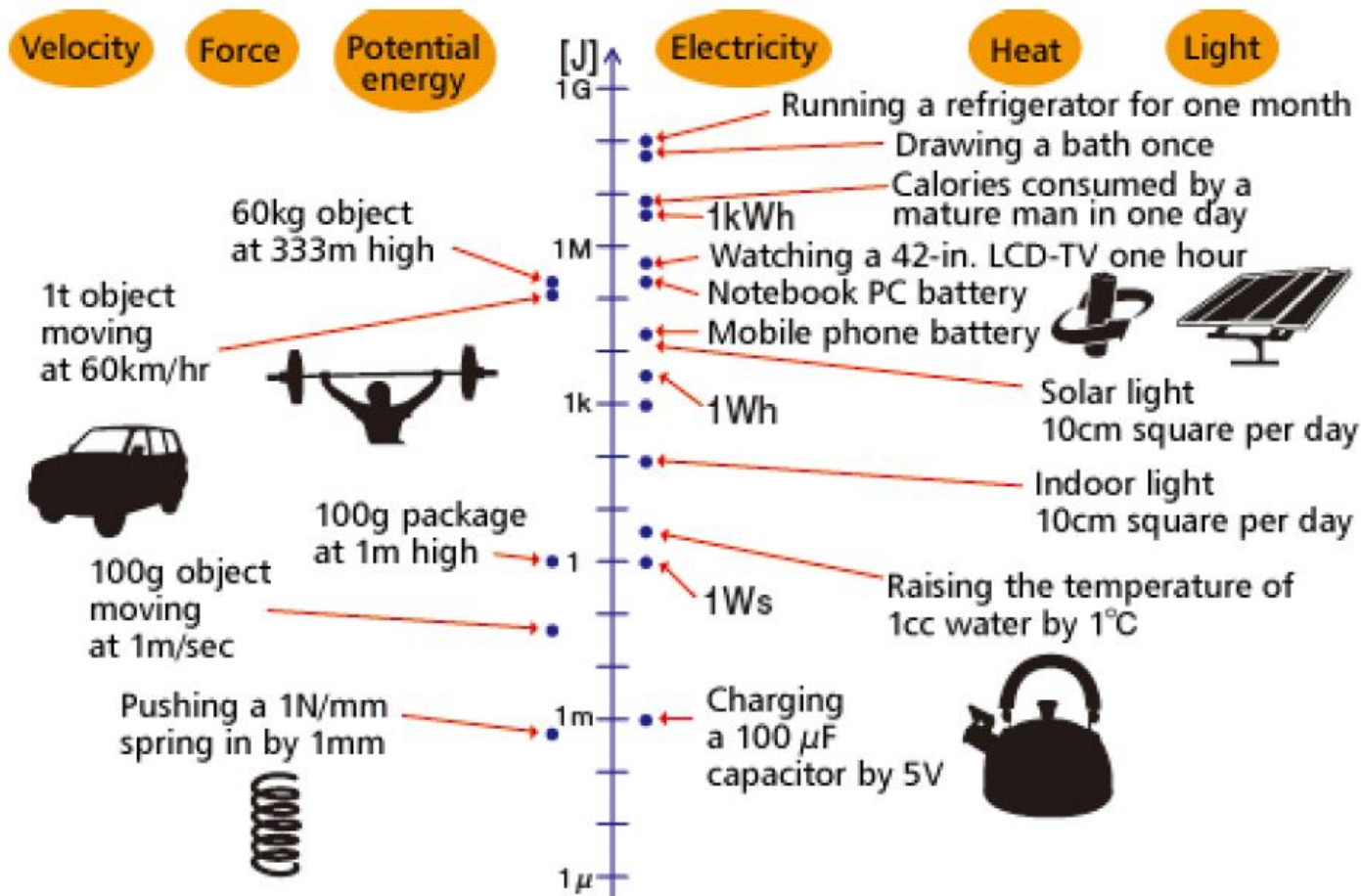


Coleta de Energia Conceitos

Aquiles
2019

ENERGY COMPARISON

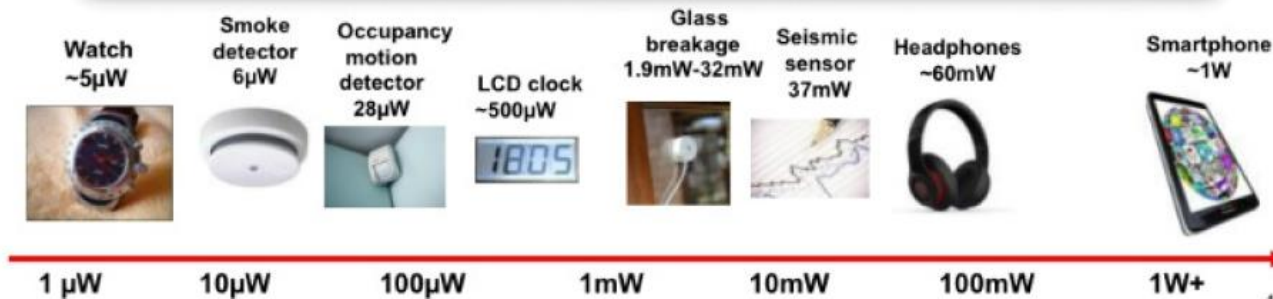


ENERGY HARVESTING(EH) TECHNOLOGY AND DEVICES

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POWER AVAILABLE FROM ENERGY SOURCE

Energy Source	Characteristics	Harvested Power
Light	Outdoor	100 mW/cm ²
	Indoor	100 μ W/cm ²
Thermal	Human	60 μ W/cm ²
	Industrial	~1-10 mW/cm ²
Vibration	~Hz-human	~4 μ W/cm ³
	~kHz-machines	~800 μ W/cm ³
RF	GSM 900 MHz	0.1 μ W/cm ²
	WiFi	0.001 μ W/cm ²



ENERGY HARVESTING(EH) TECHNOLOGY AND DEVICES

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Table 1. Comparison of Power Density of Energy Harvesting Methods

Energy Source	Power Density & Performance	Source of Information
Acoustic Noise	0.003 $\mu\text{W}/\text{cm}^3$ @ 75Db 0.96 $\mu\text{W}/\text{cm}^3$ @ 100Db	(Rabaey, Ammer, Da Silva Jr, Patel, & Roundy, 2000)
Temperature Variation	10 $\mu\text{W}/\text{cm}^3$	(Roundy, Steingart, Fr��chette, Wright, Rabaey, 2004)
Ambient Radio Frequency	1 $\mu\text{W}/\text{cm}^2$	(Yeatman, 2004)
Ambient Light	100 mW/cm ² (direct sun) 100 $\mu\text{W}/\text{cm}^2$ (illuminated office)	Available
Thermoelectric	60 $\mu\text{W}/\text{cm}^2$	(Stevens, 1999)
Vibration (micro generator)	4 $\mu\text{W}/\text{cm}^3$ (human motion—Hz) 800 $\mu\text{W}/\text{cm}^3$ (machines—kHz)	(Mitcheson, Green, Yeatman, & Holmes, 2004)
Vibrations (Piezoelectric)	200 $\mu\text{W}/\text{cm}^3$	(Roundy, Wright, & Pister, 2002)
Airflow	1 $\mu\text{W}/\text{cm}^2$	(Holmes, 2004)
Push buttons	50 $\mu\text{J}/\text{N}$	(Paradiso & Feldmeier, 2001)
Shoe Inserts	330 $\mu\text{W}/\text{cm}^2$	(Shenck & Paradiso, 2001)
Hand generators	30 W/kg	(Starner & Paradiso, 2004)
Heel strike	7 W/cm ²	(Yaglioglu, 2002) (Shenck & Paradiso, 2001)

