3GPP TSG-RAN WG1 Meeting #122 R1-25xxxxx

Bengaluru, India, August 25th – 29th 2025

Agenda Item: 11.5

Source: Moderator (Ericsson)

Title: Feature Lead Summary: Idle Mode Energy Efficiency for 6GR

Document for: Discussion, Decision

# Introduction

This summary synthesizes observations and proposals from contributions submitted to 3GPP TSG RAN WG1 #122, focusing on **idle mode** energy efficiency for 6G Radio (6GR) in AI 11.5 and as described in the SID. The contributions address network energy savings (NES), user equipment power saving (UEPS), and joint NW-UE energy efficiency, emphasizing a holistic, day-one integration to overcome 5G’s limitations, such as backward compatibility constraints and fragmented feature deployment.

## Division among FLs

The FLs for the energy efficiency topic has agreed to the below approximate partitioning of topics. It is acknowledged that this partitioning is no exact science and topics may concern multiple RRC states, in which case the RRC state that is the dominant RRC state with respect to energy efficiency has been selected.

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| **IDLE mode** | **CONNECTED mode** |
| SSB | Spatial domain enhancements, including CSI enhancement, etc. |
| SIB1/system information | Frequency domain enhancements, including BWP, Multi-carrier/CA, etc. |
| WUS/WUR | Connected domain enhancements, including PDCCH monitoring reduction, cWUS operation, etc. |
| Cell DTX/DRX | Power domain enhancements (if not overlapping with waveform agenda) |
| Idle mode metrics and scenarios | Connected mode metrics and scenarios |
|  | Power model updates |

## Work plan

The energy efficiency work in the 6G Radio SI has been scheduled for three meetings and the objective is to come up with recommendations to consider for further studies in different agenda items. That means that after the present meeting, only two meetings remain. Rapporteur’s work plan for AI 11.5 Energy Efficiency is as follows [2]:

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| RAN1#122 (8 TU)   * Energy efficiency   + Identify candidate technologies for NW power saving, UE power saving, and joint mechanisms taking both NW and UE into account for power saving.   RAN1#122bis (10 TU)   * Energy efficiency   + Continue identifying candidate technologies for NW power saving, UE power saving, and joint mechanisms taking both NW and UE into account for power saving.   RAN1#123 (10 TU)   * Energy efficiency   + Complete identifying candidate technologies for NW power saving, UE power saving, and joint mechanisms taking both NW and UE into account for power saving, to be distributed to respective related agenda. |

In FL’s understanding, the term *candidate technology* represents a deliverable for the initial energy efficiency phase of the 6G radio SI.

The FL’s detailed deconstruction of the work plan is to divide the work into the following parts:

**RAN1 #122:** Agree on *topics* *for discussion* (during 3 meeting EE phase) as candidate technologies for NW/UE/joint power savings (i.e., in other AIs). In parallel, start discussion on energy efficiency models, metrics and scenarios for future use.

**RAN1 #122bis:** Agree on candidate technologies for NW/UE/joint power savings, evolve/refine agreed topics for discussion, if needed, and agree on further topics for discussion. Evolve discussions on models, metrics and scenarios.

**RAN1 #123:** Additional agreements on candidate technologies for NW/UE/joint power savings. Finalize models metrics and scenarios for future evaluation of energy efficiency.

# Discussion

## Day 1 functionality

### Companies’ views

Below is a composition of proposals relating to Day 1 requirements:

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| **Nokia - R1-2505131**   * **Proposal 2**: 6GR to consider NES-native design from the first release, with mandatory UE support of the corresponding energy-saving design and features. * **Proposal 2**: 6G should support cell DTX/DRX type of operation from day one to allow for sufficient BS sleep opportunities and achieve meaningful NES. * **Proposal 3**: The first 6G release should support a leaner carrier and signaling reduction (of SS/PBCH synchronization signals, system information, PRACH and paging occasions) including on-demand provisioning mechanisms for NES operations of cells operating under low/no load. * **Proposal 4**: The first 6GR release should support spatial adaptation (of Tx antenna ports/chains) and power adaptation, with enhanced CSI / SRS frameworks for NES operations. * **Proposal 5**: The first 6G release should support Cell DTX/DRX for all RRC states, including enhancements during Cell DTX/DRX inactive time and interactions with other features (such as spatial/power-domain adaptation). * **Proposal 13**: 3GPP specifies mandatory support for UE energy saving features from the first release of 6G.   **FUTUREWEI - R1-2505145**   * **Proposal 3**: Adopt from day one 5G UE power saving techniques as baseline mechanisms in 6G, such as:   + Duty-cycled based operations (iDRX, eDRX, cDRX),   + LP-WUS with at least PEI and DCP functionality replacement,   + Relaxed RRM measurements of neighboring cells, and   + Relaxed/Offloading to LP-WUR of serving cell measurements. * **Proposal 4**: Adopt and further enhance from day one the gNB power saving solutions developed in 5G (e.g., 5G NES features SCell with on-demand SSB or no SSB, on-demand SIB1, Cell DTX/DRX, etc.).   **Huawei, HiSilicon - R1-2505187**   * **Proposal 1**: 6GR ES design should take the following guidance principles:   + Key ES techniques for network and UE should be considered in all the aspects of the system design for 6GR Day1 as mandatory requirement     - including signal/waveform generation, initial access procedure, reference signal measurement/report, UL/DL control/data communication procedure, and UE state design etc. * **Proposal 2**: NES designs for single carrier deployment should be first studied in Day 1, in order to achieve comprehensive energy savings and provide future proof design for initial access, and NES for multi-carrier deployment can be studied later than single carrier since it will not impact initial access design.   **Ofinno - R1-2505677**   * **Proposal 4**: 6GR should support cell DTX/DRX for PCell and SCell from day-1.   **TCL - R1-2505698**   * **Proposal 4**: Discussion on how to include the impact of physical air interface design (e.g., waveform, coding, frame structure, sequence design, etc.) in 6G energy efficiency from day 1. * **Proposal 7**: Discuss potential power domain transmission technologies to improve sustainability in 6G day 1, at least including lower PAPR considerations, power control considerations, AI-assisted control and expanded deep sleep for both BS and UE PAs, adaptive emission masks and context-based EVM in RAN 1. * **Proposal 8**: Discuss whether/how to consider low-power signal design in 6G day 1 for 6G energy savings.   **Apple - R1-2505917**   * **Proposal 4**: Reduction/adaptation of common signals/channels should be considered in 6G day-1 to avoid backward compatibility issue and fully achieve the NES benefit.   + For OD-SIB1, how much additional NES gain can be obtained through SIB1 reduction in single cell case, under the assumption of increased SSB periodicity. * **Proposal 5**: Cell DTX/DRX should be considered in 6G day-1 to avoid backward compatibility issue and fully achieve the NES benefit.   **Lenovo - R1-2505995**   * **Proposal 1**: 6GR should aim to reduce TCO by utilizing the non-backward compatible opportunity provided by once in a decade new generation refresh by designing native energy efficient solution using various techniques such as time, frequency, spatial, power domain. * **Proposal 17**: Study a unified device power saving mechanism using following techniques to support diverse device types from day-1   + Time domain technique   + Frequency domain technique   + Spatial domain technique   + Measurement relaxations   + Processing domain technique   **CMCC - R1-2506101**   * **Proposal 4**: Support Cell DTX/DRX applies for both IDLE/CONNECTED mode, and more channels/signals from Day-1 in 6G.   **Vodafone, Bouygues Telecom, Deutsche Telekom - R1-2506134**   * **Proposal 3**: Study introduction of LP-WUS/WUR for all device types in 6GR air interface as a day-1 considering potential impacts and benefits.   **InterDigital - R1-2506146**   * **Proposal 1**: Support energy saving schemes for 6GR with following consideration:   + Support of power saving features from 6G Day-1   + Always on signal with longer periodicity   + Joint NW and UE energy saving   + Study all energy saving domains   + Flexible bandwidth adaptation * **Proposal 10**: Support LP-WUS targeting low power receiver capability from 6G Day-1.   **SK Telecom - R1-2506152**   * **Proposal 1**: For 6G energy efficiency, at least the following aspects should be studied:   + SSB/SIB1 transmission (longer periodicity, on-demand)   + Enhanced BWP mechanism   + Time-domain enhancement (UE-basis C-DRX vs. cell-basis DRX/DTX, LP-WUS/WUR)   + Reduced RRM measurement   + PEI   **AT&T - R1-2506237**   * **Proposal 1**: Energy efficiency is leveraged across the 6G RAN design and supported as a Day 1 mandatory feature of 6GR. * **Proposal 11**: Energy Efficiency metric(s) are included as 6GR key performance metrics from day 1.   **IIT Kanpur - R1-2506392**   * **Proposal 2**: 6GR Day 1 design, shall apply time/frequency adaptations of SS/PBCH transmission with more on-demand signal transmission and less always-on signals. Also on-demand SIB1 operation shall be supported from the Day 1 in 6G. * **Proposal 4**: 6GR Day 1 design shall enhance the low-power wake-up signal/receiver (LP-WUS/WUR) designs for improving UE power efficiency. |

