



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

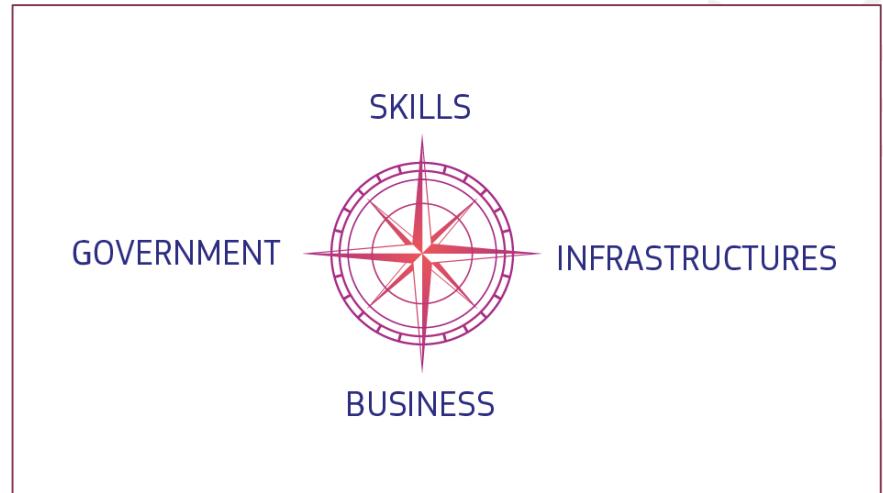
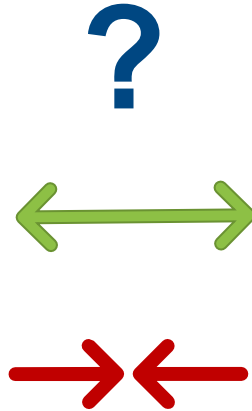
REINDEER

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

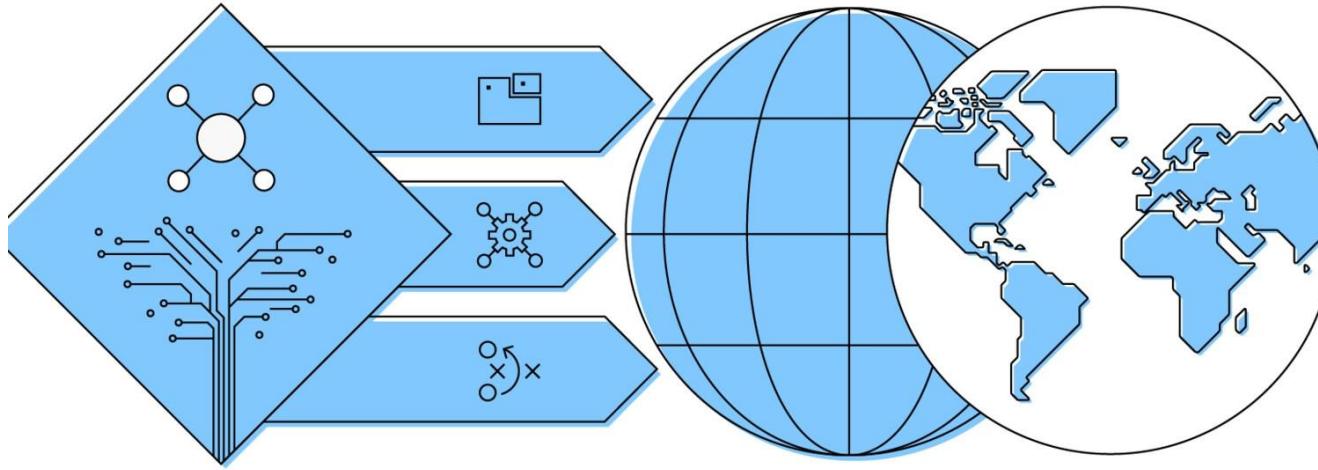
**In search of drastic energy reductions:
the potential with RadioWeaves technology**

Online, 03/02/2022
Liesbet Van der Perre, KU Leuven

‘How to make Europe greener and more digital are the twin challenges for our generation, and our success in meeting them will define our future.’



Digital compass 2030



‘Building sustainable networks:
Mobile data traffic is projected to grow significantly,
but service providers must simultaneously reduce energy consumption.’

Sustainability: can future wireless networks keep the pace in energy efficiency progress?



