OXHY

Whitepaper

CLEAN ENERGY FROM INFRARED RADIATION

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SUMMARY

1. Introduction

1.1 Global Context

The world is facing unprecedented **energy challenges**, driven by a growing demand for energy, the urgency to reduce harmful emissions, and the need to ensure a reliable and sustainable energy supply. The transition toward renewable energy sources has opened up new opportunities, but significant barriers remain, such as the intermittency of conventional sources (for example, solar and wind), the high cost of infrastructure, and the environmental impact tied to the production and disposal of traditional power systems like batteries.

In this context, the pursuit of efficiency, sustainability, and **energy resilience** is central to the global transformation. Technologies that improve energy efficiency, minimize environmental footprints, and promote energy autonomy are key to addressing these challenges and shaping the future of energy.

Energy Harvesting—the ability to recover and utilize energy from the surrounding environment (light, vibrations, radio frequencies, and thermal gradients)—is emerging as a strategic and versatile class of applications. Energy Harvesting technologies enable electronic devices, sensors, and industrial systems to operate without or with reduced use of traditional batteries, offering a revolutionary perspective for both the consumer and industrial sectors.

Moreover, Energy Harvesting plays a crucial role in the digital and industrial transformation. In the **Digital Transformation**, the growing use of IoT (Internet of Things), home automation, and smart devices has created a demand for innovative, sustainable, and autonomous power solutions. From an industrial viewpoint, the ability to extract energy from remote or hard-to-reach environments enables once-impossible applications, improving operational efficiency and reducing maintenance costs.

Oxhycell technology, with its ability to generate power continuously from infrared radiation and operate in environmental conditions where other sources are not usable, meets these needs. Not only does it help address global energy challenges, but it also fits perfectly into the Energy Harvesting and Microelectronics technology ecosystem, opening up new possibilities for a more sustainable and interconnected society.

1.2 The Energy Challenge and Energy Harvesting

According to the **International Energy Agency** (IEA), renewable energy technologies will transform the global energy mix by 2027, becoming the primary source of electricity. In particular, they are set to become the largest source of global electricity generation at the beginning of 2025, surpassing coal. The **share of renewables** in the energy mix is expected to increase by 10 percentage points during the forecast period, reaching **38% in 2027**. It is worth noting that renewables are the only source of electricity generation whose share is projected to grow, while the shares of coal, natural gas, nuclear, and oil are declining. Electricity generated by wind and photovoltaic (PV) systems will more than double over the next five years, providing almost 20% of global electricity generation by 2027 [1].

Despite the positive trend in renewables, there are certain **issues** that will negatively affect current energy supply systems in the coming decades. Beyond the well-known **scarcity** problem primarily affecting non-renewable sources, one of the greatest challenges is their **availability**. “Availability” refers to the time during which a resource can actually be used in the context of the operations of the equipment intended to exploit it (for example, a power plant or a microcontroller). Some resources are limited and cannot be regenerated on a historical timescale (such as oil, natural gas, coal, or uranium), while others are renewable, like wind, sun, and ocean waves. Some of these latter resources are also ubiquitous, though to varying degrees.

The energy mix of our modern societies heavily relies on wind and photovoltaic systems. Unfortunately, although they are almost ubiquitous, wind and solar power are also limited because their availability depends on specific **environmental conditions**. For instance, wind systems only operate when there is wind, and solar systems cannot operate in the absence of sunlight, such as at night or on very cloudy days. This forces energy technology suppliers and power grid companies to invest heavily in expensive storage systems, primarily based on electrochemical batteries.

Similar issues can be found in **Energy Harvesting** systems that rely on other low-intensity energy sources. Current energy harvesting technologies are in fact limited to specific sources such as intense electromagnetic fields, thermal gradients, or mechanical vibrations, which, in a form that can be exploited, are not always available everywhere. Despite their remarkable features, today’s energy harvesting devices generally provide a very limited amount of energy suitable for low-power electronics, mainly because they rely on **limited or hard-to-exploit energy sources** and lack the capacity to generate significant amounts of electric current over time. This restricts their scalability and potential for application beyond the microelectronics field.

These facts present critical challenges for both the renewable energy and Energy Harvesting industries, such as the need to address the **structural mismatch** between energy production and peak energy demand in various application areas. For this reason, the ability to produce energy continuously throughout the day for a longer period of time, thereby enabling more efficient fulfillment of peak energy demands, could revolutionize both the Energy Harvesting industry and the renewables sector.

1.3 Oxhy's Vision and Mission

Oxhy aspires to become a global benchmark in sustainable technological innovation, redefining how energy is generated and used across various areas of human activity. Our ambition is to lead a **paradigm shift** in the energy sector by providing solutions that are not only efficient and accessible but also contribute to a more sustainable future for our planet. Oxhy envisions a world in which energy constraints are overcome while continuously and reliably powering devices, systems, and infrastructures in an environmentally friendly way.

From this vision naturally follows our mission: to provide **sustainable energy solutions** to address some of the most urgent challenges of our time. With **Oxhycell** technology, we aim to transform invisible energy, such as that in the infrared range, into a tangible and usable resource. We want to offer our partners and customers scalable, versatile, and innovative solutions capable of improving the **energy efficiency** of a wide range of applications and reducing reliance on traditional sources that are harmful to the environment.

We are committed to bridging technology and sustainability, bringing innovation to key sectors such as IoT, microelectronics, home automation, lighting, and industry, with the goal of generating value for our customers, investors, and society as a whole. Through a **collaborative** and **transparent** approach, we aim to create a lasting impact, contributing to a more efficient and sustainable global energy ecosystem.

2. The New Science of Water

Before delving into the specifics of Oxhy's technology, it is useful to provide some background on the research that is helping us gain an increasingly refined scientific understanding of **water**, the most abundant molecule on our planet.

2.1 Recent Developments and Relevant Publications

There is a relevant line of research at the intersection of Physics, Chemistry, Biology, and Engineering that aims at better understanding and explaining the physicochemical properties of water. It is interesting to note what Philip Ball, one of the most renowned science communicators of our time, former editor of *Nature*, and author of the book "H2O: A Biography of Water," has to say on the subject: "*In reality, no one has yet managed to understand water. It is embarrassing to admit, but the substance that covers two-thirds of the planet remains a mystery. The worst part is that the more we investigate, the more problems arise: new techniques capable of studying the molecular architecture of liquid water in greater depth are bringing to light more and more enigmas.*" This observation coincides with the fact that water exhibits a series of anomalies that cannot be easily explained by classical physicochemical models of water. It's worth noting that Franks published seven volumes just to list and describe the known anomalies from 1972 to 1982!

In the attempt to investigate these phenomena, researchers from various fields have begun to deepen their understanding of water and have provided extremely relevant evidence that is consistent with the results obtained by our research group.

Some of the most influential researchers in this field include:

- **Gerald H. Pollack, University of Washington, USA**: Pollack is known for his studies on the exclusion zones (EZ) of water. He discovered that near hydrophilic surfaces, water forms a zone with structural and chemical properties different from bulk water. Among his many publications, it may be useful to consult "The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor," which summarizes the results of many years of research.
- **Rustum Roy: Pennsylvania State University, USA (deceased in 2010)**: Rustum Roy was a pioneer in studying the structural properties of water. He developed the concept of "structured water" and explored how water can assume different molecular configurations that affect its physical and chemical properties. Roy published numerous articles and books on materials science and water properties. He was a promoter of multidisciplinarity in the sciences, advocating that understanding water requires an integrated approach. He investigated the interactions of water with various surfaces and materials, contributing to the understanding of phenomena such as quantum coherence and exclusion zones.

- **William A. Tiller: Stanford University, USA (Emeritus Professor, deceased in 2022)**: Tiller is best known for his theoretical and experimental research in the physics of solidification of many materials, including water, metals, semiconductors, and polymers. He investigated the relationships between the crystallization process and the resulting material structures and their physical properties. He wrote several books and articles on these topics.
- **Martin Chaplin: London South Bank University, UK**: Chaplin conducted detailed research on the structure of water and its anomalous properties. His publications and website are key resources for the scientific community interested in these topics. He has published numerous articles in scientific journals of chemistry and physics.
- **Vladimir Voeikov: Moscow State University, Russia**: Voeikov has studied oxidation processes in aqueous systems and the role of water in biological systems, supporting Pollack's exclusion zone theory and Del Giudice's studies. He has written various articles linking biology to the new physics of water.
- **Mae-Wan Ho: Institute of Science in Society, UK (deceased in 2016)**: Mae-Wan Ho was a biologist who explored the implications of water's unique properties in biological systems. She authored *"The Rainbow and the Worm: The Physics of Organisms."*
- **Zhong Lin Wang: Georgia Institute of Technology, USA**: Wang worked on piezoelectricity and the triboelectric effect in nanostructured materials, also exploring water interactions in these systems. He has published hundreds of scientific articles in applied physics and nanotechnology.
- **Elmar C. Fuchs: Wetsus, European Centre of Excellence for Sustainable Water Technology, Netherlands**: Fuchs is known for his studies on "charged water" and research on coherent water states. He conducted experiments demonstrating unusual phenomena in water, such as the generation of electric currents and the formation of stable water structures under certain conditions. Fuchs has published several articles in scientific journals on water properties and its interactions with electric and magnetic fields.
- **Emilio Del Giudice: National Institute of Nuclear Physics, Italy (deceased in 2014)**: Del Giudice worked on coherent water theory, proposing that water can exist in quantum coherent states. He collaborated with Giuliano Preparata and Giuseppe Vitiello, developing theoretical models to explain water's unique properties, including the oxhydroelectric effect. He authored many publications, some of which are cited in the Bibliography.
- **Giuliano Preparata: University of Milan (deceased in 2000)**: Preparata was a theoretical physicist who collaborated with Del Giudice and Giuseppe Vitiello in developing coherent water theory. He wrote several scientific articles and books exploring the quantum implications of water.
- **Giuseppe Vitiello: University of Salerno, Italy (Honorary Professor)**: Vitiello worked on theoretical models explaining water's properties through quantum field

theory and quantum coherence. He collaborated with Emilio Del Giudice and Giuliano Preparata, developing a deeper understanding of exclusion zones and coherence domains in water within the context of Quantum Electrodynamics. Vitiello has published numerous articles in scientific journals and book chapters on quantum physics and its applications to biological systems and water. His work often explores the implications of quantum coherence in living systems. He co-authored the foundational article on the oxhydroelectric effect and is an advisor to OXHY Srl.

- **Vittorio Elia: University of Naples Federico II, Italy**: Elia has conducted numerous experimental studies on the anomalous properties of water treated with purely physical methods. His works explore how physical processes of liquid perturbation influence the physical properties of water, particularly its heat capacity and electrical conductivity. He, together with Roberto Germano, discovered the oxhydroelectric effect. Elia has published numerous articles in scientific journals regarding the thermodynamic and physicochemical properties of water after specific physical treatments. His work is known for its strictly experimental approach and for discussing the implications of such properties for chemistry and biology.
- **Roberto Germano: Oxhy Srl, Italy**: Roberto Germano, co-founder of Oxhy, is one of the discoverers of the oxhydroelectric effect, which demonstrates the generation of electric current in pure water exposed to infrared radiation. He has published numerous articles in peer-reviewed physics and chemistry journals, as well as some books[1], and holds patents related to these technologies.

2.2 Current Research Trends

In recent years, research streams have emerged that explore the possibility of generating electrical currents from the infrared range or using semiconductive systems with an appropriate band gap. Alternatively, from another perspective, there is a growing interest in extracting electrical currents from evaporating aqueous systems. These two directions of research are opening new avenues in renewable energy production and energy cell technologies.

2.2.1 Infrared Range Photovoltaics

On one hand, research focuses on the development of photovoltaic cells with a band gap that includes infrared radiation. One example of such research is the use of indium antimonide, a semiconductor material that allows the absorption of infrared radiation. Additionally, the use of appropriately designed nanometric systems is gaining attention. Researchers at the Idaho National Laboratory, in collaboration with Lightwave Power Inc. of Cambridge, MA, and Patrick Pinhero from the University of Missouri, have developed a

[1] R. Germano, "AQUA. L'acqua elettromagnetica e le sue mirabolanti avventure", Bibliopolis, Napoli, 2007.

method for producing plastic sheets containing billions of nanoantennas. These nanoantennas are designed to capture energy in the infrared range, converting it into electrical energy with greater efficiency.

2.2.2 Hydrovoltaic Effect

On the other hand, some researchers are exploring the "hydrovoltaic effect." This phenomenon is based on the generation of electrical current in evaporating aqueous systems. A recent study conducted by Zheng C., Chu W., Fang S., Tan J., Wang X., and Guo W., published in *Interdisciplinary Materials* in 2022, discusses materials for hydrovoltaic technology driven by evaporation. In their interpretation, the effect is considered predominantly electrostatic, resulting from the potential differences created during the water evaporation process. There are various other relevant publications exploring this research direction.

2.2.3 OXHY's innovation

However, so far, only OXHY has considered, from the perspective of **quantum electrodynamics**, that liquid water can be assimilated to a semiconductive system. This assimilation is made possible by the extensive reservoir of quasi-free electrons formed by the coherence domains of liquid water. This innovative concept opens new possibilities for using water as a medium for generating electrical current, exploiting the interaction of infrared radiation with the **coherence domains** of water. OXHY's ability to recognize and leverage these unique properties of water represents a significant step forward compared to current research trends. While most studies focus on conventional approaches, such as improving semiconductors or optimizing evaporation processes, OXHY proposes a new paradigm based on quantum electrodynamics. This innovation could lead to revolutionary developments in energy harvesting technologies and renewable energy generation.

