



Green Communication for Internet of Things (IoT) Applications

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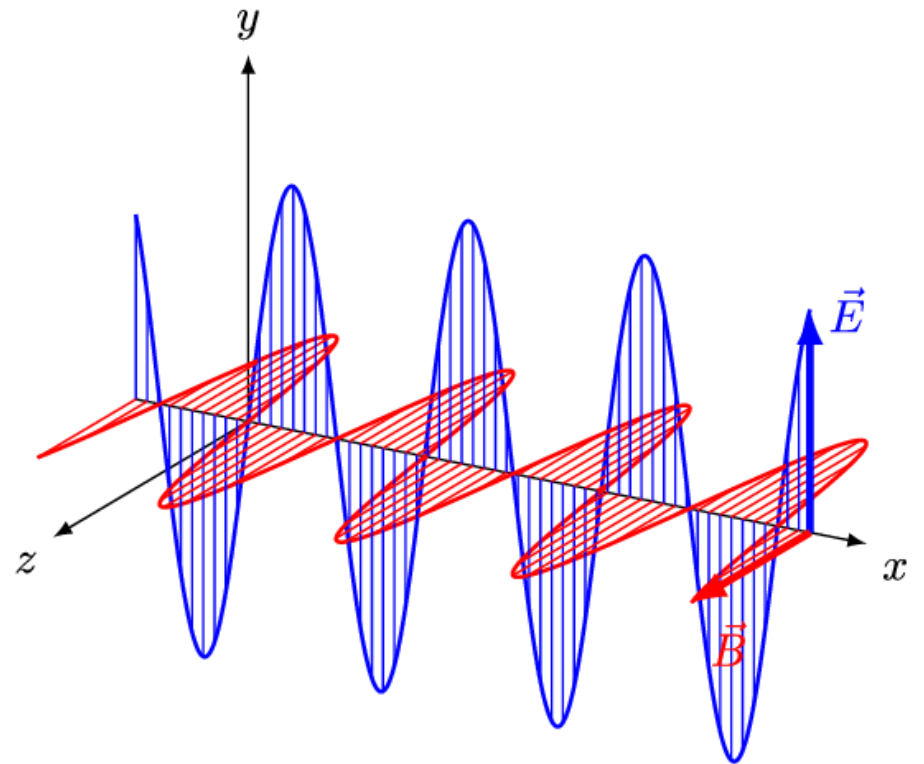
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Presentation Outline

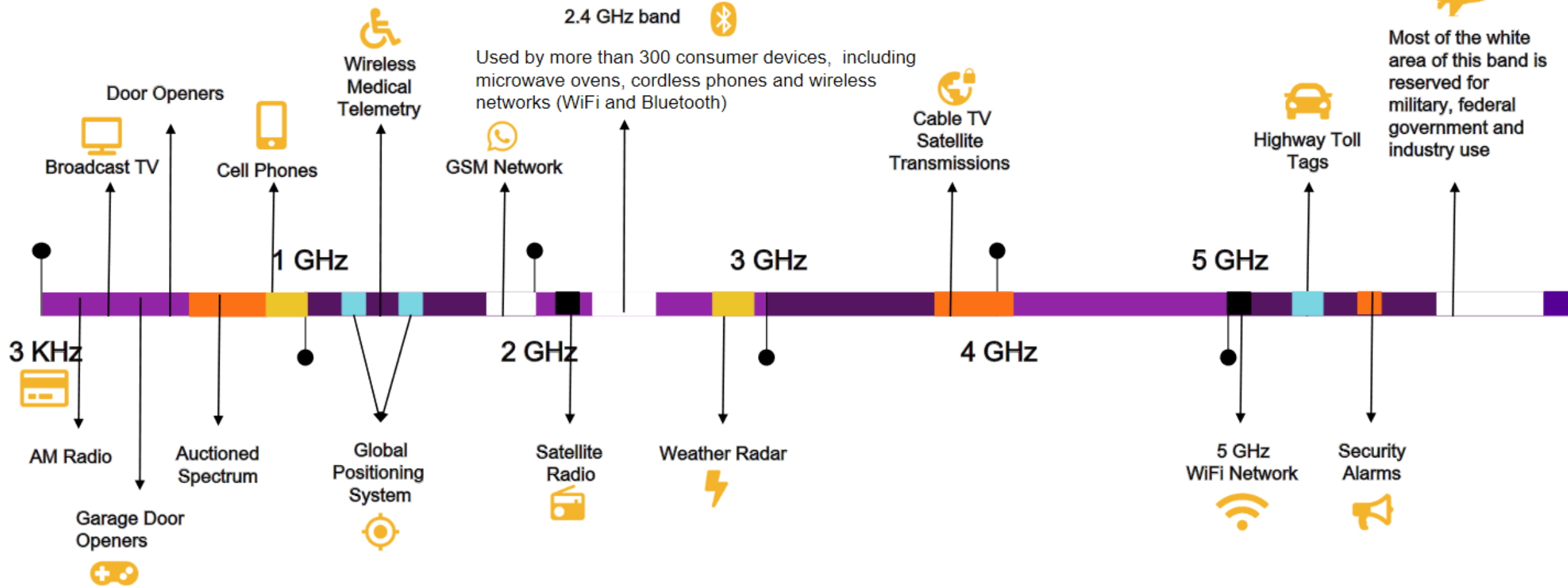
- ▶ **Background of Communication Engineering**
 - ▶ **Green Communication**
 - ▶ **Internet of Things (IoT)**
- ▶ **Software Defined Radio (SDR) in IoT**
- ▶ **SAR and EMC on IoT Devices Testing**

