

International Symposium and Workshops

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# Sustainable Solutions at Times of Transition (SuST)

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14-17 July 2022, Nisyros Island, Greece

Program • Book of abstracts

<https://susteu.com/>



## *Welcome Address*

**A**s Chairperson of the International Symposium and Workshops **'Sustainable Solutions at Times of Transition (SuST)** and on behalf of the Mayor of Nisyros (host of the Symposium), chairpersons and organizers, it is my great pleasure and honor to welcome you to Greece and especially to the island of Nisyros in the Aegean Sea.

In this time of growing ecological and humanitarian crises, when the COVID-19 pandemic exposed the ecological vulnerability of our global systems, and the unprovoked invasion of Ukraine is a re-telling of an old story of conquest and control that ends in murder, ruin, refugees, and resources catastrophe, there is an urgent need to integrate peace, well-being, ecological sustainability, resilience, and equity into all levels of society and education.

The Symposium and Workshops will be held on Nisyros, a small Greek volcanic island in the Aegean Sea, as a paradigm of areas where the access to and supply of resources are limited and under pressure, and where the cultural heritage and old knowledge are very valuable for societal resilience.

We will bring together experts, researchers, academics, engineers, practitioners, and designers for an increased socio-ecological awareness in the context of climate change, and for discussing sustainable solutions for the ecological challenges of “vulnerable communities” in which food, water, and energy resources are under serious threats.

We have the pleasure and honor of having with us as keynote speakers: Prof. **Jeffrey Sachs** from Columbia University, US and SDSN president; Prof. **Mat Santamouris** from the University of New South Wales, Sydney, Australia; and Prof. **Don Huisingh** from Tennessee University, the Emeritus Editor-in-Chief of the Journal of Cleaner Production.

The participants are kindly invited to constructively contribute to the technical and socioeconomic dimensions of sustainable solutions. We invite you to discuss and approach the interrelations of the environment, science, technology, design, with society, sustainability, resilience with an interdisciplinary approach.

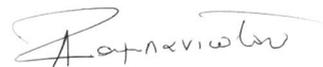
The scientific program is structured as a Symposium and Workshops. The Symposium was designed to promote a scientific dialogue with keynote speakers and senior invited speakers, to support sustainability, based upon ethically and ecologically sound paradigms, practices, and policies at the local, Mediterranean, European, and global scales. The technical, socio-economic, ecological dimensions will be addressed in the context of “Sustainable Solutions at the Times of Transition.” The Workshops will address topics of the utmost scientific and practical importance such as Circular Economy, Bioeconomy, and case studies, all of which will be concluded with plenary discussions.

I would like to acknowledge and express my deep thanks to our keynote speakers, moderators, chairpersons, and all presenters, the scientific committee, the organizing committee, and the Municipality and the people of Nisyros for the support and hospitality. I would like also to thank the Mayor of Nisyros, Prof. **Christofis Koroneos**, who dreams of transforming Nisyros into a place of socio-ecological sustainability, for hosting the event.

I am excited to meet all of you coming from different countries to this very special island in the Aegean Sea, and I am confident that the Symposium and Workshops, being held during the magical Greek summer, will be an unforgettable event for all, create vivid dialogues and strengthen collaborations and friendships!

Nisyros is a small island in the Aegean Sea. It is a peaceful, alternative destination for a simple, natural life and tourism. Its volcano adds an apocalyptic dimension, where one can be inspired and think of human futures on this planet. The picturesque villages with traditional architecture and great views bring us close to the Greek Cultural Heritage. The beaches are clean and have a relaxing atmosphere.

*I wish you a very pleasant stay in Nisyros for a unique, magical, and unforgettable experience in a highly stimulating, natural, blue-and-white environment!*



Professor Anastasia Zabaniotou, Aristotle University Thessaloniki

**Chair of the Symposium**

President-elect of the Mediterranean Engineering Schools Network  
(RMEI-Réseau Méditerranéen des Ecoles d'Ingénieurs)



## *Salutation*

**I**t is an axiom, our lives, our world is always at change. However, the rapid changes that have taken place in the past years, and the transition they bring, can be catastrophic unless concrete action is taken.

The entire world has been in a major transition adjusting to life with COVID-19-life is no longer the same.

The earth environment is rapidly changing and CO<sub>2</sub> emissions keep on increasing. The average annual global greenhouse gas emissions during the period 2010-2019 were at their highest levels in human history. It is extremely important for all humanity to realize that without deep emissions reduction now, our planet will keep on warming up surpassing the 1.5 °C increase level. Unless there is a change of the structure of the economy, unless there is a change in technology we use, unless there is a change in the way we think, life in our planet may cease to exist.

The International symposium we are organizing in Nisyros, “Sustainable Solutions at Times of Transition (SuST)” has a central objective to examine all these issues dealing with the transition period of climate change and to examine tools that will have an impact in reversing the environmental catastrophe that is ahead of us. The topics of the symposium will cover a wide spectrum of tools that can deal with climate change: Climate Change Impacts and Climate Change Mitigation Methods, Renewable Energy, Circular Economy, Bioeconomy, Sustainable Agricultural Systems, Systems Approaches (Life Cycle Assessment, Exergy Analysis, Carbon footprint, Environmental footprint, Water footprint, Nutrient footprint, Bio-diversity footprint, etc.). Beyond those tools there will be an examination of all aspects of sustainability and the interactions among the Human, Climatic, Eco-system, Technological, Economic, Policy and Ethical Dimensions.

