ENERGY HARVESTING APPLICATIONS

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Marketing Department

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ENERGY HARVESTING APPLICATIONS

Lorandt Foelkel M.Eng
FAE & BDM

ENERGY HARVESTING = ENERGY FOR FREE?

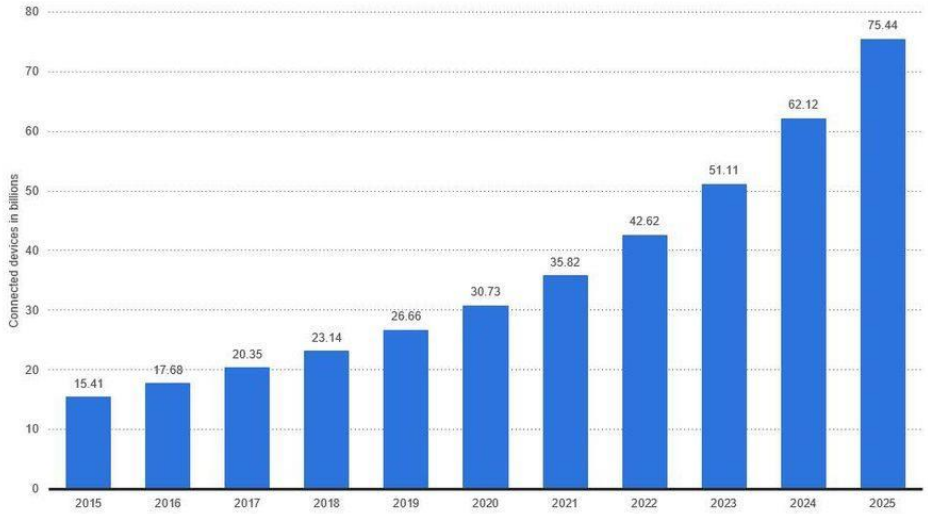
- Energy harvesting utilizes various types of materials and devices (re-chargeable batteries, Low Power IC's, magnetics, supercaps, regulators, Piezo generator, Thermo Electric Generator's, PV panels, etc.) associated with the power electronics industry for a broad range of applications (e.g. wearable devices, building management, assisted living, environmental, security, automotive, aerospace, conditional monitoring, predictive maintenance) and presents a major growth opportunity for the power electronics industry. Holistically it is anticipated that the World will have more than 1 trillion data gathering IoT devices by 2025 [source: McKinsey].
- Energy harvesting potentially presents a solution to one of the biggest impediments to the large scale adoption of such devices - the need for them to be self-powered or at least have battery life extended to manageable intervals. The power requirement is typically in the sub mW range in well-designed low data rate applications. For many applications ambient energies that can potentially supply some/or all of power needed. In terms of the load the designers of IoT devices need to understand the application needs in order to optimize the power consumed.

INTRODUCTION:

- Growing markets of IoT and condition monitoring
  - 75 bn devices connected by 2025
  - Powering of sensors in remote locations, portable and wearable devices required
  - Electronics spreading in everyday products

Internet of Things - number of connected devices worldwide 2015-2025

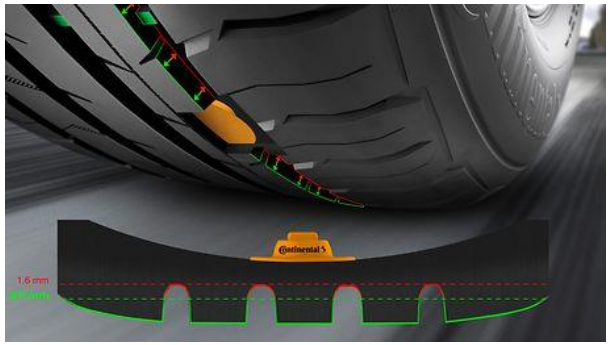
Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions) [1]



Predictive maintenance at rails (wired)

[2]

Predictive maintenance (battery)



[3]

Wearables

[4]

[1] https://objectbox.io/top-5-reasons-why-edge-computing-crucial-for-iot/

[2] https://www.lok-report.de/news/deutschland/industrie/item/4590-deutsche-bahn-sensor-zur-vorausschauenden-instandhaltung-von-weichen.html

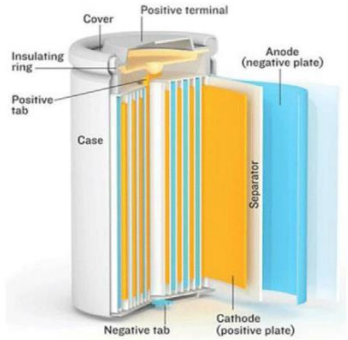
[3] https://www.continental.com/de/presse/pressemitteilungen/2014-05-07-tpms-profile-105006

