



The REINDEER project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101013425.



# REINDEER

REsilient INteractive applications through hyper Diversity in Energy Efficient RadioWeaves technology.



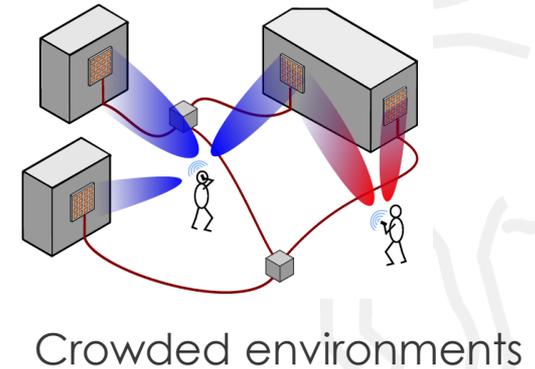
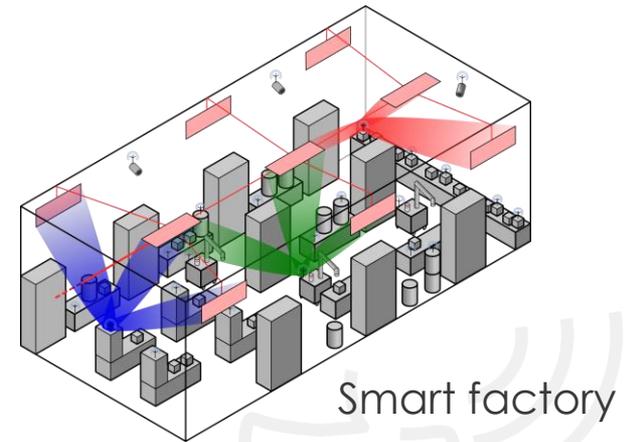
## Technological innovation and target use cases: reflecting on sustainability

6G workshop series, 18/01/2023  
Liesbet Van der Perre, KU Leuven

# REINDEER develops RadioWeaves technology

The RadioWeaves concept is introduced

1. To overcome performance and energy efficiency bottlenecks,
2. distributing a very high number of antennas, radios and computational resources throughout the environment.



'6G innovation actors to demonstrate the added value 6G will bring to our lives.'

# Technology innovation and use cases: sustainable?

Sustainable 6G

1. Distributed deployment of radio and compute resources bears a great potential for order(s) of magnitude improvement in **energy efficiency**
2. Interacting with battery-less devices for massive IoT can prevent **toxic waste** disaster
3. REINDEER innovation for **applications** potentially contributing to sustainability



# Energy consumption in 6G: Efficiency or absolute ambition? Adequate metrics?

The goal quantified:

'new G' every 10 years & 50% growth/year

→ **6G needs to be 100x more energy efficient just to stay on par**

- **Applies to all** the contributors to energy consumption:

$$E_{total} = E_{link (air)} + E_{hardware (T_x+R_x)} + E_{network}$$

- Adequate metrics (REINDEER D2.1 & references therein):
  - “the metric [Joule/bit] is appropriate at full loads,
  - when network is **operated well below capacity**, the power consumption to cover an area, [W/m<sup>2</sup>] is the most relevant energy efficiency metric.”

