**3GPP TSG-RAN WG1 Meeting #110 R1-220xxxx**

**Toulouse, France, August 22 – 26, 2022**

**Agenda Item: 9.7.1**

**Source: Moderator (Huawei)**

**Title: FL summary#1 for EVM for NR NW energy savings**

**Document for: Discussion and Decision**

# Introduction

This summary contains discussion for the following email discussion:

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| [110-R18-NW\_ES] To be used for sharing updates on online/offline schedule, details on what is to be discussed in online/offline sessions, tdoc number of the moderator summary for online session, etc |

According to Chair’s scheduleV01, the official discussion for network energy savings will be starting on

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|  | Tuesday |
| Morning coffee break: 10:30 ~ 11:00 |
| **11:00 ~ 12:00** | **Offline session @ Guillaume 1&2** |
| Lunch break: 13:00 ~ 14:30 |
| **14:30 ~ 16:30****(120 min)** | **Online session @Concorde 1&2**R18 MC-Enh (60 min) 🡺 R18 NW EnSav |
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Therefore, your input for the first round of discussion is expected by 8:00am of Tuesday, Toulouse time (around 24h from now on).

## Recommendations for possible online/GTW treatment/email approval:

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# Energy consumption model for BS

## Power states and transition time/energy

### Sleep mode definition

In order to proceed on the BS power states in multiple modes, including sleep mode, active mode and/or other mode, a first question to be addressed is how to define a sleep mode. Companies view can be summarized as below.

For a sleep mode,

* Option 1: a BS does not perform DL transmission nor UL reception [2] [6][10][14][19][20][21][22]
* Option 2: a BS can still stay in sleep mode for one direction (e.g. UL reception)-only [1][4][5][12][16][19]

**FL1 Proposal 2.1.1-1:**

**Down select between Option 1 and Option 2 for defining a sleep mode in RAN1#110.**

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| **Company** | **Comments** |
| Futurewei | Support Option 2. Especially for TDD, where DL and UL do not occur simultaneously, there is no reason or benefit to tie DL and UL together, especially for light/micro sleep modes. Another aspect to consider is that Option 1 leads us to not considering UL power savings at all, which we don’t think is the right approach.A side comment is that seems like the above should lead to decision in Proposal 2.1.1-2?  |
| LG Electronics | We support the proposal and Option 2 is preferred. From our understanding, Option 2 means that gNB does not need to switch time/energy to wake up for UL reception for simplicity of modeling. |
| Spreadtrum1 | Slightly prefer Option 1 which is like UE power model. For UL power saving, similar to UE power saving, the small power unit for WUS detection can be defined. The clear boundary of sleep mode and non-sleep mode can avoid the confusion in the further discussion. |
| DOCOMO | Support the proposal and prefer Option 1. |
| Samsung | We think each option may be depending on sleep modes, for example, if PAs are turned off in micro sleep mode, then Option 2 can be applied. However, for deep sleep mode, if common components for DL/UL are turned off, Option 1 can be applied. It can be discussed later after defining sleep modes. |

One related issue is whether there could be an IDLE state separately defined. Companies view can be summarized as below

* Option 1: a sleep mode 1. [2],[4], [5 for unused DL symbols], [6, 3rd preference] [10],[13][15][21][22]
* Option 2: active mode [6, 1st preference][15]
* Option 3: a separate state [4], [6, 2nd preference] [11, with relative power scaled from active mode][16]

Considering relatively large support of Option 1, the following can be suggested

**FL1 Proposal 2.1.1-2:**

**A state that BS does not perform DL transmission nor UL reception is considered as a sleep mode (FFS which).**

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| **Company** | **Comments** |
| Futurewei | See our comments above for Proposal 2.1.1-1, in which we support Option 2. Since DL is the primary power consumer, it should be allowed to sleep at any opportunity, regardless of what may need to happen on UL. |
| LG Electronics | The idle state can be defined as there is no loaded data but gNB’s hardware remains active. However, if the BS can switch quickly between the micro sleep mode and the active state without additional transition time, the micro sleep mode 1 can be treated as the idle state (i.e., Option 1). |
| Spreadtrum1 | IDLE state is not clear. Only SSB is also IDLE state? We do not need to introduce the extra terminologies. If there is a signal channel, it is non-sleep state, which is similar to UE power model. |
| Qualcomm1 | We prefer discussing this proposal after making more progress in FL1 Proposal 2.1.1-1. |
| DOCOMO | Support the proposal. IDLE state should have no DL transmission or UL reception. If there is no DL transmission or UL reception, it should be categorized into sleep mode. |
| Fujitsu | We are open to not define idle state and always consider inactive symbols at least in micro sleep mode. |
| Samsung | Support FL’s proposal. |

### Sleep mode categorization

Given the large range that BS power state could vary in different conditions, sleep mode can be further split into multiple levels, corresponding to different levels of components shutdown as well as resulted transition times that are required for a BS to enter/leave. The view from companies are quite different. Some companies propose to classify sleep modes by separation of RF and BB parts, some propose to classify those by transition times similar to what has been done in UE power savings, some consider the power levels from typical cases while some others may prefer to consider future trend of hardware/software development. Also, different BS types even today may differ the modes. More specifically, it seems

* A sleep mode 1 that a subset of the components used for transceiving is turned OFF: supported by [1][2][3][4][5][6][8][9][12] [13][14][15][16][17][18][19][20][22]
* A sleep mode 2 that some/most components are turned OFF: supported by

[1][2][3][4][5][6][8][9][12] [13][14][15][16][17][18][19][20][22]

* A sleep mode 3 that (almost) all of BS components is turned OFF: supported by

[1][2][3][4][5][8][9][12][13][14][15][16][17][18][19][20][22]

* A sleep mode 4 (numbered for discussion purpose) that is in between/addition to the above modes. [4][16][22]

Also, four modes for macro, and two for micro/small form BS is proposed in [10].

FL had tried to start from a common state – micro sleep as all seem to agree with in the last meeting but was not proceeded. There was preference to directly consider how many sleep modes can be defined. However, simply taking a number may cause confusion. For example, most companies that prefer 3 sleep modes consider the deep sleep (SM 3 above) of BS does not maintain UE connection (i.e. completely BS OFF), while the consideration of 4 sleep modes may refer to hibernating mode for that case. To that end, it may need to first align the understanding of what a given sleep mode refers to, which can be critical for evaluating certain schemes.

Additionally, this has to be determined in a way forward. FL currently consider there could be two solutions:

* The first one is to rely on the group to discuss and agree on a set of modes as well as profiles for each mode, likely with compromise from each side. The pros of this approach is we can have comparable results based on a single set of mode profile, while the cons is it may not be able to match the implementations of any company.
* The second one is to agree on multiple sets (hopefully two) of modes corresponding to different implementations. The cons is clear, while it may benefit from the fact that results can be closer to real implementations – whatever are proposed.

