**3GPP TSG-RAN WG1 Meeting #110bis-e R1-2210301**

**e-Meeting, October 10th – 19th, 2022**

**Agenda Item: 9.7.1**

**Source: Moderator (Huawei)**

**Title: FL summary#1 for R18 NW\_ES**

**Document for: Discussion and Decision**

# Introduction

This triggers the email discussion of the following:

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| [110bis-e-R18-NW\_ES-01] Email discussion on performance evaluation by October 19 – Yi (Huawei)   * Check points: October 14, October 19 |

The schedule for Week 1 is currently provided by Chair as

* **Monday (UTC 12:00~15:00) GTW1:** R18 MIMO (80min) => **R18 NW EnSav (30min)**
* **Wednesday (UTC 12:00~15:00) GTW1: R18 NW EnSav (50min)**

Therefore, please search for ‘FL1’ or refer to ‘Initial round’ for proposals and comments, and input for initial round is expected preferably by 1 hour ahead of the first GTW session, which is **UTC 11:59 am, Oct. 10th.**

## Recommendations for GTW/email approval:

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## Outcome of GTW/email discussion

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# Energy consumption model for BS

## Inter-sleep mode transition and handling of low-power UL signal

FUTUREWEI considers that agreement from RAN1#110 on the assumption of a non-sleep mode between adjacent sleep modes are strictly for the purpose of evaluations, and from BS operations flexibility perspective transition between any sleep modes and between sleep and non-sleep modes is supported in the BS. A WUS signal may also be received at e.g. deep sleep mode that lead to power state change.

China Telecom discusses the transition between sleep modes and illustrates how it may have impact on the calculation of additional transition energy (see section 2.2).

InterDigital considers a separate power state for the purpose of detection of WUS can be added in between light sleep and active UL.

Ericsson does not explicitly propose to model inter-sleep mode transition, while there is a similar consideration in calculation of the additional transition energy, using summation of effect of different sleep modes.

### Initial round

Based on the above, it seems that for evaluation purpose including the calculation of total additional transition energy, the inter-sleep mode transition is not strictly required. From BS operation perspective, it is also FL understanding that inter-sleep mode transition is not/cannot be precluded. What matters to RAN1 may be how the potential techniques can be investigated if it is specific to the inter-sleep mode transition.

For the use of a low power UL signal, there is a relevant agreement allowing companies to report such details including receiver and other impact on the power consumption model. In other words, this allows to optionally report a different/lower P5’ as WUS reception, with other details subject to companies report, which may be sufficient already. For the mentioned signaling via BH, if there is no other RAN1 impact and the benefits in terms of BS energy saving gain come from the triggered change of BS power states, it might be possible to be studied in RAN3 in terms of e.g. specific parameters to be sent. The details will be up to RAN3 study.

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| **FL1 Proposal 2.1.1:**  Inform RAN3 that the study of potential signaling/trigger over BH that changes the BS power state defined in RAN1 is not precluded by the following RAN1 agreements, which is for RAN1 evaluation purpose:  *Agreement*  *For initial evaluations, there is always a non-sleep mode assumed between adjacent sleep modes.* | |
| **Company** | **Comments** |
| Huawei, HiSilicon | We support the proposal. |
| LG Electronics | We are reluctant to agree on the necessity of sending LS to RAN3 since RAN1 still do not intend to restrict inter-sleep mode transition from gNB’s implementation while RAN1 restrict it only for evaluation purpose. Otherwise, if RAN1 agree some restriction from gNB’s implementation perspective, we can trigger the discussion on sending LS to RAN3. |
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## Power values per reference configuration

For reference configuration Set 1, working assumption was made for relative power values and the total transition time.

For the relative power values for Set 2 and Set 3, some companies input are available. Further, there is consideration on how to determine the values for Set 2 due to the dependency on reference configuration. For example, the smaller number of TxRU of Set 2 implies a smaller power value. On the other hand, some companies consider this cross-comparison is not needed, since both Set 1 and Set 2 use relative power value of 1 for deep sleep and companies’ input are anyway relative values based on each own results. Companies positions are shown as below.

For Set 1 reference configuration,

* The following companies consider that the relative power values and transition time as working assumption can be confirmed:
  + Huawei/HiSilicon, [Nokia/NSB], vivo, ZTE, CMCC, Rakuten, Samsung, Ericsson, Qualcomm (and clarify the value is per symbol-level)
* The following companies think small adjustment can also be considered:
  + Huawei/HiSilicon (2nd, for the purpose of aligning power values among Set 1-Set 3), NTT DOCOMO(2nd, for the purpose of aligning additional transition energy).

For Set 2/Set 3 reference configuration, apart from the agreements to use the same transition time as that for Set 1, for relative power values,

* Option 1: the values for Set 2/3 should be smaller than those for Set 1. Supported by
  + Huawei/HiSilicon (2nd), Nokia/NSB, vivo, OPPO, Ericsson, NTT DOCOMO(2nd), Qualcomm
* Option 2: the values can be based on companies input with averaging approach (similar to the approach for obtaining the values for Set 1), supported by
  + Huawei/HiSilicon, ZTE(2nd), MediaTek, Rakuten, Samsung, NTT DOCOMO, Lenovo
* Option 3: same values as Set 1 can be reused, supported by
  + ZTE, CMCC

Other reference configuration seems to be proposed by Qualcomm, see section 3.2.

The following summarizes the proposed power values for each reference configuration.

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| **Company** | **Proposals** |
| Huawei, HiSilicon, ZTE, MediaTek, Rakuten, Samsung (for Cat 2 only), NTT DOCOMO, Lenovo, | |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Power state** | **Relative Power *P* for Category 1** | | **Relative Power *P* for Category 2** | | | **Set 2** | **Set 3** | **Set 2** | **Set 3** | | Deep sleep | 1 | 1 | 1 | 1 | | Light sleep | 23 | 20 | 2.6 | 1.8 | | Micro sleep | 50 | 38 | 5 | 3 | | Active DL | 240 | 152 | 40 | 8.4 | | Active UL | 90 | 80 | 5.8 | 4.2 | |
| Nokia, NSB | **Table 1: Relative Power for FR1 Set 2 Cat.2**   |  |  |  | | --- | --- | --- | | **Power State** | | **Relative power consumption** | | **Sleep State** | Deep sleep | P1=1 | | Light sleep | P2=1.7 | | Micro sleep | P3=4,2 | | **Active state** | Active DL | P4=12 | | Active UL | P5=4,6 | |
| Ericsson | |  |  |  |  | | --- | --- | --- | --- | | **Operation/state** | *Power level, relative units (FR1 TDD)* | **Power level, relative units (FR1 FDD)** | **Power level, relative units (FR2 TDD)** | | Active DL | *280* | **[160]** | **[70]** | | Active UL | *110* | **[90]** | **[40]** | | “Micro”-sleep | *55* | **[50]** | **[20]** | | “Light”-sleep | *25* | **[23]** | **[15]** | | “Deep”-sleep | *1* | **1** | **1** | |
| Qualcomm | |  |  | | --- | --- | | **BS operation** | **Set 2 FR1** | | Active transmission (100% PRB utilization) | [270] | | Active reception (100% PRB utilization) | [80] | | Micro sleep | [50] | | Light sleep | [20] | | Deep sleep | 1 |  |  |  | | --- | --- | | **BS operation** | **Set 3 FR2** | | Active transmission (100% PRB utilization) | [74] | | Active reception (100% PRB utilization) | [46] | | Micro sleep | [15] | | Light sleep | [8] | | Deep sleep | 1 | |

### Initial round

The relative power values are closely implementation related, and when reported they are relative values so may not need to clarify it is symbol level or slot level.

When cross check the values between Set 1 and Set 2 it is reasonable to take smaller ones for Set 2/3. Thus the averaged values based on companies input for Set 2 and Set 3 has some discrepancy when cross-comparing different sets, although it gains slightly majority support.

The root cause for this discrepancy come from the input from some companies who use the same values for Set 1 and other Sets. Thus there could be several approaches for addressing this:

**Approach 1**: Do not count the input of source(s) who use same values across sets. However, this may cause another question on how to deal with the WA where the same source(s) also contributes to the relative power values, and why the values of other sources could be more practical/justified/accurate.

**Approach 2**: Revisit the relative power values/transition times in the WA for Set 1, e.g. re-assigning the values of some sources from Cat 1 to Cat 2, then the issue could also be mitigated. This although seems to be the most consistent approach, FL feels reluctant to re-open the discussion for Set 1 which is the effort/compromise from last meeting.

**Approach 3**: Use the same values for all Sets of reference configurations. This may be a further compromise given no company objects the WA for Set 1, although it may lack some insights from attempting different value ranges point of view.

FL considers Approach 1 and 2 may just cause more potential issues when addressing one. Approach 3 has a potential issue that could possibly occur if the observation for a given technique is significantly different between FDD and TDD, or between FR1 and FR2 when using different values across sets. On the other hand, the different reference configurations now are functionally incorporated into different SLS assumptions, and the evaluations can still benefit from e.g. different antenna configurations, BW etc. Thus, whether the relative power values among the sets is same or different may not be such critical. The impact on the conclusion in case of TDD/FDD or FR1/FR2 may still be investigated with individual companies’ input of relative power values, if found needed.