5G is less demanding than previous technologies when it comes to power consumption

When compared to 4G, it takes 10 times less energy to carry the same amount of data with 5G



5G will allow for the development of **solutions contributing to reducing energy:**

Smart buildings, smart cities, smart mobility...



© proximus

300

Mobile networks carry
almost 300 times more
mobile data traffic
than in 2011.

Are we given an unequal fight?

Has the fight for capacity been given priority
over the fight for energy efficiency?

Superfast but not so clean: China's 5G network is causing its carbon emissions to soar

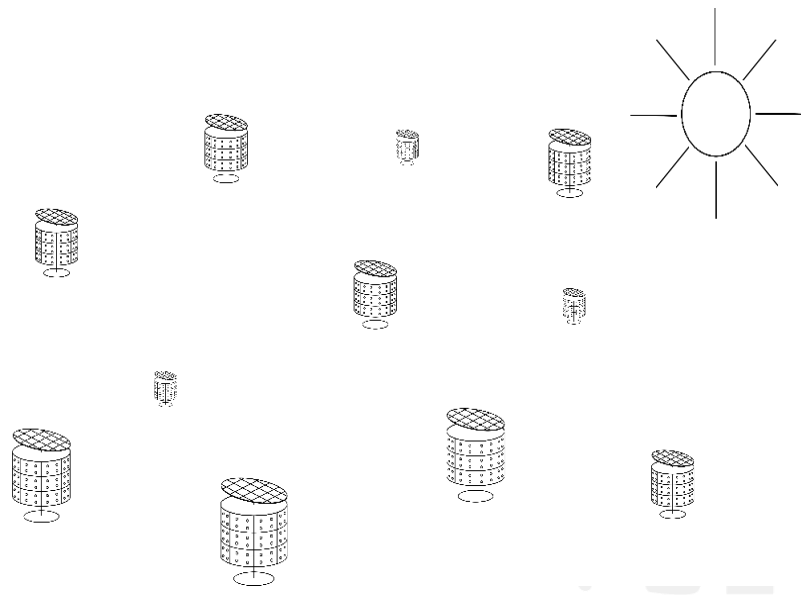


'China's digital sector will use nearly three times as much energy by 2035 thanks to 5G.'
Euronews June 2021

Towards zero carbon networks: what to do?

1. Uncover the challenge **crisply**:
physics, math, adequate metrics
2. Address **all** major contributors
3. Build the network with experts on
sustainable energy (avoid cooling, ...)

Analysis/results/ideas: REINDEER D2.1, D3.1,
personal experience and discussions



1. Uncover the challenge – 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 (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/m²] is the most relevant energy efficiency metric.”

We should be aware of greenwashing!

(my 2 personal 2 cents)

Yes, wireless networks can help increase sustainability in cities, ...

No, massive IoT is not/will not be responsible for high mobile data volume*

Yes, mmwave can provide good E_{link} efficiency (nJ/bit) for very high data rate with many antennas

No, it is not just a matter of time before HW energy penalty disappears for short packets**



Caricature by Italian artist Giacomo Cardelli

- Basic math: number of 100 bit IoT messages in one 5MByte picture – 10min UHD video (1GB)?

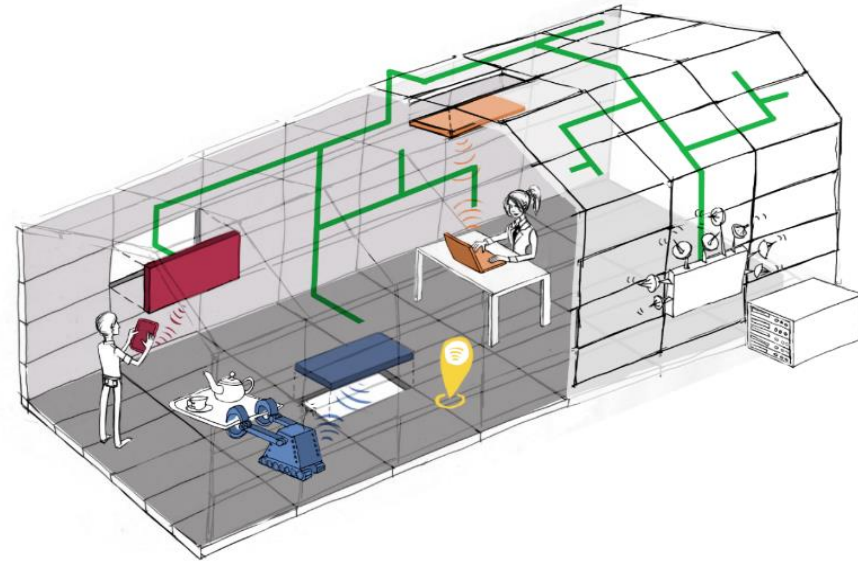
** I hope I will stay corrected by new transceiver paradigms