**FL1 Proposal 2.1.2-1:**

**Determine multiple sleep modes profiles in RAN1#110.**

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| **Company** | **Comments** |
| Futurewei | One set of modes for evaluation. Being able to compare result is the primary purpose of evaluation. |
| LG Electronics | We agree with FL's evaluation that it may need to first align the understanding of what a given sleep mode refers to, which can be critical for evaluating certain schemes. However, if the number of profiles is too large, it becomes difficult to compare the evaluation results between companies, so it is preferred to unify as one or to agree only as few profiles as possible.  |
| Spreadtrum1 | Just one set of sleep modes. Otherwise, it is very hard to compare the evaluation results. |
| Qualcomm1 | It makes sense to discuss which components can be turned off for a particular sleep mode. However, different implementations may have different components turned off. From our perspectives, it is more important to discuss transition time and then define the corresponding sleep mode.At least support two sleep modes (e.g., one with a very short transition time and another with a longer transition time). FFS additional sleep modes. |
| DOCOMO | One set of sleep modes should be preferred to minimize the evaluation work. |
| Fujitsu | We are supportive of defining only a set of sleep modes.  |
| Samsung | Fine with FL’s proposal.We support to define the multiple sleep modes. In addition, regarding the characteristics of sleep modes, it seems vague to define multiple sleep modes in accordance with which BS components is turned off. So, we think each sleep modes can be described with the required BS sleep duration or comparing with transition time, e.g. duration of sleep mode 1 should be longer than total transition time of sleep mode 1. It will be a more spec-friendly way to define the multiple sleep modes. |

### Non-sleep modes

For non-sleep mode, how to obtain the power consumption of transmission/reception is to be determined. Slot type is discussed. The current view of companies are summarized as below:

* Option 1: Slot type specific to certain channels/signals (for active mode) is not to be defined. [1][2][3][4][5][8][10][15, partially except for SSB-olny][17][21]
* Option 2: Background activities with SSB/RS transmission can be defined as a separate mode from normal active mode [13] [15, partially, SSB-only not as a separate mode but serve as an indicator for small calibration]
* Option 3: Slot type at least for separation of SSB/RS and other control/data channels. [16]

As opposed to sleep mode, there is at least SSB transmission in DL. It may not be strongly needed to consider SSB or RS transmission as a new state from active mode even if some consideration is needed. The following may be addressed, assuming no separate active mode per SSB/RS transmission.

**FL1 Question 2.1.3-1:**

**Is there a need to separate SSB/CSI-RS and other control/data channels for BS power consumption model in active mode?**

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| **Company** | **Comments** |
| Futurewei | No, for now we like to discuss what are the benefits of doing so. Scaling of the power consumption according to power/bandwidth should take care of it.  |
| LG Electronics | As the power state of SSB or CSI-RS and PDCCH+PDSCH was defined separately in the UE power saving model, at least the power consumption for control/data slot (such as PDCCH+PDSCH) and the reference signal slot (such as SSB or CSI-RS) may need to be defined separately. However, low to moderate loading scenarios are mainly considered for evaluation purposes, it may not be necessary to define a separate slot type if there is no significant difference between signal transmission such as SSB and CSI-RS and coded transmission such as PDCCH/PDSCH in terms of overall energy consumption perspective. |
| Spreadtrum1 | No. The characteristic of SSB/CSI-RS is just the “always-on” like aspect, instead of the scaling of power consumption. |
| Qualcomm1 | No, there is no need to separate SSB/CSI-RS and other control/data channels for BS power consumption model in active mode.It would be good to consider the fact that there are different types of DL slots in which PDSCH only is transmitted and separate it from the cases in which PDSCH and SSB and PDCCH is transmitted. |
| DOCOMO | No channel/RS-specific model is needed as gNB transmits several channels/RSs simultaneously. |
| Fujitsu | We prefer to define the scaling in frequency domain first. As far as the scaling according to the number of used RBs per symbol is reflected in BS power consumption model, there is no need to explicitly separate SSB/CSI-RS and other control/data channels. |
| Samsung | We think it is necessary to define the power consumption of SSB/CSI-RS for evaluating the amount of energy saving gain from enhancement on SSB or RS transmission. However, if it can be derived from DL power consumption with scaling, we are fine not to separate it for BS power consumption model. |

Other remaining issues include UL modeling for FDD and TDD.

For UL reception and DL transmission in TDD,

* Option 1: Same model applies, [1], [2], [3], [4],[10]
* Option 2: The UL power consumption is the same as that for a DL-only slot with no DL transmission [5]
* Option 3: one single value regardless scaling domains nor UL channels [17]

For simultaneous UL reception and DL transmission in FDD,

* Option 1: The power consumption is the total power of DL and UL. [2][3][6][15][19][20, while should allow for (up to companies) separating DL and UL in evaluations] [21]
* Option 2: UL part is neglected [5][22]

There is a slightly majority view for each question. The following may be suggested

**FL1 Proposal 2.1.3-2:**

**For active mode, the BS power consumption in UL reception is modeled the same as that for DL transmission. When there is simultaneous UL reception and DL transmission, the power consumption is the total power of DL and UL. FFS details of scaling, accounting for the common part of UL reception and DL transmission.**

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| **Company** | **Comments** |
| LG Electronics | The BS power consumption in UL reception s should be modeled the different from that for DL transmission considering that the DL-only transmission requires PA’s power consumption while the UL-only reception does not. However, once UL reception is modeled, other modeling, such as scaling, can be applied as well as DL transmission. |
| Spreadtrum1 | DL/UL can be separately modelled. The efforts are expected not so large, if the DL model is simple enough. UL power consumption could be a scaling of DL power consumption. |
| Qualcomm1 | “For active mode, the BS power consumption in UL reception is modeled the same as that for DL transmission.” should be removed |
| DOCOMO | Support the proposal and fine to discuss scaling for UL from DL. |
| Samsung | Support FL’s proposal. |

### Transition procedure

The state machine was agreed for further study and relevant observations/proposals are provided this meeting. Initial summary can be found below. Note some contributions do not directly express a view on the state machine, i.e. transition among sleep modes while consider that the sleep duration should be larger than the total transition time, which sounds like that the BS won’t transit from one sleep mode to another sleep mode since otherwise the sleep duration could be shorter. In view of this, it is considered as Option 2.

* Option 1: transition among SMs is allowed: [1][12][15][21]
* Option 2: transition based on state machine among SMs is deprioritized (i.e. not supported in the study of this release), only transition between a SM and active mode is considered [3][4][6][8][10][13][14][17][22]

Slight majority supports not to model the transition among different sleep modes, and there seem to be questions raised by [15] if a state machine is not adopted. Also, transition time needs to be defined clearly. It could be the total time for a UE entering into a sleep mode and leaving that sleep mode [8][10][17], or that time is relative to a micro sleep mode although no state machine is assumed [2]. On the other hand, if a state machine is adopted, transition time definition could also be different from that in UE power saving. The following is suggested.

**FL1 Proposal 2.1.4-1:**

**Down select between Option 1 and Option 2 in RAN1#110**

* **Option 1: transition among SMs is allowed**
* **Option 2: transition based on state machine among SMs is deprioritized (i.e. not supported in the study of this release), only transition between a SM and active mode is considered**

**Note transition time definition should be clarified in either option.**

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| **Company** | **Comments** |
| Futurewei | Option 1. We do not see the saving in deprioritizing this.  |
| LG Electronics | We prefer to adopt Option 1 since gNB doesn’t need to predict traffic pattern. However, for the simplicity, we can accept Option 2 as well. |
| Spreadtrum1 | Option 2. We do not understand the intention. BS can decide a sleep mode definitely. If there is a successive power ramp up or ramp down (like transition b/w sleep modes), it has been absorbed in each transition energy/time already in our view. For example, the transition from light sleep state to non-sleep mode has include the transition from light sleep to micro sleep (RF switched on, ready for transmission and reception) and the transition from micro sleep to non-sleep mode (performing transmission or reception) |
| Qualcomm1 | When transitioning from active mode to a sleep mode, gNB can transition through sleep modes with shorted transition time. However, when transitioning from a sleep mode to active mode, no transition through other sleep modes is necessary. |
| DOCOMO | We are fine with Option 2 for simplicity. If we take Option1, different transition energy and time should be defined for different transitions among sleep modes. |
| Fujitsu | We prefer option 2. |
| Samsung | Fine with FL’s proposal, and prefer Option 2. |

Some other transition related assumptions are also discussed, e.g. how a gNB determines to enter sleep, on handling of WUS as proposed in [4] etc. These may somehow be clear once the transition procedure and definition of transition time is clarified/adopted, e.g. a BS shall not go to sleep if the time duration left for a sleep mode is no longer than the corresponding transition time. Nevertheless, it is worthwhile to check that

**FL1 Question 2.1.4-2:**

**Any other assumptions you think shall also be clarified or captured about transition assumption/algorithms?**

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| **Company** | **Comments** |
| Futurewei | We would like to discuss if and whether a single transition time/algorithm can capture or represent the different approaches the network can implement in the sleep mode. |
| LG Electronics | In addition to the transition time, additional transition energy consumed during transition between sleep modes should be considered. |
| Qualcomm1 | No |
| Fujitsu | The transition time/energy related to adaptive ON/OFF of TXRU also need to be discussed somewhere. |

### Relative power of each mode and additional energy/time for transition

The relative power value is discussed and exact values are provided in some contributions.