# REINDEER in quest of drastic energy reductions: the potential with RadioWeaves technology

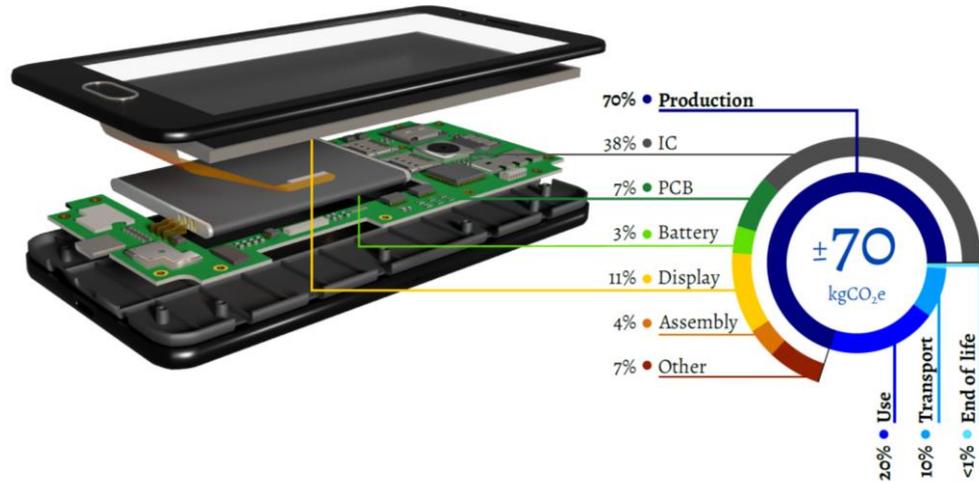


1.  $E_{link}$ : Proximity and diversity
2.  $E_{hardware}$ : research efficient PA operation, reduce DSP complexity, focus on 'golden' < 10GHz
3.  $E_{network}$ : Distributed resources: support decentralization
4.  $E_{total} - dynamics$ : Lean operation



**100x** improvement on all aspects is extremely ambitious!

# Carbon footprint of electronics: higher than operating consumption



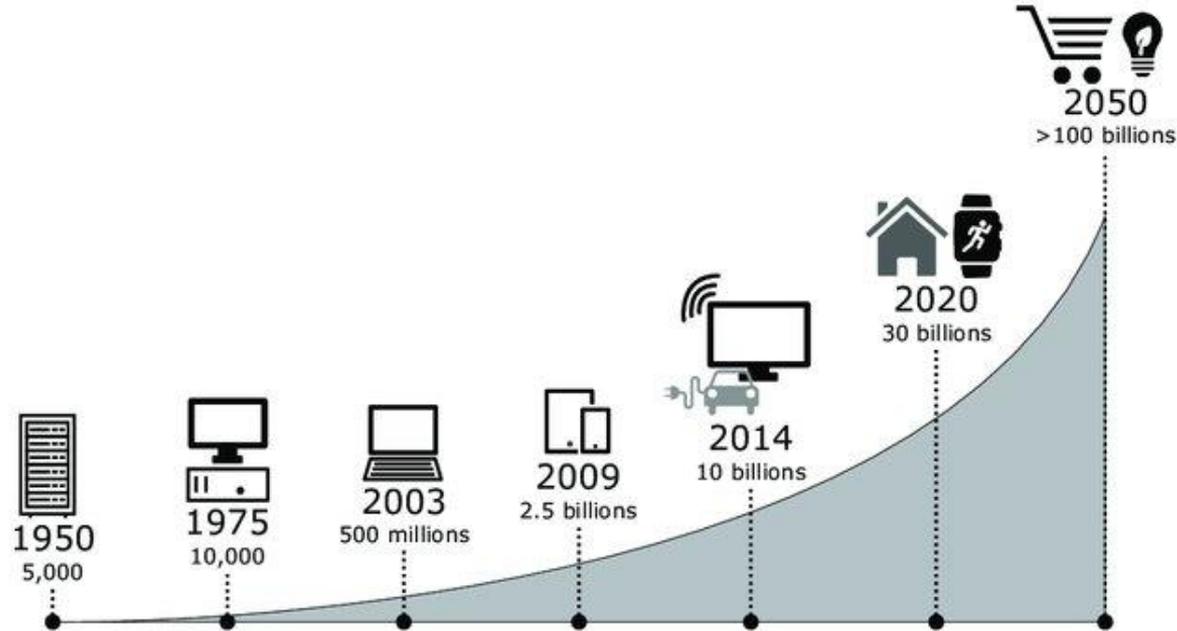
T. Pirson and D. Bol, "Assessing the embodied carbon footprint of IoT edge devices with a bottom-up life-cycle approach," *Journal of Cleaner Production*, vol. 322, p. 128966, 2021