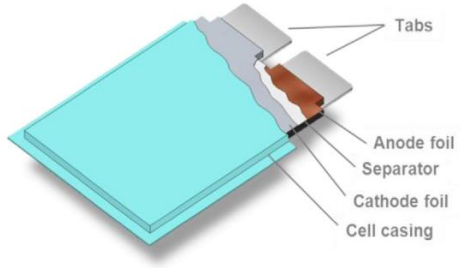
[4] http://sportmondo-sportsportal.blogspot.com/2014/04/e-textiles-electronic-textiles-2014.html

CURRENT SOLUTIONS:

- Wiring of sensor nodes:
  - Tremendous installation effort
  - Often not possible (rotating parts, remote locations)
- Batteries:
  - Toxic waste
  - Limited lifetime
- Energy Harvesting:
  - Hazardous waste (Lead-based harvesters, batteries)
  - Hi amount of electronic required per mW
  - High cost Euro per mW
  - Short term energy storage required

Current Li-ion battery





Zubi, G.; Dufo-López, R.; Carvalho, M.; Pasaoglu, G. The Lithium-Ion Battery: State of the Art and Future Perspectives. Renewable and Sustainable Energy Reviews 2018, 89, 292–308.

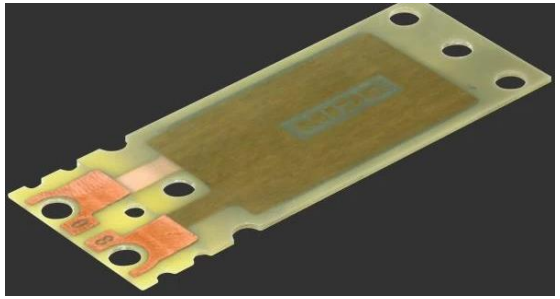
Piezo.com

PZT based

Harvester:

14 mW

234 $



https://piezo.com/collections/piezoelectric-energy-harvesters/products/piezoelectric-bending-transducer-s233-h5fr-1107xb#&gid=1&pid=1

ENERGY HARVESTING = ENERGY FOR FREE?

- Energy harvesting has recently become a topic of much discussion with its potential to self-power autonomous devices for wearables, medical devices and for IoT (the Internet of Things)

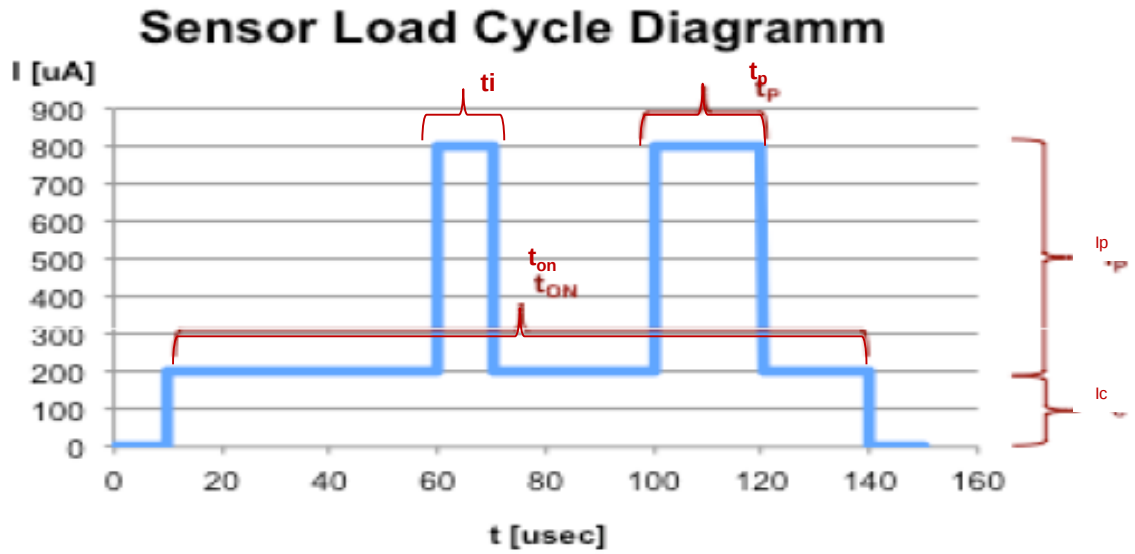
- Examples of real life use cases demonstrating that Energy Harvesting has already progressed from the laboratory to commercial applications

- We need devices that are:
  - Wireless (avoid power and communications cables)
  - Totally autonomous
  - Highly reliable with backup battery lifetime up to 15~20 years

Basic consideration for Energy Harvesting

First step:

- calculate the total energy demand for your system
- watch out for your peak energy demand



$$E_{total} = \int V * I * dt$$

$$E_{total} = V_S * (I_c * t_{on} + \sum_i I_{i,p} * t_{i,p})$$

$$P_{AVG} = \frac{E}{\Delta t} = \frac{E_{total} * DC_{AVG}}{\Delta t}$$

Vs: Supply Voltage

$t_{i,p}$: pulse duration

Ic: continuous current

t_{on}: system on time

Ip: pulsed current

DC: sequence Duty Cycle

Basic consideration for Energy Harvesting

Second step:

- consider the source capabilities
- check multiple source availability (solar, thermo, motion, chemical… etc.)
- watch out for the stability over the time (use a data logger)

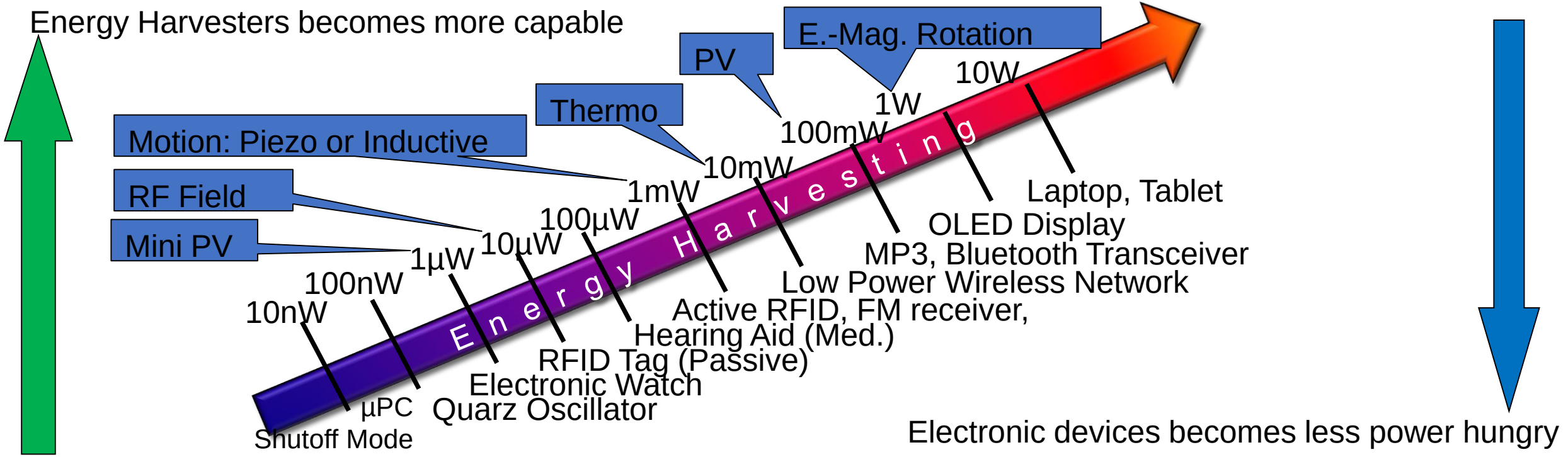
Third step:

- choose the right harvester (transducer)
- build the right voltage converter (source impedance matching)
- consider an energy storage for back up
    - capacity bank
    - supercaps
    - ultracaps (Supercap/Lithium-Ion)
    - Li-Pol rechargeable

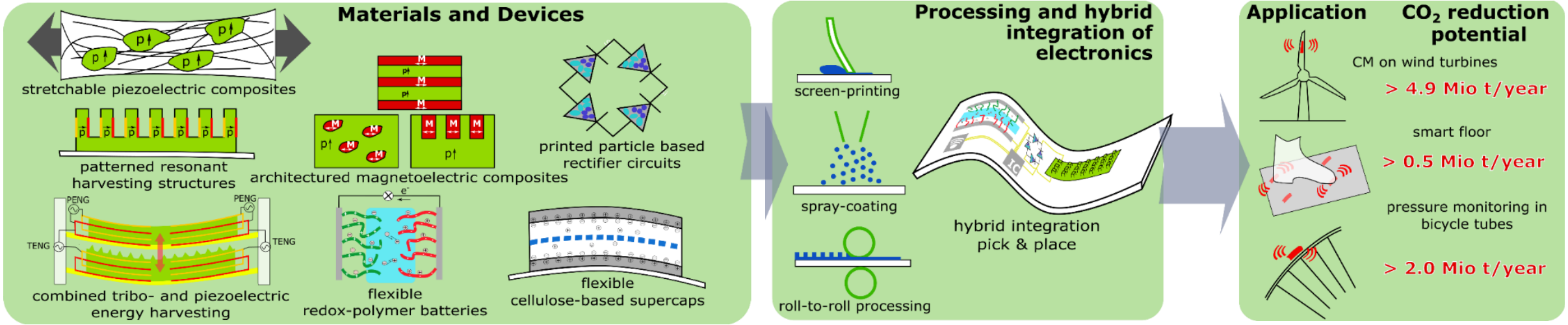
Where to find „free energy“

- Typical energy harvester output power
  - RF: 0.1µW/cm²
  - Vibration: 1mW/cm²
  - Thermal: 10mW/cm²
  - Photovoltaic: 100mW/cm²