It is our honor to have as a keynote speaker the world-renowned economics professor, bestselling author, innovative educator, academic, public policy analyst and global leader in sustainable development, Jeffrey Sachs. Professor Sachs is the Director of the Center for Sustainable Development at Columbia University and President of the UN Sustainable Development Solutions Network.

I want to welcome all the participants of the symposium to the mythical Island of Nisyros, a product of the battle between the Gods and the Titans. Gaia (Earth), the mother of all, turned the mortal Giants against the immortal Olympian Gods. Poseidon (God of the sea) had taken up the responsibility to neutralize Polyvotis (a Giant), who crossed the Aegean in an attempt to save himself. Poseidon caught up with him near Kos. With his trident he detached a part of Kos and hurled it at Polyvotis who was crushed under the rock's weight. That rock, as the myth describes, is Nisyros. This myth vividly represents the continuous battle between humans and nature, between change and stagnation.

Professor Christophis Koroneos  
Mayor of Nisyros  
Co-Chairman of SuST



## Opening Message

The title of this year's Symposium turns out to be well-thought-out. The unexpected Russian invasion in Ukraine resulted, among other, in an unprecedented energy price increase, above all regarding natural gas. These developments, taking place amid energy transition from fossil to renewable sources, are at the same time a threat and a challenge: A threat, because fears are raised that electricity and fossil fuel prices will remain at high levels; a challenge, because sustainable solutions that are within reach can help us put things right:

- ◆ The world needs a multiple of today's amount of climate-friendly electricity. It looks as if serious efforts are initiated to substantially increase the electric power generation share of new renewables (above all, solar and wind energy).
- ◆ The energy sector will more and more rely on climate-friendly hydrogen, produced preferably with climate-friendly electricity via electrolysis.
- ◆ Synthetic fuels produced from climate-friendly hydrogen and carbon dioxide, preferably captured directly from point sources (e.g. power plants or industrial plants), are generally seen as a pillar of any viable solution to the global energy and climate problem. They will contribute, for instance, to significant greenhouse gas emission reductions, possibly even to a complete climate neutralization of the existing fleet of more than one billion vehicles with internal combustion engines.
- ◆ More importantly, synthetic fuels represent the most promising and sustainable way for storing renewable energy surpluses. Hence, they can also help solving energy autonomy problems of isolated communities and, in particular, of smaller islands like Nisyros.

To some extent, the latter could be seen as a compensation for the hospitality that sustainability engineers and scientists experience in the recurring Symposia hosted in this beautiful island.

Professor Nicolas Moussiopoulos, Aristotle University Thessaloniki  
Member of the German National Academy of Sciences Leopoldina

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The International  
Journal of Life Cycle  
Assessment

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# PROGRAM

Thursday, July 14 <sup>th</sup> , 2022		ZOSIMOPOULIO CONFERENCE HALL
<b>SYMPOSIUM OPENING</b>		
10:00-11:30	<b>Registration</b>	
11:30-12:30	<b>Welcome addresses</b>	
	<i>Anastasia Zabaniotou, Conference Chair</i>	
	<i>Christofis Koroneos, Mayor of Nisyros</i> <b>The Nisyros Project - The Vision &amp; Implementation for Environmental Conservation with ZERO Status</b>	
12:30-13:00	<i>Petros Kokkalis, Member of EU Parliament</i>	
13:00-13:30	<b>Short welcoming messages by supporting institutions</b>	
13:30-18:00	<i>Lunch and Midday Break</i>	
17:00-18:30	<b>Registration</b>	
18:30-19:00	<b>Bus to Volcano - Volcano Theater</b>	
	<i>Moderators: Ch. Koroneos, A. Zabaniotou, N. Moussiopoulos</i>	
19:30-20:30	<b>Keynote speaker</b> <b>Jeffrey Sachs</b> <i>Professor and SDSN President</i> <b>Sustainable Solutions at Times of Transition</b>	
21:00-24:00	<b>Dinner at Nikia village</b>	

Friday, July 15 <sup>th</sup> , 2022		ZOSIMOPOULIO CONFERENCE HALL
<b>SYMPOSIUM</b>		
8:30-9:30	<b>Registration</b>	
	<i>Moderators: A. Zabaniotou, Ch. Koroneos</i>	
9:00-9:40	<b>Keynote speaker</b> <b>Mat Santamouris</b> <i>Scientia Professor, Anita Lawrence Chair High, University New South Wales, Sydney Australia</i> <b>Regional Climate Change and Mitigation Potential</b>	
<b>S1</b>	<b>Invited speakers</b>	
9:40-10:00	<b>Konstantinos Aravossis:</b> Addressing the effects of climate change	
10:00-10:20	<b>Nicolas Moussiopoulos:</b> Industry and climate change, possible pathways in a globalized world	
10:20-10:40	<b>George Tsatsaronis:</b> Challenges associated with the use of hydrogen for decarbonization	
10:40-11:00	<b>Discussion</b>	
11:00-11:30	<b>Coffee Break</b>	
<b>S2</b>	<b>Climate change</b> <span style="float: right;"><i>Moderators: G.Zarotiadis, D. Sarigiannis</i></span>	
11:30-11:50	<b>Nicolaos Theodosiou:</b> Climate change adaptation measures for sustainable urban water management	