# Technology innovation and use cases: sustainable?

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2. Interacting with battery-less devices for massive IoT can prevent **toxic waste** disaster
3. REINDEER innovation for **applications** potentially contributing to diverse KVIs



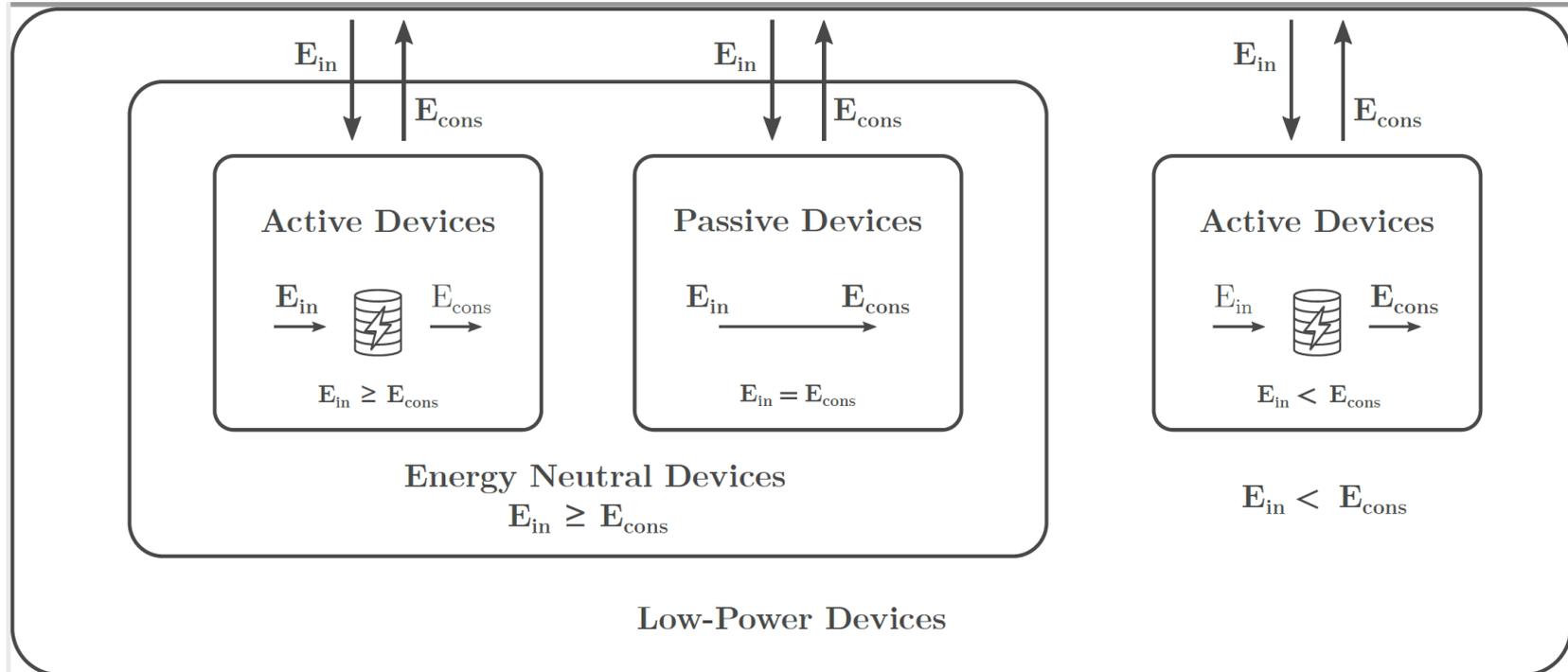
# Avoiding toxic e-waste: deploy massive IoT?