Background of Communication Engineering

- ▶ System build and design to interconnect the world.
- ▶ Radio Frequency (RF)
- ▶ Electromagnetic Radiation (EMR)



Inside the radio wave spectrum



Green Communications

- ▶ Intergovernmental Panel on Climate Change

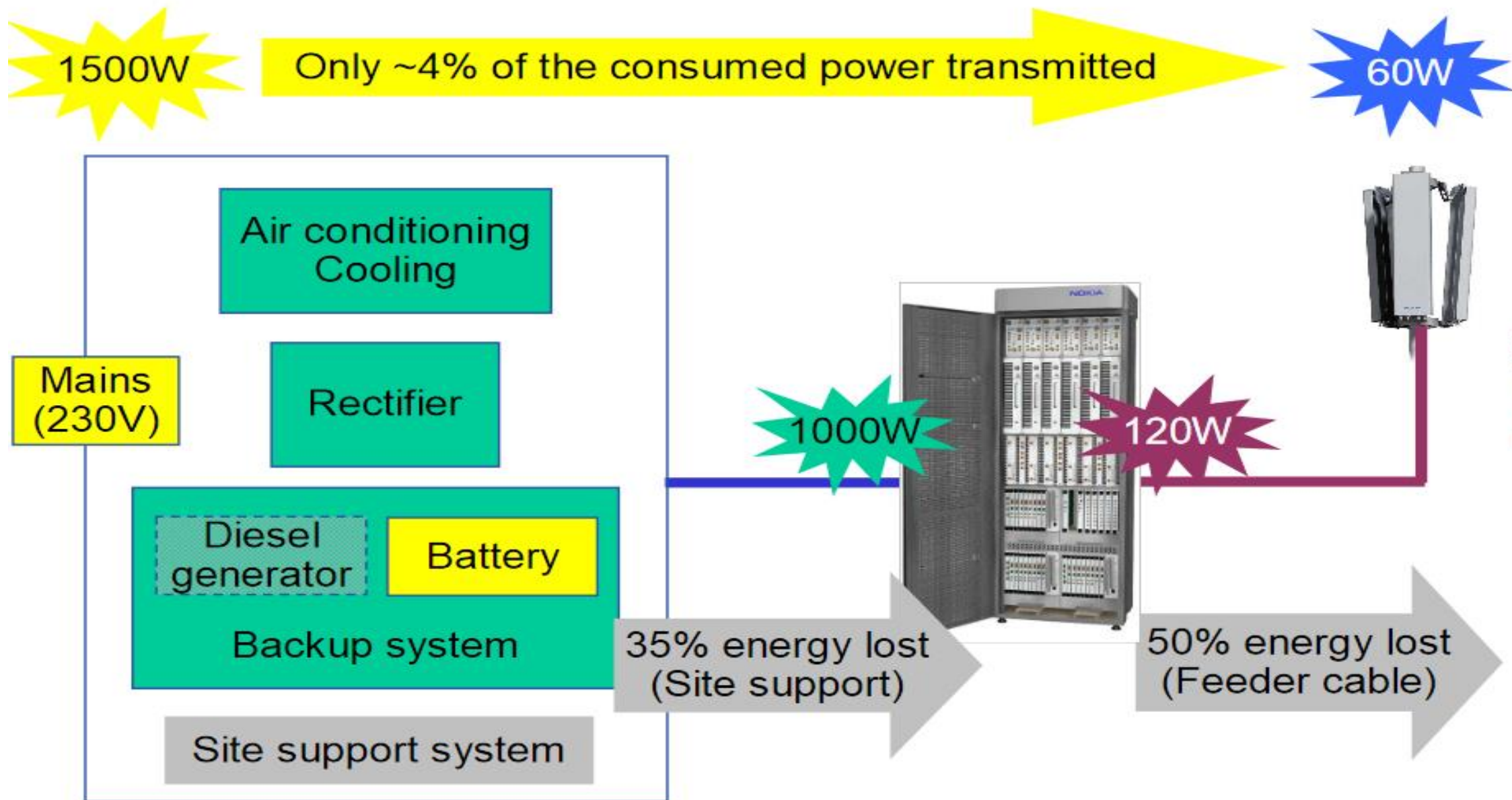
“The IPCC has unequivocally affirmed the warming of our climate system, and linked it directly to human activity (greenhouse gas emissions).”

