a dedicated study and some network operators explicitly asked for normative work that will allow for network energy savings in Rel-18 networks. Several companies mentioned that network energy consumption should be accounted for in the development of any new feature. While some companies might consider this to be sufficient, several companies also think that a dedicated study is necessary, and several companies noted that it might be difficult to evaluate each and every feature of a new release in each individual work item. There was also a suggestion for a RAN-level WID summarizing the network energy aspects of all Rel-18 features. So it seems that a first step would anyway require a separate study providing at least a network consumption model and evaluation methodology. If normative work is targeted for Rel-18, the study should also identify areas specifically for improving network energy consumption.

Q1: should every work item be evaluated for network energy efficiency in Rel-18? If so, do you consider this is sufficient, or should 3GPP (instead or additionally) target a dedicated study for enhancements specifically for improving network energy consumption? If each Rel-18 feature is to be evaluated for network energy efficiency, should it be done in each individual work item or as a final activity (e.g. RAN-level) of Rel-18?

Feedback Form 5: Please provide your views on Q1

1 – Futurewei Technologies We do not see the need to have every work item be evaluated for network energy efficiency in Rel-18. A dedicated study is more important. Of course, normative work for network energy saving will need to consider interaction with other features which is business as usual.
2 – China Telecom Corporation Ltd. We don't think the evaluation for network energy efficiency of every WI in Rel-18 is needed. And a dedicated study for network energy consumption enhanced is needed in Rel-18. This feature should be done in an individual work/study item.
3 – Apple Benelux B.V. *While we agree that every feature 3GPP develops should be energy efficient, both for UE and network, we are not sure that it would be practical to have a formal "energy efficiency evaluation" for each and every feature. We prefer a dedicated study.*
4 – CATT We don't think every feature should include the evaluation of network energy saving since the network operates different features in the same time. For DL transmission and UL reception at the gNB, different features and UEs (CONNECTED or IDLE/Inactive) could be active in the same slot. Thus, the network energy saving should be considered with general operation but not individual feature. We could evaluate some features individually linked to network energy saving techniques.
5 – InterDigital Belgium. LLC Network energy efficiency can be considered as criterion for some Rel-18 work item but this may not be sufficient to bring significant improvements. It is preferable to target a dedicated study.

6 – Motorola Mobility UK Ltd.

We think a separate Rel-18 SI followed by a Rel-18 WI is necessary to enhance energy efficiency for basic Rel-15 features, e.g. initial access, mobility, and beam management. In parallel, for new features specified in Rel-18, network energy efficiency can be considered as one of design criteria in each WI.

7 – Spreadtrum Communications

Spreadtrum It should be a dedicated study. From UE features perspective, we think there are some features conflicting, e.g. coverage ehancement vs. UE power saving. But it has no problem. It is up to NW to enable/disable the feature. For network energy saving, the features may conflict with some other features. It is also up to NW to enable/disable them. It is traditional that the features are decoupled as much as possible. We should avoid too complicated design/analysis.

8 – Qualcomm Incorporated

We think we should have a *dedicated* Rel-18 item for network energy saving, with the following two main objectives:

1. Specification of a network energy consumption model and methodology
2. Study techniques and features to enable network energy saving

Whether Rel-18 should also have normative work, need not be discussed at this time in our view.

9 – Intel K.K.

We suggest having a dedicated study item that can at least focus on developing network power consumption model and evaluation methodology, including developing KPIs. One or more reference network configurations can be identified for evaluations. We do not think every WI needs to separately include considerations in this regard, at least at the moment.

10 – KT Corp.

We would prefer to see dedicated study for network energy saving. This will be one of the important feature for 5G-Advanced shown to public that Telecommunication industry is trying every means to achieve carbon-neutral environment.

11 – Beijing Xiaomi Mobile Software

General principle had already there in TS38.913, beyond the dedicate work item we think it might be difficult to evaluate every work item for Rel_18, unless companies have strong energy efficiency concern on any individual item.

12 – Samsung Electronics Co.

In principle, every WI should take into account the KPI of energy efficiency. However, similar with others, it is more practical to have a dedicated item.

13 – vivo Communication Technology

We support a general study item for network power saving.

14 – Guangdong OPPO Mobile Telecom.

Taking the network power consumption in to one critiria, it will make a quite different study methodologies of a WI. We would doubt how complex this will make further decision.

We are open to a discussing an dedicated NW power saving item.

15 – VODAFONE Group Plc

A dedicated study on energy saving would allow us to :

a) look for energy related improvements in the features that have been introduced in Release 15-17; AND

b) to define a model from which KPIs can be used to measure deployed equipment.

For new R18 SIDs/WIDs, energy aspects should be taken into account in a pragmatic manner during the study phase (at the end of the WID it is too late!).

16 – ZTE Corporation

We think a dedicated study for network energy saving is better, which provides the possibility to use a unified methodology to evaluate and compare the benefits and performance impact of all the possible power saving techniques.

17 – China Mobile Com. Corporation

We don't see the necessary of evaluate every work item for network energy efficiency in R18. A dedicated study item followed by a work item in R18 for enhancements to improve network energy consumption is proposed.

18 – KDDI Corporation

Agree with above companies that we start from a dedicated study item in Rel-18

19 – Panasonic Corporation

Our view is a dedicated study for enhancements specifically for improving network energy consumption would be more useful especially a network consumption model and evaluation methodology. If some working methods are established, to evaluate it in each WI may be possible but not yet such phase in our view.

20 – Fujitsu Limited

At first we need to define a generic evaluation method in a dedicated SI. It might be used for evaluation of network energy efficiency in some other items, but not for every Rel-18 WIs.

21 – Ericsson LM

All work items should have network energy efficiency in mind, but we think it is not feasible for every WI to evaluate NW EE without having an agreed evaluation framework for NW energy consumption in 3GPP. So, we prefer this happens in a separate item.

22 – Deutsche Telekom AG

Energy efficiency should be in general a design criteria for all RAN features under consideration, but separate evaluation for each feature in different WIs doesn't make sense.

We would prefer to have a Rel-18 SI on NW energy efficiency that initially defines KPIs and the evaluation framework. A follow-up phase may work on evaluation of the benefits of different features and possible tradeoffs between energy saving and potential performance losses.

23 – TELECOM ITALIA S.p.A.

Agree with Vodafone, especially on

For new R18 SIDs/WIDs, energy aspects should be taken into account in a pragmatic manner during the study phase (at the end of the WID it is too late!).

And the work should be not done in isolation. Impacts on system level performance should be evaluated:

- improvements in a single gNB / feature may cause degradation to the overall system power consumption
- relaxation of UE RF performance requirements (e.g. TRP, TRS) definitely impact the overall power consumption

At least RAN4 performance requirements need to be assess in terms of carbon footprint

24 – MediaTek Inc.

Design consideration is different for design evaluation. For each WI to conduct SLS and evaluate the corresponding network energy efficiency impact, there will induce huge duplicated efforts. Instead, a dedicated SI for developing the evaluation methodology and identifying essential network energy saving techniques will be much efficient. R16 UE power saving SI is a good example, which establishes good foundation for effective UE power saving WIs in R16 and R17. In this regard, a dedicated SI for Rel-18 is suggested.

25 – HUAWEI TECHNOLOGIES Co. Ltd.

R18 would be the first release to study NR network energy saving in PHY layer, and thus our view is that 3GPP should at least target a dedicated SI/WI item for it, aiming for establishing basic network power consumption model and evaluation methodology first, and then to identify enhancements specifically for improving network energy consumption. It would be impossible/impractical for each feature to 'evaluate' the network energy saving if there is no common baseline/model setup yet. After WG has clear common understanding on the basic power consumption model and evaluation methodology, as the outcome of a (first) dedicated SI/WI, new features being developed in other WI/SI of R18 can be reasonably reviewed. This is the common practice in 3GPP as UE power saving features in a dedicated UE power saving SI/WI vs. features being discussed in other SI/WI.

Furthermore, simply assessing how "other work items" impact network energy consumption provides no guarantee that significant network energy savings would be achieved in Rel-18 without a dedicated study/-work item and functionalities developed specifically for network energy savings. So the priority should be given to a dedicated study/work item on network energy savings in Rel-18.

26 – CEWiT

Every added features will work together and hence we do not see the need to have evaluation of every work item seperately for network energy efficiency. A dedicated study for network energy consumption in Rel-18 is needed to provide overall performance impact and energy saving gain.