3. Overview of the Technology

3.1 The Initial Technological Context

As previously mentioned, in recent years, the increasing demand for sustainable energy solutions and the heightened focus on energy efficiency have driven the research and development of innovative technologies for energy recovery and generation. In this context, **oxyhydroelectric technology** stands out as one of the most promising solutions for energy harvesting, offering an efficient method of converting thermal energy into usable electricity.

Oxhydroelectric technology is based on the principle of the **oxhydroelectric effect** (see [19]; https://en.wikipedia.org/wiki/Oxhydroelectric_effect), leveraging special water-based polymers which, when exposed to ambient infrared radiation, generate an electric current. This technology has the potential to revolutionize various industrial sectors, thanks to its ability to continuously produce energy.

3.1.1 Current Energy Harvesting Technologies

Energy Harvesting represents a critical frontier in the global energy landscape, as it aims to capture small amounts of energy dispersed in the environment and convert it into usable electrical power. Currently, the most common Energy Harvesting technologies include:

- **Light Energy Harvesting:** Uses solar cells to convert light into electricity.
- **Vibration Energy Harvesting:** Employs piezoelectric materials to generate electricity from mechanical vibrations.
- **Radio Frequency (RF) Energy Harvesting:** Converts radio waves into electrical power.
- **Thermal Energy Harvesting:** Exploits temperature gradients to generate electricity through thermoelectric materials or thermodynamic cycles.

In this context, Oxhy's technology stands out for its ability to harness ambient background infrared radiation, offering a versatile solution that can be potentially more efficient in specific application scenarios.

3.1.2 Uniqueness of Oxhy's Technology

Oxhydroelectric technology offers numerous advantages that make it unique and particularly appealing for a wide range of applications in today's Energy Harvesting landscape:

- **Energy Efficiency:** The ability to directly convert thermal energy into electricity reduces energy losses, improving the overall efficiency of the system.
- **Environmental Compatibility:** Using water, non-toxic hydrogels, and easily sourced materials makes this technology environmentally sustainable and suitable for various contexts without significant environmental impacts.
- **Application Versatility:** The technology can be integrated into different configurations, making it suitable for portable electronic devices, wireless sensors, implantable medical devices, and industrial monitoring systems.
- **Scalability:** The possibility of miniaturizing oxhydroelectric cells allows them to be adapted to various formats and sizes, facilitating integration into small devices or more complex modular systems.
- **Innovation and Competitiveness:** As an emerging technology, it offers new opportunities for product innovation and can provide a competitive advantage to companies that adopt it early.

3.2 Oxhycell Technology

In this section we provide a general overview on the Oxhycell Technology based on the Oxhydroelectric Effect which is explained in what follows.

3.2.1 Definition and Operating Principle

The Oxhydroelectric Effect derives from a series of studies in the context of Quantum Electrodynamics which have brought to light a new scientific view of liquid water. This is an emerging perspective that has its roots in recent studies of Solid State Physics and which suggests that liquid water may present an organization -at a microscopic level- that goes beyond its molecular structure. The scholars who have mainly contributed to the development of this new vision are *Gerald H. Pollack, Martin Chaplin, Rustum Roy, Vladimir Voeikov, Elmar Fuchs, Vittorio Elia, Emilio del Giudice, Giuliano Preparata and Giuseppe Vitiello*.

Traditionally, liquid water has been considered as a homogeneous and disordered substance at the microscopic level (monophasic structure). However, recent research has brought to light new clues that suggest the existence of a more ordered structure within liquid water (biphasic structure).

This biphasic structure is characterized by the fact that some parts of the water volume are disordered while others are ordered. These ordered parts have been variously called “Exclusion Zones” or “Coherence Domains”. In a certain sense, liquid water forms regions or groups of molecules that organize themselves in a coherent way, creating a sort of order at the level of molecular aggregates. These ordered regions, called "coherence domains", can have dimensions of a few nanometers and persist for relatively long periods of time.

The idea behind "coherence domains" - which have been studied through various experimental techniques, such as nuclear magnetic resonance spectroscopy and X-ray diffraction - is that liquid water can present a dynamic structure in which molecules organize themselves into groups, maintaining a certain coherence between them. This organization at the microscopic level turns out to influence the macroscopic properties of water and its behavior, including how it reacts to external influences such as electric fields or radiation.

This new perspective on liquid water opens new perspectives on understanding water itself and its physical properties. This view challenges the traditional conception of water as a simple disordered liquid, suggesting that a more complex and organized underlying structure may exist. Future research on this topic could contribute to a deeper understanding of water and its crucial role in a wide range of physical and biological phenomena.

3.2.2 The Physics of the Oxhydroelectric Effect

Every physical system, according to quantum mechanics, tends towards a "**ground state**" of minimum energy. This energy, proportional to the various oscillation frequencies of the electromagnetic field that permeates physical space, is called "zero point energy". However, contrary to what classical physics predicted, even at the absolute zero temperature, this energy is not zero at all, indeed, since the modes of oscillation of the electromagnetic field are infinite, the energy of the so-called "Quantum Vacuum" is practically infinite.

This simple concept lies at the basis of the extensive developments of QED, and in particular of **Coherent QED**, which represent a real scientific revolution underway; in fact, while its application to particle physics is now standard, only in recent years is it starting to be applied to Condensed Matter Physics.

Furthermore, another fundamental concept of Quantum Mechanics is the fact that a set of particles respects the so-called **uncertainty principle**, that is, the principle which, in one of its forms, states that the more determined the number of particles is, the less determined is the "phase". Phase is one of the well-known typical characteristics of waves.

There are two extreme cases:

- if the number of the set of particles is perfectly defined, then the phase is totally indeterminate and this is called "incoherent state", as in the case of a gas;
- if the number of particles is very, very large, it happens that the uncertainty regarding their number grows very much; then the phase is perfectly defined (its value is known without any indeterminacy) and this is called a "coherent state".

In the second case, i.e. the one in which the phase is perfectly defined, we find ourselves faced with a real wave. A wave of matter. From these premises some relevant consequences arise for the world around us.

It is well known that the chemical-physical "**anomalies**" of the most common of substances, water, are far greater than the properties that can be explained with current models, so much so that those who have tried to deal with them have needed 7 volumes to describe them.

By applying the concepts of QED (Quantum Electrodynamics) to water, if we have a number of particles (atoms, molecules) with discrete energy levels (i.e., "quantum jumps")—meaning they exist under standard physical conditions (typical Earth temperatures, pressures, concentrations)—it becomes energetically favorable for **quantum fluctuations** to "resonate" with the oscillations of the electromagnetic field at the frequency corresponding to the energy jump. This means there is a direct relationship between energy and frequency.

"Quantum fluctuations" are "**energy oscillations**" arising from the fact that **zero-point energy** is not null. These oscillations last for a very short time because they are constrained by another "form" of the uncertainty principle: the shorter the duration of the fluctuation, the higher the energy it can possess. Therefore, if the time is very brief, the energy can be quite high.

Returning to the particles (atoms or molecules), if their number is large enough, a "**collective phenomenon**" occurs: they synchronize their energy transitions, doing so in unison with the electromagnetic field. This, in turn, increases the amplitude of the electromagnetic field, and so on. This leads to a true transition of the quantum vacuum's Ground State, from a condition where matter and field oscillate incoherently to a new Coherent Ground State of the quantum vacuum, where matter fully assumes a wave nature and both matter and field undergo large in-phase oscillations.

All of this is possible—it does not violate the **conservation of energy** principle—because the interaction energy is negative, and there is a well-defined threshold related to the total number of particles (sufficiently large), the density (sufficiently high), and the temperature (sufficiently low), making this transition energetically favorable, or spontaneous.

This mechanism describes—for the first time in the history of physics—the origin of the **vapor-liquid transition**! In the case of water, we are talking about a density factor 1600 times greater in the liquid compared to vapor, and this density increase not only happens spontaneously but even releases energy: "the latent heat of liquefaction."

Furthermore, since the energy "jumps" of atoms generally correspond to wavelengths on the order of 100 nanometers (i.e., 100 billionths of a meter), space naturally divides into many domains of comparable size, within which several tens of thousands of atoms can exist, and where the Electric and Magnetic Fields evolve in phase. Thus, a "temporal cadence" gives rise to a "spatial cadence," creating a domain structure known as **Coherence Domains** (CD).

Guided by this paradigm, we have identified a new experimental phenomenon that we have named the "**Oxhydroelectric Effect**" which confirms that this approach can lead to the discovery of entirely new experimental facts with potential technical and industrial applications based on very simple technologies.

3.2.3 Description of the Energy Conversion Mechanism

The first version of the Oxhydroelectric Effect that we described involves extracting an electric current from bi-distilled water using two identical platinum electrodes. This current is powered by simple ambient heat (Infrared - IR) and mediated by oxygen molecules, without any temperature differences, unlike the thermoelectric effect, for example. The following figures, diagrams, graphs, and schematics illustrate different versions of the system along with its operation in accordance with the observed physical principles.

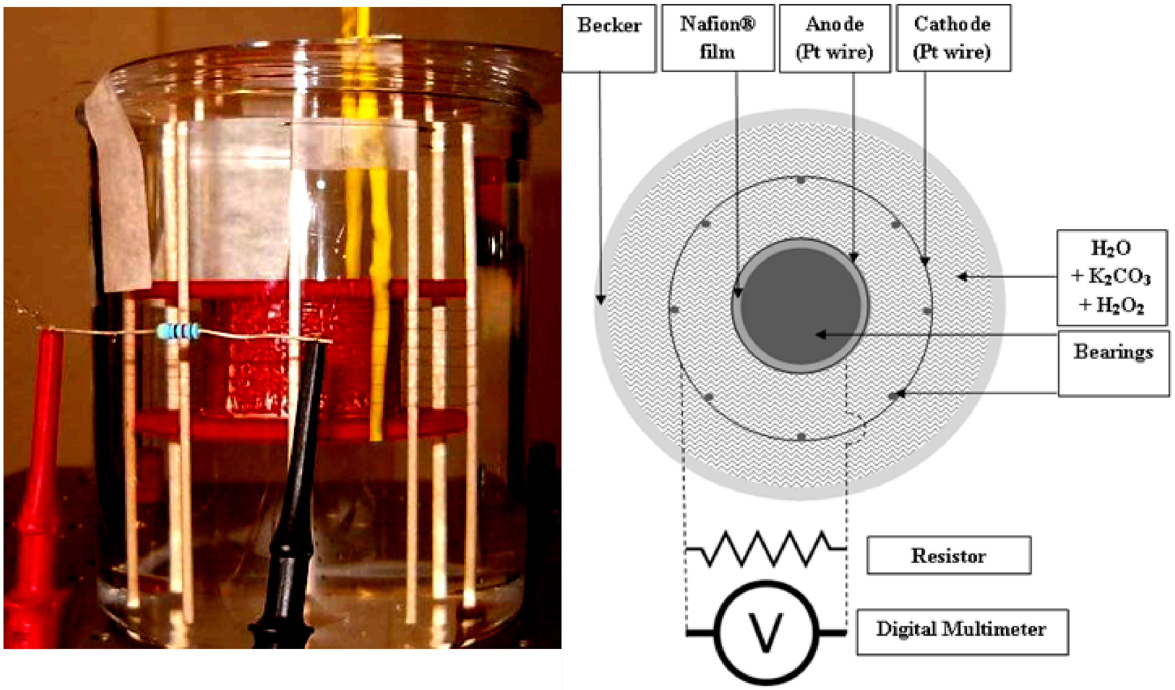


Fig. 1 – Photo and diagram of the first version of the experimental system with which we demonstrated the Oxhydroelectric Effect (in an electrolytic solution).

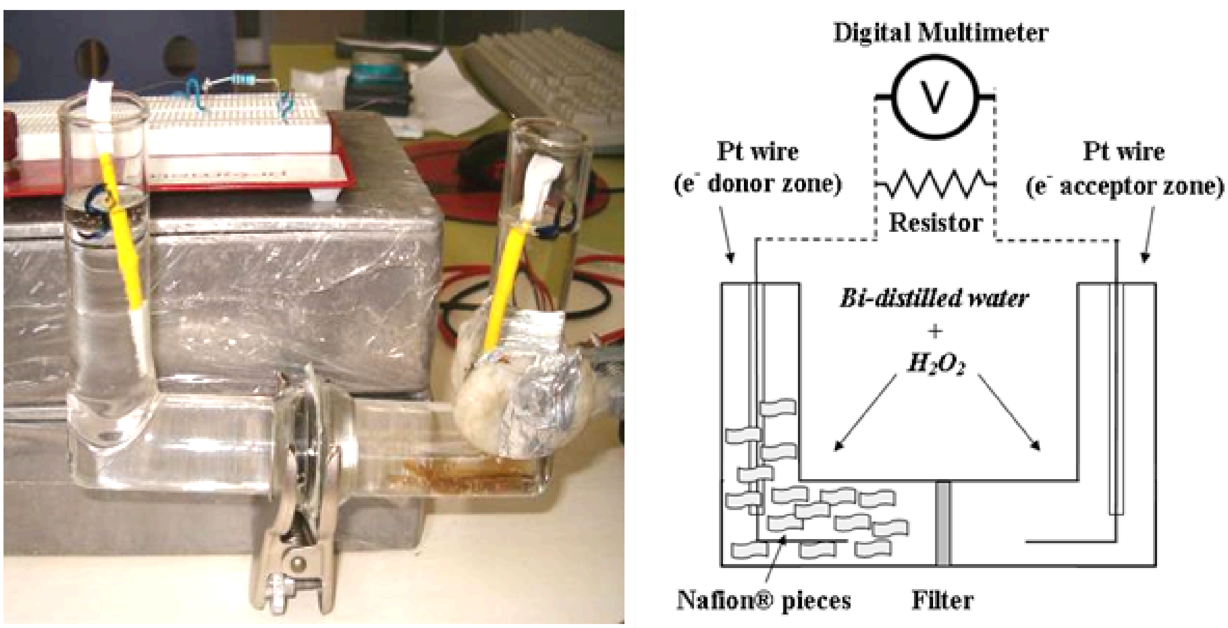


Fig. 2 – Photo and diagram of the subsequent version of the experimental system in which we demonstrated the Oxhydroelectric Effect in double-distilled water.

