Plant-e
Spark of nature

POWERSTICK BY PLANT-E

PLANTPOWER & REMOTE SENSING

European Innovation Council

PowerStick by Plant-e

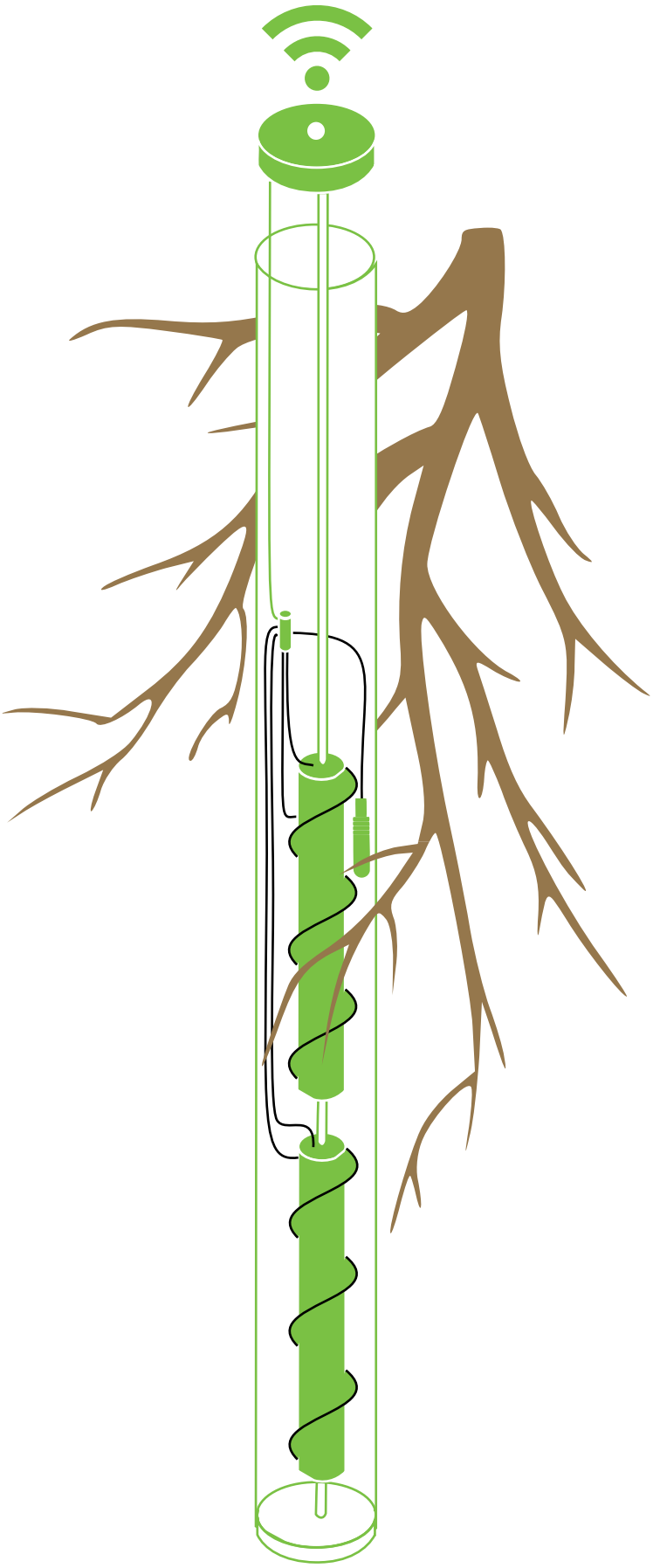
The PowerStick is a low-power and year-long source of electricity. It harvests natural energy from plant-soil-microbial interactions, charging up a storage element.