### Summary

The Day 1 functionality proposals collectively address the critical need to integrate energy efficiency as a foundational principle in the initial 6G Radio (6GR) specification, overcoming the limitations of 5G NR where energy-saving features were introduced incrementally in later releases (e.g., Rel-16 to Rel-19), leading to fragmented adoption, optional implementation, and suboptimal effectiveness due to backward compatibility constraints. These proposals emphasize embedding energy-efficient mechanisms from Day 1, including:

* **Network Energy Savings (NES)**: Proposals advocate for leaner carrier designs, reduced signaling (e.g., on-demand SS/PBCH, SIB1, PRACH, paging), and Cell DTX/DRX to maximize base station (gNB) sleep opportunities, addressing 5G’s inefficiencies where always-on signals (e.g., SS/PBCH every 20ms or SIB1 every 160ms) limited deep sleep modes, achieving 83.7% NES for Cat-1 and 52.5% for Cat-2 under low load (TR 38.864) (Nokia Prop. 3, FUTUREWEI Prop. 4, Apple Prop. 4, IIT Kanpur Prop. 2).
* **UE Power Saving (UEPS)**: Mandatory UE energy-saving features, such as low-power wake-up signals/receivers (LP-WUS/WUR), duty-cycled operations (iDRX, eDRX, cDRX), relaxed RRM measurements, and unified power-saving mechanisms across time, frequency, spatial, and processing domains, are proposed to support diverse device types (e.g., IoT, XR/AR) from Day 1 (Nokia Prop. 13, FUTUREWEI Prop. 3, Lenovo Prop. 17, Vodafone Prop. 3, InterDigital Prop. 10).
* **System Design**: Proposals emphasize integrating energy efficiency into all aspects of 6GR design, including waveform, coding, frame structure, initial access, and power domain techniques (e.g., low-PAPR, adaptive emission masks, AI-assisted control), to ensure a sustainable air interface that balances performance, latency, and coverage (Huawei Prop. 1, TCL Prop. 4, Prop. 7, Prop. 8).
* **Performance Metrics**: Energy efficiency is proposed as a mandatory key performance indicator (KPI) from Day 1 to ensure evaluations reflect total system power consumption, avoiding 5G’s fragmented approach (AT&T Prop. 11).
* **Avoiding Backward Compatibility Issues**: By prioritizing single-carrier deployments and non-backward compatible designs, the proposals aim to embed energy-saving features natively, avoiding 5G’s challenges where features like PDCCH skipping and on-demand signaling were not universally adopted due to varying UE capabilities and complex network configurations (Huawei Prop. 2, Apple Prop. 4, Prop. 5).

These proposals collectively aim to create a lean, sustainable 6GR design that maximizes energy savings for both network and UE, reduces total cost of ownership (TCO), supports diverse use cases (e.g., IoT, NTN) in new spectrum (~7 GHz), and ensures energy efficiency is a core metric from the outset, enabling a more effective and unified approach compared to 5G’s incremental and constrained deployments.

### 1st round of FL comments and proposals

Many companies discuss the importance for Day 1 functionality for energy savings. In FL’s view, the whole purpose with the EE phase of the 6G Radio SI is to identify what such Day 1 functionality should be. Hence, there is little need to explicitly discuss this area further. Nevertheless, FL has one proposal related to Day 1 functionality, to get companies aligned regarding the ambitions with the EE phase.

FL Proposal 2.1‑1:

**RAN1 to strive for energy efficiency features that are mandatory from Day 1 to maximize energy gains.**

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| **Company** | **View** |
| Google | Yes, as companies views arranged by FL, we should avoid backward compatibility issues, which has been observed in 5G deployment. In such way, 6GR can benefit more from EE features. |
| InterDigital | Support |

## SSB requirements

### Companies’ views

Below is a composition of proposals relating to SSB requirements:

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| Nokia - R1-2505131   * **Proposal 3**: The first 6G release should support a leaner carrier and signaling reduction (of SS/PBCH synchronization signals, system information, PRACH and paging occasions) including on-demand provisioning mechanisms for NES operations of cells operating under low/no load. * **Proposal 6**: 6G studies to consider trade-off between network energy saving and UE complexity for initial access, including relaxing the default SS/PBCH periodicity. * **Proposal 7**: On-demand reference signal, e.g. SS/PBCH, operation shall be studied in 6G. * **Proposal 8**: For 6G design with SS/PBCH-less SCell operation, it is proposed to consider more flexible and scalable solutions that can fit in with different deployment scenarios.   FUTUREWEI - R1-2505145   * **Proposal 4**: Adopt and further enhance from day one the gNB power saving solutions developed in 5G (e.g., 5G NES features SCell with on-demand SSB or no SSB, on-demand SIB1, Cell DTX/DRX, etc.).   CATT - R1-2505297   * **Proposal 3**: In order to reduce the initial access delay due to sparse SSB, the solution of increasing the detection probability of SSB in one period of SSB burst set for initial cell selection should be studied, i.e., the UE can detect the PSS/SSS and decode the PBCH successfully within only one period of SSB burst set. * **Proposal 4**: To increase the detection probability of SSB in one period of SSB burst set for initial cell selection, SSB repetition with one SSB period, PBCH repetition within one SSB or PBCH with a lower coding rate should be studied. * **Proposal 5**: In 6GR, both network-triggered on-demand SSB and UE-triggered on-demand SSB for UEs in idle mode and connected mode should be introduced.   Spreadtrum (UNISOC) - R1-2505176   * **Proposal 5**: The following technologies can be studied for 6GR joint NW&UE power saving:   1. Reduce always-on signal and improve one-shot detecting performance of common signal/channel.   Xiaomi - R1-2505467   * **Proposal 7**: Default SSB periodicity extension and/or sparse synchronization raster should be considered for 6GR with taking UE requirement into account. * **Proposal 8**: Enhancements on RO adaptation and joint adaptation between RO and SSB can be considered in 6G to further reduce energy consumption. * **Proposal 9**: Joint condensed common signal/channel design and L1-based paging adaptation can be considered for 6GR NES.   Samsung - R1-2505589   * **Proposal 1**: Extend ‘Default’ SSB transmission periodicity longer than that of NR where a UE assumes the default value for initial cell selection. * **Proposal 2**: Set Day 1 SSB design principle accommodating coverage, diverse devise type, and energy efficiency.   ZTE - R1-2505607   * **Proposal 23**: Two stage SSB can be considered for UE and NW energy saving.   Ericsson - R1-2505625   * **Proposal 3**: 6GR should support default SSB periodicity of 160 ms to enable network deep sleep states while maintaining acceptable UE Idle mode performance. * **Proposal 5**: Study periodic bursts of SSB and SIB1 repetitions, where in each period multiple SSB and SIB1 repetitions are provided during a short time interval followed by a longer inactive interval. * **Proposal 6**: 6GR should support coordinating system information broadcast with other common signals/channels in order not to interrupt sleeping opportunities. * **Proposal 7**: Study a design with two GSCN raster subsets: a primary raster where UE assumes extended SSB periodicity and a secondary raster where UE assumes 20 ms SSB periodicity. * **Proposal 8**: Study enhancements of on-demand SSB to extend its applicability. * **Proposal 10**: SSB-less SCells operation should be included as baseline functionality in 6GR.   Tejas Networks Ltd. - R1-2505631   * **Proposal 19**: Enhancements to the SSB RO mapping and RAR can be studied to reduce the overhead of indicating SSBs to the base station and reduce the RAR overhead associated with each RO.   Ofinno - R1-2505677   * **Proposal 6**: 6GR should support OD-SSB and RAN1 to study cases where OD-SSB can be supported (e.g., PCell, SCell, on/off synch raster).   Quectel - R1-2505769   * **Proposal 1**: The OD-SSB/OD-SIB1 structure simplifying SSB/SIB1 needs discussion in 6G.   Panasonic - R1-2505789   * **Proposal 1**: To study synchronization signal design with options to be on-demand and adaptive in proper use cases.   Fraunhofer IIS, Fraunhofer HHI - R1-2505834   * **Proposal 5**: The 6GR study should investigate the possibility of increasing common signal periodicity and enable on demand common signals. * **Proposal 8**: The 6GR study should investigate the possibility of limiting the search area for synchronization signals so the UE does not have to search for the entire frequency grid.   LG Electronics - R1-2505858   * **Proposal 1**: Study the default periodicity of synchronization signal (SS) larger than 20 msec. * **Proposal 2**: Study on-demand SS and/or PBCH procedure and how to utilize SS/PBCH with adaptation for measurement.   Apple - R1-2505917   * **Proposal 4**: Reduction/adaptation of common signals/channels should be considered in 6G day-1 to avoid backward compatibility issue and fully achieve the NES benefit.   + For SSB, study to introduce two types of SSBs, one is an always-on signal and designed for RRC\_IDLE UEs and the other is on-demand SSB for RRC\_CONNECTED UEs.   Fujitsu - R1-2505972   * **Proposal 3**: Study the methods to enable on-demand transmission of cell common signals, such as SS, PBCH and SIB1, without limitations on applicable scenarios.   + The above aspects can be included in the initial access related discussions.   CAICT - R1-2506005   * **Proposal 1**: the coverage and the capacity carrier can be defined to enable dynamic on/off carrier, the SSB signal with long periodicity and on demand SSB can be transmitted in the capacity carrier ,and the always on RS can be transmitted in the coverage carrier.   Sharp - R1-2506014   * **Proposal 2**: To reduce unnecessary power consumption and signalling overhead, on demand reference signal in Pcell should be supported.   CMCC - R1-2506101   * **Proposal 2**: RAN1 to further consider and study the following case for single carrier scenario in 6GR:   + Case 1: no “6G SSB” transmitted on a carrier by default, and UE triggers “6G SSB” transmission (and other common channels/signals if needed) by demand:     - UE can pre-receives or pre-configures the uplink wake-up signal (UL-WUS) configuration, and transmits UL-WUS on the carrier with the assist of pre-stored information or other information (e.g. GNSS).     - 6G BS can turn off TX part while enabling RX part for UL-WUS reception (e.g. sliding window detection).   + Case 2: always-on “6G SSB” transmitted on a carrier with large periodicity by default (e.g. 160ms), and UE on-demand triggers short period SS transmission (and other common channels/signals if needed):     - The always-on “6G SSB” is used for cell detection, basic sync and provide necessary info (e.g. UL-WUS configuration), while the on-demand short period SS can be used for finer sync or fast measurement. * **Proposal 3**: RAN1 to further consider and study the following case for multi-carrier scenario in 6GR:   + The common signal transmission/reception procedure (e.g. SIB1 transmission, RACH reception) for multiple carriers can converge to one anchor carrier. Therefore, other carrier (i.e. NES carrier) can turning off or only transmit long period SS by default, so as to obtain more NES gain.   + NES carrier can be activated per NW guidance or UE demand and UE can initiate access on NES carrier, so as to achieve better UE experience or load balancing for network.   ETRI - R1-2506069   * **Proposal 9**: Study the definition of a default SSB periodicity substantially longer than 20 ms (e.g., 160 ms). * **Proposal 10**: Study increasing the SSB resource size to enable one-shot SSB detection. * **Proposal 12**: Study the use of on-demand SSB for several use cases.   InterDigital - R1-2506146   * **Proposal 5**: Minimize the need to configure always-on signals (e.g., only present with long periodicities of at least 160 ms). Support configurations that do not require provisioning of always-on signals on all carriers. * **Proposal 6**: Support on-demand signals/channels (e.g., configurable, dynamic (de)activation, and/or UE-requested) where it is applicable.   SK Telecom - R1-2506152   * **Proposal 1**: For 6G energy efficiency, at least the following aspects should be studied:   + SSB/SIB1 transmission (longer periodicity, on-demand)   Qualcomm - R1-2506222   * **Proposal 16**: Sync signal design should consider both NW energy saving, UE complexity and user experience.   AT&T - R1-2506237   * **Proposal 16**: Derive an updated 6GR initial access procedure with SSB periodicity extended beyond 20ms, followed by evaluation of the performance and the underlying energy savings. * **Proposal 17**: Study the pros and cons of the UE monitoring relatively fewer frequency raster points during the prospective 6GR initial access procedure.   NTT DOCOMO - R1-2506310   * **Proposal 4**: Study the following directions to achieve better energy efficiency than NR for initial access procedure:   + Study placing sync-raster on specific band   + Study longer periodicity from NR such as 40 ms, 80 ms   + To achieve the above, study reducing the number of defined sync raster, thereby mitigating delays and UE burden through initial cell search.   + Coarser sync raster locations   + Limiting bands with sync raster by the specification * **Proposal 5**: Study a mechanism to provide OD-RS transmission dynamically with less signalling overhead on PCell.   + Consider at least NW triggering mechanism, and UE triggering including the necessity and its criteria.   + Study dense RS transmission within one periodicity and use of each RS as a measurement sample for RRM   + Assumption: Static AO-SSB is transmitted with a long periodicity (e.g., ~160ms).   WILUS Inc. - R1-2506324   * **Proposal 2**: Study On-Demand SSB/SSB1 for 6GR   + Enable on-demand SSB/SIB1 transmission for UEs in Idle, Inactive, or RRC\_Connected modes to maximize energy savings and deep-sleep opportunities for gNBs. * **Proposal 3**: Study Extended SSB Periodicity for 6GR   + Introduce longer SSB periodicities to enable deeper gNB sleep modes, leading to substantial energy savings.   Rakuten Mobile, Inc. - R1-2506346   * **Proposal 1.1**: RAN1 to define a study topic under the 6GR SID to evaluate the Beacon/Anchor/Data carrier architecture, including much higher sync signal periodicity, carrier roles, and SSB/SIB transmission strategies. * **Proposal 1.2**: RAN1 to study implications of, SIB1 and paging transmitted by Anchor Carriers on demand or at ultra-low periodicity and Data Carriers remain dormant until scheduled user activity is detected.   CEWiT - R1-2506363   * **Proposal 1**: 6G should support energy efficiency enhancements for common signals including   1. On-Demand Signals for initial access including OD-SSB & OD-SIB1 a. Simplified SSB   2. SSB periodicity extension beyond 20ms.   IIT Kanpur - R1-2506392   * **Proposal 2**: 6GR Day 1 design, shall apply time/frequency adaptations of SS/PBCH transmission with more on-demand signal transmission and less always-on signals. Also on-demand SIB1 operation shall be supported from the Day 1 in 6G. |

### Summary

The above proposals collectively address the challenge of reducing energy consumption in 6G Radio (6GR) networks by minimizing the overhead of always-on Synchronization Signal/Physical Broadcast Channel (SS/PBCH, or SSB) transmissions, which contribute to network energy inefficiency in 5G NR, particularly under low or no traffic conditions. In 5G, the default 20 ms SSB periodicity prevents base stations (gNBs) from entering deep sleep modes, leading to substantial energy usage (e.g., limiting energy savings to less than 84.8% as per TR 38.864) (Ericsson Obs. 1, Samsung Obs. 1, MediaTek Obs. 1). The proposals advocate for solutions such as extending SSB periodicity (e.g., to 40 ms, 80 ms, or 160 ms), cf. Figure 1. When needed, on-demand SSB (OD-SSB) may be provided, triggered by either the network or a UE. Additionally, SSB-less SCell operations may be used in certain deployments, allowing deeper network sleep states and reduce UE complexity.



Figure 1: Zero-traffic energy consumption with increased SSB periodicity [12].

Additional enhancements include sparser sync rasters, SSB repetition, two-stage SSB designs, and simplified SSB structures to reduce UE search latency and complexity while maintaining coverage, particularly for new spectrum (~7 GHz) and diverse device types (Spreadtrum Prop. 5, NTT DOCOMO Prop. 4, Samsung Prop. 2). These proposals aim to overcome 5G’s backward compatibility constraints, which restricted on-demand SSB to SCells or non-standalone scenarios, ensuring a leaner, energy-efficient 6GR design from Day 1 that balances network energy savings (NES) with UE accessibility and user experience (Ofinno Prop. 6, Sharp Prop. 2, Qualcomm Prop. 16).

### 1st round FL comments and proposals

It is the FL’s understanding that companies have very different views on how an increased SSB periodicity would work. No company propose to only increase SSB to 160 ms and do nothing else to compensate the resulting decreased UE performance. For that reason, FL proposes that RAN1 focuses on what mitigation techniques would be useful to achieve 160 ms SSB periodicity with minimal impact on the UE performance.

Some companies object to the long SSB periodicity and instead propose a LP radio. In FL’s view, there is not necessarily any contradiction between LP radio and 160 ms (AO-)SSBs if these are combined with 20 ms OD-SSBs. In that case, the LP Radio would still have the same power performance as 20 ms (AO-)SSBs.

FL Proposal 2.2‑1:

**Study NW energy saving from increasing the default periodicity of cell-defining SSB on synchronization raster. Additionally, study UE performance impact and mechanisms to mitigate UE performance degradations in important use-cases, considering:**

* **SBB types (always-on SSB, on-demand SSB),**
* **SSB periodicity(ies),**
* **Synchronization raster granularity, incl. prioritized raster points,**
* **SSB detection performance,**
* **SCell operation,**
* **Etc.**

Companies are welcome to share their views on the above FL proposal.

