

Energy-neutral devices versus sustainability goals: from smart dust to smart waste?

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and EU-project teams
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Energy-neutral devices versus the SDGs

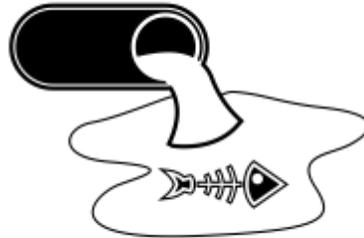
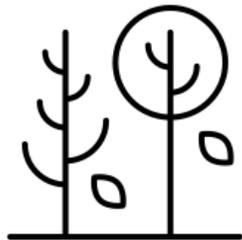


To waste or to smart waste?



Novel vistas for SDG-friendly energy-neutral devices deployments

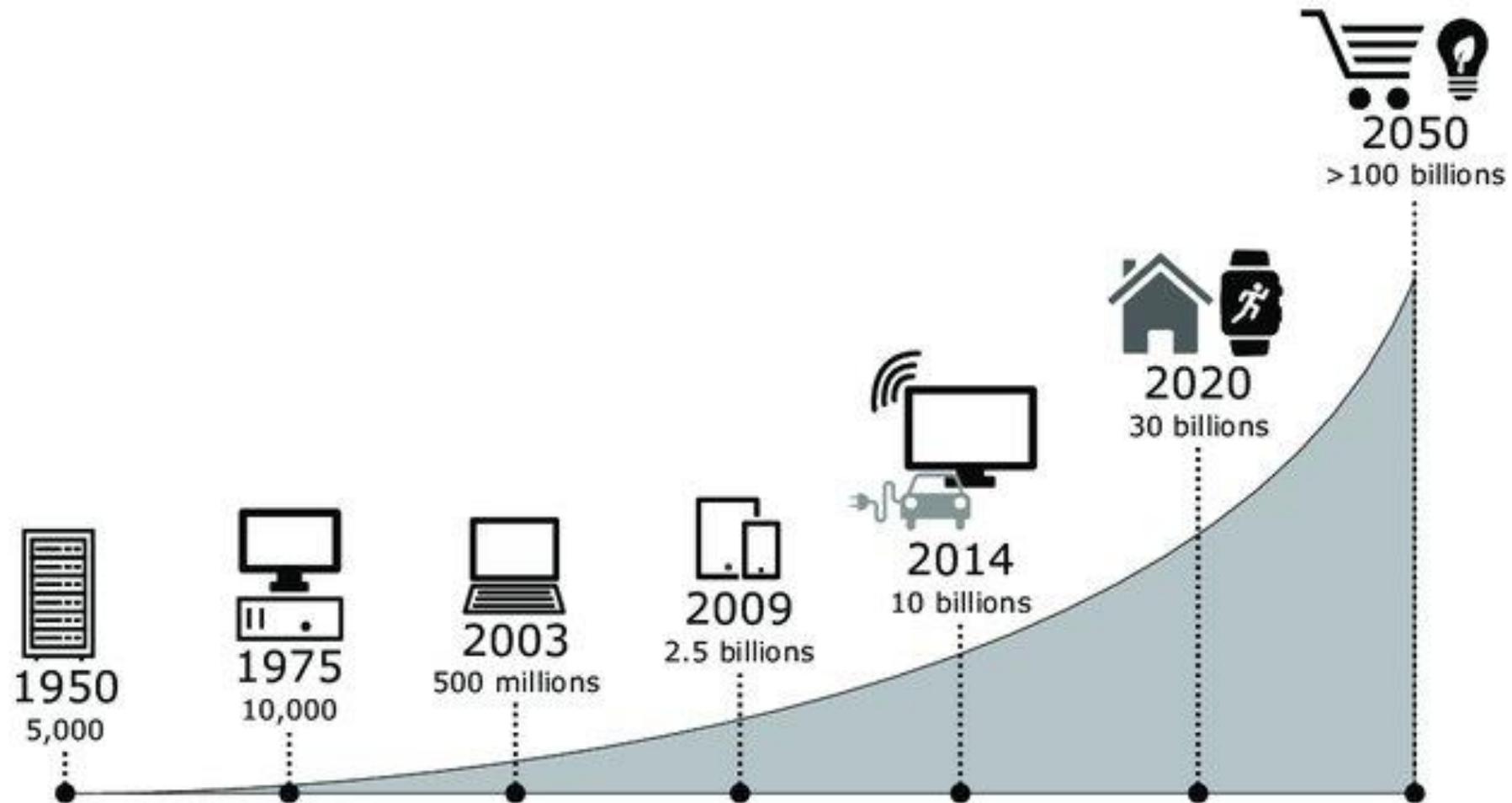
IoT can help to address 'hard' problems in 'soft' themes: connecting for a sustainable future



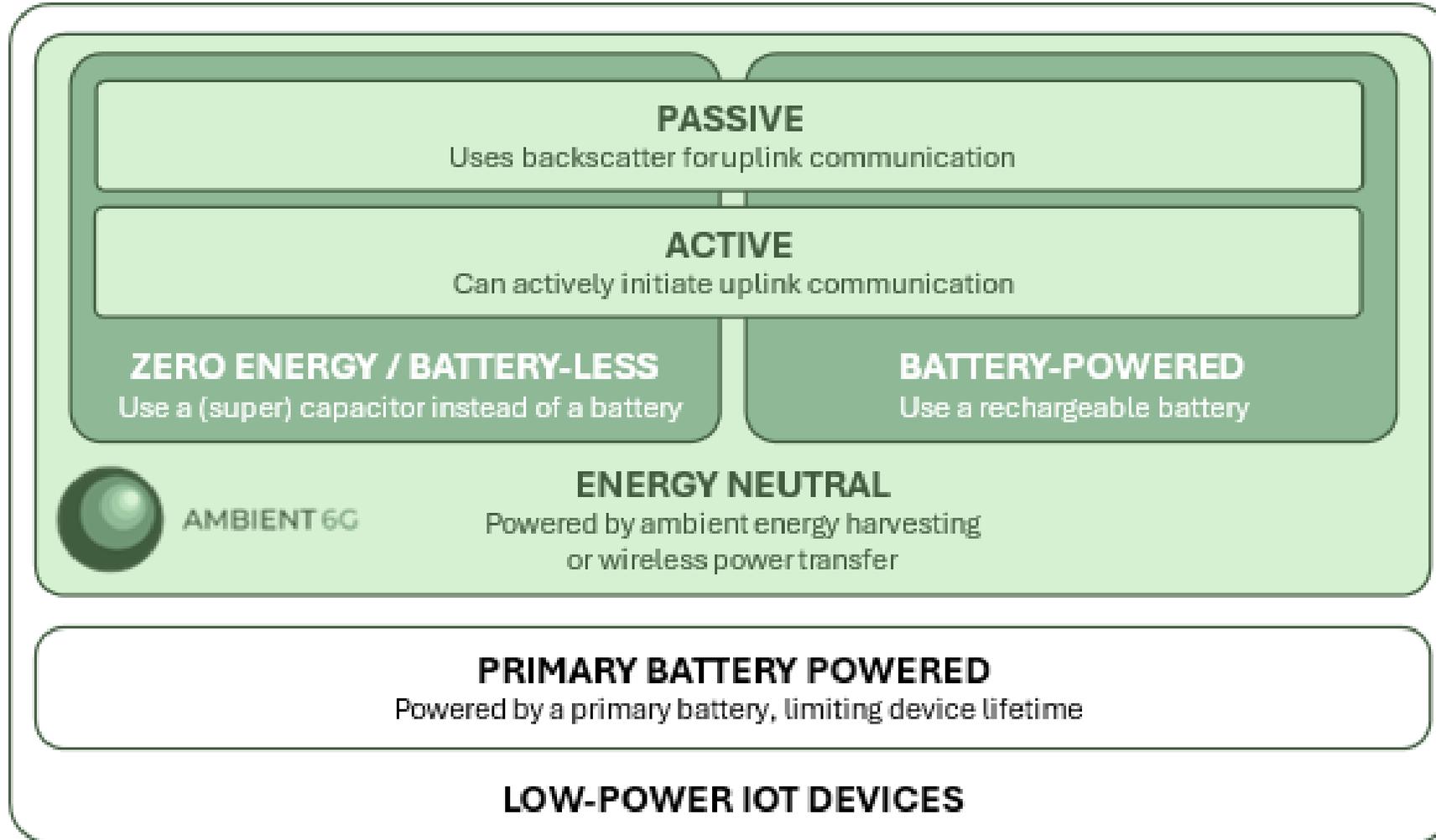
'smart dust' vision:

Sensors or devices
few millimeters in size,
and can share information
over a wireless network.

The risk: from smart dust to sleep to toxic dust?



How we define 'energy-neutral devices'





Energy-neutral devices versus the SDGs

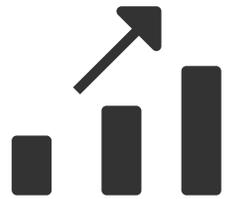


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Novel vistas for SDG-friendly energy-neutral devices deployments

IoT technology needs to get more sustainable

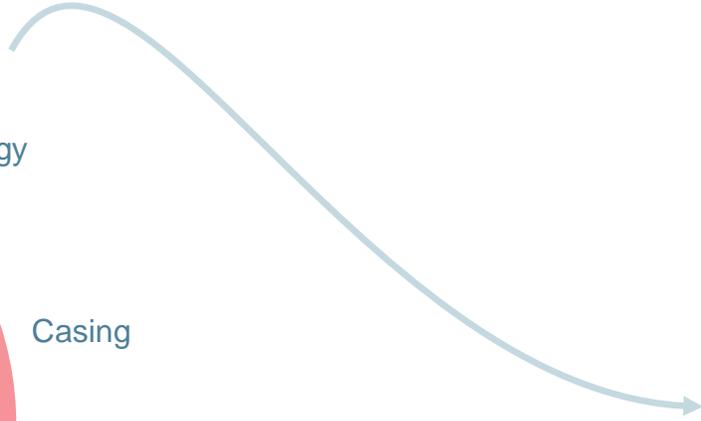
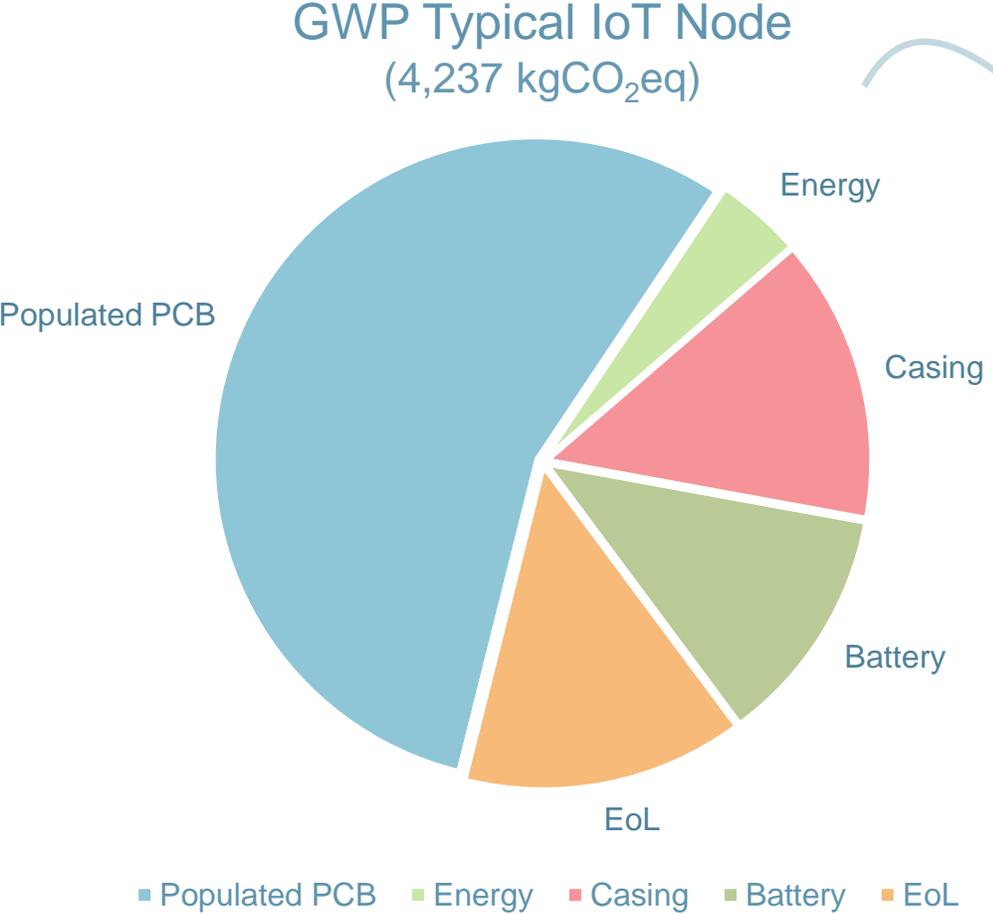


Fast growing number of IoT edge devices
5-10 billion in 2020 up to **200+ billion** in 2030



Lots of **e-Waste** associated with it
Need to minimize!