- **Typical energy harvester voltages**
  - RF: 0.01mV
  - Vibration: 0.1 ~ 0.4 V
  - Thermal: 0.02 ~ 1.0 V
  - Photovoltaic: 0.5 ~ 0.7 V typ./cell



EU FUNDING PROJECT: SYMPHONY



Raw Materials → New Materials → New Devices → Integrated energy autonomous sensor system (EASS) → CO_2 relevant use cases → CO_2 savings and reduction of hazardous waste based on LCA

SYMPHONY FACT SHEET:

Start Date: 01/05/2020

End date: 30/04/2024

Duration in months: 48

Website: www.symphony-energy.eu

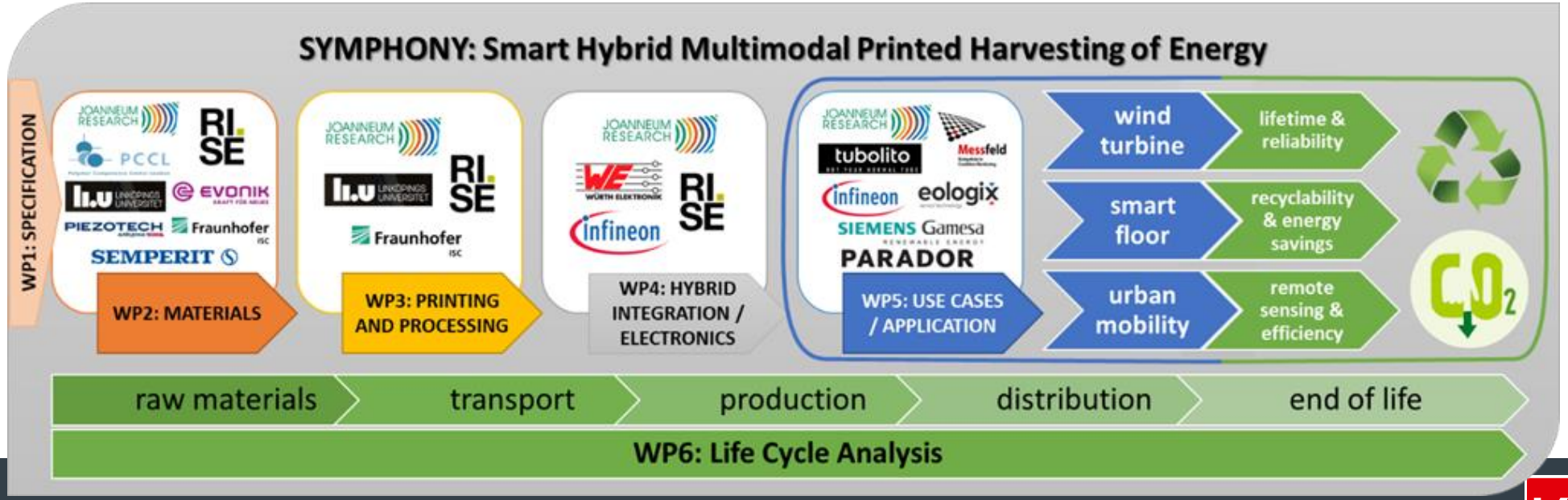
Grant Agreement number: 862095

Project budget: 6,82 M€

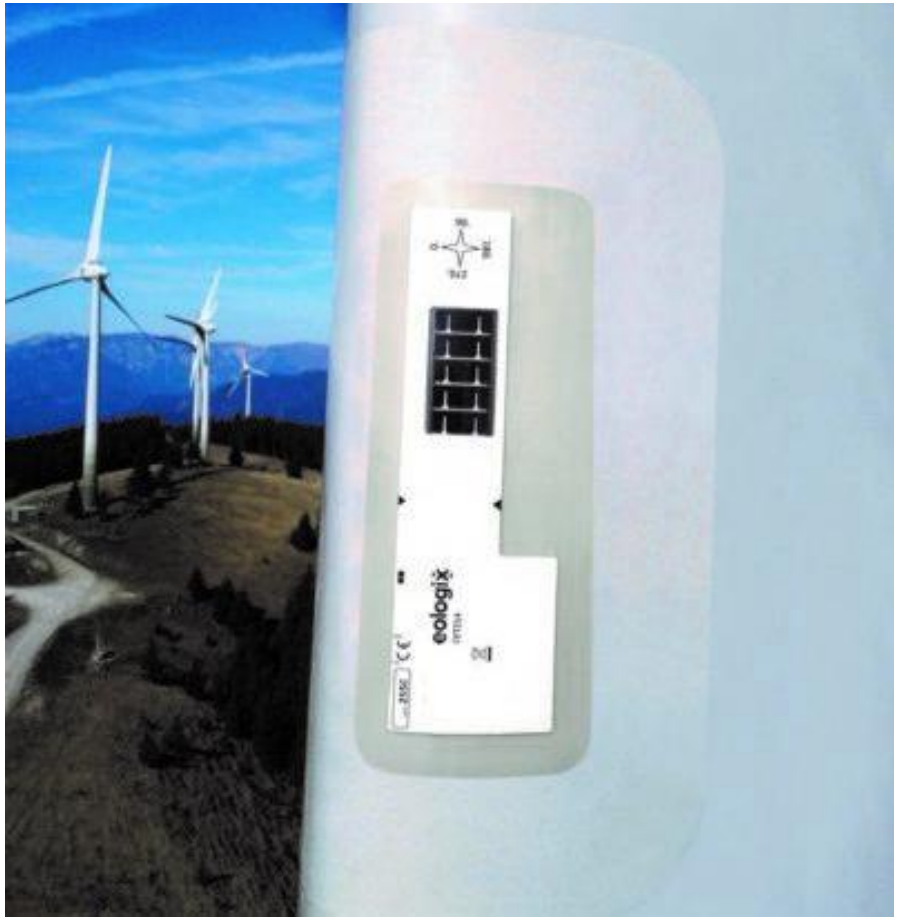
Joanneum budget: 1758615€

Coordinator: Dr. Jonas Groten, Joanneum HEP group (Austria), jonas.groten@joanneum.at

Consortium:



SYMPHONY USE CASES:



Use case:
Sensor skin for wind turbine condition monitoring – energy self-sufficient eologix sensors are mounted directly on the rotor blade surface.
(Copyright: eologix sensor technology GmbH)

The project will develop an integrated sensor skin based on the SYMPHONY Energy Supply Platform and P(VDF-TrFE) sensors that allow Condition Monitoring of rotor blades of wind turbines to increase their lifetime and reduce downtimes.

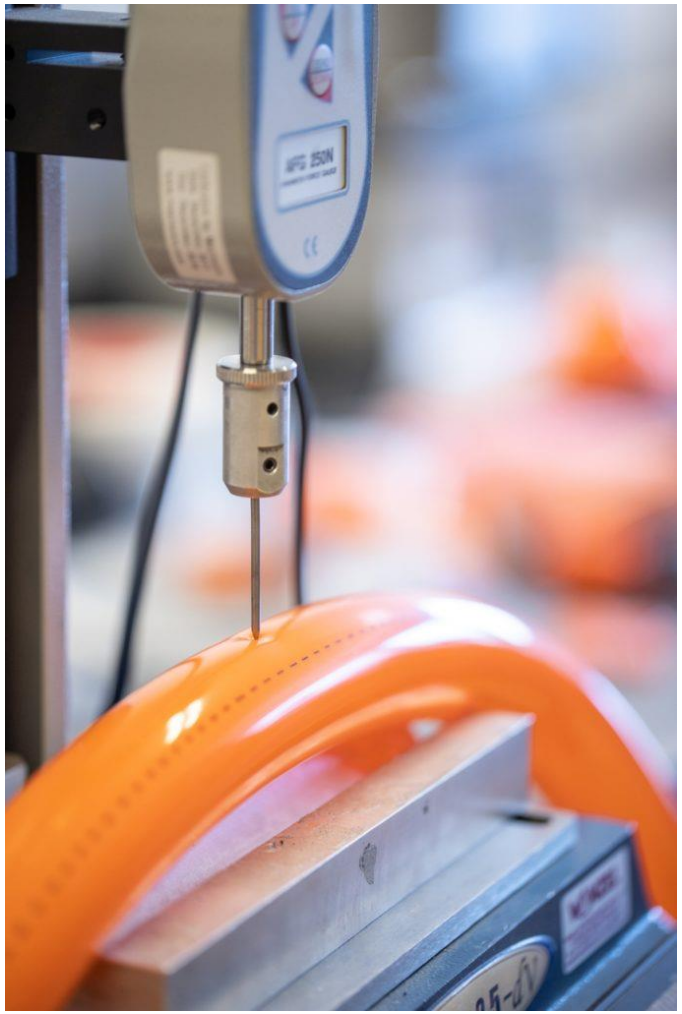
SYMPHONY USE CASES:

Use case**:**
Smart floor
(Copyright: Joanneum Research – MATERIALS)

SYMPHONY platform enables precise, high-resolution motion tracking to be carried out without endangering the customer's privacy or requiring additional installation steps.