Potential Ambient Energy-Harvesting Sources
and Techniques - Faruk Yildiz

The Journal of Technology Studies

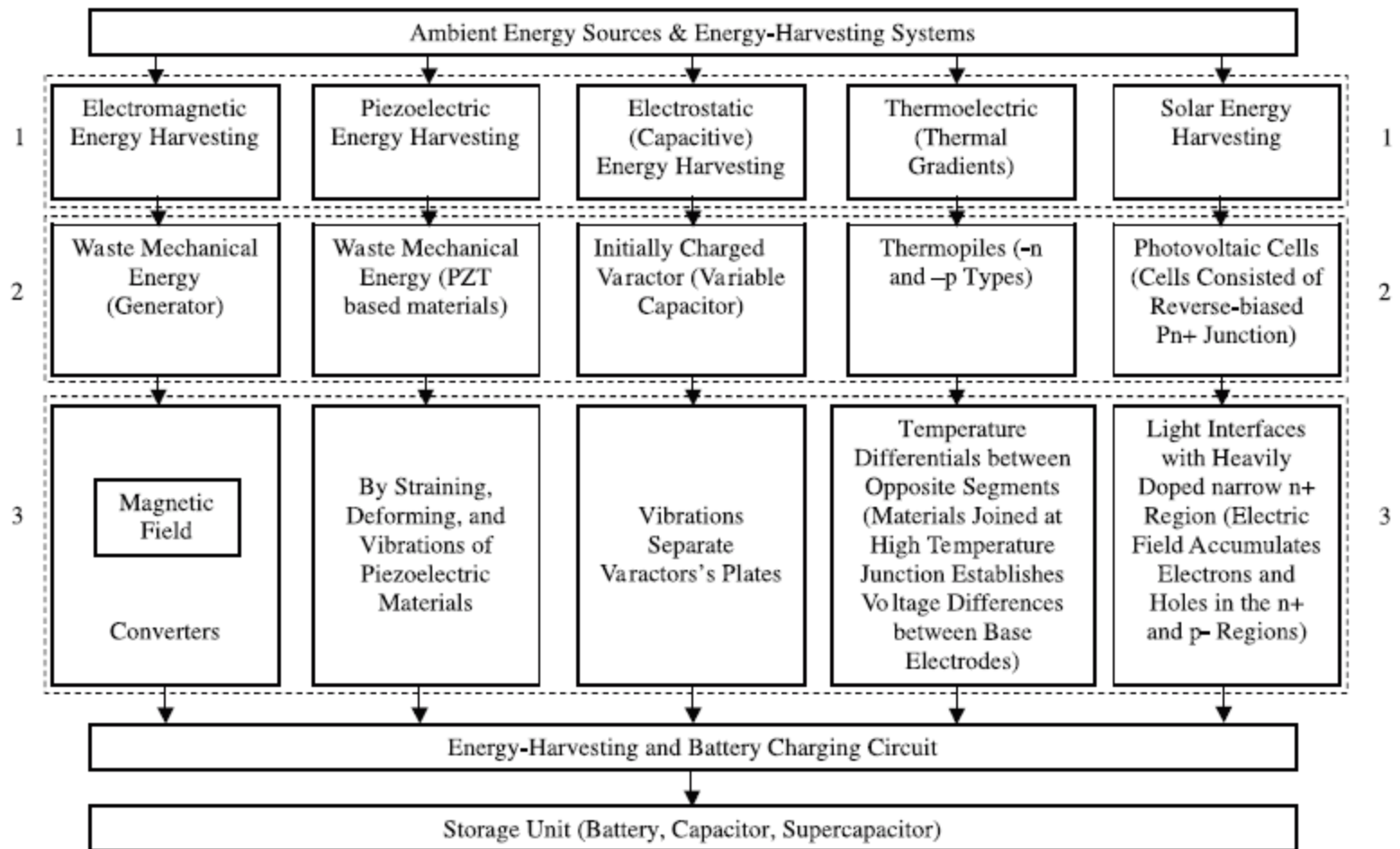


Figure 1. Ambient Energy Systems

Potential Ambient Energy-Harvesting Sources and Techniques - Faruk Yildiz

The Journal of Technology Studies

Table 2. Comparison of Vibration Energy-Harvesting Techniques

	Electrostatic	Electromagnetic	Piezoelectric
Complexity of process flow	Low	Very High	High
Energy density	4 mJ cm ⁻³	24.8 mJ cm ⁻³	35.4 mJ cm ⁻³
Current size	Integrated	Macro	Macro
Problems	Very high voltage and need of adding charge source	Very low output voltages	Low output voltages

Potential Ambient Energy-Harvesting Sources
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from inductors, coils and transformers