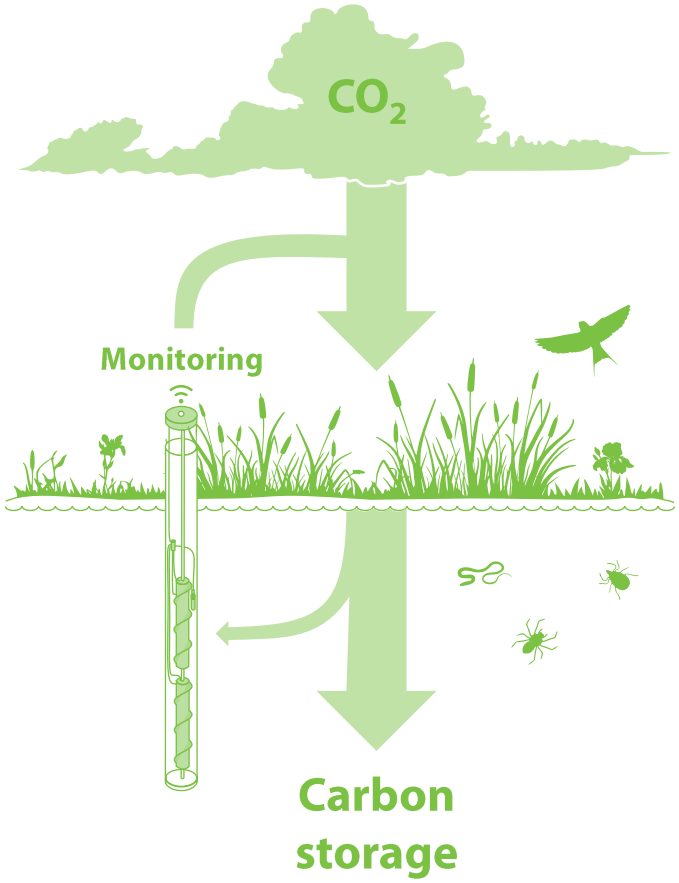
Wireless sensors can be powered indefinitely by the PowerStick and outlast conventional photovoltaic- and alkaline battery-powered solutions. The PowerStick increases the reliability and reduces the cost, maintenance and environmental footprint of remote sensing projects.

The PowerStick is an innovative power source that harvests energy from microorganisms that decompose organic matter released by plant roots

Based on the Plant-Microbial Fuel Cell (P-MFC) technology, the PowerStick relies on natural electrochemically active bacteria (EAB) that thrive in wetlands, to generate electricity.

After quick and easy installation in waterlogged soil, the PowerStick is able to connect to a diverse portfolio of low-power IoT sensor types (soil moisture, temperature, pH, *etc.*), providing electricity for sustained operation.





Wetlands are the most potent land-based carbon sinks in the world and highly productive ecosystems, providing wildlife habitat, flood control, and many more benefits

To ensure their health, it is important to monitor wetlands with remote environmental wireless sensors. With the global count of IoT devices already in the billions, it is important to be mindful of the environmental impact of batteries used.

P-MFCs are a unique solution for powering remote wireless sensors in wetlands by harmlessly harvesting energy from the environment. They offer an alternative to traditional battery-powered applications, thereby reducing the environmental impact of wetland monitoring.