For sleep modes, the relative power value would be closely related to the categorization and sleep mode profiles, thus can be discussed together in section 2.1.2, including which mode can be taken as reference with power value set=1. As a record, the following options can be observed according to contributions.

The relative power value of SM-X is taken as 1 for evaluation,

* Option 1: X=most energy saving mode [2][5][8][10][17][18][19]
* Option 2: X= a deep sleep mode other than the most energy saving mode [4][22]
* Option 3: X is the deep sleep mode of UE [3]

For active mode, it is clarified that the relative power value is provided with transmission/reception using full BW and total number of Tx/Rx as in reference configuration [8][17][19][22]. This can be determined with

**FL1 Proposal 2.1.5-1:**

**For active mode, the relative power value is provided with transmission/reception using full BW and total number of Tx/Rx as in reference configuration.**

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| **Company** | **Comments** |
| Futurewei | Option 1 |
| LG Electronics | We support the proposal. Besides, it is not clear why deep sleep mode and most energy saving mode are different. |
| Spreadtrum1 | Option 3. The hibernate or stand-by or ultra-deep sleep mode can use the fractional number, e.g. 0.1 |
| Qualcomm1 | Support |
| DOCOMO | Support the proposal but share the same question as LGE on the difference between the most energy saving mode and deep sleep mode. In our understanding, the deep sleep mode is the most energy saving mode. |
| Samsung | Support with minor update.**FL1 Proposal 2.1.5-1:****For active mode, the relative power value is provided with transmission/reception using total DL power level, full BW and total number of Tx/Rx as in reference configuration.** |

The additional transition energy/transition time is also closely related to sleep mode categorization and adoption of state machine, thus can be determined later.

## Scaling

### General aspect

As a general question of whether scaling can be applied for sleep mode, although related to whether sleep mode can be applied only on one transmission direction (e.g. DL), there is less contribution mentioned [2][12]. FL consider to conclude this as

**FL1 Proposal 2.2.1-1:**

**In the BS energy consumption modeling and evaluation, scaling does not apply to any sleep mode.**

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| **Company** | **Comments** |
| Futurewei | Decision on this should be taken together with 2.2.2-1 below |
| LG Electronics | We support the proposal. |
| Spreadtrum1 | Different form UE power saving, the symbol-level scaling is agreed to be introduce at least for non-sleep modes. Thus, it can be also applied to sleep modes. For example, 1 slot micro-sleep has different power consumption from 4 symbols micro-sleep. |
| Qualcomm1 | We can discuss this later after making progress on modelling sleep mode in Section 2.1 |
| DOCOMO | Support the proposal. |
| Samsung | We would like to defer to discuss after determining the sleep modes. |

### Scaling details

Various scaling details are proposed, for each domain or just reuse of the scaling as in UE power saving [CATT(R1-2206411, for non-sleep mode)], [LG(R1-2207037, for Antenna part)].

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| BWP in DL | MTK (R1- 2206979, 0.4 + 0.6 \* (X - 20) / 80)OPPO(R1-2206308, X MHz = [0.5] + [0.5] \* X / Y)CATT(R1-2206411, X MHz = a + b \* X / 100)Intel(R1-2206595, [0.6] + [0.4]· X/100)SS(R1-2206838, [0.4] + [0.6] \* (X - 20) / 80)CMCC(R1-2206925, with RB utilize)ZTE(R1-2207059, 0.6+0,4\*X/B\_ref)Rakuten(R1-2207079, [0.5] + [0.5] x [X/100])QC(R1-2207245, for x% PRB and BO dB, the power is $\left(1-x\right)P\_{0}+ x\left(0.3+0.7\frac{μ\_{NOM}}{μ\left(BO,x\right)}\right)P\_{max}$E///(R1-2207437, X MHz = [0.4] + [0.6] \* X /100 for set1) |
| BWP in UL | Vivo(R1-2206053, alpha + (1-alpha) \* (Y - 20) / 80)QC(R1-2207245, X MHz = 0.8 + 0.2 \* (X – 20) / 80)E///(R1-2207437, X MHz = [0.8] + [0.2] \* X /100 for set1)  |
| CA in DL | HW/HiSi (R1-2205860, depends on whether the RF/PA is sharing)MTK (R1-2206979, X CC=(1+0.7\*(X-1))×1CC)Vivo(R1-2206053, the sum of per RF power value)Nokia(R1-2206074, as$ P$=$10,60\*β\*γ\*σ+1.62\*β\*σ+P\_{Static}$)OPPO(R1-2206308, 2 CCs = [1.7] \* 1CC/4 CCs = [3.4] \* 1CC)CATT(R1-2206411, 1.3/1.9 for 2/4CC FR1; 1.5/2.5 FR2)Intel(R1-2206595, M CCs = 1.3\*(M –1))SS(R1-2206838, 1.7 for 2CC/3.4 for 4CC)CMCC(R1-2206925, α for 2CC and β for 4CC)ZTE(R1-2207059, P1+P2 for inter-band and beta\*(P1+P2) for intra-band)QC(R1-2207245, 2 CCs = [1.7] \* 1CC/4 CCs = [3.4] \* 1CC)E///(R1-2207437, [1.7]\*0.5\*n) |
| CA in UL | HW/HiSi (R1-2205860, depends on whether the RF/PA is sharing)MTK (R1-2206979, X CC=(1+0.7\*(X-1))×1CC)Vivo(R1-2206053, 2CC is beta x1CC, 4CC is 2\*beta x1CC)QC(R1-2207245, 2 CCs = [1.7] \* 1CC/4 CCs = [3.4] \* 1CC)Intel(R1-2206595, 1.3/2.6 for 2/4CC) |
| Spatial in DL | Vivo(R1-2206053, FR1 with gamma1 while FR2 with gamma2)MTK(R1-2206979, 0.1+0.9\*X/64)Nokia(R1-2206074,$ P=(0,033\*N\_{Tx}\*P\_{T}) + (0,025\* N\_{Tx})+1,79$)OPPO(R1-2206308, M Tx/ Rx RUs = [0.5] + [0.5] \* M / N)CATT(R1-2206411, 0.75/0.625 for 32/16tx from 64tx)Intel(R1-2206595, N antenna = 0.7^(64/N – 1))SS(R1-2206838, 0.7 for 32Tx)CMCC(R1-2206925, α for 32tx and β for 16tx)ZTE(R1-2207059, 0.2+0.8\*X)Rakuten(R1-2207079, [0.35]+[0.65] x(Tx/64))QC(R1-2207245, [0.1] + [0.9] \* X/N) |
| Spatial in UL | Vivo(R1-2206053, FR1 with sigma1 as while FR2 with sigma2)Intel(R1-2206595, N antenna = 0.7^(64/N – 1))SS(R1-2206838, 0.7 for 32Tx)QC(R1-2207245, [0.1] + [0.9] \* X/N)E///(R1-2207437, [0.4] + [0.6]\*(x/64) at least for FR1) |
| PSD | MTK(R1-2206979, $0.4+0.6×10^{(X-55)/10}$, PDSCH offset)Vivo(R1-2206053, (P/P0)\*(X4-X3)+X3)Nokia(R1-2206074,$ P=(0,033\*N\_{Tx}\*P\_{T}) + (0,025\*N\_{Tx})+1,79$)CATT(R1-2206411, [Y+(1-Y)\* (PT/Pmax), Y=~[0.8-0.95])ZTE(R1-2207059, 0.6+0.4\*X)E///(R1-2207437, FFS max Pout)QC(R1-2207245 for x=100% PRB and BO dB for a new PSD: $\left(0.3+0.7\frac{μ\_{NOM}}{μ\left(BO,x=1\right)}\right)$ |
| Time domain | MTK (R1-2206979, X/14)Vivo(R1-2206053, in simple superposition based on previous setting)Nokia(R1-2206074, P\_(α% load)=P\*α+P\_microsleep\* (1-α))Fujistu(R1-2206172,$ EC\_{dl}=\sum\_{k=0}^{K}(F\_{k}\left(mode\right)+G\_{k}(N\_{trx\\_ON}, RUR\_{slot}))$)OPPO(R1-2206308, Z symbols = Z/14 + (Pmicro / Pactive) \* (14 - Z))Intel(R1-2206595, 0.25 for symbol 1–4: 0.5 for 5–8: 1 for 9–14)CMCC(R1-2206925, X symbols=α\*X/14)ZTE(R1-2207059, P1\*α+P2 \* (1-α)) |
| Load | Spreadtrum, InterDigital, QC (for DL only?) |
| TRP | HW/HiSi (R1-2205860, calculated for each TRP), ZTE(R1-2207059, sum as γ\*(P1+P2)), QC(R1-2207245, 2TRP is 2x 1TRP), |

