**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 for Post-110-R18- NW\_ES2**

**Document for: Discussion and Decision**

# Introduction

This triggers the email discussion of the following:

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| * [Post-110-R18- NW\_ES2] Email discussion on remaining details of NW EnSav performance evaluation methodology by September 1 – Yi (Huawei) |

Note there is discrepancy on the deadline between that in Chair notes and that in the email from Chair over reflector. Sep. 1 is intended so let’s be prepared. Initial input are expected by Monday 23:59 UTC time.

Agreements made during the meeting week are captured in Annex-E for your information. The moderator summary we had last week are in [R1-2208216](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/R1-2208216.zip).

## Recommendations for email approval:

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# Energy consumption model for BS

## Remaining issues for power consumption model

### Inter-sleep mode transition

* *FFS: Optionally, a state machine where BS may transit between sleep modes without entering non-sleep mode can be considered. Companies are to report the involved sleep modes and the assumptions for inter-sleep mode transition time used in their evaluations.*

Several issues were mentioned based on the assumption of always existence of non-sleep state during transition [15]. According to FL understanding, the major concern seems to be the unrealisticness for BS predicting the UE traffic. On the other hand, it is not crystal clear to FL that how this can be overcome by using the proposed algorithm. If the traffic is not predictive at all, the BS may still go to deeper sleep while there is traffic coming later, and the threshold does not help. In this case the gNB actually waste some time that could be used for deeper sleep from the beginning thus less energy saving, while the consequence to UE is the same. Also, it is not clear how BS should monitor the traffic in order to perform this algorithm during sleeping, and whether this consumes further energy. Frequent check during inter-sleep states seems to be required and the delay/transition time could be longer since the one-shot transition is interrupted. Overall, the prediction of UE traffic is a common project. In the study, with currently 3 sleep states introduced, the gap between each other seems sufficient for gNB to select one – if the load/traffic is large, micro sleep without transition can be choosed; if the traffic is further reduced, either light or deep sleep for Category 1 and light sleep (with transition time close to paging circle) for Category 2 can be considered. FL consider the original proposal is good enough, for the interest of study. If results draw more attention in the next meeting, we can consider whether to bring more simulations based on that.

**Proposal 2.1.1-1:**

* **For initial evaluations, there is always a non-sleep mode assumed between adjacent sleep modes.**
* **Companies are encouraged to check the results, if provided, based on an incremental state machine (details in** [R1-2206979](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206979.zip)**) where BS may transit between sleep modes without entering non-sleep mode, and discuss whether this can be an additional power consumption model for further evaluations.**

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| **Company** | **Comments** |
| CATT | In our understanding, the transition time of deep/light sleep is to the micro sleep, which is also considered in Rel-16 UE power saving since the gNB’s wakeup from deep/light sleep might not at the symbol/slot for immediate DL Tx/UL Rx. gNB could easily transition to non-sleep state of DL Tx or UL Rx without transition time. Thus, the transition time should be defined in the same way is to transition between deep/light sleep and micro sleep (standby for any active Tx/Rx). The transition time between deep/light sleep mode to micro sleep in standby active Tx/Rx should be considered as the same as transition between deep/light sleep mode to active Tx/Rx. |
| ZTE, Sanechips | We support that there is always a non-sleep mode assumed between adjacent sleep modes.  For network power consumption modeling and evaluation, transition between sleep modes without entering non-sleep mode doesn’t result in significantly difference in evaluation results in terms of power saving gain, latency, etc, but greatly increases the simulation complexity.  For the transition between sleep modes, more discussion are required within the limited remaining SI phase, for example, how to trigger the transition into a deeper/lighter sleep state, how to calculate the associated transition energy. In the  From our understanding, the benefits of considering transition between sleep modes are not clear, we do not think an additional power consumption model is needed. |
| CMCC | Support that there is always a non-sleep mode assumed between adjacent sleep modes. |
| Samsung | We are fine with FL’s proposal for initial evaluation. |
| Intel | We think the intention of the first bullet is that only transition between [non-sleep/micro-sleep] mode and light sleep/deep sleep mode is assumed. We support this proposal..For evaluation purpose, we think modeling BS transitions from sleep to [non-sleep/micro-sleep] mode (and vice versa) is sufficient. It may be possible in real implementations that BS may enter different sleep modes in stages (e.g., BS enters light sleep mode first, then deep sleep mode). While we are open to state transitions models that allow switching from one sleep mode to another, as well as transitions model that only allow sleep mode to change to an active state, our preference is to have one transition model for evaluations. We expect potential insights obtained from evaluations with either models may not be significantly different and support of a single transition model is preferred.  Although BS may not predict arrival of traffic with certainty, in our view BS is never fully off and it’s backhaul and controller are expected to be always functioning so that BS can receive traffic requests and wake up from sleep modes. Depending on imminent or upcoming transmissions/receptions, BS can enter appropriate sleep modes. |
| LG Electronics | We are generally OK with Proposal 2.1.1-1 and we still think it is worth considering and evaluating the incremental state machine. |
| OPPO | We support the transition between non-sleep mode and sleep as always for the simulation purpose. |
| vivo | We support the proposal. |
| DOCOMO | We are fine with FL’s proposal for initial evaluation. |
| Huawei, HiSilicon | We don’t prefer to consider very complicated models to transit among different sleep modes. The power model is used for evaluation and transition energy and time are already considered when UE transits to/from a sleep mode to non-sleep mode. It can certainly reflects the energy consumption of transits.  Regarding the transitions among different sleep state, it may be impacted a lot by the implementation algorithm. Therefore, even if we consider to model gNB transit among different sleep modes, it would be also different from realistic and just add more difficulties to align results/observations from companies. |
| Ericsson1 | In our understanding transition between sleep states is implicitly covered by transition energy assumption for the evaluations. It is sufficient to model the transition between active state and each of the sleep state. |
| Qualcomm1 | If the discussion is for computing the additional transition energy, we don’t think the proposal is needed since companies can provide the numbers or it can be computed based on a formula (prefer the former approach).  However, if the discussion is for modelling power state transition in simulations, we suggest updating the proposal as follows:   * For evaluation purpose, BS may transition from a sleep state to a non-sleep state or transition from a non-sleep state to a sleep state.   In SLS, if we model transition between different sleep states (e.g., to go into deep sleep from active state, we have to model transition as active 🡪 micro sleep 🡪 light sleep 🡪 deep sleep), it will complicate the simulation effort while we may not get additional insights. Note that transition between different sleep modes may be used in computing the additional transition energy. |

### Handling of low-power UL signal

* *FFS: Details on how to use the above table for low power uplink reception (e.g. for WUS).*

WUS reception would in the end, if adopted, be one kind of UL channel/signal. There does not seem to be any difference from other UL channel/signals. Therefore it is not clear why it cannot be considered as normal UL-only reception as in active UL in the power consumption model, whatever the DL state is (despite the name of DL as sleep or active). From implementation point of view, if a separate receiver is used, this then could be applied to all other UL channel for this given implementation as well. Overall for a given implementation, with processing components for UL (partially) shared or non-shared with DL, the difference can be reflected in the power states values and transition times. FL consider it is sufficient to let companies report the details including the assumption of power states and transition time before/after the reception of the low-power-UL channel/signal.