The SYMPHONY self-powered solution will replace batteries and lead based energy harvesters, avoiding toxic waste, through the use of resource efficient and large scale production technologies.

SYMPHONY USE CASES:



Use case:
Automated pressure monitoring of bike tubes
(Copyright: Markus Frühmann, Tubolito GmbH)

Bicycle tire pressure directly affects rolling resistance, ride comfort, puncture protection, and grip. In e-biking (typically 3-5 bar), rolling resistance also affects battery life.

An automatic remote monitoring of the pressure of bike tubes will help to keep it, will reduce the maintenance costs for rental e-bike systems and will overall decrease the electrical energy consumption.

A wireless tire pressure sensor mounted in the tire tubes could improve driving experience and comfort as well.

SYMPHONY IMPACT:

SYMPHONY will contribute significantly to acceleration of future low-carbon competitive economy.

The printed technology can be integrated cost effectively in stretchable and flexible devices, representing a huge potential for usage in a wide range of further IoT-supported applications.

The SYMPHONY platform will provide functionalities such as Condition Monitoring, Predictive Maintenance or Energy Management in three application areas:

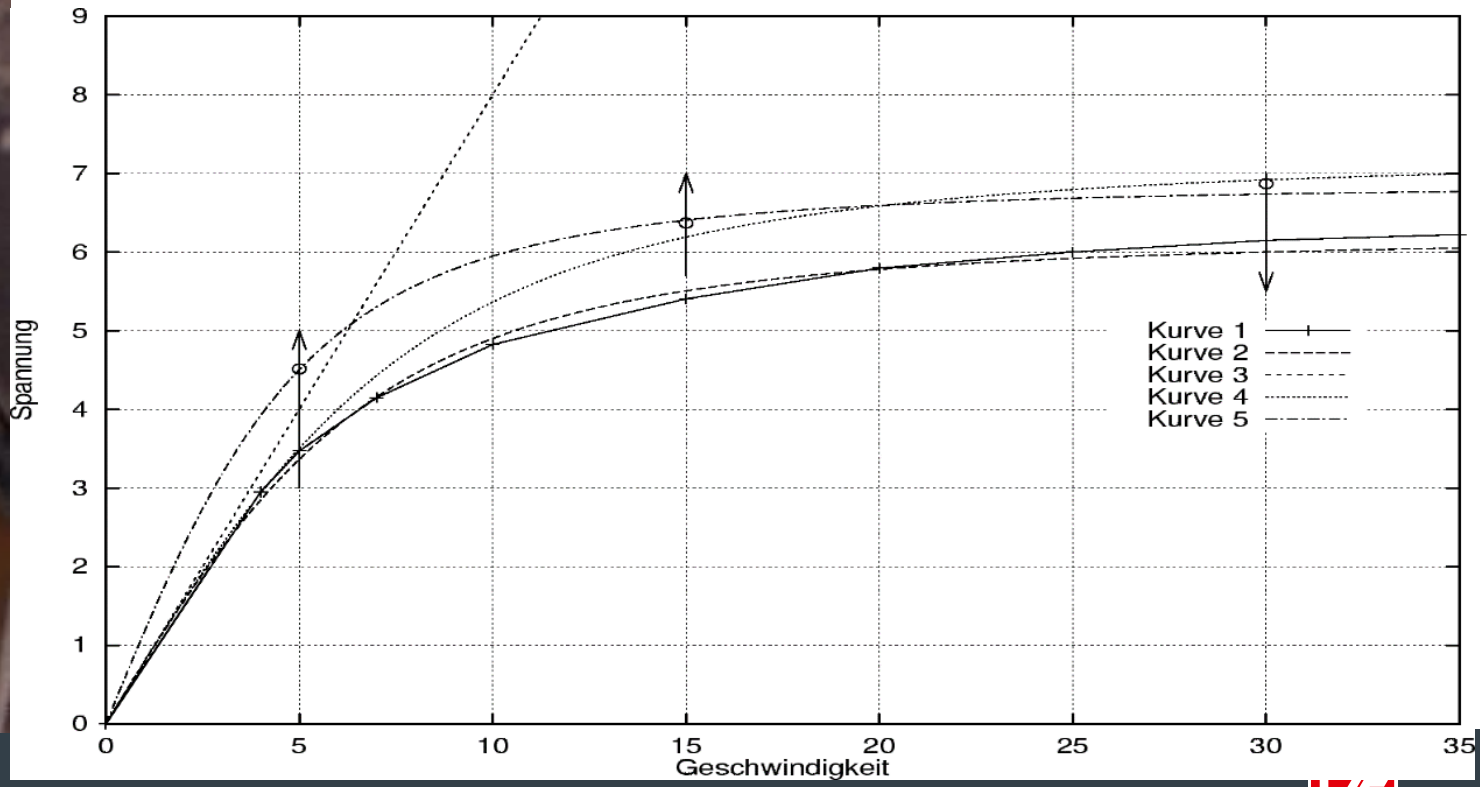
- **Renewable energy generation**
- **Room heating/cooling**
- **E-mobility**