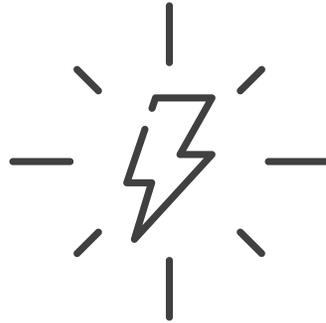
FIRST RESULTS | Life Cycle Assessment (LCA)



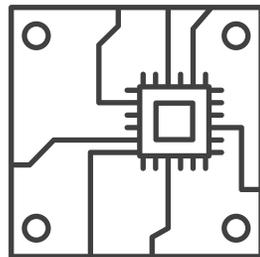
Energy small impact
10 years operation,
mixed grid

Method used
ReCiPe 2016 v1,1 Midpoint
(H)

FIRST RESULTS LCA | INSIGHTS



Energy consumption small compared to total GWP



PCBs & ICs very big impact



Battery is toxic and finite

The problem(s) with conventional IoT (and many other electronic solutions)



- Too much embedded
- Lifetime not long enough, battery runs out
- Not easy to repair
- Harmful / valuable components left in nature
- Recycling possibilities limited/not considered
- “Fire and forget”¹ approach

¹ desired for easy deployment, yet not anticipating on End-of-Life (EOL)

Self-impact: device side



R&D vista: towards a circular IoT

Reuse

Design concepts for reuse and repair



Longevity

Energy-neutral devices, in-situ recharging batteries



Recovery

(Drone-based) guaranteed/automated recuperation



Extend autonomy by harvesting

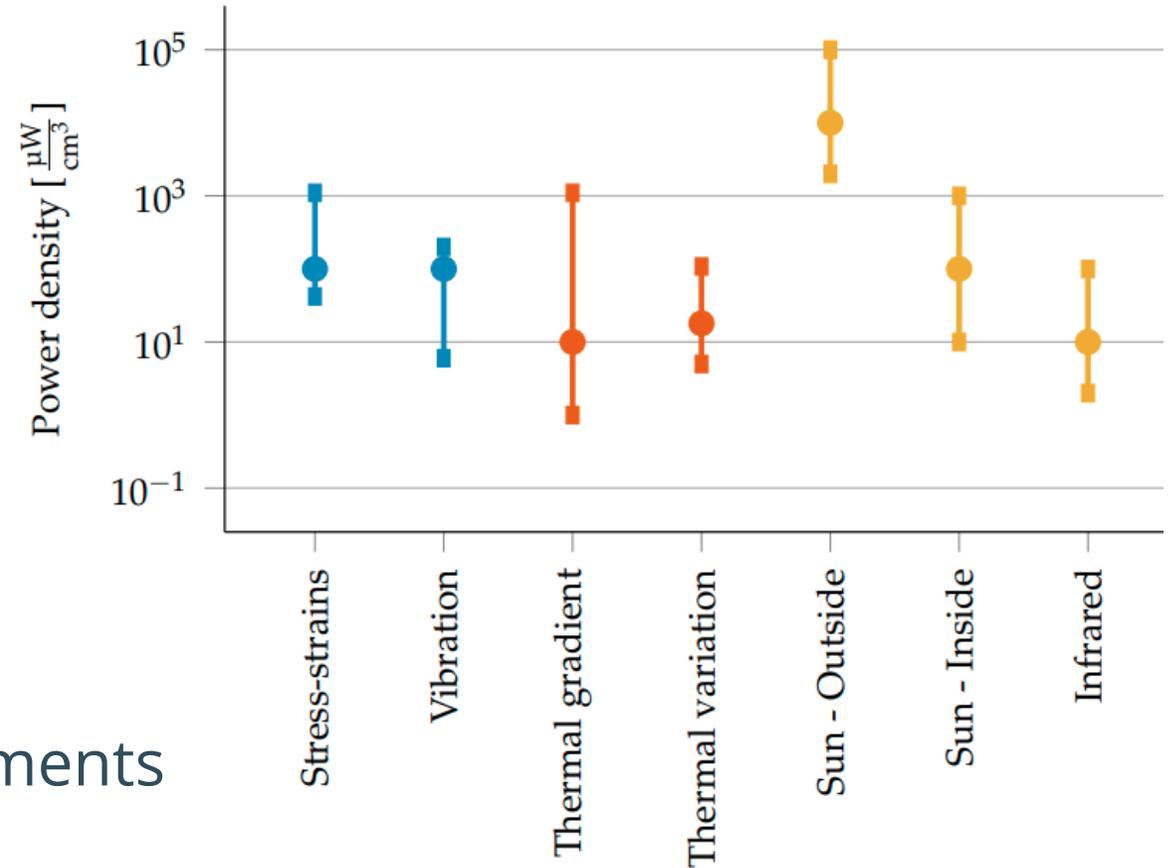
Mechanical sources

Thermal sources

Radiant sources

Disadvantages:

- Not usable in dark windless environments
- Low power density
- Need for extra circuitry and transducers





Energy-neutral devices versus the SDGs

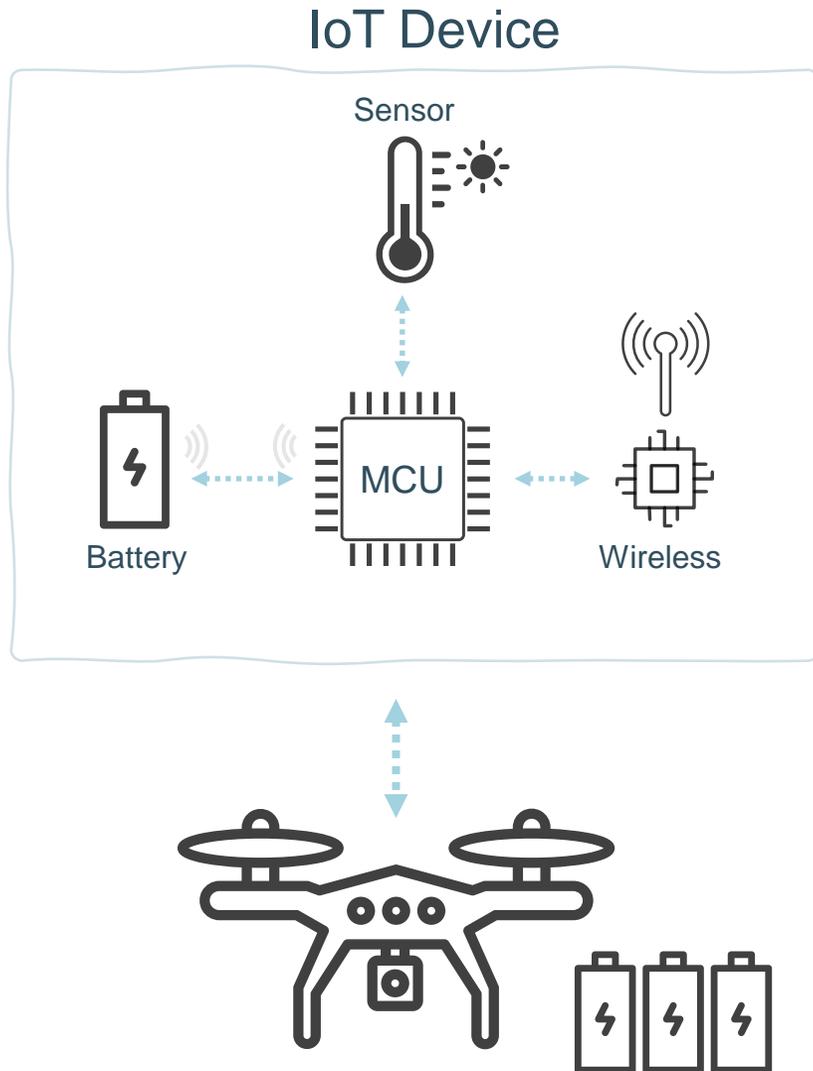


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Novel vistas for SDG-friendly energy-neutral devices deployments