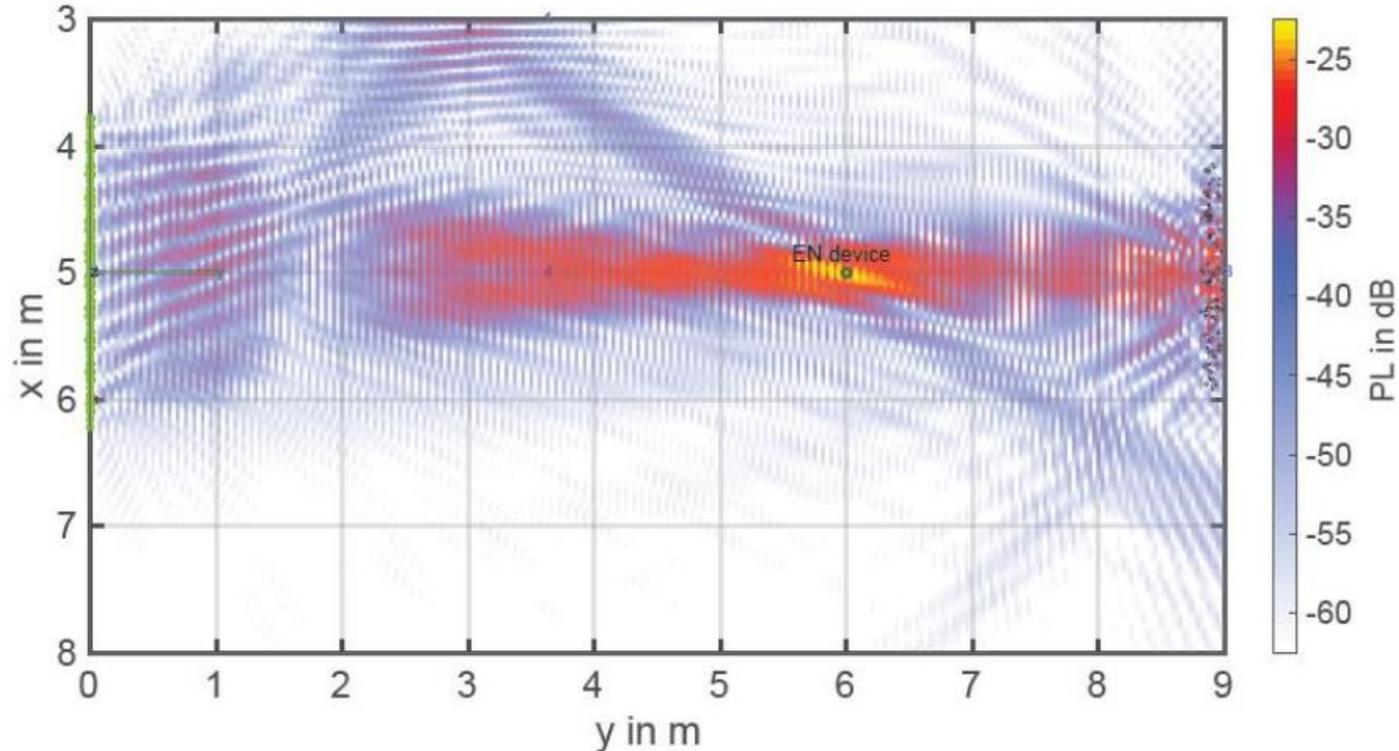
© Capra, M. et Al. (2019). Edge Computing: A Survey On the Hardware Requirements in the Internet of Things World. Future Internet. 11. 100. 10.3390/fi11040100.

S. Higginbotham, "The internet of trash [Internet of Everything]," in *IEEE Spectrum*, vol. 55, no. 6, pp. 17-17, June 2018

# Could we connect to sustainable battery-less IoT nodes in 6G networks?



# Large, distributed, arrays improve proximity and 'spot focus' towards energy-neutral devices



# Technology innovation and use cases: sustainable?

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# The story of the elephant and the blind men - could be the story of 6G/a reindeer for sustainability?



Moreau, N. et Al.