Ban Ki-moon, UN Secretary-General

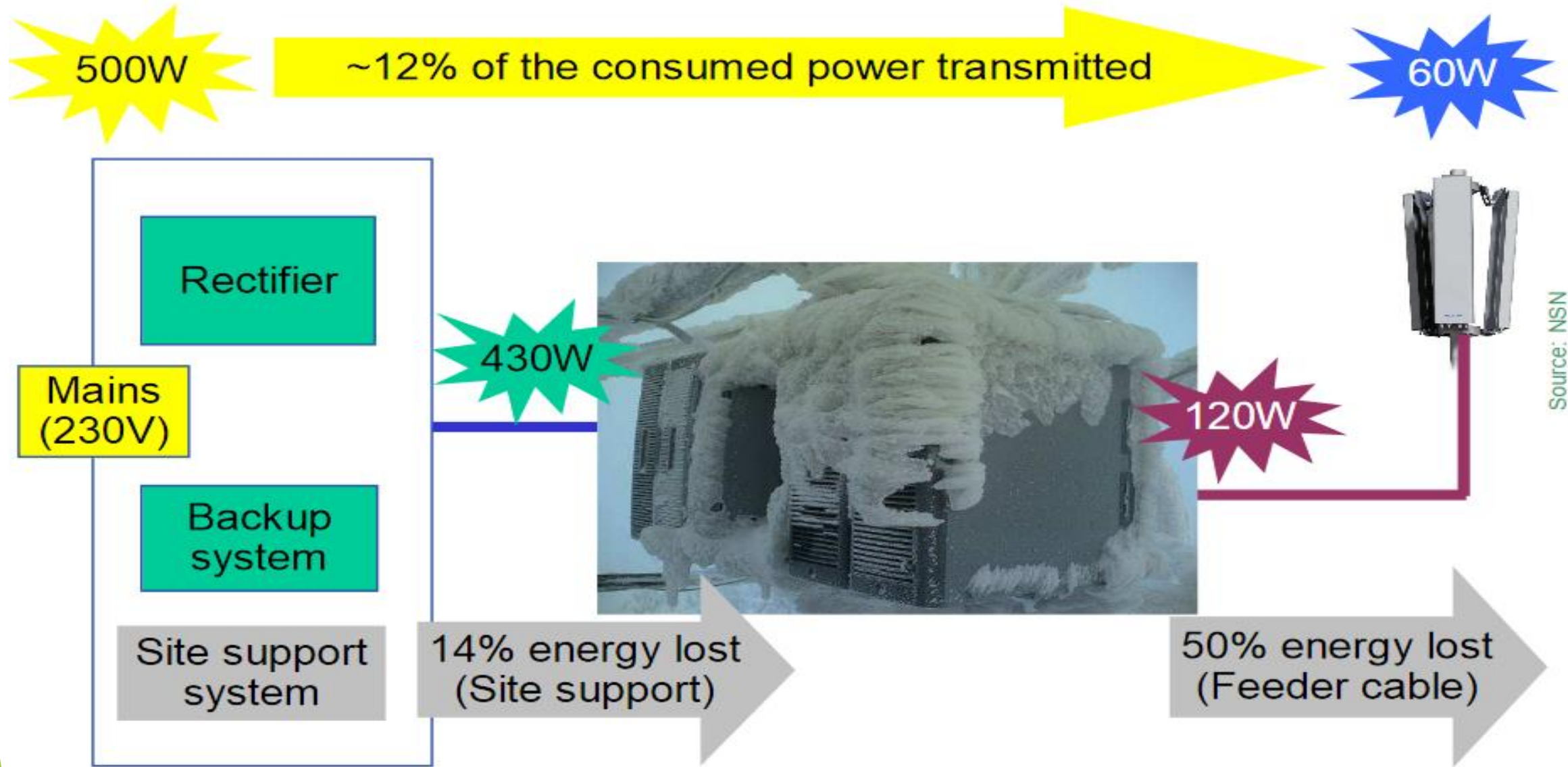
“We simply must do everything we can in our power to slow down global warming before it is too late. The science is clear. The global warming debate is over.”