The 'flying doctor' approach for sustainable IoT



Modular IoT design

Self-deployment and diagnostics

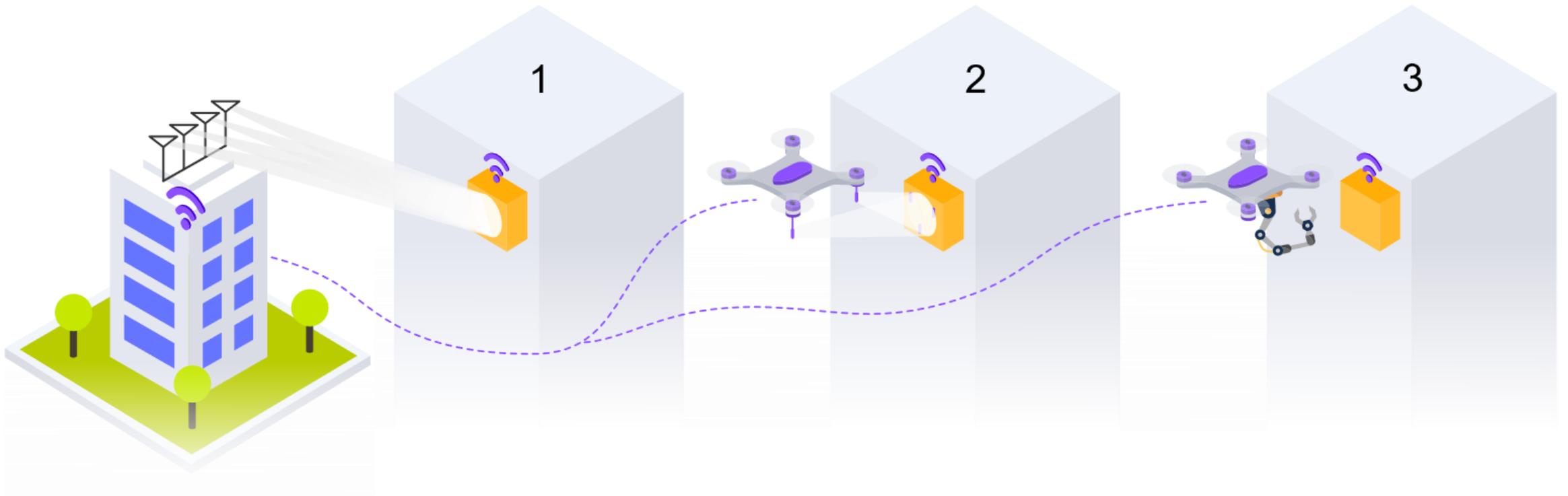
Recharge device on the spot - by RF or U(A)V

Replace parts/whole IoT device by U(A)V

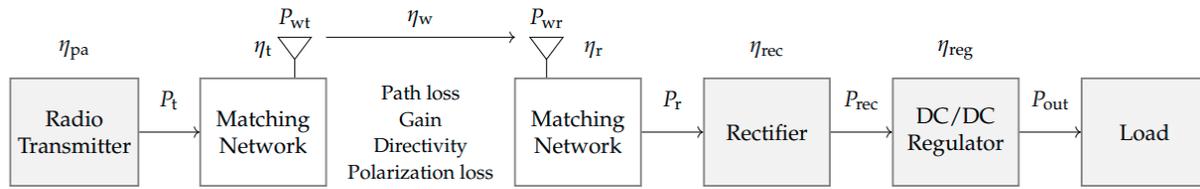
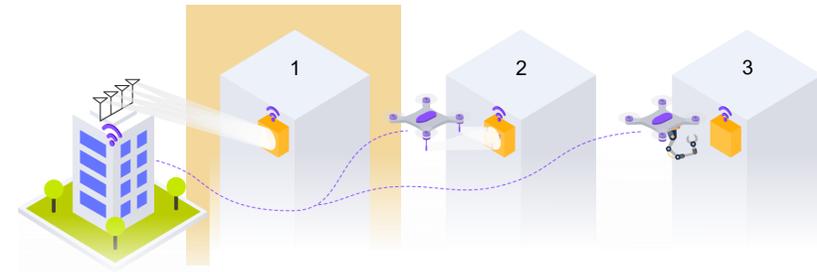
- ① Replacing battery
- ② ...sensors...
- ③ ...whole device...