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| **FL1 Proposal 2.2.1:**  **Confirm the Working Assumption with the following udpate:**   * **For RAN1 evaluation purpose, for reference configuration set 1/2/3, the values are provided as below. ~~FFS set2 and set 3.~~** * **Other values can be optionally reported.**  |  |  |  |  |  | | --- | --- | --- | --- | --- | | **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. | | |
| **Company** | **Comments** |
| Huawei, HiSilicon | Although these values may not reflect the exact values of product, they can be used as a starting point for evaluation. We are fine with the proposal. |
| LG Electronics | Considering the parameters (such as a total number of DL TX RUs, bandwidth, and total DL power level) of the agreed reference configuration, it would be more practical that the relative power values for reference configuration set 2 and set 3 is lower than those for set 1. However, we can agree with the proposal if the majority supports this proposal. |
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## Additional transition energy

For the calculation of additional transition energy, there are a few possible approaches.

* Option 1: as discussed in RAN1#110 meeting and similar to the methodology of UE power saving study, i.e.
* + where is the difference of the relative power between sleep mode and micro sleep active state and is the corresponding total transition time to sleep mode , accounting for both ramping down and ramping up
* This is supported by Nokia/NSB, vivo, OPPO, CATT, CMCC, LGE, Samsung,
* Option 2: in addition to the formula used in Option 1, need to apply further adjustment in order to meet certain constraints, mainly considering the situation that BS entering into a deeper sleep may preferably be able to obtain more energy savings.
  + This is supported by Huawei/HiSilicon, Spreadtrum, Intel, ZTE, MediaTek
  + Although consider the logic makes sense, NTT DOCOMO proposes alternatively to revisit the transition time in the working assumption such that the formula in Option 1 applies without manual change, e.g. 6 ms-> 10 ms for light sleep.
* Option 3: if inter-sleep mode transition is not allowed E\_tran (n)=(2P\_n+P\_a0+P\_a1 )\*T\_n/2 where Pa0 and Pa1 refers to the power level of the previous and subsequent active state (DL or UL); otherwise E\_tran (m,n)=(P\_m+P\_n )\*(T\_m-T\_n)/2. With a similar consideration of stepwise mode transition but different formula, the transition energy can also be calculated as
  + This is supported by China Telecom (former), Ericsson(later)
* Note some companies also consider that the additional transition energy for three sets of reference configurations can be the same, especially if the total transition time (as agreed) and relative power values are the same across sets.
  + ZTE, CMCC

The following summarizes the transition energy values proposed in contributions.

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| **Company** | **Proposals** |
| Huawei/HiSilicon | *Proposal 8: The additional transition energy of Set 1 is recommended as follow.*   |  |  |  | | --- | --- | --- | | Power state | Additional transition energy | | | Category 1 | Category 2 | | Deep sleep | 1326 | 13172 | | Light sleep | 150 | 2173 |   For Set 2 FR1 FDD and Set 3 FR2, the same calculation method can be applied.  *Proposal 9: For Set 2 and Set 3, the additional transition energy is recommended as follow.*   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Power state | Additional transition energy | | | | | | Set 2 Category 1 | Set 2 Category 2 | Set 3 Category 1 | Set 3 Category 2 | | Deep sleep | 1213 | 17533 | 1021 | 8767 | | Light sleep | 135 | 1534 | 90 | 767 | |
| Nokia/NSB, vivo, OPPO, CATT,CMCC, LGE | |  |  |  |  | | --- | --- | --- | --- | | Power State | | Additional Energy (relative power\*duration in ms) | | | Set 1 FR1  (as per agreed power consumption values, cat 2) | Set 2 FR1  (as per proposed power consumption values) | | Sleep State | Deep sleep | 22500 | 96 | | Light sleep | 1088 | 3500 | | Micro sleep | 0 | 0 | | Active state | Active DL | NA | NA | | Active state | Active UL | NA | NA |  |  |  |  | | --- | --- | --- | | Power state | Additional transition energy | | | Category 1 | Category 2 | | Deep sleep | 1350 | 22500 | | Light sleep | 90 | 1088 | |
| Intel | |  |  |  | | --- | --- | --- | | Power state | Additional transition energy  (unit in relative power\*ms) | | | Category 1 | Category 2 | | Deep sleep | 1350 | 13000 | | Light sleep | 90 | 1088 | |
| ZTE | Table 2 Additional transition energy calculated by the shadow area   |  |  |  | | --- | --- | --- | | Power state | Additional transition energy | | | Category 1 | Category 2 | | Deep sleep | 1350 | 22500 | | Light sleep | 90 | 1088 |   Or  Table 3 Additional transition energy for different reference configuration sets   |  |  |  | | --- | --- | --- | | Power state | Additional transition energy | | | Category 1 | Category 2 | | Deep sleep | 1250 | 12000 | | Light sleep | 90 | 1088 | |
| MediaTek | |  |  |  | | --- | --- | --- | | Power state | Additional transition energy | | | Category 1 | Category 2 | | Deep sleep | 1350 | ~~22500~~ 17000 | | Light sleep | 90 | 1088 | |
| Samsung (with set 1 values same as Nokia/NSB, vivo… etc.) | * **For set 1, the additional energy (unit in relative power\*(duration in *ms*)) is**  |  |  |  | | --- | --- | --- | | **Power state** | **Additional transition energy** | | | Category 1 | Category 2 | | Deep sleep | 1350 | 22500 | | Light sleep | 90 | 1088 |  * **For set 2, the additional energy (unit in relative power\*(duration in *ms*)) is**  |  |  |  | | --- | --- | --- | | **Power state** | **Additional transition energy** | | | Category 1 | Category 2 | | Deep sleep | 1225 | 20000 | | Light sleep | 81 | 768 |  * **For set 3, the additional energy (unit in relative power\*(duration in *ms*)) is**  |  |  |  | | --- | --- | --- | | **Power state** | **Additional transition energy** | | | Category 1 | Category 2 | | Deep sleep | 925 | 10000 | | Light sleep | 54 | 384 | |
| Ericsson | |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Transitions** | **Additional transition energy (Relative power x ms)** | | | *Transition time (ms)*  *(incl. ramp down/up)*  *shown for completeness* | | FR1-TDD  Set 1 | FR1-FDD  Set 2 | FR2  Set 3 | | Active  microsleep | **0** | **0** | **0** | *0* | | Active  light-sleep | **[90]** | **[80]** | **[15]** | *6* | | Active  deep-sleep | **[810]** | **[760]** | **[330]** | *50* | |
| Qualcomm | |  |  |  |  | | --- | --- | --- | --- | | **Sleep state** | **Additional transition energy**  **(relative power x ms)** | | **Transition time**  **(ms)** | | **Set 1 FR1 for Category 1** | **Set 2 FR1** | | Micro sleep | 0 | 0 | 0 | | Light sleep | [90] | [90] | 6 | | Deep sleep | [760] | [620] | 50 | |

### Initial round

Option 1 itself has already been justified in previous UE power saving study. It is mostly because of the averaged power values and transition time that lead to potential issue, instead of the formula itself. If companies are ok with the averaged power values and transition times for Set 1, there seems to be no strong issue to reuse the same formula as used in UE power saving for calculating the transition energy.

Option 2 attempts to address an issue in Option 1 by further adjustments on some individual entries. However, such adjustment in Option 2 will not be needed in other cases, e.g. whenever a single company wants to do energy consumption calculation based on their own measurements without being averaged with other companies input. So such adjustment would only be useful for RAN1 group evaluation purpose.

Option 3 provides a new method that also makes some technical sense, and seems to be able to address the potential issue caused by Option 1. Thus if it is adopted it would be useful for future use as well. On the other hand, it may not be necessarily always true even from some implementation point of view, since when a BS decides to go to deep sleep directly, it may use a different approach of components shut-down compared to the case that BS goes to light sleep first then deep sleep, e.g. components can be shut-down parallelly without being step wise. In this case, Option 1 still holds and is aligned with the initial assumptions.

Nevertheless, the root cause seems not to be the formula in Option 1 but more about the averaged transition times/power values, and it would be good to take a consistent assumption for evaluations. Given this is mainly concerned for the case of deep sleep, allowing an optional handling could be considered.

Further, it could be useful that the determination formula can be captured in TR instead of only the values, as in UE power saving study. This on one hand can be good reference for future use, and on the other hand may help companies explain, if other values are used, how they are differently obtained from the formula in Option 1.