27 – Nokia France

It is important that every work item that adopts solutions that might impact network power consumption should consider those impacts as part of the assessment of different solutions. For example, UE power consumption should not be considered in isolation without considering the impact on network power consumption. If a dedicated study is adopted, it should be additional to suitable evaluations in other WIs, and it should also provide a suitable model for those other WIs to use.

Summary of responses on scenarios

Various scenarios were proposed e.g. for FR1/FR2, FDD/TDD, macro/micro/small cells, urban and rural, targeting various traffic loads. Several companies mentioned that some focus would be needed in order to allow time for normative work in Rel-18. The target scenarios would require more discussion, either in scoping phase or as part of the study. There seems to be wide support for starting from the downlink, and good support for scenarios of urban micro in FR1 with TDD massive MIMO, rural macro in FR1, FR2 beam-based scenarios with massive MIMO, as well as some support for DSS.

Q2: do you agree that a Rel-18 study on network energy savings should prioritize downlink and target the following scenarios:

- *Urban micro in FR1 with TDD massive MIMO*
- *FR2 beam-based scenarios with massive MIMO*
- *Rural macro in FR1*
- *DSS*

Feedback Form 6: Please provide your views on Q2

1 – Futurewei Technologies

We are ok with this list of scenarios. One question about the FR2 massive MIMO scenario. Is the scenario referring to large number of antenna element but limited antenna ports (after analogue beam forming)? If not, may the proponents clarify?

2 – SoftBank Corp.

We want to clarify that inclusion of DSS scenario does not imply any spec change of LTE for the purpose of network energy saving. In addition, DSS in the scenario list looks weird to me because the category is different from other items. I wonder if the following is moderator's intention

- Urban micro in FR1 with TDD massive MIMO
- FR2 beam-based scenarios with massive MIMO
- Rural macro in FR1 without DSS
- Rural macro in FR1 with DSS

Then we are fine with the moderator's proposal.

3 – China Telecom Corporation Ltd.

We agree that the downlink should be prioritized for the Rel-18 network energy saving. We think the network energy is a common feature for the NR, which can be impacted by the antennas. Therefore, we are fine with the scenarios in the lists, most of which are typical scenarios reflecting the impact of RF from spatial/frequency aspects. The list can be a good start point for the work, but may not limited to it.

4 – Apple Benelux B.V.

We agree to support the scenarios listed in Q2, but we are also open to add more scenarios as per operator requirements, if needed.

5 – CATT

DL should be the focus of network energy saving. However, we should have one deployment scenario as the baseline for calibration. Other scenarios could be reported by the proposed network saving techniques.

6 – InterDigital Belgium. LLC

Yes.

7 – Motorola Mobility UK Ltd.

We are supportive to prioritize downlink and to target the above listed scenarios for study.

8 – Verizon UK Ltd

We support all these scenearios - but may revise our view after collecting more information.

9 – Spreadtrum Communications

Spreadtrum FR2 beam-based scenarios with massive MIMO could be down-prioritized. In some country, FR2 is not widely deployed. And FR2 is usually used for capacity improvement, so the network power saving for this area may impact user experience. But if it is the bottleneck of power consumption, we accept that it is worth up-prioritized.

10 – Qualcomm Incorporated

We generally agree the above scenarios are associated with high power consumption, and when a network node is active, Tx (i.e., downlink) may consume more power than Rx (i.e., uplink). However, we think it is too early at this point to do such (de)prioritization of the scope, and we should defer this discussion after getting more alignment on the focus areas, model, methodology and relevant KPIs.

At this point, we propose to focus the study on both FR1 TDD and FR2.

Given that LTE changes will not be in scope for the potential study, the benefits of making DSS a focus area seem questionable. More clarification on this would be appreciated.

11 – Intel K.K.

We think both DL and UL activity need to be considered in the evaluation. We are fine with the top three scenarios. We also suggest including multi-TRP, as we think this is a potential area where power savings can be achieved. Whether DSS can be included needs further discussion.

12 – Beijing Xiaomi Mobile Software

Agree with DL should be prioritized and we are general fine with the scenarios listed.

13 – vivo Communication Technology

In principle fine. For indoor deployment / small cell, LTE Rel-13 has studied on small cell on/off, we think similar small cell scenario can be considered for NR as well.

14 – Samsung Electronics Co.

We would like study the scenarios of both FR1/FR2 and DL/UL.

15 – Guangdong OPPO Mobile Telecom.

OPPO

In the first look, DL would be more helpful for NW power saving. We would like to make it as more open question, e.g. confirm that during the evluation/study phase. However, we would be fine to agree that if all companies can accept.

16 – VODAFONE Group Plc

1) With regard to DSS, what is important is that we do not optimise NR in a manner that looks good for sub 2GHz NR-only cells but fails to provide energy savings on DSS cells.

DSS operation should be included where the topic is relevant for the IoT coverage bands (e.g. sub 2 GHz bands).

2) The base station's downlink transmissions seem to be the biggest consumer of energy in the system, so a focus on this is logical.

17 – ZTE Corporation

We agree that the listed scenarios need to be considered to reduce network energy consumption. However, we think it is too early to down-select the scenarios of interested, more discussions are needed before the prioritization.

18 – China Mobile Com. Corporation

Although both downlink and uplink constitute the network energy consumption, downlink accounts for a higher proportion due to PA power consumption and more slots in TDD, so we can prioritize downlink. Considering the target scenarios, we are open to the list, common part of the above scenarios can be prioritized and dedicated solutions to specific scenarios can be considered, if time allows.

19 – Panasonic Corporation

We are ok with above scenarios.

20 – KDDI Corporation

We are open to all the scenarios and think more discussions are needed. We might revise our consideration with more detailed information.

21 – Fujitsu Limited

We agree to prioritize DL. We also think the benefit of including DSS here needs to be clarified.

22 – Ericsson LM

We think both DL and UL (including PRACH reception) should be considered, and we do not see the need to explicitly prioritize only DL. We are OK with the proposed list of deployment scenarios as starting point.

23 – Deutsche Telekom AG

From our perspective the FR2 related scenario can be down-prioritized compared to the others listed.

W.r.t. the first one (Urban micro in FR1 with TDD massive MIMO) does it mean that only higher bands with TDD, e.g. at 3.5 GHz, will be considered?

We would also see EN-DC/NR-DC macro scenarios with FDD anchor bands on lower frequencies and TDD/Massive MIMO on higher FR1 frequencies as a relevant scenario.

24 – Telstra Corporation Limited

We agree with Ericsson comments on including both UL & DL. In terms of the presented list, Rel-18 study should prioritise the Rural macro in FR1 scenario with & without DSS included in this scenario.

25 – MediaTek Inc.

For the power consumption improvement techniques during data activity, e.g., PA efficiency improvement techniques, prioritizing downlink is proper from network energy saving perspective. On the other hand, **since UE (background) uplink activities will affect gNodeB energy saving during data inactivity, it may be too early to "prioritize downlink"**.

For the scenarios, moderator suggestion looks a good start point. **Since TRP and simple small cell are not included, it looks not consistent with the potential enhancement "Wake-up signal for gNB, gNB/TRP/beam dormancy and efficient offloading".**

26 – HUAWEI TECHNOLOGIES Co. Ltd.

It is understandable that the DL has relatively large impact on network energy consumption, thus ok to focus downlink, i.e. focus on network energy saving from transmission perspective. However, we want to clarify that it doesn't mean only specification work for downlink channel/signaling is needed, some UE assistance/feedback for help of network energy saving may also require standard efforts. In addition, if time permits network energy saving from reception perspective can be studied also.

The scenarios list above look good as starting point. In addition, we think Urban macro in FR1 is typical scenario also, thus proposed to make the following change for the third bullet□

- Urban/Rural macro in FR1

In our understanding, even we have target scenarios here, it doesn't mean the corresponding network energy saving technologies are not allowed to apply to other scenarios.

27 – CEWiT

We are ok with the list but we think the study should not be limited, instead it should be open to other scenarios like IAB. Hence, the study should deal with total power consumption optimization from gNB which can be in uplink and/or downlink.

28 – Nokia France

We suggest not to limit the study in terms of scenarios at this phase, but rather first analyse the energy saving potential of the different scenarios.