Flying doctor at the rescue

energy surfing on RF waves or boarding a drone



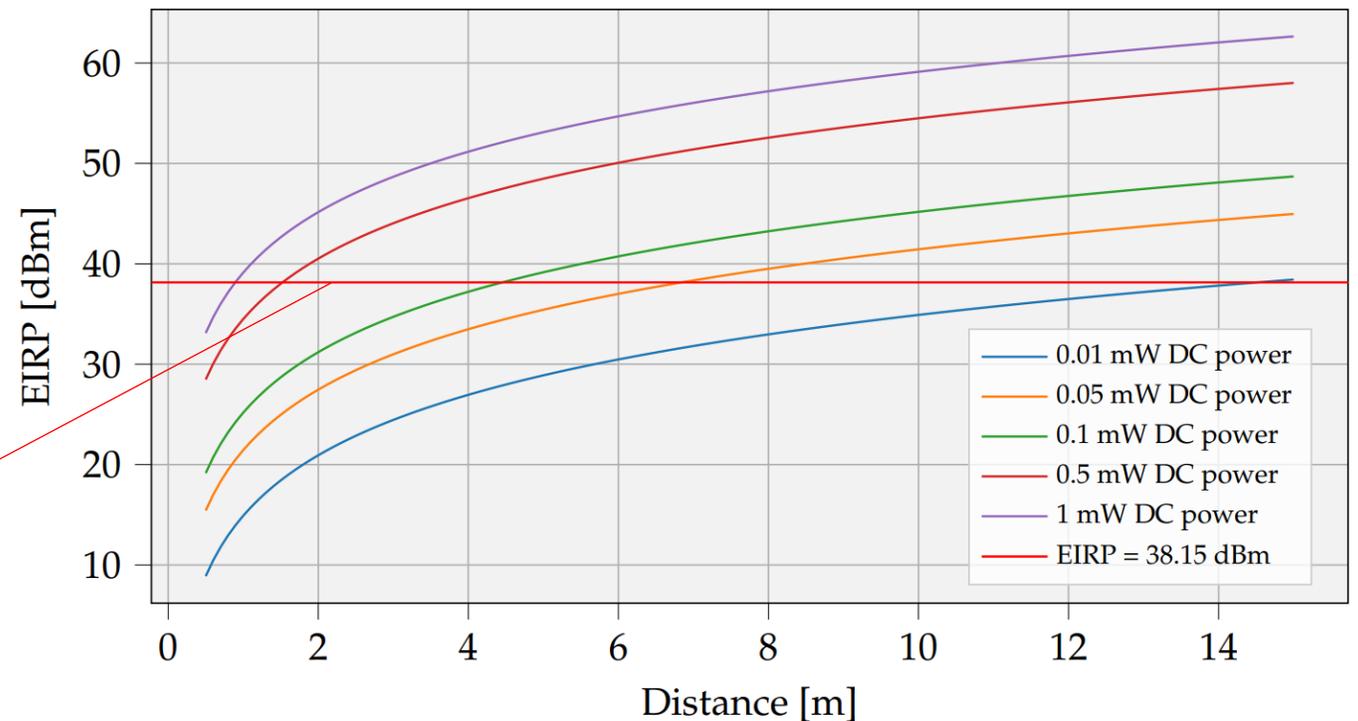
Uncoupled Wireless Power Transfer → RFPT



SISO

Energy harvester

Evaluation board
AEM40940



EIRP is limited by standards
E.g., ETSI EN 302 208

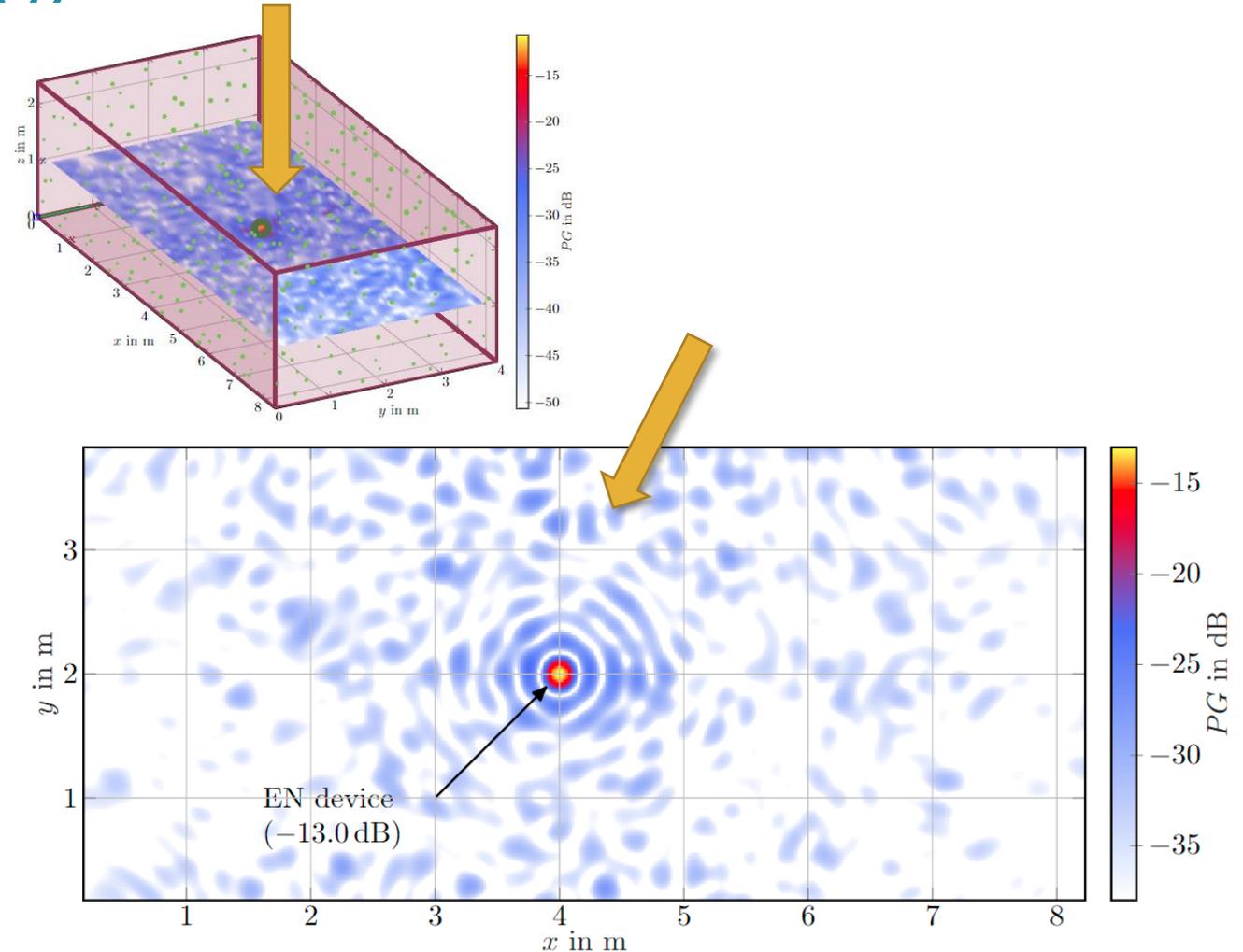
With 38.15 dBm equals to 6.5 W of radiated power