Arnold Schwarzenegger, Governor of California

Power consumption of a traditional cellular site



Power consumption of a modern cellular site



Internet of Thing (IoT)

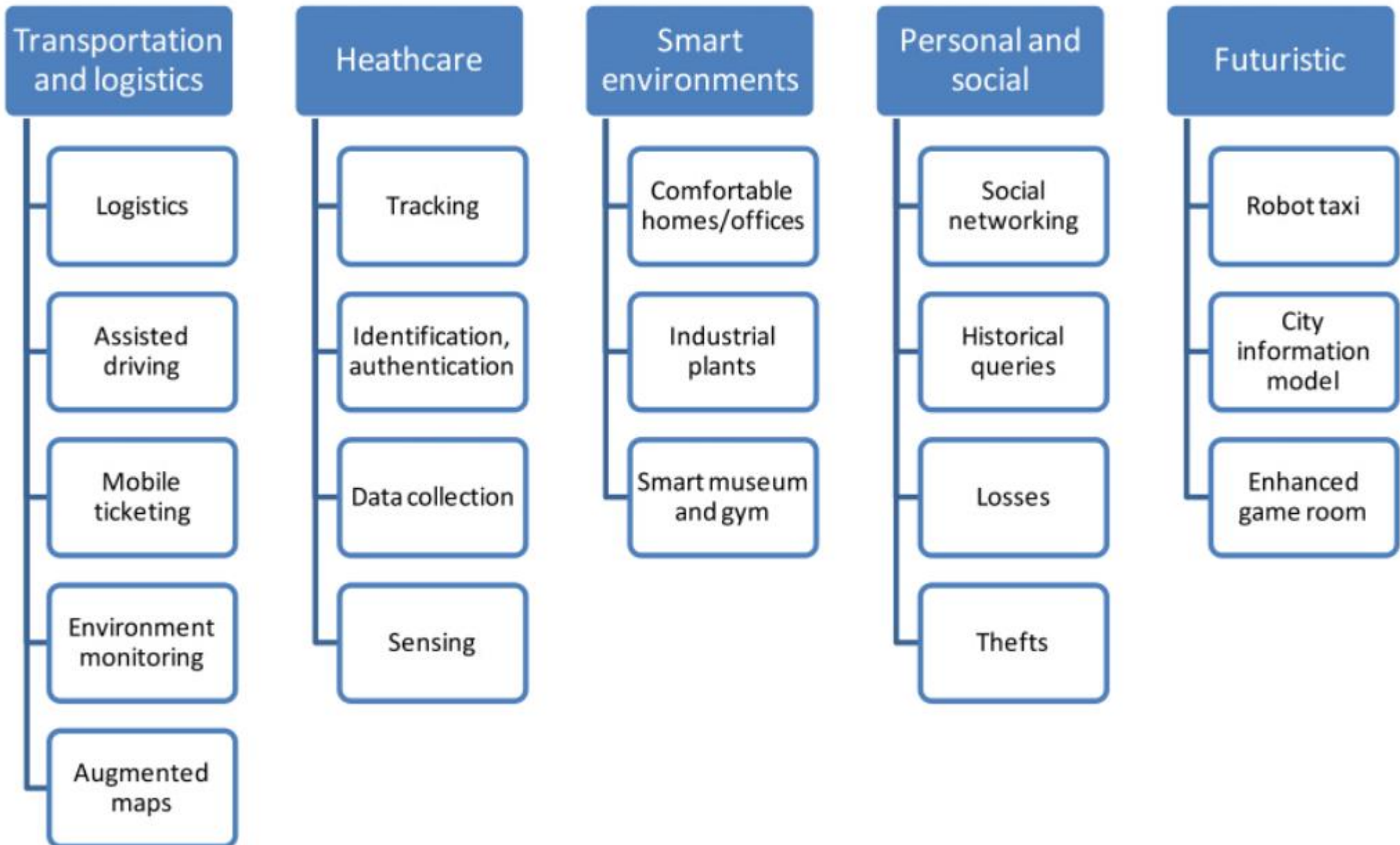
- ▶ Internetworking of a variety of objects (e.g., sensors, actuators, mobile phones, appliances) with unique addresses to enable their interactions with each other and with the cyber world
- ▶ RFID, WSN, WPAN, WBAN, gateways, IP, telemetry, command-control, client-server, cloud computing, big data.



Everyday things get connected for smarter tomorrow