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| **FL1 Proposal 2.3.1:**   * **For set 1/2/3, the additional energy (unit in relative power\*(duration in ms)) is**  |  |  |  | | --- | --- | --- | | **Power state** | **Additional transition energy** | | | Category 1 | Category 2 | | Deep sleep | 1350 | 22500 | | Light sleep | 90 | 1088 |  * **Other values for deep sleep transition can be optionally used and reported.**   **Capture the following in TR:**   * **The additional transition energy in the above tables are determined based on the following for evaluation purpose, assuming that BS enters from non-sleep mode to a sleep mode and BS leaves the same sleep mode to non-sleep mode.** * **where is the difference of the relative power between sleep mode and micro sleep, and is the corresponding total transition time of sleep mode .** * **Other values, if reported, may be possible for deep sleep transition in order to account for step-wise transition, or help BS decide to enter deep sleep with less transition energy.** | |
| **Company** | **Comments** |
| Huawei, HiSilicon | We support Option 2 but can live with Option 1. |
| LG Electronics | We support the proposal. |
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## Scaling details

Two alternatives (Alt 1 or its variation, and Alt 3 or its variation) were extensively discussed in the post meeting email discussion of RAN1#110 in R1-2208312.

*Conclusion*

*Companies are encouraged to check discussion in section 2.2.2 of* [*R1-2208312*](file:///D:\Users\erdem.bala\Downloads\Docs\R1-2208312.zip) *for scaling discussion in the next meeting.*

According the contributions submitted in this meeting:

**Based on (revised) Alt 1,**

* Huawei/HiSilicon considers the power of static part shall equal to the power of micro sleep mode, i.e. given no scaling applied for the static part and it is no active transmission (same definition as micro sleep) when the dynamic part power is zero. It also considers that the PA efficiency can be non-linearly modelled if needed, with formula provided in this case.
* Nokia/NSB considers the power of static part shall not equal to the power of BS in Micro sleep mode as Tx may still be scalable in BS micro sleep, and there is a BW factor applied to the dynamic part of active DL power (which can be assumed to be 1 for evaluations). Also, the dynamic Tx antenna element adaptations may require a further delay/interruption which may needs to be considered when performing scaling or calculating the energy consumption.
* Spreadtrum wants to discuss the profile of each part of e.g. Alt 1 on .e.g., whether the static part power include the transmission for common signal and consider it could be beneficial if the power consumption of micro sleep is lower than that of the static part.
* vivo, MediaTek, NTT DOCOMO consider and other dynamic parts for DL should meet the constraint that the sum of all components equals (similar constraints applies to UL).
* China Telecom considers both Alt 1 and Alt 3 has similar structure and need to consider some constraints similar to vivo.
* As a second preference, CATT could also consider this approach with consideration that 1) the power of static part should include additionally power consumed by cross-symbol processing, network control function, and data processing, in addition to the power of BS in micro sleep, 2) PA can be 1 or 0.34 and 3) value s\_f should be defined as the ratio of RF BW and maximum system BW.
* Fujitsu shares that in Alt 1 the Pstatic can be set as a same or close value with the relative power of micro sleep, which is also useful considering the gap of P3 and P4 is similar between two categories and the results can be more aligned.
* Intel proposes an unified scaling including both UL and DL split by time domain symbols, and considers and PA efficiency can be 1 by default.
* ZTE consider Pstatic can be the power of BS in micro sleep, and that the same scaling factors applies between Cat 1 and Cat 2.
* CMCC consider Pstatic can be the power of BS in micro sleep.
* MediaTek consider the PA efficiency can be set as 0.5 from RAN1 evaluation perspective and LS to RAN4 for providing suggested power consumption scaling for PA-related transceiver processing enhancements.
* Samsung consider Pstatic can be the power of BS in micro sleep, PA efficiency of 0.34 as a reasonable/practical value, and provides candidate values for scaling factors of each domain.
* Ericsson (2nd) considers adjustment is needed in order to better reflect the antenna scaling w.r.t. network load for the interest of this study. In time domain, since symbol level is proposed the total energy consumption is the summation of powers of symbols in a slot, so as to reflect the effects of different BW per symbol, etc.

**Based on (revised) Alt 3,**

* Vivo, NTT DOCOMO consider it can be optionally reported.
* China Telecom consider that there is conflicts in the current Alt 3 formula and modification is needed to satisfy the constraint P3<0.03\*P4.
* OPPO supports this approach and consider the power of static part equals P3.
* LGE and Rakuten consider this approach is easier/simpler and accurate enough from discussion point of view compared to Alt 1.
* Qualcomm consider this is applied in DL, and the static power is P3 and the total power is P4. With that the dynamic part power (P4-P3) is further scaled jointly (or separately when scaling factor for some domain=1). A ratio between a reference PA efficiency and actual PA efficiency is defined and used.

**Other Alternatives, e.g. Alt 2 where power scaling in time, frequency, spatial, and power domain are defined based on the framework of the power model defined for UE power consumption in TR38.840**

* Supported by CATT(1st), Ericsson(1st), Qualcomm (for UL)

The following summarizes the scaling approaches and relative power values submitted from contributions.

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| **Company** | **Proposals** |
| Huawei/HiSilicon | *Proposal 5:* *For active DL with revised Alt1-update, and are recommended to set as 7.3 and 9.6 respectively, while or a fixed value.*  *Proposal 6: For active UL, the BS power consumption can be provided as , where and is recommended as 1.*  *Proposal 7: For Set 2 and Set 3 reference configuration, the same scaling formula as Alt 1 is reused and*  *where is the respective relative power value of BS micro-sleep. Other parameters are recommended as below:*   * *For Set 2, ,,* * *For Set 3, ,,* * *can be either non-linearly modelled or a fixed value, for simplicity.* |
| Nokia/NSB | and assuming the following parameters:   * fixed feeder loss=0,8 dB * fixed PA efficiency factor =35%   Table 3: DL power scaling coefficients with Set 1 and Set 2 for Cat.2   |  |  |  | | --- | --- | --- | | Parameters | Set 1 FR1 | Set 2 FR1 | |  |  |  | |  |  |  | |  |  |  |   Table 4: UL power scaling coefficients with Set 1 and Set 2   |  |  |  | | --- | --- | --- | | Parameters | Set 1 FR1 | Set 2 FR1 | |  |  |  | |  |  |  |   In time domain,  +  For CA,  where >1  For multi-TRP, |
| vivo | *Proposal 6: Value of in the Revised Alt 1-update is the same as power value of Micro sleep power state.*  *Proposal 7: Value of*  and  *in the Revised Alt 1-update should meet the condition that the sum of and* *is the same as power value of Active DL power state.*  *Proposal 8: Support the following scaling method for BS UL reception*   * + - = power *value of Micro sleep power state (i.e. P3)*     - =*power value of Active UL power state (i.e. P5) - power value of Micro sleep power state (i.e. P3)*   *Proposal 9: For time domain scaling, the following formula is used when slot level model is provided:* (1-alpha-beta)\*P3 + alpha\*P4+beta\*P5 |
| China Telecom | |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | | Category 1 | 55 | 100 | 180 | | Category 2 | 5.5 | 10 | 22 | |
| OPPO | Proposal 5: When a slot-level model is used, the BS power consumption over a slot can be scaled by , where is the ratio of the number of active DL symbols within a slot. |
| CATT | * + - : a static part of which the power is not scaled based on reference configurations. Value is to be determined based on       * Category 1: [140]       * Category 2: [16]     - : a dynamic part of the power that is scaled based on reference configurations based on , where       * + is   Category 1: [110]  Category 2: [12]   * + - * + is   Category 1: [30]  Category 2: [4]   * + - * + is the PA efficiency   For initial evaluations, ,  The and should be reported along with , which may not be perfectly the candidate values in the current list  FFS whether/how to use a non-linear function to represent.   * + - * + , , is the percentage of active TxRUs, the radio of RF bandwidth and maximum system BW in frequency domain and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively. |
| Intel | ,  where,   * = P3, a static part for which the power does not scale based on the reference configurations. P3 refers to Micro-sleep state power value.   + should be 55 and 5.5 for Category 1 and Category 2 models, respectively. * and represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot, respectively. * , where   + , , refer to the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively.   + is the PA efficiency, for which default value is 1. Other values < 1 can be optionally evaluated   + refers to component of dynamic power that is scaled based on number of active set of antennas only     - We suggest value of 110 for this part for Category 1   + refers to component of dynamic power that is scaled based on both number of active set of antennas and amount of occupied BW     - We suggest value of 115 value for this part for Category 1 * , where P5 refers to active UL state relative power for the reference configuration. |
| ZTE | * : * Category 1: [55] * Category 2: [5.5]  * : * Category 1: [103] * Category 2: [12.5]  * : * Category 1: [61] * Category 2: [7] * as the PA efficiency: * =0.5   Proposal 10: The time domain scaling is (1-alpha)\*P3 + alpha\*P4 where alpha represents the ratio of the number of active DL symbols within a slot to the number of symbols within a slot  Proposal 11: In frequency domain, for at least inter-band CA, the total power consumption of BS is calculated as the sum of the power consumption of each cell. |
| LGE | Proposal #3: For the time domain scaling, the formula α\*P4+(1-α)\*P3 can be used, wherein P4 is the power for active DL, P3 is the power of micro-sleep, α is the ratio of active DL symbols within a slot.  Proposal #4: For the frequency domain scaling, the power consumption can be calculated as the sum of the power consumption of each cell for inter-band CA while a proper scaling factor for dynamic power can be considered for the intra-band CA. |
| MediaTek | DL   * is chosen so that Active DL power when = 1 while = 0   + Accordingly, the following values are utilized for different BS categories and Set 1/2/3  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Value of | | | | | | | Category 1 BS | | | Category 2 BS | | | | Set 1 | Set 2 | Set 3 | Set 1 | Set 2 | Set 3 | | 57 | 46 | 22.8 | 7.3 | 11 | 0.36 |  * is chosen so that Active DL power when   + Accordingly, the following values are utilized for different BS categories and Set 1/2/3  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Value of | | | | | | | Category 1 BS | | | Category 2 BS | | | | Set 1 | Set 2 | Set 3 | Set 1 | Set 2 | Set 3 | | 84 | 72 | 45.6 | 9.6 | 12 | 2.52 |   UL   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Value of | | | | | | | Category 1 BS | | | Category 2 BS | | | | Set 1 | Set 2 | Set 3 | Set 1 | Set 2 | Set 3 | | 55 | 40 | 42 | 1 | 0.8 | 1.2 |   Time domain |
| Samsung | * the BS power consumption for active DL is provided by   + - : a static part of which the power is not scaled based on reference configurations. Value is to be determined based on       * Category 1: 55       * Category 2: 5.5     - : a dynamic part of the power that is scaled based on reference configurations based on , where       * + is   Category 1: 15  Category 2: 1.5   * + - * + is   Category 1: 71  Category 2: 8.5   * + - * + is the PA efficiency   For initial evaluations, 0.34   * + - * + , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively.         + The percentage of active TRxRUs : {1 for 64 TRxRUs, 0.67 for 32 TRxRUs, 0.67^2 for 16 TRxRUs, 0.67^3 for 8 TRxRUs}         + The ratio of RF bandwidth : 0.35+0.65\* Xf /100MHz, Xf [MHz] = {10, 20, 40, 50, 80, 100}         + The ratio of PSD per TxRU between the DL transmission and reference configuration : 0.67^(Xp /3[dB]), Xp = {0, 3[dB], 6[dB]} * the BS power consumption for active UL is provided by   + - : a static part of which the power is not scaled based on reference configurations. Value is to be determined based on       * Category 1: 55       * Category 2: 5.5     - : a dynamic part of the power that is scaled based on reference configurations based on       * Category 1: [FFS]       * Category 2: 1         + The percentage of active TRxRUs : {1 for 64 TRxRUs, 0.67 for 32 TRxRUs, 0.67^2 for 16 TRxRUs, 0.67^3 for 8 TRxRUs} |
| Ericsson | For Set 1, downlink Cat 1, downlink active power P = P4 \* ( [0.4] + [0.6] \* sf\*sp) \* ([0.4] + [0.6]\*sa), where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively  [Alternate proposal to Proposal 5 ] For Set 1, downlink Cat 1, downlink active power with the dynamic power defined as ,   * 1. *, , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively.*   2. *is the PA efficiency*   Antenna adaptation delay is explicitly modeled with a transition time of [1-3] ms.  For Set 1, uplink Cat 1, uplink active power P = P5 \* ( [0.8] + [0.2] \* sf) \* ([0.4] + [0.6]\*sa), where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW, respectively |
| NTT DOCOMO | * + In CA case     - For intra-band CA, a scaling factor is applied to considering RF is shared among CCs.     - For inter-band CA, the power consumption is the sum of the power consumption of each cell considering different RFs are used among CCs. |
| Qualcomm | DL   * *and are relative power values of micro sleep and active DL transmission based on reference configuration, respectively* * *is the ratio between the actual number of TxRUs and the reference number of TxRUs for DL transmission* * *is the ratio between the actual number of frequency resources and the reference number of frequency resources for DL transmission* * *is the ratio between PSD of the actual DL transmission and PSD of the reference DL transmission.* * *is the ratio between a reference PA efficiency and actual PA efficiency*   + - *when = 1*     - *α and are provided in the below table*  |  |  |  | | --- | --- | --- | | *Parameters* | *FR1* | *FR2* | |  | *[31%]* | *[8%]* | |  | *[0.86]* | *[0.24]* | |  | *[0.025]* | *[0.01]* |   UL  *Power consumption of an active UL reception is adapted in spatial and frequency domain as*   * *is the power consumption of the active UL reception based on the reference configuration.* * *is the ratio between the actual number of RxRUs and the reference number of RxRUs for UL reception* * *is the ratio between the actual number of frequency resources and the reference number of frequency resources for UL reception.*   *For CA, the total power consumption is the sum of the power consumption of configured cells*   * + *For intra-band CA with contiguous CCs, the power consumption of the Scell is scaled by [0.75].*   *For multi-TRP, the total power consumption is the sum of the power consumption of configured active TRPs.* |

### Initial round

Based on the above, general support of Alt 1 can be observed while there is slightly increased support for Alt 3 compared to last meeting. Majority including the proponents of Alt 3 consider a static part shares the power as BS in micro sleep. This could be a baseline for evaluations while we allow for other values for the interest of study. Regarding the component values of , it is observed that companies of Cat 2 have proposals for Cat 1 while companies of Cat 1 mainly propose a different/modified scaling (modified Alt 1 or Alt 3). Therefore, FL does not pick up the values proposed by Cat 2 companies for Cat 1 while only take one value directly from a Cat 1 company. It might be beneficial to allow for different values in small, medium or larger level respectively to further account for different implementations and various PA efficiency, therefore multiple candidate values remain without down-selection at this stage. Particularly, one or an averaged one is taken for each PA efficiency to reduce the workload. DL and UL can be unified based on majority preference, and also due to the fact that UL does not contribute to a significant part of power consumption at least for the study of this release.

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| **FL1 Proposal 2.4.1:**   * **The BS power consumption in a slot is provided by**   + - For slot-level modelling, represents the ratios of the number of active DL and UL symbols within a slot to the number of symbols within a slot and ; for symbol-level modelling, represents the number of active DL and UL symbols within a slot and .     - : a static part of power for BS in active, which is not scaled based on reference configurations.       * Baseline:       * Other values can be optionally reported     - : a dynamic part of power for BS in active, which is scaled based on reference configuration.       * Baseline: , where , , is the percentage of active TRxRUs, the ratio of RF bandwidth and maximum system BW and the ratio of PSD per TxRU between the DL transmission and reference configuration, respectively, and         + is the PA efficiency. For evaluation purpose, .         + : [1.5] for , [9.9] for , [110] for         + : [8.5] for , [8.3] for , [115] for       * Other values can be optionally reported, satisfying when , ,.       * Optional for other approaches, e.g. **,** or where  is the ratio between a reference PA efficiency and actual PA efficiency, up to company report       * Baseline:       * Other values can be optionally reported, satisfying when .   + For multi-carrier: for inter-band multi-CC, the total power consumption of BS is calculated as the sum of the power consumption of each CC; for intra-band with contiguous CCs, the power consumption of each additional CC is scaled by [0.75].   + For multi-TRP with separate RF chains, the total power consumption of BS is assumed as the sum of the power consumption of each TRP   + Antenna adaptation delay is explicitly modelled with a transition time of [1-3] ms, if not fall into micro-sleep.   + Other scaling, e.g. cell-load dependent scaling can also be reported. * Send LS to RAN4 about the above, and ask for feedback, with details of proposed in Alt 3 also captured in the LS. | |
| **Company** | **Comments** |
| Huawei, HiSilicon | We are in general fine with the framework and proposal, with the following detailed comments:   1. For the PA efficiency of , we are wondering this is realistic value and can be achievable. Therefore, we propose not to assume in the evaluation. We are fine to keep 0.34 and 1 as typical PA efficiency values; 2. Antenna adaptation delay may or may not zero depends on whether fall into micro sleep. Therefore,    * Antenna adaptation delay is zero if the transition-to state if micro-sleep state. Antenna adaptation delay can be reported ~~is explicitly modelled~~ with a transition time of [1-3] ms, if not fall into micro-sleep. 3. For intra-band CC, we think the value of 0.65 would be more accurate.    1. For multi-carrier: for inter-band multi-CC, the total power consumption of BS is calculated as the sum of the power consumption of each CC; for intra-band with contiguous CCs, the power consumption of each additional CC is scaled by [0.~~7~~65]. |
| LG Electronics | We are generally fine with the proposal but we would like to clarify the follows.   * + Why is the baseline in ?   + Whether the scaling for the power consumption of each additional CC is applied only to the dynamic part for the intra-band CA case   + Which formula Alt 3 in the last bullet refers to?   In addition, if is up to company report, isn't there no need to send LS to RAN4? |
|  |  |

## Power model feasibility/applicability

Nokia observes that the different Categories defined for BS power model may lead to different conclusions for a given technique, and propose to discuss the practical hardware feasibility of two types of implementations. Nokia also proposes that the TR to capture that the discussed BS power model is a simplified model from real BS power consumption, and is applicable to single-RAT BS only.

OPPO wants to discuss whether power scaling and sleep mode is supported by legacy BS to align the evaluation baseline for BS energy saving study.

Fujitsu observes similarly as Nokia w.r.t. the difference of categories, and further notes that the difference on the power of active DL compared to micro sleep is relatively small.

Samsung observes that the gap between micro and active UL in Cat 1 seems a bit high thus may need to be further investigated.

### Initial round

It was FL observation, based on previous discussion, that the different power states are closely related to implementations, and companies may not be able to dig into details on how each state is achieved, BS component wise. For now, it is unsure what FL can do for this discussion point to address companies concern. The following can be a starting point.

|  |  |
| --- | --- |
| **FL1 Proposal 2.5.1:**   * Capture in TR that, the BS power model defined in this study is a simplified model of the real BS power consumption, considering single-RAT NR BSs only. This does not mean a BS cannot benefit from the identified techniques when serving multi-RAT. * In TR, explicitly capture companies input of relative power values and transition times for different sets of reference configurations, as collected in the excel sheet of R1-xxx (*NOTE: if no update from source comapnies, this will be x8312*), and Add a note in TR that an approximate average is performed for determining the entries of the power model table. * Capture that, different power states and transition times is possible for BS today, although different BS types with different number of power state levels, relative power values and transition times can exist. * Companies are invited to share more that can be discussed about feasibility of each category. For example, whether/how to capture hardware operations for state transition. | |
| **Company** | **Comments** |
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## Total energy consumption

OPPO clarifies that, the total BS energy can be calculated as below.

Where includes the energy consumption of each power state and additional transition energy and and are relative power value and time duration in unit of slot for power state *i*, and are transition energy and the number of transitions for sleep mode *i*.

### Initial round

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| --- | --- |
| **FL1 Proposal 2.6.1:**  Clarify and capture the below formula into TR as calculation of total energy consumption.  Where includes the energy consumption of each power state and additional transition energy and and are relative power value and time duration in unit of slot for power state *i*, and are transition energy and the number of transitions for sleep mode *i*. | |
| **Company** | **Comments** |
| Huawei, HiSilicon | We generally support the proposal. However, there needs some clarification: the unit of *Ei* is (power unit\*ms). So, we think a scaling factor should be introduced in the equation to convert slot number to number of ms:  , where is the subcarrier spacing. |
| LG Electronics | We support the proposal. |
|  |  |

# Methodology

## KPI and traffic model

Nokia consider that we should be able to benefit from using some multi-dimensional EE KPIs that jointly consider the energy consumption of the network and system/UE performance for a given technique, such as

|  |  |  |  |
| --- | --- | --- | --- |
| **Metric ​** | **Metric formula​** | **Unit** | **Description​** |
| **UPT-aware EE** |  | [Mbps] | The ratio of the UPT (defined as packet size divided by the total time spent to deliver the packet) to the network power consumption. Cell edge (5-ile) UPT and average UPT to be considered. |
| **Cell throughput-aware EE** |  | [Mbps] | The ratio of the average cell throughput to the network power consumption. ​ |
| **Cell-edge UE throughput-aware EE** |  | [Mbps] | The ratio of the cell-edge UE (instantaneous) throughput to the network power consumption.  Note: This metric corresponds to the coverage aware EE KPI defined by ETSI. |
| **Data Volume-aware EE** |  | [Mbit] | The ratio of the data volume carried during an observation time to the average network power consumption during the observation time. |

Furthermore,

* Huawei/HiSilicon, Nokia, Samsung: multiple QoS target values, e.g. UPT loss can be defined.
* Nokia: minimum QoS target per deployment scenario is needed and shall be defined.
* Vivo: two options can be considered for evaluations of BS energy saving gains for better fitting certain traffic model with meaningful comparison, two approaches can be considered for performing non-uniform UE distributions and a hearbeat traffic model is further proposed for potential assumption for UE in RRC-idle state.
  + *Option 1: The energy saving gain of the energy saving scheme compared to the baseline scheme, when the average UPT loss/latency or 5% UPT loss/latency meets the threshold requirement.*
  + *Option 2: The energy saving gain of the energy saving scheme compared to the baseline scheme, when the proportion of packets meeting latency requirements is greater than X%, X = 95 or 99.*
  + *Approach 1: UE dropping is only allowed in part of the cells which are selected randomly from cells within simulation area.*
  + *Approach 2: UE dropping is only allowed in several cluster area that is randomly generated within the simulation area.*
* China Telecom: no need to define exact requirements/QoS target while an universal EE can be used, defined as where *V\_K* refers to the focused evaluated performance KPI and *EC* refers to the energy consumption (in Joule).
* Fujitsu: no need to define exact requirements/QoS target for UPT impact, while propose that both average UPT and 5% UPT are reported along with gains.
* ZTE: FTP3 with the packet size of 20K Bytes can be used for evaluation and UPT is reported as where average UPT is assumed.
* LGE: new energy efficiency is defined as the ratio of throughput to reference power consumed by gNB, as one of KPIs for this study. Additionally, both of gNB’s performance gain and UE’s performance loss compared to the reference scenario (i.e. scenarios without network energy saving techniques) can be reported.
* Samsung: use KPIs of Energy saving gain, Latency (packet latency and scheduling latency), UPT, Coverage, UE power consumption.

### Initial round

There has been rounds of attempt for almost all of the above points while no consensus could be made. FL consider those could be up to company report.

On the other hand, it may be useful to agree on a template for collection of company’s results next meeting. Note the Editor Note does not serve a requirement, but they are informative and can be kept.

**FL1 Proposal 3.1.1:**

* **Use the following table as a draft template for collection of simulation results, when appropriate.**
* **The template can be further adjusted with input, and when captured into TR.**
* **Other formats are not precluded.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Company | NW energy saving scheme | ES Gain | ES gain for each configuration | UPT/latency  (Optional: Energy Efficiency) | Other impact | Evaluation methodology/baseline assumption | Note |
|  |  | *Editor Note: includes a range for different configurations, if possible.* | *Editor Note: include gain for each configuration, if possible. For example, per Load, configurations of common signals etc.* | *Editor Note: may include average UPT, target UPT (95%/50%/5%) and UPT loss per ES techniques.*  *May also include scheduling latency, user plane latency etc.*  *Optionally, results with EE can be included with clear definition reported.* | *Editor Note: include coverage, UE power consumption etc.* | *Editor Note: include selected parameters/baselines etc, if there are multiple.* | *Editor Note: other important setting that needs to be reported, e.g. the selected options/approaches as mentioned in* [R1-2208654](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208654.zip)*.* |

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Huawei, HiSilicon | We are fine with the template. We think energy efficiency can be moved to column of “other impact”, considering “Energy efficiency” belongs to some other impacts rather than impact on UE performance.   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | Company | NW energy saving scheme | ES Gain | ES gain for each configuration | UPT/latency  (Optional: Energy Efficiency) | Other impact | Evaluation methodology/baseline assumption | Note | |  |  | *Editor Note: includes a range for different configurations, if possible.* | *Editor Note: include gain for each configuration, if possible. For example, per Load, configurations of common signals etc.* | *Editor Note: may include average UPT, target UPT (95%/50%/5%) and UPT loss per ES techniques.*  *May also include scheduling latency, user plane latency etc.*  *~~Optionally, results with EE can be included with clear definition reported.~~* | *Editor Note: include coverage, UE power consumption, Energy efficiency etc.* | *Editor Note: include selected parameters/baselines etc, if there are multiple.* | *Editor Note: other important setting that needs to be reported, e.g. the selected options/approaches as mentioned in* [R1-2208654](file:///C:\Users\w00250081\AppData\Local\Docs\R1-2208654.zip)*.* | |
| LG Electronics | We are generally ok with the proposal. But it is necessary to clarify what is the difference between ES Gain and ES gain for each configuration, and if there is no difference, it can be combined into one column. |
|  |  |

## Simulation assumption

Huawei/HiSilicon and Intel: add channel model for FR1.

Nokia: proposes SLS assumptions for different sets of reference configurations.

OPPO: clarify the channel model and percentage of high loss and low loss building type.

CATT: baseline configuration and normal network operation should be defined in order to obtain the energy consumption of normal network operation and to identify the potential network energy saving technique.

MediaTek: propose detailed configurations for common signals of SSB and SIB1.

Nokia provides a relatively complete table includes FR2 SLS assumptions, and Samsung, Lenovo consider the proposal in the FFS of previous agreements is reasonable and considerable, with small clarification for BS antenna configurations traffic model, and total Tx power etc in order to address potential concern raised in the previous discussion w.r.t. prioritized Urban Micro. Ericsson view Table A2.1-1 of TR 38.802 can be used as the baseline for FR2.

Qualcomm consider that***:*** *the actual total DL transmission power is adjusted according to the actual bandwidth and the number of active TxRUs as follows*

* *, and are total DL power level, bandwidth, and the number of TxRUs in the reference configuration, respectively.*

*and are the actual bandwidth and the number of active TxRUs, respectively*.

### Initial round

For FR1, since there are baseline SLS assumptions ready, FL tends to identify the delta parts that would be additionally needed. Given what Nokia/NSB is proposing, it seems more configurations can be clarified, which meanwhile can be partially served as a ‘normal network operation’ as preferred by CATT, except that the paging transmission, CORESET configuration, UL control resources, CA/DC configurations (including PDCCH and CSI-RS configuration in SCell) are still missing.

For FR2 SLS assumptions, proposals are available based on a few contributions. FL takes Nokia’ proposal which is a complete set on the table.

As for the reference configuration, if there are other parameter used than the agreed reference configurations, Qualcomm proposed formula could be considered. Note if we can agree on a set of unified power values and transition time as being proposed by FL in section 2.2, the proposal from Qualcomm will not have impact on other relevant calculation, e.g. transition energy, scaling etc.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Companies are invited to share your view on which of the rows are needed for alignments; otherwise, the corresponding parameters could be up to company report.  **FL1 Proposal 3.2.1:**   * **For FR1 SLS assumptions, add parameters in the below table as additional SLS parameters.**  |  |  |  |  | | --- | --- | --- | --- | |  |  | Set 1 FR1 | Set 2 FR1 | | **1** | **Channel model** | 3D-Uma as in TR 38.901 | 3D-Uma as in TR 38.901 | | **2** | **percentage of high loss and low loss building type** | 100% low loss | 100% low loss | | **3** | **Guard band ratio on simulation bandwidth** | TDD: 2.08% (272 RB for 30kHz SCS and 100 MHz bandwidth) | FDD: 6.4% (104RB for 15kHz SCS and 20 MHz BW) | | **4** | **HARQ scheme** | Ideal | Ideal | | **5** | **Max HARQ retransmission** | 3 | 3 | | **6** | **Target BLER** | 20% of first transmission | 20% of first transmission | | **7** | **Power control parameters** | Open loop, Alpha=1, P0=-106 dBm | Open loop, Alpha=1, P0=-106 dBm | | **8** | **CSI acquisition** | Periodic, CQI on 2 ms period | Periodic, CQI on 2 ms period | | **9** | **SSB periodicity** | 20 ms |  | | **10** | **SS blocks per SSB burst** | 8 for 3 GHz < FR1 <= 6 GHz | 8 for 3 GHz < FR1 < =6 GHz | | **11** | **SSB time resource** | 2 SSBs per slot  4 symbols for each SSB | 2 SSBs per slot  4 symbols for each SSB | | **12** | **SSB frequency resource** | 20 RBs | 20 RBs | | **13** | **Number of SIB1** | 1 SIB1 per SSB | 1 SIB1 per SSB | | **14** | **SIB1 transmission repetition periodicity** | 20 ms or 80 ms,  multiplexing pattern 1 with SSB | 20 ms or 80 ms,  multiplexing pattern 1 with SSB | | **15** | **SIB1 time resource** | 1 slot | 1 slot | | **16** | **SIB1 frequency resource** | 24 RBs for 20 ms periodicity,  48 RBs for 80 ms periodicity | 24 RBs for 20 ms periodicity,  48 RBs for 80 ms periodicity | | **17** | **RO periodicity** | 20 ms | 20 ms | | **18** | **RO time resource** | 2 slots | 2 slots |  * **For (Set 3) FR2 SLS assumptions, use Table 9 in x8518 as baseline assumptions** * **Other parameters can be optionally reported.** * **The actual total DL transmission power can be optionally adjusted according to the actual bandwidth and the number of active TxRUs as follows** * , and are total DL power level, bandwidth, and the number of TxRUs in the reference configuration, respectively. * and are the actual bandwidth and the number of active TxRUs, respectively. | |
| **Company** | **Comments** |
| Huawei, HiSilicon | There are cases where gNB could reduce the PSD and increase the bandwidth to keep the same transmission power. This cannot be covered by the equation of Pt. So, we would suggest not to agree the following bullet and ask company to report.   * **~~The actual total DL transmission power can be optionally adjusted according to the actual bandwidth and the number of active TxRUs as follows~~** * ~~, and are total DL power level, bandwidth, and the number of TxRUs in the reference configuration, respectively.~~ * ~~and are the actual bandwidth and the number of active TxRUs, respectively.~~ |
| LG Electronics | In general, we support the proposal, but we have two comments.  Firstly, the last bullet doesn’t seem to be necessary since the effects of the actual bandwidth and the number of active TxRU are already reflected by the scaling method. Secondly, for row 6, we think 10 % BLER for the first transmission is more typical value.. |
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# Others for performance evaluation, if any

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| --- | --- |
| **Company** | **Comments** |
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# Preliminary results

Many companies have provided their preliminary simulation results to this meeting. It would be good to take a look into those while it may be premature to capture observations into TR at this stage. Therefore, after discussed with Intel, FLs consider the preliminary results can be used as a discussion panel for companies to share questions/comments/clarifications, such that in future the simulations can be adjusted/verified if needed. When comments are received, it is preferred that proponents can clarify when possible. Note some results submitted to A.I. 9.7.2 are also gathered here. Before making comments/questions, companies are also invited to read each individual tdoc for details from the source companies.

### Initial round

#### Source 1: Nokia/NSB

|  |  |
| --- | --- |
| **Single carrier**   1. **Relaxed periodicity for both SIB1/SSB/RO**     Figure : ES gain and impact on UPT from relaxing SSB/SIB/RO periodicity   1. **Reduced number of SSBs per SS Blocks and per slot**     Figure : ES gain from reducing the number of SSBs  **Multi-carrier**   1. **SSB-less operation in the ES CC (as per release 17)**     Figure : ES gain and impact on UPT from SSB-less operation in ES CC   1. **SIB1-less operation in the ES CC**     Figure : ES gain and impact on UPT from SIB1-less operation in ES CC   1. **SSB&SIB1-less operation in the ES CC**      1. *RO periodicity=20 ms*      1. *RO periodicity=160 ms*   Figure : ES gain and impact on UPT from SSB&SIB1-less operation in ES CC | |
| **Company** | **Comments** |
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#### Source 2: vivo

(Additionally, vivo has more results submitted also in [R1- 2208655](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208655.zip) in AI 9.7.2)

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| Table . Network resource utilization of different traffic loads   |  |  |  |  |  | | --- | --- | --- | --- | --- | | **Load** | **Zero load** | **Low load** | **Light load** | **Medium load** | | **RU** | 0.0% | 6.2% | 20.3% | 36.3% |   Table . The UPT and transmit latency performance under different loads   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | **Load** | **Transmit latency (ms)** | | | | **UPT (Mbps)** | | | | | **Mean** | **5%** | **50%** | **95%** | **Mean** | **5%** | **50%** | **95%** | | **Baseline** | Low load | 8.18 | 5.08 | 6.19 | 15.82 | 616.02 | 250.57 | 689.30 | 789.96 | | **ES scheme** | 9.23 | 5.83 | 7.43 | 16.30 | 541.83 | 251.79 | 588.92 | 719.47 | | **Baseline** | Light load | 12.05 | 5.52 | 8.50 | 26.58 | 524.03 | 216.85 | 535.17 | 750.73 | | **ES scheme** | 13.69 | 6.43 | 9.49 | 27.07 | 469.77 | 202.96 | 482.78 | 668.89 | | **Baseline** | Medium load | 21.56 | 6.22 | 12.72 | 53.88 | 436.73 | 165.77 | 424.40 | 699.71 | | **ES scheme** | 21.58 | 7.11 | 13.48 | 54.12 | 401.10 | 162.97 | 393.80 | 634.67 |   Table . Power consumption performance under different loads   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | **Load** | **BS power consumption** | | | | **UE power consumption** | | | | | **Mean** | **5%** | **50%** | **95%** | **Mean** | **5%** | **50%** | **95%** | | **Baseline** | Zero load | 75.52 | 75.52 | 75.52 | 75.52 | 89.00 | 89.00 | 89.00 | 89.00 | | **ES scheme** | 63.32 | 63.32 | 63.32 | 63.32 | 89.00 | 89.00 | 89.00 | 89.00 | | **ES gain** | 16.15% | 16.15% | 16.15% | 16.15% | 0.00% | 0.00% | 0.00% | 0.00% | | **Baseline** | Low load | 86.27 | 81.79 | 84.85 | 94.55 | 95.06 | 92.02 | 93.88 | 100.77 | | **ES scheme** | 74.23 | 69.59 | 72.72 | 83.28 | 94.95 | 92.01 | 93.88 | 100.33 | | **ES gain** | 13.96% | 14.92% | 14.30% | 11.92% | 0.11% | 0.01% | 0.00% | 0.44% | | **Baseline** | Light load | 110.61 | 98.72 | 108.07 | 123.93 | 96.09 | 92.22 | 94.74 | 103.39 | | **ES scheme** | 99.97 | 86.60 | 97.08 | 114.55 | 96.06 | 92.28 | 94.78 | 103.01 | | **ES gain** | 9.62% | 12.28% | 10.17% | 7.57% | 0.03% | -0.07% | -0.04% | 0.37% | | **Baseline** | Medium load | 138.35 | 121.48 | 136.23 | 161.79 | 97.76 | 92.73 | 96.18 | 106.74 | | **ES scheme** | 129.75 | 111.17 | 126.45 | 156.58 | 97.82 | 92.73 | 96.22 | 107.12 | | **ES gain** | 6.22% | 8.49% | 7.18% | 3.22% | -0.06% | 0.00% | -0.04% | -0.36% |   Figure . SLS result curves for baseline and energy saving scheme | |
| **Company** | **Comments** |
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#### Source 3: OPPO