Summary of KPIs and network energy consumption modelling

It seems to be the common view that evaluations should not focus on a single KPI, but allow evaluating how to enable system-level network energy savings while balancing impact to network/user performance (spectral efficiency, capacity, UPT, latency) and UE power consumption/complexity. Most companies consider that the definition of the set of KPIs would be part of the study on the evaluation methodology.

There are broadly two views on the network energy consumption metric: absolute energy consumption (e.g. Joule/bit such as from 3GPP TS 38.913, ITU-T M.2083, ETSI, SA5) vs. relative energy consumption based on reference configurations and relative power consumption model such as defined in 3GPP TR38.840 for UEs.

Q3: do you support that both types of network energy consumption metrics are defined and evaluated in the study, or do you support selecting one type of metric (absolute vs. relative) for the 3GPP study/work on network energy savings, and why?

Feedback Form 7: Please provide your views on Q3

1 – Futurewei Technologies

We prefer to support relative energy consumption metric. It could be difficult to have a generic and accurate modeling of network energy consumption for absolute metric. For study purpose, a relative metric is sufficient and allow us to compare different proposals and assess potential benefits. But we're open to reasonable proposals of absolute metric.

2 – China Telecom Corporation Ltd.

We think the relative metric is better for the 3GPP work, while some definitions in the existed absolute metric can be referenced. The relative metric (e.g. metric in TR 38.840) can avoid the alignment of base station of different vendors, which is not needed for the enhancement evaluation. The existed absolute energy consumption metrics are defined from the prospective of realistic network evaluation, the realistic numeric value may be difficult to adopted for the 3GPP study/work, but the KPI and related configurations/scenarios can be referenced and adopted, which can reflect the energy consumption associated with network performance/UE experience.

3 – Apple Benelux B.V.

We have a preference for the relative metrics, for the reason that absolute metrics may depend on implementation details which might be outside of 3GPP scope.

4 – CATT

Relative metrics would be used to identify the energy saving.

5 – InterDigital Belgium. LLC

Yes, we can define and evaluate according to both/either types of metric depending on the type of enhancement targeted.

6 – Motorola Mobility UK Ltd.

Can adopt a relative energy consumption metric for simplicity of evaluation.

7 – Verizon UK Ltd

Absolute energy consumption is used today very easily and it is very useful. We are interested in model based relative consumption analysis too.

8 – Qualcomm Incorporated

Some clarifications may be needed for this question, specifically the meaning of absolute and relative metrics.

First, we believe it is sufficient and simpler (in terms of standardization) to define energy consumption metrics that are *normalized* or *relative* to some reference energy consumption values (e.g., energy consumed in a sleep mode).

Second, and as mentioned in the summary, the relative energy metrics (or KPIs) should be normalized to the number of transmitted/received bits and considering other aspects (such as spectral efficiency).

9 – Spreadtrum Communications

Spreadtrum The absolute energy consumption can be the first-round modeling, and finally we can get to the relative energy consumption for ease of evaluation.

10 – Intel K.K.

We think at least relative energy consumption based on reference configurations should be considered, following TR 38.840. Absolute metric can be optionally considered.

11 – vivo Communication Technology

A relative metric is more appropriate.

12 – Samsung Electronics Co.

We think that relative metric can be free from implementation variants.

13 – Guangdong OPPO Mobile Telecom.

OPPO

For evaluation methodology, network energy consumption metrics can be defined and evaluated relative power value, similar as in 38.840. We prefer have one method. This will also help to make comparable evaluation for UE side.

Our understanding it does not make much different to absolute method.

14 – ZTE Corporation

We think using a relative power consumption model based on reference configuration similar with TR38.840 is sufficient. The BS power consumption depends on various factors in the implementation. It is difficult to accurately quantify the power consumption model in terms of Joule/bit considering all possible factors such as number of equipped TX/RX antennas, BW, etc. Hence, a relative power consumption model is suggested.

15 – VODAFONE Group Plc

Absolute energy consumption is important in focussing our work (e.g. Q2 asking to focus on the downlink). However, within a particular SID, models for relative power consumption are likely to be needed.

16 – China Mobile Com. Corporation

Select one type of metric is prefered. It may be difficult to align the absolute power consumption value of different implementations. So relative energy consumption based on reference configurations and relative power consumption model can be adopted to compare different power saving solutions.

17 – Panasonic Corporation

We think relative energy consumption based on reference configurations and relative power consumption model are more reasonable as the absolute value would be different depending among the implementations. It is similar to UE power consumption model.

18 – Fujitsu Limited

We support to use the relative metric and are open to discuss further on the absolute metric.

19 – Ericsson LM

Relative vs absolute can be discussed as part of the study itself, and no need for high-level objectives to weigh in one way or another.

20 – HUAWEI TECHNOLOGIES Co. Ltd.

Our view is that relative energy consumption should be used as the metric for future study, accounting for various gNB implementations that can be largely different according to network vendors, operators' deployments, sites and channel conditions etc. It will be very difficult to establish consumption model based on absolute power consumption.

For clarification, if really needed similar metric as Joule/bit can also be used in relative energy consumption, e.g. reference power unit/throughput.

21 – MediaTek Inc.

Absolute power value will be very implementation dependent and may be out of date when manufacturing process is changed. In UE power saving, relative power values are defined for different UE operations. The ratios can stay around constant since they are more related to the fundamental computations required. In this regard, **defining relative power values are suggested for network energy saving. But companies are not restricted to translate the relative power values and metrics to absolute ones according to their internal mapping.**

22 – Nokia France

Relative energy consumption modelling is what is relevant to 3GPP specification work and should be used, in order to ensure smooth progress and meaningful comparisons.

Proposals for network energy consumption modelling can be summarized as follows:

- Adopt a known network power model (from the literature such as reference provided by Nokia) or extend the 3GPP UE power consumption model of TR38.840 to gNB, to allow modelling:
  - Main functionalities and their associated relative energy consumption for DL and UL
  - Potential sleep states and the associated transition times
- Definition of one or more reference parameters/configurations
  - E.g. FR1/FR2, number of carriers, macro/micro/small BS, TRP/IAB, number of Rx/Tx chains, bandwidth, periodicity of SSB, (potentially new) traffic models
- Identification of KPIs related to network energy consumption evaluation under various traffic models and traffic loads

Q4: do you agree with the above summary of the steps needed towards network energy consumption modelling? What are the benefits/drawbacks of starting from TR38.840 vs. starting from another known network power model? Which approach should be selected?

Feedback Form 8: Please provide your views on Q4

1 – Futurewei Technologies

We are generally ok with the summary. Deciding the exact power model can be part of the study item.

2 – China Telecom Corporation Ltd.

We are generally fine with the summary. We think the model in TR 38.840 can be a good start, but details need to be further studied. Starting from TR38.840 provide us an explicit evaluation methodology, we can refer to the definition of the sleep modes and associated transition time for UE to define that of the network. Some reference configuration, e.g. periodicity of SSB, can also be adopted. However, since the TR38.840 is focus on the UE side, the specific feature for BS need to be take into consideration (e.g. the KPI reflects the network performance/UE experience associated with the traffic loads, the factors impact the energy consumption for network).

3 – Apple Benelux B.V.

Agree with the summary

4 – CATT

We are OK with the summary

5 – InterDigital Belgium. LLC

Agree with the summary. For the power model, we can adapt the power consumption methodology of TR38.840 to the network side utilizing information from known models / external references.

6 – Motorola Mobility UK Ltd.

In principle, we agree with the above steps. Considering that many in 3GPP are familiar to the Rel-16 UE power saving study, extending the UE power consumption model of TR38.840 to gNB may be a good option to start from. On the other hand, using another known network power model should not be precluded at this point.

7 – Qualcomm Incorporated

We generally agree with the summary, with the following further comments:

- 1. We prefer to adopt a known network power model (from literature such as reference provided by Nokia) as the starting point.
- 2. The exact parameters (e.g., consumed power in different modes, transition times, etc.) and associated values of the adopted model should be further discussed and decided.
- 3. We would like to capture PA efficiency as a reference parameter in the provided list.

8 – Spreadtrum Communications

Spreadtrum We agree basically. Could we add a note? For example, the absolute power consumption model is not excluded in the study.

9 – Intel K.K.