Applications of IoT



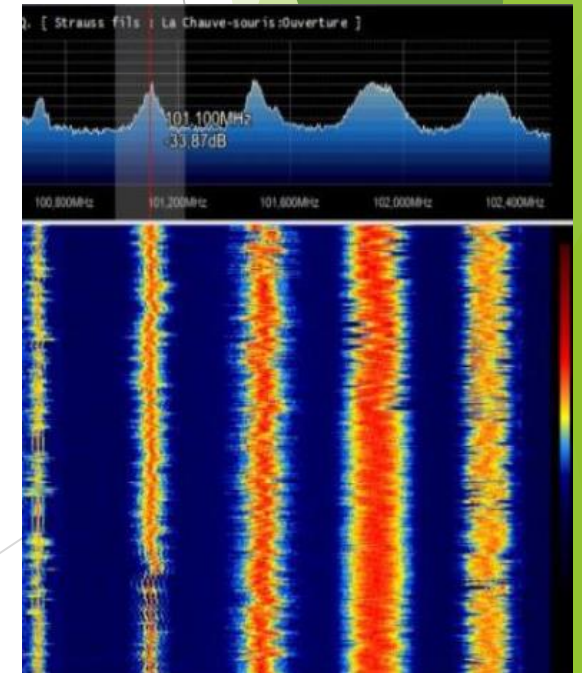
General Principles of Green Communication in IoT

- ▶ Turn off facilities that are not needed
 - ▶ *E.g: sleep scheduling*
- ▶ Send only data that are needed
- ▶ Minimize length of data path
 - ▶ *E.g: energy-efficient routing schemes*
- ▶ Minimize length of wireless data path
 - ▶ *E.g: energy-efficient architectural design*
- ▶ Trade off processing for communications
 - ▶ *E.g: data fusion, compressive sensing*
- ▶ Advanced communication techniques
 - ▶ *E.g: MIMO, cognitive radio*
- ▶ Renewable green power sources