The view does not seem to have quick common part in detail, while generally it seems to acknowledge that there is a static part in most cases/domains accounting for the power which is anyway maintained as long as there is transmission or reception, and in time, the scaling can be somehow (piece-wise) linear with the number of active symbols. For spatial domain, the power can be considered to be linearly scaled with active number of TxRx over the number of TxRx in full load of reference configuration. For frequency domain and power domain, in line with the previous agreement/FFS, they can be co-related to each other, accounting for a non-linear part due to PA, corresponding to certain number of active TxRx. Nevertheless, some discussion may be needed during the meeting.

**FL1 Proposal 2.2.2-1:**

* **The scaling of BS power consumption includes at least a static part regardless of other domain configurations.**
* **In time domain, the scaling is linearly scaled with number of active symbols within a slot.**
* **FFS other domain scaling rules in RAN1#110, including whether some of them can be scaled jointly or separately.**

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| **Company** | **Comments** |
| Futurewei | A question for clarification for the FL. The FFS of this proposal seems to imply that scaling can still apply to the sleep mode? If so, is there contradiction to the implication of agreeing to Proposal 2.2.1-1? |
| LG Electronics | We are generally OK with the proposal. Meanwhile, it needs to discuss whether the formula for linear scaling with the number of TX RUs can be applied to gNB power consumption model, by clarifying how gNB implementation for power amplifier can be assumed for evaluation purpose. |
| Spreadtrum1 | Basically agree. The different scaling for different domain could be accurate but with a little large discussion efforts. |
| Qualcomm1 | * **In time domain, the scaling is linearly scaled with number of active symbols within a slot:**

We do not support this bullet since this is only applicable if the BS power consumption is provided per slot. However, we will need to discuss first whether the BS power consumption is provided per slot or per symbol.* **FFS other domain scaling rules in RAN1#110, including whether some of them can be scaled jointly or separately.**

In our view, power domain and frequency domain are jointly scaled, constituting a (non-linear) PAE scaling factor. The aim is to provide a correct model, addressing both dynamic adjustment of transmission power (PSD) and frequency domain (BW) scaling.We propose to make the following update: “**power domain and frequency domain are jointly scaled in a nonlinear manner**” |
| DOCOMO | Support the proposal. |
| Samsung | Fine with FL’s proposal in principle. For a static part, we would like to clarify the definition of static part. |

## Reference configuration

The view for the remaining issues of reference configuration is summarized as below.

[5] proposes to clarify the total number of TxRx and total DL power level is per RU.

For FR1 FDD TxRx:

* Option 1: Confirm the Working Assumption: [2][4, or based on typical implementations],[14][15][17][21][22]
* Option 2: 4 [5]

For FR1 FDD total DL power level:

* Option 1: 52 dBm [2]
* Option 2: 49 dBm [4][5][8, and should be further scaled down with simulation BW], [13][14][15][17][19][21][22]

For set 3 FR2 TDD, for those who provided concrete numbers, the setting for {total DL power level, EIRP limit} in dBm

* Option 1: 34, 63 [2][14]
* Option 2: 37, 63 [5, considering micro BS]
* Option 3: 43, 78 [8][13][17][19]
* Option 4: 40, 73 [10][21, for macro]
* Option 5: 40, 68 [15, considering micro BS]
* Option 6: 33, 78 [19, as set 4]
* Option 7: 33, 68 [21, for micro]
* Option 8: 63 for EIRP is sufficient [22]

The setting for FR2 may also be related to the target scenarios including BS types [5]. As this may be coupled with the discussion of evaluation scenario in section 3.3, the setting for FR2 can be determined later. Therefore,

**FL1 Question 2.3-1:**

**Shall we clarify that** **the total number of TxRx and total DL power level is per RU?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Spreadtrum1 | Maybe it could be absorbed in the scaling in spatial domain, e.g. the scaling factor is different for different number of TRx RUs. |
| Qualcomm1 | Is this question for FR1 only? What is the purpose of this question? |
|  |  |

**FL1 Proposal 2.3-2:**

**For set 2 FR1 FDD TxRx reference configuration, confirm the WA as 32 in reference configuration.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We support the proposal. |
| Qualcomm1 | Support |
| DOCOMO | Support the proposal. |
| Samsung | Fine |

**FL1 Proposal 2.3-3:**

**The total DL power level is 49 dBm for set 2 FR1 FDD reference configuration.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We support the proposal. |
| Qualcomm1 | Support |
| DOCOMO | Support the proposal. |
| Samsung | Fine |

## Other general aspects for the framework

One general aspect related to the BS energy consumption modeling is the slot/symbol level calculation detail.

* Support slot-level, while allow symbol-level BS power consumption by linearly scaling within a slot. [1][2][3][4][5][15][16][17, at least for SSB/CSI-RS][20]
	+ Resource utilization, i.e. frequency domain resource used for symbols, should also be considered [7][10, with weighted average]
* Symbol level modeling should be defined. [6, instead of scaling from slot-level model] [19, averaging of symbol-level relative power consumption results in slot-level calculation][22, with slot level calculation obtained by the sum of the power level of each symbol]

With the agreements achieved in the last meeting and what is to be discussed in the scaling session, it is not so clear what additionally needs to be agreed on for evaluation purpose.