wind, water flow, ocean currents, and solar

vibration, mechanical stress and strain

Vibration

Heat

Light

Positional energy

Electric potential difference

Heat

Vibration

waste energy from furnaces, heaters, and friction sources

chemical and biological sources

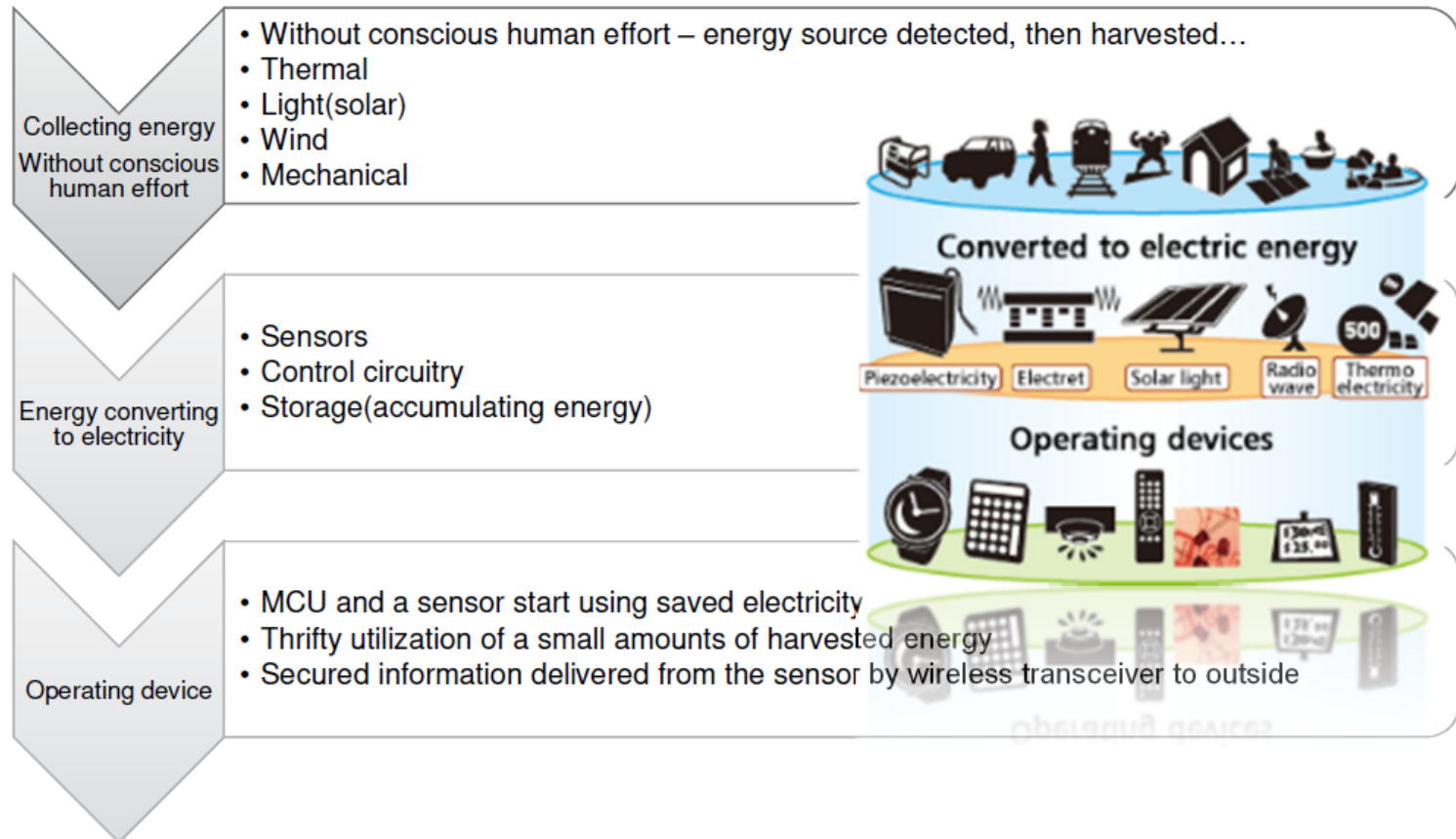
Sunlight, room light via photo sensors, photo diodes, or solar panels

mechanical and thermal energy naturally generated from bio-organisms, walking and sitting

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WHAT IS ENERGY HARVESTING?

Energy harvesting(also known as power harvesting or energy scavenging) is the process by which energy is derived from external sources (e.g., solar power, thermal energy, thermal energy, wind energy, salinity gradients, and kinetic energy)



ENERGY HARVESTING(EH) TECHNOLOGY AND DEVICES

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WHEN DOES ENERGY HARVESTING MAKE SENSE?

One or more of these characteristics are required for energy harvesting to make sense

Harvestable energy available

Wiring too expensive

Difficult to power device

High installation cost

Numerous devices

Difficult to reach for maintenance

Environment friendliness required

High uptime demanded

Energy harvesting can generate only very small amounts of power.

- Wearable electronics / fashion technology
- Wireless sensor networks
- Long term low power sensors
- Low power applications that generally extend beyond the capabilities of a typical battery.

Importance of energy harvesting

- Need for endless energy supply to electronic system
- To reduce dependency on batteries
- Accelerated interest for powering ubiquitously deployed sensor networks and mobile electronic products
- To conserve energy consumption and promote environmental friendliness

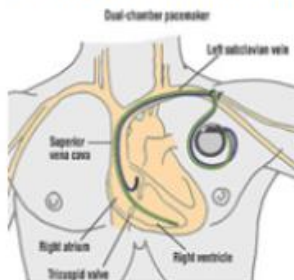
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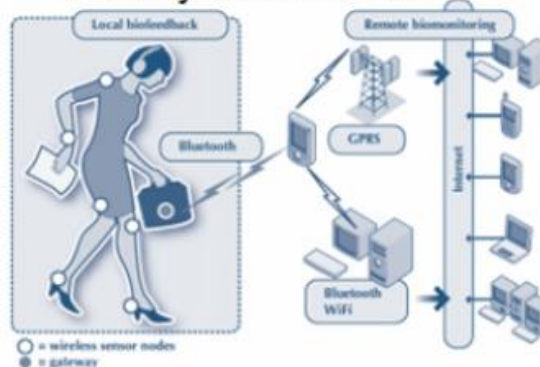
ENERGY HARVESTING APPLICATION

Low data rate, low duty cycle, ultra-low power

◆ Medical and Health monitoring



◆ Body Area Network



◆ Wireless Sensor Networks



◆ Structure Health monitoring



◆ Smart building



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Which one do you want to have?