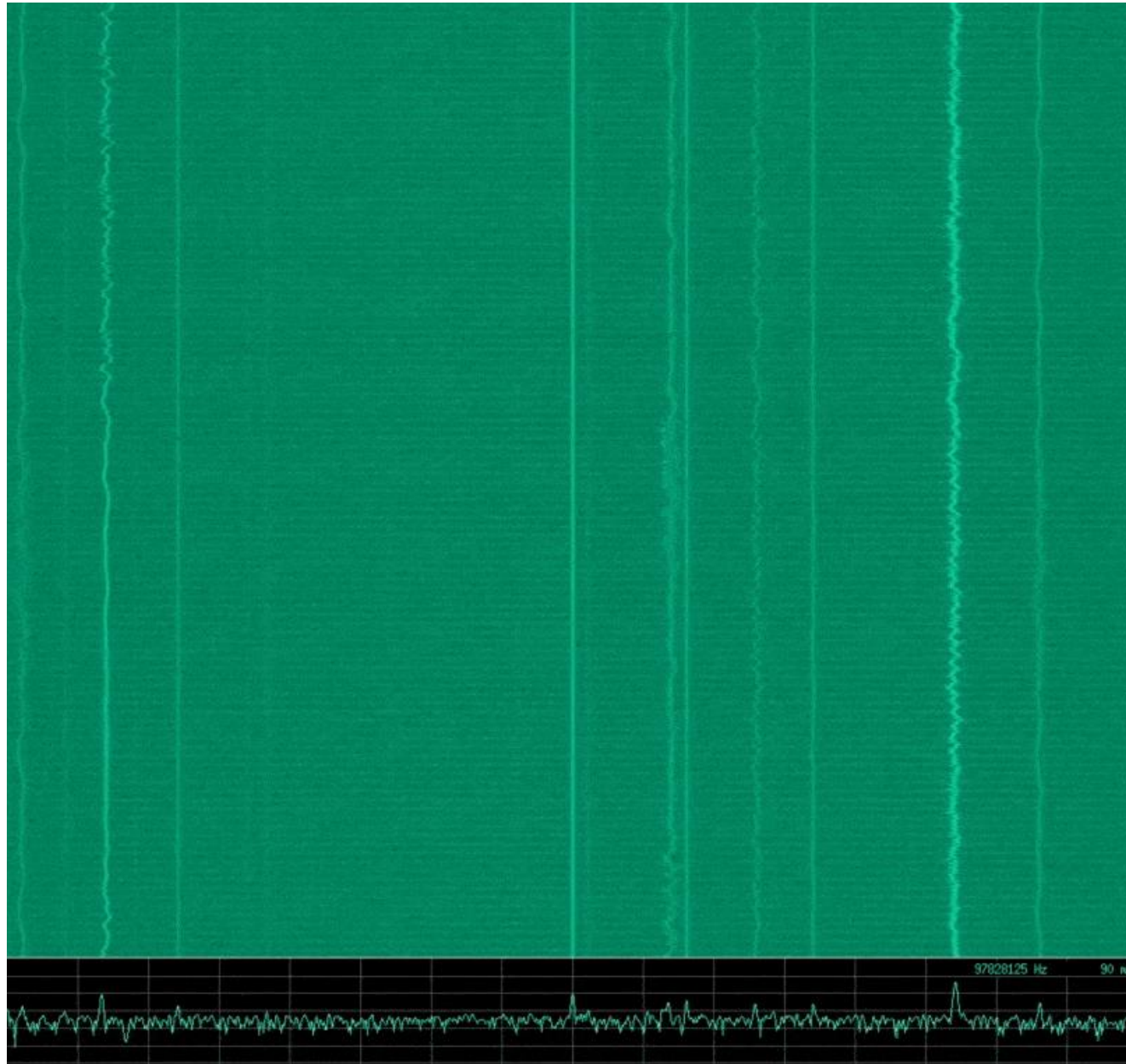
Examination Radio Frequency (RF) signals using Software Defined Radio (SDR)