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| Fig 3. RU, BO and ρ comparison for FTP3 model with 0.5MB packet size and 200ms inter-arrival time    Fig 4. Latency, UPT and energy consumption comparison for FTP3 model with 0.5MB packet size and 200ms inter-arrival time    Fig 5. RU, BO and ρ comparison for FTP3 model with 0.5MB packet size and 200ms inter-arrival time    Fig 6. Latency, UPT and energy consumption comparison for FTP3 model with 0.5MB packet size and 200ms inter-arrival time    Fig 7. Latency, UPT and energy consumption comparison for FTP3 IM model with 0.1MB packet size and 2s inter-arrival time      Fig 8. Latency, UPT and energy consumption comparison for FTP3 IM model with 0.1MB packet size and 2s inter-arrival time | |
| **Company** | **Comments** |
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#### Source 4: CATT

(Additionally, CATT has more results submitted also in [R1-2208988](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208988.zip) in AI 9.7.2)

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| Reduction in the transmission of common control channel/signal in time domain Table : Energy saving gain of increasing common control channel periodicity with different system loads   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | |  | SSB/SIB transmission periodicity | System loads | | | | | **Zero** | **9%(low)** | **15%(light)** | **30%(Medium)** | | Energy saving gain | 20ms(baseline) | - | - | - | - | | 40ms | 18.8% | 9.0% | 6.5% | 4.9% | | 80ms | 67.7% | 24.9% | 12.3% | 8.5% | | 160ms | 82.6% | 27.1% | 14.0% | 9.6% | | Note:  a) Category 1 power model is applied.  b) Relative power of SSB and SIB1 =280.  c) For number of beam sweeping L=4, i.e., 4 SSB within one SSB burst for FR1. | | | | | |  gNB DTX/DRX scheme Table : The energy saving gain (ESG) of the gNB DTX transmission under different system loads   |  |  |  |  | | --- | --- | --- | --- | |  | System load = 9% | System load = 15% | System load = 30% | | Average ESG of gNB DTX/DRX | 75.3% | 66.1% | 50.1% |  Cell ON/OFF scheme Table 5: The energy saving gain (ESG) of semi-static/dynamic cell ON/OFF   |  |  |  | | --- | --- | --- | |  | Percentage of Cell ON | Network Energy Saving gain of Cell ON/OFF scheme | | Cell without DTX | 63.1% | 23.8% | | Cell with DTX | 65.5% | 47.3% |   Spatial domain  Table : The energy saving gain (ESG) of the gNB with TxRU dynamic adaptation under different system loads   |  |  |  |  | | --- | --- | --- | --- | | System load | Average ESG | Average UPT loss | Average latency loss | | 9.0% | 6.9% | 1.2% | 1.7% | | 15.0% | 10.9% | 1.8% | 2.6% | | 30.0% | 10.8% | 1.7% | 2.88% | | |
| **Company** | **Comments** |
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#### Source 5: ZTE

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| Time domain  Figure 2 Evaluation results of SSB-less and SIB-less scheme  Frequency domain  Figure 3 Evaluation results of SSB-less for inter-band CA  Spatial domain  Figure 4 Energy saving gain and UPT impact of antenna reduction | |
| **Company** | **Comments** |
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#### Source 6: InterDigital

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| **Table 2: Downlink Evaluation results**   |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load 1: { = {0.14, 0.33} | | | | User traffic load 2: { = {0.33, 0.67} | | | | | Baseline  (Always ON)  Mean UPT(Mbps) | NES  Mean UPT  (Mbps) | UPT gain/loss  (NES vs Baseline)  (%) | ESG  (NES vs Baseline)  (%) | Baseline  (Always ON)  Mean UPT  (Mbps) | NES  Mean UPT  (Mbps) | UPT gain/loss  (NES vs Baseline)  (%) | ESG  (NES vs Baseline)  (%) | | 47.51 | 45.27 | -4.93% | 54.59% | 23.81 | 22.67 | -4.78% | 25.65% |   **Table 3: Uplink Evaluation results – 40 ms gNB sleep cycle**   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load: = 0.24 | | | | | | | | | | |  | | | |  | | | | | | | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | | | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs.  NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | | 21.35 | 23.77 | +11.34% | -3.00% |  |  | 21.92 | 22.92 | +4.56% | -3.12% |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load: = 1.0 | | | | | | | | | | |  | | | |  | | | | | | | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | | | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs.  NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | | 23.03 | 24.11 | +4.70% | -1.67% |  |  | 22.20 | 22.90 | +3.15% | -1.82% |   **Table 4: Uplink Evaluation results – 160 ms gNB sleep cycle**   |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load: = 0.24 | | | | | | | | | | |  | | | |  | | | | | | | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | | | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs.  NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | | 17.51 | 23.84 | +36.14% | -5.95% |  |  | 17.37 | 23.07 | +32.78% | -6.20% |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | User traffic load: = 1.0 | | | | | | | | | | |  | | | |  | | | | | | | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | NES  (Sleep w/o WUS)  Mean UPT (Mbps) | | | Enhanced NES  (Sleep with WUS)  Mean UPT (Mbps) | UPT gain/loss  (Enhanced NES vs.  NES)  (%) | ESG  (Enhanced NES vs. NES)  (%) | | 19.76 | 24.27 | +22.83% | -3.03% |  |  | 18.83 | 23.56 | +25.14% | -3.08% | | |
| **Company** | **Comments** |
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#### Source 7: Samsung

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| Time domain  Table 3: Preliminary evaluation results of SSB adaptation   |  |  |  |  |  | | --- | --- | --- | --- | --- | | NW energy saving scheme | ESG for each traffic loads | | Evaluation methodology/baseline assumption | Note | | **Category 1** | **Category 2** | | SSB adaptation  From 8 SSBs to 2 SSBs | Light\_0 load: 5.20 %  Light\_1 load: 7.25 %  Low load: 10.60 % | Light\_0 load: 3.61 %  Light\_1 load: 4.71 %  Low load: 6.24 % | Baseline: {8 SSBs in burst, ssb-periodicity: 20 ms}  Reduced: {2 SSBs in burst, ssb-periodicity: 20 ms} | Traffic loads [RU]:  {28.56%, 17.42%, 6.03%} | | Light\_0 load: 2.82 %  Light\_1 load: 3.89 %  Low load: 6.30 % | Light\_0 load: 1.89 %  Light\_1 load: 2.43 %  Low load: 3.40 % | Baseline: {8 SSBs in burst, ssb-periodicity: 40 ms}  Reduced: {2 SSBs in burst, ssb-periodicity: 40 ms} | Traffic loads [RU]:  {28.56%, 17.42%, 6.03%} | | Light\_0 load: 1.01 %  Light\_1 load: 1.58 %  Low load: 3.66 % | Light\_0 load: 0.48 %  Light\_1 load: 0.62 %  Low load: 0.88 % | Baseline: {8 SSBs in burst, ssb-periodicity: 160 ms}  Reduced: {2 SSBs in burst, ssb-periodicity: 160 ms} | Traffic loads [RU]:  {28.56%, 17.42%, 6.03%} |   Frequency domain  Table 4: Preliminary evaluation results of BWP adaptation   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | NW energy saving scheme | ESG | UPT loss | Scheduling latency | Packet latency | Evaluation methodology/baseline assumption | Note | | BWP adaptation  from 100 MHz to 60 MHz. | Cat 1 with deep sleep: 39.41 % | 29.93 % | No increase | 41.34% | Baseline: 100MHz with 55 dBm  Reduced: 60 MHz with 53 dBm. | Baseline traffic load:  28.56 % RU  Reduced BW traffic load: 20.42 % RU | | |
| **Company** | **Comments** |
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#### Source 8: NTT DOCOMO

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| Evaluation on sleep modes     1. Relative power consumption (b) Packet throughput   Fig. 1 Power consumption and throughput performance on different sleep modes  Evaluation on power domain techniques    (a) Relative power consumption (b) Packet throughput  Fig. 2 Power consumption and throughput performance on static power reduction | |
| **Company** | **Comments** |
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#### Source 9: Qualcomm

