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

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

**Agenda Item: 9.7.1**

**Source: Moderator (Huawei)**

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

**Document for: Discussion and Decision**

# Introduction

This summary contains discussion for the following email discussion:

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

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

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

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

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# Energy consumption model for BS

## Power states and transition time/energy

### Sleep mode definition

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

For a sleep mode,

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

**FL1 Proposal 2.1.1-1:**

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

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

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

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

**FL1 Proposal 2.1.1-2:**

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

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### Sleep mode categorization

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

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

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

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

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

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

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

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

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

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

**FL1 Proposal 2.1.2-1:**

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

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### Non-sleep modes

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

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

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

**FL1 Question 2.1.3-1:**

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

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| **Company** | **Comments** |
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Other remaining issues include UL modeling for FDD and TDD.

For UL reception and DL transmission in TDD,

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

For simultaneous UL reception and DL transmission in FDD,

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

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

**FL1 Proposal 2.1.3-2:**

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

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| **Company** | **Comments** |
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### Transition procedure

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

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

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

**FL1 Proposal 2.1.4-1:**

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

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

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

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

**FL1 Question 2.1.4-2:**

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

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

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

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

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

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

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

**FL1 Proposal 2.1.5-1:**

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

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

## Scaling

### General aspect

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

**FL1 Proposal 2.2.1-1:**

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

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| **Company** | **Comments** |
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### Scaling details

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

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

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

**FL1 Proposal 2.2.2-1:**

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

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| **Company** | **Comments** |
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## Reference configuration

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

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

For FR1 FDD TxRx:

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

For FR1 FDD total DL power level:

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

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

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

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

**FL1 Question 2.3-1:**

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

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**FL1 Proposal 2.3-2:**

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

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**FL1 Proposal 2.3-3:**

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

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## Other general aspects for the framework

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

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

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

**FL1 Question 2.4-1:**

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

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

**FL1 Proposal 2.4-2:**

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

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

**FL1 Proposal 2.4-3:**

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

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# Methodology

## KPI and metrics

### Load definition

The discussion for load definition is summarized.

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

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

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

**FL1 Proposal 3.1.1-1:**

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

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

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

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| **Company** | **Comments** |
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### KPI

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

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

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

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

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

**FL1 Proposal 3.1.2-1:**

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

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

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

**FL1 Proposal 3.1.2-2:**

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

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| **Company** | **Comments** |
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### Gain definition

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

**FL1 Proposal 3.1.3-1:**

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

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| **Company** | **Comments** |
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## Traffic model

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

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

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

**FL1 Proposal 3.2-1:**

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

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

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| **Company** | **Comments** |
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Regarding UE C-DRX configurations,

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

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

**FL1 Proposal 3.2-2:**

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

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

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |

## Evaluation scenario

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

For FR1, the BS to be assumed for study is

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

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

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

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

Given the interest of study,

**FL1 Proposal 3.3-1:**

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

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |

## Simulation assumption

### SLS assumptions

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

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

**FL1 Proposal 3.4.1-1:**

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Parameter** | **Comments** |
| *Company A* | *Channel model* | *The channel model should xxx.* |
| *Device deployment* | *The parameter is yyy.* |
|  |  |  |
|  |  |  |

### Other EVA assumptions/settings

There are other issues as below.

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

**FL1 Proposal 3.4.2-1:**

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

|  |  |  |
| --- | --- | --- |
| **Company** | **Issue** | **Comments** |
|  |  |  |
|  |  |
|  |  |  |
|  |  |  |

# Other issues/discussion points/missing proposals

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

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

# References

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

# Annex –

## A. Reference SLS configurations

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

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

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

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

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

- P: Number of polarizations

- Mg: Number of panels in a column;

- Ng: Number of panels in a row;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## C. SID abstraction

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

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

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

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

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

|  |  |  |
| --- | --- | --- |
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