Towards Sustainability (SDG) Goals in 6G

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SuITE Research Group
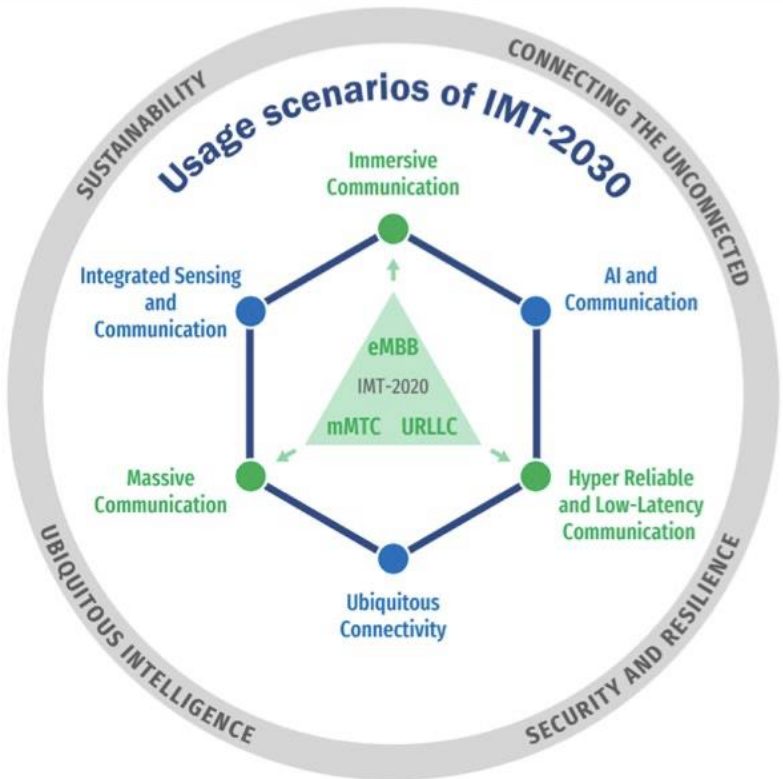
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IMT-2030 Use Case Scenarios

6G Capabilities

- Communication
  - Mobility
  - Densification
  - Coverage
  - Integrated Sensing & Comms
- Resiliency
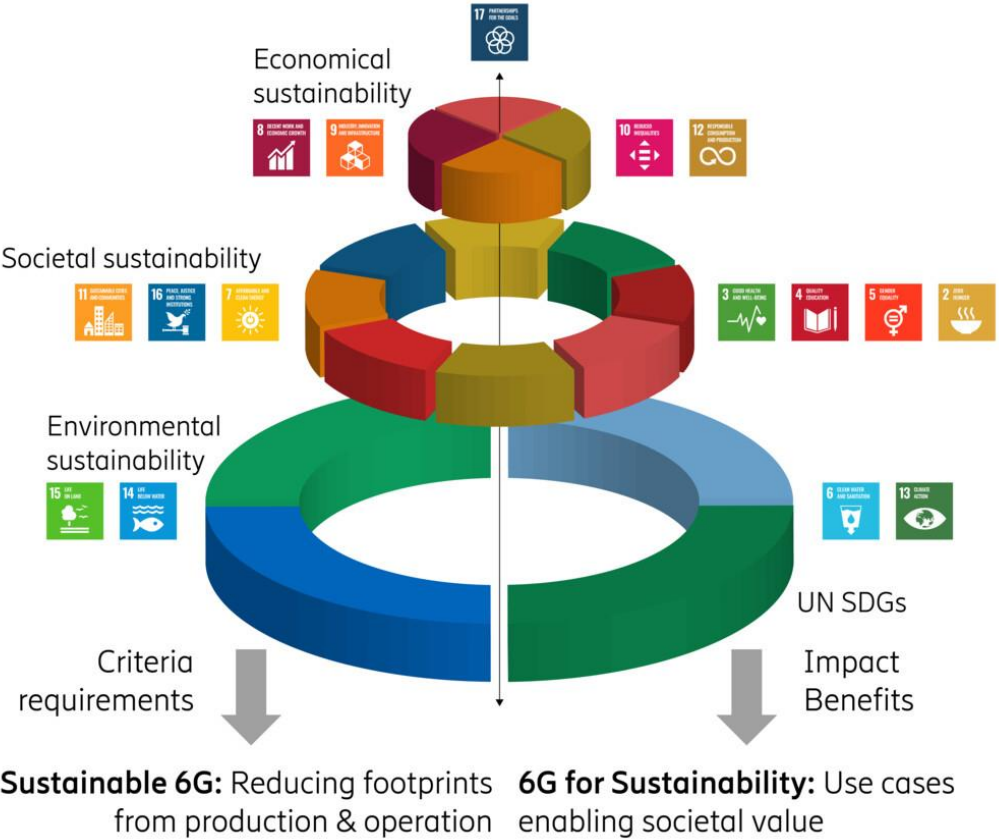 - Confidentiality
  - Integrity
  - Availability