Regarding adopting an appropriate network power consumption model, we prefer to extend the 3GPP UE power consumption model as captured in TR 38.840. The cited paper by Nokia can be considered to adapt the model based on framework discussed in TR 38.840.

One note is that the paper assigns reference power value for different sub-components of gNB for a given reference configuration and it is not quite clear from the paper which sub-components are actually turned off in different sleep modes and how scaling relationship could hold for different sub-components.

We are fine with the summary.

10 – vivo Communication Technology

support the proposal by moderator.

TR38.840 has some sophisticated models and some revision of the power values is needed for gNB instead of UE. And we are also fine to discuss any new power models.

11 – Samsung Electronics Co.

TR38.840 can be a starting point. The difference between UE power consumption (detection, decoding, …) and gNB power consumption (mainly TX perspective) should be taken into account.

12 – Guangdong OPPO Mobile Telecom.

OPPO we are generally OK with the steps.

13 – ZTE Corporation

We think the power consumption model with reference configurations is a good starting point. More comments can be seen in our reply to Q3.

14 – VODAFONE Group Plc

Generally OK with this approach. Note that an earlier Telecom Italia comment on studying realistic network scenarios rather than an isolated base station is important.

15 – China Mobile Com. Corporation

OK with the summary, detail analysis and down selection of different modelling schemes can be part of the study.

16 – Panasonic Corporation

Our preference is to starting from TR38.840. 3GPP internal defined model allows to adjust parameters depending on the needs and discussion.

17 – Fujitsu Limited

As for the network energy saving model, we are generally ok with the above summary but we understand the potential sleep states only refers to time domain network energy saving function. Propose to reword it like " potential energy save mode, e.g. sleep states" for general description.

Starting from the known network power model also considering the way for UE in TR38.840 may be a suitable method.

18 – Ericsson LM

We think most of these questions can be handled at WG-level. We propose to update the first bullet from "Adopt a known network power model (from the literature such as reference provided by Nokia) or extend the 3GPP UE power consumption model of TR38.840 to gNB, to allow modelling:" to "Define a NW energy consumption model considering the following". In addition to the typical sleep states considered (e.g. micro, light and deep sleep states), we also propose to include MIMO sleep state reflecting the potential spatial sleep during data activity times.

19 – Deutsche Telekom AG

We are also in general fine with the modelling summary. Furthermore, we support E///'s view on possible updates and also QC's comment on inclusion of a PA efficiency model.

20 – HUAWEI TECHNOLOGIES Co. Ltd.

The moderator's proposal is generally fine at this stage. Some comments as below:

1. Further discussion for adoption/potential down-selection of the model (i.e. the two models in the first bullet) is expected considering different gNB implementations, workload/TUs and the feasibility for use in PHY evaluation, as part of the study.

2. In our understanding, the first sub-bullet "Main functionalities and their associated relative energy consumption for DL and UL" is to define the consumption model for network active state, in this case it is not clear what does main functionalities here mean, if it means the transmission of different channel/signal, we would not agree because it may not need to differentiate the relative power level for different channel/signal, instead an overall relative power level can be defined taking into different factors into account, e.g. the number of CC, TxRU number, the number of beams, etc. However, this kind of details can be discussed/decided in the study phase. Therefore, we suggest to change the first sub-bullet to "active state and their associated relative energy consumption for DL and UL".

3. The third bullet "identification of KPIs related to network energy consumption evaluation under various traffic models and traffic loads" looks like more related to evaluate methodology, not network consumption model. To cover the third bullet also, we suggest to change the main bullet of the proposal to "Proposals for network energy consumption modelling and evaluation methodology".

21 – MediaTek Inc.

Moderator proposal looks reasonable to move forward. **However, it is not clear how UE power consumption impact can be included in the evaluation framework. As commented by many companies, it is important that the introduction of network energy saving techniques should not revert UE power saving benefits achieved in Rel-16 and Rel-17.**

Also, It is useful that the evaluation framework can be used to evaluate system-wise energy efficiency, including both network nodes and UEs. In this way, the power saving techniques that can benefit both sides can also be identified.

22 – Nokia France

The reference provided earlier is specifically designed for the network side. It is therefore more appropriate than the UE model of TR38.840. We agree that the reference parameters need to be defined; we do not think new traffic models are necessary – existing traffic models should be reused.

Summary of proposed focus areas

Apart from one company proposing that the focus area is defined by each WI within which network energy savings are evaluated, other companies seem to have broadly common views on exploring ways to achieve more dynamic and finer granularity adaptation of transmissions in time, frequency, spatial, power domains. Several companies also mentioned UE assistance information and coordination between network and UE including CSI enhancements, and network node coordination and intra-network assistance information.

The following example areas where provided by various companies:

- Spatial domain
  - Dynamic TX/RX port/panel/beam adaptation including ON/OFF
  - Radiation shaping patterns, on-demand beamforming
  - CSI-RS enhancements
  - CSI measurement/report enhancement
- Time domain
  - Micro Tx OFF, dynamic symbol or subframe switch off
  - Reduced number of active symbols including for beam training
  - Wake-up signal for gNB, gNB/TRP/beam dormancy and efficient offloading
  - Broadcast/common signal periodicity adaptation
- Frequency domain

        - CA/DC adaptation, including with UE assistance information
        - Reduce SIB/paging transmission in some carriers
        - Dynamic TX/RX bandwidth adjustment
    - Power domain
        - Improving PA efficiencies at gNB and related processing at gNB/UE
        - Improving PA efficiencies at UE
        - Dynamic DL power control

Q5: do you agree that the main focus area of a study on network energy savings is to study how to achieve more dynamic and finer granularity adaptation of transmissions in one or more of time, frequency, spatial, and power domains, with supporting/assistance information from UE?

Feedback Form 9: Please provide your views on Q5

1 – Futurewei Technologies We think the list is a good starting point to formulate the study in R18.
2 – China Telecom Corporation Ltd. We are fine with the listed main focus areas, but more areas are needed. Only the focus areas of RAN1 lead are listed currently. In the initial phase discussion, most companies also proposed UE Assistance information and intra-network information/coordination. On the other hand, these are RAN2/RAN3 lead focus areas, they should be explicitly listed.
3 – Apple Benelux B.V. *We support to study energy efficiency optimizations with adaptation of transmissions in one or more of time, frequency, spatial, and power domains.* *Regarding the EU assistance, that particular aspect seems to belong to a much later phase of the study or even a normative work. Suggest to leave that part out for now.*
4 – CATT We should simply the list in top level only, such as antenna/spatial, time, frequency, and power domain. From the outcome of LTE network energy saving in Rel-10, a lot of proposals in network energy saving are not significant. One requirement to be set for network energy saving is the backward compatibility to legacy UEs for any network energy saving techniques.
5 – InterDigital Belgium. LLC Yes.
6 – Motorola Mobility UK Ltd. We think it is important to define a standalone network energy saving SI and WI in Rel-18 with manageable work scope. Thus, we prefer to prioritizing study on flexible transmission adaptation in time, frequency, and spatial domains in Rel-18. While CSI enhancement for accurate link adaptation may reduce "ON" time at a network node by reducing retransmission, it is not directly related to adaptation of network node configurations and can be addressed in a MIMO WI.

7 – Spreadtrum Communications

Spreadtrum Something could be more high level. For example:

Micro Tx OFF, dynamic symbol or subframe switch off: Could we say ”symbol or slot or subframe”?

Reduced number of active symbols including for beam training: Could we say ”active symbols/slots/subframes”?

Thanks.

8 – Qualcomm Incorporated

We agree. However, that is only with the understanding that “more dynamic and finer granularity adaptation of transmission in the *power domain* with supporting/assistance information from UE” includes mitigation techniques employed by the UE to compensate for signal quality degradation as the result of the transmission adaptation for network energy savings.

We should further support required coordination on the network-side.

9 – Intel K.K.

We are fine in principle with the directions. However, we think, instead of listing detail proposals, it is sufficient to capture the following: “*studying NW energy savings based on adaptation of transmissions and/or receptions in one or more of time, frequency, spatial, and power domains*”. Also, it maybe a bit too early to assume there is a need of UE assistance information for certain adaptation scheme at this stage.

10 – Beijing Xiaomi Mobile Software

General OK with the study areas, maybe the impact on UE power consumption can be listed somewhere in the same time.

11 – vivo Communication Technology

In general fine. Some of the listed examples is not clear.