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| **Company** | **View** |
| Google | On UE performance impact, we understand it at least includes latency of accessing a cell. In addition to UE performance impact, the NES on CD-SSB in 6GR should also consider UE complexity, e.g., detection number increasing with the larger default SSB period. |
| InterDigital | Generally fine with the intention of the proposal. But, we have some comments on the original proposal.  1. Increasing the default periodicity is not the only issue which needs to be considered. In addition, we don’t need to restrict the consideration on cell defining SSB or SSBs on sync raster.  2. For sync raster granularity, we do not want to highlight one specific solution (i.e., the prioritized raster points). We believe that it would be better to have a generalized study area on sync raster granularity/location rather than pointing out one specific solution.  3. In our view, sync signals, MIB and PBCH may have different performance requirements. Having said that, in the current stage, we believe that it would be better to generalize the discussion.  4. As this discussion is triggered for IDLE modes, we prefer to focus on PCell operation in this discussion.  FL Proposal 2.2‑1:  **Study NW energy saving aspects considering ~~from increasing~~ the default periodicity of ~~cell-defining~~ SSB ~~on synchronization raster~~. Additionally, study UE performance impact and mechanisms to mitigate UE performance degradations in important use-cases, considering:**   * **SBB types (e.g. always-on SSB, on-demand SSB),** * **SSB periodicity(ies),** * **Synchronization raster granularity/location~~, incl. prioritized raster points,~~** * **~~SSB d~~Detection performance of sync signals, MIB and PBCH,** * **~~SCell operation,~~** * **Etc.** |

## SIB-1 availability

### Companies’ views

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| Nokia - R1-2505131   * **Proposal 3**: The first 6G release should support a leaner carrier and signaling reduction (of SS/PBCH synchronization signals, system information, PRACH and paging occasions) including on-demand provisioning mechanisms for NES operations of cells operating under low/no load. * **Proposal 9**: Consider extending the Rel-19 OD-SIB1 for different deployment scenarios, including the single cell scenario. * **Proposal 12**: On-demand SIB1 operation shall be studied in 6G, including support for legacy operation in PCell and other applicable scenarios.   FUTUREWEI - R1-2505145   * **Proposal 4**: Adopt and further enhance from day one the gNB power saving solutions developed in 5G (e.g., 5G NES features SCell with on-demand SSB or no SSB, on-demand SIB1, Cell DTX/DRX, etc.). * **Proposal 5**: Develop consistent energy efficiency solutions among all UE states. For instance, consistent on-demand control SIB1 signaling for all IDLE, INACTIVE and ACTIVE UEs.   CATT - R1-2505297   * **Proposal 6**: In 6GR, on-demand SIB1 should be supported for both homogeneous network and heterogeneous network. * **Proposal 10**: To simplify the on-demand mechanism of multiple common signals, a unified common signal request mechanism can be considered.   Spreadtrum (UNISOC) - R1-2505176   * No SIB1 or OD-SIB1-related proposals.   Xiaomi - R1-2505467   * **Proposal 9**: Joint condensed common signal/channel design and L1-based paging adaptation can be considered for 6GR NES.   Samsung - R1-2505589   * No SIB1 or OD-SIB1-related proposals.   ZTE - R1-2505607   * No SIB1 or OD-SIB1-related proposals.   Ericsson - R1-2505625   * **Proposal 5**: Study periodic bursts of SSB and SIB1 repetitions, where in each period multiple SSB and SIB1 repetitions are provided during a short time interval followed by a longer inactive interval. * **Proposal 6**: 6GR should support coordinating system information broadcast with other common signals/channels in order not to interrupt sleeping opportunities.   Tejas Networks Ltd. - R1-2505631   * **Proposal 1**: Transmission of SIB1/SI corresponding only to one SSB beam will improve NES and is targeted for the low load scenario, and transmission of SI corresponding to all the active SSB beams will reduce the number of requests from different UEs and is used during the high load scenario. * **Proposal 22**: Standalone OD-SIB1 needs to be studied in 6G to determine potential benefits as compared to the non-standalone case defined in 5G NR.   Ofinno - R1-2505677   * **Proposal 5**: 6GR should support OD-SIB1 and RAN1 to study supporting OD-SIB1 for a standalone cell.   Quectel - R1-2505769   * **Proposal 1**: The OD-SSB/OD-SIB1 structure simplifying SSB/SIB1 needs discussion in 6G.   Panasonic - R1-2505789   * **Proposal 3**: To study system information design and framework facilitating common channel/signal ON/OFF and adaptation.   Fraunhofer IIS, Fraunhofer HHI - R1-2505834   * **Proposal 5**: The 6GR study should investigate the possibility of increasing common signal periodicity and enable on demand common signals.   LG Electronics - R1-2505858   * **Proposal 3**: Study on-demand SIB1 procedure for single-cell scenario (where a cell provides UL WUS configuration for its own on-demand SIB1) as well as for multi-cell scenario (as introduced in Rel-19 NES). * **Proposal 6**: Study a unified/integrated on-demand procedure for multiple common signals/channels.   Apple - R1-2505917   * **Proposal 4**: Reduction/adaptation of common signals/channels should be considered in 6G day-1 to avoid backward compatibility issue and fully achieve the NES benefit.   + For OD-SIB1, how much additional NES gain can be obtained through SIB1 reduction in single cell case, under the assumption of increased SSB periodicity.   Fujitsu - R1-2505972   * **Proposal 3**: Study the methods to enable on-demand transmission of cell common signals, such as SS, PBCH and SIB1, without limitations on applicable scenarios.   + The above aspects can be included in the initial access related discussions.   Lenovo - R1-2505995   * **Proposal 2**: 6GR should enhance common signals/channels transmission and periodicity for network energy saving under various cell load.   HONOR - R1-2506003   * No SIB1 or OD-SIB1-related proposals.   CAICT - R1-2506005   * **Proposal 1**: the coverage and the capacity carrier can be defined to enable dynamic on/off carrier, the SSB signal with long periodicity and on demand SSB can be transmitted in the capacity carrier ,and the always on RS can be transmitted in the coverage carrier.   Sharp - R1-2506014   * **Proposal 2**: To reduce unnecessary power consumption and signalling overhead, on demand reference signal in Pcell should be supported. * **Proposal 7**: On demand signalling for dual-side joint mechanisms for network and UE should be supported in energy efficiency.   ETRI - R1-2506069   * **Proposal 13**: Study on-demand system information transmission as a complementary mechanism to periodic transmission.   Vodafone, Bouygues Telecom, Deutsche Telekom - R1-2506134   * No SIB1 or OD-SIB1-related proposals.   InterDigital - R1-2506146   * **Proposal 6**: Support on-demand signals/channels (e.g., configurable, dynamic (de)activation, and/or UE-requested) where it is applicable.   SK Telecom - R1-2506152   * **Proposal 1**: For 6G energy efficiency, at least the following aspects should be studied:   + SSB/SIB1 transmission (longer periodicity, on-demand)   Qualcomm - R1-2506222   * No SIB1 or OD-SIB1-related proposals.   AT&T - R1-2506237   * No SIB1 or OD-SIB1-related proposals.   NTT DOCOMO - R1-2506310   * **Proposal 6**: Study both of the following directions for OD-SIB1 operation   + Direction1: Standalone OD-SIB1 operation with introducing pre-defined/pre-configured UL WUS.   + Direction2: Representative cell/carrier to deliver NES cells’ system information.   WILUS Inc. - R1-2506324   * **Proposal 2**: Study On-Demand SSB/SSB1 for 6GR   + Enable on-demand SSB/SIB1 transmission for UEs in Idle, Inactive, or RRC\_Connected modes to maximize energy savings and deep-sleep opportunities for gNBs.   Rakuten Mobile, Inc. - R1-2506346   * **Proposal 1.2**: RAN1 to study implications of, SIB1 and paging transmitted by Anchor Carriers on demand or at ultra-low periodicity and Data Carriers remain dormant until scheduled user activity is detected.   CEWiT - R1-2506363   * **Proposal 1**: 6G should support energy efficiency enhancements for common signals including   1. On-Demand Signals for initial access including OD-SSB & OD-SIB1 a. Simplified SSB   IIT Kanpur - R1-2506392   * **Proposal 2**: 6GR Day 1 design, shall apply time/frequency adaptations of SS/PBCH transmission with more on-demand signal transmission and less always-on signals. Also on-demand SIB1 operation shall be supported from the Day 1 in 6G. |

### Summary

The above proposals address the energy inefficiency caused by the frequent periodic transmission of SIB1 in 5G NR, typically every 20 ms or up to 160 ms, which consumes network resources and prevents gNBs from entering deep sleep modes, particularly in low or no-traffic (Sharp, Nokia Obs. 1, Ericsson Obs. 1, MediaTek Obs. 1). This always-on broadcasting limits network energy savings (NES), which could be reduced by up to 83.7% for Cat-1 and 52.5% for Cat-2 base stations under low load, as per TR 38.864. The proposals aim to mitigate this by enabling OD-SIB1, possibly triggered by UE requests via uplink wake-up signals (UL-WUS) or network conditions, allowing gNBs to remain in low-power states during idle periods (Sharp Prop. 7, NTT DOCOMO Prop. 6, FUTUREWEI Prop. 5). They address 5G’s backward compatibility constraints, which restricted OD-SIB1 to capacity cells in non-standalone scenarios, by advocating for support in standalone operation of on-demand SIB1, and both homogeneous and heterogeneous networks (Ofinno Prop. 5, Tejas Prop. 22, CATT Prop. 6). Additional enhancements include simplifying OD-SIB1 procedures, using default configurations or extended Master Information Blocks (MIB) to reduce signaling overhead, coordinating SIB1 with other common signals to avoid interrupting sleep opportunities, optimizing SIB1 transmission to specific SSB beams based on traffic load, and integrating with unified common signal request mechanisms to streamline operations (Ericsson Prop. 6, OPPO Prop. 13, CATT Prop. 10, Tejas Prop. 1). These changes ensure minimal impact on UE performance, such as access latency, while supporting diverse device types and new spectrum (~7 GHz) for a leaner, energy-efficient 6GR design from Day 1 (Apple Prop. 4, IIT Kanpur Prop. 2, Lenovo Prop. 2).