Design

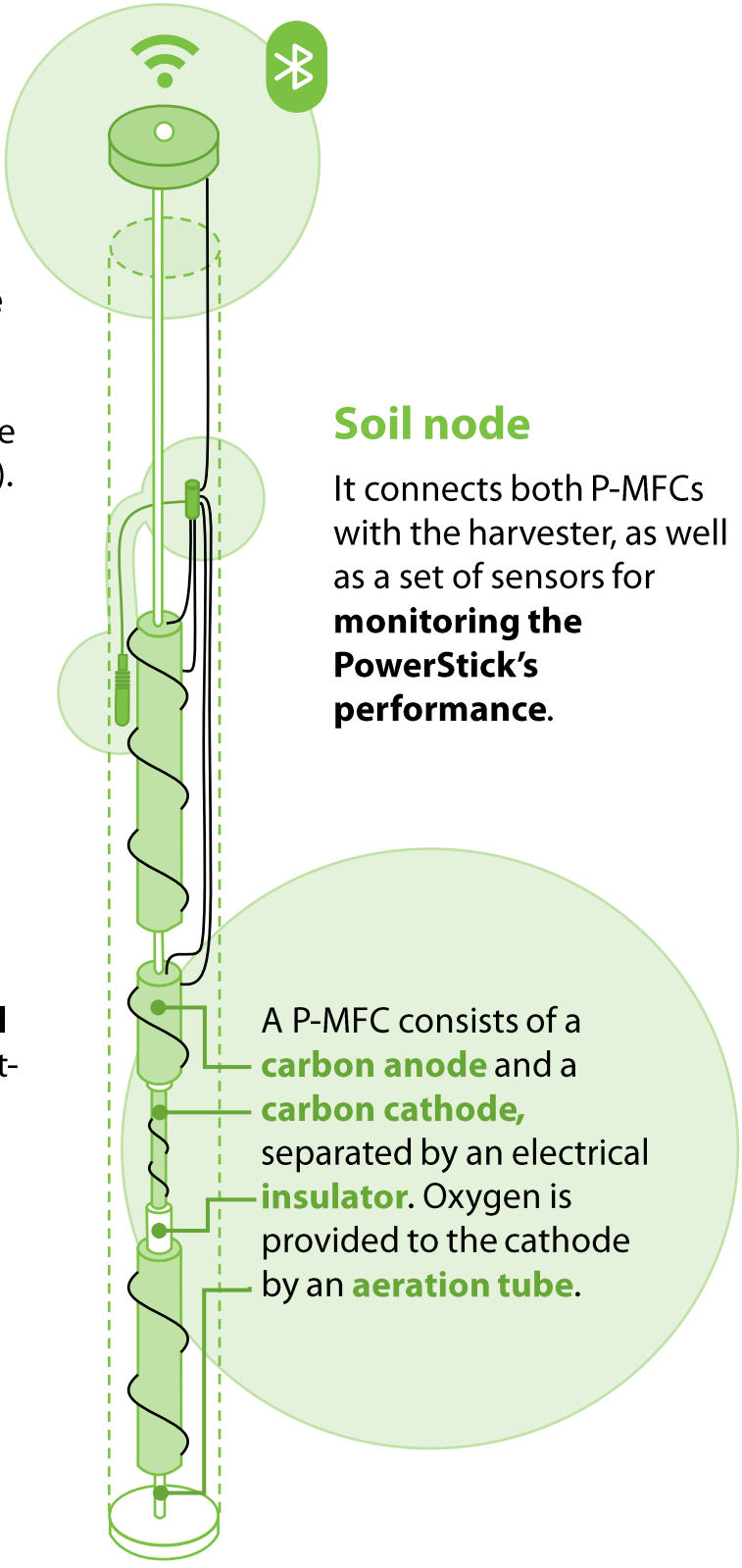
The PowerStick is designed with three key elements in mind: sustainability, practicality, and durability.

Continuous effort is made to ensure it is constructed from sustainably sourced, inert and long-lived raw materials.

The "all-in one" stick design allows for quick and easy installation of the PowerStick in wetlands using an earth auger drill

Energy harvester

The harvester enclosure contains the core of the PowerStick's electronics. It **harvests electricity from the P-MFCs** in the soil and connects the PowerStick to a low-power IoT sensor of choice (water level, temperature, *etc.*).



Soil node

It connects both P-MFCs with the harvester, as well as a set of sensors for **monitoring the PowerStick's performance**.

P-MFCs

The **Plant-Microbial Fuel Cell** (P-MFC) is the essence of Plant-e's technology. It is capable of **generating electricity from microbes** in the soil that feed on organic matter released by **plants**. Each PowerStick contains a pair of P-MFCs for robustness.

A P-MFC consists of a **carbon anode** and a **carbon cathode,** separated by an electrical **insulator**. Oxygen is provided to the cathode by an **aeration tube**.

Plants to Power

Plant-Microbial Fuel Cells (P-MFCs) generate electricity from naturally-occuring microorganisms in the soil. These microorganisms thrive in wetlands and eat small organics deposited by plants in the soil.