**FL1 Question 2.4-1:**

**Can we agree that in the evaluation, symbol-level BS power consumption calculation, when needed, is obtained by linearly scaling from the power consumed based on the referred number of symbols within a slot?**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We support the slot-level BS power consumption as a baseline and symbol-level modeling can be additionally considered on top of it if necessary. |
| Spreadtrum1 | Yes |
| Qualcomm1 | No support |
| DOCOMO | Yes |
| Samsung | Agree, it seems to overlap with discussion in section 2.2.2. |

Some proposals mention BH [10] and power system [19]. It is more realistic to consider that

**FL1 Proposal 2.4-2:**

**The study of BS energy consumption model in this release does not specifically account for BH, repeater, power system, e.g., DC-DC converter loss, main power supply loss, active cooling.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We support the proposal. |
| Spreadtrum1 | It seems being absorbed into the power model. |
| Qualcomm1 | Support |
| DOCOMO | Support the proposal. |
| Samsung | Okay |

Also [5] propose that the study should be limited to single RAT. FL consider this is reflected by SID discussion that specification work is only expected for NR. On the other hand, proposals for LTE and NR co-existence with spec work on NR-only is allowed, according to FL understanding. If this is the intention of [5], perhaps

**FL1 Proposal 2.4-3:**

**There is no specification change for LTE expected for the study of this release.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We support the proposal. |
| Qualcomm1 | Support |
| Samsung | Support |

# Methodology

## KPI and metrics

### Load definition

The discussion for load definition is summarized.

* Option 1: below (FFS further refinement), [2], [5], [9], [17]
* Option 2: in addition to resource utilization ratio, include traffic density and/or number of UEs per cell [4]

|  |
| --- |
| Load definition: resource usage by data (UE specific PDSCH / PUSCH).Note: resource allocation for common signal can be treated as overhead when evaluating UPT/throughput. |
| Empty load | Recommend range: X% [X=0, 5, 10 or PRBs are only used for SSB/SIB] |
| Light/medium load | Y%[Y=10, 15, 20, 30, 35, 50] |
| Heavy/full load | Z%[Z=50, 70, 100] |
| For multi CCs, the load should be calculated among the total CCs. Unbalanced load among CCs can be showed in evaluation results |

The number of UEs can be provided in SLS to reflect the load. Also, traffic density can be reflected by traffic model used in the evaluations, possibly with re-adjustment as to be discussed in section 3.2. Therefore,

**FL1 Proposal 3.1.1-1:**

* **The traffic load for BS energy saving evaluation is considered as**

|  |
| --- |
| Load definition: resource usage by data (UE specific PDSCH / PUSCH).Note: resource allocation for common signal can be treated as overhead when evaluating UPT/throughput. |
| Empty load | Recommend range: X% [X=0, 5, 10 or PRBs are only used for SSB/SIB] |
| Light/medium load | Y%[Y=10, 15, 20, 30, 35, 50] |
| Heavy/full load | Z%[Z=50, 70, 100] |
| For multi CCs, the load should be calculated among the total CCs. Unbalanced load among CCs can be showed in evaluation results |

* **FFS the value of X, Y, Z (to be determined in RAN1#110).**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We are generally OK with the proposal. However, Z values may not be necessary, considering that the load scenario where BS can save energy is mainly low to medium loads. |
| Spreadtrum1 | Empty load is nothing transmission/[reception] which only includes the static part. The common signal/channel (e.g. SSB/SIB/paging) takes 10%. Light/medium load is 30% load. Heavy/full load is 50%. |
| Qualcomm1 | Support |
| NTT DOCOMO | We are fine to define empty/low/mid/high traffic load for evaluation. For simplicity, the proposal could be summarized as follow. * **The following traffic load levels are considered for evaluation**
	+ **Empty load: RU 0%**
	+ **Light load: RU 10%**
	+ **Medium load: RU 30%**
	+ **Heavy load: RU 50%**

**For multi CCs, the load should be calculated among the total CCs. Unbalanced load among CCs can be showed in evaluation results** |
| Fujitsu | In empty load, PRBs are only used for SSB/SIB. The range of light/medium load is specified after the range of empty load is agreed.  |
| Samsung | We are fine with FL’s proposal with small updates:**FL1 Proposal 3.1.1-1:*** **The traffic load for BS energy saving evaluation is considered as**

|  |
| --- |
| Load definition: resource usage by data (UE specific PDSCH / PUSCH).Note: resource allocation for common signal can be treated as overhead when evaluating UPT/throughput. |
| Empty load | Recommend range: less than X% ~~[X=0, 5, 10 or PRBs are only used for SSB/SIB]~~ |
| Light/medium load | Recommend range: X% ≤ RU < Y%~~[Y=10, 15, 20, 30, 35, 50]~~ |
| Heavy/full load | Recommend range: Y% ≤ RU ~~Z%~~~~[Z=50, 70, 100]~~ |
| Note: For empty load, [X=0, 5, 10 or PRBs are only used for SSB/SIB], and for light/medium load, [Y=10, 15, 20, 30, 35, 50].For multi CCs, the load should be calculated among the total CCs. Unbalanced load among CCs can be showed in evaluation results |

**FFS the value of X, Y~~, Z~~ (to be determined in RAN1#110).** |

### KPI

A set of KPIs has been agreed in the last meeting. In this meeting, [2][16] propose to use joint KPIs of those agreed KPIs (which already includes consideration of both gNB and UE side performance gain/impact).

In addition, multiple QoS target (e.g. UPT) [2][5][13, and also latency requirement] is proposed, which sounds reasonable for evaluation and real implementation.

A few other proposals include to define/add (new form of) KPI for

* Option 1: network energy saving evaluation, e.g. multi-dimensional EE KPIs, or a KPI as aggregated UPT divided by normalized energy consumption [5][7], certain performance KPI over energy consumption (in Joule) [12][16]
* Option 2: new channel/signal in terms of performance, complexity, overhead, detection reliability etc.[9]
* Coverage [13]

And load should be also reported [2][3][9] associated with those KPIs.

**FL1 Proposal 3.1.2-1:**

* **To determine limited set of UPT target/requirement (e.g. 5%, 10%, 15% UPT loss) in the energy saving gain evaluation, corresponding to the reported load and evaluated technique(s).**
	+ **FFS latency requirements**
* **Coverage, overhead and other new KPIs can be optionally reported**
* **For potential new channel/signals, e.g. WUS from UE, the performance/complexity/detection reliability in terms of e.g. miss-detection rate at BS side can be considered**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | It seems that the first bullet and “overhead” in the second bullet in the proposal need to be clarified. Besides, Energy efficiency should be included to second bullet as one of KPIs in evaluation methodology for network energy savings.  |
| Qualcomm1 | More discussion is needed |
| NTT DOCOMO | We have a slight concern on the simulation workload of defining a UPT target (e.g. x% loss). To achieve a specific loss the of UPT, we need to try several evaluations with different parameters. Any supplementary statements to reduce the simulation workload is highly appreciated.   |
| Samsung | We are fine with FL’s proposal, with small updates.**FL1 Proposal 3.1.2-1:*** **To determine limited set of UPT target/requirement ~~(e.g. 5%, 10%, 15% UPT loss)~~ in the energy saving gain evaluation, corresponding to the reported load and evaluated technique(s).**
	+ **FFS target UPT loss**
	+ **FFS latency requirements**
* **Coverage, overhead and other new KPIs can be optionally reported**
* **For potential new channel/signals, e.g. WUS from UE, the performance/complexity/detection reliability in terms of e.g. miss-detection rate at BS side can be considered**

For the coverage, we think it should be reported, if it was changed by NWES techniques.For latency, we think the any NWES technique should ensure the latency requirement. Several other companies also mentioned the latency should not be impacted, we should find a way to evaluate the latency impact, either restrict the latency is always met, or define a probability threshold that the latency is not met. |

One reason to FFS latency is that clarification may be needed to define accurate latency KPI, including [13]