Distributed RFPT with large arrays: simulations predicted energy boost

Simulation-based
assessment in
REINDEER project

Techtile testbed Ghent
Dimensions 8.4 x 2.4 x 4 m
280 TX antenna's

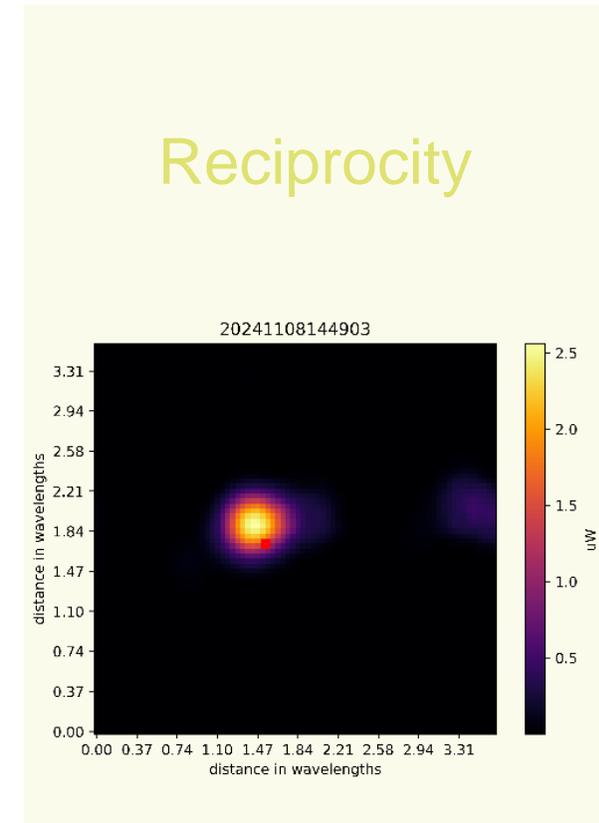
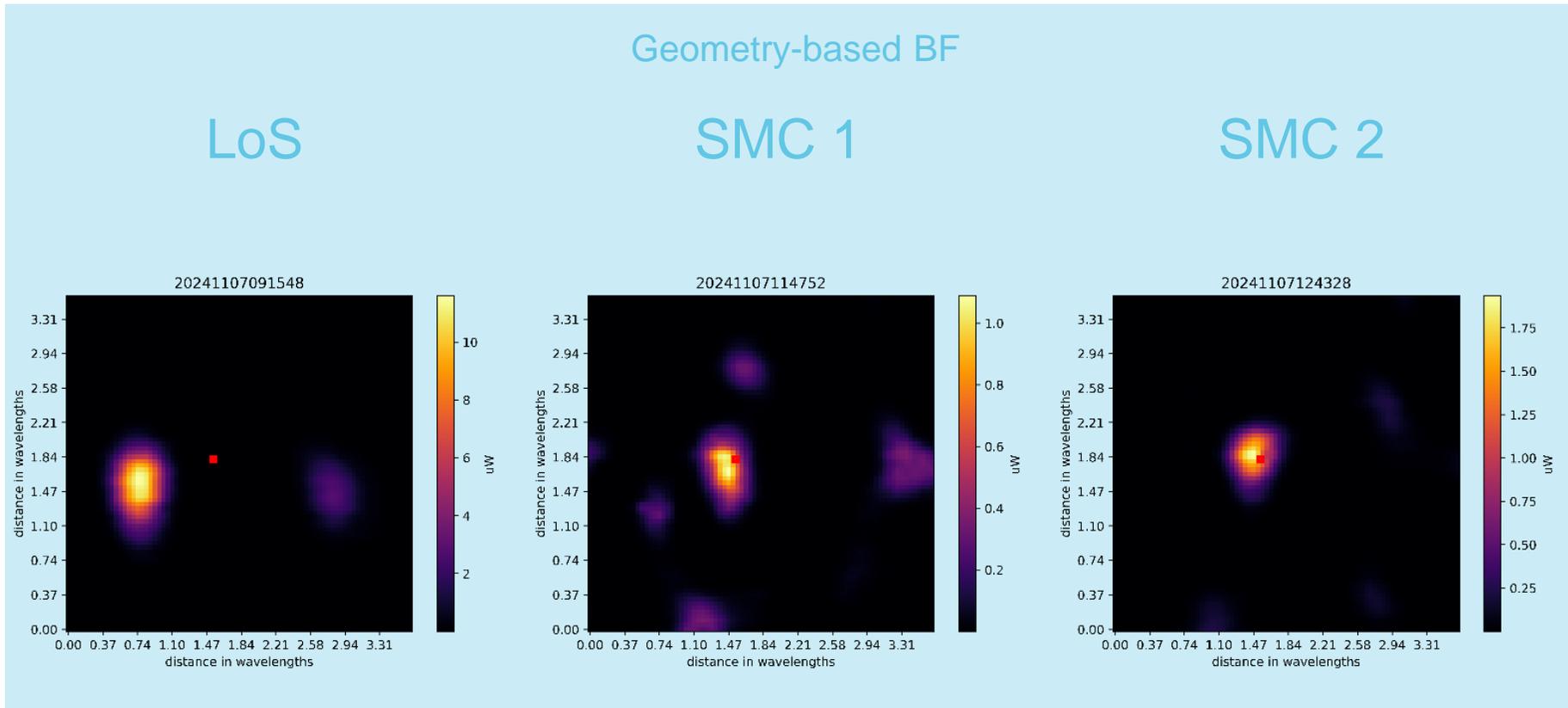
Power spot (4, 2, 1)
PG = -13.0 dB



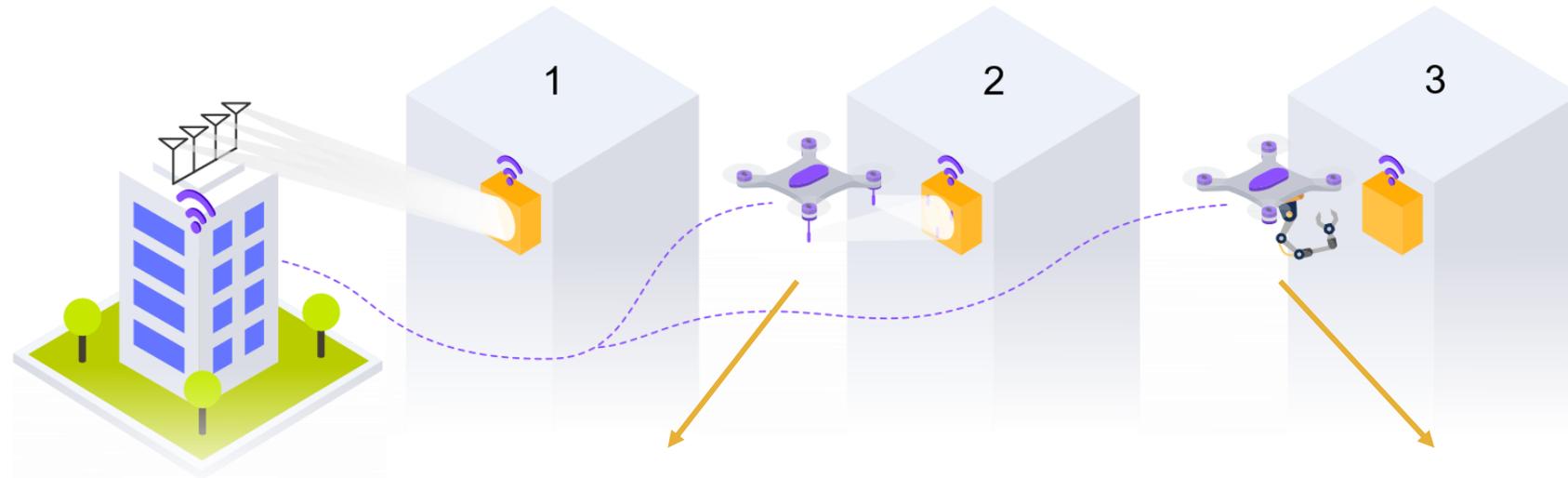
Going experimental: confirming efficiency boost



