tinyML® EMEA

Enabling Ultra-low Power Machine Learning at the Edge

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Smart, open & accurate: Sensors in the sustainable Onlife era

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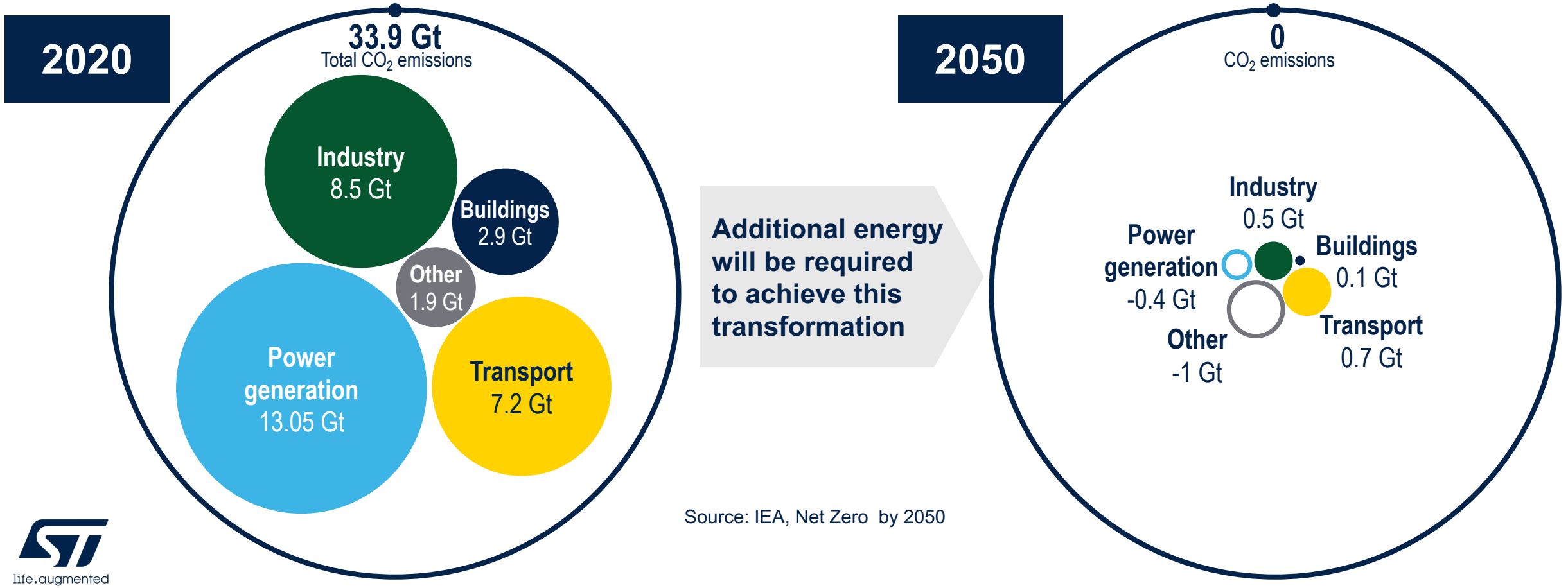
Artificial Intelligence Strategy

STMicroelectronics

Main focus on CO_2 emissions

Carbon dioxide emissions reached **~34 Gtons** in 2020, where power sector represents the major contributor with 40% of the total



Source: IEA, Net Zero by 2050

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The path to carbon neutrality