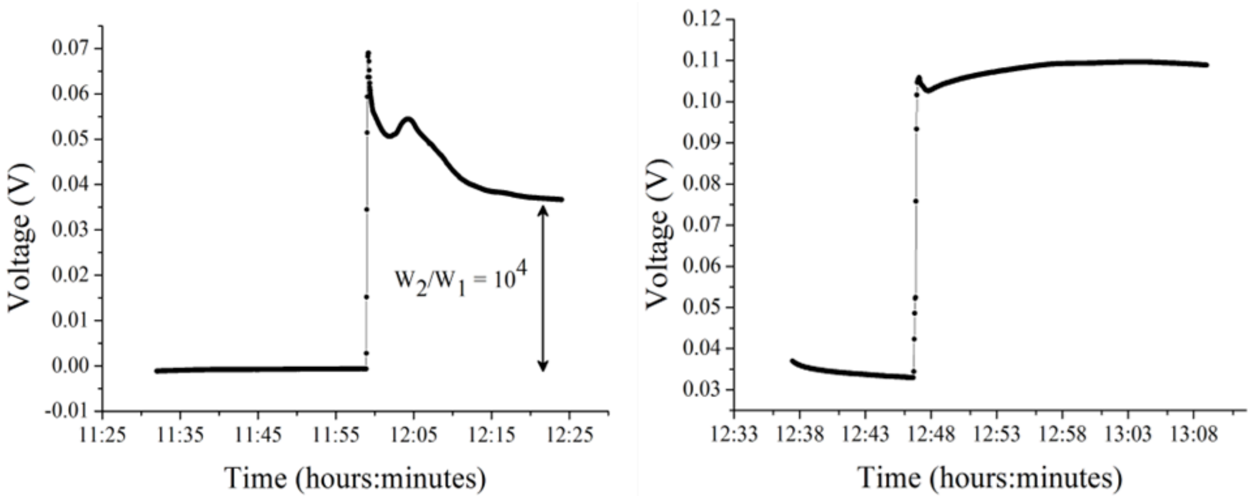
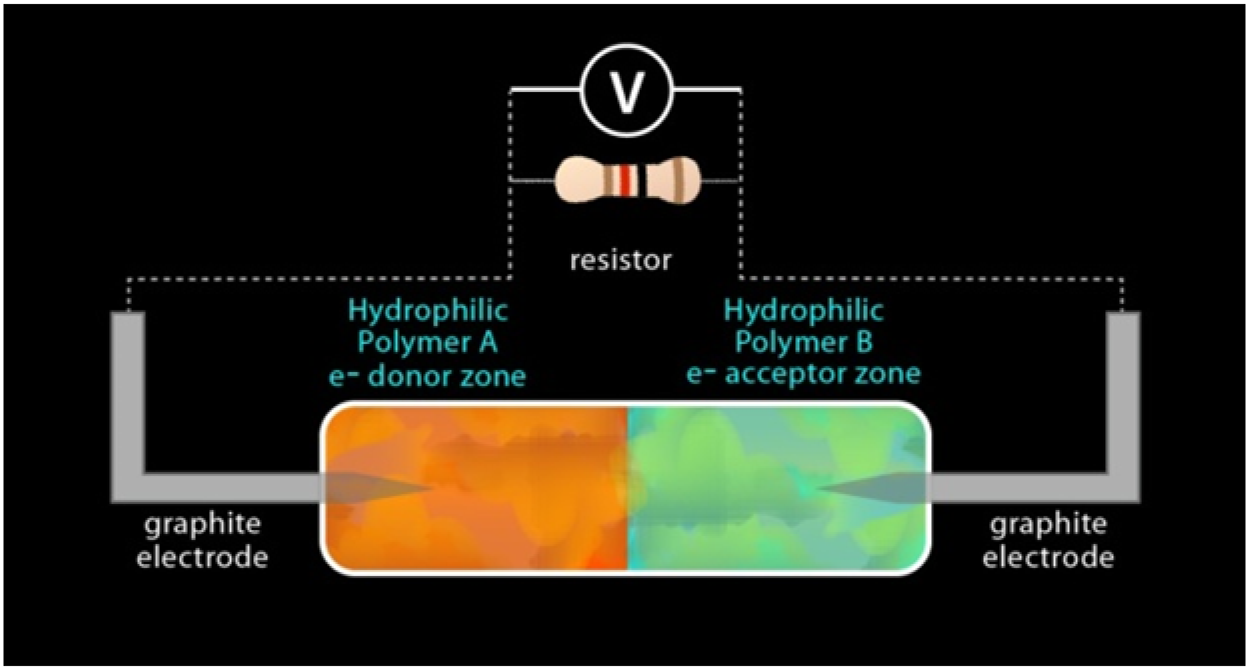


Fig. 3 - Typical graph of the voltage over time across the resistor, before and after the addition of H2O2. Fig 3(a): Note the jump from an electrical power of W1 = 2.6 picoW to a power plateau of W2 = 0.03 microW (W2/W1 ~ 10^4). Fig. 3(b): A subsequent addition of a similar amount of H2O2 to both half-cells generates another jump in extracted electrical power, reaching up to W3 = 0.2 microW, approximately 5 orders of magnitude higher compared to the initial value W1 (W3/W1 ~ 80,000).



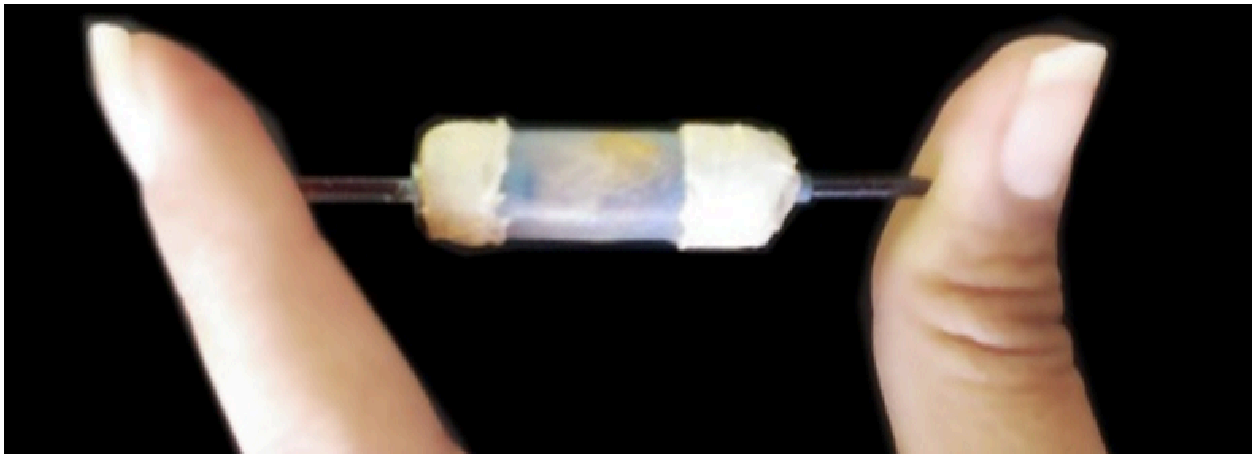


Fig. 4 – The miniaturized version uses a highly hydrophilic polymer, a more cost-effective material replacing NAFION®; it shows the extraction of electrical current for the entire (long) measurement period (limited only by the mechanical properties of the polymers); it uses low-cost electrodes (e.g., graphite); the micrometric filter is no longer necessary; it functions even without hydrogen peroxide; it is highly sensitive to infrared radiation.

It's important to note that **every object** at room temperature **emits infrared radiation**, according to the “black body” emission law. On Earth, we are constantly immersed—even at night—in a **bath of infrared radiation**.

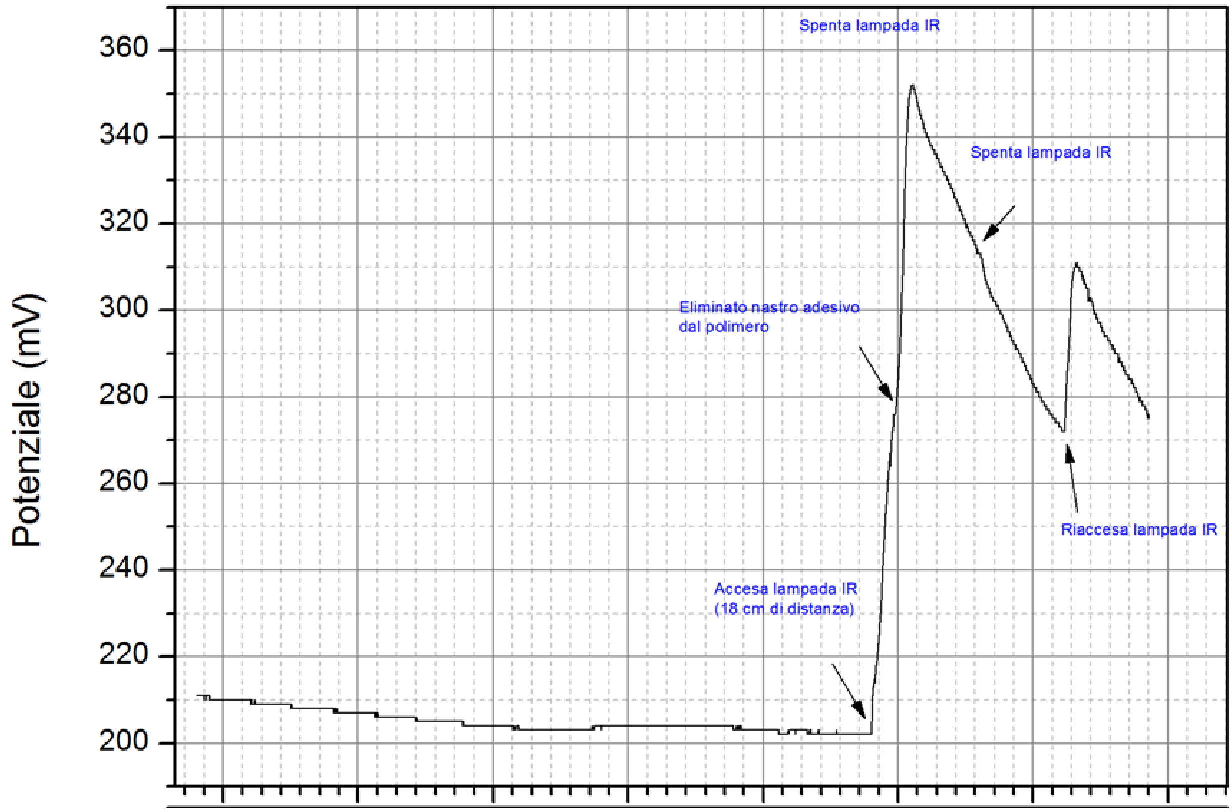


Fig. 5 – Example of response to the addition of infrared energy to the ambient energy: Turning on the IR lamp registers a jump from 0.85 microWatts extracted (IR lamp off) to 2.6 microWatts extracted (IR lamp on), which represents a **300% increase in extracted electrical power**. Note the relatively stable value of the extracted current in the first phase of the graph, where the system is exposed to ambient thermal radiation for about 13 hours, from 00:00 to about 13:00. (Note that the voltage graphed is measured across a 47 kΩ resistor).

It is also important to note that at room temperature, the extracted electrical power is already equal to 0.85 microwatts (≈ **1 microwatt**).

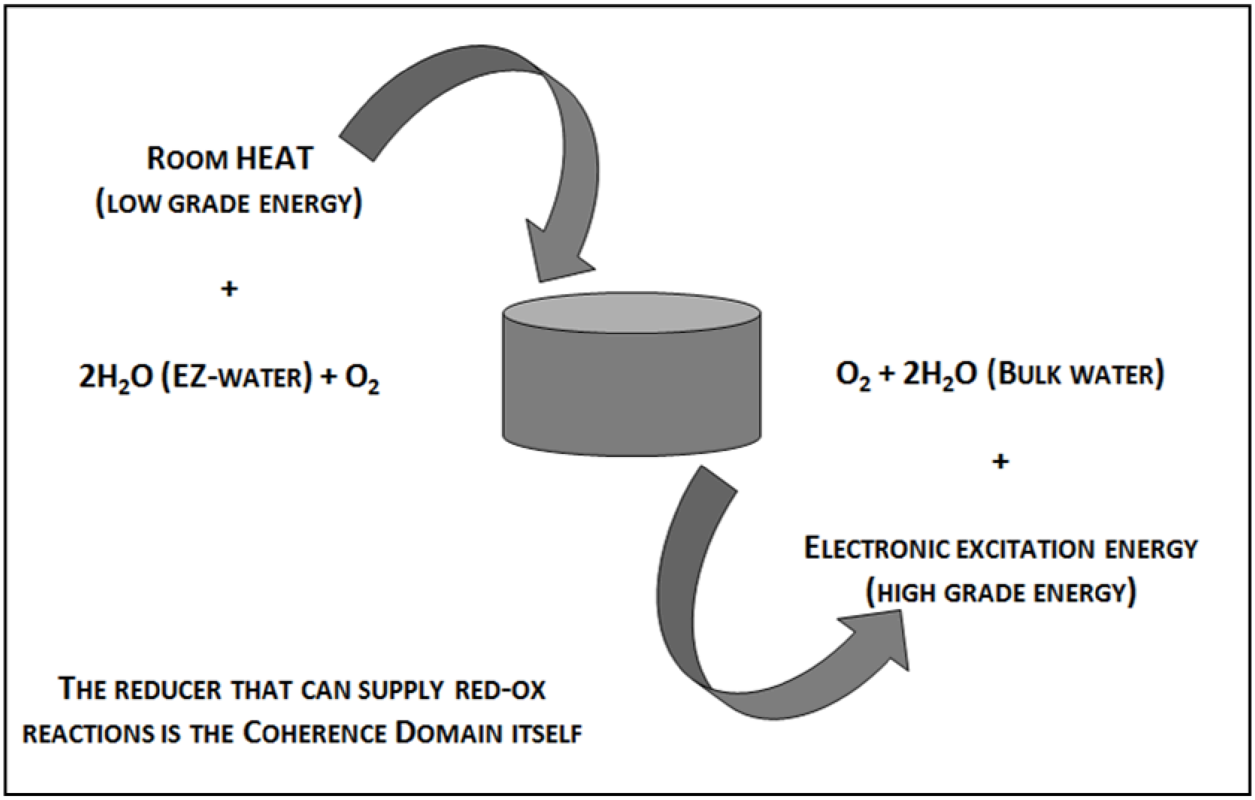


Fig. 6. Diagram of the operating principle of the cell.

