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

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

**Agenda Item: 9.7.1**

**Source: Moderator (Huawei)**

**Title: FL summary for Post-110-R18- NW\_ES2**

**Document for: Discussion and Decision**

# Introduction

This triggers the email discussion of the following:

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| * [Post-110-R18- NW\_ES2] Email discussion on remaining details of NW EnSav performance evaluation methodology by September 1 – Yi (Huawei)
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Note there is discrepancy on the deadline between that in Chair notes and that in the email from Chair over reflector. Sep. 1 is intended so let’s be prepared. Initial input are expected by Monday 23:59 UTC time.

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

## Recommendations for email approval:

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# Energy consumption model for BS

## Remaining issues for power consumption model

### Inter-sleep mode transition

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

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

**Proposal 2.1.1-1:**

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

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| **Company** | **Comments** |
| CATT | In our understanding, the transition time of deep/light sleep is to the micro sleep, which is also considered in Rel-16 UE power saving since the gNB’s wakeup from deep/light sleep might not at the symbol/slot for immediate DL Tx/UL Rx. gNB could easily transition to non-sleep state of DL Tx or UL Rx without transition time. Thus, the transition time should be defined in the same way is to transition between deep/light sleep and micro sleep (standby for any active Tx/Rx). The transition time between deep/light sleep mode to micro sleep in standby active Tx/Rx should be considered as the same as transition between deep/light sleep mode to active Tx/Rx.  |
| ZTE, Sanechips | We support that there is always a non-sleep mode assumed between adjacent sleep modes.For network power consumption modeling and evaluation, transition between sleep modes without entering non-sleep mode doesn’t result in significantly difference in evaluation results in terms of power saving gain, latency, etc, but greatly increases the simulation complexity. For the transition between sleep modes, more discussion are required within the limited remaining SI phase, for example, how to trigger the transition into a deeper/lighter sleep state, how to calculate the associated transition energy. In the From our understanding, the benefits of considering transition between sleep modes are not clear, we do not think an additional power consumption model is needed. |
| CMCC | Support that there is always a non-sleep mode assumed between adjacent sleep modes. |

### Handling of low-power UL signal

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

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

**Proposal 2.1.2-1:**

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

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| **Company** | **Comments** |
| CATT | The Power model of low-power UL channel would depend on the receiver sensitivity, which would decide the coverage of the signals. The low-power UL channel has specific designed to minimize the power consumption. The proponent should provide detailed front end receiver architecture and the receiver sensitivity of the operation frequency band for the low power uplink reception in order to define the power model.  |
| ZTE, Sanechips | Compared with DL transmission, the power consumption of UL reception is very small. But the exact power value of the low power UL reception depends on detailed implementation, we think it is okay to let companies to report the details including transition time/energy, etc.Furthermore, we agree with FL that this low-power UL reception should be applied to other UL signals, we don’t need to limit it to WUS. |
| CMCC | The energy consumption for UL reception and processing only accounts about 10% of BS energy consumption. In such a small account of energy, the difference of energy consumption for receiving WUS or normal channel/signal can be ignored.  |

### Total transition time and additional transition energy

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

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

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

**Proposal 2.1.3-1:**

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

* $E\_{i}≈\frac{1}{2}×∆×T\_{i}$

**where**

* $∆$ **is the difference of the relative power between sleep mode** $i$ **and micro sleep**
* $T\_{i}$ **is the corresponding total transition time of sleep mode** $i$**, which is a two-way time, assuming no inter-sleep state transition.**