Energy generation

From fossil to renewable energy sources

Industry

Use of highly efficient equipment

Transportation

Migration to electric vehicle

Building

Low emission energy source and efficient systems

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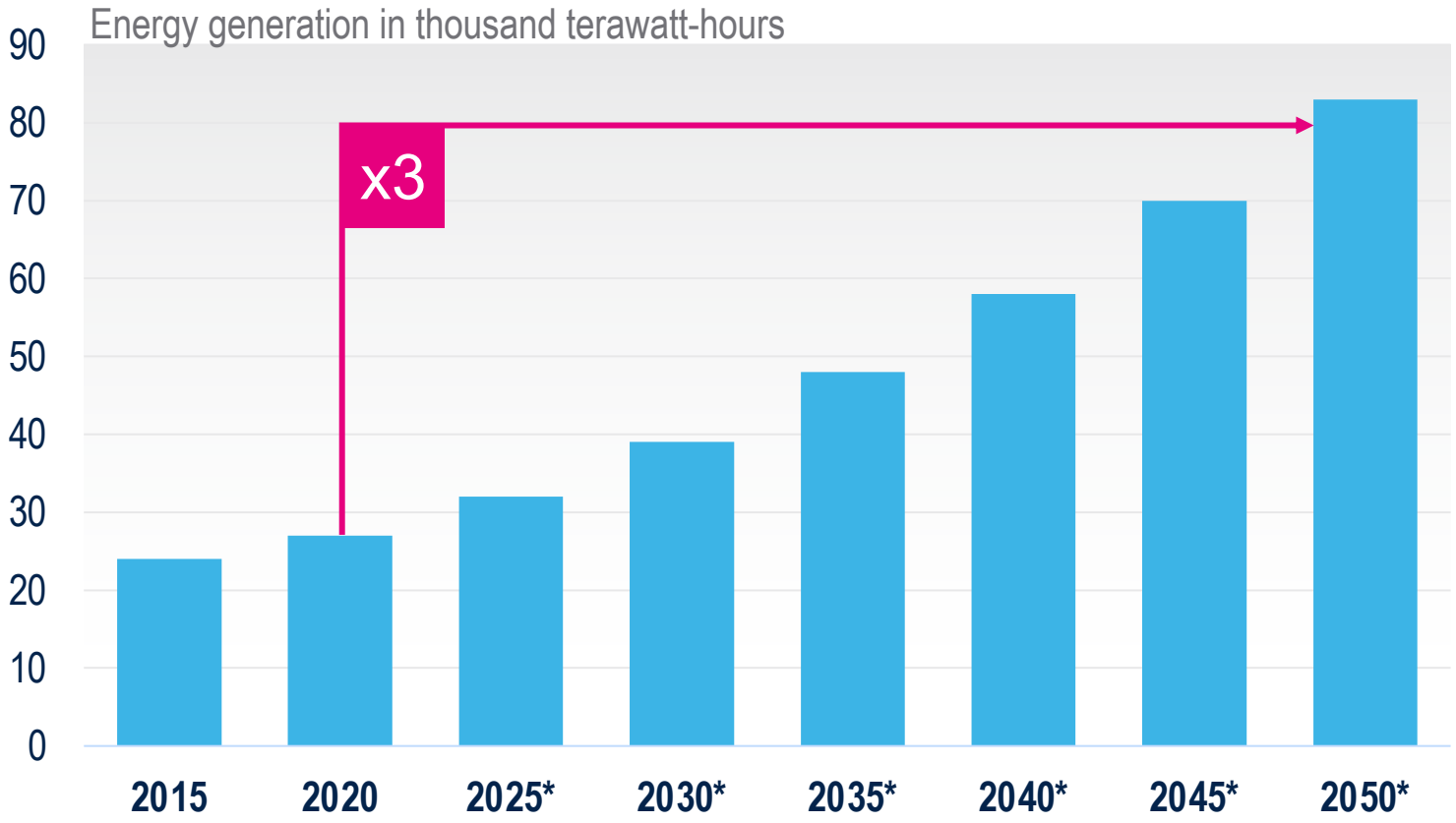
Electricity generation worldwide trend

Electricity generation worldwide is forecast to triple in the next three decades, reaching **83,000 terawatt-hours by 2050**



3x power generation largely **driven by decarbonization efforts** and **electrification** of the transportation and building sectors

Source: Statista, Worldwide; McKinsey & Company

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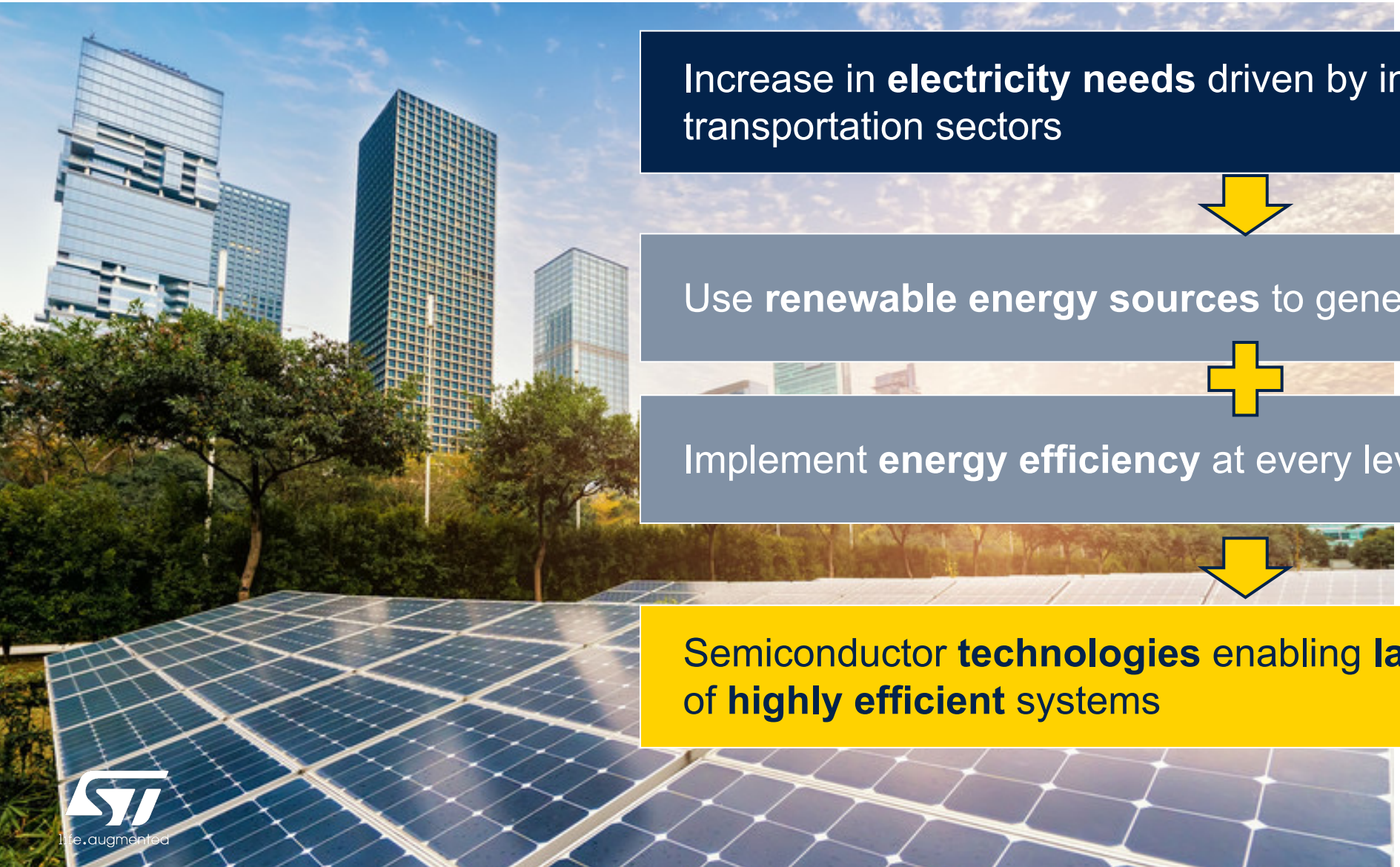
The right path is by no means obvious