### 1st round FL comments and proposals

Companies agree that SIB1, as the only periodically transmitted SIB, is an obstacle to NW energy efficiency. The views on what to do about it differ, though. A UE-centric approach is a UE-initiated OD-SIB1 (and OD-SSB), as presented in Figure 1, whereas a NW-centric approach combines a more efficient SIB1 transmission with NW-initiated OD-SIB1 transmissions.



Figure 2: Illustration of UE-centric OD-SIB functionality [8].

In FL’s understanding, OD-SIB provisioning is not necessarily limited to SIB1 for which reason the FL proposes to generalize the discussion to overall system information.

FL proposes that companies study more detailed alternatives for OD-SIB and their respective potential gains.

FL Proposal 2.3‑1:

**Study and evaluate on-demand system information operation with respect to, e.g.,**

* **NW and UE energy savings potential,**
* **Acquisition delay**
* **Applicable deployment scenarios**
* **NW and UE complexity**

Companies are welcome to share their views on the above FL proposal.

|  |  |
| --- | --- |
| **Company** | **View** |
| Google | On the FL Proposal 2.3-1, we would like to have a revision as below, to emphasize the concept in Figure 2 above, which is really helpful on reducing the cell accessing latency. In addition, we can also consider integration of UL-WUS with MSG1 in the subsequent RA procedure, since the UL-WUS can be PRACH as well in 6GR.  FL Proposal 2.3‑1:  **Study and evaluate on-demand system information operation with respect to, e.g.,**   * **NW and UE energy savings potential,** * **Acquisition delay, e.g., integration of one request for different OD common signal.** * **Applicable deployment scenarios** * **NW and UE complexity** |
| InterDigital | Support |

## DL WUS/WUR requirements

### Companies’ views

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| --- |
| FUTUREWEI - R1-2505145   * **Proposal 3**: Adopt from day one 5G UE power saving techniques as baseline mechanisms in 6G, such as:   + Duty-cycled based operations (iDRX, eDRX, cDRX),   + LP-WUS with at least PEI and DCP functionality replacement,   + Relaxed RRM measurements of neighboring cells, and   + Relaxed/Offloading to LP-WUR of serving cell measurements.   Spreadtrum (UNISOC) - R1-2505176   * **Proposal 3**: The following technologies can be studied for 6GR UE power saving:   1. Bandwidth adaptation, SCell dormancy, TX/RX antenna adaptation, paging enhancement, WUS/WUR, etc.   vivo - R1-2505420   * **Proposal 3**: Study the introduction of wake-up signal and wake-up receiver for paging, PDCCH monitoring, and serving cell measurement for 6GR.   ZTE - R1-2505607   * **Proposal 25**: Low power WUS should be supported in 6GR.   Ericsson - R1-2505625   * **Proposal 17**: 6GR should adopt a simplified OFDM-based LP-WUS/WUR design for idle/connected mode UE power saving, with improved coverage and spectral efficiency compared to NR.   NEC - R1-2505641   * **Proposal 13**: Study the enhancement of low-power wake-up signal/receiver (LP-WUS/WUR) for paging and PDCCH monitoring for 6GR. * **Proposal 14**: Study the design of low-power synchronization signal (LP-SS) for serving cell measurement with low-power wake-up receiver for 6GR. * **Proposal 19**: Study the enhancements of PDCCH skipping and SSSG switching with wake-up signal for 6GR.   Ofinno - R1-2505677   * **Proposal 8**: 6GR should support a framework for LP-WUS as a baseline for power saving for RRC\_IDLE/INACTIVE UEs. * **Proposal 9**: RAN1 to study improving coverage for LP-WUS, e.g., by introducing repetition and/or low modulation order and coding rate, without increasing UE complexity.   OPPO - R1-2505761   * **Proposal 4**: 6GR can consider to unify DCP/PEI/LP-WUS to avoid multiple variants of wake-up signal design in order to achieve better UE power saving performance.   Panasonic - R1-2505789   * **Proposal 8**: To study possible LP-WUS/LP-SS integration with 6GR and the support by MRSS.   LG Electronics - R1-2505858   * **Proposal 13**: Study DL WUS to control UE wake-up during active time, e.g., PDCCH monitoring, as well as wake-up for paging/measurement for idle/inactive mode.   Apple - R1-2505917   * **Proposal 1**: Time domain adaptation techniques like C-DRX, PDCCH skipping, SSSG switching, and LP-WUS should be considered for a simplified/harmonized design to reduce UE power consumption for PDCCH monitoring. * **Proposal 2**: LP-WUS/WUR design targeting all device types should be based on OFDM waveform to achieve better coverage and spectral efficiency, and should be applicable to both idle/inactive and connected mode UEs.   Fujitsu - R1-2505972   * **Proposal 6**: For UE power saving, the following should be considered: C-DRX, PDCCH monitoring reduction, WUS for idle mode, etc.   KT Corp. - R1-2505991   * **Proposal 3**: A low-power receiver is mandatory for both 6GR BS and UE.   HONOR - R1-2506003   * **Proposal 6**: The design of low-power WUS should be considered on both the UE side and the network side to save energy.   Sharp - R1-2506014   * **Proposal 6**: To complement the paging mechanism for UE energy efficiency, low-power WUS should be introduced in the 6GR design.   MediaTek - R1-2506024   * **Proposal 5**: Study WUR for UE synchronization and measurements in addition to wake-up functionality. * **Proposal 19**: For 6G, WUS/WUR should consider OFDM-based design to achieve better coverage and spectral efficiency.   CMCC - R1-2506101   * **Proposal 5**: Support the following UE power saving techniques to be further adopted in 6GR:   + Time domain:     - PDCCH Skipping/SSSG switching/cross-slot scheduling     - I-DRX, Extended-DRX including PTW     - RRM/RLM/BFD relaxation     - LP-WUS/WUR for paging, PDCCH monitoring and serving cell measurement   + Frequency domain: SCell activation/deactivation/dormancy for CA scenario, BWP switching * **Proposal 6**: RAN1 to further consider and study the enhancement of LP-WUS/WUR in 6GR:   + Signal design aspect, aim for better performance on coverage/robustness/efficiency:     - Better receiver detection method for 6G LP-WUR more than envelope detection, can be considered.     - The receiver accuracy, e.g., option 3 or 4 in 3GPP TR 38.845 (~0.1-1mW) can be considered as start point with justified power saving gain.     - Overlaid-wise signals are not necessary to avoid unnecessary design trade-offs.     - Both RRC IDLE / CONNECTED mode are supported.   + Procedure design aspect, aim for extend the usage:     - For 6G LP-WUS,       * It can be considered to carry small payload size data or extra indications, which can further reduce the turning-on time of MR and the complexity of PDCCH monitoring.       * In addition, it can be considered together with the usage of PDCCH skipping to control PDCCH monitoring in a more power efficient way.     - For 6G LP-SS,       * It can be considered for neighbor cell/TRP measurement at least for cell selection/reselection procedure in addition to serving cell measurement.       * It should consider a harmonized design of UE measurement can be targeted between 6G LP-SS for LP-WUR and “6G SSB” for Main Radio, in order to avoid too much always-on signals being transmitted by BS.   Vodafone, Bouygues Telecom, Deutsche Telekom - R1-2506134   * **Proposal 3**: Study introduction of LP-WUS/WUR for all device types in 6GR air interface as a day-1 considering potential impacts and benefits.   InterDigital - R1-2506146   * **Proposal 10**: Support LP-WUS targeting low power receiver capability from 6G Day-1. * **Proposal 11**: Support multiple types of modulations with different receiver architectures considering different power consumption levels and achievable coverages. * **Proposal 12**: Support low power receiver operations for mobility and cell (re)selection.   SK Telecom - R1-2506152   * **Proposal 1**: For 6G energy efficiency, at least the following aspects should be studied:   + SSB/SIB1 transmission (longer periodicity, on-demand)   + Enhanced BWP mechanism   + Time-domain enhancement (UE-basis C-DRX vs. cell-basis DRX/DTX, LP-WUS/WUR)   + Reduced RRM measurement   + PEI   NTT DOCOMO - R1-2506310   * **Proposal 13**: Study LP-WUS/WUR to control UE wake-up for PDCCH monitoring. * **Proposal 14**: Study LP-WUS/WUR for RRM measurement. * **Proposal 15**: Study extension of LP-WUS/WUR for neighbor cell measurement in idle/inactive mode, as well as serving cell measurement.   IIT Kanpur - R1-2506392   * **Proposal 4**: 6GR Day 1 design shall enhance the low-power wake-up signal/receiver (LP-WUS/WUR) designs for improving UE power efficiency. |