#1 Rhizodeposits

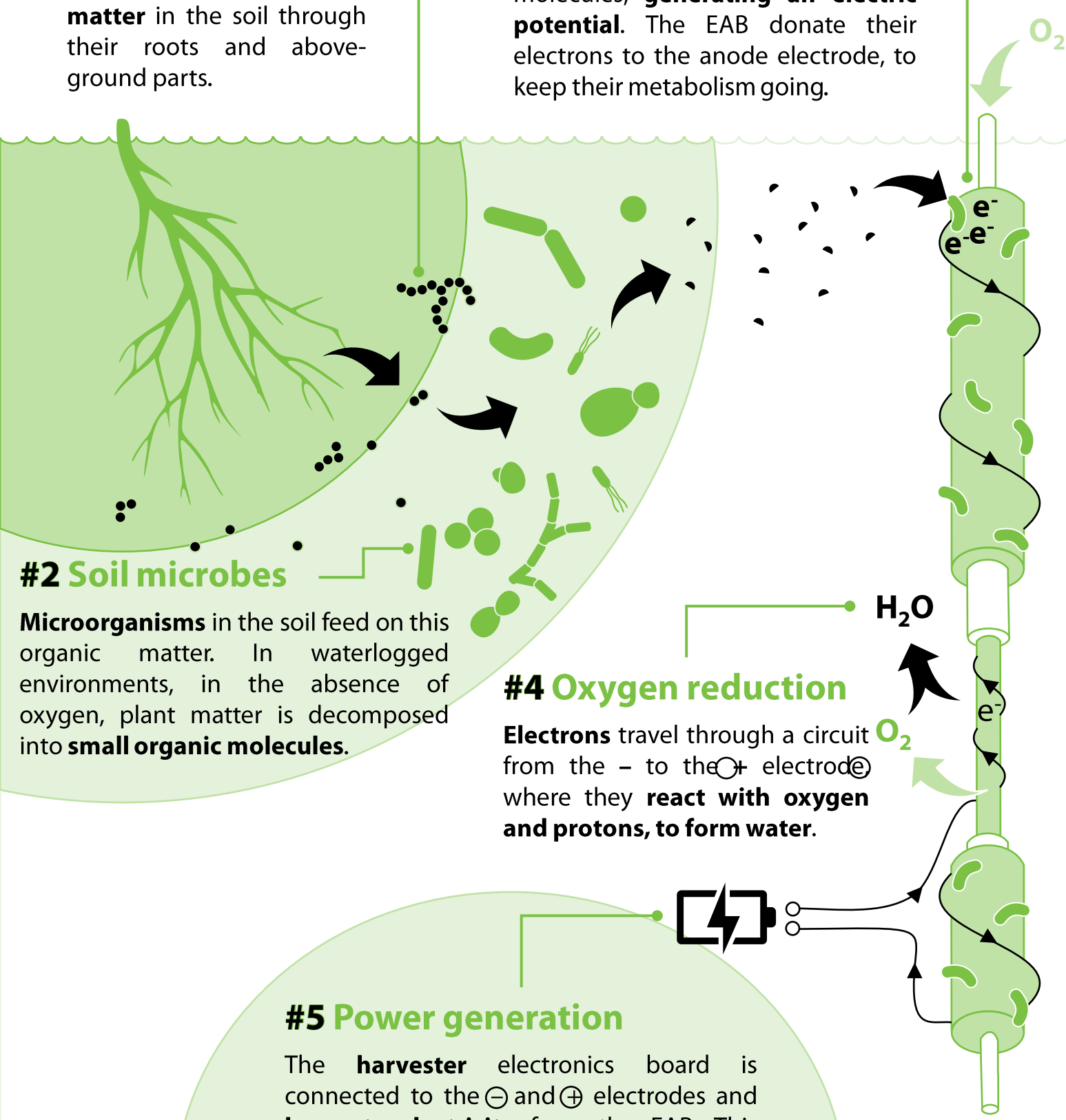
Plants release organic matter in the soil through their roots and above-ground parts.

#2 Soil microbes

Microorganisms in the soil feed on this organic matter. In waterlogged environments, in the absence of oxygen, plant matter is decomposed into **small organic molecules**.

#3 Electrogens

Electrochemically active bacteria (EAB) are microorganisms that thrive in the absence of oxygen. In wetlands, they degrade organic molecules, **generating an electric potential**. The EAB donate their electrons to the anode electrode, to keep their metabolism going.