A complex equation



Increase in **electricity needs** driven by industry, buildings and transportation sectors

Use **renewable energy sources** to generate electricity

Implement **energy efficiency** at every level

Semiconductor **technologies** enabling **large-scale** deployment of **highly efficient** systems

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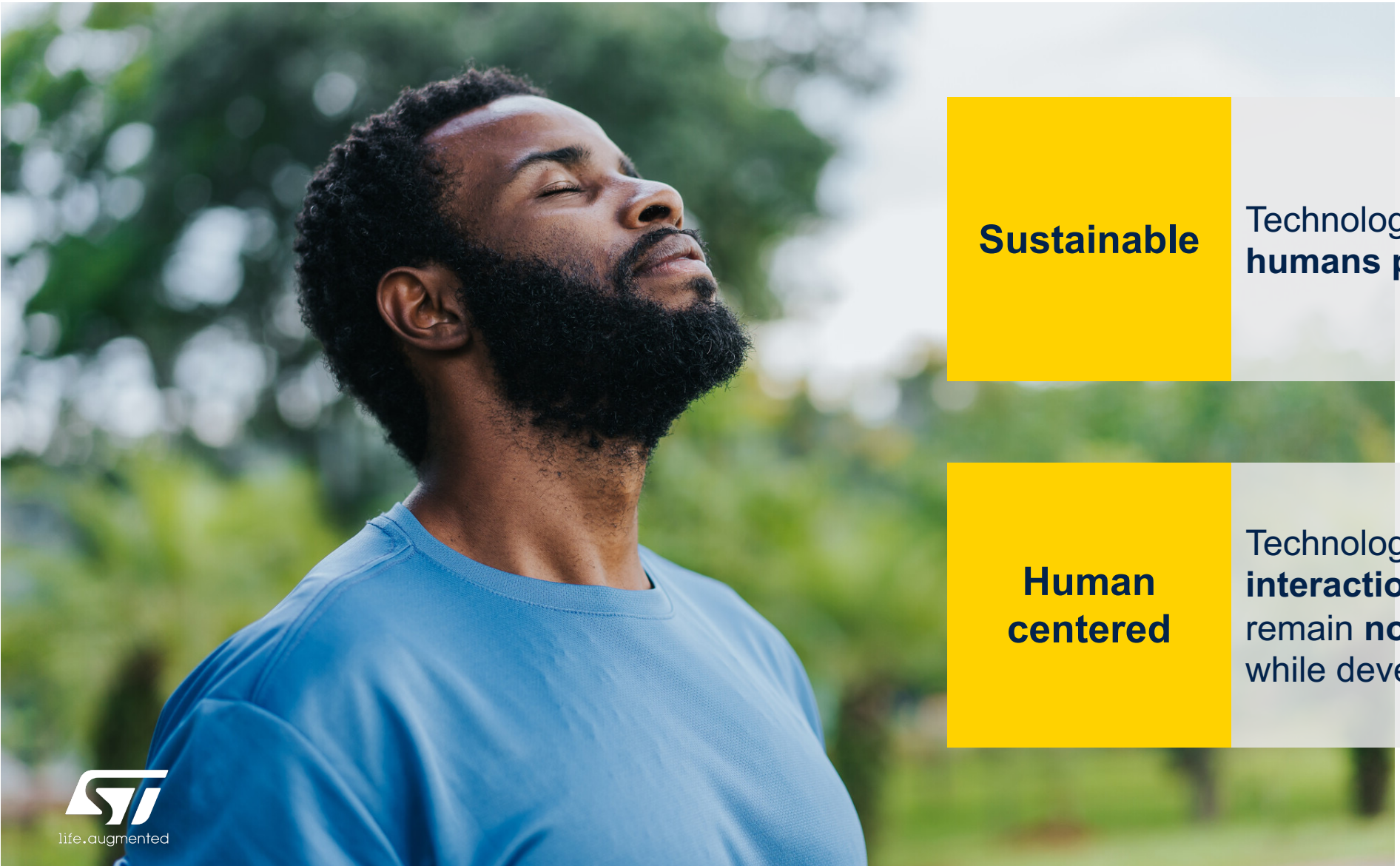
What do human expect from technology today?



Sustainable

Technologies that **protect** and **help humans protect** the planet

Human centered

Technologies that improve the **interaction** with the world around us, remain **non-invasive** and **secure** while developing our **creativity**

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Sensors at the heart of our interactions with the digital world

Human centered

Sensors are the key components to **bridge** the **physical** and the **digital worlds**

Sustainable

Sensors becoming **smart** answer **human expectations** while ensuring a **sustainable future**

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Smart sensors making our world a better place

Offline Era

2000

A paradigm change in the man-machine interface

MEMS technology: from a concept to a product.