11:50-12:10	<b>Panagiotis Nastos:</b> Domestic rainwater harvesting systems as practices to create resilience to climate change and to enhance water security in small dry islands
12:10-12:30	<b>Dionysis Assimacopoulos:</b> Stakeholders' perception on climate change impacts and adaptation actions in Greece
12:30-12:50	<b>Andreas Matzarakis:</b> (Bio)Climate as decision factor in short- and long-term climate change adaptation in cities
12:50-13:10	<b>Spyros Voutetakis:</b> Sustainable thermochemical energy storage abundant materials.
13:10-13:30	<b>Johannes Orphal:</b> Sustainable urban transformation – A new paradigm for the 21 <sup>st</sup> century
13:30-14:00	<b>Discussion</b>
14:00-16:00	<b>Lunch and Midday Break</b>
<b>S3</b>	<b>Sustainability</b> <span style="float: right;"><i>Moderators: P. Nastos, N. Theodossiou</i></span>
16:00-16:20	<b>Denis Sarigiannis:</b> Towards the development of safe and sustainable by design chemicals, materials and products
16:20-16:40	<b>Charisios Achillas:</b> Digitizing culture as a means of promoting social sustainability and enhancing equity for vulnerable communities
16:40-17:00	<b>Dimitrios Aidonis:</b> Sustainable tourism development through accessibility and equity: Novel tools for improving ease of access for all in tourism destinations
17:00-17:20	<b>Paris Fokaides:</b> First evidence of sustainability assessment of educational building units with the use of Building Information Modelling tools
17:20-17:30	<b>Discussion</b>
17:30-18:00	<b>Coffee Break</b>
<b>S4</b>	<b>Environnement</b> <span style="float: right;"><i>Moderators: N. Moussiopoulos, F.Figueiredo</i></span>
18:00-18:20	<b>Eftichios Sartzetakis:</b> International environmental agreements with emission, abatement and adaptation choices
18:20-18:40	<b>Constantinos Sioutas:</b> Mineral dust concentration and light absorption: real-time measurements in central Los Angeles
18:40-19:00	<b>Grigoris Zarotiadis:</b> Dutch disease In Eastern Mediterranean
19:00-19:20	<b>Athanasios Konstantopoulos:</b> Towards methods and protocols for nanoplastic aerosol generation, characterization and impact assessment
19:20-19:40	<b>Piergiuseppe Morone:</b> Tracing waste to assess Circular Economy gaps from a global perspective
19:40-20:00	<b>Discussion</b>
20:30-21.30	<b>Drinks and Creative Reflections (Porfyris hotel)</b>

<b>Saturday, July 16<sup>th</sup>, 2022</b>		<b>ZOSIMOPOULIO CONFERENCE HALL</b>
<b>WORKSHOPS</b>		
<i>Moderators: A. Zabaniotou, Ch. Koroneos</i>		
9:00-9:40	<b>Keynote speaker</b> <b>Don Huisingh</b> <i>The Institute for a Secure and Sustainable Environment, University of TN, US</i> <b>In the Context of Climate Change what are the Roles of Divestment and Other Tools in Accelerating the Transition to Equitable, Livable Sustainable Post-Fossil Carbon Societies?</b>	

<b>W1</b>	<b>Energy Transitions</b>
9:40-9:55	<b>Denis Sarigiannis:</b> The climate exposome
9:55-10:10	<b>Yannis Sebos:</b> Assessment of the economic impact of actions targeting climate resilience in Greece
10:10-10:25	<b>Nikolaos Katsoulakos:</b> Rethinking EU energy landscape at the basis of ethical and social concerns
10:25-10:40	<b>Ann Wolter:</b> The Potential of Future Floating Wind Farms from a Socio-Economic and Financial Perspective in view of a Greek isolated and non-isolated tourist and industrial areas
10:40-10:55	<b>Theocharis Tsoutsos:</b> Non-technological parameters of the sustainable development of offshore wind and wave power generation
10:55-11:15	<b>Discussion</b>
11:15-11:30	<b>Coffee Break</b>
<b>W2</b>	<b>Nisyros and Islands</b> <i>Moderators: E. Sartzetakis, P. Fokaides</i>
11:30-11:45	<b>John Kaldellis:</b> Clean-green solution for remote islands. The case study of Nisyros
11:45-12:00	<b>Marina Nastou:</b> Cultural and natural heritage of Nisyros and climate change; effects and the need of protection and sustainability
12:00-12:15	<b>Avraam Kartalidis:</b> Clean energy transition of Nisyros Island, through renewable energy production: Simulations and Energy Management concerns
12:15-12:30	<b>Maria Papandreou:</b> New and flexible modes of electromobility in Southern Aegean
12:30-12:45	<b>Ioannis Mamounakis:</b> A holistic energy planning platform supporting energy transition and smartification of geographical and energy islands
12:45-13:00	<b>Stavroula Tournaki:</b> Simplified model on Sustainable Mobility planning in small insular tourism destinations. The case of Platanias, Crete
13:00-13:15	<b>Discussion</b>
13:15-14:00	<b>POSTER PRESENTATIONS</b>
14:00 -16:00	<b>Lunch and Midday Break</b>
<b>W3</b>	<b>Transport and Informatics</b> <i>Moderators: A. Matzarakis, F. Ashour</i>
16:00-16:15	<b>Elliot Chevet:</b> Modelling of air pollution in Mediterranean coastal cities due to marine traffic
16:15-16:30	<b>Dimitris Margaritis:</b> Monitoring the environmental impact of transport and promotion of electromobility in island areas
16:30-16:45	<b>Horst Junker:</b> Problems of sustainability informatics development
16:45-17:00	<b>Paris Fokaides:</b> Numerical investigation of the thermal performance of a solid biofuel boiler
17:00-17:15	<b>Thomas Pietsch:</b> Sensor technology enables sustainable work
17:15-17:30	<b>Carsten Domann:</b> Future of work – A mind game about use cases with AR, VR and XR
17:30-17:45	<b>Naima El Haoud:</b> Future of work in Morocco in artificial intelligence age
17:45-18:00	<b>Filipa Figueiredo:</b> Life-Cycle Assessment of forest ecosystem in Portugal for roundwood production: Eucalyptus globulus
18:00-18:15	<b>Discussion</b>
18:15-18:30	<b>Coffee Break</b>
18:30-20:00	<b>Closing Session</b> <i>Moderators: Ch. Koroneos, A. Zabaniotou, N. Moussiopoulos</i>
21:00-24:00	<b>Gala Dinner (Mandraki village)</b>