#4 Oxygen reduction

Electrons travel through a circuit from the – to the + electrode where they **react with oxygen and protons, to form water**.

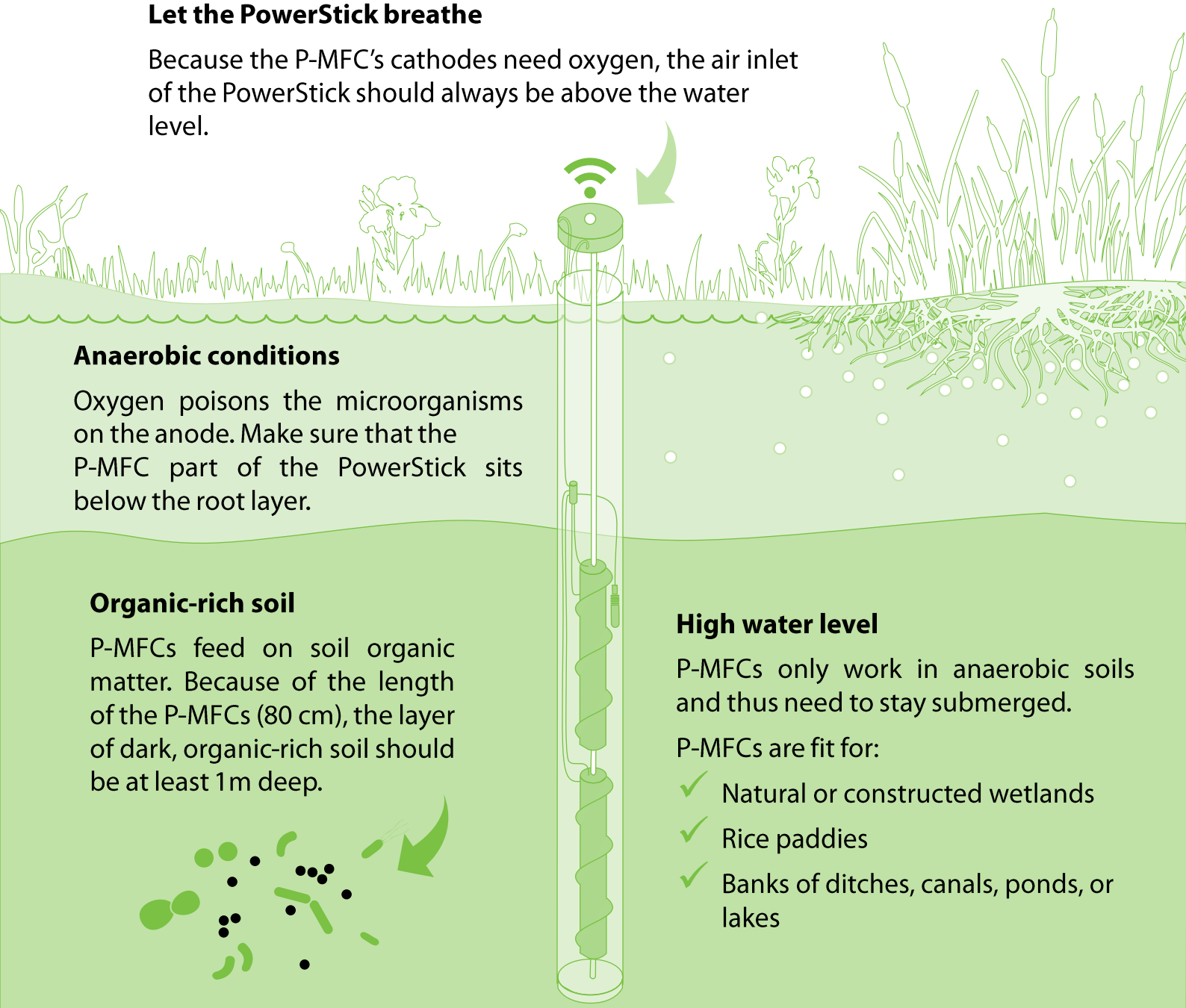
#5 Power generation

The **harvester** electronics board is connected to the ⊖ and ⊕ electrodes and **harvests electricity** from the EAB. This electricity is stored in a storage element and used to power an IoT sensor.