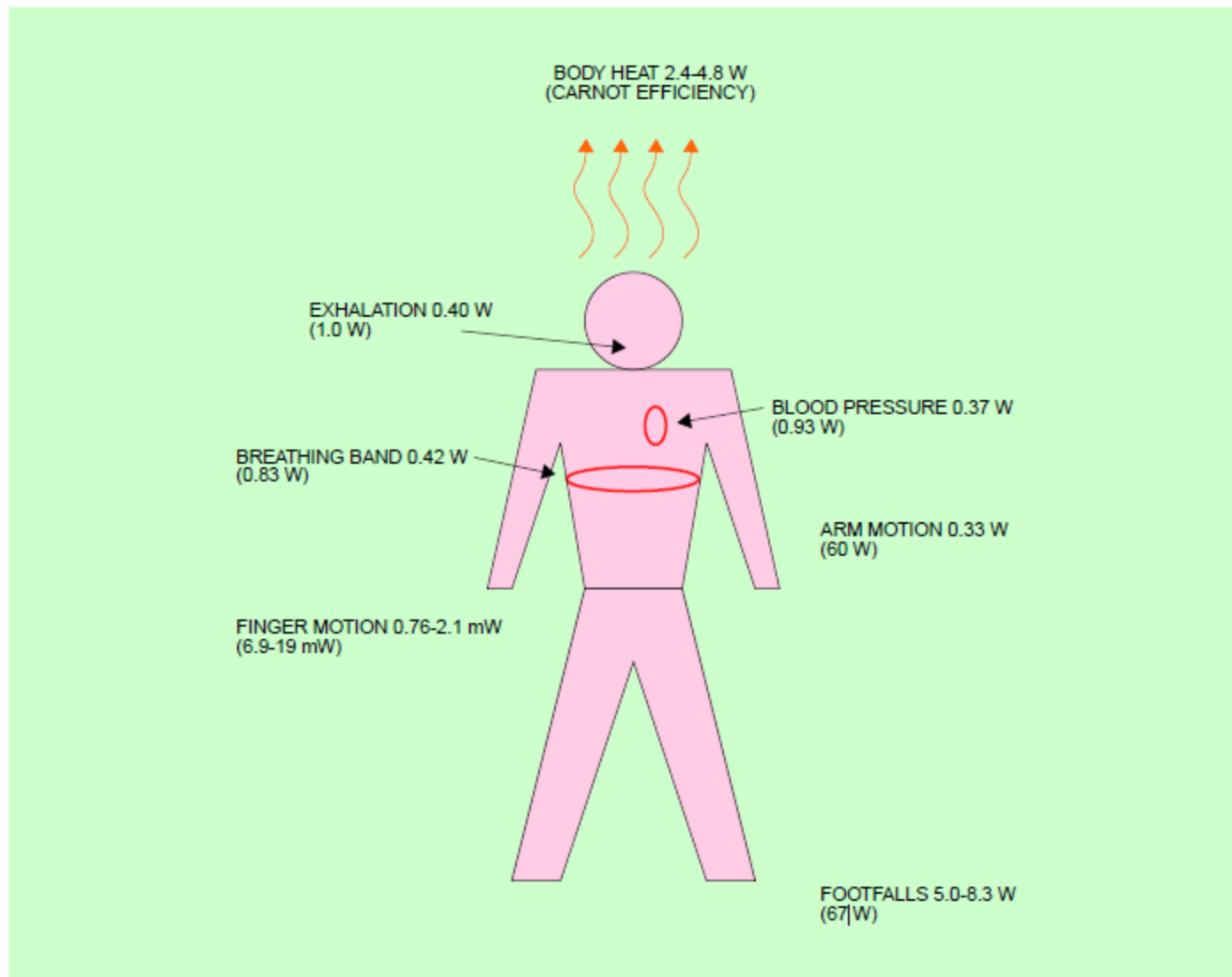


Battery-based



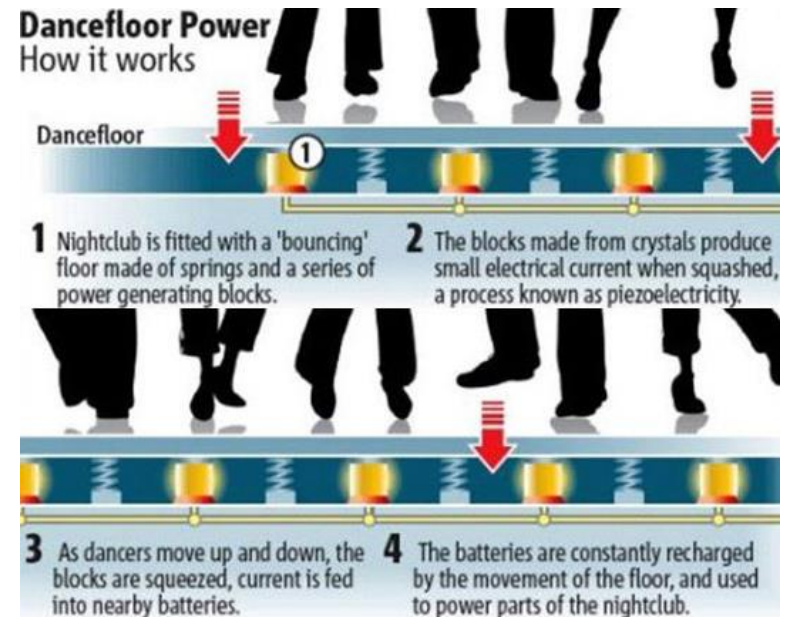
"Forever"-based

Figure 4 Power from body-driven sources; total power for each action is included in parentheses



Piezoelectric Effect (Pressure)

- Converts mechanical strain to electric current
- Produces power on the order of mW
- Useful for small applications
 - Handheld devices
 - Light bulbs



- Human Motion
- Acoustic Noise
- Vibrations
- Pressure



<https://row.bioliteenergy.com/products/campstove-2?variant=13844609466477>

- Acesso dia 26/2/2019



Thermoelectric Generator Demonstrator



Solar Powered Stirling Engine



http://www.fogaosolar.net/Tipos_fogoes.html

Acesso dia 26/2/2019

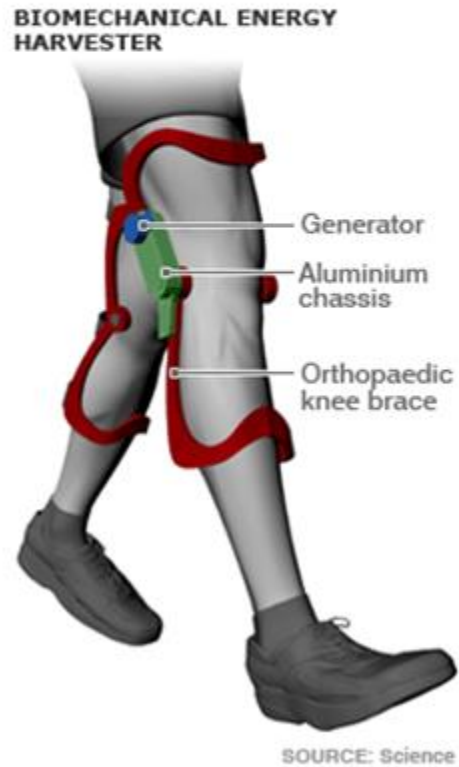


GravityLight Portable Self-Powered LED Lamp

<https://www.deciwatt.global/gravitylight>

Acesso dia 26/2/2019

Biomechanical Energy Harvester

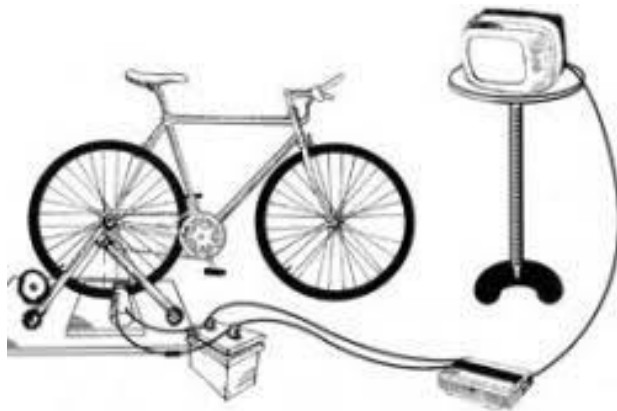




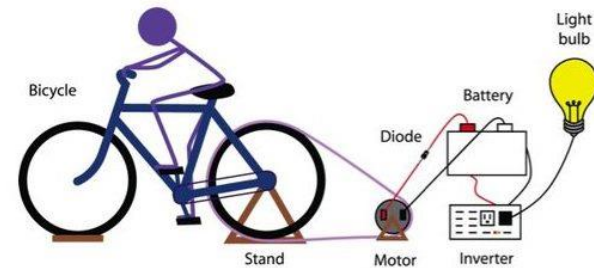
<https://www.nokero.com/>
Acesso dia 26/2/2019



