



XXIV Congreso Internacional en
Innovación Tecnológica Informática 2026



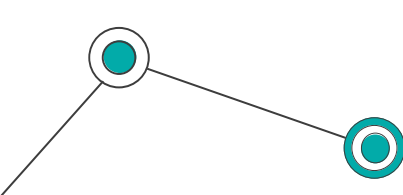
Universidad Abierta
Interamericana

Automation Applied to Energy Efficiency

[Biagio Boi](#)

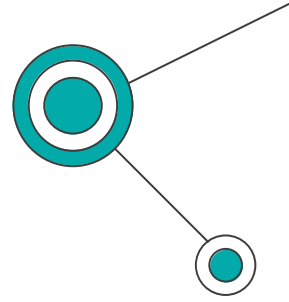
University of Salerno, Italy

bboi@unisa.it



Motivation

You cannot optimize energy you cannot see



Invisible waste

HVAC, lighting and motors often run on fixed schedules, not on real demand.

Coarse data

Monthly bills and a single main meter hide where and when energy is lost.

Manual reaction

Human-driven adjustments are slow, occasional and do not scale across sites.

Motivation

You cannot optimize energy you cannot see

Invisible waste

HVAC, lighting and motors often run on fixed schedules, not on real demand.

Coarse data

Monthly bills and a single main meter hide where and when energy is lost.

Manual reaction

Human-driven adjustments are slow, occasional and do not scale across sites.

Automation turns *measurement* into continuous, closed-loop *action*.

Sense

Distributed sensors:
temperature,
occupancy, current,
vibration



Connect

Low-power
wireless:
LoRaWAN, BLE,
Zigbee, NB-IoT



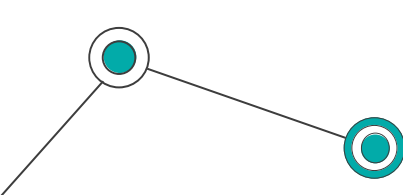
Decide

Edge and cloud
analytics: rules,
forecasting, ML
models



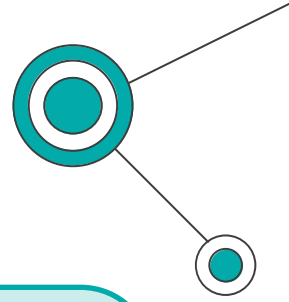
Act

Actuators: HVAC,
lighting, drives,
storage, demand
response



Problem

The battery bottleneck



A sensor network is only as sustainable as its power supply.

Maintenance

Battery swaps dominate lifetime cost when nodes number in the thousands.

Access

Sensors sit inside walls, rotating machines and remote grid assets.

Waste

Every replaced cell adds e-waste, working against the sustainability goal.

Solution #1

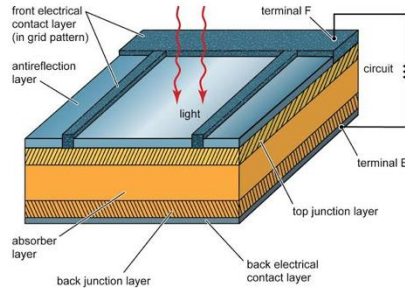
Energy Harvesting

Low power, but **enough for a duty-cycled sensor node** — and free of maintenance.

LIGHT

Photovoltaic cells

Indoor: $\sim 10\text{--}100\ \mu\text{W}/\text{cm}^2$. Outdoor: up to $\sim 10\ \text{mW}/\text{cm}^2$.

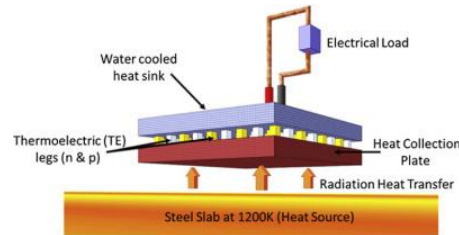


© Encyclopædia Britannica, Inc.

