

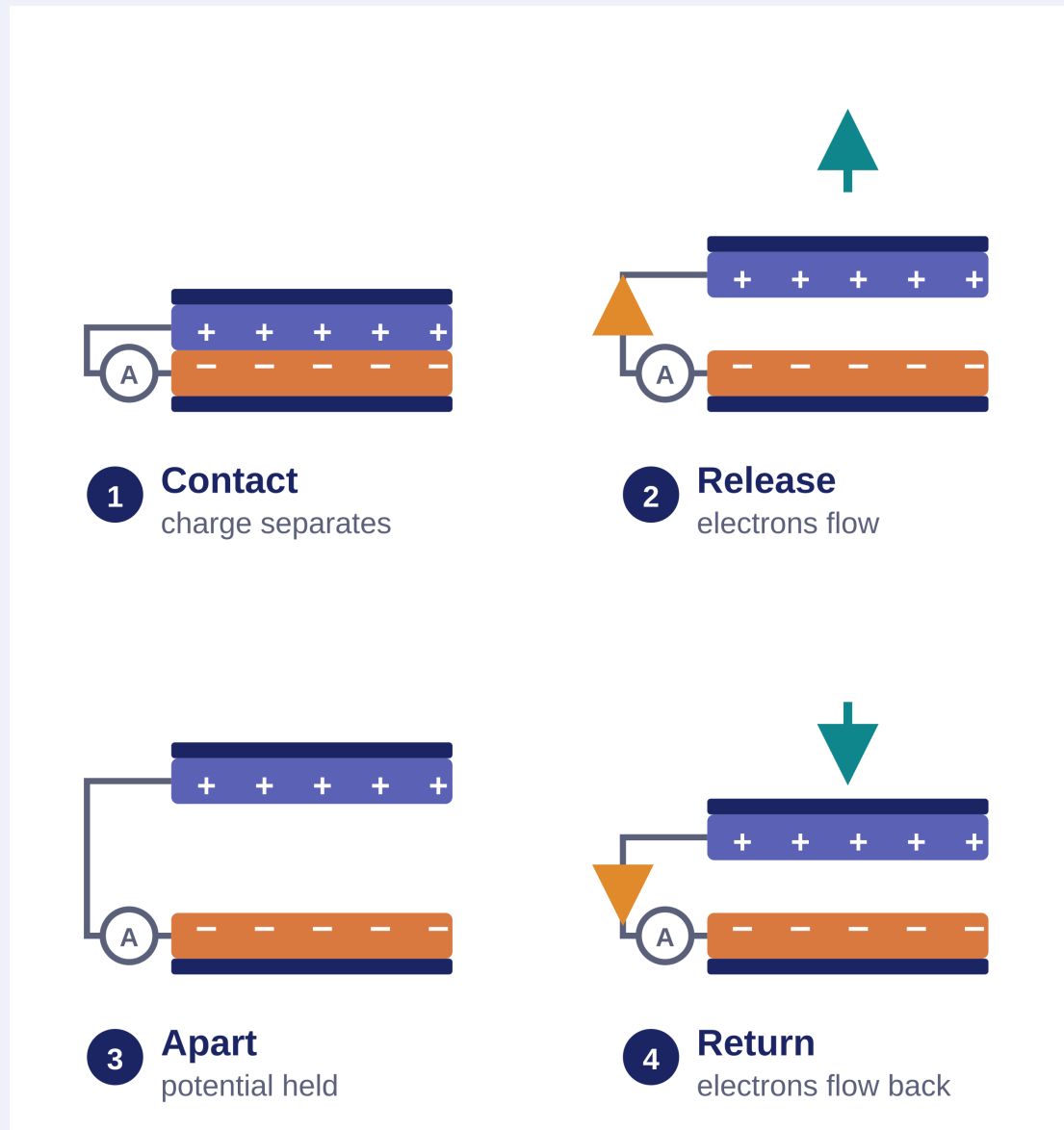
A Vibration-Powered Module for Battery-Free Sensors

Triboelectric energy harvesting and supercapacitor storage — for sensors that cannot be wired or re-batteried

1 The Problem

- Sensing is cheap. Powering the sensor is not.
- Wires mean conduit, cable runs, and labor at every point.
- Batteries mean replacement across thousands of nodes, many unreachable.
- A dead node is a blind spot — and more copper and e-waste.

2 Operating Principle: TENG



Two dissimilar materials touch and separate under vibration. Charge transfers at the interface, the electrodes swing potential, and current flows once per cycle.

Motion is the only input — no light, no heat, no fuel.