Choosing the right environment for the PowerStick

Let the PowerStick breathe

Because the P-MFC's cathodes need oxygen, the air inlet of the PowerStick should always be above the water level.



Anaerobic conditions

Oxygen poisons the microorganisms on the anode. Make sure that the P-MFC part of the PowerStick sits below the root layer.

Organic-rich soil

P-MFCs feed on soil organic matter. Because of the length of the P-MFCs (80 cm), the layer of dark, organic-rich soil should be at least 1m deep.

High water level

P-MFCs only work in anaerobic soils and thus need to stay submerged.

P-MFCs are fit for:

- ✓ Natural or constructed wetlands
- ✓ Rice paddies
- ✓ Banks of ditches, canals, ponds, or lakes

Favorable temperatures

Below 7°C the microbial activity in the soil is very low. Thankfully, in temperate regions, most soils stay above this temperature in winter.

Spec sheet

An overview of the material and electric features of Plant-e's PowerStick.

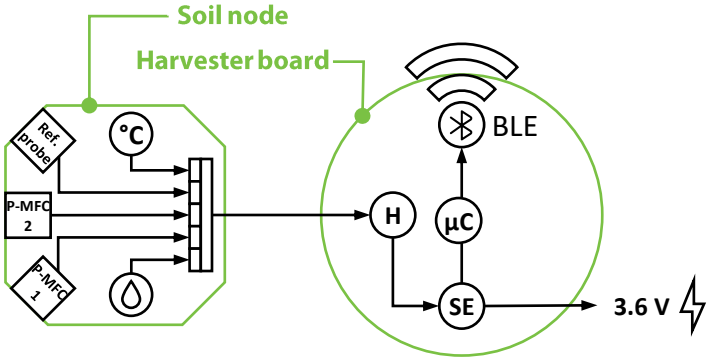
The electronic parts of the PowerStick are divided over the Harvester board and a Soil node

The soil node connects the two P-MFCs, a soil thermometer (°C), and a water/conductivity sensor (◯).

The harvester board contains :

- An energy harvesting circuit (H)
- A storage element (SE)
- A microcontroller (µC)
- A power outlet (3.6V)
- An I2C and UART output connection for changing settings and reading soil- and P-MFC-monitoring data.
- A bluetooth connection (BLE) for a mobile phone app interface.

PowerStick Electrical Specifications	
Output	
Voltage *(direct from storage element or regulated)*	3.6 V
Power outlet type	Screw terminal
Data connection type *(output of soil sensors, battery status and P-MFC performance)*	I2C / UART / BLE
Storage element	
(Rechargeable battery or supercapacitor)	
Typical nominal voltage	3.6 V
Average energy harvested into battery	1-10 $mAh.day^{-1}$
Storage capacity	1-100 F (Li) supercap. 2000-4000 mAh (bat.)
Mobile app for P-MFC status	
Harvesting voltage settings *(changeable via app)*	400 mV (winter) 500 mV (summer)
Data available	• Battery status • Power of P-MFCs • Drought detector • Soil temperature