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

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| **Company** | **Comments** |
| CATT | The formula is correct. However, the transition energy and transition time should have only single value similar to that defined in Rel-16 UE power saving. The transition energy should be defined as single value of the transition between deep/light sleep and micro sleep, which is standby of active Tx/Rx.  |
| ZTE, Sanechips | Proposal 2.1.3-1 is a good start to calculate the additional transition energy between sleep mode and non-sleep mode.What’s more, a condition should be met that the BS power consumption when the BS enter into a deeper sleep mode should lass than that of the BS enter into a lower sleep mode. |
| CMCC | As FL’s clarification, the calculation of total transition time would be the same between using micro-sleep and using non-sleep as reference, we prefer to use non-sleep as reference. It is more realistic for network operation, when the conditions are satisfied, BS will wake up to active mode for DL transmission or UL reception.Besides, the additional transition energy may be also defined as the energy that BS enters from non-sleep mode to a sleep mode for the consistent definition for transition time and transition energy.Furthermore, in Proposal 2.1.3-1, $E\_{i}$ represents the energy that BS enters from **non-sleep mode** to a sleep mode $i$, $∆$ is the difference of the relative power between sleep mode $i$ and **micro sleep**, could FL clarify why $E\_{i}$ is using non-sleep mode as reference and$ ∆$ is using micro sleep as reference. |

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

Although there were some input during the meeting (see [Power state and transition time-offlineThursday\_v02.docx](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/drafts/9.7%28FS_Netw_Energy_NR%29/9.7.1/FLS3/Power%20state%20and%20transition%20time-offlineThursday_v02.docx)), in general it seems incomplete and would be better to allow for another round of input considering that companies may understand more on how we use the input to determine the values. In the first round, please companies provide your values based on the [Templates](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/drafts/9.7%28FS_Netw_Energy_NR%29/9.7.1/Post-110-R18-NW_ES2/Template_collection%20of%20relative%20power_EnSav_v00.xlsx) in the [folder](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/drafts/9.7%28FS_Netw_Energy_NR%29/9.7.1/Post-110-R18-NW_ES2/Template_collection%20of%20relative%20power_EnSav_v00.xlsx) for set 2 and set 3 reference configuration respectively. Plan is to draw Working Assumptions (as that for set 1) for this post email discussion. The input for set 1 is also attached in the xls sheet for information.

Other comments can be provided below, if any.

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| **Company** | **Comments** |
| CATT | We could complete set 2 and set 3 at next meeting when more inputs would be provided. |
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## Scaling

The scaling based on a single formula gains general support in the first round while three companies prefer per domain scaling in the second round. Further offline of offline discussion led to three alternatives to be further discussed (see Recommendation part in the [document](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/drafts/9.7%28FS_Netw_Energy_NR%29/9.7.1/FLS3/offline/R1-2208216%20110-NWES%20EVA%20FLS3_v01_update_FL3_proposals-Friday%20offline.docx)), which seems to bring the discussion back to the starting point: slot level v.s. symbol level, jointly v.s. separately. Also, the Alt 4 recorded in the documents seems incomplete, so further clarification/corrections may be required.

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

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

**Proposal 2.2-1**

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

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| **Company** | **Comments** |
| CATT | The power scaling model should be defined for individual domain, e.g., time, frequency, spatial, and power with simple model of static component + dynamic component. The static component is the fraction of fixed power consumption associated with the overall power consumption in a given domain. When the power scaling in time domain to derive the power consumption for fractions number of the Tx symbols in a slot, the static component is the power consumption of option 1 of micro sleep “P3”. However, the static component of frequency, spatial and power domain scaling is not equal to “P3” since they are the fraction of total active Tx/Rx, which is option 2 of a\*P4.  The dynamic component would be defined in association with the variation in time, frequency, spatial and power domain. For joint power scaling model, we should discuss it once we finalize the individual power scaling for each domain.  |
| ZTE, Sanechips | For Alt 1-1, regarding the static part of the power, P3 is a good choice because the power consumption of micro sleep should be the minimum value of the power consumption of active DL. For the dynamic part, Alt 1-1 can reflect the impact of the frequency domain, spatial domain, and power domain on the power consumption of active DL.For Alt 2, it is similar with UE power consumption model. It is assumed that scaling factor of individual domain can be directly multiplied if adaptation in multiple domains is considered in the evaluation. It should be noted that with this assumption, it should be additionally consider a lower bound of scaling, i.e., the active DL power consumption should be larger than micro sleep even adaptation in multiple domains is used. That is, the power consumption of active DL is equal to min(P3, Alt 2).What’s more, with a proper design, Alt 1 and Alt 2 may not differ greatly from evaluation respective. Considering the scaling factor calculation for multi-domain adaption, alt-1 is slightly preferred. And we are also okay with the majority views.For the power consumption model, slot level is simple and preferred.For the time domain scaling, the power consumption should be calculated according to the number of active symbols within a slot. And the symbol without active DL should be treated as micro sleep. Therefore, the time domain scaling can be α\*P4+(1-α)\*P3, wherein P4 is the power for active DL, P3 is the power of micro-sleep, α is the ratio of active DL occupation within a slot.For the scaling of inter-band CA, Alt 1-F-1is preferred. For inter-band CA, the RF chains and other components of difference cells are independent. Therefore, the total energy consumption of multiple cells is basically equal to the sum of the power consumption of each cell. |