2. Address all contributors – mind physics & do the math correctly (disclaimer: preliminary/simplified)

- E_{link} : spectacular improvements need to continue: shorten link distance, improve directivity of transmission, optimize for actual propagation and real antennas
- $E_{hardware}$:
 - Conventionally PA dominated, ~output power (E_{link}) and back-off (efficiency), remains a bottleneck
 - DSP complexity 'catching up': ~algorithmic complexity and HW platforms efficiency @basestation (FPGA vs ASIC total LCA – footprint?)
 - mind the gap <10GHz and (very) high frequencies
- $E_{network}$: early data reduction ('deep-edge'), decentralize storage, ...

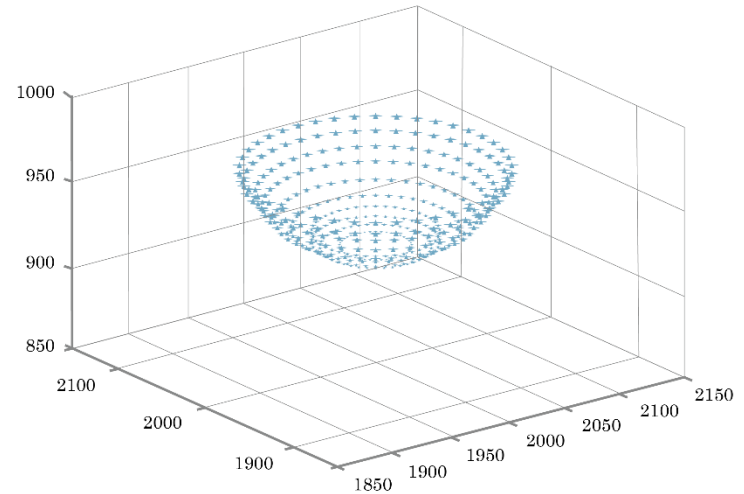
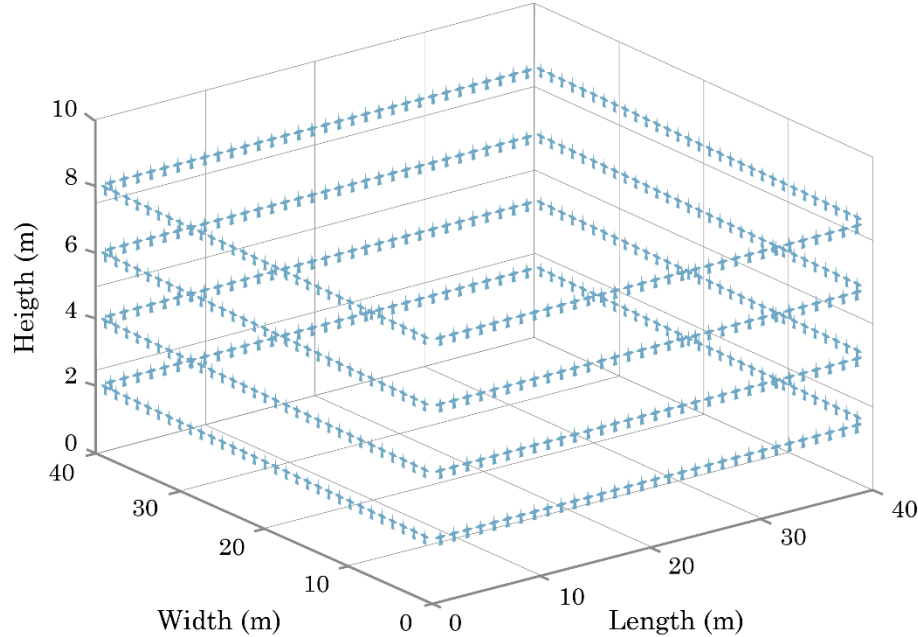
REINDEER in quest of drastic energy reductions: the potential with RadioWeaves technology