The hydrophilic film generates a region of coherent water at the boundary between its surface and the water, thus creating a separation between "**more coherent water**" and "**less coherent water**"; the presence of O2 molecules in the electrolyte (ensured by the addition of H2O2) stimulates the excitation of quasi-free electrons from the water CDs, which would need to overcome an energy barrier of 0.44 eV, thereby making O2 molecules privileged receptors of electrons tunneling out of the CD. The schematic of the possible general mechanism at play for extracting electron current from water mediated by O2 molecules is as follows: (ambient heat, i.e., IR) + 2H2O (EZ water) + O2 → O2 + 2H2O (bulk water) + (electronic excitation). Likely “intermediaries” are $CO3^{-}$ carbonates. The "reductant," which allows the development of redox reactions, is the coherence domain of the water itself.

This dual system can perform **internal work** to sustain its non-equilibrium state due to the **negentropy** that arises from the spontaneous conversion from the incoherent state to the coherent state of liquid water (a quantum phenomenon, not thermodynamic), while the radiant energy of the environment (ambient heat, i.e., IR) returns the system to its initial state, and so on, like a "**microscopic engine**", similar in many ways to Maxwell's Demon in his famous Thought Experiment.

It is worth emphasizing once again that this is **not a thermodynamic phenomenon**, but a **quantum** one, just as the heat emitted by radioactive materials cannot be understood within the conceptual framework of thermodynamics.

The Oxhydroelectric Effect could pave the way for an entirely **new class** of **non-polluting** electrical **power generation systems** and chemical reactors that, by mimicking biological systems, could directly convert "low-quality" energy (ambient heat, i.e., infrared radiation) into "high-quality" energy (electricity, chemical energy) without the need for sophisticated micro-technologies or nanotechnologies. Paraphrasing Richard Feynman, we can say: "**There is plenty of room around here!**"

3.3 Development Stage

OXHY has achieved significant technological milestones that lay the groundwork for the future industrialization of Oxhycell technology. Current progress has focused on three main areas: **miniaturization**, **efficiency optimization**, and the development of **functional prototypes**.

3.3.1 Technology Readiness Level (TRL)

Technology Readiness Level (TRL) is a measurement scale used to assess the maturity of a particular technology. This scale ranges from TRL 1, which represents observed basic principles, to TRL 9, which indicates a system fully proven in a real operational environment.

Currently, the oxhydroelectric cell technology is transitioning between TRL 4 and TRL 5. Below is a detailed overview of the progress made so far in relation to the various TRL levels:

- **TRL 1 – Basic Principles Observed and Reported:** The initial observations of the oxhydroelectric effect, such as the anomalous behavior of pure water exposed to infrared radiation, established the basic principles on which this technology is based. These early studies provided the theoretical groundwork necessary for subsequent development.
- **TRL 2 – Technology Concept Formulation:** Based on these basic principles, the initial technology concepts were formulated. These include the idea of harnessing the oxhydroelectric effect to generate electric current without electrolytes, using highly hydrophilic materials like Nafion to create a physical asymmetry in water.
- **TRL 3 – Experimental Proof of Concept:** At this level, laboratory experiments demonstrated the feasibility of the technology concept. Independent, peer-reviewed studies confirmed the presence of the oxhydroelectric effect and the ability to

generate electric current from pure water under infrared exposure. These findings were published in scientific journals, further validating the concept.

- **TRL 4 – Validation of the Proto-Concept in a Laboratory Environment:** The technology was further developed and tested in a controlled laboratory environment. Preliminary prototypes of oxhydroelectric cells were built, and experiments were conducted to optimize materials and configurations. These tests allowed identification of the key parameters affecting the technology’s performance.
- **TRL 5 – Validation of the Proto-Concept in a Simulated Environment:** The technology is currently moving out of TRL 4 and beginning to enter TRL 5, where prototypes are tested in simulated environments that replicate real-world conditions. This phase involves verifying the performance of oxhydroelectric cells under realistic conditions, evaluating their ability to efficiently and steadily generate energy, as well as their capacity to power target electronic devices. Experiments at this level aim to identify and resolve any practical issues that may arise during actual use.

Next Steps toward TRL 6 and Beyond

To progress to TRL 6 and higher, it will be necessary to test the prototypes in real operational environments. This includes integrating oxhydroelectric cells into commercial devices—which we are beginning to do—and evaluating their performance in practical applications. Additionally, further studies will be needed to optimize the long-term durability and reliability of the technology.

In summary, oxhydroelectric cell technology has reached a promising level of technological maturity, with experimental results confirming its feasibility. However, further developments and testing are required to bring this technology to higher TRL levels and make it ready for widespread commercial adoption.

3.3.2 Prototypes and Demonstrators

In our journey, we have developed a targeted plan to create a series of prototypes and demonstrators aimed at testing and validating the advancement of TRL, addressing the needs of our target audience from the outset, and progressively increasing the **Business Readiness Level**.

The first prototype, following the initial experimental models, was a cell approximately 2 cm^3 in size (Fig. 4). To date, we have iteratively reduced the prototype size through two steps: the first achieved a 1 cm^3 cell, and the second, more recent step, produced a cell approximately **27 mm^3** in volume. The prototype casing is made from hydrophobic material. The identified technologies will allow us to reach the important milestone of a cubic millimeter per cell.

An additional step involved identifying a **prototyping process** to produce a wafer containing multiple **millimeter-scale cells**. This approach enables series connections of cells by directly linking the electrodes on a board.

The creation of **wafer modules** with multiple cells provides significant application flexibility and simplifies integration with the circuits of target electronic devices. Integration tests with commercial microcontrollers, sensors, and capacitors are already underway. Fig. 7 below showcases the intermediate prototypes mentioned.

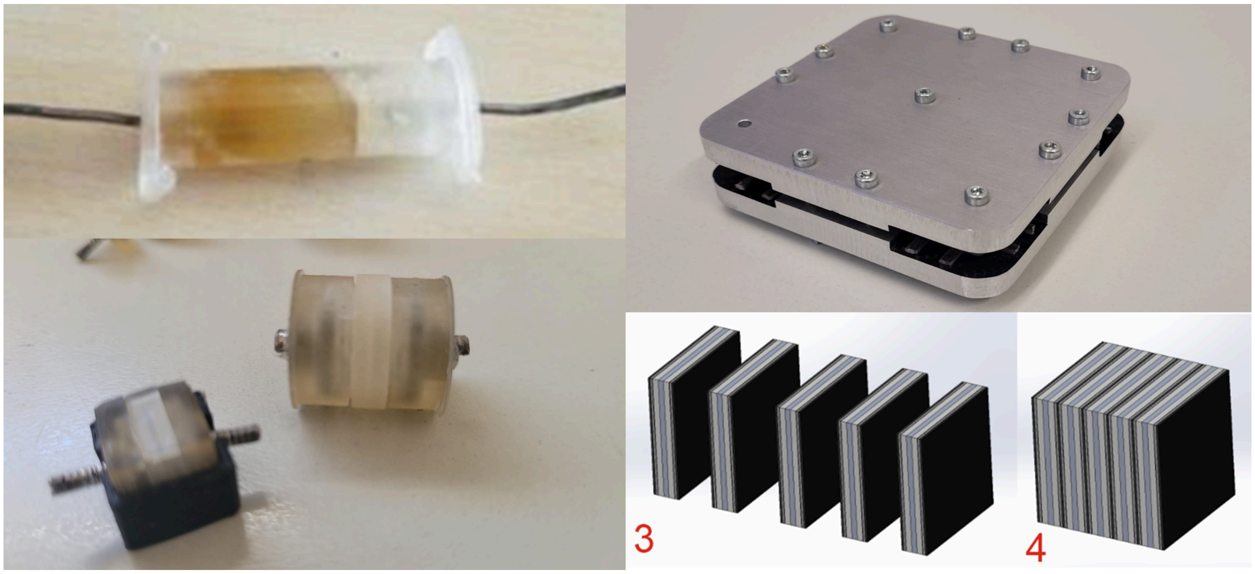


Fig.7. Oxhydroelectric cell prototypes: top left shows the initial 3.5 cm cell, below are iterations from 1 cm^3 to 27 mm^3, and on the right are wafer modules with multiple cells, each a few millimeters thick (currently under development).

Our development plan focuses on miniaturization, efficiency improvement, stability enhancement, and prototype development. Progress in these areas can be summarized as follows:

- **Miniaturization:** R&D efforts have led to the creation of oxhydroelectric cells with a current volume of only 20 mm^3. This achievement marks a decisive step toward integrating the technology into practical applications in both the consumer and industrial sectors. The ability to scale cell dimensions without compromising performance is key to expanding the target market.
- **Efficiency:** The latest iterations of Oxhycell design have shown significant improvements in energy production and long-term stability. The electric current generated by the cells has been optimized using innovative materials such as eco-sustainable polymers, ensuring high and durable performance. Additionally,

overcoming operational limits related to liquid evaporation has made the system more stable and reliable over time.

- **Prototype Development:** Oxhy is developing the first modular prototypes of the technology, including demonstrators for specific use cases. For example, a modular "Modular Set" prototype is being developed, featuring a power core capable of powering Ambient Light Sensors (ALS) and IoT devices, showcasing the technology's versatility. Another prototype under development integrates Oxhycell with low-temperature thermodynamic cycles for industrial energy recovery. Each prototype is designed to be scalable and easily integrable into larger configurations, addressing diverse application needs.
- **Test Results and Measured Performance:** Tests conducted on Oxhycell have confirmed steady electricity production over extended periods, generating stable currents in the microWatt range per cell. Additionally, the developed wafers (comprising 7x7 cell arrays) have demonstrated the ability to be assembled into multiple configurations, culminating in cubes of seven layers, each containing 49 cells. This modular approach achieves incremental energy density adaptable to the power requirements of various devices.

The progress achieved to date reflects Oxhy's commitment to transforming scientific innovation into practical and scalable technology, poised to revolutionize the Energy Harvesting sector.

3.4 Unique Benefits of the Technology

Oxhycell—the Oxhydroelectric Cell—is a groundbreaking technology in the field of current extraction, based on principles of **Quantum Electrodynamics** and associated experimental results. This innovative technology enables the conversion of low-quality energy, such as heat from ambient thermal radiation (i.e., IR), into high-quality energy, specifically electrical energy. This potentially overcomes the limitations of current renewable technologies, opening new horizons for energy efficiency and sustainable energy production. Below, we outline its main advantages.

Energy Efficiency and Sustainability: Oxhycell converts the invisible energy of infrared radiation into electricity, offering a more efficient alternative to traditional technologies. This approach reduces dependency on disposable batteries, significantly contributing to environmental impact reduction. Additionally, the use of eco-sustainable materials, such as next-generation polymers, reinforces its role as an environmentally friendly and sustainability-oriented energy solution.

Modularity and Adaptability to Diverse Use Cases: The technology is highly flexible thanks to its modular structure, which allows adaptable configurations to meet the specific needs of various sectors. From ALS sensors to IoT devices, remote controls, home automation systems, and industrial energy harvesting solutions, Oxhycell can be scaled and tailored to a wide range of applications, demonstrating its versatility and added value for multiple markets.

Compatibility with Industrial and Consumer Solutions: Oxhycell seamlessly integrates into both consumer products and industrial solutions. Its ability to generate reliable and continuous energy, even in extreme environments or with limited access to traditional power sources, makes it ideal for autonomous devices, minimizing maintenance and replacement requirements. This compatibility, combined with potential ease of implementation, positions it as a competitive and innovative option for a wide array of applications.

Thanks to these advantages, Oxhycell establishes itself as a cutting-edge solution capable of effectively addressing global energy challenges while promoting the adoption of more sustainable and innovative production models.

3.4.1 Advantages over Competing Technologies

Compared to conventional renewable technologies, the Oxhydroelectric Effect offers several significant advantages:

- **Operation Independent of Light Conditions:** Current extraction via the Oxhydroelectric Effect can occur under any lighting condition, including complete darkness, enabling continuous and reliable use. This eliminates limitations tied to direct sunlight availability or other light-based energy sources, which are typical of conventional photovoltaic technologies.
- **Utilization of Low-Temperature Heat Sources:** The Oxhydroelectric Effect enables current extraction from low-temperature heat sources, including temperatures ranging from 0 to 100 °C. This means it can leverage common ambient heat sources, such as air or water, without requiring high temperatures. This flexibility creates new opportunities for energy efficiency by utilizing thermal energy that would otherwise be wasted.
- **Overcoming Power Limitations of Existing Energy Recovery Technologies:** While current energy recovery devices produce limited amounts of energy (see Exhibit 1), the Oxhydroelectric Effect promises to generate significant amounts of electrical energy. This opens new opportunities for large-scale application of the technology, offering a more reliable and efficient renewable energy source.