- **AI-Native**
  - Workload management
  - Inference accuracy
  - Model latency
- **Green**
  - Network Efficiency
  - Network Carbon Efficiency
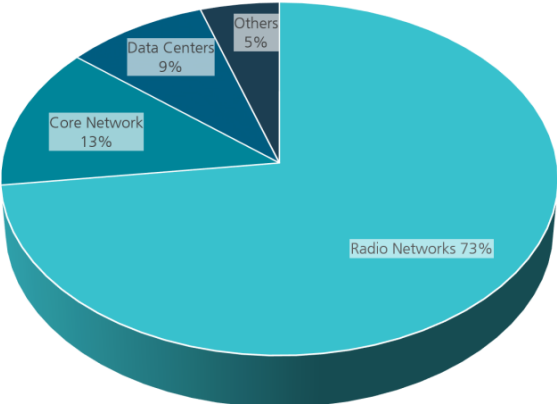 - Battery requirement
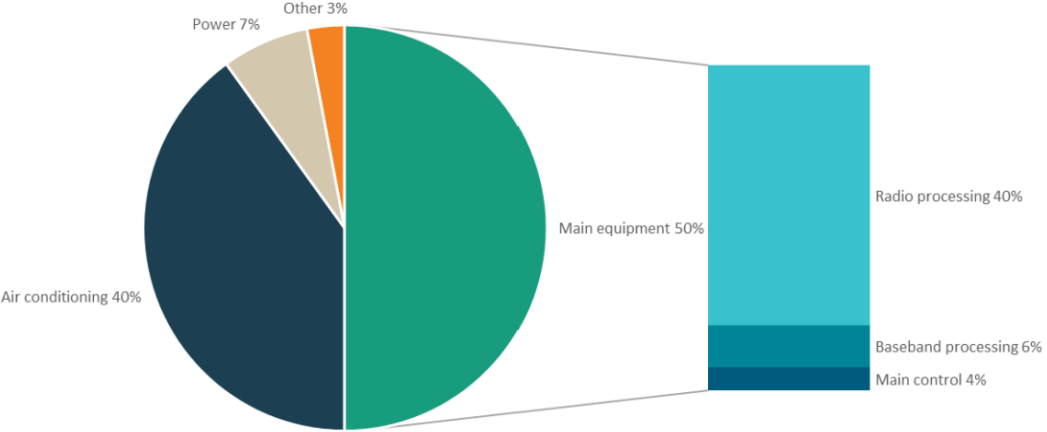
Sustainable 6G or 6G for Sustainability

Source: Ericsson, 2023

RAN Energy Consumption

Source: GSMA, 2021

Source: NGMN, 2022
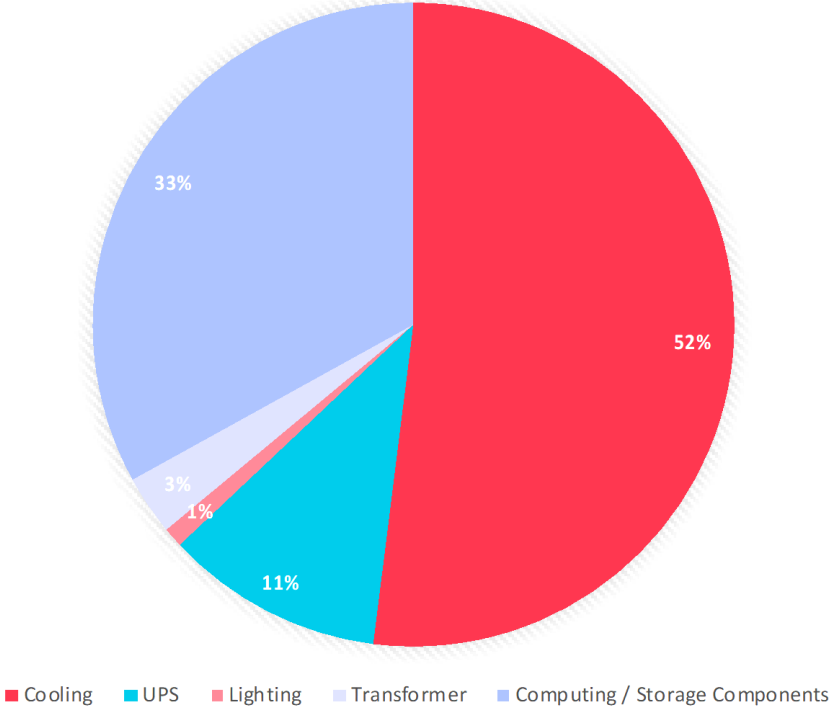
IT Energy Consumption