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

**Proposal 2.2-2**

* **The BS power consumption for active UL is provided by** $P\_{static}^{UL}+s\_{a}\*P\_{dynamic}^{UL}$

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| **Company** | **Comments** |
| CATT | We need to discuss the UL power scaling similar to DL power scaling.  |
| ZTE, Sanechips | Compared with DL transmission, the power consumption of UL reception is very low. Since the PA can be muted when there is no DL transmission, the scaling rule/factor for UL is different from DL |

# Methodology

## KPI

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

**Proposal 3.1-1:**

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

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| **Company** | **Comments** |
| CATT | We are generally fined with the proposal. The UPT loss/gain would depend on the network energy saving techniques and their associated power saving gain. We need to look at the values of UPT loss and network power saving gain in bundle.  |
| ZTE, Sanechips | Okay. |
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## C-DRX Configurations

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

**Proposal 3.2 -1:**

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

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

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| **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 msFR2: 4 ms | FR1: 10 msFR2: 5 ms | FR1: 4 msFR2: 2 ms |

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| **Company** | **Comments** |
| CATT | We are OK with the assumption |
| ZTE, Sanechips | Okay. |

## Simulation assumption

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

**Proposal 3.3-1:**

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

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| **Company** | **Comments** |
| CATT | We are OK with the proposal |
| ZTE, Sanechips | For FR1 FDD, the frame structure definition is not needed. |

# Others

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

# References

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| --- | --- | --- | --- |
| [1] | [R1-2205755](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205755.zip) | BS Energy Consumption Model and Sleep States | FUTUREWEI |
| [2] | [R1-2205860](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205860.zip) | Discussion on performance evaluation for network energy saving | Huawei, HiSilicon |
| [3] | [R1-2205999](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2205999.zip) | Discussion on performance evaluation of network energy savings | Spreadtrum Communications |
| [4] | [R1-2206053](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206053.zip) | Discussions on NW energy savings performance evaluationns on | vivo |
| [5] | [R1-2206074](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206074.zip) | NW energy savings performance evaluation | Nokia, Nokia Shanghai Bell |
| [6] | [R1-2206141](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206141.zip) | On network energy savings evaluation methodology and power model | Panasonic |
| [7] | [R1-2206172](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206172.zip) | Discussion on NW energy savings performance evaluation | Fujitsu |
| [8] | [R1-2207685](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/R1-2207685.zip) | Discussion on NW energy savings performance evaluation | OPPO |
| [9] | [R1-2206411](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206411.zip) | Evaluation Methodology and Power Model for Network Energy Saving | CATT |
| [10] | [R1-2207694](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/R1-2207694.zip) | Discussion on Network energy saving performance evaluations | Intel Corporation |
| [11] | [R1-2206665](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206665.zip) | Performance evaluation for network energy saving | InterDigital, Inc. |
| [12] | [R1-2206696](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206696.zip) | Discussion on BS energy saving model and evaluation | China Telecom |
| [13] | [R1-2206838](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206838.zip) | NW Energy Savings Performance Evaluation | Samsung |
| [14] | [R1-2206925](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206925.zip) | Discussion on network energy saving performance evaluation | CMCC |
| [15] | [R1-2206979](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2206979.zip) | NW energy savings performance evaluation | MediaTek Inc. |
| [16] | [R1-2207037](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207037.zip) | Discussion on performance evaluation for network energy savings | LG Electronics |
| [17] | [R1-2207059](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207059.zip) | Discussion on NW energy saving performance evaluation | ZTE, Sanechips |
| [18] | [R1-2207079](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207079.zip) | Evaluation and power model for network energy savings | Rakuten Mobile, Inc |
| [19] | [R1-2207245](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207245.zip) | NW energy savings performance evaluation | Qualcomm Incorporated |
| [20] | [R1-2207343](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207343.zip) | On NW energy savings performance evaluation | Apple |
| [21] | [R1-2207418](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207418.zip) | Discussion on NW energy savings performance evaluation | NTT DOCOMO, INC. |
| [22] | [R1-2207437](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_110/Docs/R1-2207437.zip) | Network energy consumption modeling and evaluation | Ericsson |
| [23] | [R1-2208216](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_110/Inbox/R1-2208216.zip) | FL summary#3 for EVM for NR NW energy savings  | Moderator (Huawei) |