Calculadora solar



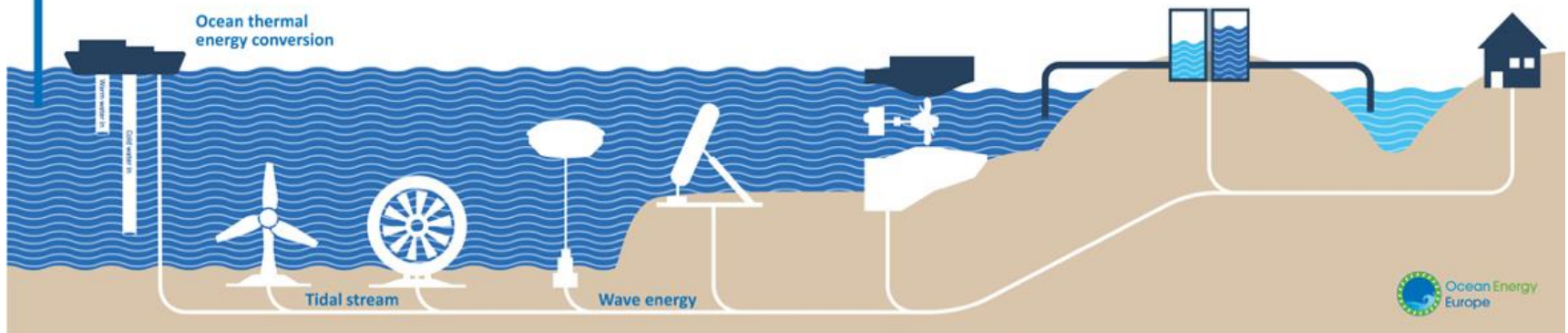
A bicycle generator uses human power to generate electricity...



<http://nextenergyrevolution.com/2016/06/08/pedal-for-power-diy-bike-generator/> - acesso dia 25/02/2019

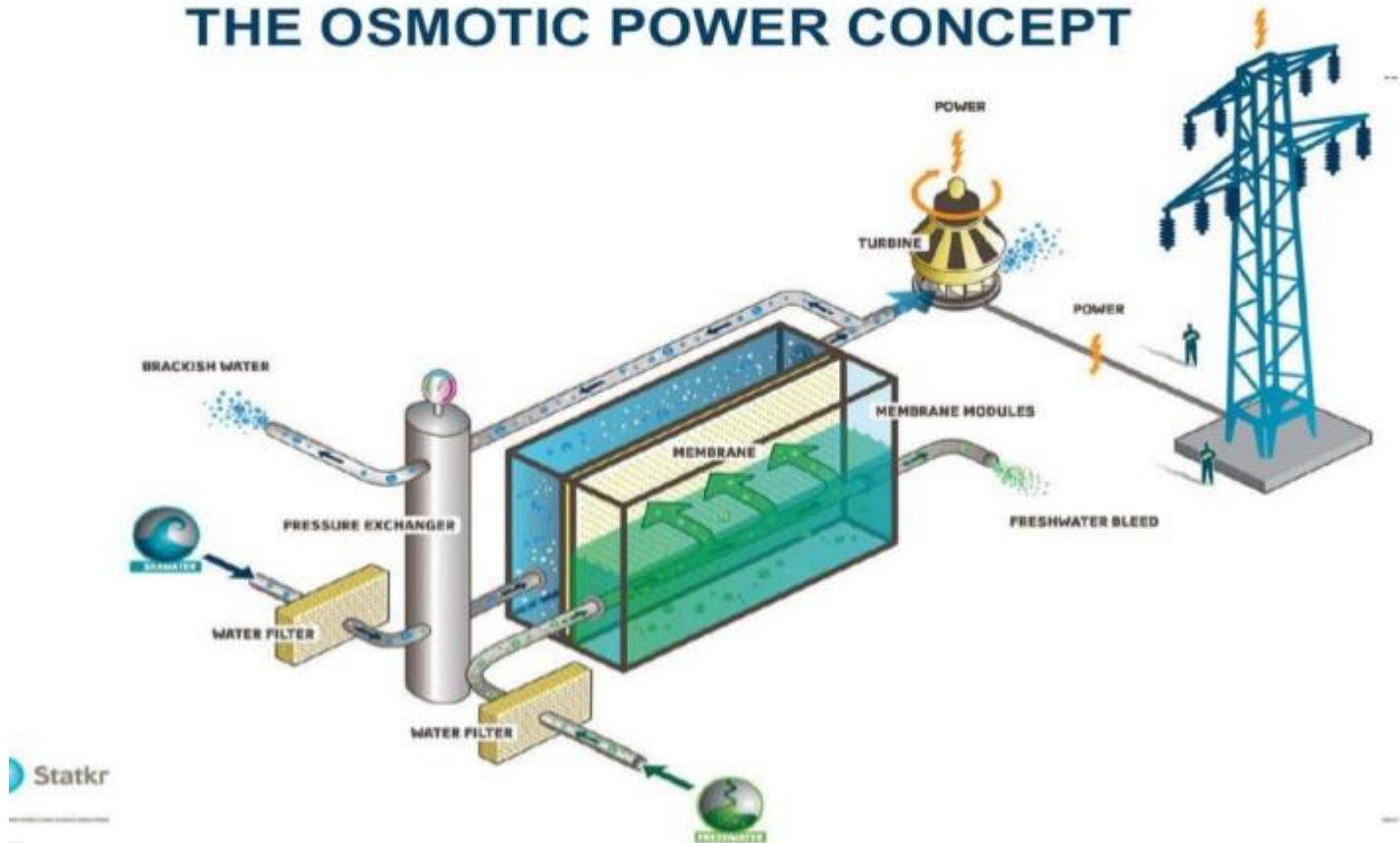
Ocean Energy

5 technologies creating
renewable energy from seas and oceans.



<https://www.oceanenergy-europe.eu/ocean-energy/> - acesso dia 25/2/2109

THE OSMOTIC POWER CONCEPT



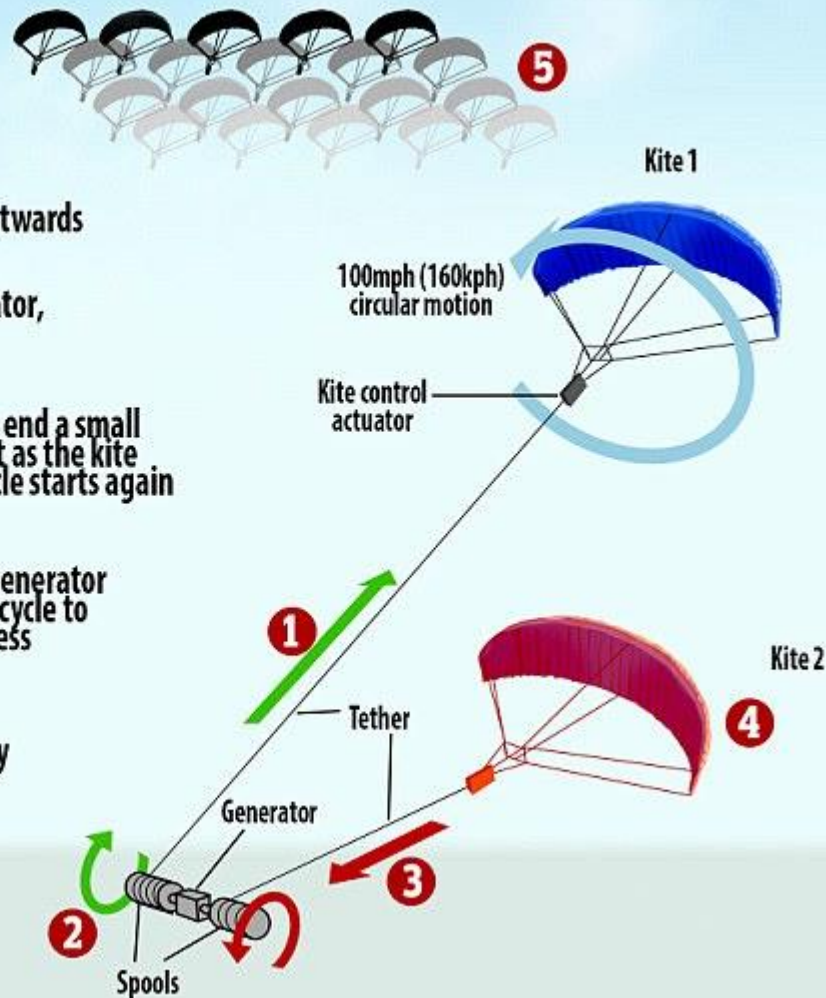
When placing a semi-permeable membrane (i.e. a membrane that retains the salt ions but allows water through) between reservoirs containing fresh water and sea water respectively, a net flow of water towards the salt water side will be observed because of osmosis. If the saltwater compartment has a fixed volume the pressure will increase towards a theoretical maximum of 26 bars. This pressure is equivalent to 270 meters high water column.