Online Era

2010

Sensor proliferation and connections to the Cloud

Performance improvement and technology fusion.

Onlife Era

2020

The fusion of technology and life

MEMS sensors able to sense, process, and act.

Sustainable Onlife

Sustainable sensorization of the world

MEMS sensors sending only the **meaningful data** to the cloud

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MEMS sensors attributes for sustainable Onlife

Smart

Sensors able to **process data**

Open

Sensors configured to **your needs**

Accurate

Sensors providing a **correct set of data**

Meaningful data provided in an optimal way

Human centered

Sustainable

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Smart

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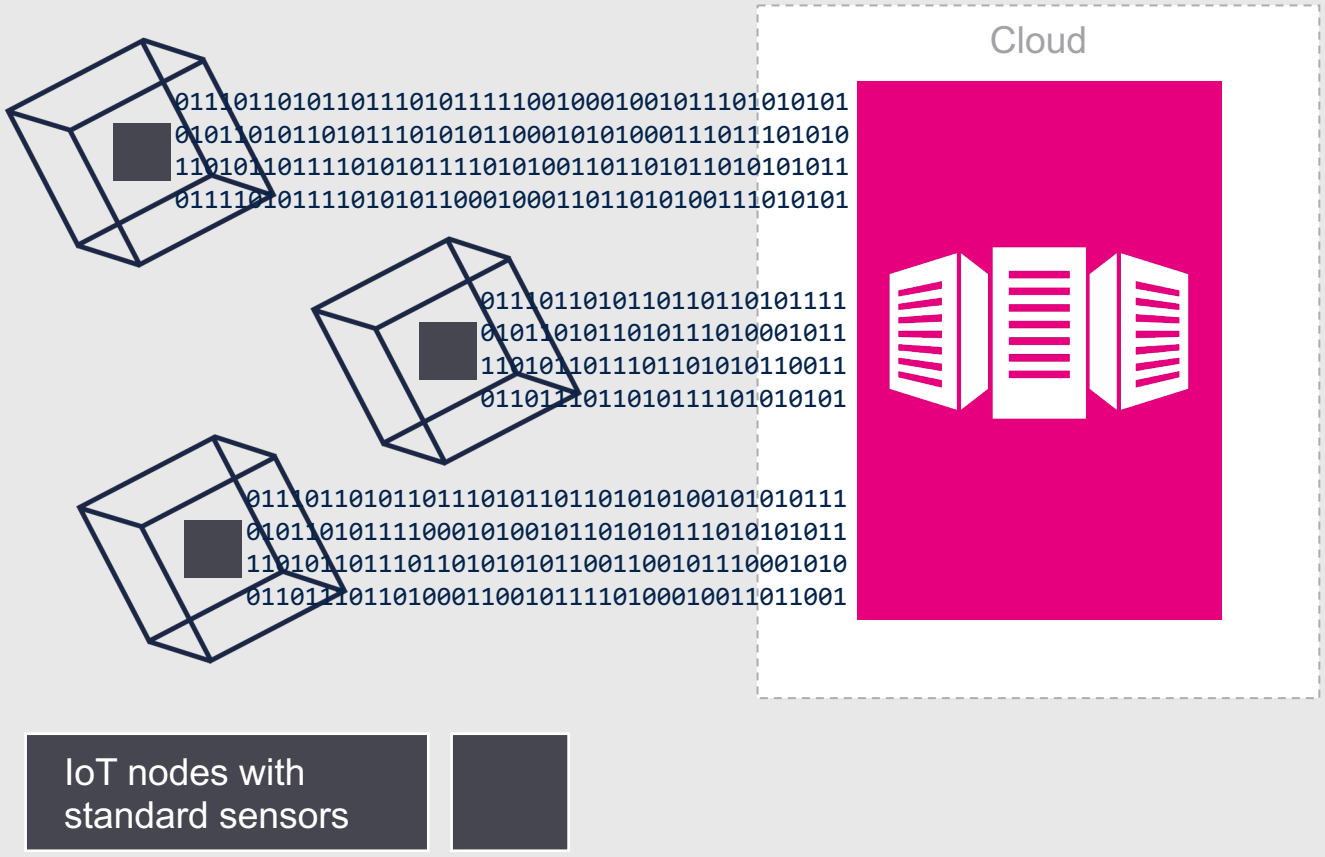
More data = more power



Sensors embedded in more and more IoT nodes

Data to process are increasing exponentially

With a centralized processing approach, the required cloud infrastructure is huge

Associated power consumption is not sustainable

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Smart as an octopus!
Learn from the environment
Brain in-the-edge
Always-aware
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Adding intelligence to make sensorization sustainable