* Option 1: user plane latency increase
* Option 2: scheduling latency increase

**FL1 Proposal 3.1.2-2:**

**To determine in RAN1#110 whether specific latency type (e.g. user plane latency, scheduling delay, access delay etc.) should be clarified and included for evaluation of certain techniques.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Spreadtrum1 | UE power saving gain can be reported as an additional benefit. In our view, BS DTX can be aligned to UE DRX. |
| Qualcomm1 | More discussion needed |
| NTT DOCOMO | It can be reported by companies on how latency is calculated in their evaluation.  |
| Samsung | Support to define the user plane latency and scheduling delay. The latency is one of key factor for system performance, so to evaluate the NWES techniques, latency should be reported. Therefore, we think it is needed to define RAN1 specific latency. For latency, we are considering the following two types of latency. User plane latency, $L$ = $t\_{decoded} - t\_{arrival}$,Scheduling latency, $L^{'}$ = $t\_{scheduled} - t\_{arrival}$,We think the user plane latency defined similar as in 38.913. For simplicity and RAN1 specific discussion, we assumed inter layer latency can be ignored, because it may take small faction of latency. It is calculated as the delay between the time when a packet arrivals and the time when the packet is decoded for the service performance. However, when we are evaluating the NWES techniques, like BWP adaptation, it seems not suitable KPI, because portion of adaptation will be directly translated as latency increases. In addition, it’s not key performance under low traffic scenario. Hence, the scheduling delay used in UE PS can be used to show the performance impact on scheduling. It is calculated as the delay between the time when a packet arrivals and the time when the packet is scheduled. It would be desirable KPIs to evaluate the performance under low traffic scenarios for NWES. |

### Gain definition

The gain definition was discussed last meeting. It seems whether it is averaged per slot is concerned. FL understanding is that the energy saving gain is described as relative power, which is normalized by the energy calculation over a time duration (not necessary a slot). [2][17]

**FL1 Proposal 3.1.3-1:**

**The energy saving gain is described as relative power, which is normalized by the energy calculation over a time duration (not necessary a slot).**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We are OK with the proposal. |
| Spreadtrum1 | Fine. |
| Qualcomm1 | OK |
| NTT DOCOMO | We are fine with the proposal.  |
| Samsung | Support |

## Traffic model

On the traffic model to be assumed for evaluation, views from contributions include

* Option 1: no further prioritization among the agreed models is to be considered. [2][13][21, same model for DL and UL]
* Option 2: prioritize certain traffic model. [5, DL traffic to be prioritized, or FTP model with re-adjusted packet size/inter-arrival rate], [17, FTP models], [19, FTP3]
* Option 3: new model, or additional modifications for certain traffic model can be considered.
	+ Heartbeat (TR38.875) [4, with modified arrival rate],
	+ XR or other model with varied packet size [9]

The current models seems typical enough, also covering various packet sizes. Any modification, refinement or new models may have values on its own. Thus,

**FL1 Proposal 3.2-1:**

**It is up to company report which traffic model is used among the agreed three traffic models in their evaluations.**

* **Other models as well as parameter (e.g. packet size and arrival rate) adjustment can be optionally considered and reported.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We support the proposal.  |
| Qualcomm1 | OK |
| NTT DOCOMO | We are fine with the proposal.  |
| Fujitsu | We are fine with the proposal. |
| Samsung | Support |

Regarding UE C-DRX configurations,

* Option 1: should be included in the baseline [9][15]
	+ With shorter inactive timer compared to TR 38.840 [15]
* Option 2: when reported, the following configurations are assumed for alignment
	+ As per TR 38.840 [5][19]

One thing FL has different understanding is that the C-DRX seem to be mandatory with capability signaling, thus not mandated to be in the baseline. This could be similarly reported up to proponent, as the traffic model.

**FL1 Proposal 3.2-2:**

**It is up to company report the use of UE C-DRX.**

* **for alignment, the configuration if reported is as per TR 38.840.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Qualcomm1 | We should agree on a set of C-DRX configs so that KPI analysis can be aligned across companies. |
| NTT DOCOMO | We are fine with the proposal.  |
| Samsung | Support |

## Evaluation scenario

It has been prioritized to study FR1 urban macro BS. Further considerations in this meeting include:

For FR1, the BS to be assumed for study is

* Option 1: urban macro as prioritized is sufficient [2], [5]
* Option 2: additionally, urban micro [3], [4, including TDD massive MIMO], [21, optional with details referring to micro layer in Dense urban per TR38.802]
* Option 3: additionally, rural macro [4, without DSS],
* Option 4: additionally, small cell [3]

For FR2, the BS to be assumed for study is:

* Option 1: macro [2]
* Option 2: beam-based scenarios [4]
* Option 3: (urban) micro [5?][19][21, with details referring to micro layer in Dense urban per TR38.802]

Also single-carrier in homo deployment and multi-carrier in HetNet deployment scenarios is considered [9],[10].

Given the interest of study,

**FL1 Proposal 3.3-1:**

* **For FR1, urban micro can be optionally considered.**
* **For FR2, urban micro is prioritized.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| LG Electronics | We are OK with the proposal. |
| Spreadtrum1 | Fine. |
| Qualcomm1 | OK |
| NTT DOCOMO | We are fine with the proposal.  |
| Samsung | Fine |

## Simulation assumption

### SLS assumptions

There is an FFS on the potential alignment needed for SLS. There are also proposals on reusing SLS assumptions in previous study in e.g. IMT-2020 [2][9], TR 38.802 [8][22] or TR 38.840[4][9] or direct proposals on SLS parameters [15]. Nevertheless, to avoid potential confusion, it may be good to clearly agree on a set of parameters.

Also, baseline setting for SSB & SIB1 is proposed in [2][17] and also mentioned as background activities in e.g. [13]. As a whole, companies are invited to check the Annex-A reference SLS configurations as baseline for FR1, and comment on the part that you prefer to change/add/clarify. For FR2, SLS parameter is also expected after determination of questions in section 3.3.

**FL1 Proposal 3.4.1-1:**

**Companies are invited to check Annex-A reference SLS configurations as baseline for FR1, and share your comments. FFS FR2 (to be determined in RAN1#110).**

|  |  |  |
| --- | --- | --- |
| **Company** | **Parameter** | **Comments** |
| *Company A* | *Channel model* | *The channel model should xxx.* |
| *Device deployment* | *The parameter is yyy.* |
| NTT DOCOMO | CSI feedback | The feedback periodicity of RI is usual 100/200 slots in the network. Current setting of RI periodicity of 5 slot is not reasonable.  |
|  |  |  |

### Other EVA assumptions/settings

There are other issues as below.

1. [1] considers that details or assumptions of the different power savings techniques deployed should be provided or accompany the evaluation results to justify the different power consumption levels of the various sub-state(s).
2. [4] Determination of non-uniform UE distribution.
3. [14] propose that for CA, propose to set the CC combinations from {2.6GHz, 2.6GHz}, {2.6GHz, 4.9GHz}, {2.6GHz, 700MHz},{700MHz, 900MHz}, {1.8GHz, 1.9GHz}.
4. [22] evaluation of the energy saving gain should consider overall network energy usage for performing a certain operation (e.g., equal to several FTP sessions) as opposed to instantaneous power consumption.
5. [22] the average value across multiple cells can be considered for the qualitative analysis via SLS; average values of each cell and other statistics may also be added.