► Capturing and Analysing RF Signals

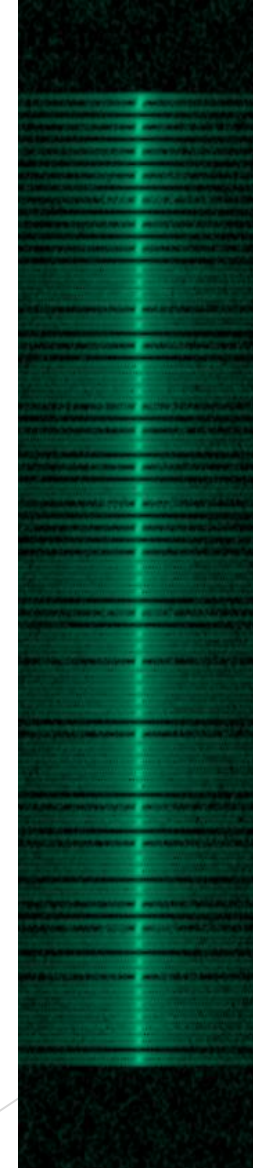
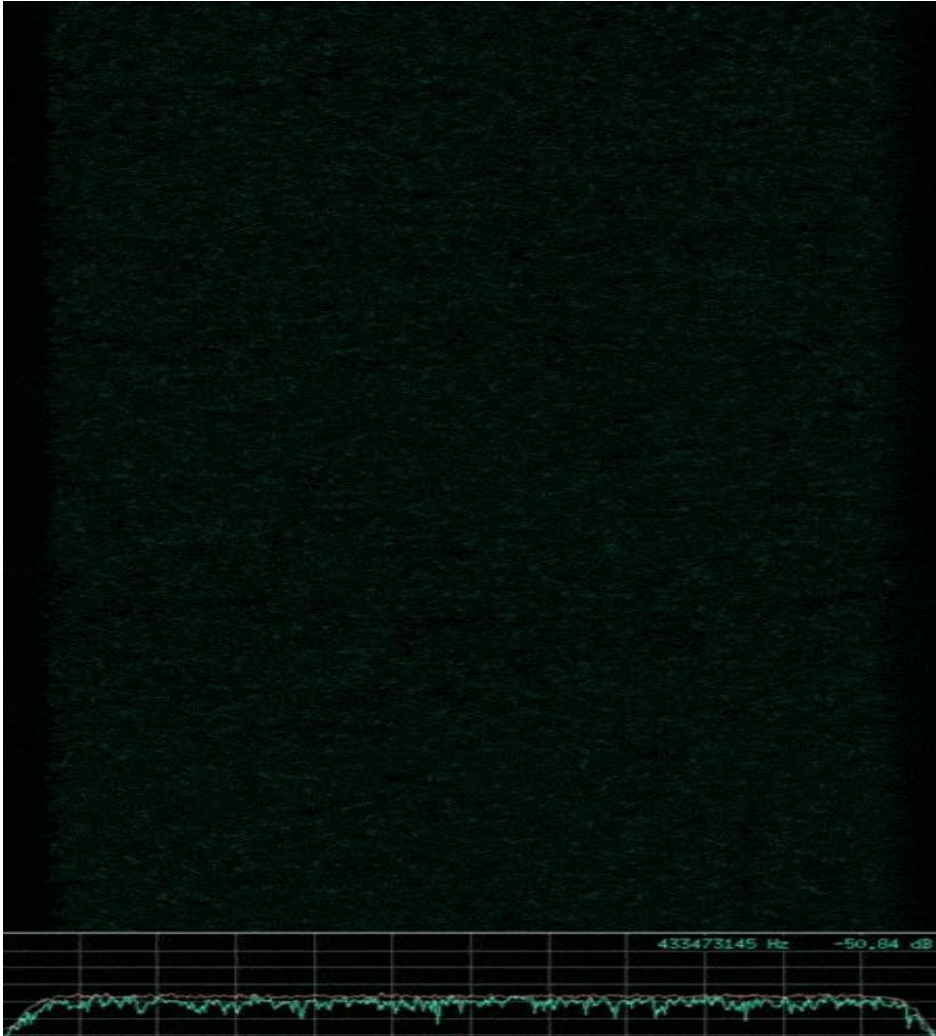
- Pipe the data received from the SDR device into Baudline. This is quite simple with both an RTL_SDR device or the HackRF, using their CLI commands `rtl_sdr`, or `hackrf_transfer` respectively.
- Both *RTL_SDR* and *HackRF* use two channels to sample the quadrature values I and Q previously talked about. In the case of the *HackRF*, the samples are 8-bit signed values, and this needs to be relayed to *Baudline* in order to correctly interpret the data.