Smart sensors process the data in the edge

Only a reduced, meaningful set of data is transferred to the network

The required cloud infrastructure is limited

In-the-edge processing makes the sensorization of the world sustainable

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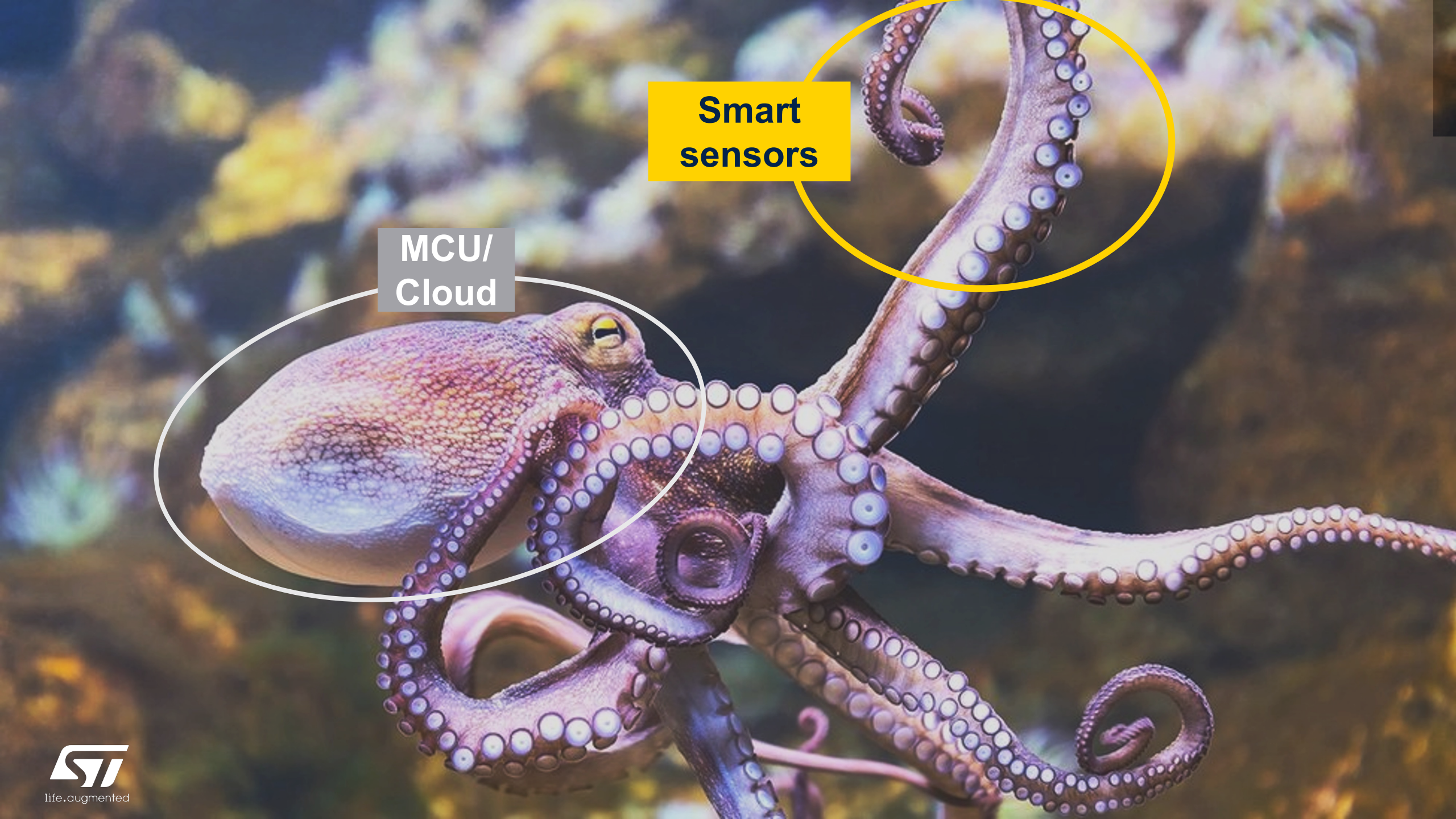