# Annex –

## A. Reference SLS configurations

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

|  |  |
| --- | --- |
|  | Parameters |
| Basic parameters | Channel model | 3D/HF-Uma based on TR 38.901 | 3D/HF-Uma based on TR 38.901 |
| Device deployment | 80% indoor, 20% outdoor | 80% indoor, 20% outdoor |
| Inter-site distance | 500m | 500m |
| Network Topology | 7\*3 Sector | 7\*3 Sector |
| Carrier Frequency | 2.1GHz | ~~4GHz~~ 2.6GHz |
| Multiple access | OFDMA | OFDMA |
| Duplexing | FDD | TDD |
| Numerology | 15KHz,14 OFDM symbol slot | 30kHz,14 OFDM symbol slot |
| Guard band ratio on simulation bandwidth | FDD: 6.4% (104RB for 15kHz SCS and 20 MHz BW) | TDD: 2.08% (272 RB for 30kHz SCS and 100 MHz bandwidth) |
| Simulation bandwidth | FDD: 20 MHz, (equal split of 10 MHz for UL and DL) | TDD: 100 MHz |
| Frame structure | Full downlink | DDDSU |
| UT attachment | Based on RSRP | Based on RSRP |
| Wrapping around method | Geographical distance based wrapping | Geographical distance based wrapping |
| Traffic model | Burst buffer with load <10%, 30%, 50% Packet size: 0.5M, 0.1M | Burst buffer with load <10%, 30%, 50%Packet size: 0.5M, 0.1M |
| BS parameters | BS antenna height | 25 m | 25 m |
| BS noise figure | 5 dB | 5 dB |
| BS antenna element gain | 8 dBi | 8 dBi |
| Antenna configuration at TRxP | For 32T: (M,N,P,Mg,Ng; Mp,Np) = (8,8,2,1,1;2,8)(dH, dV)=(0.5, 0.8)λ | For 64T:  ~~(M,N,P,Mg,Ng; Mp,Np) = (12,8,2,1,1;4,8)(dH, dV)=(0.5, 0.8)λ;~~(M, N, P, Mg, Ng) = (8, 8, 2, 1, 1).based on 38.802 |
| UE parameters | UE power class | 23dBm | 23dBm |
| UE noise figure | 9 dB | ~~7~~ 9 dB |
| UE antenna element gain | 0 dBi | 0 dBi |
| UE antenna height | Outdoor UEs: 1.5 m; Indoor Uts: 1.5m or consider floor height | Outdoor UEs: 1.5 m; Indoor Uts: 1.5m or consider floor height |
| Antenna configuration at UE | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2)(dH, dV)=(0.5, N/A)λ | For 4R: (M,N,P,Mg,Ng; Mp,Np)= (1,2,2,1,1; 1,2)(dH, dV)=(0.5, N/A)λ |
| Transmission parameters | Modulation | Up to 256 QAM | Up to 256 QAM |
| Transmission scheme | SU-MIMO  | SU-MIMO  |
| SU dimension | For 4Rx: Up to 4 layers | For 4Rx: Up to 4 layers |
| DL CSI measurement | Non-precoded CSI-RS based | Precoded CSI-RS based |
| DL codebook | Type I/II codebook | non-PMI transmission |
| SRS transmission | N/A | For UE 4 Tx ports: Non-precoded SRS |
| CSI feedback | PMI, CQI, RI: every 5 slot; Subband based  | CQI, RI: every 5 slot; Subband based  |
| Interference measurement | SU-CQI; CSI-IM for inter-cell interference measurement | SU-CQI; CSI-IM for inter-cell interference measurement |
| Scheduling | PF | PF |
| Receiver | MMSE-IRC | MMSE-IRC |
| Channel estimation | Non-ideal | Non-ideal |
| Common RS | SSB/SIB1 period | 20ms | 20ms |
| SSB time resource | ~~Slot#0~slot#3,~~ Slot#0, slot#1, 2 SSB per slot4 symbols for each SSB | ~~Slot#0, slot#1~~ Slot#0~slot#3, 2 SSB per slot4 symbols for each SSB |
| SSB frequency resource | 20RB | 20RB |
| SIB1 time resource | ~~slot#10 ~ slot#17~~slot#10 ~ slot#13 | ~~slot#10 ~ slot#13~~slot#10 ~ slot#17 |
| SIB1 frequency resource | 40RB | 40RB |