- It seems ’Improving PA efficiencies at UE’ is about the UE power saving and it is not clear to us how does it save gNB power.
- For ‘Micro Tx OFF, dynamic symbol or subframe switch off’, we think current Rel-15/16/17 specification allows gNB dynamic slot and/or symbol on/off, we would like to know the specification impact
- For ‘Broadcast/common signal periodicity adaptation’, we would like to know whether it means SIB1 or other SIB. Other SIB can be scheduled on demand so it is already very flexible. For SIB1, we think backward compatibility should be considered.
- For ‘Reduce SIB/paging transmission in some carriers’, we would like to know whether it is related to overhead reduction? Similar discussion in set 14 CA/DC enhancement.
- For ‘CA/DC adaptation, including with UE assistance information’, it is not clear what additional Rel-15/16 UE assistance information need to be discussed. So far, Rel-16 support to report *maxCC-Preference-r16* as UE assistance information.
- For ‘Dynamic TX/RX bandwidth adjustment’, we would like to know whether it refers to the BWP adaptation, in that sense, we would like to know what is the additional specification impact.

12 – Samsung Electronics Co.

Regarding ”*dynamic and finer granularity adaptation”,* we think semi-static adaptation together with time/frequency/spatial/power domain approach should be still in scope.

13 – Guangdong OPPO Mobile Telecom.

OPPO Direction is OK, we also suggest to put it more general. Remove ”dynamic”/”semi-static” like words should be better.

14 – ZTE Corporation

(1)The listed items only involve RAN1. We agree with China Telecom, other items such UE assistance information (RAN2), and network coordination for NW energy saving (RAN3) should also be explicitly listed.

(2) Antenna adaption should also be considered in spatial domain adaptation.

- Spatial domain

 Dynamic TX/RX port/**antenna**/panel/beam adaptation including ON/OFF

(3) The spatial domain adaptation may have impact on CSI, hence, the enhancement of SRS transmission can be also considered, especially in TDD with DL- UL reciprocity. Hence, our suggestion is as below.

- Spatial domain

 CSI-RS/**SRS** enhancements

(4) The time domain on-off should not be limited to symbol or subframe, other granularity such as slot, millisecond can be also considered.

- Time domain

 Micro Tx OFF, dynamic symbol, ~~**or**~~ subframe, **slot, or millisecond** switch off

 Reduced number of active symbols, **subframes, slots, or milliseconds** including for beam training

15 – VODAFONE Group Plc

OK, but we need to include some way of gathering realistic information on how quickly base station transmissions/PAs can be stopped and (re)started.

16 – China Mobile Com. Corporation

A: Yes, the power saving gain is limited for semi-static implementation based solution, since it can not reflect real-time traffic/UE distribution characteristics, dynamic and finer granularity adaptation of transmissions in above listed domains is useful. As other companies pointed out, UE assistance information and network coordination need to be included. Note that UE assistance information can help to improve gNB dynamic decision, but solutions should be independent on it.

17 – Panasonic Corporation

We agree to study how to achieve more dynamic and finer granularity adaptation of transmissions in one or more of time, frequency, spatial, and power domains, with supporting/assistance information from UE. This would allow to have the balance the network power saving and the system performance.

18 – Fujitsu Limited

We generally agree that the main focus area is to study adaptation of transmissions in time, frequency, spatial, and power domains.

We think the dynamic combination in time, frequency, spatial and power domain energy savings should be identified and studied. Besides, intra-system network coordination should also be considered as an important area for higher layer.

19 – Ericsson LM

We agree with the proposed focused areas, but it should reflect adaptations in both downlink and uplink, i.e. include "efficient adaptation of receptions" in the study . Additionally, intra-NW assistance information should also be considered as part of the focused areas.

20 – TELECOM ITALIA S.p.A.

yes

21 – Deutsche Telekom AG

We generally agree with the main domains listed in the proposal. To define already all details at current point in time seems to be too early.

As raised by different companies in both feedback rounds we would also like to see the impact by NW node coordination approaches and potentially UE assistance information to be considered.

22 – Telstra Corporation Limited

Yes, the list is a good starting point

23 – HUAWEI TECHNOLOGIES Co. Ltd.

We agree that achieving more dynamic and finer granularity adaptation of transmission in different domains should be the main focus of the study, or at least this should be included as part of the study for R18 physical layer enhancements. A semi-static adaptation for network energy saving may already be possible based on gNB implementation or based on the enhancement from high-layer study (e.g. RAN3). A strong desire to enable further reduction/management of network power consumption by finer breakdown of transmission and reception in all possible dimensions is shared among most companies.

In addition, we have two comments on the summary of the example areas from the moderator:

1. The "improving PA efficiencies at UE" may not fit the main interest of the study, even if UE power is to be jointly considered. This can be a general enhancement in other UE power saving related topics.

2. For time domain, in our understanding enhancements for broadcast/common signal should not be restricted to periodicity adaptation, simplifying common channel/signal transmission is promising also. Therefore, we suggest to change the last sub-bullet for time domain to "Broadcast/common channel/signal, including periodicity adaptation and simplified channel/signal transmission".

24 – MediaTek Inc.

We think the categorization is a reasonable starting point although the potential proposals look too many. Further email discussion can consolidate the proposals of higher consensus.

Regarding time-domain enhancements, we see **WUR design is also important for gNodeB energy saving**. **The ultra-low-power characteristics allows more timely monitoring by gNodeB so that gNodeB can be more timely waked up without keeping higher power reception for conventional access schemes**. In this regard, we would suggest the study to include

"Ultra-low-power WUR and WUS" for gNB, gNB/TRP/beam dormancy and efficient offloading

25 – CEWiT

We support to study gNB transmissions adaptation in time, frequency, spatial, and power domains for network energy efficiency enhancements. A dedicated network energy saving study item in Rel-18 with flexible work scope is a good start. The effect on user performance and user process to tackle the effects should be considered.

26 – Nokia France

We agree that these are the main domains that could be considered. For now, we suggest to focus on the main bullets. The sub-bullets are already making assumptions about solutions, which would need to be identified and prioritised for consideration in a study phase first.

4 Final phase

Summary of question 1 on the organization of potential work/study

Many companies consider that it would be too complex to evaluate each new feature for network energy efficiency in separate WIs, but agree that network energy efficiency should considered in the design of RAN features, and that a system-level approach is preferable in the evaluations. It was also pointed out that while network energy efficiency can be considered as criterion for Rel-18 work items, this may not be sufficient to bring significant improvements. Therefore the vast majority of companies support having a dedicated study item on network energy savings in Rel-18 starting with developing a network energy consumption model and an evaluation methodology, and leaving the possibility for normative work in Rel-18.

Moderator's intermediate conclusion on the organization of potential work/study: assuming network energy savings is part of Rel-18, it should be a dedicated study item developing a network energy consumption model and an evaluation methodology, also studying techniques and features to enable network energy saving, and leaving the possibility for normative work in Rel-18.

Summary of question 2 on scenarios

Thank you for the responses on the possible scenarios of interest. At this point we may list the scenarios companies are interested in, with potential selection of the target scenarios in the study phase or when scoping the study item description. It should be clarified that not all details are intended to be included, for example TRPs are always deployed so this is not mentioned but these scenarios may not be limited to sTRP or mTRP. Likewise, some of the scenarios may be applicable with small cells. Regarding the prioritization for DL, many companies agreed that DL is where most of the power consumption happens at the network side and thus should be the first target for where reducing energy consumption, while several companies propose to not exclude the UL from the study and that the modeling should be developed to include both DL and UL. It was also clarified that some support on the uplink may be needed to achieve energy savings on the DL.

Moderator's intermediate conclusion on scenarios: at least as a starting point, the following scenarios can be considered as targets for system-level studies on network energy savings:

- Urban micro in FR1, including TDD massive MIMO

- FR2 beam-based scenarios with massive MIMO

- Urban/Rural macro in FR1 with/without DSS (no impact to LTE expected in case of DSS)

- EN-DC/NR-DC macro with FDD anchor band and TDD/Massive MIMO on higher FR1 frequency band

Summary of question 3 on KPIs and network energy consumption metric:

Although there is interest in absolute metric of network energy consumption, most companies prefer at least working with a relative energy consumption metric (similar with TR38.840 with relative energy consumption based on reference configurations and relative power consumption model), because it looks sufficient for the purpose of improving network energy efficiency, it allows for better alignment avoiding dependency on implementation details, it is simpler for standardization work and more future-proof to future evolutions of components. While some companies prefer to leave decision to the study, it looks like at least a model based on relative energy consumption metric (similar to TR38.840) should be pursued in the study.