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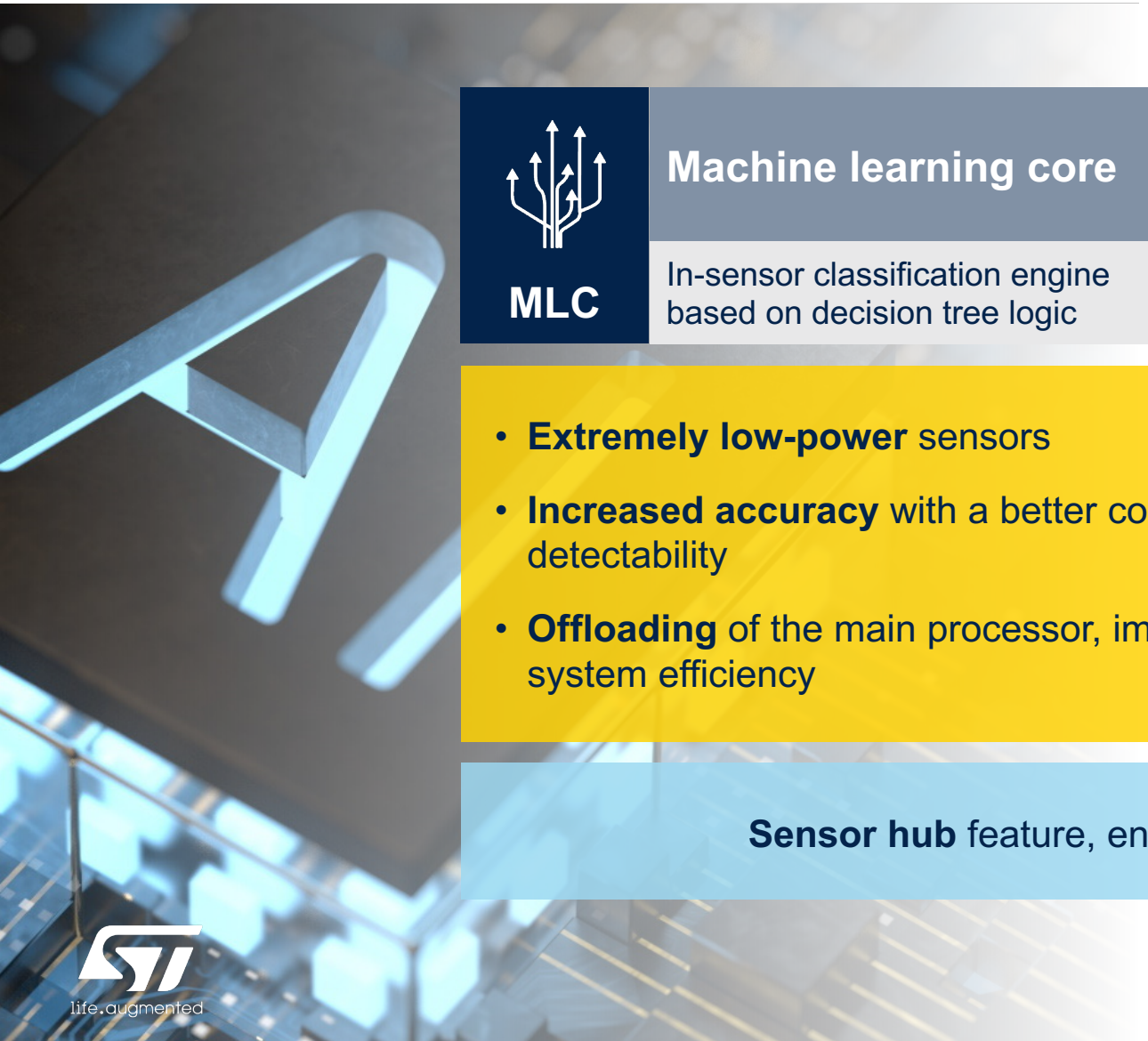
Smart sensors for sustainable Onlife



MLC

Machine learning core

In-sensor classification engine
based on decision tree logic

- **Extremely low-power** sensors
- **Increased accuracy** with a better context detectability
- **Offloading** of the main processor, improving system efficiency

ISPU

Intelligent sensor processing unit

Highly specialized DSP
for machine learning and processing

- **Ultra-low power** consumption at **system level**, thanks to **optimized data transfer**
- High-processing capability with **AI-enabled programmable core**
- Comprehensive **ecosystem**

Sensor hub feature, enabling connection of external standard sensors

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Open

Open the sensor ecosystem till (in) the edge

Sensor hub

Sensors **host** other sensors data making them **intelligent and processed** in the edge.

Sensor ecosystem

An **open ecosystem** to accelerate innovations with **partners** and **customers,** gaining a sustainable competitive advantage.

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ST MEMS sensor hub

Enabling connection of external standard sensors

Helps to **integrate data from other sensors** (up to 4) by connecting them directly to our sensors

Data from all sensors are **processed in ST MEMS sensor**

Allows keeping the **intelligent in-the-edge**, further improving energy efficiency

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ST MEMS sensor ecosystem

OPEN

Jointly create value for customers

- Leveraging **on partners**
- **Sharing** state-of-the-art, high-quality components
- Ability to host partners' IP in our solutions
- Shortening customer's **time-to-market**
- New strategic set-up**: flexibility and sustainability**

Accurate

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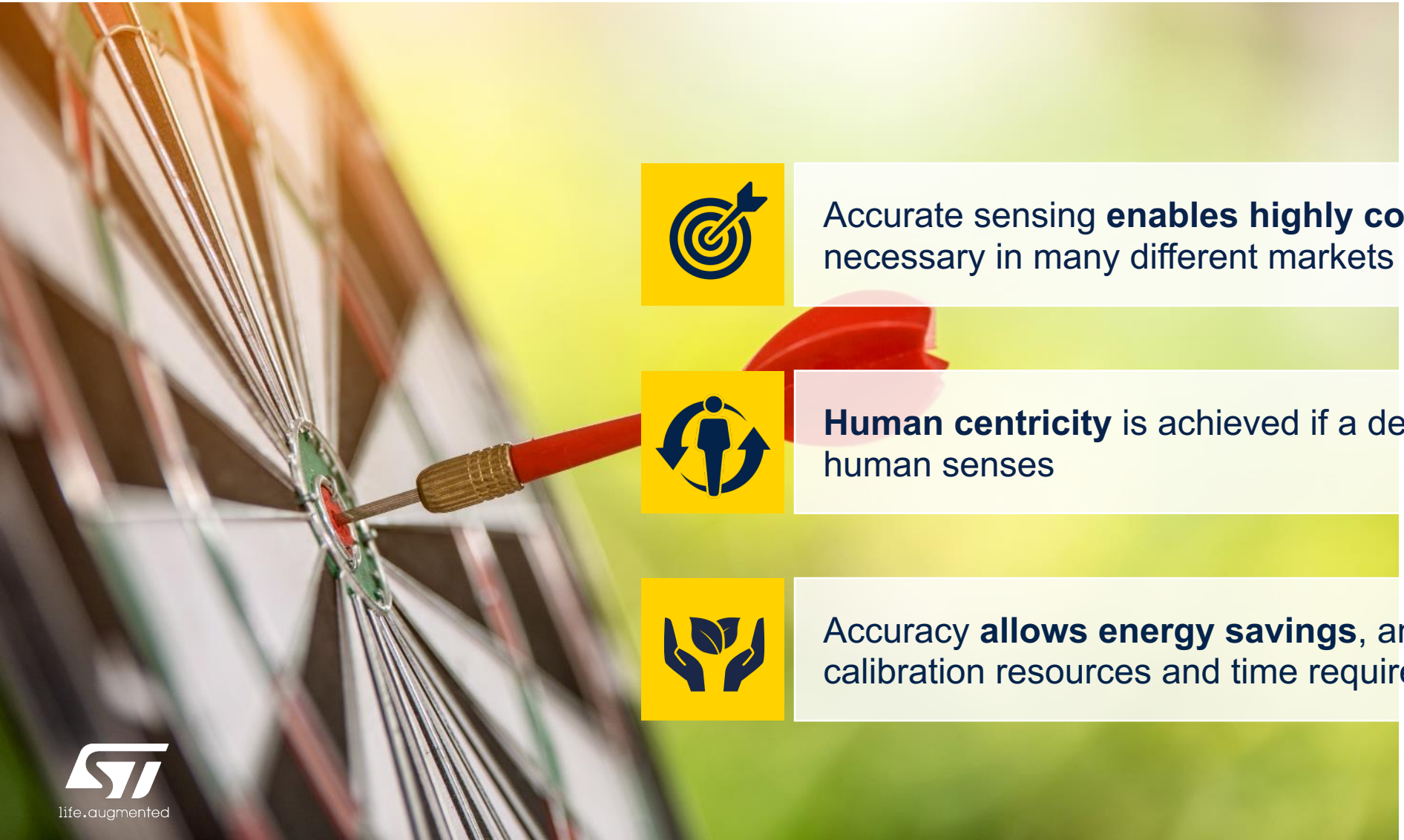
Accurate



Accurate sensing **enables highly complex algorithms**, necessary in many different markets

Human centricity is achieved if a device is capable of imitating human senses

Accuracy **allows energy savings**, and reduces the factory calibration resources and time required

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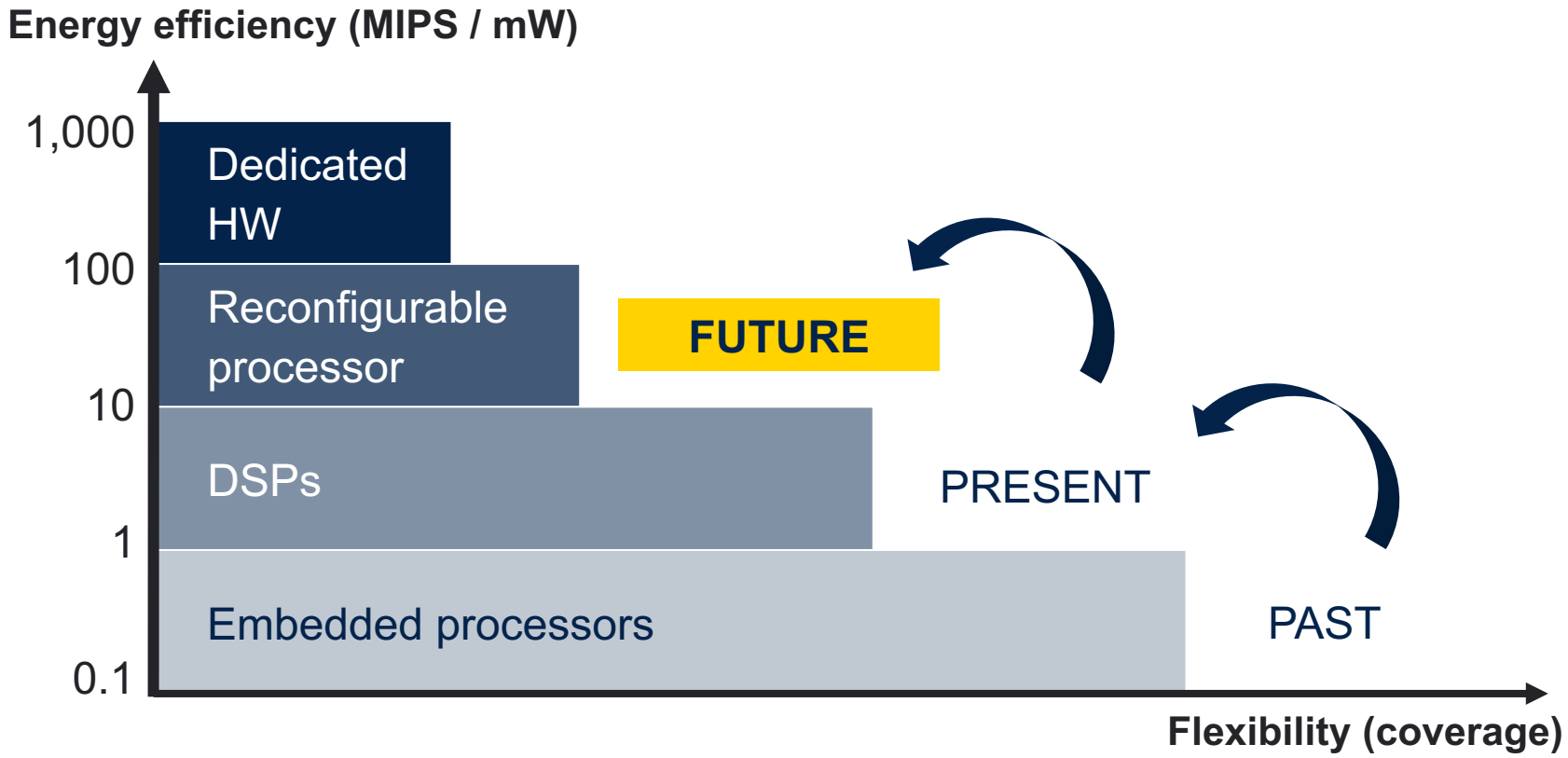
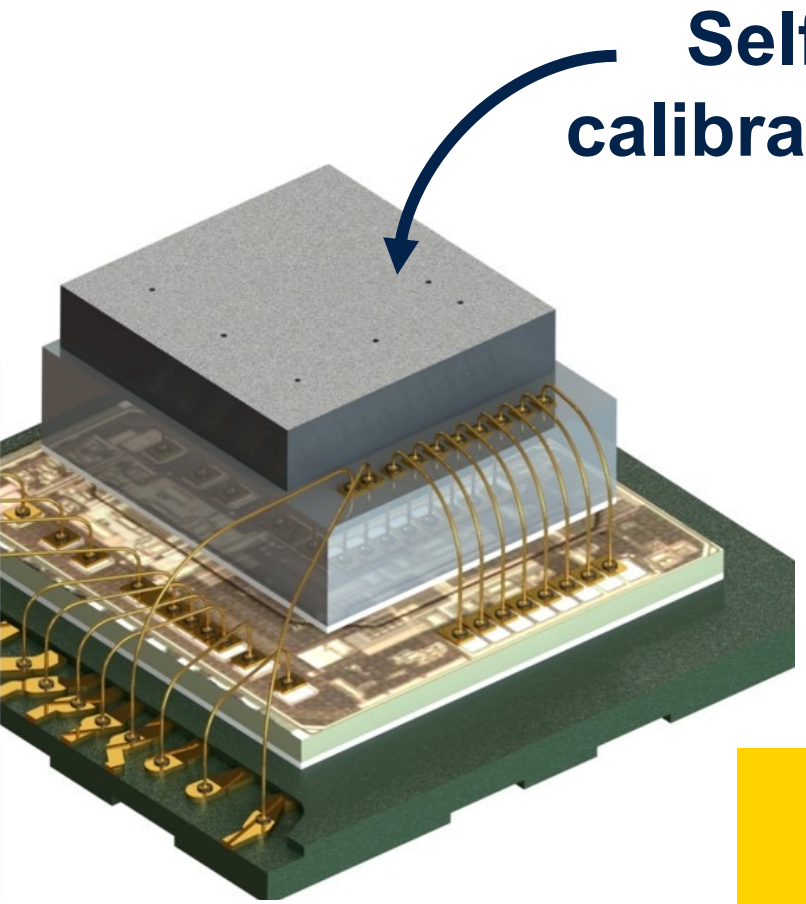
MEMS sensors: the path toward energy efficiency