Typical Data Centre Energy Use

52% Cooling
33% Computing / Storage Components
11% UPS
3% Transformer
1% Lighting

Legend: Cooling · UPS · Lighting · Transformer · Computing / Storage Components

Source: NGMN, 2023

Vertical Sustainability Expectations-(1)

- **Manufacturing**
  - monitor and manage energy and water usage, reduce carbon emissions, and leverage renewable energy to power operations. 20%-30%

- **Smart agriculture**
  - real-time data collected by IoT-enabled drones and sensors resulted in more efficient and accurate pesticide spraying that could reduce overall pesticide use by 50%.

Vertical Sustainability Expectations-(2)

- **Energy**
  - 5G-connected smart grids will reduce gas and electricity consumption by 12% — and 6G will accelerate that progress.
  - The ICT industry already has a large footprint (about 1/10th of global electricity consumption) and is <u>projected to rise significantly</u>.
  - The wireless communication industry, a big part of the ICT sector, has made it a primary 6G objective to reduce energy usage and incorporate sustainability in its operational processes and lifecycle management.

Sustainability Complexity Tree in Future Mobile Networks
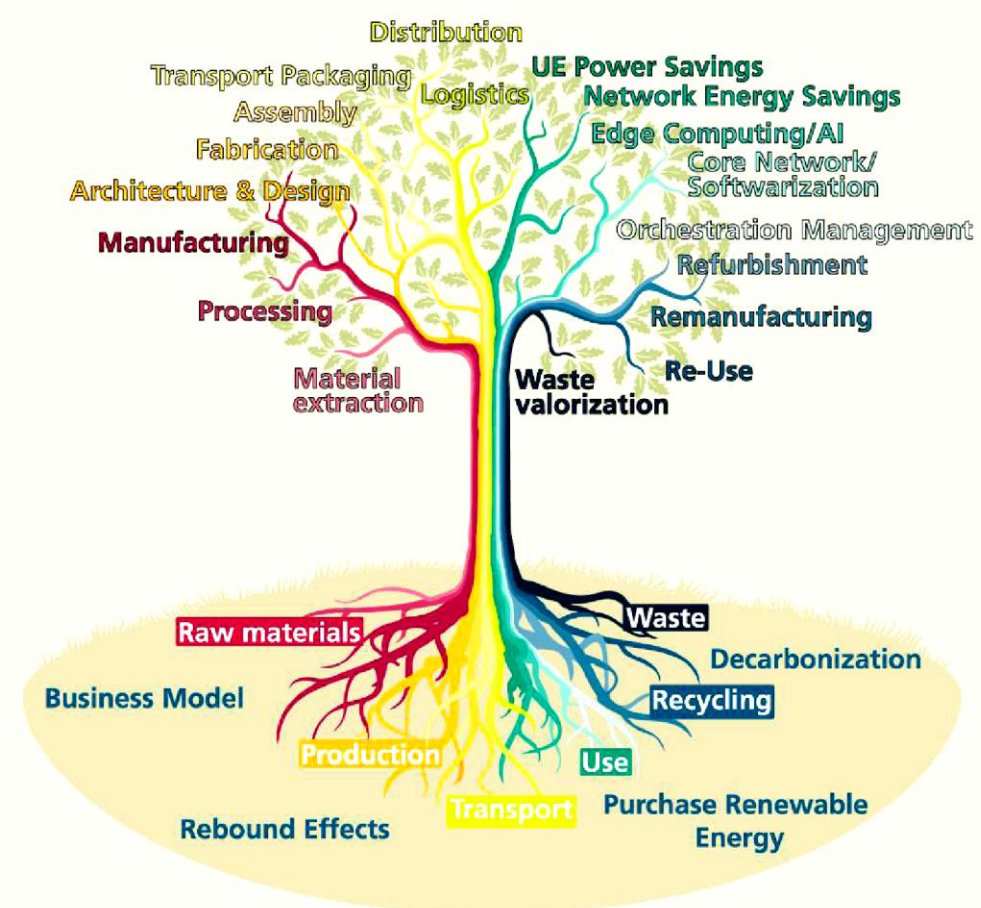
Source: Fraunhofer, Energy Efficiency and Sustainability, 2023

UE Energy Savings

- 5G NR features for UE power saving

  - Discontinuous Reception (DRX) and the new Radio Resource Control (RRC) Inactive state

  - Transition from RRC Inactive to RRC Connected involves less signaling.