Overall, the Oxhydroelectric Effect represents a promising solution for current extraction, offering key advantages over existing renewable technologies. Its ability to convert low-quality thermal energy into high-quality electrical energy, continuously and under any lighting condition, creates new prospects for a sustainable and efficient energy supply.

4. Potential Applications

4.1 Primary Areas of Application

Oxhydroelectric cells represent an innovative technology with a wide range of potential applications across various industries. With their ability to generate electricity from water exposed to infrared radiation, these cells can be deployed in areas requiring sustainable, low-power energy solutions where other sources are unavailable. Below are some of the key application areas for Oxhycell:

1. **Internet of Things (IoT):**
   Oxhydroelectric cells can power IoT devices in both indoor and outdoor environments. Their ability to generate energy from infrared light allows them to be integrated into wireless sensors, environmental monitoring devices, and home automation systems. Operating without traditional batteries reduces maintenance costs and enhances the sustainability of IoT devices.
2. **Industrial Applications:**
   These cells can be used in connection with thermodynamic cycles (e.g., ORC) to recover energy from low-temperature waste heat in ranges where existing technologies cannot operate. This capability makes them particularly suitable for reducing energy costs in industrial processes across various sectors (see our **Go-to-Market Strategy** and **Competitive Analysis**).
3. **Security and Alarm Systems:**
   Oxhydroelectric cells can power motion sensors, surveillance cameras, and alarm systems. Their ability to continuously generate energy ensures these systems remain operational even without an external power source, providing consistent security.
4. **Wearable Medical Devices:**
   The technology can be employed in wearable medical devices, such as fitness monitors, health trackers, and biometric sensors. These devices benefit from a continuous and autonomous energy source, reducing the need for frequent recharging and improving user convenience.
5. **Autonomous Sensors:**
   The oxhydroelectric cell serves as a self-powered IR sensor. This feature can be leveraged to create a completely new generation of IR sensors in microelectronics. Additionally, this technology is particularly suitable for powering environmental sensors that monitor parameters such as temperature, humidity, air quality, and pollution levels. Sensors powered by oxhydroelectric cells can be deployed in remote or hard-to-reach locations where battery replacement is impractical.

6. **Smart Cities:**
   Oxhydroelectric cells can contribute to the development of intelligent infrastructure in smart cities by powering sensors for traffic monitoring, public lighting, and waste management. This technology can help create more sustainable and energy-efficient cities.
7. **Agricultural Sector:**
   In agriculture, oxhydroelectric cells can power sensors for monitoring soil conditions, moisture levels, and crop health. These sensors can enhance the efficiency of farming practices, reduce resource usage, and increase productivity.
8. **Renewable Energy:**
   Oxhydroelectric cells can be integrated into renewable energy systems, such as solar panels, to improve overall system efficiency. They can provide supplemental energy during nighttime hours or low-light conditions, enhancing the reliability of renewable energy sources.

The technology behind oxhydroelectric cells offers significant potential to transform various industries by enabling sustainable and autonomous energy generation. The applications outlined above demonstrate how this technology can contribute to innovative energy solutions, reducing dependency on traditional batteries and improving the operational efficiency of numerous devices and systems.

4.2 A Few Specific Use Case in Microelectronics

We are developing a series of **demonstrators** designed to showcase various applications of Oxhycell technology across different sectors and contexts where Oxhycell modules can be used as power systems. Below are the main use cases currently addressed by the demonstrator:

- Indoor Lamps
- Ambient Light Sensors
- Alarm Sensors and Devices
- Programmable Thermostats
- Remote Controls
- Toys

4.2.1 Indoor Lamps

The Oxhycell demonstrator includes a module for indoor lamps designed to illustrate various applications of Oxhycell technology in indoor lighting. Lamps powered by Oxhycell can offer a sustainable alternative to traditional mains-powered or battery-operated lamps—or at least increase their efficiency. Below are specific applications of indoor lamps supported by the Oxhycell demonstrator, organized by power and specific features:

- Nightstand and Night Lamps
- Battery-Powered Reading Lamps
- Decorative LED Lamps
- Desk and Table Lamps

4.2.2 Ambient Light Sensors

The Oxhycell demonstrator includes a power module for ambient light sensors, demonstrating its application in lighting sensors. Oxhycell-powered ambient light sensors provide a sustainable alternative to battery-powered or wired sensors. Below are specific applications of ambient light sensors supported by the Oxhycell demonstrator, categorized by power requirements and specific characteristics:

- Ambient Light Sensors for Display Brightness Control
- Brightness Sensors for Automated Lighting
- Brightness Sensors for Indoor Climate Control Systems
- Brightness Sensors for Security and Surveillance Systems

4.2.3 Alarm Sensors and Devices

Applications for alarm devices can vary in complexity. A typical low-power alarm system consists of the following components:

- **Detection Sensors:** Monitor environmental parameters such as motion, temperature, humidity, smoke, and gas, detecting anomalies.
- **Control Unit:** Acts as the system's brain, receiving signals from sensors and activating alarms when necessary. It can connect to a communication network to send notifications during emergencies.
- **Power Supply:** Provides continuous power to ensure system functionality, either through internal batteries or external power supplies.
- **Communication Module:** Enables the system to send notifications via Wi-Fi, GSM, or other communication channels.
- **Alarm Devices:** Include bells, flashing lights, or audible signals activated during emergencies.

Oxhycell can enhance the efficiency of low-power alarm systems in several ways:

- **Reduced Energy Consumption:** Integrating Oxhycell into sensors and the control unit significantly decreases the system's energy consumption, prolonging battery life and reducing maintenance.
- **Autonomous Power Supply:** Oxhycell's ability to generate energy from environmental sources eliminates the need for batteries or power cables.
- **Maintenance Cost Reduction:** Oxhycell-powered alarm systems require less frequent battery replacements, lowering long-term operational costs.
- **Enhanced Battery Life:** Prolonging battery life ensures continuous, reliable system operation.

Currently, our focus is on powering sensors, with the potential to extend Oxhycell's power supply capabilities to all system components.

4.2.4 Programmable Thermostats

Programmable thermostats are devices used to automatically control and regulate the temperature within a space based on a preset schedule. They can be applied across a variety of settings, from residential homes to commercial environments. Applications for programmable thermostats are generally simpler than those for alarm systems but still exhibit a certain degree of variability. A typical programmable thermostat consists of the following components:

- **Temperature Sensor**: Detects the ambient temperature of the area to be controlled.
- **Control Unit**: Processes the information from the temperature sensor and adjusts the heating or cooling of the environment based on the preset settings.
- **User Interface**: Allows users to set the desired temperature and the operating schedule of the programmable thermostat.
- **Power Supply**: The thermostat can be powered by batteries or an electrical connection.

The components that consume the most power in a programmable thermostat are typically the control unit and the user interface, especially if it features a backlit display.

By integrating Oxhycell into the power system of the programmable thermostat, it is possible to improve energy efficiency and ensure the device operates continuously**.**

- **Battery-Powered System:** In the case of a battery-powered programmable thermostat, Oxhycell can provide autonomous energy, thereby reducing the frequency of battery replacements and improving system reliability.

- **Electric-Powered System:** In the case of a thermostat powered through an electrical connection, Oxhycell can be used as a backup power system, ensuring continuous operation even during main power outages.

In both cases, integrating Oxhycell allows for extending the operational lifespan of the thermostat, with a focus on low-power systems, reducing maintenance costs, and improving the overall efficiency of the system.

4.2.5 Remote Controls

Remote controls are widely used in homes and offices to manage electronic devices such as TVs, audio systems, and air conditioners. Oxhycell integration in remote controls can significantly reduce energy consumption, improve device efficiency, and decrease battery replacement frequency.

Applications include:

- Remote Controls for Home Entertainment Systems
- Remote Controls for Air Conditioners and Fans
- Universal Remote Controls

The integration of Oxhycell into remote controls reduces energy consumption and extends battery life. Additionally, the environmentally harvested energy decreases the frequency of battery replacements and reduces the environmental impact associated with battery production and disposal.

4.2.6 Toys

Toys represent an important category of devices that could significantly benefit from the implementation of Oxhycell technology, as many rely on batteries and can have a considerable environmental impact due to the frequent replacement of depleted batteries.

- **Educational and Interactive Toys (average power: 0.1 - 0.5 W):**
  This category includes toys such as interactive books, educational robotics, and programmable toys. Many of these devices require batteries to function and are designed to operate with relatively low power consumption.
- **Motorized Toys (average power: 0.1 - 2 W):**
  This category includes toy vehicles, electric trains, drones, and other toys that require motors for movement. While some of these toys may demand slightly higher power, many are designed to operate with low energy consumption.
- **Interactive Dolls and Games (average power: 0.1 - 0.5 W):**
  This category includes interactive dolls, sound-emitting plush toys, electronic games

(non-video games), and other toys that provide an interactive experience. While many of these toys are powered by low-power batteries, implementing Oxhycell technology could further reduce their energy consumption.

By integrating Oxhycell into toys, it is possible to reduce dependency on disposable batteries and enhance the environmental sustainability and safety of the toys. For a more detailed description of our strategy and initial target market, please refer to our GTM (Go-to-Market) and Competitive Analysis.

4.2.7 A Few Advanced Applications

The Oxhycell technology opens up promising prospects in cutting-edge sectors such as Artificial Intelligence (AI), cybersecurity, and data centers. In the field of AI, Oxhycell can power **edge computing** devices, where the ability to generate autonomous energy is essential to ensure operational continuity in the absence of traditional infrastructures. Additionally, the technology could be integrated into **advanced sensors** used for real-time data collection and processing, supporting AI systems with reliable and distributed power requirements.

In the realm of **cybersecurity**, Oxhycell could find applications in **autonomously powering security devices**, such as hardware encryption systems and physical keys used to secure networks and devices. The continuous and autonomous energy provided by Oxhycell can enhance the reliability of these systems, contributing to global cybersecurity.

Finally, **data centers**, which are responsible for significant energy consumption, could benefit from Oxhycell to power distributed sensors for monitoring energy efficiency, temperature control, and infrastructure management. The adoption of a sustainable technology like Oxhycell in these contexts represents a step toward reducing the ecological footprint of data centers, contributing to more sustainable energy management.

4.3 Expected Benefits in Target Applications

The applications of Oxhycell technology go far beyond traditional Energy Harvesting markets, reaching strategic sectors and opening new horizons for technological innovation. Whether in consumer devices, industrial solutions, or emerging technologies like AI and cybersecurity, Oxhycell promises to profoundly transform the energy landscape with a sustainable approach. The adoption of Oxhycell technology in the target applications described above offers numerous benefits. Thanks to its unique features, this technology can address many current challenges and improve operational efficiency across various sectors. Below are the key expected benefits:

1. **Reduced Dependence on Traditional Batteries:** The ability of oxhydroelectric cells to generate electricity from pure water exposed to infrared radiation could eliminate or significantly reduce the need for traditional batteries. This translates into lower maintenance and battery replacement costs, as well as a reduced environmental impact from disposing of spent batteries.
2. **Continuous and Reliable Operation:** Oxhydroelectric cells can provide a continuous energy supply regardless of environmental conditions. This is particularly advantageous for sensors and devices that require uninterrupted operation, such as security systems, environmental sensors, and wearable medical devices.
3. **Sustainability and Environmental Friendliness:** Using ubiquitous and non-polluting materials like water and the ability to generate energy without complex chemical processes make oxhydroelectric cells a sustainable energy solution. This technology reduces the need for toxic and non-renewable materials, contributing to a lower overall environmental footprint.
4. **Ease of Integration:** Oxhydroelectric cells can be seamlessly integrated into a wide range of existing devices and systems. Their versatility allows them to be used in multiple applications without requiring substantial modifications to current designs.
5. **Increased Energy Efficiency:** Oxhydroelectric cells can help improve the energy efficiency of devices by more effectively converting available energy. This is particularly valuable in sectors like the Internet of Things (IoT) and smart cities, where energy efficiency is critical for optimal performance.
6. **Applications in Remote and Hard-to-Reach Environments:** Oxhydroelectric cell technology is ideal for powering devices located in remote or hard-to-reach environments where battery replacement is impractical or costly. This includes agricultural applications, environmental sensors, and industrial use cases.
7. **Reduced Operational and Maintenance Costs:** By eliminating or reducing dependence on traditional batteries, devices powered by oxhydroelectric cells can have significantly longer operational lifespans. This reduces costs associated with maintenance and replacement of the devices themselves.
8. **Technological Innovation and Competitiveness:** Adopting innovative technology like oxhydroelectric cells can give companies a competitive edge in the market. Advanced and sustainable energy solutions are increasingly in demand by consumers and industries, fostering growth and success for businesses that implement them.

5. Strategy and Development Roadmap

We have put together a **development roadmap** and a series of targeted plans aimed at achieving our objectives through an iterative approach. At each stage of progress, the best results are selected, and targeted actions are implemented to improve upon them, working toward maximizing the identified performance indicators. The areas covered by our roadmap include **R&D**, **Product** and **Market**. With our resources and the support of government programs, we aim to achieve a series of specific results.

5.1 Technological Development Goals

The **technological roadmap** of Oxhy serves as a strategic guide toward achieving the key objectives in the development and industrialization of Oxhycell technology. It is structured across two time horizons: short-term goals aimed at consolidating the foundation of the technology and product, and long-term goals focused on scalability and global market expansion. Additionally, the roadmap includes specific milestones to monitor progress and ensure consistent advancement.

5.1.1 Short-term goals

Over the next 12-18 months, the focus will be on two main priorities: completing the Minimum Viable Product (MVP) and developing modular demonstrators for various use cases.