## PARALLEL WORKSHOPS

W4	<i>Circular Economy</i>	<i>Moderators: J. Kaldellis, P. Fokaides</i>
10.30-10:45	<b>Nikolaos Efkolidis:</b> Circular utilization of post-consumer plastic waste via 3D printing- A preliminary study	
10:45-11:00	<b>Fatma Ashour:</b> The use of diapers scrap in the manufacture of clay bricks	
11:00-11:15	<b>Noura Fathy Adel Salam:</b> Optimization of Methyl Orange Removal from Textile Waste-water by Electro-Coagulation cell using RSM	
11:15-11:30	<b>Aggelos Lappas:</b> Recycling of end-of-life tyres via pyrolysis and catalytic vapour up-grading	
11:30-11:45	<b>Discussion</b>	
11:45-12:00	<b>Coffee Break</b>	
W5	<i>Bioeconomy</i>	<i>Moderators: D. Assimacopoulos, Ch. Achillas</i>
12:00-12:15	<b>Maria Proestou:</b> A critical global analysis of bioeconomy visions in bioeconomy policies	
12:15-12:30	<b>Nicolai Schulz:</b> Salience of resilience challenges in bioeconomy policies: A comparative analysis	
12:30-12:45	<b>Magdalena Wojnarowska:</b> Sustainable innovations. Empirical evidence from the bio-economy sector	
12:45-13:00	<b>Amalia Tzianopoulou:</b> Balancing technology and nature: Water management restoration techniques applied to agrivoltaics and their climatic impact compared with conventional photovoltaic systems	
13:00-13:15	<b>Filipa Figueiredo:</b> Towards zero food waste and losses: development of sustainable innovative solutions for artisanal meat sausages value chain in Portugal	
13:15-13:30	<b>Celine Gisèle Jung:</b> Health risk assessment due to some vegetable cultivated on a former MSW landfill	
13:30-13:45	<b>Discussion</b>	
13:45-14:00	<b>POSTER PRESENTATIONS</b> (ZOSIMOPOULIO CONFERENCE HALL)	
14:00 -16:00	<b>Lunch and Midday Break</b>	
W6	<i>Case-studies</i>	<i>Moderators: G. Tsatsaronis, G. Jung</i>
16:00-16:15	<b>Tatiana Morosuk:</b> LCA of green hydrogen production and liquefaction	
16:15-16:30	<b>Pantelis Manakas:</b> Sustainability assessment of incumbent and emerging technologies for waste valorization from the juice industry	
16:30-16:45	<b>Despoina Fytilli:</b> Agri waste to energy in energy in circular bioeconomy: Observational evidence of the Thessaly region in Greece	
16:45-17:00	<b>Attilio Torre:</b> Mediterranean wetlands to mitigate the effects of climate change. The case of Aghios Mamas Natura 2000 site, Halkidiki, Greece	
17:00-17:15	<b>Periklis Kafasis:</b> Towards a circular economy era - Integrated and innovative management of Used Cooking Oils through digital tools - The case of Western Macedonia	
17:15-17:30	<b>Panagiota Saranti:</b> Sustainable urban development: the concept of home and community composting	
17:30-17:45	<b>Kiriaki Sakellariou:</b> Mapping of agri-food and bio-based industries in the region of W.Macedonia for potential valorization of agri-food residual streams into high-added value products	
17:45-18:00	<b>Discussion</b>	
18:00-18:30	<b>Coffee Break</b> (ZOSIMOPOULIO CONFERENCE HALL)	
18:30-20:00	<b>Closing Session</b> (ZOSIMOPOULIO CONFERENCE HALL)	