FM radio stations signals

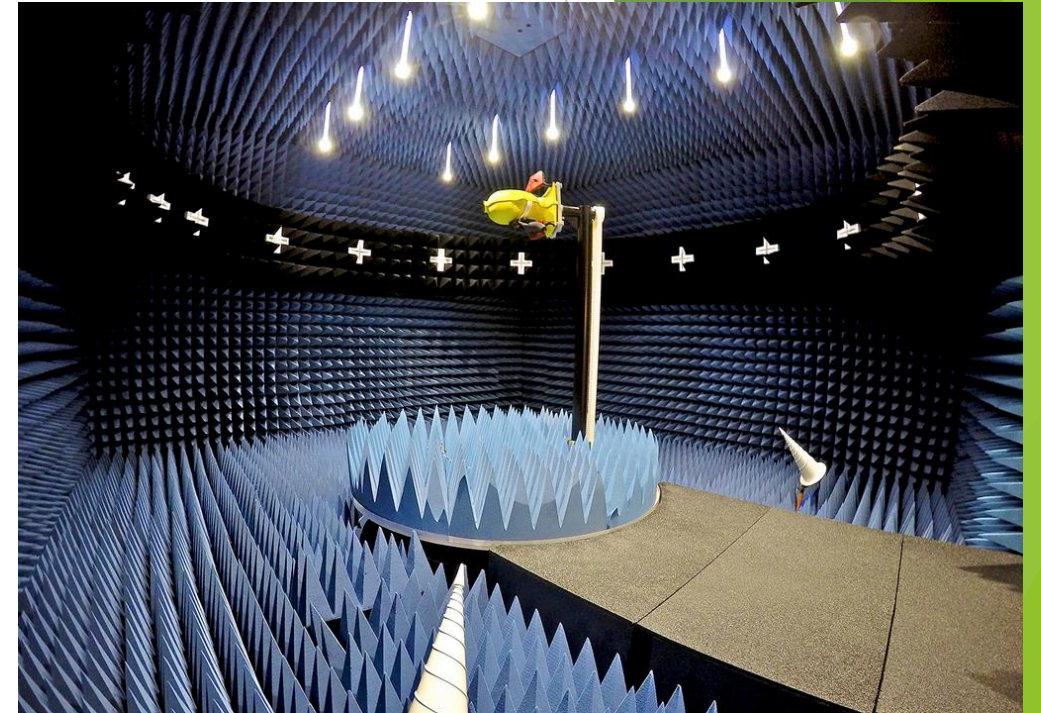


Home and Business Security System



SAR and EMC: Testing IoT Device Signals and Radiation

- ▶ Electromagnetic Compatibility (EMC) tests evaluate wireless devices's reliability, performance and safety.
- ▶ Specific Absorption Rate (SAR) testing measures RF exposure on human dummies to ensure that mobile devices don't cause damage.
- ▶ Check FCC Regulations:
 - ▶ FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications.
 - ▶ No station may transmit with a transmitter power exceeding 1.5 kW PEP.



THANK YOU

The background features abstract, overlapping geometric shapes in various shades of green, ranging from light lime to dark forest green. These shapes are primarily located on the right side of the frame, creating a modern, layered effect against the white background.