### Summary

The DL WUS and WUR proposals address the significant UE energy consumption in 5G NR, particularly during PDCCH monitoring, paging, and RRM measurements, which account for approximately 30% of UE power usage due to frequent wake-ups that prevent the main radio (MR) from entering deep sleep states (Apple Obs. 1, MediaTek Obs. 2). These proposals aim to enhance UE power saving by introducing low-power wake-up signal (LP-WUS) and wake-up receiver (WUR) mechanisms as mandatory Day 1 features in 6GR, using OFDM-based designs or advanced detection methods (e.g., beyond envelope detection) to improve coverage, robustness, spectral efficiency, and reduced overhead/NW energy consumption compared to 5G NR (Ericsson Prop. 17, MediaTek Prop. 19, CMCC Prop. 6). They target minimizing unnecessary UE wake-ups for PDCCH monitoring, paging, and serving/neighbor cell measurements in both RRC\_CONNECTED and RRC\_IDLE/INACTIVE modes, enabling UEs to remain in low-power states longer (LG Prop. 13, Ofinno Prop. 8, NTT DOCOMO Prop. 15). Proposals advocate harmonizing LP-WUS/WUR with other power-saving techniques like C-DRX, PDCCH skipping, and SSSG switching, unifying designs with Paging Early Indication (PEI) and DCI-based Power Saving (DCP) to reduce complexity (Apple Prop. 2, OPPO Prop. 4, NEC Prop. 14). They address 5G’s limitations, such as underutilized WUS due to late standardization and multiple waveform variants (e.g., OOK vs. OFDM), by proposing simplified, robust designs with techniques like repetition or low modulation order, supporting diverse device types (e.g., IoT, XR/AR) in new spectrum (~7 GHz), and enabling mobility and cell (re)selection, achieving significant power savings (e.g., 10–20 times lower than MR per 3GPP Rel-18 studies, up to 80–90% compared to 5G paging) while maintaining low latency and compatibility with diverse 6GR use cases (Ofinno Prop. 9, InterDigital Prop. 10, vivo Prop. 3).

### 1st round FL comments and proposals

Most companies support an OFDM-based WUS/WUR due to its superior coverage, reduced overhead, and greater additional energy efficiency potential from, e.g., synchronization and RRM. For that reason, agreeing to an OFDM-based WUS is the first firm agreement put forward.

A natural consequence of such an agreement is for RAN1 to further study additional use for an OFDM-based WUS. This is presented in a follow-up proposal in FL Proposal 2.4‑2.

FL Proposal 2.4‑1:

**Propose OFDM-based DL WUS as a candidate technology for further studies in the 6G Radio SI.**

Companies are welcome to share their views on the above FL proposal.

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| **Company** | **View** |
| Google | We are fine with studying OFDM-based DL WUS for enhancing WUS performance, especially for coverage consideration. But meanwhile, we should also consider whether OFDM-based DL WUS is applicable for diverse device types anticipated in 6GR. |

FL Proposal 2.4‑2:

Study further use cases and potential energy efficiency gains for an OFDM-based DL WUS/WUR, apart from wake-up indication, e.g.,

* Synchronization,
* RRM measurements (e.g., neighbor cells),
* Small control information and/or data,
* Etc.

Companies are welcome to share their views on the above FL proposal.

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| --- | --- |
| **Company** | **View** |
| Google | We are supportive of use case of synchronization. Given that likely increased SSB periodicity, an additional signal in between two SSBs would be helpful for UE’s sync performance. |

## Cell DTX/DRX and sleep mechanisms

### Companies’ views

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| Nokia - R1-2505131   * **Proposal 2**: 6G should support cell DTX/DRX type of operation from day one to allow for sufficient BS sleep opportunities and achieve meaningful NES. * **Proposal 3**: The first 6G release should support a leaner carrier and signaling reduction (of SS/PBCH synchronization signals, system information, PRACH and paging occasions) including on-demand provisioning mechanisms for NES operations of cells operating under low/no load. * **Proposal 4**: 6G should support lean carrier operation in capacity cells where always-on signals can be turned off in the absence of traffic. * **Proposal 9**: Consider extending the Rel-19 OD-SIB1 for different deployment scenarios, including the single cell scenario.   FUTUREWEI - R1-2505145   * **Proposal 4**: Adopt and further enhance from day one the gNB power saving solutions developed in 5G (e.g., 5G NES features SCell with on-demand SSB or no SSB, on-demand SIB1, Cell DTX/DRX, etc.). * **Proposal 5**: Develop consistent energy efficiency solutions among all UE states. For instance, consistent on-demand control SIB1 signaling for all IDLE, INACTIVE and ACTIVE UEs.   CATT - R1-2505297   * **Proposal 2**: In 6GR, cell DTX/DRX should be supported for both homogeneous network and heterogeneous network. * **Proposal 6**: In 6GR, on-demand SIB1 should be supported for both homogeneous network and heterogeneous network. * **Proposal 10**: To simplify the on-demand mechanism of multiple common signals, a unified common signal request mechanism can be considered.   Xiaomi - R1-2505467   * **Proposal 9**: Joint condensed common signal/channel design and L1-based paging adaptation can be considered for 6GR NES.   ZTE - R1-2505607   * **Proposal 4**: Cell DTX/DRX should be supported in 6GR to allow sufficient BS sleep opportunities.   Ericsson - R1-2505625   * **Proposal 4**: Study cell DTX/DRX to allow sufficient BS sleep opportunities, including support for legacy operation.   Tejas Networks Ltd. - R1-2505631   * **Proposal 6**: Cell DTX/DRX should be supported in 6GR to enhance energy efficiency for BS under various traffic load. * **Proposal 22**: Standalone OD-SIB1 needs to be studied in 6G to determine potential benefits as compared to the non-standalone case defined in 5G NR.   Ofinno - R1-2505677   * **Proposal 4**: 6GR should support cell DTX/DRX for PCell and SCell from day-1.   OPPO - R1-2505761   * **Proposal 2**: Cell DTX/DRX can be studied for 6GR to allow sufficient BS sleep opportunities and achieve meaningful BS energy saving. * **Proposal 13**: For the 6GR, OD-SIB1 without relying on cell A can be studied with the following considerations:   + further simplify the OD-SIB1 procedure compared to the 5G OD-SIB1 counterpart,   + consider adopting default configurations, allowing the necessary OD-SIB1 parameters to be inferred with minimal signaling, or consider introducing an extended MIB to provide necessary configuration.   Quectel - R1-2505769   * **Proposal 1**: The OD-SSB/OD-SIB1 structure simplifying SSB/SIB1 needs discussion in 6G.   Panasonic - R1-2505789   * **Proposal 3**: To study system information design and framework facilitating common channel/signal ON/OFF and adaptation.   Fraunhofer IIS, Fraunhofer HHI - R1-2505834   * **Proposal 3**: The 6GR study should investigate the possibility to deactivate the capacity cell in case of no or low traffic load.   LG Electronics - R1-2505858   * **Proposal 3**: Study on-demand SIB1 procedure for single-cell scenario (where a cell provides UL WUS configuration for its own on-demand SIB1) as well as for multi-cell scenario (as introduced in Rel-19 NES). * **Proposal 6**: Study a unified/integrated on-demand procedure for multiple common signals/channels.   Apple - R1-2505917   * **Proposal 5**: Cell DTX/DRX should be considered in 6G day-1 to avoid backward compatibility issue and fully achieve the NES benefit.   Fujitsu - R1-2505972   * **Proposal 2**: Study the methods to turn off always-on signals in capacity cells without traffic for energy saving, and enable fast activation of the cell when traffic arrives. * **Proposal 3**: Study the methods to enable on-demand transmission of cell common signals, such as SS, PBCH and SIB1, without limitations on applicable scenarios.   + The above aspects can be included in the initial access related discussions.   Lenovo - R1-2505995   * **Proposal 2**: 6GR should enhance common signals/channels transmission and periodicity for network energy saving under various cell load.   CAICT - R1-2506005   * **Proposal 1**: the coverage and the capacity carrier can be defined to enable dynamic on/off carrier, the SSB signal with long periodicity and on demand SSB can be transmitted in the capacity carrier ,and the always on RS can be transmitted in the coverage carrier.   Sharp - R1-2506014   * **Proposal 5**: Cell DTX/DRX should be supported in 6GR to allow sufficient BS sleep opportunities and achieve meaningful BS energy saving.   CMCC - R1-2506101   * **Proposal 3**: RAN1 to further consider and study the following case for multi-carrier scenario in 6GR:   + The common signal transmission/reception procedure (e.g. SIB1 transmission, RACH reception) for multiple carriers can converge to one anchor carrier. Therefore, other carrier (i.e. NES carrier) can turning off or only transmit long period SS by default, so as to obtain more NES gain.   + NES carrier can be activated per NW guidance or UE demand and UE can initiate access on NES carrier, so as to achieve better UE experience or load balancing for network.   InterDigital - R1-2506146   * **Proposal 3**: Support cell DTX/DRX to allow sufficient BS sleep opportunities where it is applicable. * **Proposal 6**: Support on-demand signals/channels (e.g., configurable, dynamic (de)activation, and/or UE-requested) where it is applicable.   SK Telecom - R1-2506152   * **Proposal 1**: For 6G energy efficiency, at least the following aspects should be studied:   + SSB/SIB1 transmission (longer periodicity, on-demand)   + Enhanced BWP mechanism   + Time-domain enhancement (UE-basis C-DRX vs. cell-basis DRX/DTX, LP-WUS/WUR)   + Reduced RRM measurement   + PEI   NTT DOCOMO - R1-2506310   * **Proposal 2**: Study cell DTX/DRX operation for 6GR, including support for legacy operation in PCell.   WILUS Inc. - R1-2506324   * **Proposal 2**: Study On-Demand SSB/SSB1 for 6GR   + Enable on-demand SSB/SIB1 transmission for UEs in Idle, Inactive, or RRC\_Connected modes to maximize energy savings and deep-sleep opportunities for gNBs.   Rakuten Mobile, Inc. - R1-2506346   * **Proposal 1.2**: RAN1 to study implications of, SIB1 and paging transmitted by Anchor Carriers on demand or at ultra-low periodicity and Data Carriers remain dormant until scheduled user activity is detected.   CEWiT - R1-2506363   * **Proposal 1**: 6G should support energy efficiency enhancements for common signals including   1. On-Demand Signals for initial access including OD-SSB & OD-SIB1 a. Simplified SSB   2. SSB periodicity extension beyond 20ms. |

