The LoLiPoP-IoT Project: Long Life Power Platforms for Internet of Things

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***Abstract*—The LoLiPoP-IoT project aims to pioneer Long Life Power Platforms for IoT to extend battery life, minimize maintenance, and facilitate installation within existing environments. With a focus on supporting an inclusive ecosystem of developers, integrators, coordinators, and users, the project's Grand Objectives encompass a range of aims, including providing long-lasting battery solutions, reducing battery waste, enhancing asset tracking and predictive maintenance, and improving energy efficiency in buildings. These objectives are realized through nine selected practical applications across three primary domains: Asset Tracking, Condition Monitoring and Predictive Maintenance, and Energy Efficiency and Comfort in Buildings. Expected impacts of the LoLiPoP-IoT project include significantly extended battery life, reduced maintenance overhead, decreased costs associated with asset location, improved asset management efficiency, enhanced building comfort with reduced energy consumption, and substantial revenue generation for industry partners. The project's strategic objectives are notably harmonized with key EU initiatives outlined in the Green Deal, Circular Economy, and the New Industrial Strategy for Europe.**

Keywords*—*Internet of Things, Low Power, Electronic Design, Energy Harvesting, Energy Efficiency, EU Project.

I. Introduction

In the early evolution of the Internet, its paradigm was the Internet of Computers. This changed to the Internet of People when social networks appeared. Later, the term *Internet of Things* (IoT) appears. There is no unique definition of IoT; however, according to [1], the most accurate definition of IoT would be: *"An open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment"*. In the era of IoT, different objects with the so-called *smart functionality* are interconnected and individually addressable, to be able to communicate with them. The IoT paradigm was earlier defined as the *Machine to Machine* (M2M) communication [2].

From the perspective of the end device to the upper layers, the IoT can be viewed in three domains: **1) The Device Domain:** where M2M communications occur. This domain contains the end devices; sometimes constructed as a *Wireless Sensor Network* (WSN). **2) The Network Domain:** contains network access communication utilizing various network protocols (e.g., Ethernet, LTE, etc.). **3) The Application Domain:** includes servers, cloud services, and other application infrastructure. [3]

The applications of IoT include (but are not limited to): monitoring, for example, for security and safety reasons [4], [5], (re)distribution of resources [6], monitoring of objects [7], water levels in the nature [8], or detection of fires in nature [9]. Other applications include improving efficiency, such as in agriculture [10], [11].

Some IoT devices are fixed and connected to a stable network, enabling them to draw power from the mains. However, others are mobile or in areas that lack a fixed network infrastructure. These devices rely on extended wireless networks like Wi-Fi or *Bluetooth Low Energy* (BLE) or sometimes specialized IoT networks such as LoRaWAN, Sigfox, or *Narrowband IoT* (NB-IoT). Because of their mobility or remote location, these devices must have their own power source. One common challenge with these devices is the need for battery replacement or recharging, which can be impractical in scenarios where access to the device is limited or the number of devices is high. Some devices use primary batteries, raising questions about the ecological aspects. However, some applications tackle this challenge through *Energy Harvesting* (EH), a method that captures energy from the surrounding environment [12]. The energy obtained through EH varies significantly depending on the environment and the EH technology used. Still, in many cases, the EH part of the wireless IoT device can be optimized based on the specific purpose and, thus, the operating environment of the wireless node. The amount of energy available through this method is often limited, making it essential to implement energy-

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saving measures at the IoT wireless node and use the available power [13].

In the LoLiPoP-IoT project, our objective is to overcome the limitations of WSNs by employing EH techniques and principles that minimize WSN's power consumption. This takes place on several levels: 1) design of HW platforms and SW algorithms for energy efficiency (i.e., minimization of energy consumption); 2) design, improvement, and optimization of existing EH components and technologies; 3) new and modern technologies for power management are to be used for maximization of power conversion and energy storage efficiency.

This paper is organized as follows. The state of the art for the focus of the LoLiPoP-IoT project is presented in Section II. The introduction to the LoLiPoP-IoT project is presented in Section III. The objectives and methodologies of the project are shown in more detail in Section IV. Section V describes various use cases for the outcomes of the LoLiPoP-IoT project, and Section VI concludes the paper.

II. State of the Art

This section describes the current state of the art of problematics towards which the LoLiPoP-IoT project focuses. Because the project has a broad scope, the state-of-the-art literature is divided into several sub-sections based on their topic. These include low-power hardware and software design, energy harvesting, energy storage, energy management, and low-power communication and protocols.

It might happen that the cited literature covers multiple of these aspects or even the complete design of an IoT ecosystem. In such cases, the cited publication is presented in connection with aspects in which we consider it to have the most significant contribution.

A. Low-Power Hardware and Software Design

Trends in ultra-low power, ultra-low voltage, and ultra-low leakage hardware are presented in [14]. The authors of [15] demonstrate a complex system with multisource EH, but interestingly, they use algorithms to predict energy availability for given node locations, calling it the *PERPS project*. In [16], an interesting algorithm is presented, which plans the energy consumption accumulated in a supercapacitor. The important aspect of this is that the algorithm considers the non-ideal properties of the used supercapacitor, considering its leakage current. This technology belongs to those that have potential use in our project.

B. Energy Harvesting

In [17], the authors present a very comprehensive overview of EH technologies. The paper also includes a very useful table showing the approximate expected power density for various types of EH devices, including their advantages and disadvantages. This is very useful for those of our partners who have not yet been given the opportunity to work with any EH technologies. In [18], the analysis of piezoelectric EH device is presented that use vibrations to power wearable sensors. Vibrational EH is also used in [19], where the authors present an analysis of their use on noise cancellation barriers in traffic. The paper [20] presents the *Radio Frequency* (RF) EH for collecting energy from ambient radio waves. The paper also presents related work in a very handy table, stating the efficiency achieved for various frequency bands, including the power of the main sourcing transmitters. The results presented in previous publications on vibrational and RF EHs could be potentially used to compare solutions developed within the LoLiPoP-IoT project. In paper [21], the approach called *nantenna* is used to collect energy from sunlight. The authors of [22] demonstrate the EH from a waste thermal energy, including a proof-of-concept and its detailed measurements. In [23], a very interesting approach is presented of super-thin solar panels that can transform any surface to collect energy. A very unusual EH method is presented in [24], which collects energy from biofuel bacteria. This is a very interesting approach; however, our consortium, to the best of our knowledge, does not plan to use similar approaches. A very promising approach of combining energy from a (possibly arbitrary) number of multiple EH devices is presented in [25].

C. Energy Storage

In [26], the authors present a comparative study of lithium-ion batteries and supercapacitors. In [27], an approach that saves battery life is presented, which uses lithium-polymer batteries and supercapacitors. Although it is meant for kinetic EH applications, it can serve as a demonstration for other EH applications as well.

D. Energy Management

In [28], a study analyzes the unpredictability of EH sources in relation to the energy needs of the appliance. A model is presented that minimizes the disproportion of the energy harvested and required by the device. The authors of [29] present an approach that allows for separation between idle and active mode energy paths. This approach is useful for unpredictable energy sources and allows for increased efficiency, as the authors present in their simulation. In [30], the *Maximum Power Point Tracking* (MPPT) solar panel energy management with 96% efficiency is presented. The authors used simulation to find the optimal configuration. In paper [31], the piezoelectric vibrational EH for car tires is presented. However, it uses a new active energy balancer for supercapacitors, which are used to store the harvested energy. All of these publications are very informative, and the research provided in them can be helpful either as a state-of-the-art to improve or as a source of knowledge to use in the project.

E. Communication and Protocols

The authors of [32] present a comprehensive analysis of the protocol stack for devices with limited resources and power. They focus on the efficiency, reliability, security, and light nature of the protocols themselves. The study mentions protocols on different layers, particularly application layer protocols (e.g., MQTT, XMPP), network layer protocols (e.g., IPv6), and data-link layer protocols (e.g., BLE, Z-Wave). In [33], the power analysis of a WSN is presented that uses ZigBee on the data link layer to communicate. In addition, approaches that can save energy in ZigBee WSNs are discussed. In paper [34], the NB-IoT protocol is discussed as a possible candidate for aviation applications. In addition, the authors tested the power consumption in different use cases. The authors indicate that battery life can be extended to the magnitude of years by utilizing proper energy-saving mechanisms. A low-voltage and low-power RF receiver is presented in [35]. It uses the power of $45\,\mu\mathrm{W}$ at the voltage of $0.35\,\mathrm{V}$. In our project, we target mainly already-standardized communication protocols, as we need to ensure compatibility between the current nodes and communication gateways but also between the current nodes and possibly newer gateways. Thus, research aimed at standardized communication is significant for us. However, for us, research on non-standard protocols is beneficial for a basic comparison of the energy requirements of communication protocols.

III. The LoLiPoP-IoT Project

The following section provides a brief overview of the LoLiPoP-IoT project. Many things are simplified, but as a whole, a reader should be able to create a picture of the main targets of the project as well as the application domains of the conducted research.

The aim of the LoLiPoP-IoT project is to design futuristic and novel advanced EH and micro-power management solutions that can empower long-lasting WSN sensor devices. These will be retrofitted onto or near the monitored equipment and infrastructure. These sensors serve as pivotal technology platforms for data collection, enabling anomaly detection, efficiency enhancement, and performance monitoring, thus enhancing the potential of the trillion-sensor economy projected for 2025. The use of the collected data promises unprecedented opportunities, potentially saving billions of euros, reducing carbon emissions, and increasing the use of renewable energy, thus delivering benefits across various industries.

A. Application Domains

The LoLiPoP-IoT addresses challenges in three core functionalities targeting three application domains:

Asset Tracking: In the context of the factory environment, asset tracking facilitates production flow optimizations and also manufacturing throughput management. It enables the identification of bottlenecks, resulting in notable reductions in production cycle time and inventory costs. In this context, the registration and search of moving properties also helps to save time and thus reduce costs. In smart mobility contexts, asset tracking helps to minimize loss, theft, and downtime while optimizing transportation cycle times and reducing energy consumption and carbon footprint.

Condition Monitoring and Predictive Maintenance: Allows for continuous monitoring of the equipment and machinery parameters (e.g., vibrations, temperature, etc.) to detect anomalies that could indicate developing faults. By incorporating the *Industry 4.0* principles, predictive maintenance offers the potential to minimize maintenance overhead and downtime by enhancing operational efficiency and significantly reducing costs.

Energy Efficiency and Comfort Optimization: Using data from sensors allows us to predict and minimize the energy consumption of equipment or even whole buildings. In addition, by optimizing the working environment to suit human needs, a more productive workforce is created in a comfortable environment.

The key digital technologies used in all these application domains are shown in Figure 1.

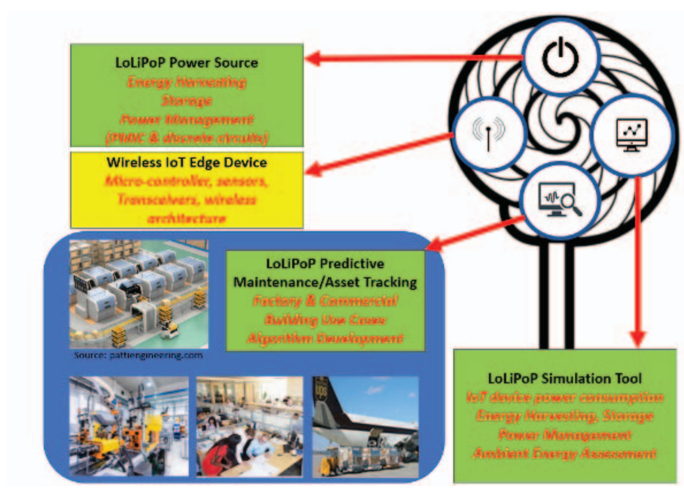

Figure 1. Overview of the key digital technologies in the LoLiPoP-IoT project, taken from [36].

B. Project Challenges and Solutions

Despite the potential benefits, the widespread adoption of IoT sensors faces several challenges, mainly related to limitations in battery life. These include environmental concerns related to battery disposal and the demand for high-resolution data that quickly consumes power resources. Addressing these challenges is essential to unlock the full potential of IoT technology.

To overcome these obstacles, LoLiPoP-IoT proposes a suite of key technologies aimed at extending battery life and enhancing sensor capabilities:

Multi-source EH: Harvesting energy from light, vibrations, electromagnetic fields, and temperature differences to generate electricity for WSN modules.

Ultra-low Power Components and Algorithms: Developing HW and SW (i.e., components and algorithms) that significantly reduce power consumption within WSN modules.

Innovative Architectures for Data Collection: Researching and proposing novel design architectures that minimize power consumption while still ensuring data accuracy and relevance.

Simulation Models: Using advanced modeling and simulation technologies to optimize sizes of EH and energy storage components.

WSN Edge Device Algorithms: Implementing algorithms for asset tracking, condition monitoring, and energy optimization in edge devices is important to further minimize the energy demands needed by otherwise verbose communication.

The strategic objectives of the LoLiPoP-IoT project align closely with key EU initiatives, including the Green Deal, Circular Economy, and the New Industrial Strategy for Europe.

C. Use Case Demonstrations

The LoLiPoP-IoT project includes a wide range of different use cases with specific functionalities and applications. These include both field-based and lab-based demonstrations.

Field-Based Demonstrations: These real-life demonstrations cover asset tracking, condition monitoring, and building energy efficiency and comfort optimization across various industry segments. Specific use cases span through multiple segments.

Lab-Based Demonstrations: These environments for controlled experiments serve as sandboxes for testing and debugging technologies before broader deployment. They enable scalability and interoperability across diverse use cases, facilitating the development of standardized and interoperable technology platforms.

D. The Project Impact

The LoLiPoP-IoT project aims to deliver value in the technologies directly developed as a result of the project and also to enable significant positive value by allowing a whole new class of products and services in the application domains investigated within the project. Last but not least, the project also aims to set a new standard for efficiency and sustainability.

E. The Project Consortium

The consortium of the LoLiPoP-IoT project brings together universities, research centers, and industrial partners. Our collaboration aims to deliver long-lasting WSN nodes for diverse IoT applications. With 41 entities from 10 countries initially involved, including crucial experts in nanoelectronics, EH, energy management, *Machine Learning* (ML), and *Artificial Intelligence* (AI), LoLiPoP-IoT utilizes and, where needed pioneers, advanced technologies to support innovation.

IV. Project Objectives and Methodology

The LoLiPoP-IoT project comprises multiple *Grand Objectives* (GOs). These are to demonstrate impact and propose the measurement of success:

GO 1: Provide long battery life solutions for the trillion sensor economy. It is expected to extend the battery life up to 5 years, typically improving the lasting of batteries to 400% over commercially available solutions. This will be done through research and development of new EH power sources, power management circuits, and advanced system integration techniques.

GO 2: Reduce the number of batteries going into landfills. Fulfillment of this GO can be evaluated by demonstrating a reduction of more than 80% of batteries being replaced in the edge device nodes. This will be done by integrating the technology researched and designed in GO 1 into the project platforms, supported by simulations and modeling.

GO 3: Improving asset tracking, especially for industrial and smart mobility applications. This GO is fulfilled when the ability to track assets in various project use cases, for example, by demonstrating a significant reduction of lost or stolen devices. This GO is addressed by researching new algorithms implemented in the platforms utilized within the belonging use cases.

GO 4: Improving predictive maintenance of machinery and mobile assets – reducing maintenance costs and downtime. To fulfill this, newly created WSN modules should be successfully integrated into existing use cases, and the ability to correctly predict failures from collected data should be demonstrated. This should result in financial savings (e.g., more than 20% of the previous losses). This will be addressed by introducing new ML and AI algorithms in combination with miniaturized sensor nodes implemented into the project use cases.

GO 5: Improving energy efficiency and comfort in buildings. This GO is fulfilled when occupant feedback is demonstrated in related use cases in this project, achieving more than 20% of energy savings in the district heating system of the building. This will be simulated, implemented, and put into practice in the related project use cases.

GO 6: Creating a series of interoperable technology platforms. This GO aims to use key digital technologies across multiple use cases. This will be achieved by a steady specification, using standards and interoperable algorithms.

GO 7: Disseminating scientific results and contributing to standardization bodies and roadmaps. This will be achieved by participating in industrial exhibitions and booths (>4), producing scientific publications in conferences and journals (>40), organizing workshops and webinars (>6), and attending standardization committee meetings or road mapping initiatives. Furthermore, the societal benefits of LoLiPoP-IoT will be disseminated through the project's website, social media, flyers, and newsletters.

V. Project Use Cases

The LoLiPoP-IoT demonstrates its technology in various types of *Use Cases* (UCs). Each of these UCs belongs to one or multiple application domains: 1) Asset Tracking; 2) Condition Monitoring and Predictive Maintenance; and 3) Energy Efficiency and Comfort Optimization. An overview of the UCs can be observed in Figure 2.

A. UC 1: Medical Device Factory Asset Tracking (Pacemakers)

During the production process, BSL Clonmel handles valuable materials and devices, including partially assembled pacemakers. However, these are sometimes misplaced due to human error or intervention, such as incorrect movement between manufacturing cells or temporary storage locations. This can lead to bottlenecks and disruptions in production flow.

To address these issues, the company plans to develop wireless tracking tags with a long battery life powered by EH technology. These tags will automatically detect unauthorized or unusual activity (i.e., push alerts) and provide real-time location information when needed (i.e., pull mechanism). This system aims to ensure seamless operations and enhance security within the facility.

B. UC 2: Medical Device Factory Asset Tracking (Orthopedics)

At present, accurate asset tracking is vital for the digital transformation of Johnson and Johnson's De Puy's (DPS) global supply chain operations. Specifically, the focus is on tracking totes within the orthopedic manufacturing facility, which includes the production of artificial knees and hips.

To address existing challenges in the UC 2, a comprehensive asset tracking system will be implemented. The proposed solution integrates mobile robotics capable of entering physical proximity to assets. This allows for line-of-sight interaction with assets, improving real-time information integration into manufacturing processes, as well as backend inventory and production control systems. Furthermore, to ensure continuity and reliability, a secondary sensory approach is incorporated. In the event of primary sensory technology failure, the secondary approach provides backup support, minimizing disruptions to smart manufacturing processes, and ensuring the validity of information.

C. UC 3: Laboratory Testing

This UC incorporates laboratory testing and is thus not considered an ordinary UC. It is a *sandbox* for system integration and preliminary testing of the LoLiPoP-IoT technology platforms.

D. UC 4: Wireless Air Cargo Asset Tracking

Each year, billions of dollars are lost due to damage or theft of air cargo assets managed by SAT. Due to the urgency of this problem, efforts are made to establish reliable asset tracking as a cost-effective solution to monitor and locate assets. The system will be designed to be retrofitted to existing unit load devices, including standard ARK containers, pallets, and high-value materials.

The proposed solution will involve the development of an energy-efficient platform. This platform will focus on low-power wireless tracking and communication, coupled with light EH technology to prolong battery life to over 10 years for air cargo assets. To optimize efficiency, the system will adhere to three fundamental principles of low-power IoT design: sleeping as frequently as possible, operating or becoming active for minimal duration, and communicating briefly when in flight.

E. UC 5: Paint-dying Facility Condition Monitoring

At the Arcelik factory, processes for the manufacturing of home appliances are handled. Currently, the setup involves the placement of various sensors at different stations to ensure business continuity and regulate factors such as pressure, fluid temperature, and tension of the conveyor belt. However, these are inadequate for maintaining the quality of parts at the end of the production line. In addition, it is necessary to monitor the energy consumption of the system to optimize oven temperatures and electrical usage.

To address these challenges, additional sensors will be installed in the oven. These will leverage thermal energy within the oven itself to power themselves. In addition, measures will be implemented to detect heat leaks in the oven and monitor the input and output temperatures of the burners from the chimney and the entrance of the oven, thus minimizing energy wastage.

Additionally, a range of parameters including electric voltage, current, electromagnetic force, power, friction, and vibration will be monitored using additional sensors. The data collected will be analyzed using predictive maintenance applications to improve efficiency and prevent potential system failures.

F. UC 6: Bearing Condition Monitoring

This use case is about the condition monitoring of an industrial vehicle, primarily powered by an electrical battery, and rotational energy harvesting, mainly through the bearing.

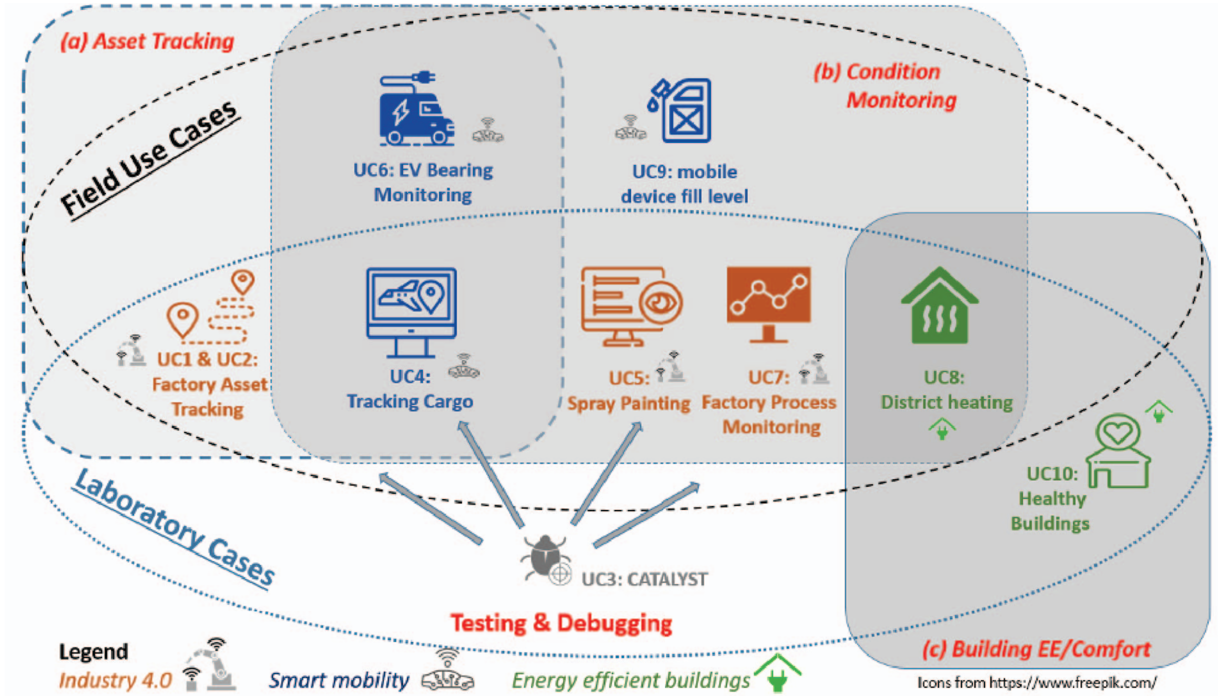

Figure 2. Overview of the LoLiPoP-IoT project use cases, taken from [36].

Smart sensor devices will be developed and mounted with sensors for temperature, vibration, speed, and position, integrated into the wheel bearing or its vicinity. These devices will utilize signal processing capabilities through microcontrollers, all designed based on the physical characteristics of the wheel bearing and hub. They will adeptly harvest energy from various sources, with a special emphasis on rotary kinetic energy to effectively prolong battery life.

To ensure efficient monitoring while minimizing wireless data transmission, unsupervised learning models will be developed to directly monitor the bearing's condition on the edge device. Furthermore, a *Variable Reluctance Energy Harvester* (VREH) will be designed to suit the specific constraints of the smart bearing. The validation of the resulting device will utilize both lab verification and field testing to ensure its reliability and effectiveness in real-world scenarios.

G. UC 7: Process Equipment Monitoring

This application is designed to prevent fermentation or spontaneous combustion processes in bulk containers or silos by continuously monitoring the condition of the material. Unlike intervention systems that detect carbonization gas residues too late, this project uses wireless, energy-autonomous sensor nodes to measure temperature, determine silo fill levels, and monitor CO2 concentration.

The sensors transmit data to a base station located outside the silo. The base station can aggregate data from multiple silos within a plant complex, allowing the initiation of preventive measures such as N2 gas or extinguishing foam flooding based on sensor values that trigger warnings or alarms.

H. UC 8: District Heating Optimization

This application presents a smart heating system designed to seamlessly transition to morning mode, adjusting temperature and integrate smart lighting modules for natural light optimization. An AI assistant forecasts the day's weather and proactively modifies room temperature accordingly. Central energy distributors provide orchestration to prevent consumption spikes.

The system includes an "Away Mode" that activates when rooms are empty, using beacon-type sensors to provide precise data on temperature, humidity, and CO2 levels. This reduces energy costs and also minimizes the carbon footprint. Providing various modes, the system allows remote user adjustments, real-time energy monitoring, and window-opening detection with alarms.

I. UC 9: Lightweight Mobile Tanks Filling Levels (at High Dynamic Motion)

This application focuses on equipping a motorcycle fuel tank with self-powered sensors for temperature, pressure, fuel residues, and precise fill level measurement. Overcoming challenges such as the inability to connect to the on-board network and ensuring ATEX compliance is a priority.

The sensors, housed in the tank lid and in direct contact with the tank atmosphere, must respect to size constraints. Vibration energy harvesting transducers will provide the necessary energy. Data transmission will be achieved through Bluetooth low energy, connecting the sensors to a smartphone.

J. UC 10: Energy-efficient Light Control and Comfort in Healthy Buildings

This use case, centered on building optimization, is divided into three 'sub-use cases'.

UC 10.1: Indoor Environmental Quality, Climate, and Indoor Air Quality: Ensuring thermal comfort extends beyond mere indoor and outdoor temperatures – personal preferences add complexity. Optimizing ventilation in light of real-time filter performance and, for example, COVID-19 considerations can significantly affect both energy consumption and air quality. In addition, the individual setup of the place has the potential to influence the feelings of people in both negative and positive ways.

UC 10.2: Visual Comfort, Personalized Human-centric Lighting control: To achieve energy efficiency in building lighting, dimming strategies based on occupancy and daylight sensing are employed, with the potential for further customization to meet individual needs.

The development of lighting control in buildings entails sensor monitoring of light distribution, prompting inquiries into sensor types, camera resolutions, and performance criteria. Optimizing lighting conditions for individuals involves considerations of visual performance, visual experience, and biological effects.

UC 10.3: Context and Behavior: In addition to traditional physical aspects monitoring, this sub-UC underscores the importance of monitoring and controlling subjective human factors related to well-being and comfort.

In this sub-UC, monitoring data sources that support aspects of human behavior and contextual understanding are studied. This contributes to sub-UC 10.1 (Climate) and 10.2 (Light).

VI. CONCLUSIONS

This paper describes the objectives of the ongoing LoLiPoP-IoT project, whose aim is to investigate, design, and develop innovative *Long Life Power Platforms*. These platforms will maintain longer battery life through lower power consumption, minimizing maintenance, and easing installation by retrofitting them into already existing environments. The project aims to create a comprehensive ecosystem of developers, integrators, coordinators, and users to develop these platforms.

The LoLiPoP-IoT project stated these GOs: 1) Provide long battery life solutions for the trillion sensor economy. 2) Reduce the number of batteries going to landfills. 3) Improving asset tracking, especially for industrial and smart mobility applications. 4) Improving predictive maintenance of machinery and mobile assets – reducing maintenance costs and downtime. 5) Improving energy efficiency and comfort in buildings. 6) Creating a series of interoperable technology platforms. 7) Disseminating scientific results and contributing to standardization bodies and roadmaps.

These GOs are to be implemented in various selected practical applications of the LoLiPoP-IoT project, totaling nine use cases. These use cases were chosen to be representative and belong to three main application domains: 1) Asset Tracking, 2) Condition Monitoring and Predictive Maintenance, and 3) Energy Efficiency and Comfort in Buildings.

The expected impacts of the LoLiPoP-IoT project include: 1) Extending the average battery life from approximately 18 months to over five years. 2) Decreasing maintenance overhead for mobile and fixed assets from over 30% to below 15%. 3) Lowering costs associated with asset location by approximately 100K Euros annually per use case. 4) Enhancing asset flow, management, and throughput by identifying bottlenecks, resulting in reductions exceeding 10% in production time, cycle time, and inventory costs. 5) Enhancing the comfort and well-being of building occupants while simultaneously reducing energy consumption by more than 20%. 6) Generating revenues exceeding 10 million Euros annually for LoLiPoP-IoT industry partners providing asset tracking and condition monitoring services.

The strategic objectives of the LoLiPoP-IoT project closely align with key EU initiatives such as the Green Deal, Circular Economy, and the New Industrial Strategy for Europe.

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