**Could Unsustainable Electronics Support Sustainability?**

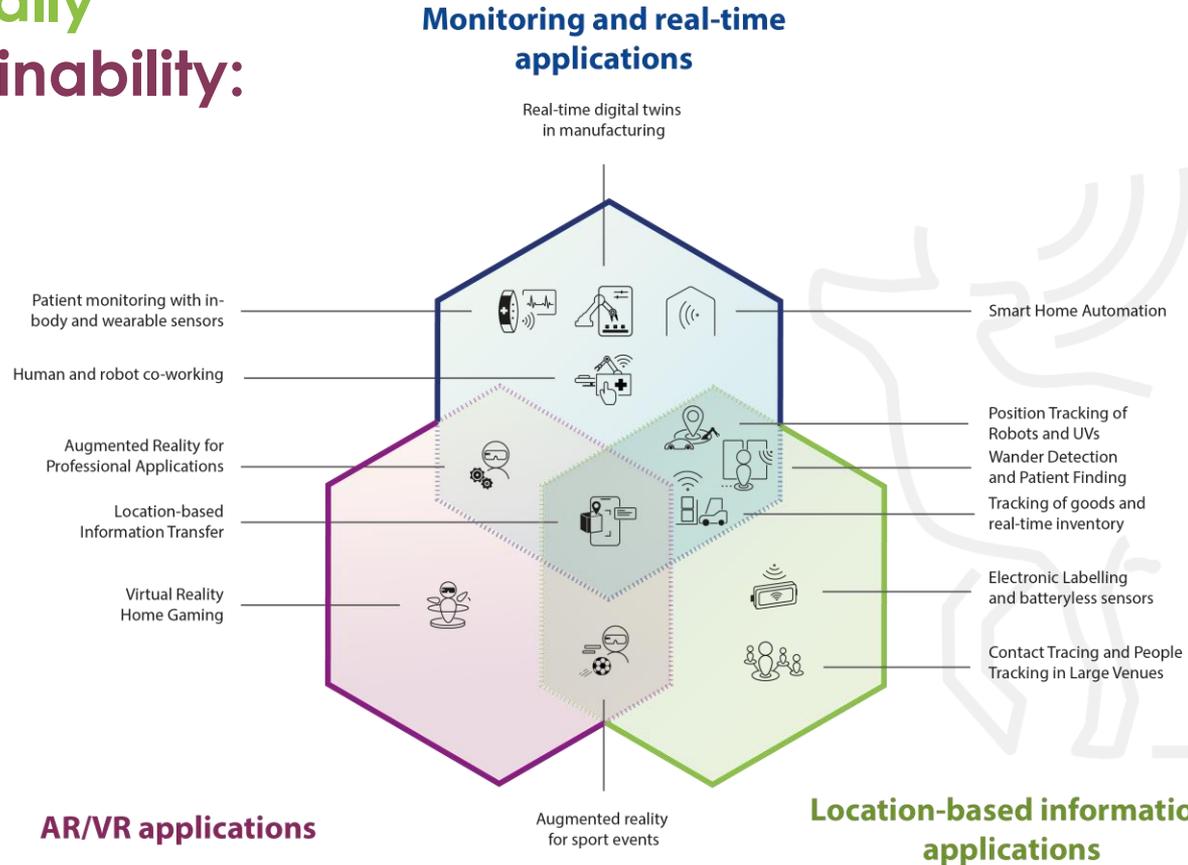
Sustainability 2021, 13, 6541. <https://doi.org/10.3390/su13126541>

# Towards a human-centric 6G on the road to the SDGs: How can we help?

- Health/care: wander detection, finding lost equipment, ...: indoor **positioning** functionality, connectivity to low-cost **battery-less devices**
- Environmental monitoring: will 6G offer more/better support?
- The divers set of SDGs: how will we contribute?



# REINDEER innovation for applications **potentially** contributing to sustainability:



# REINDEER Grant Agreement No. 101013425



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