  - The use of a Wake-up Signal (WUS)

  - Number of Antennas for both uplink and downlink

  - Frequency of the RRM measurements

  - Paging Early Indication (PEI): The UE needs to monitor Paging Occasions (POs) to respond to incoming network messages (e.g. incoming call).

Network Savings-(1)

- Hardware Evolution

  - From CPU, FPGA, TPU, NPU

  - Energy measurement for recording the energy consumption of computing

- Virtualisation Evolution

  - Runtime environment (from VM to containers, Unikernels and WebAssembly).

  - A green design of AI must ensure that its implementation will excel resource saving benefits

    - Transfer learning

    - neural network pruning

    - Weight quantization

    - Subspace methods

Network Savings-(2)

- RAN

  - Efficient beam management

  - The role of RIS: Electromagnetic properties can be dynamically adjusted

  - Distributed MIMO: In a wide coverage area, they jointly serve UEs using the same resources.

Network Savings-(3)

- **Network automation and orchestration**

  - VNF and network-slicing

  - Move compute loads to data centres that have access to renewable energy

- **Edge**

  - Due to the high-power consumption in idle mode, servers in part-load also generally do not operate in an energy-efficient manner.

  - Pushing ML and analytics in the edge

  - Outage/Failures management

KPIs for Energy/Power Efficiency

Metric	Unit	Description
Power Consumption	W	Energy that is either transferred or converted per time unit
Energy Consumption	KWh	Amount of power used over a period time
Energy Efficiency	KWh/unit	Ratio of output of performance in goods, service to the energy input
Power Efficiency	%	Output power/input power
Energy Performance	Mbps/KWh	Ratio between the produced work and the consumed power for producing this work in a time period

Short-to-Long Term Expectations

- Short-Term: Process Optimisation

- Medium Term: Engineering Optimisation

- Long-Term: New technology enablers

The Pathway to Climate Goals

- Science-Based Targets:
  - It provides a clearly defined pathway for companies and financial institutions to reduce greenhouse gas (GHG) emission.
  - Global warming is limited to well below 2 C towards 1.5 C.

- Net-Zero
  - it specifies short- and long-term CO2 reduction targets.

Standardisation Activities-(1)

- **ISO technical committee to environmental management**
  - Committee SC5 (Life Cycle Assessment-LCA)
    - It is a standardized methodology to quantify the environmental impact to processes, products and services.
  - Committee SC7 (Greenhouse gas management)

Standardisation Activities-(2)

- **Next Generation Mobile Networks Alliance (NGMA)**
  - Green Mobile Networks
    - End-to-end service footprint calculation
    - Network Energy Efficiency
- **Alliance for Telecommunications Industry Solutions**
  - Green G working group
    - Reducing energy consumption and environmental impact on future wireless subsystems

Standardisation Activities-(3)

- 3GPP

  - LTE network saving signaling (Release 9)

  - UE savings (from Release 16 and onwards)

    - further power savings have been defined for devices with reduced capabilities (e.g. wearables-medical devices, smart watches or industrial wireless sensors)

  - RAN consumption (Release 18)

Standardisation Activities-(4)

- ETSI
  - LCA on ICT goods, products, services. Its application is regulated by ISO standards 14040 and 14044.
  - Energy efficiency of wireless access networks and equipment, core networks.
  - Efficiency metrics/KPI definition for equipment and network
  - Network standby energy footprint
  - Circular economy standards
- ITU
  - Study Group S5: Environment and circular economy topics
  - ETSI and ITU SG5 are working together to develop technically aligned standards on energy efficiency, power feeding solution, circular economy and network efficiency KPI and eco-design requirement for ICT.

Questions

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6G Technology Enablers

- THz communications

- Reconfigurable Intelligent Surfaces

- Integration of Communication and Sensing

- AI-native 6G network architectures (self-learning, self-configuration, self-healing)