Moderator's intermediate conclusion on KPIs and network energy consumption metric: at least a model based on relative energy consumption metric (similar to TR38.840) should be pursued in a study on network energy savings.

Summary of questions 4 and 5 on network energy consumption modelling and focus areas

Several companies suggested to simplify the proposal. Similar to questions 3, the majority of companies supported starting from extending the 3GPP model of TR38.840 to the network side. Several comments were received on the detailed sub-bullets of the potential focus areas. It is clarified here that the sub-bullets in the example areas were provided as a summary of companies' proposals (which could certainly be improved). At this point in time there is no intent to agree on this list of examples, thus an update is not provided here. These could be considered as potential proposals to be provided by interested companies during the study.

The final proposal below tries to provide high-level objectives of a potential study on network energy savings with some guidance considering the comments received on network energy consumption modelling, evaluation methodology and KPIs, high-level focus areas and potential target scenarios.

Final proposal

Potential scope of a study on network energy savings:

1. Definition of a network energy consumption model
    a) Note: it is suggested to adapt the power consumption methodology of TR38.840 to the network side utilizing information from known models / external references, including relative energy consumption for DL and UL, sleep states and the associated transition times, and one or more reference parameters/configurations

2. Definition of an evaluation methodology, including KPIs

    a) Note: evaluation methodology should not focus on a single KPI, but allow evaluating how to enable system-level network energy savings while balancing impact to network/user performance (e.g. spectral efficiency, capacity, UPT, latency) and UE power consumption/complexity

3. Study techniques and features to enable network energy saving

    a) Note: the main focus area is on how to achieve more dynamic and finer granularity adaptation of transmissions and/or receptions in one or more of time, frequency, spatial, and power domains, with support from UE. Additional areas of the study may include UE assistance information and intra-network information/coordination.

As a starting point, the following scenarios can be considered as targets for system-level studies on network energy savings:

- Urban micro in FR1, including TDD massive MIMO
- FR2 beam-based scenarios with massive MIMO
- Urban/Rural macro in FR1 with/without DSS (no impact to LTE expected in case of DSS)
- EN-DC/NR-DC macro with FDD anchor band and TDD/Massive MIMO on higher FR1 frequency band

— end of final proposal —

Feedback Form 10: Companies are invited to comment on the final proposal

1 – CATT We are generally fine with the scope of network energy saving by moderator. Since NR network operation would have both Rel-18 and up UEs and legacy UEs, the new feature of network energy techniques should not change the network access and UE behavior of legacy UEs. We would suggest to study the network energy saving techniques with the requirements of no impact to the legacy UEs in bullet 3 as follows, Study techniques and features to enable network energy saving ”without impacts to the network access and behavior of the legacy UEs”.
2 – Futurewei Technologies We support the proposal from the moderator.
3 – China Telecom Corporation Ltd. We agree with the scopes proposed by moderator in principle. The scenarios listed as the starting point are fine for us, and we are also open to other scenarios. And we think that the TR38.840 mainly provides a relative metric for reference, we still need to refer to other literature and specs for the improving the specific modeling on network side. However, such issues are just better to be furthered discussed in the study item, we are fine with the proposals currently.

4 – Motorola Mobility UK Ltd.

We are supportive of the final proposal.

5 – InterDigital Belgium. LLC

We support the final proposal.

6 – Beijing Xiaomi Mobile Software

Fine with the final proposal.

7 – Spreadtrum Communications

Spreadtrum We are basically supportive for the proposal. For ”definition of a network energy consumption model”, in our view, the corresponding UE power model in TR38.840 may be updated accordingly. We share the similar view as some companies that the absolute energy consumption model can be studied in the first stage. We suggest the following revision:

Note: it is suggested to adapt the power consumption methodology of TR38.840 to the network side utilizing information from known models / external references, including relative energy consumption for DL and UL, sleep states and the associated transition times, and one or more reference parameters/configurations. **The UE power model in TR38.840 could be updated accordingly. In additon to the relative power consumption model like TR38.840, the absolute power consumption model can be studied.**

8 – Intel K.K.

The potential scope of SI seems reasonable to us. Including “support from UE” in general in the note of item 3) seems a bit premature and needs more careful study. Hence, we suggest revising this to “…., potentially with feedback from UE”. Moreover, “intra-network information/coordination” can be revised to “intra-network information exchange/coordination”. CATT’s suggestion considering impact to legacy UEs looks fine to us.

We are fine with the provided list of scenarios as starting point, with the understanding that during study phase, target scenarios can be selected.

9 – LG Uplus

We are supportive for the proposal. Thanks for leading the discussion and recommendations.

10 – Deutsche Telekom AG

We are generally fine with the moderator’s proposal. We are also ok with the use of relative energy consumption values, but based on the reference scenarios to be defined it should be possible to derive absolute energy consumption values which are also important from an operator’s perspective.

11 – Qualcomm Incorporated

For the power model in the first item of the proposal, we propose to add **PA model** to the note as follows:

1. Definition of a network energy consumption model

a) Note: it is suggested to adapt the power consumption methodology of TR38.840 to the network side utilizing information from known models / external references, including relative energy consumption for DL and UL, sleep states and the associated transition times, ***PA model****, and one or more reference parameters/configurations.*

We could not agree with the third item of the proposal as it is currently written because it does not capture any transmission power efficiency enhancements. Hence, we propose to add "***and how to achieve optimized power efficiency of transmissions***" to the note as follows:

3. Study techniques and features to enable network energy saving

Note: the main focus area is on how to achieve more dynamic and finer granularity adaptation of transmissions and/or receptions in one or more of time, frequency, spatial, and power domains, ***and how to achieve optimized power efficiency of transmissions****, with support from the UE. Additional areas of the study may include UE assistance information and intra-network assistance.*

12 – VODAFONE Group Plc

Broadly OK with the moderator's proposal for a dedicated study item, however:

a) we do believe that each new SID should take the energy aspects into account in a pragmatic manner - and this should be reported to plenary.

b) 'absolute' energy consumption is important in deciding where to focus our optimisation work

13 – KDDI Corporation

We are fine with final proposal

14 – Orange

Orange is strongly supportive of the work on network power saving and generally in agreement with the proposed work package. However we do agree with DT and Vodafone that 3GPP should also attempt to modelise calculations for absolute energy consumption values.

Besides, we do believe that the study on network power saving should consider enablers for SON and AI/ML related optimisation. The techniques considered for power saving with finer granularity should be used with automation.

15 – Telia Company AB

We are agree with moderator's final proposal, but as stated by Deutsche Telekom and Vodafone it should be also possible to derive absolute energy consumption values as they are important for operators running the real commercial networks.

16 – vivo Communication Technology

We agree with the proposals in principle. Reiterate our previous two comments which we think need further to be addressed from our interests.

(1) LTE Rel-13 has studied small cell on/off and based on that some specification work is completed, which is useful for network power saving. We think similar small cell scenario can be considered for NR as well. But however, the current list of the scanarios does not include such sceanrio. And we noticed other companies also show interests and does not want to precllude other scanrios, can we add a subbullet 'other scanarios, e.g., small cell deployment, can be considered'

(2) As CATT commented, UE backward compatibility is important. So we also would like to ensure that studing techniques and features to enable network energy saving "without impacts to the network access and behavior of the legacy UEs".

17 – Apple Benelux B.V.

We are supportive of the rapporteur's summary and the proposals.

We also agree with Intel and others in that "UE assistance" part is premature to be included as such an early stage. We are not excluding potential UE assistance, but that is something we will need to discuss at a later stage.

18 – Samsung Electronics Co.

We do agree "more dynamic and finer granularity" adaptation enables network energy saving. However, for the purpose of study, we suggest to make it more generic (i.e., to remove "more dynamic and finer granularity") (as already commented in the intermediate phase):

3. Study techniques and features to enable network energy saving

a) Note: the main focus area is on how to achieve ~~more dynamic and finer granularity~~ adaptation of transmissions and/or receptions in one or more of time, frequency, spatial, and power domains, with support from UE. Additional areas of the study may include UE assistance information and intra-network information/coordination.