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| Dynamic antenna port adaptation  Figure : Network energy consumption  Chart  Description automatically generated  Figure : Impact on UPT and coverage (DL SINR)  Dynamic TRP adaptation    Figure : Network energy consumption & UPT  Dynamic DL Tx power adaptation  Figure : NW energy consumption  Chart  Description automatically generated    Figure : Impact on UPT and coverage (DL SINR)  Dynamic UE-group PCell switching      **33%**  Figure : Comparison between 1-CC case and 2-CC case depending on cell loading | |
| **Company** | **Comments** |
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#### Source 10: Huawei/HiSilicon

([R1-2208425](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2208425.zip), submitted in AI 9.7.2)

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| Figure 4 Initial system-level simulation results for SSB/SIB1-less operation | |
| **Company** | **Comments** |
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#### Source 11: Fujitsu

([R1-2209023](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209023.zip), submitted in AI 9.7.2)

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| グラフ, 棒グラフ  自動的に生成された説明グラフ, 棒グラフ  自動的に生成された説明  Figure 5. Simulation results in terms of energy consumption and energy efficiency with and without TxRU adaptation  Table I. UPT performance with and without TxRU adaptation   |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | 30% RUR | | 50% RUR | | | Baseline | Dynamic TxRU adaptation | Baseline | Dynamic TxRU adaptation | | 5% UPT [Mbps] | 27.1 | 27.5 | 17.6 | 17.6 | | 50% UPT [Mbps] | 55.2 | 53.5 | 42.3 | 41.6 | | Average UPT [Mbps] | 64.6 | 63.1 | 51.6 | 50.7 | | |
| **Company** | **Comments** |
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#### Source 12: Intel

([R1-2209064](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209064.zip), submitted in AI 9.7.2)

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| --- | --- |
| Time domain        Figure 17. Comparison of cell throughput and power consumption in load, light, and medium load scenarios with 20 or 160 msec SSB periodicity (Cat 1 BS Power Model)  Frequency domain    Figure 27. Comparison of slot utilization with average of 0.57 user per cell (corresponding to very low load of RU of 1.1% in case of full BW usage) and using 100%, 50%, and 25% of the system bandwidth    Figure 28. Comparison of slot utilization with average of 3.29 user per cell (corresponding to low load of RU of 7.9% in case of full BW usage) and using 100%, 50%, and 25% of the system bandwidth      Figure 29. Comparison of slot utilization with average of 7 user per cell (corresponding to light load of RU of 20.9% in case of full BW usage) and using 100%, 50%, and 25% of the system bandwidth  Spatial domain    Figure 30. Comparison of slot utilization with average of 3.28 user per cell (corresponding to low load of RU of 7.9% in case of full BW and full TxRx usage) and using 100%, 50%, and 25% of the number of antenna elements.    Figure 31. Comparison of slot utilization with average of 7 user per cell (corresponding to light load of RU of 20.9% in case of full BW and full TxRx usage) and using 100%, 50%, and 25% of the number of antenna elements.    Figure 32. Comparison of slot utilization with average of 11 user per cell (corresponding to medium load RU of 38.3% in case of full BW and full TxRx usage) and using 100%, 50%, and 25% of the number of antenna elements.  Power domain    Figure 33. Comparison of slot utilization with average of 3.28 user per cell (corresponding to low load of RU of 7.9% in case of full BW and full TxRx usage) and using 100%, 25%, and 6.25% of maximum transmit power.    Figure 34. Comparison of slot utilization with average of 7 user per cell (corresponding to light load of RU of 20.9% in case of full BW and full TxRx usage) and using 100%, 25%, and 6.25% of maximum transmit power.    Figure 35. Comparison of slot utilization with average of 11 user per cell (corresponding to medium load RU of 38.3% in case of full BW and full TxRx usage) and using 100%, 25%, and 6.25% of maximum transmit power. | |
| **Company** | **Comments** |
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#### Source 13: MediaTek

([R1-2209501](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2209501.zip), submitted in AI 9.7.2)

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| Ref.  10.6%↓  Ref.  28.5%↓  Figure 2: BS power consumption comparison with aligned UE DRX offsets (VoIP traffic)  3.0%↓  Ref.  7.4%↓  0.3%↓  0.1%↓  Ref.  Figure 7: BS power consumption comparison with SSB/SIB1-less SCell (video traffic for CA setting)  Ref.  21.7%↓  20.3%↑  4.8%↑  Ref.  19.1%↓  Ref.  15.8%↓  16.3%↓  Figure 8: BS power consumption and data latency comparison with reduced #TxRU in light load (15% - 30%) case with video traffic  Ref.  6.8%↑  31.3%↓  25.3%↓  81.1%↑  36.6%↓  Ref.  Ref.  26.8%↓  Figure 9: BS power consumption and data latency comparison with reduced #TxRU in medium load (30% - 50%) case with video traffic  Figure 10: BS power consumption and data latency comparison with reduced PDSCH power/PSD-level in light load (15% - 30%) case with video traffic  Figure 11: BS power consumption and data latency comparison with reduced PDSCH power/PSD-level in medium load (30% - 50%) case with video traffic | |
| **Company** | **Comments** |
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#### Source 14: CEWiT

([R1-2210113](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110b-e/Docs/R1-2210113.zip), submitted in AI 9.7.2)

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| Fig. 1: Energy savings by mandating transmission of lighter version of SSB by inactive gNBs for various loads | |
| **Company** | **Comments** |
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# Annex –

## A. Agreements@AI 9.7.1

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| @RAN1#109-e  [**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).  @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.**  **Agreement**  **For initial evaluations, there is always a non-sleep mode assumed between adjacent sleep modes.**  **Agreement**  **Companies to report the assumption details for the reception of a low-power UL channel/signal, if used, including power states, additional transition energy, and transition times, receiver details (e.g. architecture and receiver sensitivity), and other impact/change on the power consumption model.**  **Agreement**  **Update the RAN1 agreements with the following changes**  In the evaluation,   * 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 * 15~~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. | |   **Proposal 2.1.3.2-1-rev2:**   * **During the transition time period,** **relative power of sleep mode is assumed to be consumed. Additional transition energy and total transition time also include energy and time for both ramping down and ramping up ~~spent in two-way (ramping down and up) during the transition period is considered~~.** * ~~(Working Assumption) for set 1, the additional energy (unit in relative power\*(duration in~~ *~~ms~~*~~)) is~~  |  |  |  | | --- | --- | --- | | ~~Power state~~ | ~~Additional transition energy~~ | | | ~~Category 1~~ | ~~Category 2~~ | | ~~Deep sleep~~ | ~~1350~~ | ~~22500~~ | | ~~Light sleep~~ | ~~90~~ | ~~1088~~ |   **Proposal 2.1.4.2-1-rev1:**   * **The total transition time for set 2 and set 3 is the same as that for set 1.** * **Companies are encouraged to check the input and values provided in section 2.1.4.2 of R1-2208312 for further determination.**   **Conclusion**   * **Companies are encouraged to check discussion in section 2.2.2 of R1-2208312 for scaling discussion in the next meeting.**   **Proposal 3.1.2-1-rev2:**   * **FFS whether to set exact requirements/QoS target for UPT and/or latency impact** * **Other KPIs can be optionally reported, conditioned with clear definition/descriptions provided.** * **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).**   **Proposal 3.2.2-1-rev1:**  **It is up to company report the use of UE C-DRX.**   * **the baseline configuration (for alignment/calibration) for C-DRX, if reported, can be as below;** * **Other inactivity timer values can be optionally reported**  |  |  |  |  | | --- | --- | --- | --- | | **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 |   **Proposal 3.3.2-1-rev2:**   * **For FR1, adopt the Reference SLS configurations in Annex-A in R1-2208312 as baseline SLS assumptions.**   + **Other carrier frequencies can be optionally considered.** * **FFS For FR2 adopt the Reference SLS configuration used in Dense Urban Config.B in Table2 of RP-180524 for IMT-2020 with the following clarification/update as initial SLS assumption.**   + **BS antenna configurations**     - **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)**   + **Traffic model & UE density**     - **Follow previous agreements with adjusted UE density**   + **Total transmit power per TRxP**     - **Value scaled from that in set 3 reference configuration considering BW** * **Further adjustment/clarification can be discussed in the next meeting.** |

## B. Agreed SLS configurations for FR1

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

|  |  |  |  |
| --- | --- | --- | --- |
|  | Parameters | | |
| Basic parameters | Channel model | ~~3D/HF-Uma based on TR 38.901~~  (low-loss O2I penetration model) | ~~3D/HF-Uma based on TR 38.901~~  (low-loss O2I penetration model) |
| 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 | 4.0GHz or 2.6GHz |
| Multiple access | OFDMA | OFDMA |
| Duplexing | FDD (for set 2 ref. config) | TDD (for set 1 ref. config.) |
| 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 | Follow reference configuration, (equal split of 10 MHz for UL and DL) | Follow reference configuration |
| 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 | Follow previous RAN1 agreements | Follow previous RAN1 agreements |
| 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, MP, NP,) = (8, 8, 2, 1, 1, 4, 8).  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 | Company to report the assumptions | Company to report the assumptions |
| 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

## 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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