HEAT

Thermoelectric generators

Tens of $\mu\text{W}/\text{cm}^2$ from a few kelvin of gradient.



VIBRATION

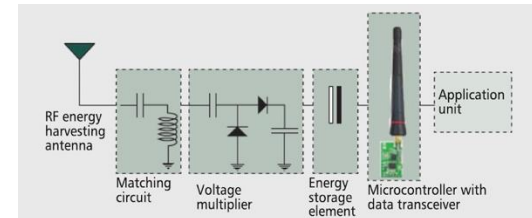
Piezoelectric, electromagnetic

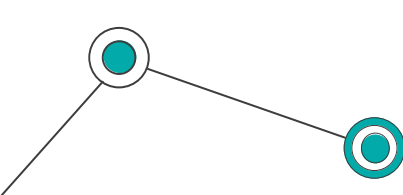
μW to mW , tied to frequency and amplitude.

RF

Rectennas

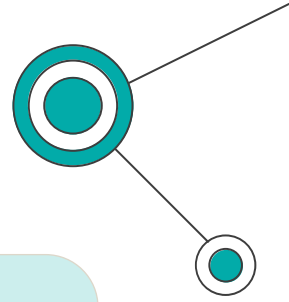
nW to μW ambient; more with a dedicated transmitter.





Solution #2

Efficient Algorithms

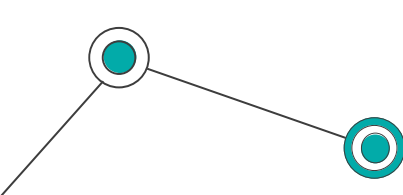


ON THE NODE

- **Adaptive duty cycling:** sleeping by default and waking up when needed.
- **Edge processing:** do not send what is not needed, aggregation, Tiny ML models.
- **Energy-aware scheduling:** tasks run according to stored energy, and checkpointing lets computation survive power loss.

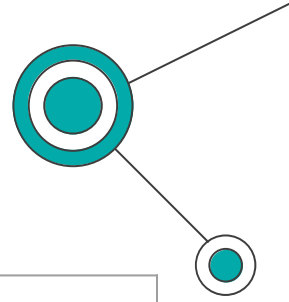
IN THE SYSTEM

- **Predictive control:** forecasts of occupancy, weather and load drive HVAC and lighting ahead of time instead of reacting late.
- **Anomaly detection:** it catches waste such as equipment left running, drifting setpoints or failing motors.
- **Load shifting:** flexible loads move to hours when energy is cheaper or greener.



Solution #3

Lightweight Communication



Technology	Range	Best for
LoRaWAN / NB-IoT	km	Grid, outdoor, remote assets
BLE / Zigbee / Thread	tens of m	Buildings, mesh networks
EnOcean	tens of m	Batteryless switches and sensors

Transmit Less

Event-driven reporting, aggregation and compression.

Listen Smarter

Wake-up receivers, low-power listening, scheduled access (TSCH) and adaptive data rate.

Backscatter

The node reflects existing RF signals instead of generating its own, so it can transmit at μW levels.

Use Cases for Automation

SMART BUILDING

Batteryless switches and light-powered occupancy and CO₂ sensors drive demand-based HVAC and lighting.

No energy spent on empty rooms

SMART GRID

Self-powered sensors on lines, transformers and substations harvest from the current they monitor.

Fault detection and load balancing, no wiring

INDUSTRY 4.0

Vibration- and heat-powered sensors on motors, pumps and pipes feed predictive maintenance.

Fewer failures, less idle consumption

Conclusions

HARVEST

Harvesting removes the battery bottleneck: maintenance-free, ultra-long-life sensor networks.

COMPUTE

Efficient algorithms save energy twice: in the node and in the system it controls.

COMMUNICATE

Lightweight communication tames the radio, the most energy-hungry part of the node.

Co-design harvesting, computation and communication around one energy budget.

Thank you!