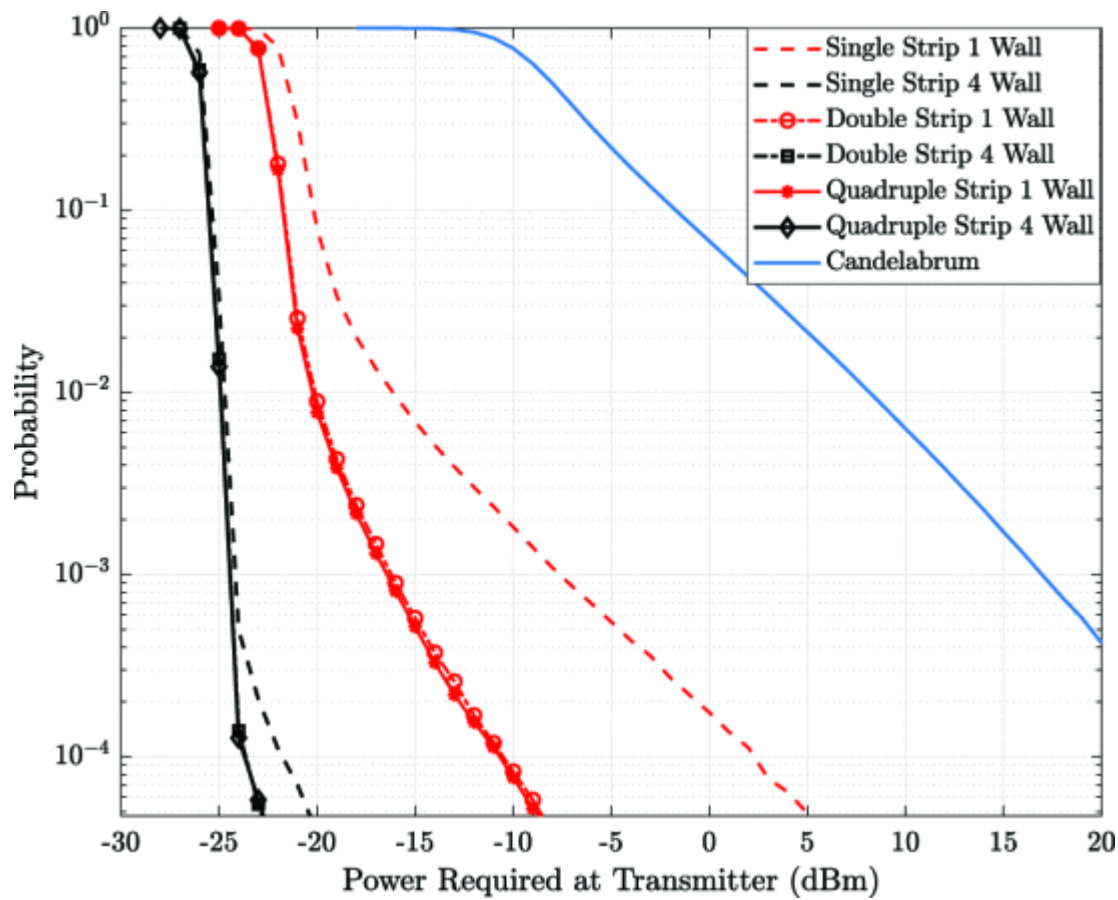
1. E_{link} : Proximity and diversity
2. $E_{hardware}$: research efficient PA operation, reduce of DSP complexity (algorithms & platforms), focus on 'golden' < 10GHz
3. $E_{network}$: Distributed resources: support decentralization
4. Interaction with energy-neutral devices



100x improvement on all aspects is extremely ambitious!

Link energy: the potential with RadioWeaves





REINDEER D3.1 & references therein

U. K. Ganesan, E. Björnson and E. G. Larsson, "RadioWeaves for Extreme Spatial Multiplexing in Indoor Environments," *2020 54th Asilomar Conference on Signals, Systems, and Computers*, 2020, pp. 1007-1011.

On the road to zero carbon - and other important SDGs



- Distributed deployment of radio and compute resources bears a great potential for order(s) of magnitude improvement in energy efficiency (link, hardware?, network?)
- Energy consumption/carbon emission should be a base principle to start from, rather than an optimization criterion 'post facts'
- Interacting with battery-less devices for massive IoT can prevent toxic waste disaster
- We should dare to innovate bravely:
 - Raise the bar and overcome known obstacles (e.g. in deployment, regulations)
 - Prioritize KPIs and KVLs that target Sustainable Development Goals

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