- **Completion of the MVP:** The primary goal is to finalize a fully functional MVP that represents a prototype of the Oxhycell with optimized characteristics in miniaturization, efficiency, and stability. This prototype will serve as the foundational platform for market testing, strategic feedback collection, and technological validation with partners and clients.
- **Modular Demonstrators:** To showcase the versatility of Oxhycell technology, modular demonstrators will be developed. Among these: (a) The “Oxhy Modular Set” will demonstrate applications such as the PowerCore for powering ambient light sensors (ALS), IoT devices, and LED systems. (b) The ORC+Oxhycell Demonstrator will, with quicker applicability, showcase the use of the technology for energy recovery from low-temperature thermodynamic cycles in industrial environments.

These demonstrators will be crucial for attracting strategic partnerships and investments, highlighting the technology's adaptability to various sectors and use cases.

5.1.2 General Goals

The roadmap outlines a development pathway that will advance the technology from its current maturity level (TRL 4-5) to higher levels (TRL 6 and beyond) within 24 months. Special attention will be given to increasing the **Business Readiness Level** to ensure a smooth transition from advanced prototyping to commercialization.

Achieving TRL 6: Technological validation in real-world operational environments will be critical to reaching TRL 6. This will include rigorous testing to confirm reliability and durability, as well as optimizations in materials, production processes, and technological integrations.

Production Scalability: Oxhy aims to develop scalable and automated production processes to meet market demand. Component standardization and automation in production processes will be central to reducing costs and ensuring long-term economic sustainability.

5.1.3 Key Technological Milestones

Milestones serve as key reference points for measuring progress along the technological and commercial roadmap:

1. **Q2 2025 - MVP Completion:** Development of a functional Oxhycell prototype with cell miniaturization down to a few cubic millimeters.
2. **Q3 2025 - Modular Demonstrator Development:** Creation of the “Modular Set Oxhy,” including a PowerCore for applications such as ALS sensors and IoT systems. Development of the ORC+Oxhycell prototype for industrial applications.
3. **Q4 2025 - Testing and Validation:** Conducting operational tests to verify the efficiency, stability, and durability of Oxhycell in real-world conditions.
4. **Q1 2026 - First Industrial Pilot:** Launch of a pilot project in collaboration with a strategic partner in the Energy Harvesting sector.
5. **Q3 2026 - Scalability:** Design of a pre-industrial production line to support initial commercialization.
6. **Q4 2026 - TRL 6 Achievement:** Full validation of the technology to ensure operational readiness and commercial adoption with miniaturized cell systems.

5.2 Go-to-Market Strategy

As reiterated multiple times, the oxhydroelectric cell—Oxhycell—is an innovative technology designed to convert ambient infrared radiation into electrical energy, providing a continuous and reliable solution for Energy Harvesting (EH) applications. This groundbreaking technology promises to overcome the limitations of existing EH technologies, such as solar and electromechanical solutions, by delivering 24/7 energy and operating across a wide range of temperatures. We have developed a comprehensive and detailed Go-to-Market strategy that, once implemented, will enable us to position Oxhy as a leader in this industry. This achievement will also be made possible through the resources potentially secured from new investors.

5.2.1 Objectives and Strategy

Oxhy aims to establish itself as a leader in the Energy Harvesting (EH) market by focusing on the miniaturization and efficiency of its cells for applications in microelectronics and industry. The strategy involves developing new applications by integrating Oxhycell and Organic Rankine Cycle (ORC) technology into the processes and products of selected partners, initially through pilot projects. This approach will accelerate time-to-market.

5.2.2 Key Strategy Points

Oxhy's focus is on miniaturizing and increasing the efficiency of its oxhydroelectric cells, targeting microelectronics applications. However, these require a relatively long development timeline. To expedite our Go-to-Market (GTM) strategy, we aim to develop applications integrating Oxhycell with low-temperature thermodynamic cycles, such as Organic Rankine Cycles (ORC). The strategy involves acquiring—currently underway—and developing new patents in this area to ensure a higher initial TRL (Technology Readiness Level) and a faster time-to-market, estimated at one year.

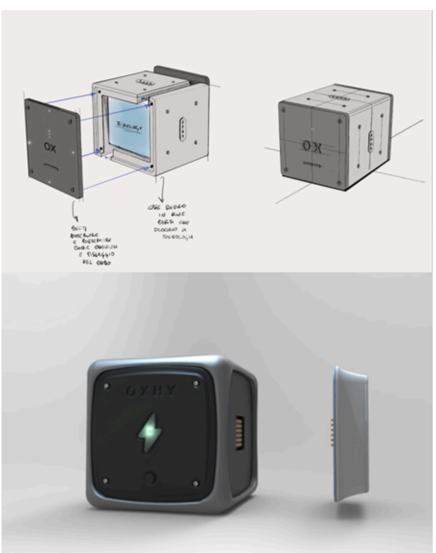


Fig 8. The first two prototypes under development: (a) the Modular Set with PowerCore and modules; (b) the ORC+Oxhycell system for energy recovery in industrial settings. Click here to view a presentation video of the latter project, which is crucial for our Go-to-Market strategy. Click here to see a demo of the first version of the PowerCore recharging a capacitor, powering a microcontroller with Bluetooth communication, and an ambient light sensor (ALS).

5.2.3 Market

The Energy Harvesting (EH) market is experiencing rapid growth due to increased demand for sustainable energy solutions and the proliferation of IoT devices and wearables. Analysts predict that the EH sector will grow at a compound annual growth rate (CAGR) of 10-15% over the next five years, with projections indicating the market will reach $800 million by 2026. Industries where the solution can be applied include microelectronics, consumer electronics, IoT, power supply systems, batteries, steel, glass, cement, chemical/petrochemical, food, paper, textile industries, automotive, waste treatment, wastewater plants, and energy production facilities (e.g., solar). The market is essentially global, and the combination of the current EH market segments with the identified industrial segments represents an enormous multibillion-dollar market (TAM $315Bn), where Oxhy aims to grow its business.

5.2.4 Competitors Technologies

Energy Harvesting technologies in the market include solar, electromechanical, RF, and others (e.g., thermoelectric, thermodynamic cycles like ORC). Key competitors in the low-power electricity generation segment of the EH market include Powercast, Sunpower, Enocean, Orbray, Enervibe, and Perpetua. Major competitors in the industrial EH market include ElectraTherm, Turboden, Ormat Technologies, and Rank. While competitor solutions are well-established, they rely on low-power-density energy sources that are not consistently available everywhere.

5.2.5 Positioning and Diffrentiation

Oxhy’s oxhydroelectric cell, integrated with ORC technology, offers a unique approach to industrial energy recovery, ensuring continuous and reliable energy regardless of environmental conditions. Our advanced technology reduces environmental impact while improving efficiency and sustainability. Leveraging the high energy density of infrared radiation, we aim to achieve efficiency levels increasing from 15% to 30%, with versatile applications across various industrial sectors.

5.2.6 Sales Goals

Our aim is to develop the market by building partnerships with customers interested in piloting our technology in the identified segments, transitioning to broader-scale delivery. Given our TRL, the solution still requires complete development and market validation. However, we have outlined a potential commercial rollout starting in the early stages. Our sales objective for the initial 2025-2026 period aligns with the goals declared in our Business Plan.

5.2.7 Implementation Plan

The plan begins with an initial Research and Development phase, followed by OEM production and market launch, sales, and distribution. The marketing strategy includes media outreach, social media campaigns, participation in trade fairs and conferences, and targeted advertising. Sales will initially focus on the B2B channel, emphasizing strategic partnerships before expanding distribution. Risk mitigation measures are built into the plan. Necessary resources—currently being secured—include: a Research and Development team, a Design and Prototyping team, a Production team, a Marketing and Sales team, Laboratories and equipment.

The integration of Oxhycell with ORC technology represents a key strategic move to accelerate our entry into the Energy Harvesting market. This allows us to offer a highly efficient, sustainable, and scalable solution ready for adoption across various industrial sectors, helping us establish an early foothold in the market.

5.3 Commercial Expansion

The commercial expansion of Oxhy is closely aligned with the company's strategic vision to bring Oxhycell technology to global markets, solidifying its role as an innovator in the Energy Harvesting sector. To achieve this goal, Oxhy has outlined an action plan focusing on two main fronts: strategies for penetrating international markets and a structured plan to build strategic partnerships and launch pilot projects.

5.3.1 Strategies for entering global markets

Oxhy aims to position itself as a global leader in the Energy Harvesting field, targeting key sectors such as Microelectronics, IoT, lighting, smart home systems, and energy recovery from industrial processes. The strategy for entering international markets is built on:

1. **Focus on High-Potential Markets**: Prioritizing regions with strong demand for Energy Harvesting solutions, such as Europe, North America, and Asia, where IoT and industrial applications are rapidly growing. The starting point will be Italy.
2. **Participation in International Fairs and Events**: Engaging in industry fairs and global conferences to showcase Oxhycell technology to decision-makers, potential clients, and strategic partners.
3. **Adaptation to Local Markets**: Customizing Oxhycell applications to address the specific needs of various markets, enhancing penetration and driving adoption.
4. **OEM Business Model and Licensing**: Promoting a licensing model with OEM manufacturers to enable the integration of Oxhycell into their existing products, reducing go-to-market time and increasing scalability.
5. **Expansion of the Commercial Network**: Building a global distribution network through partnerships with suppliers, distributors, and leading companies in target sectors.

5.3.2 Plans to build strategic partnership and pilot projects

A key element for the success of Oxhy's commercial expansion lies in developing strategic partnerships and launching pilot projects to demonstrate the validity and potential of the Oxhycell technology.

1. **Strengthening strategic partnerships**:
    - **Identifying Leading Companies in Target Sectors**: Targeting leaders in sectors such as sensor manufacturing, IoT devices, and lighting systems.
    - **Developing Collaborations with Early Adopters**: Partnering with companies willing to adopt the technology early, accelerating its market penetration.
    - **Formalizing Letters of Intent and Collaboration Agreements**: Establishing partnerships with industrial players in both Italy and international markets through agreements and pilot testing collaborations.
2. **Launching Pilot Projects**:
    - **Implementation of Pilot Projects**: Testing the technology in real operational conditions to validate its performance.
    - **Initial Focus on Industrial and Consumer Applications**: Concentrating on use cases like ALS sensors for lighting, remote controls, and IoT devices to demonstrate the technology's effectiveness and scalability.
    - **Collaboration with Research Partners**: Partnering with universities and research organizations to validate results and enhance technological credibility.
3. **Creating a Reference Base**:

    - **Developing Case Studies**: Producing case studies based on pilot project results to serve as communication tools for attracting new investors and customers.
    - **Publishing White Papers and Technical Documentation**: Strengthening Oxhy's position as an innovative leader in the sector through detailed and accessible technical literature.
4. **Ongoing Support for Partners**:
    - **Providing Technical Assistance**: Offering technical consultancy and support for integrating Oxhycell technology into partner products or processes.
    - **Creating Support Tools**: Developing resources like technical manuals and modular demonstrators to simplify the adoption of Oxhycell technology.

With a strategic approach focused on global expansion and strong emphasis on partnership consolidation, Oxhy is preparing to transform its technology into a globally adoptable solution. Pilot projects and strategic collaborations will serve as the foundation for building a network of applications that will drive Oxhy's commercial and technological growth.

6. Value for Partners and Collaborators

6.1 Collaboration Opportunities

The Oxhycell technology presents a unique opportunity to establish strategic partnerships and joint projects that enable innovation, sustainability, and energy efficiency in advanced industrial and technological sectors. Oxhy is committed to creating a collaborative ecosystem where OEM manufacturers, universities, and research centers can leverage significant synergies and gain a unique competitive advantage.

6.1.1 Benefits for OEM Manufacturers

OEM manufacturers have the chance to integrate revolutionary technology into their products, enhancing the value of their solutions for end users. The key benefits include:

- **Increased Energy Efficiency**: By generating energy from the infrared range, Oxhycell reduces reliance on traditional batteries and improves device autonomy.
- **Product Innovation**: The modularity and flexibility of Oxhycell enable the creation of new product lines based on Energy Harvesting, positioning partners as market innovators.
- **Reduced Operational Costs**: Integrating Energy Harvesting technology can lower maintenance and battery replacement costs, offering a sustainable and economically advantageous solution.
- **Enhanced Competitiveness**: OEM partners adopting Oxhycell can differentiate themselves in the market by offering high-performance, environmentally friendly, and forward-looking solutions.

6.1.2 Benefits for universities and research centers

For academic institutions and innovation hubs, collaborating with Oxhy unlocks new frontiers in applied research. Key opportunities include:

- **Access to Pioneering Technology**: Oxhycell provides a unique field of study to explore the interactions between infrared radiation, water, and natural semiconductors.
- **Joint Research Projects**: Oxhy is open to partnerships on innovative studies that explore new applications of the technology, resulting in high-impact publications and potentially co-developed patents.

- **Experimentation with New Energy Paradigms**: Researchers can test the technology in advanced contexts such as IoT, smart home systems, industrial sensors, and consumer devices.
- **Human Capital Development**: Collaborations on research programs and industrial PhD initiatives provide opportunities to train new generations of specialized researchers and engineers.

6.1.3 Joint projects for new technological applications

Oxhy fosters value co-creation through joint projects with industrial and academic partners. Examples of collaborative initiatives include:

- **Testing Specific Applications**: Pilot projects to validate the effectiveness of Oxhycell technology across various applications and market segments, from biomedical devices to edge computing.
- **Development of New Modular Demonstrators**: Creation of advanced systems to showcase the versatility of the technology in real-world settings.
- **Patent Expansion**: Development of new patents that extend the potential of the technology into unexplored areas.
- **Sustainability Initiatives**: Projects focused on reducing the environmental impact of traditional power technologies.