Geometry Beamforming: it also works



UAV-based service: Operating principle and recharging concept

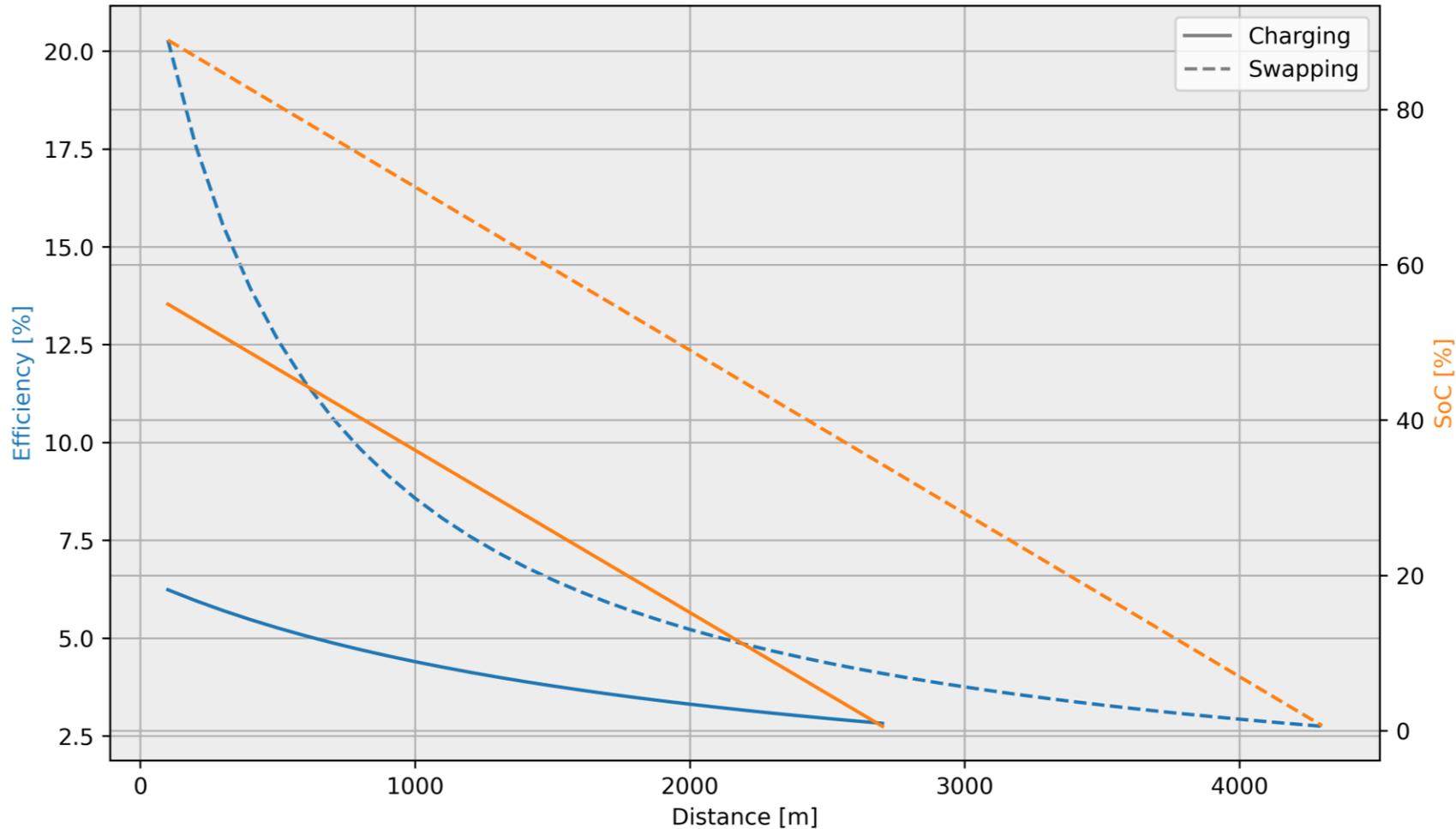


1. Outward flight to IoT node
2. Charge IoT battery with energy from UAV battery
3. Return flight to charge station

1. Outward flight to IoT node (incl. charged battery)
2. Swapping IoT battery
3. Return flight to charge station

Overall efficiency comparison

Same assumptions used

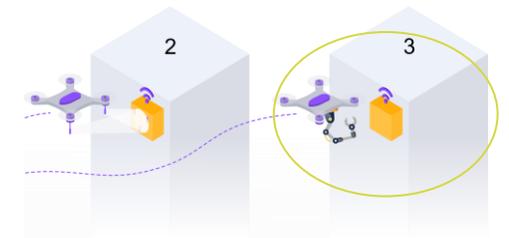


$$\eta_{charge} = \frac{E_{delivered}}{E_{uav,consumed}}$$

$$\eta_{swap} = \frac{E_{delivered}}{E_{uav,consumed} + E_{delivered}}$$

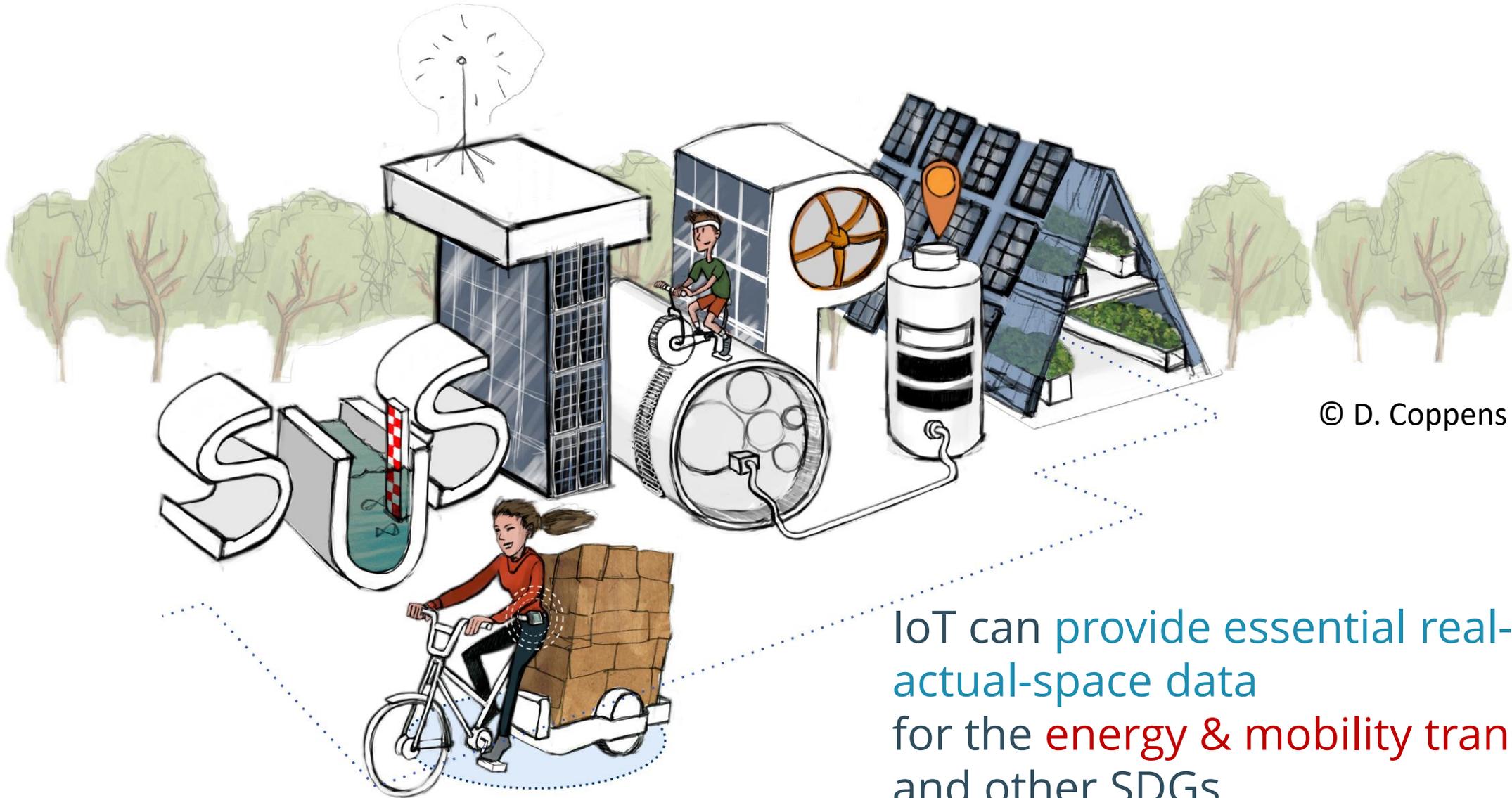
C Wireless charging requires more energy than swapping

C Swapping more efficient



R Investigation swapping mechanism

Lessons learned and lessons to learn?