**FL1 Proposal 3.4.2-1:**

**Companies are invited to choose from the above about issues to be further determined/captured for discussion in RAN1#110.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Issue** | **Comments** |
| NTT DOCOMO |  | Set low priority items at least for this meeting. If discussion time is limited, and above issues are not discussed, the related setting can be reported by each companies.  |
|  |  |  |

# Other issues/discussion points/missing proposals

If there is any other issue/discussion point/missing proposal that you consider should be discussed but not captured above, please share your proposal below.

|  |  |  |
| --- | --- | --- |
| **Company** | **Domain (optional, for potential categorization)** | **Issue content/comments/questions** |
|  |  |  |
|  |  |  |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [R1-2205755](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205755.zip) | BS Energy Consumption Model and Sleep States | FUTUREWEI |
| [2] | [R1-2205860](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205860.zip) | Discussion on performance evaluation for network energy saving | Huawei, HiSilicon |
| [3] | [R1-2205999](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205999.zip) | Discussion on performance evaluation of network energy savings | Spreadtrum Communications |
| [4] | [R1-2206053](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206053.zip) | Discussions on NW energy savings performance evaluationns on | vivo |
| [5] | [R1-2206074](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206074.zip) | NW energy savings performance evaluation | Nokia, Nokia Shanghai Bell |
| [6] | [R1-2206141](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206141.zip) | On network energy savings evaluation methodology and power model | Panasonic |
| [7] | [R1-2206172](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206172.zip) | Discussion on NW energy savings performance evaluation | Fujitsu |
| [8] | [R1-2207685](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/R1-2207685.zip) | Discussion on NW energy savings performance evaluation | OPPO |
| [9] | [R1-2206411](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206411.zip) | Evaluation Methodology and Power Model for Network Energy Saving | CATT |
| [10] | [R1-2207694](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/R1-2207694.zip) | Discussion on Network energy saving performance evaluations | Intel Corporation |
| [11] | [R1-2206665](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206665.zip) | Performance evaluation for network energy saving | InterDigital, Inc. |
| [12] | [R1-2206696](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206696.zip) | Discussion on BS energy saving model and evaluation | China Telecom |
| [13] | [R1-2206838](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206838.zip) | NW Energy Savings Performance Evaluation | Samsung |
| [14] | [R1-2206925](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206925.zip) | Discussion on network energy saving performance evaluation | CMCC |
| [15] | [R1-2206979](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206979.zip) | NW energy savings performance evaluation | MediaTek Inc. |
| [16] | [R1-2207037](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207037.zip) | Discussion on performance evaluation for network energy savings | LG Electronics |
| [17] | [R1-2207059](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207059.zip) | Discussion on NW energy saving performance evaluation | ZTE, Sanechips |
| [18] | [R1-2207079](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207079.zip) | Evaluation and power model for network energy savings | Rakuten Mobile, Inc |
| [19] | [R1-2207245](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207245.zip) | NW energy savings performance evaluation | Qualcomm Incorporated |
| [20] | [R1-2207343](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207343.zip) | On NW energy savings performance evaluation | Apple |
| [21] | [R1-2207418](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207418.zip) | Discussion on NW energy savings performance evaluation | NTT DOCOMO, INC. |
| [22] | [R1-2207437](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207437.zip) | Network energy consumption modeling and evaluation | Ericsson |

# Annex –

## A. Reference SLS configurations

**Table A The evaluation assumption for BS power consumption model**

|  |  |
| --- | --- |
|  | Parameters |
| Basic parameters | Channel model | 3D/HF-Uma based on TR 38.901 | 3D/HF-Uma based on TR 38.901 |
| Device deployment | 80% indoor, 20% outdoor | 80% indoor, 20% outdoor |
| Inter-site distance | 500m | 500m |
| Network Topology | 7\*3 Sector | 7\*3 Sector |
| Carrier Frequency | 2.1GHz | 4GHz |
| Multiple access | OFDMA | OFDMA |
| Duplexing | FDD | TDD |
| Numerology | 15KHz,14 OFDM symbol slot | 30kHz,14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (104RB for 15kHz SCS and 20 MHz BW) | TDD: 2.08% (272 RB for 30kHz SCS and 100 MHz bandwidth) |
| Simulation bandwidth | FDD: 20 MHz | TDD: 100 MHz |
| Frame structure | Full downlink | DDDSU |
| UT attachment | Based on RSRP | Based on RSRP |
| Wrapping around method | Geographical distance based wrapping | Geographical distance based wrapping |
| Traffic model | Burst buffer with load <10%, 30%, 50% Packet size: 0.5M, 0.1M | Burst buffer with load <10%, 30%, 50%Packet size: 0.5M, 0.1M |
| BS parameters | BS antenna height | 25 m | 25 m |
| BS noise figure | 5 dB | 5 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| Antenna configuration at TRxP | For 32T: (M,N,P,Mg,Ng; Mp,Np) = (8,8,2,1,1;2,8)(dH, dV)=(0.5, 0.8)λ | For 64T: (M,N,P,Mg,Ng; Mp,Np) = (12,8,2,1,1;4,8)(dH, dV)=(0.5, 0.8)λ; |
| UE parameters | UE power class | 23dBm | 23dBm |
| UE noise figure | 9 dB | 7 dB |
| UE antenna element gain | 0 dBi | 0 dBi |
| UE antenna height | Outdoor UEs: 1.5 m; Indoor Uts: 1.5m or consider floor height | Outdoor UEs: 1.5 m; Indoor Uts: 1.5m or consider floor height |
| Antenna configuration at UE | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2)(dH, dV)=(0.5, N/A)λ | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2)(dH, dV)=(0.5, N/A)λ |
| Transmission parameters | Modulation | Up to 256 QAM | Up to 256 QAM |
| Transmission scheme | SU-MIMO  | SU-MIMO  |
| SU dimension | For 4Rx: Up to 4 layers | For 4Rx: Up to 4 layers |
| DL CSI measurement | Non-precoded CSI-RS based | Precoded CSI-RS based |
| DL codebook | Type I/II codebook | non-PMI transmission |
| SRS transmission | N/A | For UE 4 Tx ports: Non-precoded SRS |
| CSI feedback | PMI, CQI, RI: every 5 slot; Subband based  | CQI, RI: every 5 slot; Subband based  |
| Interference measurement | SU-CQI; CSI-IM for inter-cell interference measurement | SU-CQI; CSI-IM for inter-cell interference measurement |
| Scheduling | PF | PF |
| Receiver | MMSE-IRC | MMSE-IRC |
| Channel estimation | Non-ideal | Non-ideal |
| Common RS | SSB/SIB1 period | 20ms | 20ms |
| SSB time resource | Slot#0~slot#3, 2 SSB per slot4 symbols for each SSB | Slot#0, slot#1, 2 SSB per slot4 symbols for each SSB |
| SSB frequency resource | 20RB | 20RB |
| SIB1 time resource | slot#10 ~ slot#17 | slot#10 ~ slot#13 |
| SIB1 frequency resource | 40RB | 40RB |

(M, N, P, Mg, Ng; Mp, Np)

- M: Number of vertical antenna elements within a panel, on one polarization

- N: Number of horizontal antenna elements within a panel, on one polarization

- P: Number of polarizations

- Mg: Number of panels in a column;

- Ng: Number of panels in a row;

- Mp: Number of vertical TXRUs within a panel, on one polarization

- Np: Number of horizontal TXRUs within a panel, on one polarization

## B. Agreements for EVM@RAN1#109-e

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [**R1-2205308**](file:///C%3A%5CUsers%5Cw00250081%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2205308.zip) **FL summary#1 for performance evaluation for NR NW energy savings Moderator (Huawei)**AgreementFor evaluation purpose, the energy consumption modeling for a BS includes at least the following:* Reference configuration
	+ FFS other details
	+ Note FR1 and FR2 to be separately considered for detailed parameters
* Multiple power state(s) including sleep/non-sleep mode(s) with relative power, and associated transition time/energy
* Scaling method to be applied at least for non-sleep mode.
	+ FFS other details including scaling for sleep mode

[**R1-2205402**](file:///C%3A%5CUsers%5Cw00250081%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2205402.zip) **FL summary#2 for performance evaluation for NR NW energy savings Moderator (Huawei)**AgreementFor evaluation purpose, the BS energy consumption model should at least include the power consumption of BS on slot-level.* Note that symbol-level power consumption to reflect different BW (or RB utilization) / time-occupancy / tx-rx direction of different symbols in a slot is considered.
	+ FFS details (e.g. explicit symbol-level power modelling, scaling slot-level power to symbol level power for various cases, etc.)
	+ Note: system simulation evaluations can be per slot regardless of detailed approach for calculating symbol-level power consumption.