### Summary

The proposals for cell DTX/DRX, cell activation/inactivation, and System Information (SI) signaling for capacity cells address the energy inefficiency in gNB, driven by the continuous transmission of always-on signals like Synchronization Signal Blocks (SSBs) and System Information (SI, e.g., SIB1), which prevent gNBs from entering deep sleep modes, particularly in low or no-traffic scenarios, prohibiting network energy savings (NES) of 83.7% for Cat-1 and 52.5% for Cat-2 base stations under low load, as per TR 38.864 (Nokia Obs. 1, Ericsson Obs. 1). These proposals aim to enhance 6GR energy efficiency by implementing cell DTX/DRX to enable gNB sleep states during idle periods, supporting both primary (PCells) and secondary cells (SCells) in homogeneous and heterogeneous networks (Nokia Prop. 2, CATT Prop. 2, Ofinno Prop. 4). They advocate dynamic activation/inactivation of capacity cells, turning off always-on signals when traffic is absent and enabling rapid reactivation to maintain responsiveness (Fujitsu Prop. 2, Fraunhofer Prop. 3). Additionally, they propose converging SI signaling to anchor or coverage carriers in multi-carrier scenarios, allowing capacity (NES) carriers to deactivate or use minimal, long-periodicity signals, enhancing NES and load balancing (CAICT Prop. 1, CMCC Prop. 3, Rakuten Prop. 1.2). Further enhancements include on-demand SIB1 transmission across all UE states (IDLE, INACTIVE, CONNECTED), simplified procedures with default configurations or extended Master Information Blocks (MIB), and unified common signal request mechanisms to reduce signaling overhead (FUTUREWEI Prop. 5, OPPO Prop. 13, CATT Prop. 10). These changes address 5G’s backward compatibility constraints, which restricted such mechanisms to specific scenarios like non-standalone deployments and promote Day 1 integration in 6GR to support diverse deployments and new spectrum (~7 GHz) while ensuring UE accessibility and system performance (Apple Prop. 5, NTT DOCOMO Prop. 2).

### 1st round FL comments and proposal

There is large support for cell DTX/DRX among companies although the understandings of what cell DTX/DRX implies and includes differ as well as what gains may result from it. It is also pointed out by companies that a joint framework for both UE and gNB DTX/DRX should be included in this study. For that reason, FL proposes to further study such a joint framework.

FL Proposal 2.5‑1:

**Study joint Cell DTX/DRX and UE DTX/DRX regarding,**

* **Common (idle mode) signal adaptation and clustering,**
* **UE effects (latency and synchronization),**
* **Etc.**

Companies are welcome to share their views on the above FL proposal.

|  |  |
| --- | --- |
| **Company** | **View** |
| Google | We support this proposal, which is a good starting point of joint NW/UE DTX/DRX. |
| InterDigital | Support |

Moreover, an LP radio has been proposed by companies, e.g., for transmitting SSB or SIB1 or receiving UL WUS or requests for OD-SSB or OD-SIB1. It is the FL’s view that the RAN1 spec does not concern implementation matters like particular radio implementations. For that reason, FL proposes as a first step to study the spec impact, if any, with such a radio.

FL Proposal 2.5‑2:

**Study the spec impact, if any, of a gNB implementation with an LP stage for idle mode signal support.**

Companies are welcome to share their views on the above FL proposal.

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| **Company** | **View** |
| InterDigital | In our view, we prefer to have the proposal in the same level with proposal 2.5-1. Given the situation, we suggest the following proposal.  Study utilization of low power transmitter/receiver at gNB in IDLE mode. |

FL Proposal 2.5‑3:

**Study and evaluate anchor cell SI signaling for capacity cells.**

Companies are welcome to share their views on the above FL proposal.

|  |  |
| --- | --- |
| **Company** | **View** |
| Google | Although understanding the intention, perhaps we should have definition of anchor cell and capacity cell first, to avoid possible different understanding across companies. |
| InterDigital | Fine |