## POSTERS

- E. Afthentopoulos:** Experimental study on the gasification of industrial wastes with steam or carbon dioxide for syngas production
- Anastasios Balaskas:** The energy profile of households in mountainous areas. The case of Metsovo
- Charisios Achilles:** Bridging the gap between the cultural pillar and other pillars of sustainability
- Christos Koidis, Ch.Achillas:** KYKLOS 4.0: Developing a Circular Manufacturing Framework
- Denis Sarigiannis:** Life cycle-based health risk assessment of plastic waste
- Dimitra Chondrogianni:** Powering electric vehicles' connection to building infrastructures: The future of energy and mobility
- Eleni Niarchou:** Environmental education and climate change: Actions in schools of the 3<sup>rd</sup> Primary Directorate of Athens
- Elisa Papadis:** Effects of flexible heat, fuel and electricity-producing facilities on future German electricity prices
- K. Zacheila:** Evaluation of urban and industrial wastes for energetic uses through gasification with carbon dioxide streams. A TG-MS study
- Konstantinos Papamonioudis:** Utilization of food waste towards a Circular Economy In the context of the sustainable development in Greece
- Maria Chanoumidou:** The basic need for clean water: How a school project can reach the concept of sustainability
- Mertin Sebastian Triebs:** Modeling exergetic emission allocation in linear optimization programs
- Naima El Haoud, Oumaima Hali Brahim Saber:** Adoption of AI in higher education using the structural equations model: The case of Morocco
- Paris A. Fokaides:** Numerical assessment of solar assisted plastics pyrolysis for sustainable utilization of plastic waste
- Vera Proskynitopoulou:** Anaerobic digestate exploitation from biogas plants originated in Western Macedonia

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## INDUSTRY AND CLIMATE CHANGE, POSSIBLE PATHWAYS IN A GLOBALIZED WORLD

NICOLAS MOUSSIOPOULOS

*Faculty of Engineering, Aristotle University of Thessaloniki  
Member of the German National Academy of Sciences Leopoldina  
Email: [moussio@auth.gr](mailto:moussio@auth.gr)*

Since the 1st Industrial Revolution, industry symbolizes progress and prosperity. The need for workers, already in the 19th century, led to migration and hence also to inequity increases and social imbalance phenomena. Yet, the replacement of human muscles by machines, later by robots, resulted in a substantial global GDP increase that was accompanied by a rapid increase of the world population. Energy (or, more precisely, exergy) needed to run the machines started been considered as a factor of production, next to labor and capital.

Even before the climate change discussion, concerns that energy supply might become uncertain in the foreseeable future led to concerted efforts of the international community towards decoupling the productivity (and GDP) increase from energy demand increases. This succeeded to a large extent, but the energy intensity decreases achieved are worthless regarding climate change mitigation.

Several industrial branches cause significant GHG emissions, above all fossil fuel fired power plants. Considerable problems are associated also to iron and steel production, cement industries and various chemical plants. There are several important aspects to be considered for reducing the carbon footprint of individual branches. An obvious problem is unemployment resulting if energy transition occurs in an abrupt manner, as presently with the process of abandoning coal for electricity production. On the other hand, political decisions in several countries may differ substantially, leading not only to drastic changes regarding international competitiveness, but also to geostrategic tensions. At the same time, less developed countries, especially in Africa, have the moral rights to request that they be exempted from the urgent need to cut fossil fuel emissions. It is evident that environmental sustainability is strongly interconnected to economic growth and to issues related to social cohesion.

Innovation is undoubtedly the only way out of the above outlined deadlock. Several encouraging developments will be presented and discussed in the lecture, including the prospects of a large-scale production and utilization of synthetic fuels and the enormous potential of production line modifications in the frame of the 4th Industrial Revolution.

**Keywords:** *Industrial GHG emissions, climate change mitigation, defossilization, global sustainability*

## CHALLENGES ASSOCIATED WITH THE USE OF HYDROGEN FOR DECARBONIZATION

GEORGE TSATSARONIS

*Chair of Energy Engineering and Environmental Protection, Technische Universität Berlin,  
Marchstr. 18, 10587 Berlin, Germany  
Email: [georgios.tsatsaronis@tu-berlin.de](mailto:georgios.tsatsaronis@tu-berlin.de)*

Since the 1970s, hydrogen has been considered an important element of a future energy economy. Recently and within the framework of decarbonization of the energy sector, many countries have developed national plans, strategies, or programs addressing the establishment of a hydrogen-based economy in the near future. The green hydrogen plans try to target sectors that are difficult to decarbonize as well as to address issues related to the storage and transport of decarbonized energy.

To achieve complete decarbonization, electric power must be generated exclusively from renewable sources. Power-to-X (PtX) technologies refer to the generation of hydrogen from electricity and its subsequent conversion to an energy carrier (for example, liquid hydrogen, methanol or ammonia) which can be further stored, transported and used.

Thus, the challenges associated with the establishment of a green hydrogen-based economy include those associated with (a) the expansion of renewable energies (e.g., very high capital demand, political and social issues), and (b) the production, transportation and storage of the energy carriers denoted by X in the PtX (e.g., high cost, degradation of the energy carrier quality, low overall efficiency). In addition, all current initial efforts toward a hydrogen economy increase the CO<sub>2</sub> emissions at the global level instead of decreasing them.