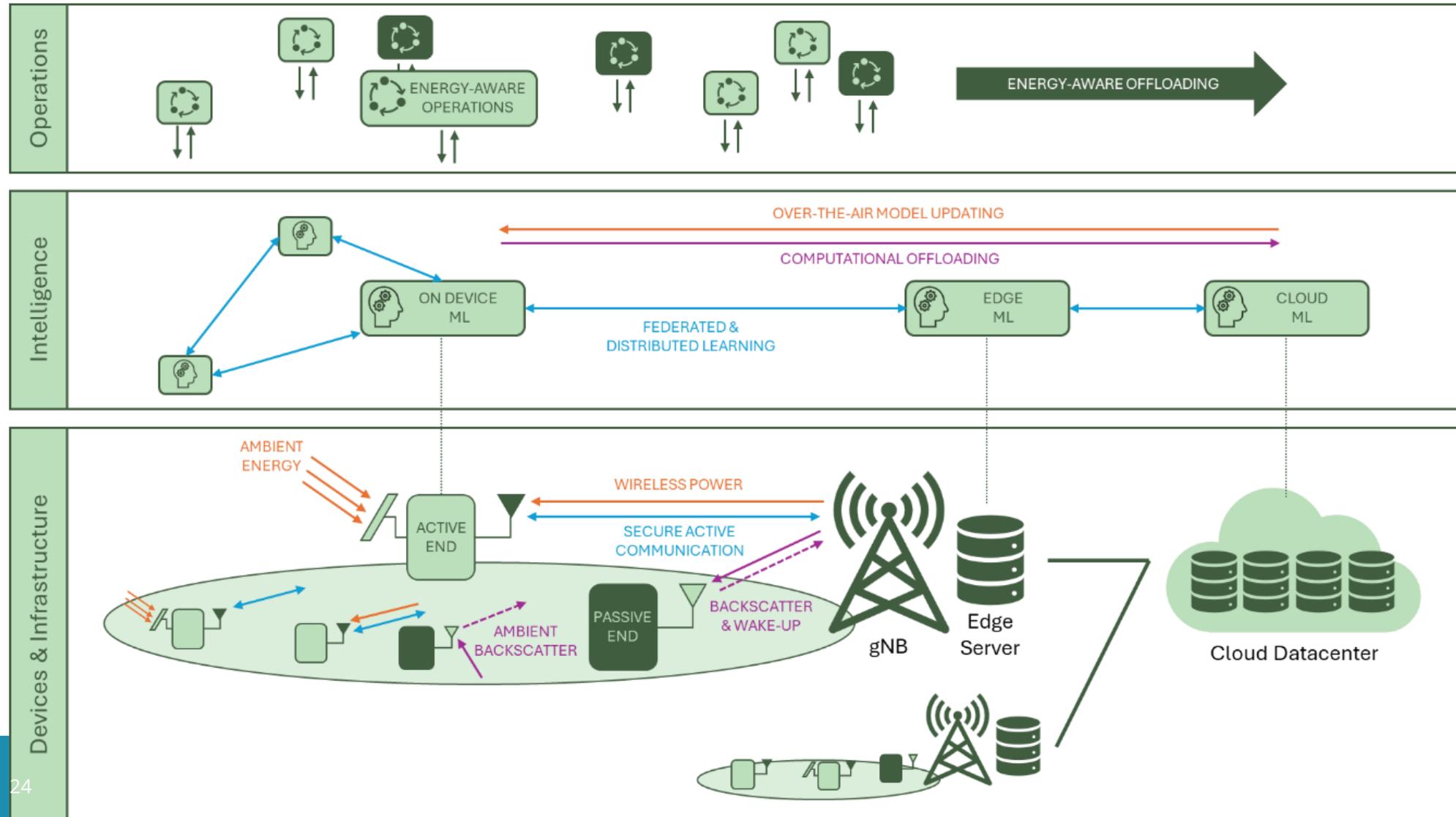
© D. Coppens

IoT can provide essential real-time actual-space data for the **energy & mobility transitions** and other SDGs

Energy-neutral devices: enjoy their long life and don't forget pick them up



Progress and optimize the integration of energy-neutral devices into 6G networks



Lessons to learn on sustainability impact: methods and mutual understanding

LCA and backcasting studies: quantify , develop **tools** and **framework**, to ease the inclusion of both direct and indirect environmental effects.



Cross-technological and multi-disciplinary cooperation to pave the way for a substantial positive net impact



Exploit the strengths and strategic orientation into a competitive advantage for Europe



This is the good time to make sure
we choose a good direction