Oxhy positions itself as a catalyst for innovative partnerships that drive technological and commercial advancement, with the shared goal of transforming the global energy market and fostering a more sustainable future.

6.2 For Investors

Investing in Oxhy offers a unique opportunity to enter the emerging and rapidly growing **Energy Harvesting** market, which is projected to expand significantly in the coming years due to the rising demand for sustainable and innovative energy solutions. The Oxhycell technology, with its distinctive positioning, provides unparalleled competitive advantages that set it apart from current competitors.

6.2.1 Growth potential of the Energy Harvesting Market

The Energy Harvesting market is at a pivotal moment, driven by the need to reduce reliance on traditional batteries and develop more sustainable technologies. The evolution of sectors such as IoT, smart home systems, microelectronics, and consumer devices has increased the demand for autonomous and highly energy-efficient solutions. Oxhy is well-positioned to capitalize on this trend with technology that perfectly meets these needs.

6.2.2 Unique positioning of the Oxhycell technology

Oxhycell stands out for its ability to convert the invisible energy of infrared radiation into usable electrical energy, overcoming the limitations of current Energy Harvesting technologies. Thanks to its modularity and adaptability, Oxhycell can be integrated into a wide range of applications, from industrial solutions for remote environments to consumer devices like sensors and remote controls. This unique positioning not only addresses existing energy challenges but also creates new market opportunities, making Oxhy a strategic choice for forward-thinking investors.

6.2.3 Revenue projections and long-term economic sustainability

Oxhy's financial projections outline a clear roadmap toward financial sustainability. Through a business model based on OEM licensing and the development of commercial prototypes, Oxhy aims to generate increasing revenues from the initial years of commercialization. The long-term prospects are promising, including expansion into high-growth strategic sectors and further development of the technology to enhance efficiency and scalability. These factors, combined with careful management and a growing commercial pipeline, provide a solid foundation for significant and sustainable returns on investment.

7. Social and Environmental Impact

7.1 Oxhy's Commitment to Sustainability

Oxhy positions itself as a key player in the transition toward a more sustainable energy future, offering a technology that overcomes the limitations of traditional power solutions, such as single-use batteries or polluting energy systems. Through its Oxhycell technology, it is possible to significantly **reduce the environmental footprint** of energy applications by eliminating or minimizing the use of high-impact materials, such as the heavy metals found in conventional batteries, thereby contributing to the reduction of technological waste.

The ability of Oxhycell to convert infrared radiation into electrical energy leverages an abundant and renewable resource without producing **polluting emissions** or causing negative environmental impacts, such as water pollution. This non-invasive approach allows Energy Harvesting to be integrated into a wide range of industrial and consumer applications without compromising ecological balance.

Oxhy actively promotes the adoption of **renewable energy-based solutions**, fostering a decentralized and self-sufficient energy model that reduces reliance on traditional grids and fossil fuels. In doing so, Oxhycell technology provides a tangible contribution to global sustainable development goals, such as those outlined in the 2030 Agenda, while encouraging awareness and the transition to more environmentally friendly practices and products.

The **positive impact** of Oxhy extends to the social level, creating new economic and technological opportunities for local and global communities by offering accessible, scalable, and sustainable energy solutions. The Oxhycell technology represents a significant step forward in combining innovation with environmental responsibility, laying the groundwork for a future where sustainability is not just an option but a tangible reality.

7.2 Supporting the SDGs (Sustainable Development Goals)

Oxhy fully aligns with the **United Nations'** Sustainable Development Goals (SDGs), making direct contributions to key objectives related to **clean energy**, technological innovation, and environmental sustainability. In particular, Oxhycell technology provides a practical and innovative solution to address some of the world's most pressing global challenges.

- **SDG 7: Affordable and Clean Energy:** Oxhycell offers an alternative to traditional energy solutions by providing sustainable and renewable electricity through Energy Harvesting. This technology enables autonomous device operation, reducing dependence on single-use batteries or polluting energy sources while improving access to energy solutions in remote or hard-to-reach areas.
- **SDG 9: Industry, Innovation, and Infrastructure:** The technological innovation at the heart of Oxhy's mission significantly contributes to the development of more efficient and sustainable industrial infrastructures. The modularity and adaptability of Oxhycell technology make it ideal for applications in sectors such as IoT, home automation, microelectronics, and industry, fostering the growth of smart, integrable technologies.
- **SDG 12: Responsible Consumption and Production:** Oxhycell technology supports a more responsible energy consumption model by eliminating the use of polluting materials and promoting solutions that reduce waste. The energy efficiency provided by Oxhycell ensures a longer and more sustainable product lifecycle.
- **SDG 13: Climate Action:** By replacing traditional energy sources with an Energy Harvesting system, Oxhycell reduces harmful emissions and greenhouse gases associated with fossil fuel-based energy production and battery disposal. This actively contributes to mitigating the risks posed by human activities on health and climate change.

Oxhy is not solely focused on technological advancement but embraces a holistic vision that promotes **sustainable innovation**, inclusion, and reduced environmental impact. With its mission, the company positions itself as a responsible global actor committed to creating a future where technology and ecological awareness collaborate to improve quality of life and ensure the planet’s sustainability.

8. Team

Despite the complexity of the challenge, Oxhy has successfully achieved significant results in a short time. This has been made possible through the implementation of an innovative approach to technology development carried out by a highly structured interdisciplinary team that is steadily expanding.

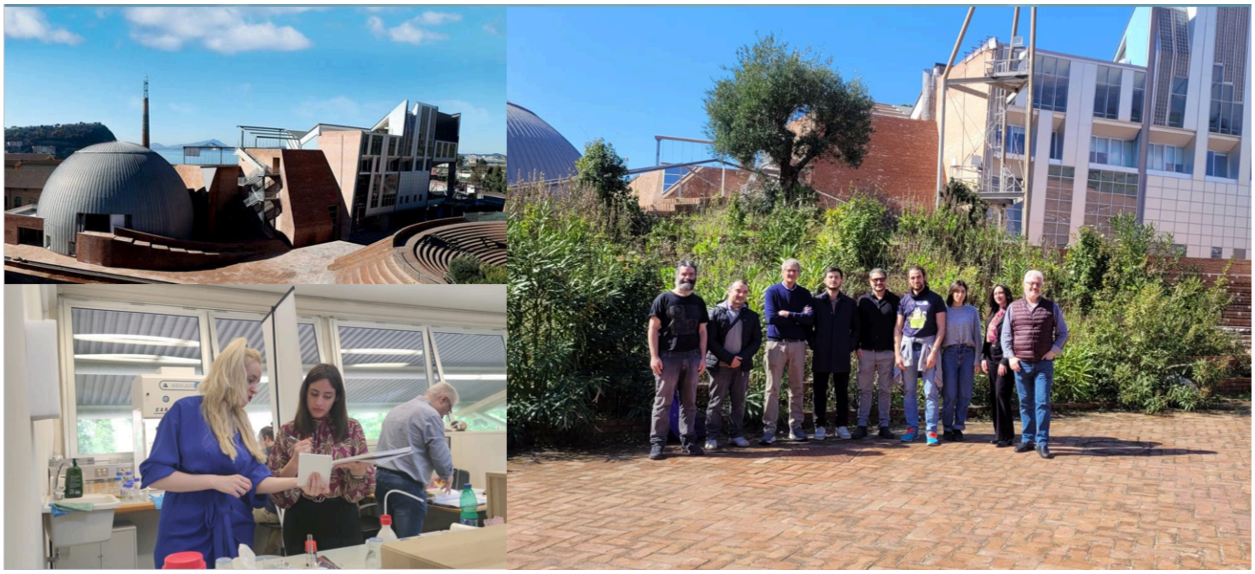


Fig 9. Where we are today. Our offices and labs are located in the Città della Scienza complex in Naples.

Team Expansion and Strengthening

Over the past few months, Oxhy has continued to invest in strengthening its team, recognizing the central role of people in achieving company objectives. In addition to the founding group, new key professionals have been added to enhance technical, scientific, and commercial skills, providing broader coverage of the strategic areas needed to advance the project.

New Hires and Strategic Collaborations

Oxhy has initiated strategic collaborations with top universities and research centers to support research and development activities. In particular:

- **Collaboration with the University of Naples Federico II** for the co-financing of an industrial PhD focused on developing advanced materials for Oxhycell.

- **Ongoing partnerships with technology innovation centers** for the creation of prototypes and technological validation tests.
- **New additions to the R&D team**, hiring specialists in advanced materials, electrochemistry, and systems engineering.

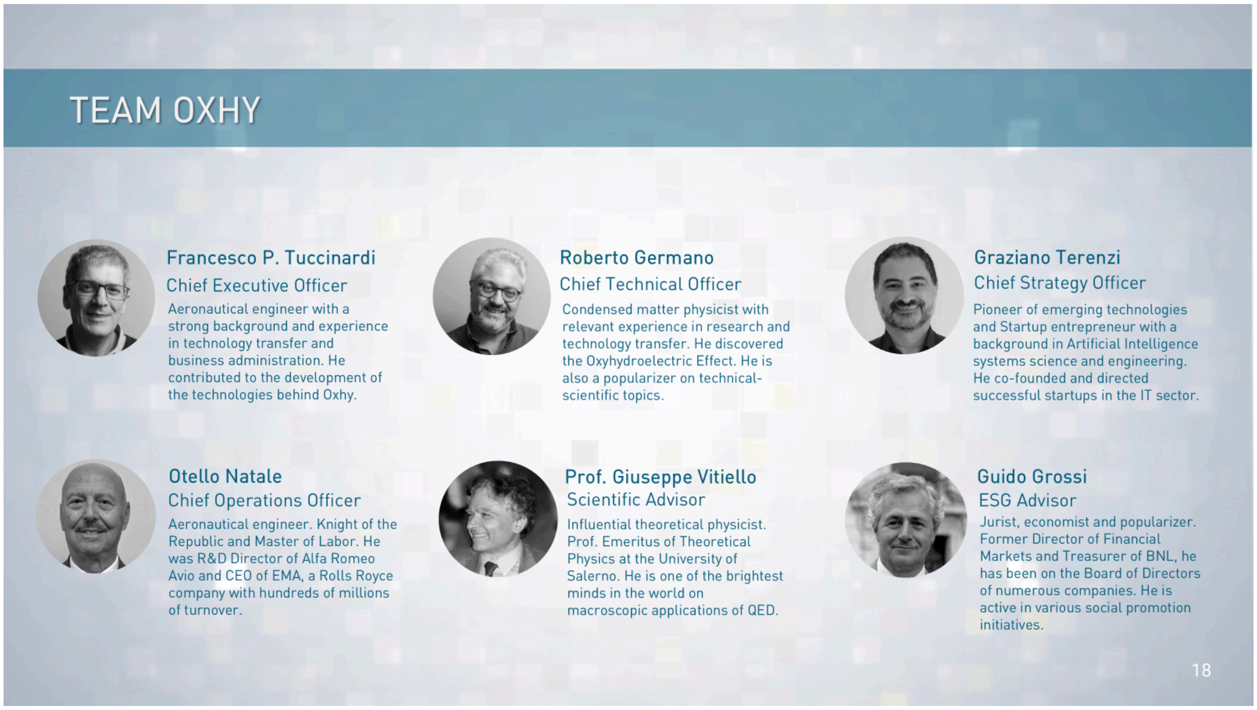
On the industrial front, Oxhy is consolidating relationships with OEM partners and leading companies in target sectors, ensuring ongoing exchanges of expertise and feedback to improve the applicability of its technology.

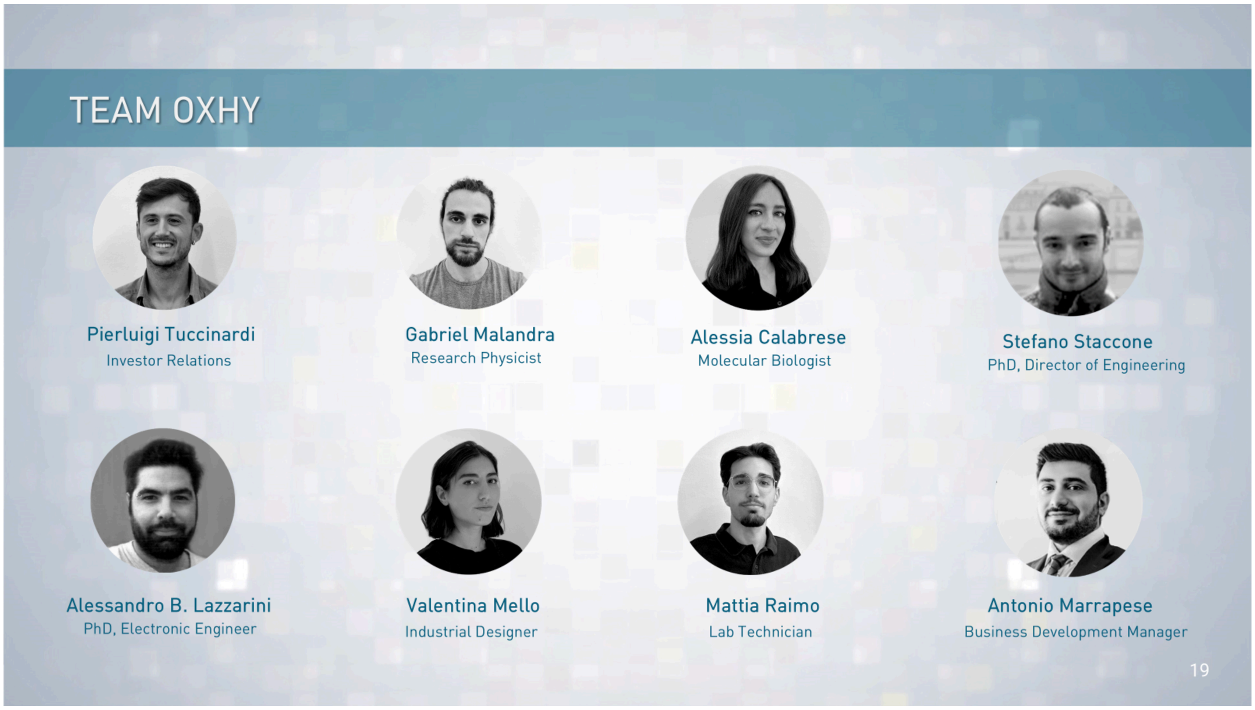
Acquired and Strengthened Expertise

These new hires and collaborations have made it possible to expand and consolidate expertise in:

- **Advanced Materials Research:** Development and characterization of hydrogels, electrodes, and assembly systems to improve Oxhycell's efficiency and stability.
- **Prototyping and Technological Development:** Implementation of pre-industrial prototyping processes and design of modular demonstrators for target markets.
- **Business Development and Marketing:** Strengthening the commercial pipeline and creating targeted strategies to penetrate key sectors.
- **Complex Project Management:** Enhancing organizational and operational capabilities to manage the project's rapid progress and strategic partnerships.