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

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

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

- P: Number of polarizations

- Mg: Number of panels in a column;

- Ng: Number of panels in a row;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## C. SID abstraction

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

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

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

Note 1: legacy UEs should be able to continue accessing a network implementing Rel-18 network energy savings techniques, with the possible exception of techniques developed specifically for greenfield deployments.Note 2: the study of energy savings specifically for IAB is not part of the scope.The study should coordinate with RAN4 as needed. |

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Contact** | **Email address** |
| Apple | Sigen Ye | sigen\_ye@apple.com |
| NOKIA/NSB | Naizheng Zheng | naizheng.zheng@nokia-sbell.com |
| Samsung | Junyung Yi | junyung.yi@samsung.com |
| ZTE,Sanechips | Mengzhu CHEN | chen.mengzhu@zte.com.cn |
| ZTE,Sanechips | Youjun HU | hu.youjun1@zte.com.cn |
| Panasonic | Hongchao LI | Hongchao.Li@eu.panasonic.com |
| Huawei, HiSilicon | Yi Wang | wangyi6@huawei.com |
| Huawei, HiSilicon | Xiaolei TIE | tiexiaolei@huawei.com |
| MediaTek | Weide Wu | weide.wu@mediatek.com |
| Xiaomi | Fu Ting | futing@xiaomi.com |
| CMCC | Yan Li | liyanwx@chinamobile.com |
| CMCC | Lijie Hu | hulijie@chinamobile.com |
| China Telecom | Hang Yin | yinh6@chinatelecom.cn |
| vivo | Gen Li | reagan.li@vivo.com |
| DOCOMO | Yugen Takahashi | yugen.takahashi@docomo-lab.com |
| DOCOMO | JIANG Yu | jiangy@docomolabs-beijing.com.cn |
| QC | Konstantinos Dimou | kdimou@qti.qualcomm.com |
| InterDigital | Erdem Bala | erdem.bala@interdigital.com |
| Spreadtrum | Huayu Zhou | huayu.zhou@unisoc.com |
| OPPO | Hao Lin | lin.hao@oppo.com |
| OPPO | Zuomin Wu | wuzuomin@oppo.com |
| Fujitsu | Tsuyoshi Shimomura | tcsimomura@fujitsu.com |
| Intel | Toufiqul Islam | toufiqul.islam@intel.com |
| Ericsson | Ravikiran Nory | Ravikiran.Nory@ericsson.com |
| Ericsson | Ajit Nimbalker | Ajit.Nimbalker@ericsson.com |

## E. Agreements during RAN1#110

**Agreement**

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

**Agreement**

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

**Agreement**

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

**FL2 Proposal 2.1.6-1 –rev2**

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

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

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

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

**Working Assumption**

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

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

**Alternative Proposal 3.1.1.1-1**

For evaluation purpose,

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

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

**FL2 Proposal 3.3.1.1-1:**

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

**FL1 Proposal 3.2-1:**

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

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

**FL2 Proposal 2.3.1-1:**

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

**Alternative Proposal 3.1.3-1:**

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