Installation

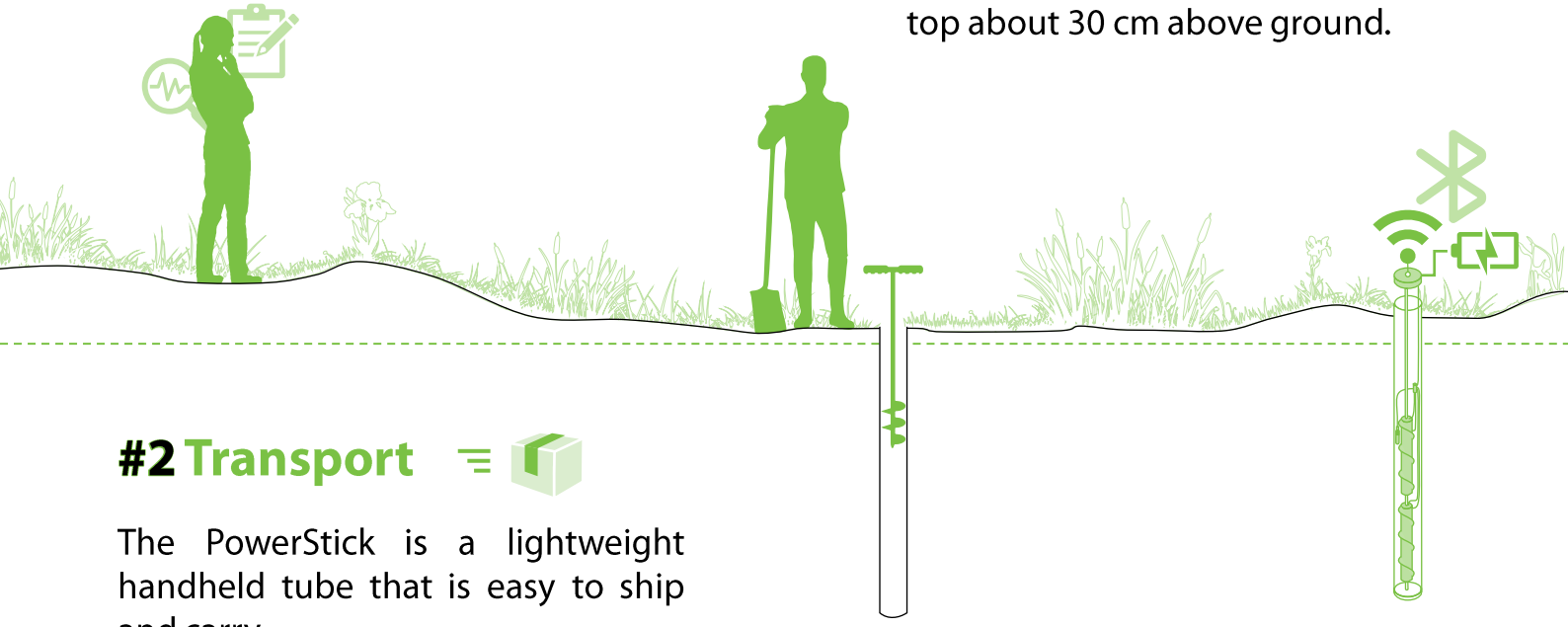
The PowerStick's "all-in one tube" design allows for quick and easy installation in wetlands using an earth auger drill. The booting and monitoring can be done via a wireless Bluetooth connection.

#1 Wetland assessment

The conditions of the chosen site are essential for P-MFCs to function properly. The main requirements are:

- ✓ High and stable water level year-round
- ✓ High organic content in the soil

See also Choosing the right environment for the PowerStick.



#2 Transport

The PowerStick is a lightweight handheld tube that is easy to ship and carry.

#3 Installation

Drill a hole at the chosen location and insert the PowerStick with the top about 30 cm above ground.

#4 Startup and operation

Connect your low-power IoT sensor of choice to the power outlet of the PowerStick. Performance of the PowerStick and soil conditions can be monitored via a bluetooth connection on your mobile phone from up to 100 m away.

The Plant-e app will allow for setting up, monitoring and debugging of a PowerStick via Bluetooth

The data tab displays the battery status, P-MFC power data, and soil conditions (the presence of water and temperature).

The settings tab allows the user to set the voltage level to optimize the energy harvesting and update device firmware.

Example projects

The Plant-e system has proven to be not only very durable, but also very reliable.

Waterboard de Dommel

Plant-e carried out a successful validation program of its PowerStick technology on the Dommel river for over a year in cooperation with Dutch semiconductor manufacturer NXP and Waterboard De Dommel.

Launched in May 2022, the field test consists of 78 PowerSticks over three locations in the North Brabant region, sending hourly water level measurements every day.