**Proposal 2.1.2-1:**

**Companies to report the assumption details of power states and transition times before/after the reception of a low-power UL channel/signal, if used.**

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| **Company** | **Comments** |
| CATT | The Power model of low-power UL channel would depend on the receiver sensitivity, which would decide the coverage of the signals. The low-power UL channel has specific designed to minimize the power consumption. The proponent should provide detailed front end receiver architecture and the receiver sensitivity of the operation frequency band for the low power uplink reception in order to define the power model. |
| ZTE, Sanechips | Compared with DL transmission, the power consumption of UL reception is very small. But the exact power value of the low power UL reception depends on detailed implementation, we think it is okay to let companies to report the details including transition time/energy, etc.  Furthermore, we agree with FL that this low-power UL reception should be applied to other UL signals, we don’t need to limit it to WUS. |
| CMCC | The energy consumption for UL reception and processing only accounts about 10% of BS energy consumption. In such a small account of energy, the difference of energy consumption for receiving WUS or normal channel/signal can be ignored. |
| Samsung | We support the proposal.  For Cat 2 of reference configuration set 1, RAN1 agreed on the transition time to be 640ms and 10s, for light sleep and deep sleep, respectively. If gNB would like to go to sleep, gNB cannot monitor UL transmission during the transition time and sleeping time. If a packet arrives at a UE when gNB just starts SM transition, the UL latency can be seconds which is clearly not acceptable.  Allowing reception of WUS not impacting the SM transition could avoid such situation. If there is no UL traffic, the gNB can sleep for a long time while keep monitoring the WUS, if there is UL traffic arrives, UE would send a WUS to wake up the gNB to avoid large UL latency. |
| Intel | It is not clear whether a separate receiver component is assumed to be functional only for receiving WUS. If so, proponents could provide what would be the operating model and assumptions, including transition between low power UL reception state to other DL/UL states and whether such state can be approximately assumed to be same as micro-sleep mode or not with same relative power.  If this is part of a potential enhancement, then it might be better if proponents can provide details including potential changes to the reference power model when such receivers are utilized.  In our view, introducing a separate UL state for receiving a certain type of signal/channel (characteristics of which is unclear) for WUS is not necessary for defining power state model for the reference scenario. |
| LG Electronics | We agree with the FL comments and the proposal. Further discussions can be considered depending on the assumption details and evaluation results reported by companies in favor of low-power WUS. |
| OPPO | We agree with FL proposal. But we think the simplest way is to model it as active UL power consumption. |
| vivo | We are OK with the proposal.  We think a sleep state that is able to have low-power UL reception is needed. For current active UL only state, it is assumed that only PA is switched off and almost all other Tx components are switched on. If there is no traffic arrival and gNB is only monitoring WUS reception, it is beneficial to have a Tx sleep state with capability of low power UL reception where almost all the Tx component are switched off but Rx component is able to receive. The power value of this Tx sleep state could be even smaller than that for light sleep. Besides, the transition time and energy to active UL could be 0, which means gNB could maintain such low power state when there is no need for DL transmission. |
| DOCOMO | We support the FL proposal.  The difference between normal UL channel/signal and low-power UL channel/signal reception would be small considering the amount of the UL power consumption compared to that of DL. |
| Huawei, HiSilicon | According to the working assumption of set1, the power consumption values are 5.5 and 6.5 for micro sleep state and active UL only state respectively for Category 1 gNB assumption. The gap is already small enough.  We think the uplink detection power shall not be significantly reduced for WUS signal compared with some other signals/channels, assuming the reception bandwidth and Rx chains number are the same. |
| Ericsson1 | OK to leave any additional modelling with sufficient justification to the proponents. |
| Qualcomm1 | Suggest making the following update:   * **Companies to report ~~the assumption details of power states and transition times before/after~~ the power consumption model for the reception of a low-power UL channel/signal~~, if used~~.** |

### Total transition time and additional transition energy

*FFS: Details on how transition energy is defined.*

There was some confusion by defining the total transition time using micro-sleep instead of non-sleep mode as reference. Since immediate transition time is assumed from micro-sleep to non-sleep, the calculation of total transition time would be the same between using micro-sleep and using non-sleep as reference, if there is no state machine, i.e. inter-sleep state transition is considered.

Clarification on how to calculate the additional transition energy is needed. Although BS power ramping could be more complicated, for modeling and evaluation purpose, it could be simpler to use a same methodology as UE power saving study, since a large portion of BS power consumption is contributed from given power states instead of transition. Further, micro-sleep is more proper as reference state since the relative power could be varying per different configurations/loads during non-sleep.

**Proposal 2.1.3-1:**

**The additional transition energy represents the energy that BS enters from non-sleep mode to a sleep mode and BS leaves the same sleep mode to non-sleep mode. For evaluation purpose, it is calculated as**

**where**

* **is the difference of the relative power between sleep mode and micro sleep**
* **is the corresponding total transition time of sleep mode , which is a two-way time, assuming no inter-sleep state transition.**

Note values will be directly given (from FL) once relative power values and transition times are determined. Therefore we only need to generally align on how the additional energy is obtained for this proposal. For details about “”, let’s see how the values will look like and for example, whether rounding is needed or not (as UE power saving did).