TYPICAL INDUCTIVE TRANSDUCERS

Average Power: 3W

Downhill Peak Power: 4W

Output Voltage: 6V @ 12Ω Load

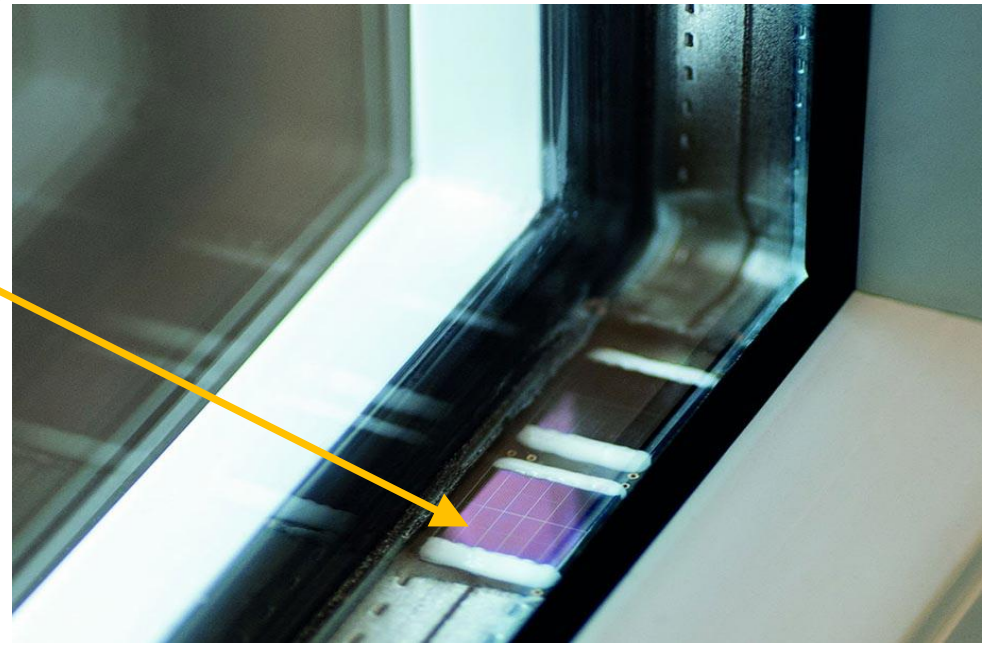


ENERGY HARVESTED APPLICATION

- Customer feedback for EH projects:
  - Total amount of harvested energy: min 50µW up to 200mW

Devices designed:

- Aftermarket solutions for Portable Navigators & Mobile Phones (Solar)
- GSM/GPS module (5W Solar)
- Window status monitoring for Hotels and Homes (Solar)
- Chainsaw electronic at engine (TEG)
- High Voltage cable monitoring (Magnetic field)
- Water purification plant PH measuring (chemical)
- Temperature measurement for engines (TEG)
- Object tracking at airport (Piezo & RF-ID)



Source:© Fraunhofer IMS

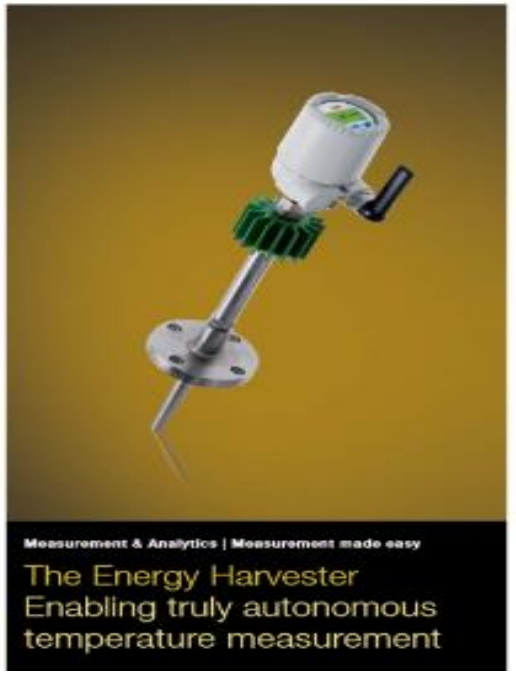
L‘OREAL UV SENSOR

The device is battery-free electronic UV sensor and it’s small enough to wear on one of your nails. Using NFC, the device can connect to your phone and deliver log data on sun exposure.

Source: L‘Oreal at dezeen.com

ABB Temp. Sensor Node

- TSP300-W with Energy Harvester
- Enables the easy addition of temperature measuring points throughout operations.
- Shorten installation times by eliminating complex wired infrastructure and lower overall implementation costs of process measurement with ABB´s wireless devices



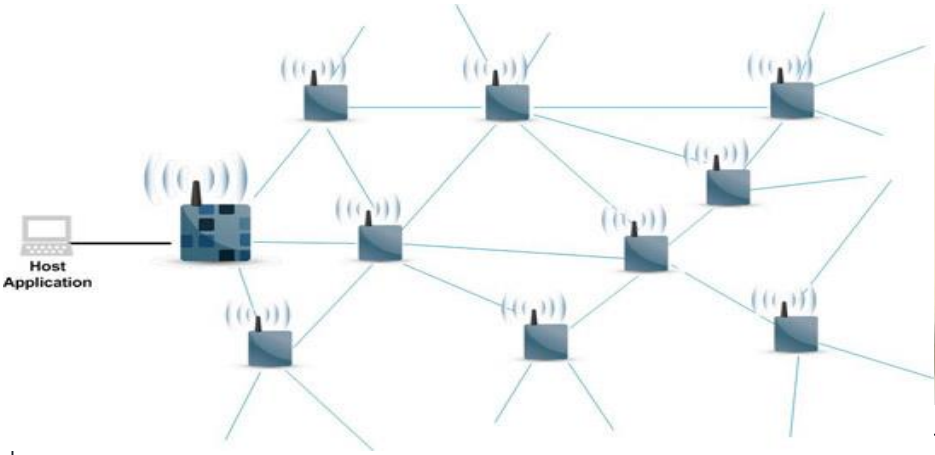
Source: ABB

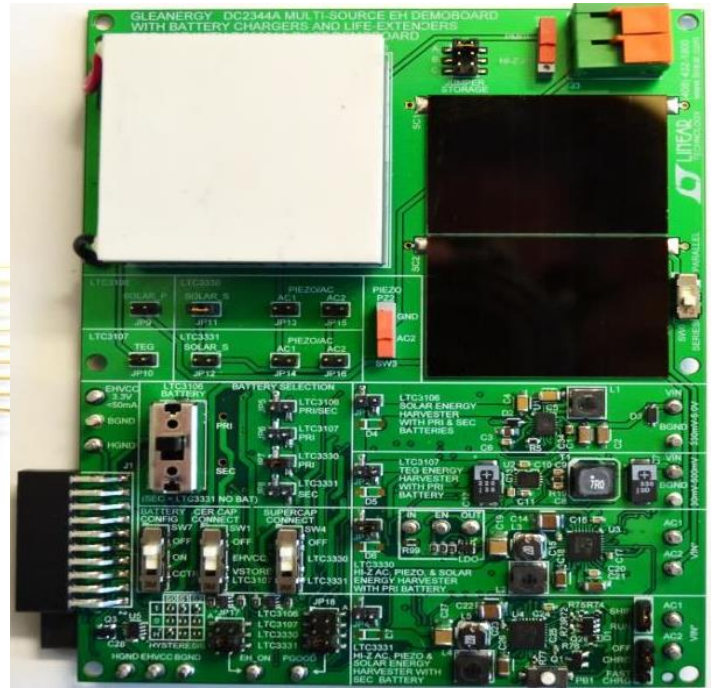
ANOTHER APPLICATION FOR HARVESTING?

Source: http://www.joaolammoglia.com/concept/1/aire-concept/

ENERGY HARVESTING KIT “GLEANERGY” WITH BATTERY LIFETIME EXTENDER

- Environment energy captured and converted into electricity for small autonomous devices making them self-sufficient.





- Thermo Electric Generator (heat)
- Piezo Electric (vibration/strain)
- Photovoltaic (light)
- Induction (motion)
- Battery (Lithium)

Regulated Voltage

Power Good

EH_ON or Batt. Information

ENERGY HARVESTING EVALUATION BOARDS:
"GLEANERGY" P/N: IC-744 888
"TO GO" KIT P/N: IC-744 885

- More information find here:
- www.we-online.com/energyharvesting

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