## Models, metrics and baseline scheme(s)

### Companies’ views

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| **Nokia - R1-2505131**   * **Proposal 1**: 6G should target meaningful energy efficiency improvements over Rel-18 for all load conditions and consider the following for NES evaluation:   + Energy consumption for BS and UE.   + Both data transmission/reception and other operations (e.g., monitoring, measurements, and signaling).   + A metric combining performance and energy efficiency, e.g., capacity or throughput per energy unit, for different load conditions and deployment scenarios. * **Proposal 17**: 6G SI to use the 5G BS power model Cat.2 in TR 38.864 as a starting point for network energy saving evaluations. * **Proposal 18**: 6G SI to use the 5G UE power consumption model (e.g. in TR 38.840 and in TS38.869) as a starting point for UE energy saving evaluations.   **FUTUREWEI - R1-2505145**   * **Proposal 1**: Adopt a comprehensive energy efficiency evaluation methodology for 6GR, which considers:   + Energy consumption for all operations (e.g., data transmission/reception, monitoring, measurements, and signaling) for both BS and UE.   + Energy efficiency metric combining spectral efficiency and energy consumption, e.g., bits/Joule, for different load conditions and deployment scenarios. * **Proposal 2**: Develop new energy efficiency metrics for 6GR, which consider new use cases, new frequency bands, and deployment scenarios, including:   + Energy efficiency for sporadic traffic.   + Energy efficiency for multi-band operation.   + Energy efficiency for diverse device types and capabilities. * **Proposal 8**: Consider studying energy consumption evaluation methodologies for AI/ML-based approaches in 6G. * **Proposal 9**: Include energy efficiency as part of the evaluation KPIs for all 6G AI/ML-based use cases based on studied and agreed methodologies.   **Huawei, HiSilicon - R1-2505187**   * **Proposal 4**: Study proper KPI for Energy-efficiency (EE) oriented 6GR system design which allows network and UE can have more opportunities for energy saving   + Study energy saving evaluation based on user experience, compared with UPT.   **Xiaomi - R1-2505467**   * **Proposal 11**: Discuss metrics on joint energy saving between network and UE.   **Ericsson - R1-2505625**   * **Proposal 1**: 6GR should target meaningful EE improvements for all load conditions, considering the following aspects for evaluation:   + Energy consumption for BS and UE, covering data transmission/reception and other operations (e.g., monitoring, measurements, and signaling).   + A metric combining performance and EE, e.g., capacity or throughput per energy unit, for different load conditions and deployment scenarios. * **Proposal 2**: Study EE evaluation methodology for 6GR considering new use cases, new spectrum, and diverse device types:   + EE for sporadic/low load traffic.   + EE for multi-band operation.   + EE for diverse device types (e.g., XR/AR, IoT).   **Tejas Networks Ltd. - R1-2505631**   * **Proposal 2**: In 6GR, EE evaluation methodology should consider new use cases, new spectrum and diverse device types for BS and UE energy efficiency improvements. * **Proposal 3**: In 6GR, EE metric should combine spectral efficiency and energy consumption (e.g., bit/Joule) for different load conditions and deployment scenarios.   **NEC - R1-2505641**   * **Proposal 11**: The evaluation methodology for 6G must account for the net energy impact, considering the power consumption of real-time model inference and monitoring operations within the RAN.   **TCL - R1-2505698**   * **Proposal 3**: Consider whether/how to define energy efficiency parameters in 6G systems, including UE side energy efficiency or NW side energy efficiency or end-to-end (including NW+UE) energy efficiency.   **OPPO - R1-2505761**   * **Proposal 1**: 6GR should adopt a comprehensive EE evaluation methodology, considering:   + Energy consumption for BS and UE for all operations (e.g., data transmission/reception, monitoring, measurements, signaling, etc.).   + EE metric combining spectral efficiency and energy consumption (e.g., bit/Joule) for different load conditions and deployment scenarios.   **Fraunhofer IIS, Fraunhofer HHI - R1-2505834**   * **Proposal 1**: Energy saving gains at network and UE sides must be considered critical metrics, alongside traditional performance indicators such as data rate and latency. These metrics should be explicitly included in performance evaluations across several key agenda items in the 6G study. * **Proposal 3**: RAN1 should focus on revising the evaluation methodology for 6GR energy savings to accommodate relevant scenarios, novel technologies like AI and ISAC, and the increased flexibility provided by the foundational design aspects like initial access. * **Proposal 4**: Once a revised version of the 6GR power saving evaluation methodology, including the power consumption models and KPIs are finalized, all relevant agenda items should employ them for evaluation.   **Apple - R1-2505917**   * **Proposal 3**: 6G should target meaningful EE improvements over Rel-18, considering:   + Energy consumption for BS and UE for all operations.   + EE metric combining spectral efficiency and energy consumption for various load conditions and deployment scenarios.   **KT Corp. - R1-2505991**   * **Proposal 1**: Procedures for managing the energy-saving balance between NW and UE are adopted in 6GR.   **CAICT - R1-2506005**   * **Proposal 2**: EE evaluation methodology for 6GR should consider energy consumption of BS and UE, and EE metric should combine spectral efficiency and energy consumption for various load conditions.   **ETRI - R1-2506069**   * **Proposal 1**: For 6GR, a comprehensive EE evaluation methodology should be developed considering:   + Energy consumption for BS and UE for data transmission/reception and other operations (e.g., monitoring, measurements, signaling).   + EE metric combining performance and energy consumption (e.g., bit/Joule) for various load conditions and deployment scenarios.   **CMCC - R1-2506101**   * **Proposal 1**: 6GR should target meaningful EE improvement, considering:   + Energy consumption for BS and UE for all operations, including data transmission/reception, monitoring, measurements, and signaling.   + EE metric combining spectral efficiency and energy consumption (e.g., bit/Joule) for various load conditions and deployment scenarios.   **InterDigital - R1-2506146**   * **Proposal 1**: Adopt comprehensive EE evaluation methodology for 6GR, considering energy consumption for BS and UE, and EE metrics combining spectral efficiency and energy consumption for various load conditions. * **Proposal 2**: Study EE evaluation for new 6GR use cases, including sporadic traffic, multi-band operation, and diverse device types.   **AT&T - R1-2506237**   * **Proposal 11**: Energy Efficiency metric(s) are included as 6GR key performance metrics from day 1. * **Proposal 12**: An energy efficiency metric based on aggregate throughput normalized by the total system power at the transmitter and/or receiver side, including power needed to operate different transmitter/receiver modules, is considered as a starting point for evaluation of energy efficiency in 6GR air interface. |

### Summary

The proposals for energy efficiency (EE) modeling and metrics address the limitations of 5G NR energy efficiency evaluation frameworks, which were introduced late (e.g., Rel-16 and Rel-18) and primarily focused on data transmission/reception, often neglecting energy consumption from other operations like monitoring, measurements, and signaling, particularly under diverse load conditions and emerging use cases such as AI/ML, Integrated Sensing and Communication (ISAC), and XR/AR (Nokia Obs. 1, Ericsson Obs. 1, Fraunhofer Prop. 3).

Proposals aim to establish EE as a key performance indicator (KPI) from Day 1 in 6GR, leveraging 5G models like the gNB power models Cat.1 or Cat.2 (TR 38.864) and UE power model (TR 38.840, TS 38.869) as baselines, while introducing new metrics (e.g., aggregate throughput normalized by total system power) and methodologies that account for all gNB and UE operations, including real-time AI/ML inference, and support new spectrum (~7 GHz) and diverse deployment scenarios (Nokia Prop. 17, AT&T Prop. 12, FUTUREWEI Prop. 8). They emphasize joint NW-UE energy saving metrics, user experience-based evaluations, and end-to-end EE parameters to ensure a holistic, standardized approach, overcoming 5G’s fragmented implementation and enabling balanced trade-offs between performance and energy consumption across all 6GR use cases (Huawei Prop. 4, KT Corp. Prop. 1, TCL Prop. 3).

### 1st round FL comments and proposals

In order to diligently assess energy efficiency techniques, models, metrics and scenarios are needed. Regarding the models, it is FL’s view, based on companies’ inputs, that RAN1 needs to discuss whether the existing models in TR 38.840 (5G NR), TR 38.875 (RedCap), TR 38.869 (UE WUR) and TR 38.864 (gNB) need to be updated, and if so, how.

Evaluation assumptions for 6G Radio are discussed in AI 11.2. The 11.2 FL has come with the following suggestion for the continued discussion:

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| **Observations and suggestions from moderator [of AI 11.2]**:   * The traffic model could be discussed as a common assumption in section 2.4. * The power consumption or energy efficiency for AI related use cases will be discussed in the agenda of AI/ML study. * Other assumptions, e.g., power model, metrics for energy efficiency evaluation, and baseline schemes could be discussed in the agenda of energy efficiency study. |

From the above it is clear that the focus of AI 11.5 should focus on power model, evaluation metrics and baseline schemes for said evaluation metrics. Furthermore, EE FLs have agreed that the majority of power models will be discussed in the connected mode discussions. Based on this, and companies’ input, the following is proposed regarding power models:

FL Proposal 2.6‑1:

**Study if and how the existing UE and network power consumption models need to be enhanced for (UE) idle mode 6G radio.**

Companies are welcome to share their views on the above FL proposal.

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| **Company** | **View** |
| InterDigital | Fine |

Regarding the evaluation metrics, and taking the discussion in AI 11.2 into consideration, it is FL’s understanding from 11.2 that the intention is to evaluate relative metrics compared to a baseline scheme. Additionally, in idle mode, it is not really relevant to discuss detailed transmission-centric metrics like bits/joule but more fundamental properties like total power consumption, duty cycle, deep sleep duration, UE access latency (in relation to energy consumption) etc. For that reason, the following is proposed for evaluation metrics:

FL Proposal 2.6‑2:

**Study idle mode energy efficiency metrics for UE EE, network EE, and joint UE and NW EE.**

Companies are welcome to share their views on the above FL proposal.

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| **Company** | **View** |
| InterDigital | In our reading, energy efficiency related metrics are proposed to reflect both system performance (e.g., throughput) and energy consumption/saving. However, as this discussion is for IDLE mode, we are not sure that we can consider system performance in this discussion. It may be better to discuss in CONNECTED mode discussion. |

Finally, RAN1 needs to agree on baseline scheme(s) for the evaluation. In FL’s understanding, this may include default NW and UE configurations, network load, deployment type, frequency ranges etc.

FL Proposal 2.6‑3:

**Study relevant baseline schemes for network and UE energy efficiency assessment, including**

* **Network and UE configurations,**
* **UE traffic types,**
* **Network load (in the range from empty to high),**
* **Network deployment, e.g. single carrier, multi-carrier**
* **Frequency ranges FR1, FR2, FR3**
* **etc.**

Companies are welcome to share their views on the above FL proposal.

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| **Company** | **View** |
| Google | We think UE types should also be considered, given that diverse UE types would be introduced in 6GR Day-1. In addition, we can also consider UE status. For example, if UE is under overheating situation, the power usage status would be impacted. |
| InterDigital | Fine |

## Omitted topics

It is the FL’s understanding that the following topics that have been discussed among contributions will be discussed elsewhere and for that reason will not be discussed in AI 11.5:

* Waveforms, that will be specifically discussed in AI 11.3.1, and
* AI/ML, that will be discussed in AI 11.6.

# Contacts

Below is a contact list for companies’ delegates following the energy efficiency topic in the 6G Radio SI:

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

# Agreements

[void]

# Topics for online discussion

TBD.

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