Agreement* For evaluation, at least for non-sleep mode and TDD, the BS powerconsumption for DL and UL are separately modelled, allowing DL-only transmission or UL-only reception.
	+ FFS: whether UL-only reception energy consumption model can be derived/simplified from DL-only transmission energy consumption model
* FFS: the impact of UL reception and/or DL transmission on sleep modes and associated transition time/energy
* FFS: whether/how to define an idle state, where BS is neither transmitting nor receiving but also doesn’t enter into any sleep mode or define it as sleep mode
* FFS: whether the model for FDD can be based on the model for TDD

Agreement* For evaluation purpose,
	+ Study how to define sleep modes and determine the characteristics for each mode from one or multiple of the below
		- Relative power
		- Transition time
		- Transition energy
		- Other approaches are not precluded
		- Note: BS components that can be turned off can be considered for discussion purpose when defining the specific values of the characteristics for sleep modes.
	+ Study whether sleep mode is defined for DL(TX) and UL(RX) jointly or separately
	+ Study the assumption of order for BS entering/resuming from a sleep mode to another mode (sleep or non-sleep) and the associated transition time and energy, i.e. state machine which may have impact on the transition energy.

Agreement* For evaluation, the scaling in a BS energy consumption model can be considered based on one or more of the following,
	+ Number of used physical antenna elements, or TX/RX chains
		- FFS: Mapping between used TX/RX chains and used antenna ports
		- FFS: Mapping between physical antenna elements and TX/RX chains
	+ Occupied BW/RBs for DL and/or UL in a slot/symbol in one CC
	+ number of CCs in CA
		- FFS dependency of RF sharing
	+ number of TRPs
	+ PSD or transmit power
		- FFS dependency on BW scaling
		- FFS: PA energy efficiency value
	+ number of DL and/or UL symbols occupied within a slot
	+ FFS other domain scaling
	+ FFS scaling is linearly or else, for each domain
* Above does not necessarily imply that BS energy consumption model that takes into account all listed scaling factors will be developed

AgreementFor BS energy consumption evaluation, in addition to the energy saving gain,* At least UPT/UE power consumption/access delay/latency should be considered for performance impact evaluation
* Note: this doesn’t necessarily mean that all the above are considered for all evaluation results. However, multiple KPIs are expected to be evaluated for a given technique. And this does not preclude to consider other KPIs when found appropriate for certain techniques/scenarios.

AgreementAt least urban macro is prioritized for FR1. FFS the baseline deployment assumption for FR2.Agreement* FTP3 (0.5MB as packet size, 200ms as mean inter-arrival time), FTP3 IM (0.1MB as packet size, 2s as mean inter-arrival time) and VOIP can be considered in the evaluation
* FFS: with possible further prioritization, different model between DL and UL, and/or other traffic models that can be optionally considered.
* FFS associated scenarios/configurations, e.g. C-DRX.

[**R1-2205468**](file:///C%3A%5CUsers%5Cw00250081%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2205468.zip) **FL summary#3 for performance evaluation for NR NW energy savings Moderator (Huawei)**AgreementFor evaluation and BS energy consumption modeling purpose, for single CC case, at least the following in table should be considered for reference configuration* + Note: other TX-RX RU number and corresponding BS antenna configuration can be considered in SLS assumptions

|  |  |  |  |
| --- | --- | --- | --- |
|  | Set 1 FR1 | Set 2 FR1 | Set 3 FR2 |
| Duplex | TDD | FDD | TDD |
| System BW | 100 MHz | 20 MHz | 100 MHz |
| SCS | 30 kHz | 15 kHz | 120 kHz |
| Number of TRP | 1 | 1 | 1 |
| Total number of DL TX RUs | 64 | (working assumption) 32 | 2 |
| Total DL power level | 55dBm | [49dBm] – to be further discussed and finalized in future meetings | 43dBm – to be further discussed and finalized in future meetingsEIRP limited to 78dBm – to be further discussed and finalized in future meetings |
| Total number of UL Rx RUs | 64 | (working assumption) 32 | 2 |

AgreementAs a starting point,* macro cell BS for FR1 is assumed for energy consumption model.
* FFS: micro cell BS for FR2 is assumed for energy consumption model.

AgreementThe evaluation baseline for energy saving study/evaluation for BS includes at least NR R15 mandatory without capability features. Optional features from R15 onwards (e.g. CA, MIMO) as well as implementation-based energy saving techniques should be explicitly reported and described if used in the evaluation baseline.* FFS: need of alignment for certain configurations/implementation-based schemes.

Agreement* Similar to UE power saving study, percentage of energy consumption reduction from the baseline is used to express BS energy saving gain.
* SLS is considered as baseline evaluation method. Other method, including numerical analysis and LLS can also be considered. At least one of the methods should be selected and used for evaluation of a specific technique (selection and criteria is up to proponent).

Working assumptionFor evaluation, for energy consumption modelling for FDD and the case of simultaneous DL transmission and UL reception for non-sleep mode, study the following with potential down-selection in RAN1#110* Option 1: the power consumption is the total of DL and UL power consumption
* Option 2: the power consumption for UL is neglected
* Other option is not precluded
* Note the DL (or UL) power consumption can be obtained using a same approach as that obtained from the DL (or UL)-only in TDD model

Final summary in [R1-2205551](file:///C%3A%5CUsers%5Cw00250081%5CAppData%5CLocal%5CTemp%5CDocs%5CR1-2205551.zip). |

## C. SID abstraction

Study Item (SI) for network energy savings for NR is approved in [1]. For the study of performance evaluation for this SI, the relevant objectives include below

|  |
| --- |
| 1. Definition of a base station energy consumption model [RAN1]
* Adapt the framework of the power consumption modelling and evaluation methodology of TR38.840 to the base station side, including relative energy consumption for DL and UL (considering factors like PA efficiency, number of TxRU, base station load, etc), sleep states and the associated transition times, and one or more reference parameters/configurations.
1. Definition of an evaluation methodology and KPIs [RAN1]
* The evaluation methodology should target for evaluating system-level network energy consumption and energy savings gains, as well as assessing/balancing impact to network and user performance (e.g. spectral efficiency, capacity, UPT, latency, handover performance, call drop rate, initial access performance, SLA assurance related KPIs), energy efficiency, and UE power consumption, complexity. The evaluation methodology should not focus on a single KPI, and should reuse existing KPIs whenever applicable; where existing KPIs are found to be insufficient new KPIs may be developed as needed.

Note: WGs will decide KPIs to evaluate and how.The study should prioritize idle/empty and low/medium load scenarios (the exact definition of such loads is left to the study), and different loads among carriers and neighbor cells are allowed. The following example scenarios (mapping between scenarios and network loads is left to the study) including single-carrier and multi-carrier deployments are used as the starting point for discussion on prioritized scenarios for the study. The following example scenarios are listed in no particular order.* Urban micro in FR1, including TDD massive MIMO (note: this scenario can also model small cells)
* FR2 beam-based scenarios (note: this scenario can also model small cells)
* Urban/Rural macro in FR1 with/without DSS (no impact to LTE expected in case of DSS)
* EN-DC/NR-DC macro with FDD PCell and TDD/Massive MIMO on higher FR1/FR2 frequency

Note 1: 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.Note 2: the study of energy savings specifically for IAB is not part of the scope.The study should coordinate with RAN4 as needed. |

## D. Contact list per RAN1#109-e

|  |  |  |
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