In addition, we also would like to add UE backward compatibility requirements.

19 – Nokia France

1. We agree that "definition of a network energy consumption model" is a good way to express this objective. However, it is too early to suggest adapting the TR38.840 model. We do not believe that companies have had time to fully assess the issues involved in adapting a UE model to the network side or to study the existing BS power models that have been developed already. Therefore we request to delete the first part of the note as follows:

1. Definition of a network energy consumption model

~~a) Note: it is suggested to adapt the power consumption methodology of TR38.840 to the network side utilizing information from known models / external references~~, including relative energy consumption for DL and UL, sleep states and the associated transition times, and one or more reference parameters/configurations.

2. We propose to delete "including KPIs": Note that no new KPIs were defined for the UE power saving work in Rel-16-17, when it was sufficient to compute the network energy saving gain compared to baseline. It is also not obvious how to define what is an acceptable trade-off between different KPIs, e.g. x% power gain for y% latency increase. At most, we could agree to adapting the wording to "including studying potential KPIs".

3. It is not clear what is meant by "more dynamic and finer granularity" or why that is the main focus. We propose to broaden the note as follows: Note: the main focus area is ~~on how to achieve more dynamic and finer granularity~~ adaptation of transmissions and/or receptions in one or more of time, frequency, spatial, and power domains, with support from UE. Additional areas of the study may include UE assistance information and intra-network information/coordination.

20 – Nokia France

Please note also that the existence of a dedicated study should not be seen as an alternative to considering the impact of solutions in other Rel-18 items on network energy consumption. E.g. any work on UE power saving may impact network energy efficiency, and that should be assessed in the respective items.

21 – ZTE Corporation

We are genearlly okay with moderator's proposal. As to the network power consumption model, we think that a relative energy consumption model is better given the various base station implementations and deployments. Regarding the scenarios, the list can be a starting point, but we are also open to other scenarios.

22 – China Unicom

We are fine with the list of scopes proposed by moderator.

23 – TELECOM ITALIA S.p.A.

We agree in principle with moderator's final proposal, but

- as stated by Deutsche Telekom and Vodafone and others it should be also possible to derive absolute energy consumption values as they are important for operators running the real commercial networks.
- We should plan the study in order to ensure normative work in Rel 18

24 – Panasonic Corporation

We support the final proposal.

25 – RadiSys

We support the final proposal by the Moderator

26 – Ericsson LM

We agree with the final proposal. We also suggest to consider NW load as part of the NW power consumption evaluation particularly during data activity time.

27 – China Mobile Com. Corporation

We are generally fine with the moderator's proposal and strongly propose a normative work followed by study item in Rel 18.

May be it is better to list the potential technique areas separately rather than in a note.

Study techniques and features to enable network energy saving

- Note: the main focus area is on how to achieve more dynamic and finer granularity adaptation of transmissions and/or receptions.

- Techniques and features to enable network energy saving include one or more of the following,
  - Time domain
  - Frequency domain
  - Spatial domain
  - Power domain

- Additional areas of the study may include UE assistance information and intra-network information/-coordination.

28 – Fujitsu Limited

We are supportive of the final proposal.

29 – Telstra Corporation Limited

We agree with the moderators proposal and support DT & Vodafones suggestion to agree on tangible metrics that can measure absolute power savings. Evaluations should also take into account the impact of NW traffic load on power consumption.

30 – CEWiT

*We are generally fine with the final proposal and also support comments on bullet 3 from Nokia France for removal of "*more dynamic and finer granularity" from bullet 3

31 – MediaTek Inc.

Thanks for moderator's summary, and we are supportive.

Since the evaluation framework now targets to consider both network nodes and UEs and **there is an merging item, ultra-low-power UE receiver and wake-up signaling, from the email discussion of [RAN93e-R18Prep-14]**, it will be reasonable if the UE power saving item can also address network energy consumption aspect. More constructively, it will also be **interesting to know whether and how a ultra-low-power wake-up mechanism can benefit both UE and network energy saving. If there are two power saving items proposed for Rel-18, we suggest to further discuss the potential synergy and unified design for both UE and network energy saving.**

As long as the methodology is generic, we also expect the developed power saving techniques can be generic for all NR devices (including network nodes and UEs).

32 – HUAWEI TECHNOLOGIES Co. Ltd.

We are fine with the proposal from moderator. In addition, we are fine to change "support from UE" to "potentially with feedback from UE" as suggested by Intel either.

As to the consumption model, we think it is reasonable to suggest adapting the TR38.840 model at least as a starting point, considering it got the most support and also it would make the study more smoothly considering 3GPP has solid experience with that model methodology.

We also think it is very reasonable to take "dynamic and finer granularity" as the starting point, it is obvious almost all companies agree this direction, and it doesn't preclude any other study also. If possible, always better to give a more concrete study objective, otherwise it would make the discussion in WG too difficult to move forward.

Additional questions (leading WG and potentially impacted WG/TSG)

Please provide your views on the leading WG of such study, and on other potential secondary responsible WGs. Do you foresee impact on or need to coordinate with SA/CT from the study (some responses in the initial round mentioned potential need for coordination with SA5)?

Feedback Form 11: Please provide your views on the question of leading WG and potentially impacted WG/TSG

1 – Futurewei Technologies

RAN1 should be the leading WG at least for study. The work can potentially impact RAN4 and maybe RAN2/3. It is not clear whether there is any impact to other TSG.

2 – China Telecom Corporation Ltd.

We think NR network energy saving can be a study item leaded by RAN1 to develop network energy consumption model, evaluation methodology (including KPIs), and RAN1 techniques to enable network energy saving.

RAN2 can be the secondary WG because of the focus area 'UE assistance information' and RAN2 impact such as signalling aspects introduced by RAN1 energy saving enhancements.

RAN3 can also be secondary WG because of the focus area 'intra-network signalling enhancement'.

Regarding possible SA/CT impact, we think the energy efficiency metric for RAN might have SA impact since SA5 is working on the overall energy efficiency metric, which is just our initial feeling.

3 – Motorola Mobility UK Ltd.

We think RAN1 should be a leading WG, and RAN2 and RAN3 (for intra-network assistance information and coordination) can be secondary responsible WGs. RAN4 may be a potentially impacted WG, as there could be impact on RRM/RLM requirements. We don't foresee immediate impact on SA/CT.

4 – InterDigital Belgium. LLC

RAN1 should be the leading WG and RAN2/3/4 may potentially be impacted.

5 – Deutsche Telekom AG

RAN1 as leading WG and RAN2/3/4 as secondary WGs.

Due to their work on enhancements on EE for 5G networks, SA5 is potentially also impacted, i..e., we see the need for alignment.

6 – Qualcomm Incorporated

RAN1 should be the primary WG for all items in the final proposal while RAN4 and RAN3 are the secondary WGs for the 3rd item of the final proposal.

We think that duplication of the work that had been done by SA should be avoided. However, this can be done by RAN alone, without the need for frequent communication with other groups.

7 – KDDI Corporation

We think RAN1 should be the leading WGs, and RAN2 can be the secondary WG. Because most of the topics listed in the focused area seems within RAN1 area, only part of the topics e.g. CA/DC , broadcast. etc. seems related to higher layer.

8 – Apple Benelux B.V.

RAN1 should be the primary group, and RAN3 the secondary group. RAN2 impacts, if any, are not clear at this stage. If functionality that potentially falls into the RAN2 scope is identified by RAN1/3, the usual LS exchange would seem to be sufficient.

9 – Nokia France

Thank you for the proposal.

1. We agree that ”definition of a network energy consumption model” is a good way to express this objective. However, it is too early to suggest adapting the TR38.840 model. We do not believe that companies have had time to fully assess the issues involved in adapting a UE model to the network side or to study the existing BS power models that have been developed already. Therefore we request to delete the first part of the note as follows:

1. Definition of a network energy consumption model

~~a) Note: it is suggested to adapt the power consumption methodology of TR38.840 to the network side utilizing information from known models / external references~~, including relative energy consumption for DL and UL, sleep states and the associated transition times, and one or more reference parameters/configurations.