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| **Company** | **Comments** |
| CATT | The formula is correct. However, the transition energy and transition time should have only single value similar to that defined in Rel-16 UE power saving. The transition energy should be defined as single value of the transition between deep/light sleep and micro sleep, which is standby of active Tx/Rx. |
| ZTE, Sanechips | Proposal 2.1.3-1 is a good start to calculate the additional transition energy between sleep mode and non-sleep mode.  What’s more, a condition should be met that the BS power consumption when the BS enter into a deeper sleep mode should lass than that of the BS enter into a lower sleep mode. |
| CMCC | As FL’s clarification, the calculation of total transition time would be the same between using micro-sleep and using non-sleep as reference, we prefer to use non-sleep as reference. It is more realistic for network operation, when the conditions are satisfied, BS will wake up to active mode for DL transmission or UL reception.  Besides, the additional transition energy may be also defined as the energy that BS enters from non-sleep mode to a sleep mode for the consistent definition for transition time and transition energy.  Furthermore, in Proposal 2.1.3-1, represents the energy that BS enters from **non-sleep mode** to a sleep mode , is the difference of the relative power between sleep mode and **micro sleep**, could FL clarify why is using non-sleep mode as reference and is using micro sleep as reference. |
| Samsung | Fine with minor update to align with **Proposal 2.1.1-1**  **Rev Proposal 2.1.3-1:**  **The additional transition energy represents the energy that BS enters from non-sleep mode to a sleep mode and BS leaves the same sleep mode to non-sleep mode. For evaluation purpose, it is calculated as**  **where**   * **is the difference of the relative power between sleep mode and a non-sleep mode ~~micro sleep~~** * **is the corresponding total transition time of sleep mode , which is a two-way time, assuming no inter-sleep state transition.** |
| Intel | We are fine with the formula. It needs to be clarified that here sleep mode *i* corresponds to light and deep sleep modes only.  There was some confusion during discussions that took place in RAN1 # 110 whether non-sleep mode such as active DL or active UL should be considered instead of micro-sleep for obtaining . Note that we have agreed that transition between non-sleep to micro-sleep takes zero transition time and energy. Hence, assuming transition between micro-sleep to/from sleep mode *i* for representing transition energy corresponding to transition between non-sleep mode (active DL or active UL) to sleep mode *i* seems to be a reasonable approximate model and a cleaner/simpler approach. Otherwise, multiple values of transition time and energy need to be reported for sleep mode *i* depending on transition to/from active DL or active UL states. |
| LG Electronics | From our perspective, the formula needs to be more clarified. In our understanding, *Ei* and *T*i are two-way energy and time, respectively, but it is necessary to clarify why delta is the difference between sleep mode i and non-sleep mode and why 1/2 term is required. |
| OPPO | We are fine with the proposal |
| Vivo | We are OK with the proposal. should be the difference of the relative power between sleep mode and micro sleep. Suggest to change to .  Just a clarification on the total transition energy: it should be the energy for sleep mode *i* in transition time + additional transition energy **.** |
| DOCOMO | Share the similar view to CMCC/Samsung, and fine with the updated proposal by Samsung. It is weird to calculate from the difference of the relative power between sleep mode and micro-sleep if take Proposal 2.1.1-1 that non-sleep mode is always assumed for the transition. |
| Huawei, HiSilicon | We are fine with the proposal and it follows the similar principle of that in UE power saving. |
| Ericsson1 | Our preference is to agree to a value directly if possible, and no need to agree to a formula.  The additional transition energy from active state to sleep mode (SM) k and vice versa should be calculated using where is the power level and half the transition time of ith sleep mode, respectively.  For TDD, we think the transition energies should be 90 for active to light sleep, ~620 for active to deep sleep. |
| Qualcomm1 | Agree with Ericsson on providing values for additional transition energy.  For Set1 FR1 & power model Cat1, we propose additional transition energy is 90 for light sleep and 760 for deep sleep. |

### Power values for ref. conf. set 2 and set 3

Although there were some input during the meeting (see [Power state and transition time-offlineThursday\_v02.docx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/drafts/9.7(FS_Netw_Energy_NR)/9.7.1/FLS3/Power%20state%20and%20transition%20time-offlineThursday_v02.docx)), in general it seems incomplete and would be better to allow for another round of input considering that companies may understand more on how we use the input to determine the values. In the first round, please companies provide your values based on the [Templates](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/drafts/9.7(FS_Netw_Energy_NR)/9.7.1/Post-110-R18-NW_ES2/Template_collection%20of%20relative%20power_EnSav_v00.xlsx) in the [folder](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/drafts/9.7(FS_Netw_Energy_NR)/9.7.1/Post-110-R18-NW_ES2/Template_collection%20of%20relative%20power_EnSav_v00.xlsx) for set 2 and set 3 reference configuration respectively. Plan is to draw Working Assumptions (as that for set 1) for this post email discussion. The input for set 1 is also attached in the xls sheet for information.

Other comments can be provided below, if any.

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| **Company** | **Comments** |
| CATT | We could complete set 2 and set 3 at next meeting when more inputs would be provided. |
| Intel | Please find inputs to the excel sheet attached. In our view, at least Set 1 TDD values can be considered for initial evaluation based on reference configuration. |

## Scaling

The scaling based on a single formula gains general support in the first round while three companies prefer per domain scaling in the second round. Further offline of offline discussion led to three alternatives to be further discussed (see Recommendation part in the [document](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/drafts/9.7(FS_Netw_Energy_NR)/9.7.1/FLS3/offline/R1-2208216%20110-NWES%20EVA%20FLS3_v01_update_FL3_proposals-Friday%20offline.docx)), which seems to bring the discussion back to the starting point: slot level v.s. symbol level, jointly v.s. separately. Also, the Alt 4 recorded in the documents seems incomplete, so further clarification/corrections may be required.

The attempt to address the non-linear PA is expected, which is FFS in previous proposal and draw an increased interest from the feedback. Some clarification may be useful on how some proposed scaling methods can accurately reflect the non-linear effects and/or whether simplified approach e.g. by jointly scaling is sufficient. Both jointly or separately scaling approach could work. With properly selected factors these two may not differ greatly, given low load as the primary study interest.

Comments for CA, time-domain may be addressed separately.

**Proposal 2.2-1**

* **The BS power consumption for active DL is provided by**
  + **Alt 1:** 
    - : a static part of which the power is not scaled based on reference configurations. Value is to be determined based on
      * Option 1: P3
      * Option 2: a\*P4 where a<1
      * Note Option 1 and Option 2 are listed for the purpose of deriving , and is not to be reflected once the value of is obtained.
    - : a dynamic part of the power that is scaled based on reference configurations, given by
      * **Alt 1-1: +**
      * **Alt 1-2:**
      * , , is the percentage of active TRxRUs, resource usage in frequency domain and scaling factors in power domain.
      * is PA efficiency, for simplicity, may be a fixed value for certain load
  + **Alt 2:** 
    - , , is the static part, and , , is the scaling factor of frequency/spatial/power domain, respectively
    - In time domain,
      * when slot level model is provided, a time domain scaling factor is linearly applied using the number of active symbols within a slot. Companies to describe how to scale for symbols with different frequency domain allocations.
      * If an explicit symbol level model is provided, scaling is not applied
  + **Alt 3: (1-x)\*P3 + x\*(a + (1-a)\*)\*P4**
    - x is resource usage, in percentage
    - a < 1, e.g. =0.3
    - is function of PA efficiency
  + **Additional notes applicable for all alternatives,**
    - In time domain,
      * when slot level model is provided, a time domain scaling factor is linearly applied on , if applicable, or on ***P***, according to the number of active symbols within a slot. Companies to describe how to scale for symbols with different frequency domain allocations.
      * If an explicit symbol level model is provided, scaling is not applied.
    - In frequency domain, for inter-band CA, the power consumption is assumed as
  + Alt 1-F-1: the sum of the power consumption of each cell
  + Alt 1-F-2: using a scaling factor that can be >1
    - In spatial domain, for M-TRP, the power consumption is assumed as
  + Alt 1-S-1: the sum of the power consumption of each TRP
  + Alt 1-S-2: using a scaling factor that can be >1
    - Note: system simulation evaluations can be per slot regardless of detailed approach for calculating symbol-level power consumption (already agreed).

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| **Company** | **Comments** |
| CATT | The power scaling model should be defined for individual domain, e.g., time, frequency, spatial, and power with simple model of static component + dynamic component.  The static component is the fraction of fixed power consumption associated with the overall power consumption in a given domain. When the power scaling in time domain to derive the power consumption for fractions number of the Tx symbols in a slot, the static component is the power consumption of option 1 of micro sleep “P3”. However, the static component of frequency, spatial and power domain scaling is not equal to “P3” since they are the fraction of total active Tx/Rx, which is option 2 of a\*P4.  The dynamic component would be defined in association with the variation in time, frequency, spatial and power domain.  For joint power scaling model, we should discuss it once we finalize the individual power scaling for each domain. |
| ZTE, Sanechips | For Alt 1-1, regarding the static part of the power, P3 is a good choice because the power consumption of micro sleep should be the minimum value of the power consumption of active DL. For the dynamic part, Alt 1-1 can reflect the impact of the frequency domain, spatial domain, and power domain on the power consumption of active DL.  For Alt 2, it is similar with UE power consumption model. It is assumed that scaling factor of individual domain can be directly multiplied if adaptation in multiple domains is considered in the evaluation. It should be noted that with this assumption, it should be additionally consider a lower bound of scaling, i.e., the active DL power consumption should be larger than micro sleep even adaptation in multiple domains is used. That is, the power consumption of active DL is equal to min(P3, Alt 2).  What’s more, with a proper design, Alt 1 and Alt 2 may not differ greatly from evaluation respective. Considering the scaling factor calculation for multi-domain adaption, alt-1 is slightly preferred. And we are also okay with the majority views.  For the power consumption model, slot level is simple and preferred.  For the time domain scaling, the power consumption should be calculated according to the number of active symbols within a slot. And the symbol without active DL should be treated as micro sleep. Therefore, the time domain scaling can be α\*P4+(1-α)\*P3, wherein P4 is the power for active DL, P3 is the power of micro-sleep, α is the ratio of active DL occupation within a slot.  For the scaling of inter-band CA, Alt 1-F-1is preferred. For inter-band CA, the RF chains and other components of difference cells are independent. Therefore, the total energy consumption of multiple cells is basically equal to the sum of the power consumption of each cell. |
| Samsung | We slightly prefer **Alt 1** for scaling for active DL.  Regarding the, we think **P3** in Option 1 seems reasonable. During micro sleep mode, we are assuming the gNB consumes minimum power to stand by the transmission or reception. It’s would be not affected by the scaling in the any domains. So, we support Option1.  In terms of to simplify the power consumption, we support **Alt 1-2** for evaluation with the following further clarification. Given Alt 1-2, the scaling factor of power domain can be reflected in conjunction with the scaling factor of frequency domain. Also, PA efficiency have already considered to determine the **P3** and **P4**.  In time domain, we also think the scaling should be applied only to . In the cases with different frequency domain allocations, total power consumption from each power consumption of different frequency domain allocations in symbol level, are calculated, and it would be normalized to 14 symbols in a slot.  Regarding the frequency domain in additional notes, we don’t think it is necessary to be restricted only for inter-band CA. Hence, we would like to generalize the wording from for inter-band CA to CA. |
| Intel | We support Alt 1, where we are fine with either Option 1 or 2 for the  **,** assuming P3 a\*P4 for the chosen a. For example, a = 19.6% results in P3 a\*P4 for FR1 Set 1 scenario.  For  **,** our view is power and frequency domain scaling can be jointly modeled. For example, we can assume fixed PSD and power consumed can be scaled linearly with occupied BW.  We support **Alt 1-2: ,** where **, b** and **c** are constants that correspond to % power consumed due to fixed and variable components where BW is scaled from reference configuration. For example, b = 0.6, c can be 0.4. Valid values of X are {5, 10, 20, 40, 80, 100 MHz}. Values of b and c can be further discussed. If changes to PSD needs to be modeled, then companies could potentially use the occupied bandwidth ratio, X/100, as the changes to the total power (stemming from changes to PSD) as an approximation. For example, if PSD is decreased by 50%, then X = 50 can be used.  And,  **=** 0.7^(64/N – 1), valid values of N = 32, 16, 8, 4.  Assuming slot level power modelling, as agreed in RAN1 # 109, a time domain scaling factor such as is linearly applied on , based on number of active symbols in the slot. Below, we provide a simple illustration and an example for relative power per slot for 5MHz, 4 OS, 32 antenna transmission in a slot.  P = P3 +  **= 55 + = 82.9**    It is not clear what resource usage *x* implies (time or frequency or both) in Alt-3 and why/how static component would vary with resource usage. Different alternatives were intended to model scaling in frequency and spatial domains only, and time domain scaling is to be applied afterwards based on notes after “**Additional notes applicable for all alternatives**”.  Before discussing inter-band CA, we need to confirm scaling for intra-band CA first since the above alternatives only consider single cell case. We are OK to consider Alt 1-F-1: the sum of the power consumption of each cell for inter-band CA.  For M-TRP, we support Alt 1-S-1: the sum of the power consumption of each TRP. In our view, different TRPs can be in active state and micro-sleep independently depending on activity. In other words, P = Pstatic + Pdynamic is computed separately for each TRP, and then added up. |
| LG Electronics | We support Alt 1-2 in favor of per domain scaling with the slot-level. ***P*dynamic** can be linearly scaled by the number of active TRxRUs, resource usage and scaling factor in power domain. |
| OPPO | We prefer Alt-2 for its simplicity. |
| vivo | We prefer Alt. 1-1 since it can handle scaling in spatial, frequency and power domain. For Alt. 1-1, we have the following comments:   1. Definition of is not clear. Is it the ratio of PSD between this transmission and reference configuration. 2. is preferred to be a fixed value.   For Alt. 1-2, it seems a transmission with different PSD compared to reference configuration can’t be handled.  For Alt. 2, the formula seems not correct and the definition of F, N and P are not clear.  For Alt. 1-3, it is not clear to handle scaling of TxRUs and PSD.  For Inter-band CA, we support Alt 1-F-1 since the RF is not shared between carriers. |
| DOCOMO | We slightly prefer Alt.1.  Regarding in Alt.1, we think Option 1 is reasonable because the power consumption in micro sleep should reflect the static power consumption in the active DL mode.  Regarding in Alt.1, we would like to hear more companies’ views. For accuracy, we slightly prefer non-linear scaling, but it would be difficult to reach consensus with non-linear model considering the limited time. If so, we are fine to go with liner scaling. |
| Huawei, HiSilicon | 1. We prefer Alt. 1-1, which is composed of the individual power consumption of corresponding component of gNB, e.g. static part that cannot be dynamically switched off, TRX chains and PA. 2. Alt.2 assumes each scaling factors in each domain. However, we need to select proper value of , , , , , to emulate the gNB power consumption. It would introduce large analysis work based on the power consumption test results. Therefore, it is not preferred. 3. Alt.1-2, due to the similar reason as Alt.2, it is not preferred by us. Also, the Alt.1-2 cannot reflect the impact on power consumption due to transmission power adaptation. 4. For Alt.3, our understanding is ” **(a + (1-a)\*)\*P4”** in the formula is the power consumption while the gNB is with full bandwidth transmission and full number of TRX chains used in the in reference configuration. And P3 is the power consumption of micro sleep state, i.e. without any transmission and reception. Alt.3 does a linearly combination between the power consumption without transmission and with transmission with full bandwidth/full TRX chains by using the resource usage ratio of X. Our concern on Alt.3 is it cannot reflect the scaling due to the adaptation of TRX chains in spatial domain and due to the adaption of transmission power.   Therefore, we prefer Alt.1-1 considering it can reflect all the scaling in frequency, spatial and power domain. The PA efficiency  is also considered in Alt. 1-1. |
| Ericsson1 | Our preference is to agree to scaling with values because it is difficult to compare the different options without understanding the values to be plugged into the formula. Our preference is as below.  P\_DL (for FR1 TDD)= P4 \* ( [0.4] + [0.6] \* sf\*sp) \* ([0.4] + [0.6]\*sa)   * , , is the percentage of active TRxRUs, resource usage in frequency domain and scaling factors in power domain, respectively. |
| Qualcomm1 | Joint vs. Split scaling  We support jointly scaling of frequency and power domains, as the power consumption is dependent also on the transmitted power which is a factor of the resource utilization in the frequency domain (e.g., number of PRBs) and the power domain (e.g., PSD).  Separately scaling for frequency and power will not support combined frequency and power scaling (e.g., reducing to 20% of the BW and increasing the PSD by 3dBs).  Even in case of only frequency domain scaling (where the PSD is kept unchanged), the scaling of the frequency domain will have to include transmitted power calculation assuming some nominal PSD  Linear vs nonlinear scaling of the PA  PA power consumption constitutes the majority of the gNB power consumption and therefore should be modeled correctly. Incorrect modeling will not allow to analyze techniques.  PA power consumption depends on the transmitted power scaled by a nonlinear factor PAE (PA efficiency). The PAE depends on the backoff from a certain reference output power. µ in figure 25 ‘Power amplifier basics’ in our contribution R1-2207246, reflects general PAE curve. Such curves maybe found in any PA datasheet or can be obtain in lab tests for companies with appropriate PAs (e.g., NW vendors).  The PAE varies with the transmitted power in the non-saturated working range of the PA. Only when in saturation (impacting both gain and impairment introduced by the PA), does the PAE also saturates to a near constant. For simplicity, a nominal PAE value can be taken for full frequency resource utilization and nominal PSD.  Given above discussion, we prefer to go with updated Alt.3   * + **Alt 3: The power consumption of DL transmission for a frequency resource utilization x and a power domain parameter is (1-x)\*P3 + x\*(a + (1-a)\*)\*P4**     - x is resource usage, in percentage     - a < 1, e.g., a = [0.3]     - **P3** and **P4** are relative power values of micro sleep and active DL transmission, respectively     - is function of frequency resource utilization and power domain parameter |

For active UL, since PA is not concerned, the scaling approach may be simplified as below, with “**Additional notes applicable for all alternatives**” applied as well.

**Proposal 2.2-2**

* **The BS power consumption for active UL is provided by**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | We need to discuss the UL power scaling similar to DL power scaling. |
| ZTE, Sanechips | Compared with DL transmission, the power consumption of UL reception is very low. Since the PA can be muted when there is no DL transmission, the scaling rule/factor for UL is different from DL |
| Samsung | We are okay with FL’s proposal with minor updates to align with BS power consumption for DL.  **Rev Proposal 2.2-2**   * **The BS power consumption for active UL is provided by**   Regarding the **,** it can be equal to for active DL. |
| Intel | Support the proposal, assuming time domain, carrier domain scaling is not considered above. |
| LG Electronics | After the details of DL scaling are defined, BS power consumption for active UL can be similarly discussed. |
| OPPO | OK |
| DOCOMO | It would be better to discuss BS power consumption for active UL based on the outcome from that of DL. |
| Ericsson1 | Similar comment as DL. Our preference is as follows.  P\_UL (for FR1 TDD) = P5 \* ( [0.8] + [0.2] \* sf) \* ([0.4] + [0.6]\*sa)   * , is the percentage of active TRxRUs and resource usage in frequency domain, respectively. |
| Qualcomm1 | Our reference for scaling power consumption of uplink reception P5 in terms of frequency resource utilization and antenna as follows:  P(sf, sa) = P5 \* ( [0.8] + [0.2] \* sf) \* ([0.1] + [0.9]\*sa)   * , is the percentage of active TRxRUs and frequency domain resource, respectively. |

# Methodology

## KPI

For UPT loss and latency requirements, the metrics are “one or more”. Therefore not mandating to report all cases. Depending on techniques and affected channels, coverage may not be a common KPI that should be pursued, however could be an interest for those affecting common signals. The following is suggested.

**Proposal 3.1-1:**

* **In the energy saving gain evaluation, along with the reported load and evaluated technique(s), one or more of the following UPT (loss) ranges are considered**
  + **Less than 5%, less than 25%, less than 50% or average UPT**
* **In the energy saving gain evaluation, along with the reported load and evaluated technique(s), one of more of the following latency type can be optionally considered**
  + **User plane latency,** **calculated as the delay between the time when a packet arrivals and the time when the packet is decoded for the service performance**
  + **Scheduling latency,** **calculated as the delay between the time when a packet arrivals and the time when the packet is scheduled**
  + **Other latency e.g. (de-)activation of spatial element**
* **Coverage can be optionally reported**
* **EE (energy efficiency) and other metrics can be optionally considered with clarified definition, if reported.**
* **Note for potential new channel/signals, e.g. WUS from UE, the assumption for detection reliability at BS side is reported (performance and complexity impact would subject to results and further discussion).**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | We are generally fined with the proposal. The UPT loss/gain would depend on the network energy saving techniques and their associated power saving gain. We need to look at the values of UPT loss and network power saving gain in bundle. |
| ZTE, Sanechips | Okay. |
| Samsung | From our perspective, at least user plane latency should be prioritized same as UPT. In addition, for user plane latency, the actual value is more of interest compared with percentage increase. The percentage increase doesn’t matter as long as the user plane latency requirement is satisfied. Considering both UPT and latency are evaluated for UE PS, same rule should apply here. Therefore, we suggest to further investigate scheduling latency used in UE PS for evaluating NWES techniques properly. We suggest the following revised proposal as below:  **Rev Proposal 3.1-1:**   * **In the energy saving gain evaluation, along with the reported load and evaluated technique(s), one or more of the following UPT (loss) ranges or User plane latency ranges are considered**   + **Less than 5%, less than 25%, less than 50% or average UPT**   + **FFS Details of user plane latency requirement, e.g. less than 10 ms or less than 20 ms target user plane latency.** * **In the energy saving gain evaluation, along with the reported load and evaluated technique(s), ~~one of more of~~ the following latency type can be optionally considered**   + **~~User plane latency,~~****~~calculated as the delay between the time when a packet arrivals and the time when the packet is decoded for the service performance~~**   + **Scheduling latency,** **calculated as the delay between the time when a packet arrivals and the time when the packet is scheduled**   + **Other latency e.g. (de-)activation of spatial element** * **Coverage can be optionally reported** * **EE (energy efficiency) and other metrics can be optionally considered with clarified definition, if reported.** * **Note for potential new channel/signals, e.g. WUS from UE, the assumption for detection reliability at BS side is reported (performance and complexity impact would subject to results and further discussion).** |
| Intel | We are fine in principle. We think UPT and energy saving gain are observed together. We suggest to report to observed UPT values for the different network configurations assumed, along with energy saving gain. Note that access delay was also listed among the options in RAN1 # 109 agreement. We suggest including it and to be reported when applicable.  It would be good if “coverage” as a metric can be clarified. Is coverage defined as number of UEs in outage, where outage is defined by certain SINR/geometry threshold? Or is coverage defined by maximum distance to the attached UE in the evaluation? Or is it defined by counting number of UEs with certain amount of loss in traffic (e.g. due to excessive delay)? Or something else? It not immediately clear, how “coverage” as a metric will be provided by the companies. If companies can provide an explicit formula, that would be great. |
| LG Electronics | We are OK with the revised proposal from Samsung except for the description of scheduling latency. Based on our understanding, we suggest the following modification as below:   * **In the energy saving gain evaluation, along with the reported load and evaluated technique(s), ~~one of more of~~ the following latency type can be optionally considered**   + **~~User plane latency,~~****~~calculated as the delay between the time when a packet arrivals and the time when the packet is decoded for the service performance~~**   + **Scheduling latency,** **calculated as the delay between the time when a first packet arrivals and the time when the packet is scheduled**   + **Other latency e.g. (de-)activation of spatial element** |
| OPPO | **OK** |
| Vivo | We agree that UPT loss is considered along with energy saving gain. However, we don’t quite understand the intention of exact value for UPT loss here. We think it is challenging for system-level evaluation to align the UPT loss to an exact value. In our view, company could report UPT loss and energy saving gain for the evaluated techniques freely. |
| DOCOMO | We are fine with the proposal. |
| Huawei, HiSilicon | We think the coverage metric should be reported. Actually, the loss of 5% UPT can reflect the coverage performance degradation in certain level. |
| Ericsson1 | 1st bullet : For UPT loss, we think proponent can directly report UPT loss and we do not understand the motivation for agreeing to a range of values.  2nd bullet : For antenna adaptation, our preference is to agree to a value than leaving it for optional consideration.  For optional KPIs, our view is proponent can directly explain details along with evaluations rather than RAN1 making agreement. |
| Qualcomm1 | We don’t think we need 2nd – 5th bullets since we already had RAN1#109e agreements to report NES gain and UPT. Other metrics are optional.  Agreement  For 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.   For the first bullet, we can update it as follows:   * **In the energy saving gain evaluation, along with the reported load and evaluated technique(s), the UPT comparison is based on 5%tile and 50%tile.** |

## C-DRX Configurations

FL consider one of the purpose of implementing UE C-DRX is for UE power saving purpose when evaluating BS energy consumption techniques. It may be a first step to understand what could be the consequence of implementing some BS EnSav techniques while maintaining the same C-DRX configurations as prior study. There are several companies prefer this approach while one company prefers to use different values e.g. shorter DRX inactivity timer. Considering the situation, the proposal is not changed.

**Proposal 3.2 -1:**

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

* **for alignment, the configuration if reported can be**

|  |  |  |  |
| --- | --- | --- | --- |
| **Traffic type** | **FTP** | **IM** | **VoIP** |
| Model | FTP model 3 | FTP model 3 | As defined in R1-070674.  Assume max two packets bundled. |
| Packet size | 0.5 Mbytes | 0.1 Mbytes |
| Mean inter-arrival time | 200 ms | 2 sec |
| DRX Period | 160 ms | 320 ms | 40 ms |
| DRX Inactivity timer | 100 ms | 80 ms | 10 ms |
| On duration | FR1: 8 ms  FR2: 4 ms | FR1: 10 ms  FR2: 5 ms | FR1: 4 ms  FR2: 2 ms |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | We are OK with the assumption |
| ZTE, Sanechips | Okay. |
| Samsung | As we commented earlier online. For DRX Inactivity timer, the values are too large and not necessary. It only increases the UE power consumption without any benefits. For NWES, gNB should aim for short time transmission to achieve long sleep time. Considering we are focusing on low/medium load scenario, the resource is sufficient. One shot retransmission or up to 1 retransmission would be the typical case. There is no need to configure such large values and require UE to keep monitoring PDCCH for a long time after receiving a new grant.  Although some companies think the same parameter of UE PS should be kept, however, the scenario of UE PS is quite different. The traffic load of a cell could be high for UE PS evaluation. For high traffic load scenario, high code rate with HARQ retransmission would be beneficial for SE, as a result, there can be multiple retransmissions and the time gap between the initial transmission and last retransmission can be large.  Based on the above reason, we suggest to change DRX Inactivity timer to 20ms for FTP and IM. |
| LG Electronics | We are OK with the proposal. |
| OPPO | OK |
| vivo | We are generally fine with the C-DRX proposal here.  One comment on the traffic type: we still prefer to list a sparse traffic model to facilitate the evaluation for idle UE evaluation, e.g.   |  |  | | --- | --- | | **Traffic mode: Heartbeat** (\*TR38.875) | | | Model | FTP model 3 | | Packet size | 100 Bytes | | Mean inter-arrival time | 60 seconds | |
| DOCOMO | We are fine with the proposal. |
| Huawei, HiSilicon | If it allows company to report whether the C-DRX is utilized, our preference is to follow the assumption in 38.840, i.e. to keep the two options of inactivity timer to allow company to report.     |  |  |  |  | | --- | --- | --- | --- | | **Traffic type** | **FTP** | **IM** | **VoIP** | | Model | FTP model 3 | FTP model 3 | As defined in R1-070674.  Assume max two packets bundled. | | Packet size | 0.5 Mbytes | 0.1 Mbytes | | Mean inter-arrival time | 200 ms | 2 sec | | DRX Period | 160 ms | 320 ms | 40 ms | | DRX Inactivity timer | 100 ms/40ms | 80 ms/200ms | 10 ms/25ms | | On duration | FR1: 8 ms  FR2: 4 ms | FR1: 10 ms  FR2: 5 ms | FR1: 4 ms  FR2: 2 ms | |
| Ericsson1 | OK to use the values for alignment. |
| Qualcomm1 | We are fine with the proposal |

## Simulation assumption

There does not seem to be any comment regarding the SLS assumptions after third round. One offline comment is to remove the details about common signal configurations except for SSB periodicity. FL understands that those details seem to be natural based on current specifications. If there is no major concern, they can be kept.

**Proposal 3.3-1:**

* **For FR1, adopt the Reference SLS configurations in Annex-A in R1-2208216 as baseline SLS assumptions.**
  + **Other carrier frequencies can be optionally considered.**
* **For FR2 adopt the Reference SLS configuration used in RP-180524 for IMT-2020 as initial SLS assumption.**
  + **Further adjustment can be discussed in the next meeting.**

|  |  |
| --- | --- |
| **Company** | **Comments** |
| CATT | We are OK with the proposal |
| ZTE, Sanechips | For FR1 FDD, the frame structure definition is not needed. |
| Samsung | Fine |
| Intel | We are generally OK with the proposal.  We would like to clarify the following for FR1:  1) There are two columns in R1-2208216, we assume TDD column corresponds to Set 1 and FDD column corresponds to set 2 for FR1. It would be good to confirm.  2) The Mp, Np values for TDD FR1 case needs to be clarified. We assume (Mp,Np) = (4,8), but it seems to be missing in R1-2208216.  3) The O2I penetration model should be clarified, whether low-loss or high-loss model is assumed for UMa.  4) We assume ‘3D/HF-Uma’ is referring to ‘UMa mode in 38.901’. It would be good to confirm.  5) We assume traffic model defined in R1-2208216 does not apply, and we use RAN1’s previous agreements on traffic model. It would be good to clarify.  6) We assume the CSI feedback periodicity is not fixed as stated R1-2208216, but companies can provide the details of the CSI feedback assumption. It would be good to clarify, whether CSI feedback should be fixed to every 5 slots or not.  7) We assume common RS section is just for reference and not fixed and ultimately each company are to provide detailed information for the simulation. If so, it would be good to clarify. We assume the gNB can update the SIB1 periodicity to other 20msec without impacting legacy UEs behaviors as this is supported by specification. The UE is still expected to perform monitoring per 20msec, but this is different from gNB sending SIB1 every 20msec. For the SIB1 frequency resource, our suggestion is to use 48 or 96 as its better divisible by 16.  We would like to clarify the following for FR2:  8) We assume Dense Urban Config B of RP-180524 is expected to be used as reference. If so, it would be good to clarify.  9) The number of gNB TXRU for Config B is set to 8. For our agreed reference, the TXRU is 2. Therefore, we assume the antenna setup needs to be clarified/revised. Our suggestion is  2 TxRU (M, N, P, Mg, Ng; Mp, Np) = (4,8,2,2,2;1,1)  (dH, dV) = (0.5λ, 0.8λ) (dg,H, dg,V) = (4.0λ, 3.6λ)  10) The number of UE TXRU for Config B is set to 4. We assume this may need to be clarified/revised.  11) traffic model for Config B is full buffer. We assume the traffic model in RP-180524 is not applicable for our SI. It would be good to clarify.  12) UE density for Config B is set to 10 per TRxP. Based on agreed traffic model, the only method to vary load is the change the UE density. We assume UE density in RP-180524 is not applicable for our SI. It would be good to clarify.  13) The power limitations for the BS for Config B is defined to be different than what we agreed. We assume the TRxP power in RP-180524 is not applicable for our SI. It would be good to clarify |
| LG Electronics | We are OK with the proposal. |
| OPPO | OK |
| vivo | We are OK with the proposal. |
| DOCOMO | We are generally fine with the proposal.  For FR2, as there are many assumption tables in RP-180524, it is better to explicit indicate which table will be used.  E.g.   * **For FR1, adopt the Reference SLS configurations in Annex-A in R1-2208216 as baseline SLS assumptions.**   + **Other carrier frequencies can be optionally considered.** * **For FR2 adopt the Reference SLS configuration used in Config.B in Table2 of RP-180524 for IMT-2020 as initial SLS assumption.**   **Further adjustment can be discussed in the next meeting.** |
| Ericsson1 | Below are some initial comments.  Common RS : further discussion is needed, e.g. we are not OK with 20ms periodicity for SIB1 transmission.  Traffic model : Needs further discussion as we agreed only to ranges during last week.  CSI reporting: the parameters can be up to proponent instead of a specific assumption in R1-2208216.  FR2 assumption : Needs more discussion. |
| Qualcomm1 | Here are our initial comments for FR1   * We should map the parameters to Set1 FR1 and Set2 FR1 respectively since some parameters were already agreed (e.g., duplexing, numerology, BW, traffic model, load). We suggest removing these parameters from the table. * For frame structure, we prefer to use DDDSUDDSUU where S has 10D:2G:2U for Set1 FR1. For Set2 FR1, suggest removing “full downlink” * For carrier frequency, we prefer to use 4GHz for Set1 FR1 * For antenna configuration for Set2 FR1, (M,N,P,Mg,Ng) = (12, 8, 2, 1, 1) * For common RS, only the periodicity is needed. Other rows should be up to the company for reporting. |

# Others

Other issues can be further considered/discussed in the next meeting.

# 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 |
| [23] | [R1-2208216](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/R1-2208216.zip) | FL summary#3 for EVM for NR NW energy savings | Moderator (Huawei) |

# 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~~ 2.6GHz |
| 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, (equal split of 10 MHz for UL and DL) | 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;~~  (M, N, P, Mg, Ng) = (8, 8, 2, 1, 1).  based on 38.802 |
| UE parameters | UE power class | 23dBm | 23dBm |
| UE noise figure | 9 dB | ~~7~~ 9 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,~~ Slot#0, slot#1, 2 SSB per slot  4 symbols for each SSB | ~~Slot#0, slot#1~~ Slot#0~slot#3, 2 SSB per slot  4 symbols for each SSB |
| SSB frequency resource | 20RB | 20RB |
| SIB1 time resource | ~~slot#10 ~ slot#17~~  slot#10 ~ slot#13 | ~~slot#10 ~ slot#13~~  slot#10 ~ slot#17 |
| 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

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| [**R1-2205308**](file:///C:\Users\w00250081\AppData\Local\Temp\Docs\R1-2205308.zip) **FL summary#1 for performance evaluation for NR NW energy savings Moderator (Huawei)**  Agreement  For 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:\Users\w00250081\AppData\Local\Temp\Docs\R1-2205402.zip) **FL summary#2 for performance evaluation for NR NW energy savings Moderator (Huawei)**  Agreement  For 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   Agreement  For 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.   Agreement  At 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:\Users\w00250081\AppData\Local\Temp\Docs\R1-2205468.zip) **FL summary#3 for performance evaluation for NR NW energy savings Moderator (Huawei)**  Agreement  For 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 meetings  EIRP limited to 78dBm – to be further discussed and finalized in future meetings | | Total number of UL Rx RUs | 64 | (working assumption) 32 | 2 |   Agreement  As 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.   Agreement  The 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 assumption  For 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:\Users\w00250081\AppData\Local\Temp\Docs\R1-2205551.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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## E. Agreements during RAN1#110

**Agreement**

For non-sleep mode, the relative power value in power model table for UL reception and/or DL transmission is provided based on reference configuration.

**Agreement**

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

**Agreement**

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

**FL2 Proposal 2.1.6-1 –rev2**

**For the purpose of evaluation, adopt the following as BS power consumption model. These entries for this table is per reference configuration set.**

* **FFS: One or multiple values for relative power and transition time.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Power state** | **Characteristic** | Relative Power | Additional transition energy3 | **Total transition time** |
| Deep sleep1 | There is neither DL transmission nor UL reception.  Time interval for the sleep should be larger than the total transition time entering and leaving this state. | P1=1 | E1 | T1 |
| Light sleep | There is neither DL transmission nor UL reception.  Time interval for the sleep should be larger than the total transition time entering and leaving this state.  (P2>P1) | P2 | E2 | T2 |
| Micro sleep | There is neither DL transmission nor UL reception.  Immediate transition is assumed for network energy saving study purpose from or to a non-sleep state. | P3 | 0 | 0 |
| Active DL | There is only DL transmission. | P4 | NA | NA |
| Active UL | There is only UL reception.  ~~FFS: Whether multiple P5 values are needed to address low power UL mode~~ | P5 | NA | NA |
| Note 1: Depending on implementations, there could be a state that the power is lower than deep sleep and requires larger total transition time, e.g. hibernating sleep or Quasi-off, which is not explicitly modeled in this study for evaluation purpose.  Note 3: Unit in relative power times duration. FFS: Details on how transition energy is defined. | | | | |

* For simultaneous DL and UL transmission for FDD, the power for UL reception is neglected in this study.
* FFS: Optionally, a state machine where BS may transit between sleep modes without entering non-sleep mode can be considered. Companies are to report the involved sleep modes and the assumptions for inter-sleep mode transition time used in their evaluations.
* FFS: Details on how to use the above table for low power uplink reception (e.g. for WUS).

**Working Assumption**

**For reference configuration set 1, the values are provided as below. FFS set2 and set 3.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Power state** | **Relative Power *P*** | | **Total transition time *T*** | |
| Deep sleep | 1 | 1 | Cat 1:  50ms | Cat 2:  10s |
| Light sleep | Cat 1: 25 | Cat 2: 2.1 | Cat 1: 6 ms | Cat 2: 640 ms |
| Micro sleep | Cat1: 55 | Cat 2: 5.5 | 0 | 0 |
| Active DL | Cat 1: 280 | Cat 2: 32 | N.A. | N.A. |
| Active UL | Cat 1: 110 | Cat 2: 6.5 | N.A. | N.A. |

**Alternative Proposal 3.1.1.1-1**

For evaluation purpose,

* a load (L) of a cell is a percentage of resources used for UE specific PDSCH / PUSCH
* The following load scenarios are considered

|  |  |
| --- | --- |
| Load scenario | Characteristics |
| Idle/empty load | * Include cell-specific signals and channels, and * L = 0 |
| low load | * Include cell-specific signals and channels, and * 0 < L≤15 |
| Light load | * Include cell-specific signals and channels, and * 0 < L≤ ~~[~~30~~]~~ |
| Medium load | * Include cell-specific signals and channels, and * ~~[~~30~~]~~ < L≤ ~~[~~50~~]~~ |
| For CA, the companies report whether the load is defined per CC or across all CCs. | |

**FL2 Proposal 3.3.1.1-1:**

* **For FR1, urban micro can be optionally considered.**
* **For FR2, urban micro is prioritized, with ISD=200 m is assumed.**

**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 may be used as well. Parameter (e.g. packet size and arrival rate) adjustment can be optionally considered and reported.**

**FL2 Proposal 2.3.1-1:**

**For set 3 FR2 reference configuration, the total DL power level and EIRP limit is set as 33 dBm and 63 dBm respectively. Note EIRP limit is also scaled with the number of TxRU.**

**Alternative Proposal 3.1.3-1:**

**For evaluation purpose, network energy saving gain is computed based on the energy consumptions for a technique and the baseline over the same duration.**