Considering all these challenges, it seems unrealistic that a hydrogen economy would contribute significantly to decarbonization within the timeframe suggested by many recent studies. The main reason for this is that a prerequisite for decarbonization enabled by the hydrogen economy is the availability of large quantities of excess “green” electricity. In the coming years we will continue to be far away from this situation. The introduction of an appropriate carbon-pricing scheme through political decisions would definitely speed up this development.

**Keywords:** *Hydrogen economy; decarbonization; Power to X; energy storage; carbon pricing*

## CLIMATE CHANGE ADAPTATION MEASURES FOR SUSTAINABLE URBAN WATER MANAGEMENT

NICOLAOS THEODOSSIOU, ELENI FOTOPOULOU

*Division of Hydraulics and Environmental Engineering, Department of Civil Engineering,  
Aristotle University of Thessaloniki, Greece  
Email: [niktheod@civil.auth.gr](mailto:niktheod@civil.auth.gr)*

Urban water management is one of the key aspects for ensuring the quality-of-life of inhabitants of modern cities. The fact that the population of people leaving in cities, is constantly growing all over the world, combined with the increasing negative impacts of climate change, makes rational water management an absolute necessity and an even more important challenge. Urban water resources management comprises three dimensions that were, completely mistakenly, considered until now, as independent. These are, the supply of clean water for consumption and for irrigation, the disposal of polluted water (the so-called wastewater) and the management of rain and storm water. According to the current trend of circular economy, these three dimensions are strongly connected and should be treated as such.

Grey water, which is definitely not wastewater, can be used to cover secondary needs like irrigation and cleaning for public places. Rainwater can be stored to be used for enhancing and supporting the –so much needed– green spaces in modern cities and so much more. Clean water consumption can be reduced to what is actually needed. In this way we preserve a significant natural resource, protect the environment, and improve the quality of life, all at the same time.

In this paper we present options, opportunities, and challenges of rational urban water resources management under the concept of circularity, for the benefit of people, the economy and the environment.

**Keywords:** *climate change, urban water, environmental impact, sustainability*

# DOMESTIC RAINWATER HARVESTING SYSTEMS AS PRACTICES TO CREATE RESILIENCE TO CLIMATE CHANGE AND TO ENHANCE WATER SECURITY IN SMALL DRY ISLANDS

ELISAVET FELONI<sup>1,2</sup>, PANAGIOTIS T. NASTOS<sup>1</sup>

<sup>1</sup>*Laboratory of Climatology and Atmospheric Environment, National and Kapodistrian University of Athens, University Campus, Athens, 15784, Greece, Email: [nastos@uoa.gr](mailto:nastos@uoa.gr)*

<sup>2</sup>*Department of Surveying & Geoinformatics Engineering, University of West Attica, Egaleo Park Campus, Ag. Spyridonos Str., Egaleo, 12243, Athens, Greece, Email: [efeloni@uniwa.gr](mailto:efeloni@uniwa.gr)*

Water scarcity in small Greek islands is one of the main problems regarding water resources management, linked to the local characteristics, i.e. small catchment areas, low rainfall and geology, especially under climate change. Particularly, during summer months, when demand peaks due to tourism and irrigation, water storage is limited.

This paper examines a typical rainwater harvesting system, operating in a household scale, both to supply freshwater for domestic use and to reduce the corresponding demand from the tap. The analysis is performed for the island of Nisyros, a small dry island in the SE Aegean Sea, in which any adaptation measures to deal with water scarcity and climate change are required.

The evaluation of this water management practice is performed through investigating the system's reliability under various combinations regarding water tanks' volumes and rainwater collection areas, taking into consideration climate change scenarios. The implementation methodology concerns daily water balance to meet non-potable domestic water demand for a household of two to four residents. Results show that these mitigation measures can contribute to local water resources management under current and future conditions, especially in the beginning of dry period.

**Keywords:** *rainwater harvesting, water balance method, domestic water, Nisyros Island, climate change*

## STAKEHOLDERS' PERCEPTION ON CLIMATE CHANGE IMPACTS AND ADAPTATION ACTIONS IN GREECE

IOANNIS SEBOS<sup>1\*</sup>, IOANNA NYDRIOTI<sup>1</sup>, PIPINA KATSIARDI<sup>1</sup>, GRIGORIOS  
KYRIAKOPOULOS<sup>2</sup>, DIMITRA BABATZELIOU<sup>1</sup>, DIONYSIOS ASSIMACOPOULOS<sup>1</sup>

<sup>1</sup> *School of Chemical Engineering, National Technical University of Athens,  
9 Heron Polytechniou Street, 15780 Athens, Greece*

<sup>2</sup> *School of Electrical and Computer Engineering, National Technical University of Athens,  
9 Heron Polytechniou Street, 15780 Athens, Greece*