2. We propose to delete ”including KPIs”: Note that no new KPIs were defined for the UE power saving work in Rel-16-17, when it was sufficient to compute the network energy saving gain compared to baseline. It is also not obvious how to define what is an acceptable trade-off between different KPIs, e.g. x% power gain for y% latency increase. At most, we could agree to adapting the wording to ”including studying potential KPIs”.

3. It is not clear what is meant by ”more dynamic and finer granularity” or why that is the main focus. We propose to broaden the note as follows: Note: the main focus area is ~~on how to achieve more dynamic and finer granularity~~ adaptation of transmissions and/or receptions in one or more of time, frequency, spatial, and power domains, with support from UE. Additional areas of the study may include UE assistance information and intra-network information/coordination.

10 – Nokia France

Sorry for pasting the answer above in the wrong box.

The answer for this question is that RAN1 should be the leading WG.

11 – TELECOM ITALIA S.p.A.

Agree with DT (RAN1 leade, RAN2/3/4 secondary and SA5 involvement. Impact on SA/CT WGs should also be assessed in the study phase)

12 – RadiSys

Agree with other companies that RAN1 as WG lead

13 – China Mobile Com. Corporation

RAN1 will be the leading WG, and RAN2 and RAN3 will be involved.

14 – Fujitsu Limited RAN1 should be the leading WG. RAN2/3/4 are potentially impacted WGs.
15 – CEWiT We think RAN1 should be the leading WG and RAN2/3/4 as impacted WGs.
16 – MediaTek Inc. RAN1 can be the leading group to start the work by developing the evaluation methodology. Joint work with RAN2, RAN3 and RAN4 (if RF/PA aspect is included in the scope) will be necessary.
17 – HUAWEI TECHNOLOGIES Co. Ltd. RAN1 is the leading WG for the study, and RAN2/3/4 may potentially impacted. So far it seems no coordination needed with SA/CT, however if some impact identified in the study phase then it can be triggered by LS.

4.1 Summary of final phase

Comments received in the final phase of the discussion show that about 18 companies supported the final proposal without any change, and 5 companies proposed some revisions to the text of the notes in the high-level objectives. There were additional comments on the absolute network power consumption model, on the impact of other WI/SI to the network energy consumption, and some comments on impact to legacy UEs. Responses to the comments are provided below with the corresponding proposed chances to the proposal. Hopefully this can address all concerns received during the final phase. Thank you all for your participation.

To CATT, vivo, Samsung, on the proposal to add a note "without impacts to the network access and behavior of the legacy UEs" or generally address UE backward compatibility. The moderator is unsure of what is being proposed, since the behaviour of a legacy UE can anyway not be changed by a later release. Perhaps the intent is to ensure that legacy UEs can still access a network implementing Rel-18 network energy savings techniques, although it could be possible that some techniques be developed for greenfield deployments. The following note 2 is proposed to address these comments: "Note 2: legacy UEs should be able to continue accessing a network implementing Rel-18 network energy savings techniques, with the possible exception of techniques developed specifically for greenfield deployments."

To Orange: our understanding is that SON related optimizations are also being discussed separately for Rel-18, and in this potential study such discussion could be taken under the area of intra-network information exchange/coordination. Perhaps some clarification will be needed later on to coordinate the scope of these two Rel-18 WI/SI. Therefore no update is provided, but it is the moderator's understanding that such optimizations are not precluded by the final summary. Application of AI/ML would first require a separate study to progress on this specific topic, as being discussed in another discussion for Rel-18. The moderator didn't feel the need to revise the proposal accordingly.

To Qualcomm: I added examples in brackets "relative energy consumption for DL and UL (considering factors like PA efficiency, number of TxRU, etc)" under the modelling bullet. Regarding the focus areas,

optimized power efficiency of transmissions seems already part of the power domain considerations, at least it is the moderator's understanding that this can be studied. To address this comment as well as Samsung's comment, I modified to "how to achieve more efficient dynamic and/or semi-static and finer granularity adaptation of transmissions…". I also changed "main focus area is" to "focus areas include", if it can help.

To Nokia: although we could go back to a very high-level description, all other companies indicated that they are fine with defining a model for the network power consumption adapted from 38.840, and I believe everyone understands that this is only about the framework, not the component nor the values of the components, which surely differ between the network and the UE. To address this, I added "framework" and hopefully this clarifies the intention. The second main bullet reflects the suggested revision to "studying potential KPIs".

To Nokia, CeWIT: All other companies supported the conclusion with "how to achieve more dynamic and finer granularity adaption of transmissions", with just one other comment from Samsung to also consider semi-static adaptation. In the moderator's view, this is already rather generic in terms of description and may not preclude any specific type of solutions. I changed "main focus area is" to "focus areas include". Hopefully this addresses your concern sufficiently well, considering the majority view.

On absolute power consumption metric: Being able to obtain absolute power consumption metric for the reference scenarios as part of the study is still of interest to several companies based on comments in the final phase. It was suggested that it should be possible to derive absolute power consumption metric from the relative power consumption metric and additional information available outside 3GPP on the absolute power consumption of relevant network components. Alternatively, an absolute power consumption model could also be studied in addition to the relative power consumption model. A note was added to that effect.

On consideration of network energy savings in other WI/SI: A couple of companies still commented on the need to assess each Rel-18 WI/SI for network energy consumption. As commented by many other companies in earlier rounds, this approach is currently not seen as practical. However, according to discussions in earlier round, there was a general understanding that it should be possible to note in the final conclusion that it is expected that new features studied or specified in other WI/SI should consider network energy consumption as a criterion in the study and design of new features when relevant.

On the question of lead WG, impacted WGs and TSGs, there is consensus that RAN1 would be the leading WG of such study, with at least RAN3 and RAN4 as secondary WGs and possibly also RAN2. Some companies mentioned a potential need for alignment with SA5 activities on enhancements on energy efficiency for 5G network.

The updated proposal is provided in the section "conclusion (after final phase)".

5 Conclusion (after final phase)

The following conclusion is proposed for this discussion on Rel-18 network energy savings.

Potential scope of a study on network energy savings

1. Definition of a network energy consumption model

    a) Note 1: it is suggested to adapt the framework of the power consumption methodology of TR38.840 to the network side, utilizing information from known models / external references and other relevant information, including relative energy consumption for DL and UL (considering factors like PA efficiency, number of TxRU, etc), sleep states and the associated transition times, and one or more reference parameters/configurations
    b) Note 2: an absolute power consumption model could also be studied in addition to the relative power consumption model, or a method could be studied for allowing to derive absolute power consumption metric from the relative power consumption metric and additional information available outside 3GPP

2. Definition of an evaluation methodology, including studying potential KPIs

    a) Note: evaluation methodology should not focus on a single KPI, but allow evaluating how to enable system-level network energy savings while balancing impact to network/user performance (e.g. spectral efficiency, capacity, UPT, latency) and UE power consumption/complexity

3. Study techniques and features to enable network energy saving

    a) Note 1: the focus areas include how to achieve more efficient dynamic and/or semi-static and finer granularity adaptation of transmissions and/or receptions in one or more of time, frequency, spatial, and power domains, with potential support/feedback from UE. Additional areas of the study may include UE assistance information and intra-network information exchange/coordination.
    b) Note 2: legacy UEs should be able to continue accessing a network implementing Rel-18 network energy savings techniques, with the possible exception of techniques developed specifically for greenfield deployments.

RAN1 would be the leading WG of such study, with at least RAN3 and RAN4 as secondary WGs and possibly also RAN2. Some companies mentioned a potential need for alignment with SA5 activities on enhancements on energy efficiency for 5G network. Several companies propose to plan the study in order to ensure normative work in Rel-18.

As a starting point, the following scenarios can be considered as targets for system-level studies on network energy savings:

- Urban micro in FR1, including TDD massive MIMO
- FR2 beam-based scenarios with massive MIMO
- Urban/Rural macro in FR1 with/without DSS (no impact to LTE expected in case of DSS)
- EN-DC/NR-DC macro with FDD anchor band and TDD/Massive MIMO on higher FR1 frequency
- Other scenarios, e.g., small cell deployment, can be considered

General note: new features studied or specified in other WI/SI should consider network energy consumption as a criterion in the study and design of new features when relevant.

6 References

[1] RWS-210659, Summary of RAN Rel-18 Workshop, June 2021.

[2] RP-211639, Additional Guidance on RAN Rel-18 Email Discussion during August 30th and September 3rd, RAN Chair.