3 Module Architecture

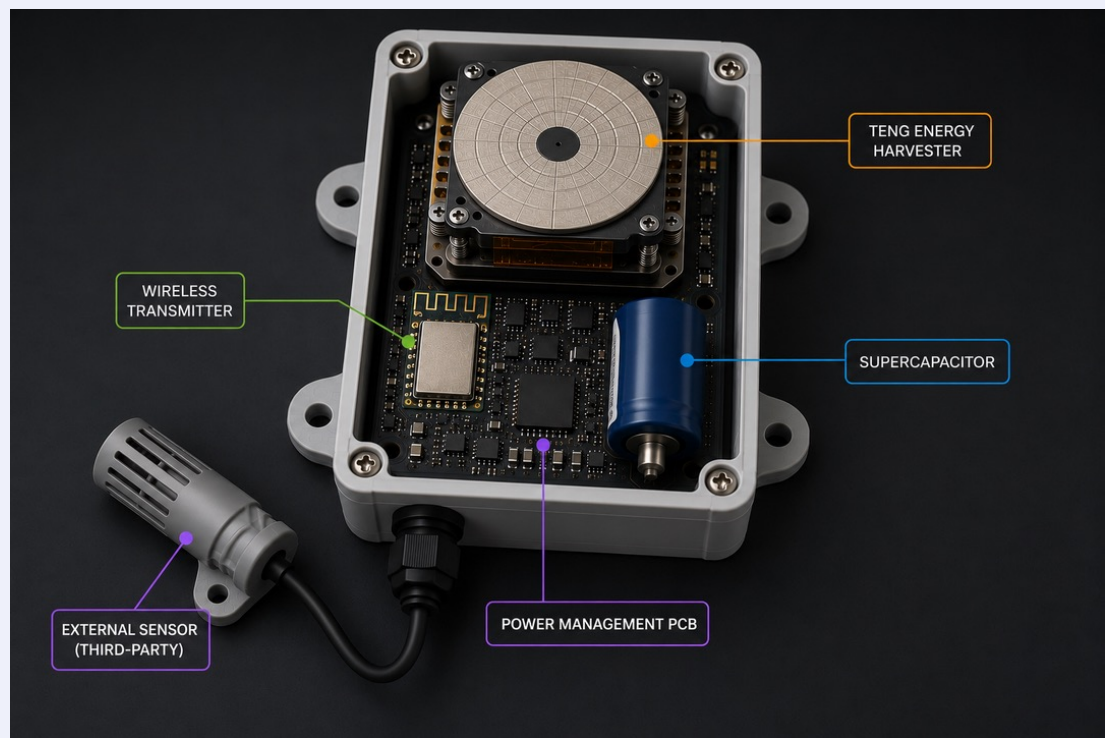
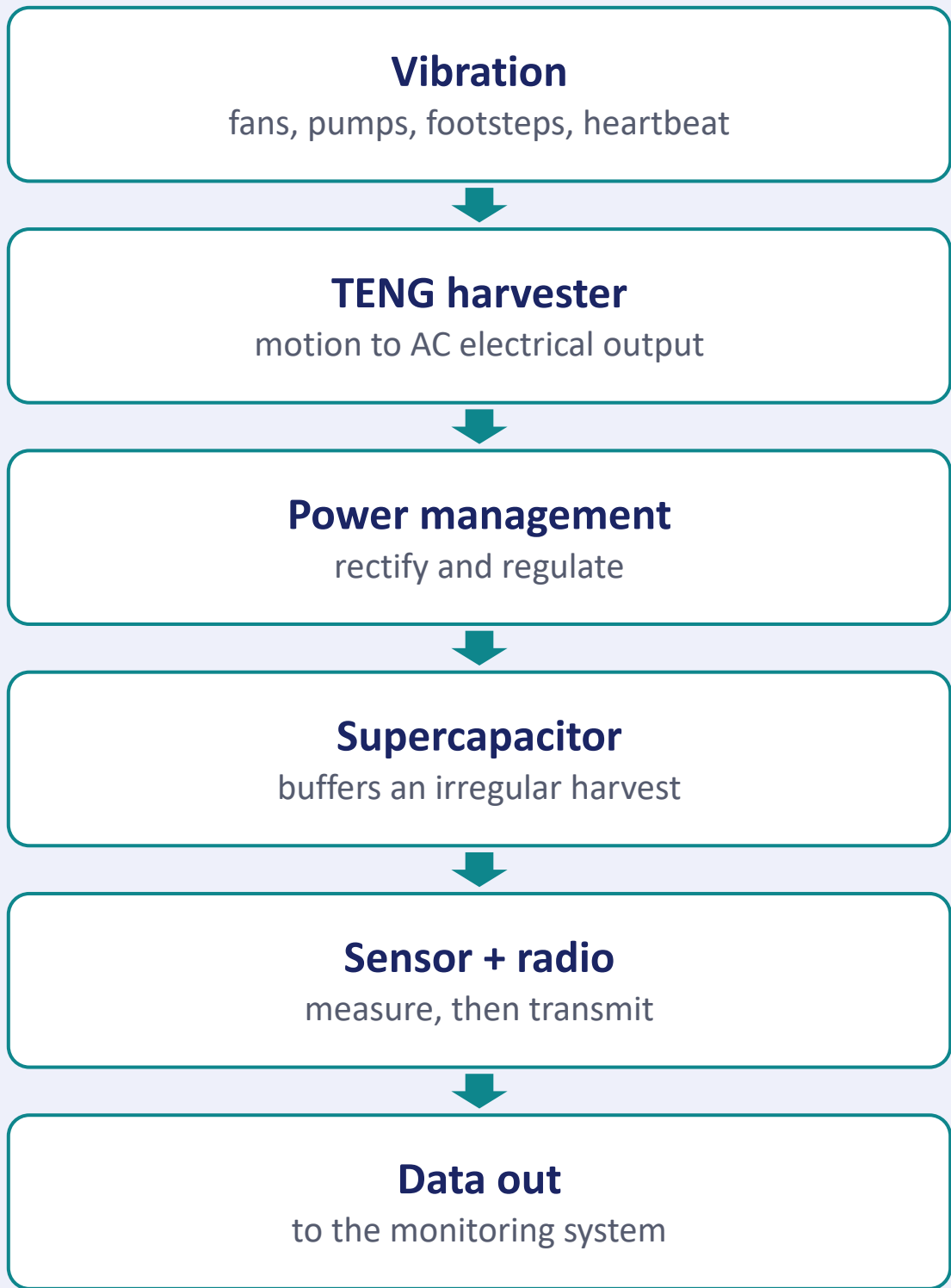