*\*Email: [isebos@mail.ntua.gr](mailto:isebos@mail.ntua.gr)*

A substantial array of scientific evidence points to a significant human contribution towards changes occurring in the world's climate, and to the importance of adaptation actions for overcoming the effects of climate change. Effective climate adaptation demands fostering awareness among a variety of key stakeholders, such as executives and staff of public administration and private actors, while determining the incentives given and the actions undertaken by them, enabling them to act at different scales of involvement, ranging from global to national and from regional to local. The scope of the present study is to investigate the level of awareness, perceived values, recommendations, and expectations on climate change of key actors throughout Greece, focusing on the consequences of climate change in the country and the concurring adaptation actions undertaken by the stakeholders involved. In this context, a web-based survey was designed and executed, and the main results were systematically approached in alignment with the responses collected, categorized, and co-evaluated. The key stakeholders considered that the planning and implementation of adaptation measures are factors of utmost importance in addressing and minimizing climate change impacts. However, it was also noted that such plans and measures are insufficient to counter the long term, devastating consequences of climate change in Greece and, thus, more systematic and targeted measures have to be adopted. It was also concluded that the most important obstacle for addressing and adapting to climate change in terms of public policy planning in Greece was the lack of human and financial resources, especially among public institutions.

**Keywords:** *Climate Change Impacts; Adaptation Actions; Knowledge and Perceptions of Key Stakeholders*

## (BIO)CLIMATE AS DECISION FACTOR IN SHORT- AND LONG-TERM CLIMATE CHANGE ADAPTATION IN CITIES

ANDREAS MATZARAKIS

*Research Centre Human Biometeorology, German Meteorological Service, 79104 Freiburg, Germany*

*Email: [andreas.matzarakis@dwd.de](mailto:andreas.matzarakis@dwd.de)*

Climate change will strongly affect life conditions esp. in cities. It is a matter of fact that most of the people are living in cities and urbanization leads to an environmental problem. As people do not have perception of air temperature but an overall sense of the thermal environment, adaptation and mitigation to climate change should also focus on the integral effect it has on humans (human thermal comfort). In order to analyse and describe human thermal comfort and other issues, several input and output parameters are required. For the quantification of thermal bioclimate, assessment methods based on the human energy balance are the most promising. They build the basis of thermal indices (e.g. Physiologically Equivalent Temperature or perceived temperature). The most influencing parameters of human thermal comfort, especially during summer conditions, are radiation fluxes (short and long wave) and wind speed. Also, the modifying factors (e.g. Sky View Factor and physical properties of surfaces) are very important. Some data and information can be obtained from measurements or can be simulated by micro scale models or in general by specific weather forecast. The models can calculate urban climate conditions based on available spatial and meteorological data. The results can be visualized graphically to show relevant information in an easily understandable, but comprehensive way.

In addition, studies on human thermal comfort and other environmental studies can be performed analysing and quantifying results from regional climate models. The results can be used for the development of mitigation and adaptation strategies facing the local aspects of global climate change and for the development of cities and urban areas with less extreme conditions in terms of biometeorology. Another option is to work on burning questions like specific events in cities, on the improvement of places, which are to be reconstructed or on new settlements to be developed with improved thermal conditions. Examples can be the development and operation of health-related heat warning systems, heat health action plans, consulting local administrations to help them to improve popular places in urban areas and urban areas, as well as investigations on the thermal conditions for individual events being held in areas with extreme climatic conditions and with large numbers of visitors like the FIFA world championship in Doha 2022.

Finally results and information have to be communicated and applied to minimize the negative effects in urban areas. The communication has to be specific and needs to give full particulars informing responsible persons or authorities. In addition, the results and information have to be delivered and presented in an easy understandable way. This is required for most of the administrative staff responsible, as well as the decision makers in general are mostly non-experts in the field of human thermal biometeorology. Another factor is the educational aspects concerning cities in the era of climate change. People need to be informed about the thermal environment they are living in and how they can avoid or adapt to stressful conditions.

**Keywords:** *Climate Change Adaptation, Warning Systems, Urban Planning, Heat Action Plans*

## SUSTAINABLE THERMOCHEMICAL ENERGY STORAGE USING ABUNDANT MATERIALS

**SPYROS VOUTETAKIS, GEORGIOS GRAVANIS, SIMIRA PAPADOPOULOU**

*Chemical Process & Energy Resources Institute (CPERI), Centre for Research and Technology Hellas (CERTH),  
Thessaloniki, Greece*

*Email: [paris@certh.gr](mailto:paris@certh.gr), [ggravanis@certh.gr](mailto:ggravanis@certh.gr), [shmira@certh.gr](mailto:shmira@certh.gr)*

Recently, the need for exploring alternative sustainable energy storage solutions has emerged due to the energy crisis and demands.

Batteries and hydrogen are well-established methods for energy storage. However, there are limitations since lithium for example, is an expensive material not easily reached.

On the contrary, using abundant materials such as limestone for energy storage, can be a competitive alternative, especially in areas that suffer from restricted access to resources either because of their location or the economic status.

The low cost of  $\text{CaCO}_3$  combined with solar power can be a highly competitive technology for energy storage. Such infrastructures can tackle the necessity for expensive utilities, special equipment with special maintenance needs, and the constant need for element replacement due to the limited lifespan of the equipment.

This study focuses on the economotechnical aspects of Thermochemical Energy Storage using abundant materials and specifically on the Concentrated Solar Power (CSP) technology. Moreover, it explores the feasibility of using such technology especially in locations where those materials are easy to find.