http://www.ijarse.com/images/fullpdf/1519729427_NMCOE3038ijarse.pdf

Acesso dia 25/2/2019

HOW THE KITE FARM WORKS

- 1** Kite pulls the tether outwards
- 2** This rotates the generator, producing electricity
- 3** Once tether reaches its end a small amount of power is lost as the kite is retracted and the cycle starts again
- 4** A second kite on each generator rotates in an opposing cycle to ensure a constant process
- 5** Twenty kite farm will produce enough energy for 5,500 homes



© MailOnline

<https://www.dailymail.co.uk/sciencetech/article-4544542/Kites-power-5-000-British-homes-2020.html> - acesso dia 25/2/2019



<https://phys.org/news/2014-05-high-flying-turbine-power.html#nRlv>

- acesso dia 25/22019

WIRELESS SENSORS



Building Automation



Structural Monitoring



Defense



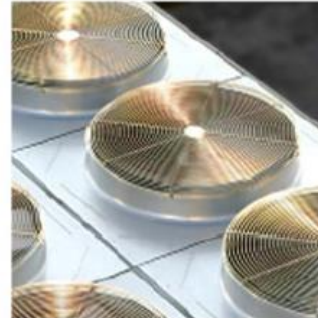
Data Centers



Security



Industrial Monitoring



Energy Management

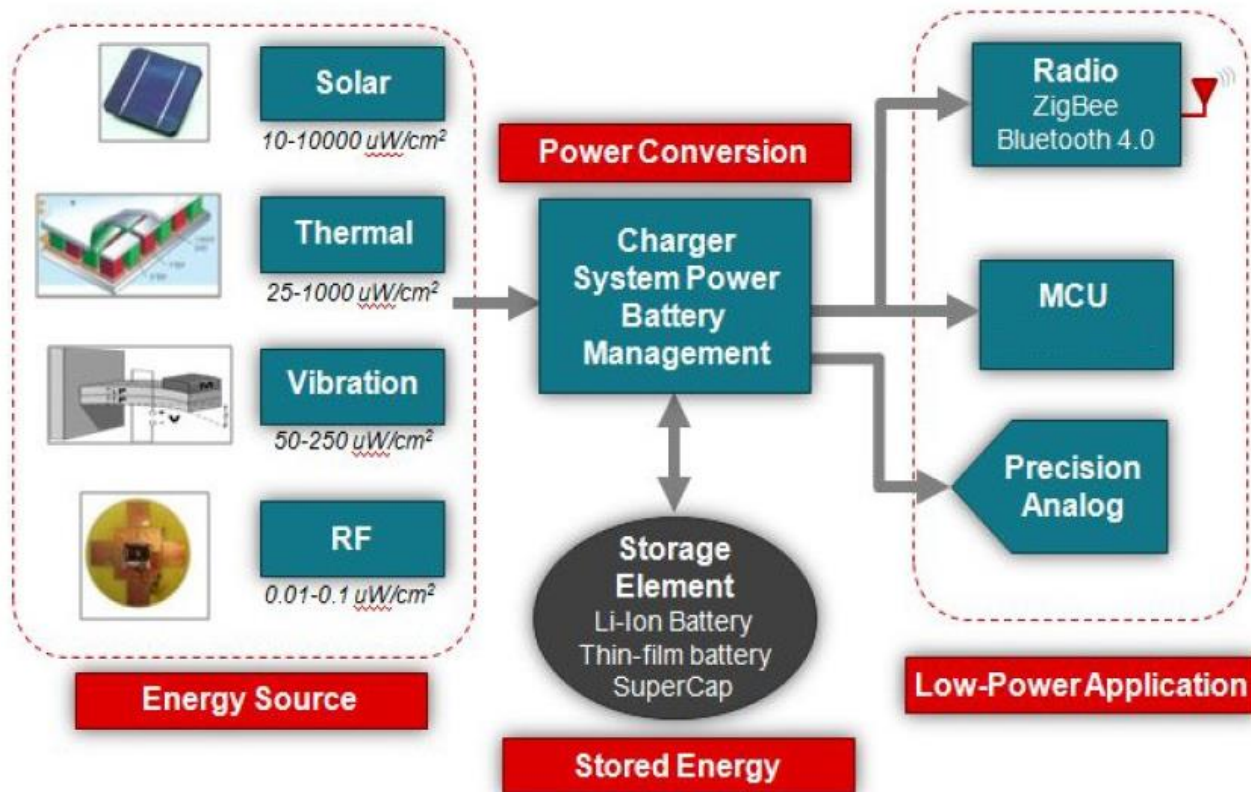


Smart Grid

ENERGY HARVESTING(EH) TECHNOLOGY AND DEVICES

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COMPONENTS OF AN ENERGY HARVESTING SYSTEM

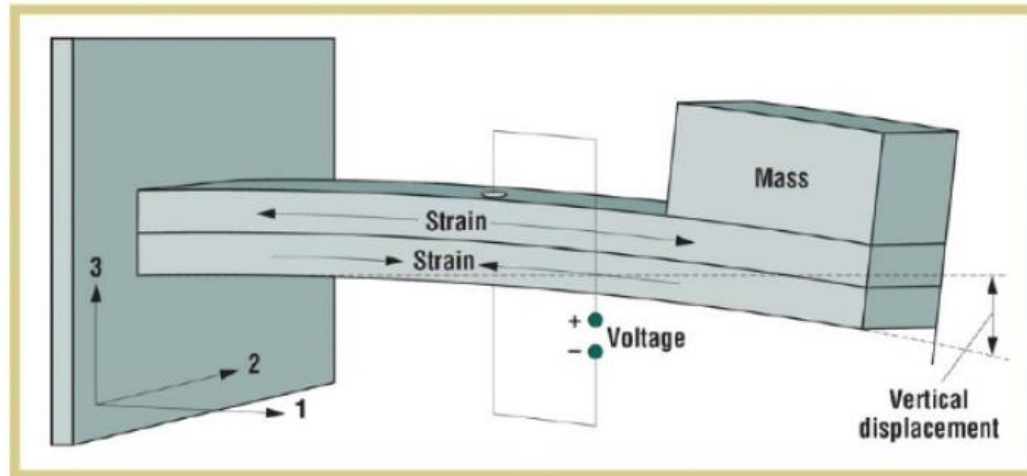


ENERGY HARVESTING(EH) TECHNOLOGY AND DEVICES

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VIBRATION HARVESTING

Piezoelectric and Electromagnetic generators

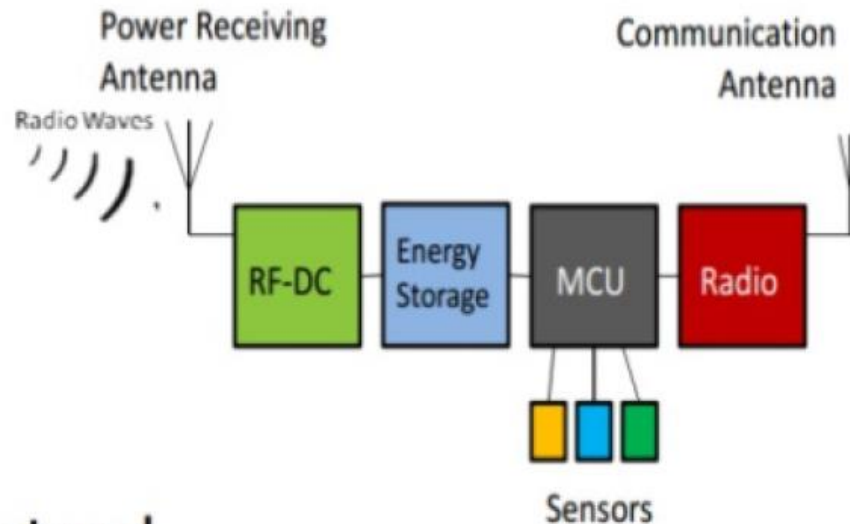


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RF ENERGY HARVESTING

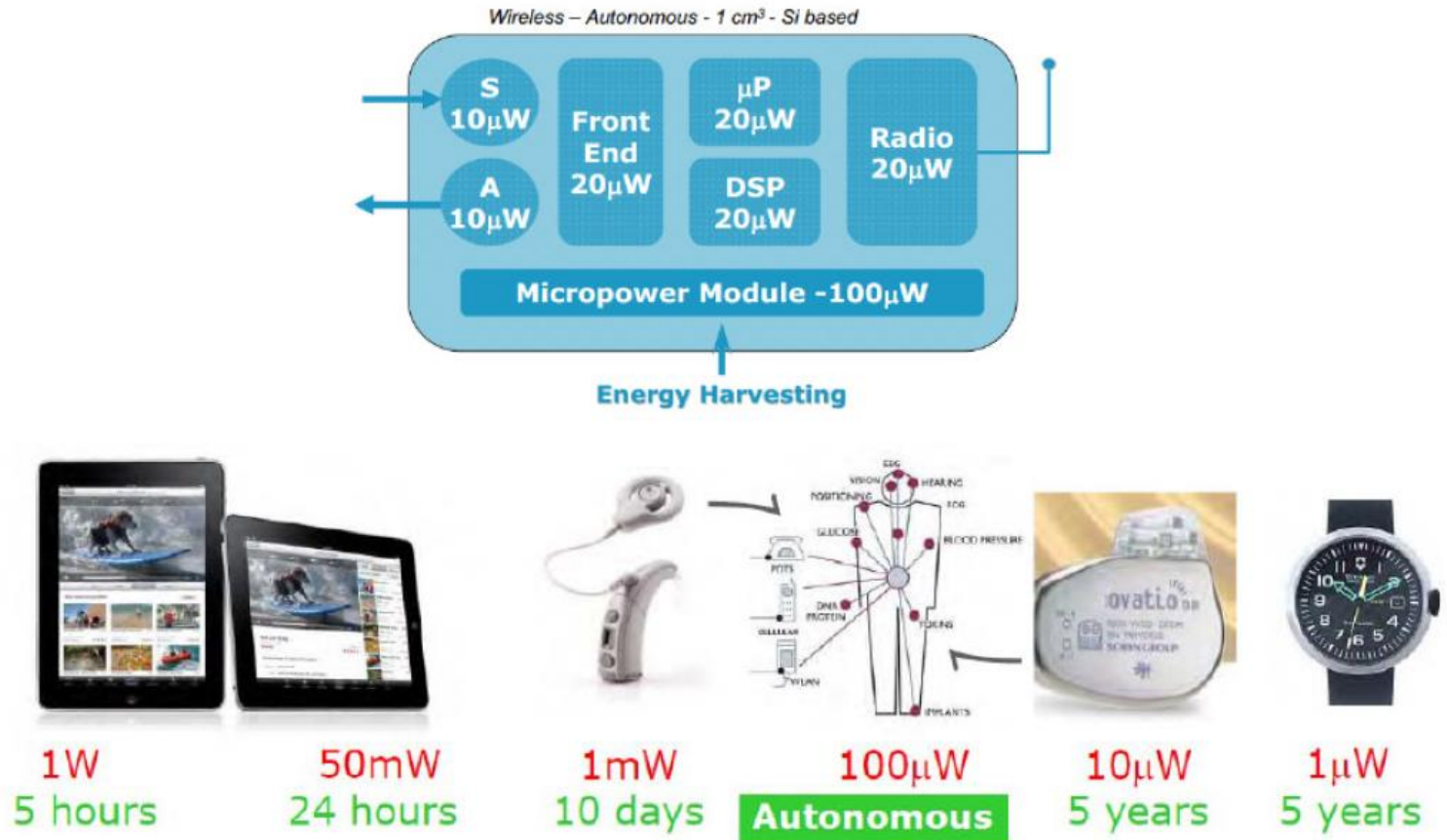
- Harvester
- Antenna
- Storage
- MCU
- Sensors
- Radio
- Comm. Protocol



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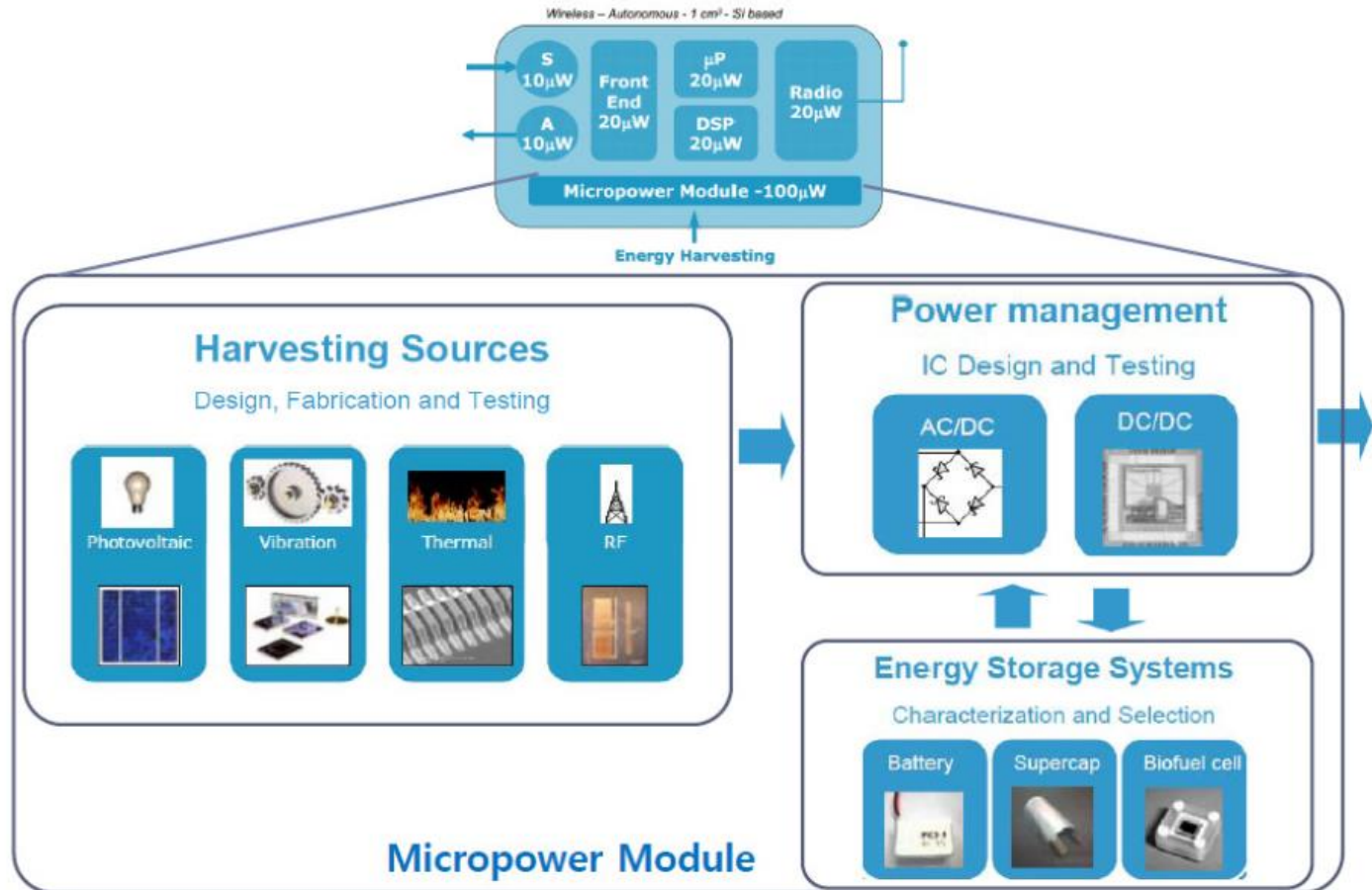
WIRELESS AUTONOMOUS SENSOR SYSTEM(WATS)



ENERGY HARVESTING(EH) TECHNOLOGY AND DEVICES

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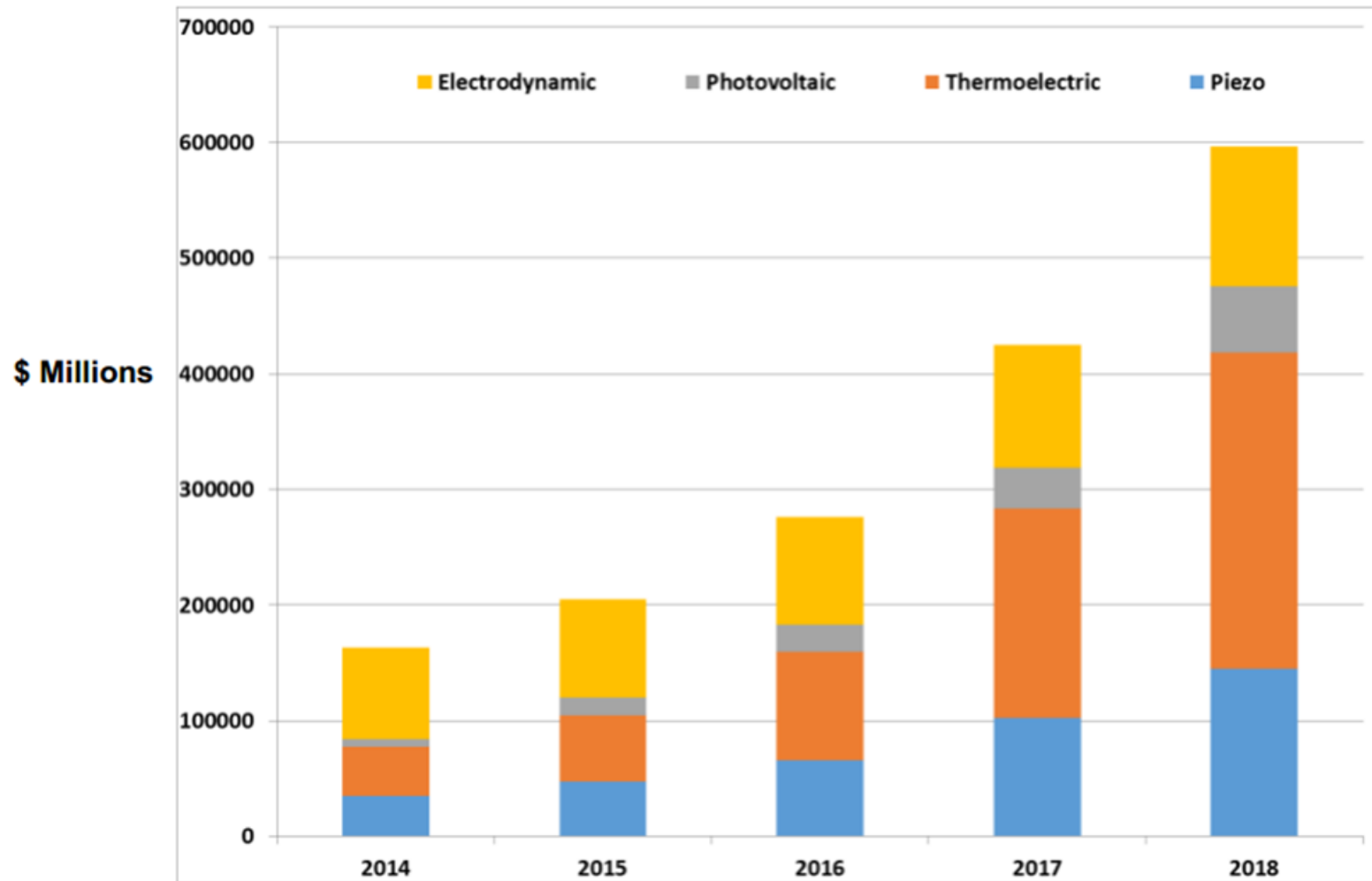
BATTERY REPLACEMENT



ENERGY HARVESTING(EH) TECHNOLOGY AND DEVICES

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(jong-ik.oh@teradyne.com)

Energy Harvesting Market Forecast by Transducer



Source: IDTechEx