From milliwatt to nanowatt with technology & AI



J. M. Rabaey, M. J. Ammer, J. L. da Silva, D. Patel and S. Roundy, "PicoRadio supports ad hoc ultra-low power wireless networking," in *Computer*, vol. 33, no. 7, pp. 42-48, July 2000, doi: 10.1109/2.869369.

The challenge: tiny self-calibration in a sensor with AI



- Sensor specifications
- Technology: 130 nm CMOS standard cells
- Tiny silicon area
- Reconfigurable hardware

53 nWatt with 8 byte memory
silicon area ~ 0.03 mm^2

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ST smart sensors contributing to carbon neutrality

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In smart buildings

You can save up to **264k tons of CO_2** with ST smart sensor monitoring the presence in office in low power mode

Assuming to retrofit all the lighting points in the 90k offices estimated in the world

Estimating 10% of the lighting points can be automatically turned off for 1h/day

Operating **TMOS** in the edge can contribute to saving 264k tons of CO_2 in 1 year without compromising on people comfort

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In personal electronics

You can save up to **70k tons of CO_2** with ST smart sensor implementing ST in-bag detection algorithm for laptop

It happens that the laptop doesn't go to standby when closed and drains in the bag overnight

Supposing it might drain in 8 hours in case of no standby, and it happens once a quarter

Estimated 70k tons CO_2 emission saved in 1 year, if all laptop (260Mu estimated in 2023) implement ST solution

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In IoT

You can save up to **1k tons of CO_2** with ST smart sensor monitoring the movement of your electric toothbrush

More advanced toothbrushes take care of your teeth by monitoring your hand movements with intelligent sensor

Recommended use is 3 minutes twice per day, assuming to use toothbrush every day

Processing IMU data locally instead of sending for 6 minutes raw data to the cloud, 1k tons of CO_2 can be saved in 1 year

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Takeaways

Today's technology must keep us safe and protect our planet to ensure a **sustainable** future

In the sustainable Onlife era, with the increasing **fusion** of technology into our daily lives, energy efficiency should be considered at every level

Smart and **accurate** sensors, together with **open ecosystems** are key for a sustainable sensorization of the world

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It takes a village to raise a child

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Our technology starts with You

Find out more at www.st.com/MEMS

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