To date, the Oxhy team includes 12 collaborators in addition to two members of the Advisory Board. The details are provided below.





Future Outlook

In the coming months, Oxhy plans to further expand the team by:

- Recruiting additional experts in various operational areas,

- Launching new collaboration programs with international research centers,
- Continuously training existing staff to bolster expertise in key fields.

Oxhy is aware that the success of the project depends on building a highly skilled, interdisciplinary, and motivated team, and will continue to invest in people as the cornerstone of its development.

9. Future Prospects

Next Steps in the Technological and Commercial Roadmap

Oxhy is at a pivotal stage in its development journey, with clear yet ambitious goals that will shape the coming months. On the technological front, the key steps planned include:

- **Completion of TRL 6:** Through the optimization of Oxhycell prototypes and testing in operational environments, we aim to validate the technology for industrial and consumer microelectronics applications.
- **Development of New Demonstrators:** Further versions of demonstrators will be developed, including modular prototypes for applications such as ALS sensors, IoT devices, lighting systems, and industrial energy harvesting. These demonstrators will enable the exploration of specific use cases and showcase the adaptability of our technology.
- **Advancements in Miniaturization:** The roadmap includes further progress in reducing the size of Oxhycell, enhancing its efficiency and versatility.

Upcoming Initiatives

To accelerate the visibility and adoption of Oxhycell technology, several strategic initiatives are planned:

- **Participation in International Trade Shows:** Oxhy will attend key industry events, such as those focused on innovative technologies, IoT, and Energy Harvesting, to promote the technology and establish new commercial connections.
- **Presentation of Demonstrators:** Advanced versions of our demonstrators are being prepared, including a modular system capable of showcasing Energy Harvesting applications in consumer and industrial settings. These will serve as essential tools for attracting new customers and partners.
- **Experimentation and Testing Programs with Strategic Partners:** We aim to collaborate with target companies to test Oxhycell technology in real-world scenarios. The first pilot programs are scheduled to begin in 2025.

Business Growth Plans

Oxhy's growth will be driven by a targeted scalability strategy both technologically and commercially:

- **Market Penetration:** The goal is to position Oxhy as a global leader in the Energy Harvesting sector, initially focusing on specific high-potential market segments such as microelectronics, IoT, and industrial energy harvesting.
- **Team Development:** We will continue to attract international talent to strengthen internal capabilities and accelerate technological and commercial development.
- **Scalability Initiatives:** Oxhy will work to expand its customer base, establish new strategic partnerships with OEM manufacturers, and secure additional funding to support growth.

Long-Term Vision

With a clear plan and concrete objectives, Oxhy aims to solidify its position as a global leader in Energy Harvesting, revolutionizing how energy is generated and utilized across numerous industries. Our innovative technology is the key to a sustainable future.

EXHIBIT 1 - Overcoming the Limitations of Current Energy Harvesting Technologies

Current Energy Harvesting technologies are based on at least one of the following sources:

- Solar Energy (photovoltaic)
- Vibrations (piezoelectric, electrostatic, and electromagnetic)
- Thermoelectric
- Radio Frequencies.

From a technical standpoint, the substantial difference lies in the power density and the availability of Infrared Radiation compared to the sources exploited by other technologies. In fact, the energy sources currently used for Energy Harvesting (EH) devices are tied to:

- Atmospheric conditions (wind) or climatic conditions (solar irradiation in the visible range) and are therefore characterized by significant spatial and temporal variability [2],
- Other energy sources, which are highly dependent on specific operating conditions (e.g., the presence of vibrations to achieve piezoelectric or electrostatic conversion) or require proximity to the EH device (e.g., electromagnetic energy recovery from radio waves, requiring the presence of surrounding sources such as cell phones, Wi-Fi, wireless local area network, transmitted TV signal or DTS, FM/AM radio signals)[3].

As previously mentioned, the Oxhydroelectric Cell is the engineering application of the Oxhydroelectric Effect[4], which has paved the way for a completely new class of electric power generation systems capable of directly and continuously transforming low-quality energy (heat, IR radiation) into high-level energy (electricity). According to quantum electrodynamics (QED) description of the structure of liquid water, liquid water is a system in a state of stable non-equilibrium due to the coexistence of two phases characterized by different thermodynamic parameters[5][6]. This dual system can perform internal work to

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[2] J. Jurasz, F.A. Canales, A. Kies, M. Guezgouz, A. Beluco, A review on the complementarity of renewable energy sources: Concept, metrics, application and future research directions, Solar Energy, Volume 195, 2020, Pages 703-724,ISSN 0038-092X, https://doi.org/10.1016/j.solener.2019.11.087

[3] Ibrahim HH, Singh MJ, Al-Bawri SS, Ibrahim SK, Islam MT, Alzamil A, Islam MS. Radio Frequency Energy Harvesting Technologies: A Comprehensive Review on Designing, Methodologies, and Potential Applications. Sensors (Basel). 2022 May 30;22(11):4144. doi: 10.3390/s22114144. PMID: 35684763; PMCID: PMC9185291.

[4] The patent is No. ITRM20120223 (A1) "Process and apparatus for the extraction of electrical energy from water" (initial application No. RM2012A000223)

[5] G. Preparata: QED Coherence in Matter (World Scientific, Singapore, 1995)

[6] R. Arani, I. Bono, E. Del Giudice, G. Preparata: Int. J. Mod. Phys. B, Vol. 9, (1995) p.1813

sustain its non-equilibrium state due to the negentropy derived from the spontaneous conversion from the non-coherent state to the coherent one. However, the radiant energy of the environment (ambient heat, IR) causes the system to return to its initial state, and so on, like a true "microscopic engine." And this environmental energy—Infrared Radiation (IR)—is always present and everywhere, and moreover, it is not shieldable.

Power Density and Efficiency

The table below summarizes the various energy sources with their harvesting potential and conversion efficiencies[7].

Harvesting Method	Power Density	Efficiency
Solar energy—indoors	100 μW/cm^3	
Vibrations (piezoelectric—shoe inserts)	330 μW/cm^3-105 Hz	25–50%
Vibrations (electrostatic conversion)	184 μW/cm^3-10 Hz	
Vibrations (electromagnetic conversion)	0.21 mW/cm^3-12 Hz	
Thermoelectric (5–20 °C gradient)	40 μW-10 mW/cm^3	0.1–3%
Magnetic field energy	130 μW/cm^3-200 μT, 60 Hz	30–74.4%
Wind energy	65.2 μW/cm^3-5 m/s	20–40%
RF energy	0.08 nW-1 μW/cm^2	30–88%

As is evident, the energy sources from which current EH systems extract energy are characterized by low power density, meaning the amount of energy available per unit volume is quite low.

In the case of oxhydroelectric cells, considering that in an environment at 25°C, the infrared energy density is approximately 454.9 watts per square meter (W/m^2), simple calculations give us the infrared energy volumetric density per cubic millimeter (W/mm^3) ≈ 455 microW/mm^3.

[7] De Mil, P., Jooris, B., Tytgat, L. et al. Design and Implementation of a Generic Energy-Harvesting Framework Applied to the Evaluation of a Large-Scale Electronic Shelf-Labeling Wireless Sensor Network. J Wireless Com Network 2010, 343690 (2010). https://doi.org/10.1155/2010/343690

Calculation of Ambient IR Radiation Power Density.

To calculate the infrared energy density in a 25°C environment, we can use the Stefan-Boltzmann formula, which links the radiation emitted by a black body to its absolute temperature.

The Stefan-Boltzmann formula is expressed as:

Emitted Power (W/m^2) = $\sigma * T^4$

Where:

- Emitted Power is the power emitted per unit area (infrared energy density),
- σ is the Stefan-Boltzmann constant ($\sigma \approx 5.67 \times 10^{-8}$ $W/(m^2 \cdot K^4)$),
- T is the absolute temperature in Kelvin.

Considering an ambient temperature of 25°C, the temperature in Kelvin will be:
T = 25°C + 273.15 = 298.15 K

Substituting into the Stefan-Boltzmann formula:
Emitted Power = (5.67×10^{-8} $W/(m^2 \cdot K^4)$) * $(298.15\ K)^4$
Emitted Power ≈ 454.9 W/m^2

Thus, in an environment at 25°C, the infrared energy density would be approximately 454.9 watts per square meter (W/m^2).

To calculate the infrared energy volumetric density per cubic millimeter (W/mm^3) from the infrared energy density per square meter (W/m^2), we need to consider the conversion from cubic meters to cubic millimeters to obtain a consistent volume measure.

Therefore, at room temperature, the infrared energy volumetric density per cubic centimeter in a 25°C environment would be approximately 455 $microW/mm^3$.

Oxhy's current system is at a TRL4 development level and extracts 1 $microW/cm^3$. Thus, it currently has very limited efficiency. However, our goal is the miniaturization and efficiency increase of the cells.
By miniaturizing the system to 1 mm^3, if, according to theory and observations gathered so far, each cell continued to deliver 1 microWatt, we would have 1000 microWatt (in 1 cm^3). In this case, if the efficiency were 100%, we would have 500 microWatts per mm^3. Hence the goal of reaching an efficiency of 30%, which would mean achieving about 170 microWatt per mm^3.
Further research on the components used in the cell could finally allow for an increase in the number of electrons extracted per unit volume. Indeed, according to the QED model of liquid water, 1 cm^3 of water—that is, 1 g of water—contains $6.7 * 10^{22}$ molecules, and thus there are $3.4 * 10^{21}$ quasi-free electrons that can be extracted with an amount of

energy equivalent to that of ambient IR radiation. This means that for every cm^3 of water at room temperature, we would have about 10^3 Coulomb "available" just for the quasi-free electrons. Until now, the oxhydroelectric effect has extracted about 1 microAmpere, which is equivalent to 1 microCoulomb per second, but there is still a billion times more energy available that could theoretically be extracted, that is, 9 orders of magnitude that could thus significantly increase the system's efficiency.
Extreme miniaturization, thanks to the effects at the micro and nanometric scale, could facilitate access to this enormous reservoir of quasi-free electrons (a billion times larger than what we currently access).

A pervasive source in space and continuous in time, with a power density already inherently greater than other sources (see Table 1) and with an efficiency that can be increased by many orders of magnitude (as theoretically predicted), will enable us to meet not only the current customer needs for low-power applications (e.g., sensor networks) with significantly superior performance, where EH technologies—with their current limitations—can still offer a usable energy solution, but also to harvest sufficient energy to power devices with a much higher energy consumption class than those currently targeted by existing EH systems.

Variability of Energy Sources

It is well known that when discussing solar or wind energy, their fluctuating nature is often summarized with the acronym VRES (variable renewable energy sources), and much of the current research is focused on investigating, analyzing, quantifying, and managing the temporal, spatial, and spatio-temporal effects of different energy sources to optimize their complementarity.
Even at the scale of EH devices, the issue of energy source availability is tied to their fluctuating nature, with implications for the applications most served by the EH sector today, namely sensor networks to be used in so-called “deploy and forget” operational conditions.
At the level of a single system, to meet customer needs, it would be necessary to increase the sensitivity of the EH device, i.e., its ability to harvest energy and operate at a low power density. The greater the sensitivity, the better the conversion efficiency due to the even limited strength of the incident signal, and therefore, the better (or at least sufficient)[8] the system's performance. On the other hand, to address the issue of energy insufficiency of a single energy harvester, hybrid energy harvesting systems have been proposed in recent years. Hybrid harvesting includes not only the collection of energy from multiple sources but also the conversion of energy into electricity through different types of transduction mechanisms. Indeed, a reasonable hybridization of multiple energy conversion

[8] Sherazi HHR, Zorbas D, O'Flynn B. A Comprehensive Survey on RF Energy Harvesting: Applications and Performance Determinants. Sensors (Basel). 2022 Apr 13;22(8):2990. doi: 10.3390/s22082990. PMID: 35458973; PMCID: PMC9026445.

mechanisms can significantly increase the output power, considering that the output power of current devices is in the milliwatt range, suitable only for low-power sensors and electronics. This is the reason behind the development of ultra-low power electronic components and increasingly fine-grained energy management systems.

However, as it is evident, the limitations of existing solutions, in terms of energy generation, lie not only in power density but also in the extreme variability of sources and their limited availability in both space and time. The starting point remains the current energy insufficiency of a single energy harvester if the goal is to scale existing systems to levels capable of powering devices with a higher energy consumption class.

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CONTACT INFORMATION

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We are always looking for partners, collaborators and investors who share our vision for a sustainable future based on energy innovation. If you would like to explore collaboration opportunities, discuss investments, or simply learn more about our project, do not hesitate to contact us.

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