Figure 1. Harvester, power electronics, storage, and radio in one sealed enclosure. The sensing element is external, so the module pairs with sensors already in use.

4 Energy Path



5 Why a Supercapacitor

	Supercapacitor	Battery
Stores charge	electrostatically	chemically
Charge time	seconds	hours
Cycle life	millions	thousands
Maintenance	none planned	scheduled swaps

Harvested energy arrives in small, irregular pulses. Sized for roughly 48 hours, so the node rides through quiet periods.

6 Impact at Data-Center Scale

Avoided	Per 1 MW	Per 300 MW
Wiring	1 km	300 km
Copper	~12 kg	~3.6 t
Disposable batteries	100	30,000

No cable and no cell removes the extraction, offcuts, and recurring e-waste from a deployment.

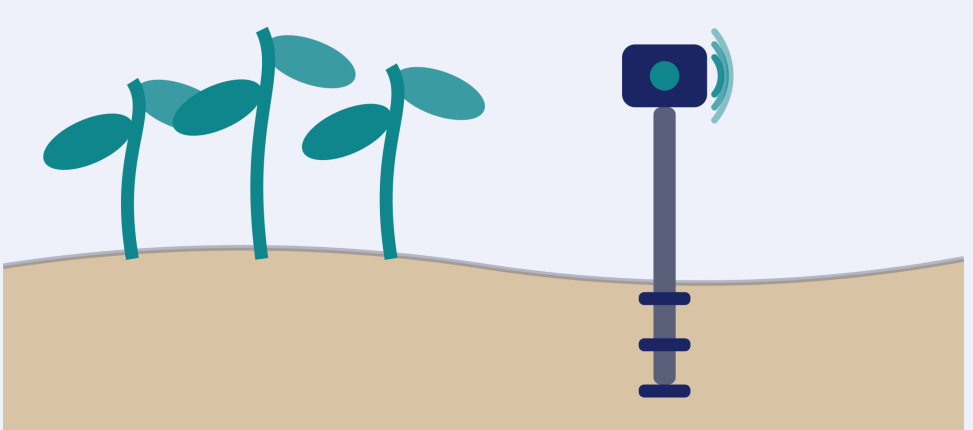
7 Applications

Any sensor mounted on something that moves can power itself.



Data centers

Fan and pump vibration, thousands of nodes per site.



Agricultural sensing

Field probes far from any outlet; pumps and wind supply the motion.



Implantable devices

Heartbeat and breathing as the power source. Research stage.

8 About the Researcher



Jason Liu

- Johns Creek High School
- 10th grade, age 15
- Competitive golf player

Acknowledgments:

