

RESEARCH - TECHNOLOGY - INNOVATION

FOR SUSTAINABLE GROWTH

Internet of things and ethical decision - making

The complex process of ethical decision-making in smart IoT ecosystems for elderly people and what a relevant publication brings to surface



Contents

- 2** | SAFETY IN AUTONOMOUS VEHICLES: CERTH'S AUTOMATED PUBLIC TRANSPORT ACHIEVEMENTS ON THE EU INNOVATION PLATFORM
- 5** | INTERVIEW: AN "ETHICAL" INTERNET OF THINGS?
- 9** | SOLAR ROADWAYS AND GREEN ENERGY IN THE FUTURE
- 11** | DISTINCTION FOR CERTH IN ELECTROCHEMICAL ENERGY STORAGE AND WASTE TREATMENT TECHNOLOGIES
- 15** | CERTH|INAB APPOINTED AS THE NATIONAL REPRESENTATIVE OF GREECE IN THE EUROPEAN CLINICAL RESEARCH NETWORK ECRIN|ERIC
- 17** | BIKEATHON FOR THE ENVIRONMENT
- 19** | PROSPECTS FOR MITIGATING THE ENVIRONMENTAL IMPACT OF MILK PRODUCTION



The research team of CERTH: Antonios Lalas, Konstantinos Votis, Dimitrios Tzovaras, Anastasios Vafeiadis, Evangelos Athanasakis, Theoktisti Marnopoulou, Dimitrios Tsiktsiris

Safety in autonomous vehicles: CERTH's automated public transport achievements on the EU Innovation Radar

Six partners participating in the EU-funded AVENUE project (Autonomous Vehicles to Evolve to a New Urban Experience) –the Centre for Research and Technology Hel-

las among them- have been listed on the [EU Innovation Radar Platform](#) for their innovations in the field of autonomous mobility.

The Innovation Radar focuses on identifying leading-edge innovations being developed in EU-funded research projects and the key innovators behind these achievements.

The innovations were assessed by the JRC's Market Creation Potential indicator framework as having a **“Very High”** and **“Noteworthy”** level of **Market Creation Potential** correspondingly.

In particular, in the framework of the AVENUE project, the research team of the Visual Analytics Laboratory (VALab), and the Virtual and Augmented Reality Laboratory (VARLab) of the Information Technologies Institute of CERTH, consisting of Dimitrios Tsiktsiris, Anastasios Vafeiadis, Theoktisti Marinopoulou, Evangelos Athanasakis, Eleni Diamantidou, Antonios Lalas, Konstantinos Votis,

Dimitrios Tzovaras, was distinguished in the category **“Market Ready”** for the two following innovations:

- In-vehicle safety services framework to enhance security, trust and passengers adherence to use autonomous mobility
- Self-learning transport organization including personal data protection

It is worth mentioning that

the innovations were assessed by the JRC's Market Creation Potential indicator framework as having a **“Very High”** and **“Noteworthy”** level of **Market Creation Potential** correspondingly.

More information is available in the following links:

<https://www.innoradar.eu/innovation/42884>

<https://www.innoradar.eu/innovation/42879>

In-vehicle safety services and self-learning transport organization including personal data protection, were the two awarded innovations of the Information Technologies Institute of CERTH



An “ethical” Internet of Things?



The revolutionary entry of the **Internet of Things (IoT)** into the technological world has developed a new dimension in the way physical objects are connected and interact with each other with the aim of creating intelligent services and applications without human intervention. In the healthcare sector in particular, Internet of Things technology promises to create innovative services to improve **the quality of life** and address health issues related to the **aging population**.

However, despite its undoubted utility, the use of the Internet of Things may raise issues of ethics, security and data integrity as well as challenges related to data privacy.

In particular, the use of this technology in large-scale pilots for the independent living of elderly, needs special planning and management, based on the well-known principles "ethics by design" and "security by design", which is reflected in decisions in accordance with the principles of Ethics and Ethical decision-making.

Exactly these ethical dimensions, which are required to characterize every action and decision regarding the use of large-scale data, are studied in the recent publication made within the framework of the ACTIVAGE research project and published in the scientific journal MDPI Healthcare (Impact Factor 2.645, with the title: "Ethical Decision Making in IoT Data Driven Research: A case study of a large scale pilot".

Sofia Segkouli, Kostas Votis and Antonis Voulgaridis, researchers of the Centre for Research and Technology

Hellas (CERTH) and main authors of this article, together with a heterogeneous scientific group of research project partners, studied the importance of defining a framework of ethical decision-making that concerns the management of sensitive medical data, which will be in line with basic principles of Ethics and ethical decision-making such as privacy, transparency, trust and justice, which are required to be applied in systems related to Healthy Aging and the Internet of Things.

In what way do the solutions provided by the Internet of Things technology contribute to the healthcare sector and more specifically to the active and healthy aging of the population?

Sofia Segkouli: The technology of the Internet of Things and the provision of digital health services has demonstrated in recent years its special benefits for active and healthy aging. In particular, within the framework of the European project ACTIVAGE solutions based on this specific technology were developed to support integrated health care services. The ACTIVAGE system managed to

reduce the need for elderly patients to make frequent visits to clinics or hospitals, with the goal of easing the burden on patients and their caregivers, reduce the cost of care for patients with chronic diseases, and ultimately providing better coordination between the healthcare providers involved.

What were the reasons for writing this article?

Sofia Segkouli: On the one hand, the main reasons were the research interest presented by the ethical and security issues. On the other hand, the investigation and analysis of the practices and tools used in

the context of ethical decision-making in smart IoT ecosystems for the elderly. Essentially, it is not only about organizational and management tools, that comply with the “system” of ethical principles and values as defined by European directives and were used for the needs of the large-scale pilot research of the ACTIVAGE project, but also for the formation of a wider ethical methodology for researchers and scientists which emerged through participatory and deliberative processes.

“ The research interest presented by the ethical and security issues regarding the IoT technology, was one of the main reasons, that led to this publication, Dr. Sofia Segkouli, Research Associate, Information Technologies Institute of CERTH

What was the core of this publication and what conclusions did you reach;

Antonis Voulgaridis: The presentation of the successful completion of a broad research work, which dealt with the complex process of ethical decision-making in smart IoT ecosystems for elderly people living alone. The results of the research reveal that among the most important factors of the proposed model of ethical decision-making and implementation were the participatory and deliberative processes that had to take place between the involved bodies at an international level with the aim of

effectively implementing basic ethical values such as privacy, transparency, trust and security of the personal data of the elderly as well as their carers or doctors. In addition, the special circumstances that took place during the pandemic period, during which the ACTIVAGE system was implemented and tested, demonstrated the need for the use of remote support and monitoring technologies for the elderly, thus emphasizing the importance of defining and implementing an ethical decision-making framework for management of sensitive personal and medical data, such as the one presented in this publication.



From left to right: Dr. Segkouli, Antonis Voulgaridis Dr. Kostas Votis

“The special circumstances, that took place during the pandemic period, demonstrated the need for the use of **remote support and monitoring technologies for the elderly**, Antonis Voulgaridis, Research Associate, Information Technologies Institute, CERTH

Where are we today in terms of defining such an appropriate framework that will ensure the issue of ethics in decision-making in IoT systems for the elderly?

Kostas Votis: In recent years, the importance of ethical decision-making and management of sensitive personal data has been highlighted and analyzed in the same way as it was once the case with issues of gender

or the environment. However, and although it is already considered a particularly important dimension, it is relatively new, which means that there are still some objective questions that ethical decision-making cannot yet clearly answer. The central aim of the ACTIVAGE project and specifically of this publication is to try to analyze and answer these questions by proposing a comprehensive ethical framework,

which has been implemented in large-scale pilots and includes both theoretical and practical tools and methodologies. However, such a framework, which concerns technologies that have entered our daily lives relatively recently, must evolve and take into account similar policies of ethical conduct while at the same time ensuring in every way possible the protection of user rights and privacy.

“ Despite the fact that in the recent years, **the ethical decision-making is considered a particularly important dimension**, there are still some objective questions, that it cannot yet clearly answer, Kostas Votis, grade C' Researcher, Information technologies Institute, CERTH

What is your personal desire regarding the adoption of mechanisms that will take into account the ethical dimensions surrounding the use of Internet of Things technology in the healthcare sector?

Sofia: The desire of every person engaged in research can be summed up in the words of a moralist "Integrity without knowledge is weak and useless, and knowledge without integrity is dangerous and terrible", Samuel Johnson. It is precisely this ethical integrity that I wish and hope to be included in the behavior and actions of every researcher

especially when it comes to handling sensitive data through cutting edge technologies such as the Internet of Things.

Antonis: Given the ever-evolving nature of IoT technology as well as the risks hidden behind its use, I consider it particularly important the early and universal adoption of a framework for the protection and respect of users' rights, which will keep in line with the modern technological trends while also give the proper attention in the area of cyber security and specifically the secure use and management of sensitive information.

Kostas: Internet of Things technology has now entered our daily lives for good. I therefore consider it necessary to implement the appropriate ethical framework that will allow the safe use of technology, always taking into account the need for continuous adaptation, improvement and evolution. Such a framework must be applied to both the research and production side, in order to ensure the safe use of IoT technologies while at the same time making full use of the enormous potential they offer.



Copyright @CERTH

Solar roadways and green energy in the future

In the energy transition, photovoltaic systems at existing highway underpasses offer a new path for Europe, transforming its economy into one that is contemporary, competitive, and resource-efficient. The technolo-

gy of solar systems constantly captures the interest of scientists, businesses, as well as political actors at the same time as communities become denser, increasing their energy needs. In response to these demands, the research project

"SELAS" developed an integrated system of management and intelligent distribution of energy from photovoltaic data that would be utilized to power significant roadway sub-structures.



The innovative system “SELAS”

A smart management platform that gathers and processes data on the production of electrical energy from photovoltaics, the consumption of the load that needs to be powered, environmental data, the charge level of the accumulators, and

data on circulation conditions supports the function of the pioneering system "SELAS." The energy consumption may be predicted as well as the likelihood of mistakes in solar systems and accumulators by using advanced forecast, management, and optimization algorithms. The platform offers

the potential for additional development, the addition of more management orders, and the introduction of more application scenarios. This fact makes it a crucial visualization tool for toll booth energy and non-energy data, as well as for error prevention and quick information.



Copyright @CERTH

Pilot Field (Egnatia Odos)

The project's implementation saw the first-ever usage of photovoltaic designs on a global scale, allowing for the production of electricity at night while effectively utilizing both ambient and passing-car lights. Therefore, this will result in continuous energy production.

The new generation photovoltaics (DSSCs) research findings at Democritus' labs were significant. The results demonstrated that when the actual conditions of low lighting and weather pilot conditions throughout the night were replicated, sufficient energy production was obtained in addition to an increase in their understanding of the current layouts in other research centres.

So, traditional photovoltaics, which will work better throughout the day, became the subject of research. Energy accumulators called "Sunlight" were developed in partnership to help the SELAS project and can function in adverse weather conditions.

Reduction of the environmental imprint and creation of new working positions

The major roadways are anticipated to gain a lot from the SELAS project. Among those advantages are the reduction of their environmental impact through the creation of renewable energy, the lowering of the cost of electricity supply, and the further promotion of energy-saving through the intelligent management

platform.

Concurrently, its role is about to be strengthened even further by the establishment of high-skill jobs, the decrease in insurance payment costs brought on by traffic accidents and the installation of warning signs in at-risk areas (supported by the SELAS system).

The transmission and energy sectors will be strengthened with new contemporary technology, increasing their competitiveness and ability to follow the "green line," which was engraved by the European Union for an emission-free future.



3D printed cases for the pVs

“ SELAS system will transform current roads into green energy zones and innovation hotspots, that will serve as a shield for the environment

Dimosthenis Ioannidis, grade C' researcher, Information Technologies Institute, CERTH



The technological contribution of CERTH

The Center for Research and Technology Hellas (CERTH), the project's coordinator has made a significant technological contribution. CERTH specifically created the SELAS system design as well as the prediction algorithms (energy requirements, faults, varied usage situations, etc.) that were

later incorporated into the system's intelligent management platform.

In addition, the team members actively took part in all stages of the hardware system's development, from early prototypes to the final pilot system, and they made sure that all systems, local and distant, were effectively connecting with one another. It is signifi-

cant that the support mounts for the PV collectors were built by the EKETA/ITI 3D printing facility. *"The SELAS system will transform current roads into green energy zones and innovation hotspots that will serve as a shield for the environment,"* said Dimosthenis Ioannidis, grade C' researcher at the Information Technologies Institute of CERTH and coordinator of SELAS.

The entire joint venture was crucial to the development of SELAS, which in addition to CERTH also consists of EKEFE Democritus, and Sunlight. The Greek government and the European Union have been funding the SELAS project through the ESPA 2014-2020 and European Regional Development Fund for the past 36 months.

Distinction for CERTH in electrochemical energy storage and waste treatment technologies

The series of Panhellenic Scientific Conference on Chemical Engineering which has been held since 1997 alternatively in Patras, Thessaloniki and Athens, has become the major, established scientific event for the Greek community of Chemical Engineers, active in Greece and abroad.

The 13th Panhellenic Scientific Conference on Chemical Engineering was held in Patras on June 2-4, 2022. Approximately 900 participants joined the event while 480 contributions were presented (200 posters and 280 oral presentations) distributed in ten thematic areas.

480 contributions were presented during the conference

All contributions were evaluated by reviewers during the conference, and at the conference closing ceremony, the best 10 poster and 10 oral presentation contributions (one per thematic area) were awarded.

The Chemical Process and Energy Resources Institute (CPERI) of the Centre for Research and

Technology Hellas (CERTH) had two distinctions in the 13th Panhellenic Scientific Conference on Chemical Engineering.

The paper entitled “**Steam electrolysis in Pressurized Solid Oxide Cells**” by Maria Eleftheria Farmaki, Kalliopi Maria Papazisi, Dimitrios Tsiplakides and Stella Balomenou was awarded as best poster in the thematic area of Electrochemical/ Electrocatalytic Processes. The study concerns the development of an innovative pressurized, solid oxide steam electrolyzer for space applications suitable for both life support (oxygen production) and fuels production (hydrogen).

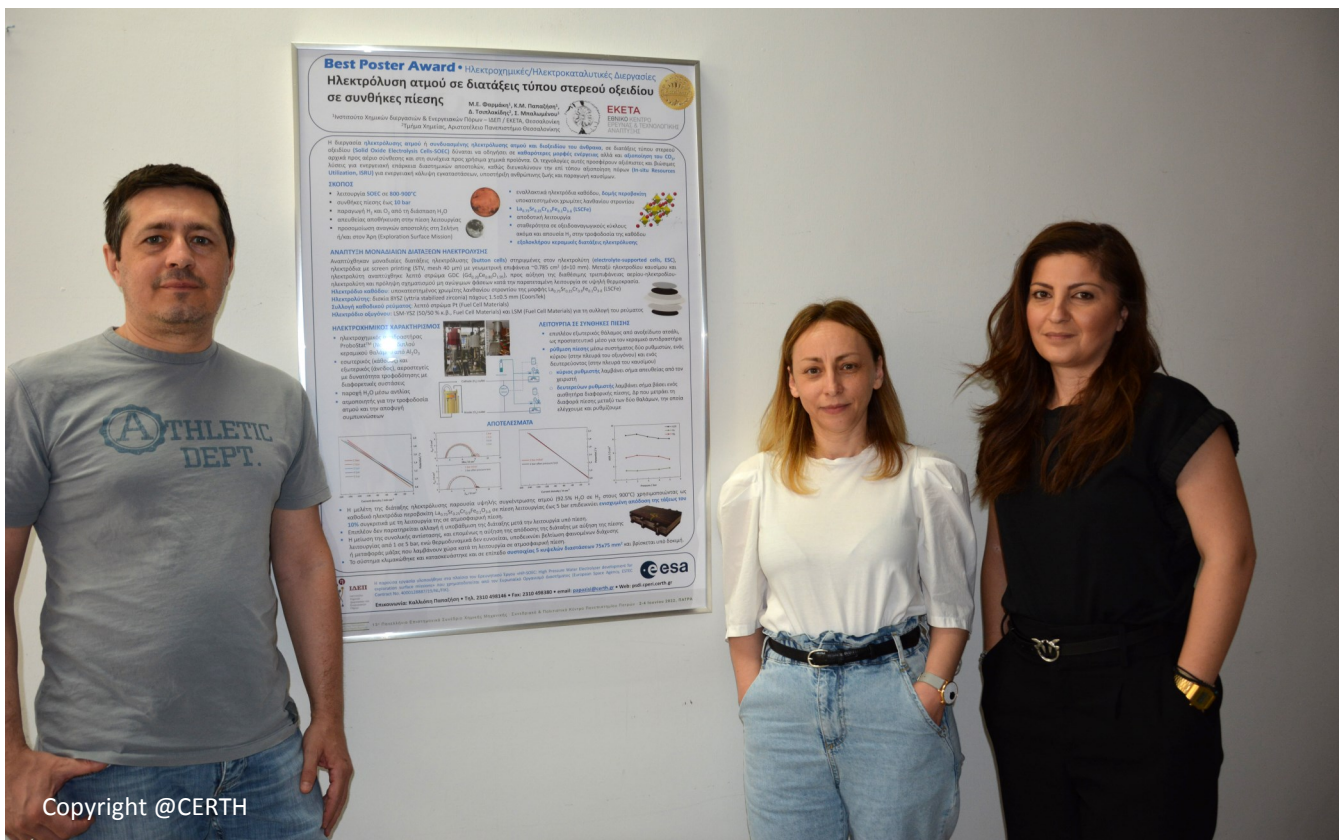
This research receives funding from the European Space Agency under the project entitled «High Pressure Water Electrolyser development for exploration surface missions – HP-SOEC» (European Space Agency, ESTEC Contract No. 4000128887/19/NL/FIK).

The work entitled: "A systematic investigation of lead and sulphate ions removal from aqueous solutions by electro dialysis" by Alexia Voutetaki, Athanasios Papadopoulos, Konstantinos Plakas, Dimitrios Bollas, Symeon

Parcharidis, Panagiotis Seferlis received the best oral presentation award in the thematic area "Waste Treatment and Utilization".

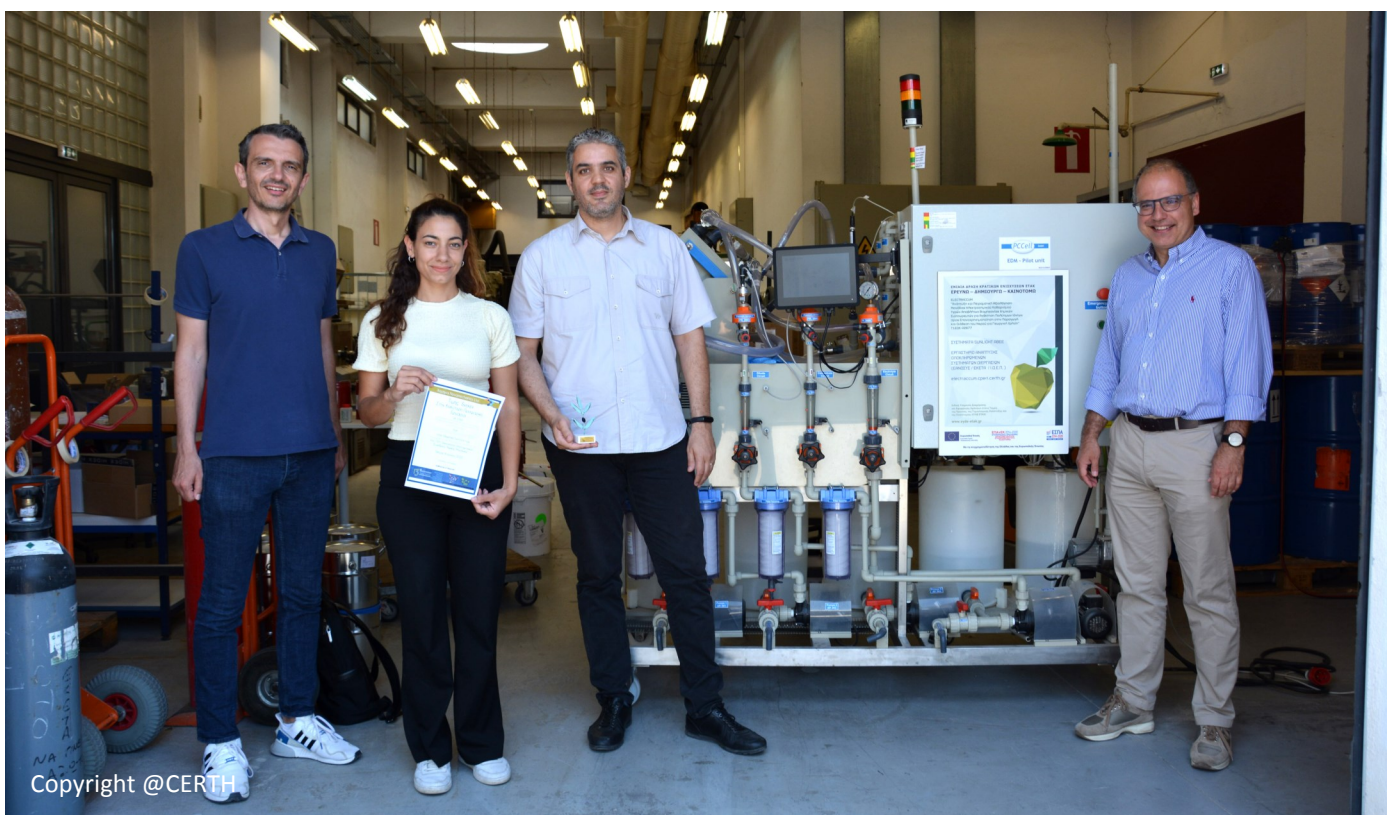
This work concerns the application of electro dialysis, as an alternative electrochemical separation technology based on ion exchange membranes, for the purification of waste effluents and the recovery of valuable ions in lead-acid battery industries.

The work was conducted in the context of the research project “ELECTRACCUM: Development and Experimental Testing of Electrochemical Unit for the Purification of Liquid Effluents of the Chemical Accumulator Industry, Recycling of Valuable Ions and Utilization of Water in Agriculture” with the participation of Sunlight Group Energy Storage Systems company, and has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH–CREATE–INNOVATE.



Copyright @CERTH

The team that received the award in electrochemical energy storage: Dimitrios Tsiplakides, Stella Balomenou, Kalliopi Maria Papazisi



Copyright @CERTH

The team that was awarded in waste treatment technologies : Athanasios Papadopoulos, Alexia Voutetaki, Konstantinos Plakas, Panagiotis Seferlis

CERTH|INAB appointed as the National Representative of Greece in the European Clinical Research Infrastructure Network – ECRIN|ERIC



The European Clinical Research Infrastructure Network (ECRIN) is a not-for-profit intergovernmental organization that supports the conduct of multinational clinical trials in Europe by overcoming current obstacles through the harmonization and interconnection of clinical centers and research organizations. Nine

European countries participate in ECRIN-ERIC as partners; both EU Member States as well as other countries like Switzerland and Norway (<https://ecrin.org/who-we-are/members-observers>).

On Wednesday, May 4th 2022, at the premises of the Centre for Research and Technology Hellas, a Work-

ing Meeting with Jacques Demotes, General Director of ECRIN, was held, regarding the participation of the Institute of Applied Biosciences of the Centre for Research and Technology Hellas (INAB-CERTH) as National Representative for Greece in the ECRIN-ERIC Network.



During the meeting, presentations were given on the Infrastructure and possibilities of ECRIN, the clinical research actions as well as the Infrastructure of INAB-CERTH, which will be utilized within the context of its participation in ECRIN.

The Working Meeting was attended by representatives of the Ministry of Development and Investments and the General Secretariat for Research and Innovation (GSRI), heads and executives of Academic and Research Institutions, as well as representatives of the pharmaceutical industry. During the meeting, presentations were given on the Infrastructure and possibilities of ECRIN, the clinical research actions as well as the Infrastructure of INAB-CERTH, which will be utilized within the context of its participation in ECRIN.

A very constructive dialogue between the participants and the representatives of the

Infrastructure ensued moderated by Kostas Stamatopoulos, Director of INAB-CERTH and Anastasia Chatzidimitriou, Research Director of INAB-CERTH. The significant contribution that Greece can have through the integrated plan proposed by INAB-CERTH was recognized. The need to mobilize decision-making mechanisms related to clinical research in Greece was highlighted, in order to capitalize on the comparative advantages of Greece and strengthen its position in this field.

As emphasized by Dimitris Tzovaras, President of the Board of Directors of CERTH, aiming at making clinical re-

search a key lever for the development of both science and economics, CERTH strongly supports the need to link research with clinical practice and harmonize procedures at European and national level and will ensure Greece's active participation in the multinational clinical trials as well as in the ECRIN-ERIC Infrastructure.

Following the Working Meeting, on May 16th 2022 the General Assembly of ECRIN-ERIC decided the participation of Greece as an official member of the Infrastructure. INAB-CERTH will serve as Greece's representative body.

BIKEATHON FOR THE ENVIRONMENT



On the occasion of the World Environment Day on Sunday 5th of June 2022 Bikeathon 2022 “Ride a bike & Go Green” was held in the center of Thessaloniki

URBAN MOBILITY IN FOCUS

On the occasion of the World Environment Day on Sunday 5th of June the Bikeathon 2022 “Ride a bike & Go Green” was successfully held with multiple events aimed to promote the EIT Urban Mobility Regional Innovation Hub Greece which is funded by the European Institute of Innovation and Technology. The Mayor of Thessaloniki, Mr. K. Zervas, the Deputy Head of Development and Environment of The Region of Central Macedonia, Mr. K. Gioutikas, and the Technical Advisor of the Mayor of Thessaloniki, Mr.

D. Mitrou were present at the event.

The Mayor of Thessaloniki, Mr. Zervas, participated in the bicycle ride to emphasize the importance of the enhancement of sustainable mobility in Thessaloniki and highlighted the contribution of cycling to urban mobility as the bike is one of the most sustainable means of transport. He also referred to Innovation in sustainable mobility in Thessaloniki and the participation of the city in the EIT Urban Mobility and also he mentioned the opportunities the EIT UM RIS Hub Greece provides for

municipalities, businesses and citizens in order to create a strong connection and implementation of innovative solutions in urban mobility.

EVALUATION OF URBAN MOBILITY SOLUTIONS AND INFORMATION ACTIVITY FOR THE CITIZENS

At the statue of Alexander the Great, the participants had the chance to learn more about urban mobility solutions that are implemented in other cities and they also could evaluate these solutions and possible implementation of them in the city of Thessaloniki.



Image 1 left: G. Voulgaroudis, in the middle: Dr. Georgia Ayfantopoulou, Mr. K. Gioutikas , right Mr. N. Giannoulides,
Image 2 right: The beginning of BIKEATHON



“ Through the EIT UM RIS Hub Greece, the conditions are created to support and accelerate entrepreneurial solutions for urban mobility, providing financial support and enabling the implementation of these solutions not only locally but also internationally, Dr. Georgia Ayfantopoulou, Research Director and Deputy Director of CERTH|HIT.

With the presence of the Deputy Head of the Development and Environment Department of The Region of Central Macedonia, Mr. K. Gioutikas and the Technical Advisor of the Mayor, Mr. D. Mitrou, and the CEO of BRAINBOX S.A. Mr. G. Voulgaroudis, HIT/CERTH held an event to inform the citizens of the activities of the EIT UM RIS Hub Greece and the solutions that have been implemented and will be implemented in Thessaloniki.

The EIT Urban Mobility RIS Hub Greece aims to fund and support Municipalities for the implementation of sustainable solutions that will address the mobility challenges in the urban environment.

“Through the EIT UM RIS Hub Greece, the conditions are created to support and accelerate entrepreneurial solutions for

urban mobility, providing financial support and enabling the implementation of these solutions not only locally but also internationally”, underlined Dr. Georgia Ayfantopoulou, Research Director and Deputy Director of CERTH|HIT.

Therefore, with the strong connection that the EIT Urban Mobility RIS Hub Greece seeks to develop, every citizen has the opportunity to be informed and actively participate in the development of the city by taking part in events such as the Bikeathon 2022 "Ride a Bike & Go Green" but also to be a part of the solutions that are being tested or implemented and to draw the attention of the competent bodies to the key issues of mobility.

The Bikeathon was concluded

successfully at the statue of Alexander the Great, where a painting competition took place, which revealed three winners. In addition, the participants of the bicycle ride had the opportunity to participate in a draw in which they won great awards.

The Bikeathon 2022 "Ride a Bike & Go Green" was co-organized by Euroconsultants S.A., which coordinates the EIT UM RIS Hub Greece, the HIT/CERTH, which is the technical coordinator of the EIT UM RIS Hub Greece, the Aristotle University of Thessaloniki, Alexandria Innovation Zone S.A., and Venture Stories Partners.

Prospects for mitigating the environmental impact of milk production



Rising concerns about global warming and climate change have led to the implementation of effective emission reduction policies both at European and international level. European Union has set itself

ambitious targets for decreasing the greenhouse gas emissions and addressing the risks of climate change in key sectors. However, the transition towards a circular economy, especially with regard to the

agricultural and livestock sectors, is a challenge. The focus on these two sectors is comprehensible, given the high contribution of dairy farming practices to global warming.



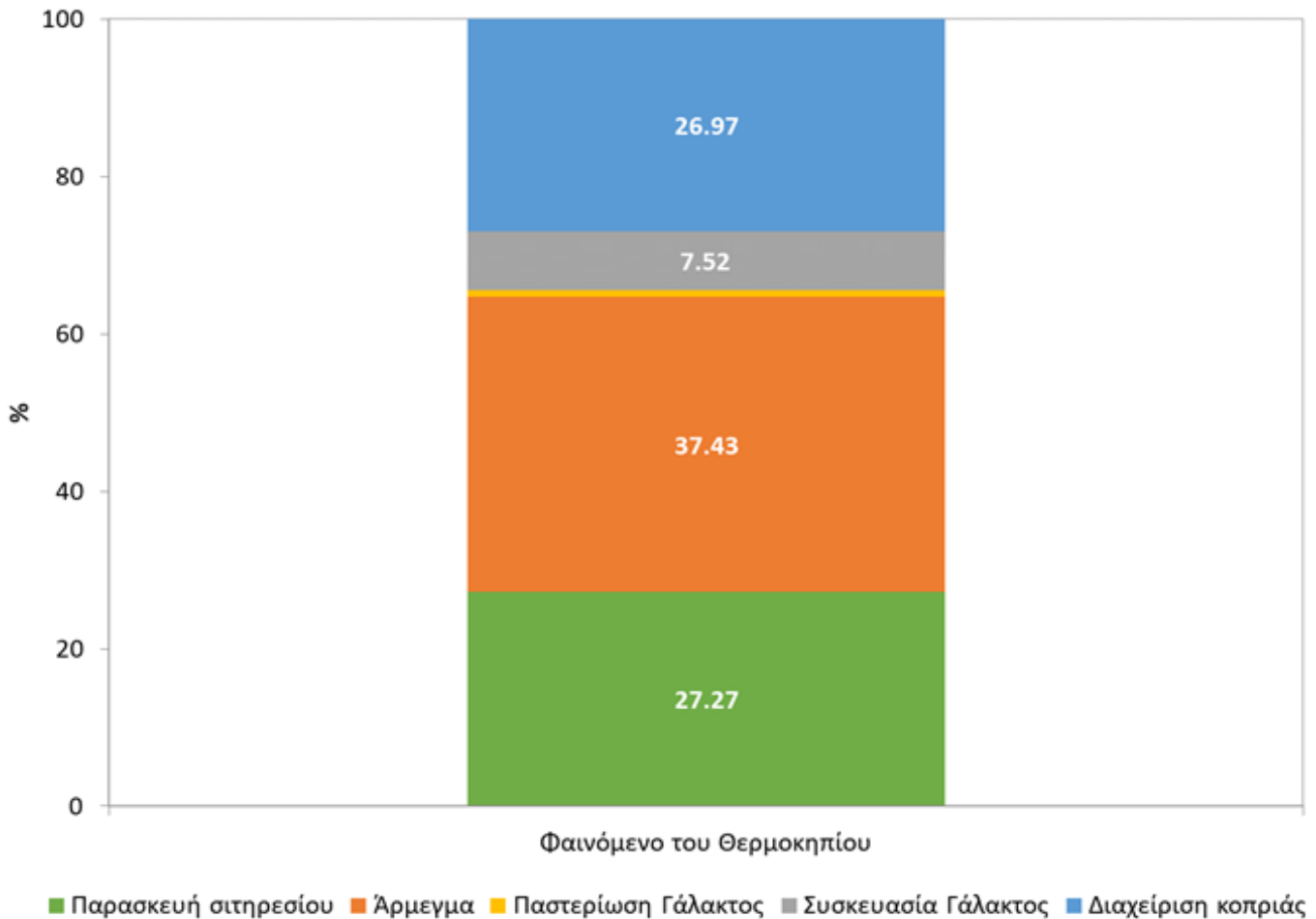
Flow diagram of milk production and processing

Life Cycle Analysis (LCA) methodology identifies opportunities and effective practices that could serve as a basis for decision-makers to plan their milk value chain activities more efficiently

BIOCIRCULAR focuses towards developing a circular economy system in dairy industry by employing the Life Cycle Analysis (LCA) Methodology. This methodology identifies opportunities and effective practices that could serve as a basis for decision-makers to plan their milk value chain activities more efficiently, with the dual aim of mitigating their carbon footprint and achieving long-term sustainability.

LCA allows the assessment of the potential environmental impacts of a product or a system across all its life cycle stages, i.e., from raw materials extraction and manufacturing process to distribution and use, and final, end-life, waste treatment/disposal. The guidelines for conducting LCA are in accordance with the relevant ISO International Standards 14040 and 14044.

The integrated LCA system developed in the framework of BIOCIRCULAR project takes into consideration the following steps: (i) crop production (maize cultivation), (ii) animal feed production (maize silage), (iii) feeding cows and milk production, (iv) milk pasteurization and packaging, and (v) animal waste (manure) management.



Percentage shares of milk production and processing in Global Warming Impact Category

LCA results indicate that the total GHG emissions for the production of 1 kg of FPCM – Fat and Protein Corrected Milk amounts to 2.2 kg CO₂ equivalent. Having addressed the entire life cycle of milk production, it can be concluded that the *milking process* is the most significant contributor to GHG emissions (~37%). This is mainly related to the fact that the milking process is energy intensive (e.g., electricity consumption for the operation of milking machines, fans, etc.); the energy

demand consists of energy mainly generated with conventional fossil fuel resources. The next significant contributor to the GHG emissions is the *animal feed production process* (27.27%), followed by the *manure management* (26.97%). In animal feed production, the highest adverse impact comes from maize cultivation for the silage production (e.g., use of nitrogen-based fertilizers, use of fossil fuels for soil preparation and other applications, electricity re-

quirements for irrigation, etc.). On the other hand, the carbon footprint of manure management is associated with the CH₄ emissions from enteric fermentation and indoor manure storage for several months.

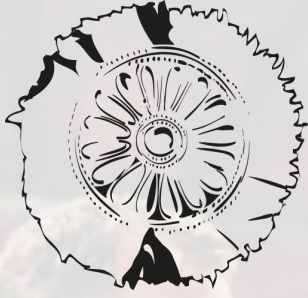
The stage of *milk packaging* is associated with much lower environmental impacts (about 7.5%) as compared to the milk production process, whereas adverse impacts of *milk pasteurization* were found to be negligible (<1%).

Different strategies could be adopted for mitigating the environmental impact of the milk production process, including: (i) the implementation of energy efficient practices and/or clean energy technologies in the entire milk value chain, (ii) the utilization of eco-friendly (e.g., recyclable) packaging, (iii) the implementation of efficient cultivation practices, and (iv) exploitation of methane produced throughout the anaerobic digestion process as an alternative energy source. It is worth mentioning that the implementation of renewable energy technologies in the entire milk production chain could lead to significant decrease in GHG emissions of the order of 30%.

Five partners are involved in the implementation of BIOCIRCULAR; (i) American Farming School, (ii) the Centre for Research and Technology Hellas (CERTH), (iii) Aristotle University of Thessaloniki with the Laboratory of Animal Husbandry of the School of Veterinary Medicine and the Laboratory of Agronomy of the School of Agriculture, (iv) Engineers for Business (EfB), and (v) Ergoplanning Ltd. CERTH participates with two Institutes, i.e., the Institute for Bio-economy and Agrotechnology (iBO) and the Chemical Process & Energy Resources Institute (CPERI). CPERI contributes to the project by providing its know-how and expertise in the fields of Life Cycle Assessment for circu-

lar agriculture. More specifically, it is responsible for the development of the LCA algorithms to be applied in small-medium vertical production dairy farms.

The project “Bioproduction System for Circular Precision Farming (Biocircular)” is co-funded by the European Regional Development Fund and is materialized in the framework of the Operational Programme Competitiveness, Entrepreneurship, and Innovation (EPAnEK). Biocircular will be finalized by August 2022. More info on the project can be found at its webpage (<https://biocircular.gr/#>).



CERTH

CENTRE FOR
RESEARCH & TECHNOLOGY
HELLAS

The **Centre for Research and Technology-Hellas (CERTH)** founded in 2000 is one of the leading research centres in Greece and listed among the TOP-15 E.U. institutions with the highest participation in competitive research grants.

Today CERTH includes the following five institutes with indicated major fields of research:

- **Chemical Process and Energy Resources Institute (CPERI)** Sustainable & Clean Energy, Environmental Technologies, Chemical & Biochemical Processes, New Functional Materials
- **Information Technologies Institute (ITI)** Informatics, Telematics and Telecommunication Technologies, Safety and Security
- **Hellenic Institute of Transport (HIT)** Smart Sustainable Mobility, Transport Safety
- **Institute of Applied Biosciences (INAB)** Agri-biotechnology, Health Translational Research, Informatics for big bio-data
- **Institute for Bio-Economy and Agri-Technology (IBO)** Bio-economy, Agri-technology