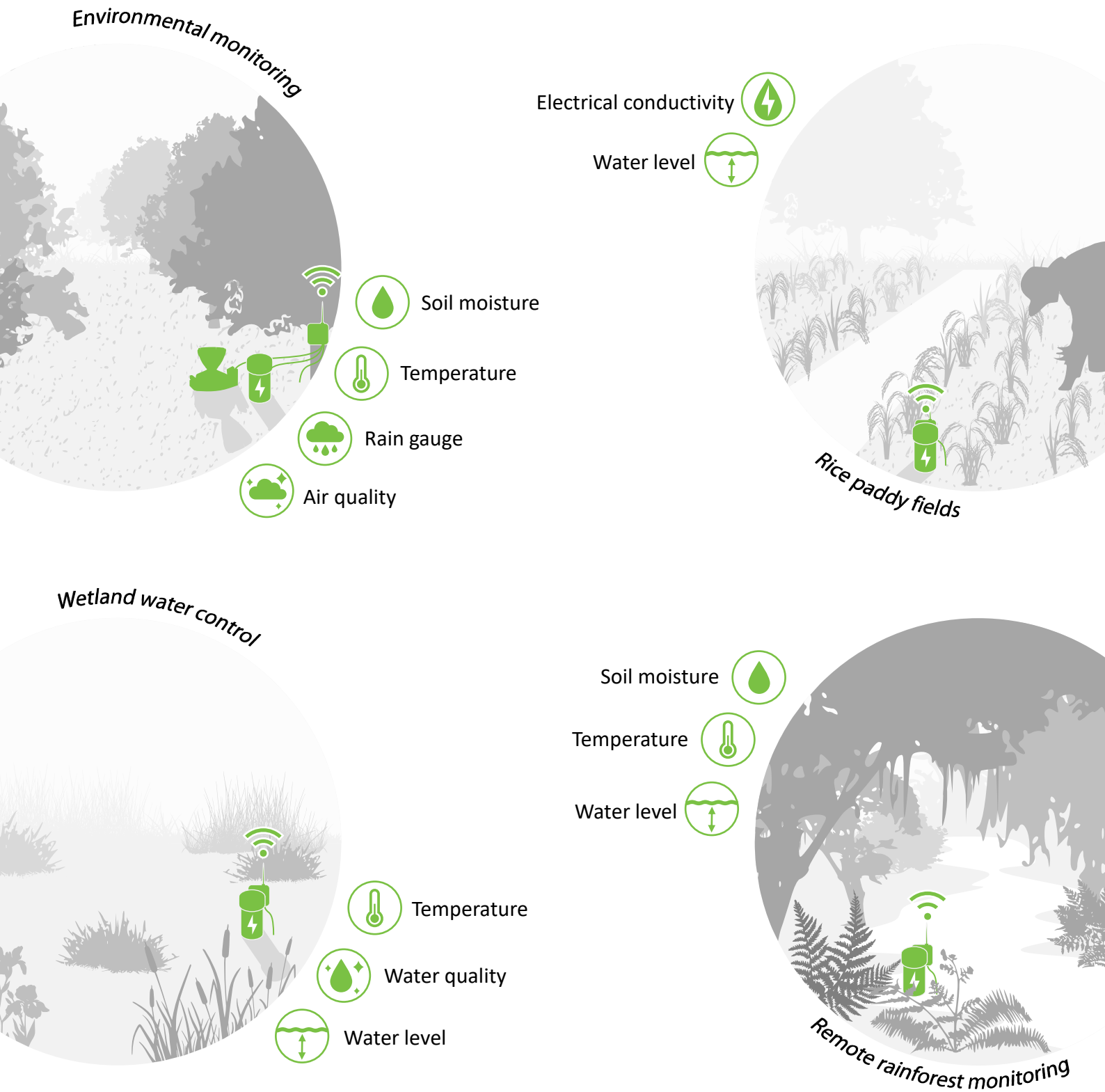
See more projects

Plant-e
Spark of nature

Waterschap De Dommel

NXP

Collaborations with IoT hardware development companies SODAQ and IRNAS led us to test numerous sensors for several use-cases



Get in touch

sales@plant-e.com

office@plant-e.com

Plant-e
Spark of nature

- ✓ Sensor data available via the cloud
- ✓ Plant-powered
- ✓ No maintenance required