Finally, we present a novel drop tube reactor tested in a CSP pilot plant, that gains the thermal power of the exothermic reaction step of the Calcium Loop (CaL).

## TOWARDS THE DEVELOPMENT OF SAFE AND SUSTAINABLE BY DESIGN CHEMICALS, MATERIALS AND PRODUCTS

D.A. SARIGIANNIS<sup>1,2,3\*</sup>, A. GYPAKIS<sup>4</sup>, S. KARAKITSIOS<sup>1,2</sup>

<sup>1</sup> Aristotle University of Thessaloniki, Department of Chemical Engineering, Environmental Engineering Laboratory, Thessaloniki, Greece, \*Email: [sarigiannis@auth.gr](mailto:sarigiannis@auth.gr)

<sup>2</sup> HERACLES Research Center on the Exposome and Health, Center for Interdisciplinary Research and Innovation, Aristotle University of Thessaloniki, Greece

<sup>3</sup> School for Advanced Study (IUSS), Science, Technology and Society Department, Pavia, Italy

<sup>4</sup> Ministry of Development, General Secretariat for Research and Innovation, Athens, Greece

In December 2020 the European Commission issued its new chemicals strategy for sustainability (CSS) setting out a vision for the EU chemical policy, to strive for a “toxic-free environment” and reduce environmental pollution to zero (the Zero Pollution ambition). The reduction of the net negative impact on ecosystems and people without burden shifting between different sectorial policy objectives, requires a clear departure from current practice. We need to move towards a more holistic approach, enabling the assessment of combined risks (by improving the methods for chemical testing and predictive toxicology) caused by exposures from different sources (by improving exposure assessment) under different regulatory frameworks, following the “one substance one assessment” principle. More interestingly for sustainable chemical innovation, the other key pillar of the CSS is the transition to chemicals that are Safe and Sustainable-by-Design. The SSbD concept is defined as a process to accelerate widespread market uptake of new and alternative chemical products and technologies that deliver greater consumer confidence in their safety, environmental and societal benefits and advance the transition towards a circular economy and climate-neutral society. Currently SSbD is at the core of institutional, process and technological systems innovation in the chemical industry and in chemical engineering in Europe and it has been integrated in the national research and innovation agenda in Greece.

In this context, the most important action of Horizon Europe, the new framework instrument for research and innovation in Europe, in chemical engineering innovation to date is the creation of the EU-wide partnership on assessment of the risk of chemicals (PARC). PARC is an EU alliance bringing together 200 public institutions aiming to support the implementation of the “Green Deal”, the “Chemicals Strategy for Sustainability Towards a Toxic-Free Environment (CSS)”, including the “Industrial Strategy”, and the “New Circular Economy Action Plan”. Even though the criteria defining specifically the SSbD concept are currently being coined by the European Commission and are expected to be issued in October 2022, the need to move towards the operationalisation of SSbD is a key objective of PARC. Thus, a SSbD toolbox integrating tools for safety and sustainability assessment coming from different policy areas and strategies as well as new tools developed in PARC is being designed. Examples of the SSbD methodology on major industrial chemicals such as plasticiser (chemicals existing in the market and their alternatives) and nanomaterials will be demonstrated, including a broad array of interconnected methodological tools that allow the refinement of the assessment of chemical risks, including their entire life cycle.

## DIGITIZING CULTURE AS A MEANS OF PROMOTING SOCIAL SUSTAINABILITY AND ENHANCING EQUITY FOR VULNERABLE COMMUNITIES

CHARISIOS ACHILLAS<sup>a,b</sup>, EMMANOUIL TZIMTZIMIS<sup>a,c</sup>, DIMITRIOS TZETZIS<sup>a,c</sup>,  
ANDREAS DARLAS<sup>d</sup>, PETROS TZIOUMAKIS<sup>e</sup>, IOANNIS ASPIOTIS<sup>f</sup>,  
ATHANASIOS ATHANASIOU<sup>d</sup>, SOKRATIS POULIOS<sup>e</sup>, VICKY CHATZIPARADEIS<sup>f</sup>,  
DIMITRIOS AIDONIS<sup>a,b</sup>, DIONYSIS BOCHTIS<sup>a</sup>

<sup>a</sup> *Institute for Bio-Economy and Agri-Technology, Centre for Research & Technology Hellas (CERTH),  
Volos, Greece Email: c.achillas@ihu.edu.gr*

<sup>b</sup> *Department of Supply Chain Management, International Hellenic University, Katerini, Greece*

<sup>c</sup> *Digital Manufacturing and Materials Characterization Laboratory, School of Science and Technology,  
International Hellenic University, Themi, Greece*

<sup>d</sup> *Ephorate of Palaeoanthropology and Speleology, Ministry of Culture and Sports, Athens, Greece*

<sup>e</sup> *Polytech S.A., Larisa, Greece*

<sup>f</sup> *Polyptychon Cultural Services, Thessaloniki, Greece*

Creating an Inclusive Society is internationally considered as one of the top priorities for communities and social policies. According to the Unesco, museums are key spaces for the promotion of social inclusion, especially for vulnerable groups. Culture offers an exceptional means for the public to express themselves, while also reassures participation in social life and promotes social inclusion. It is widely recognized that inclusion of cultural education in non-formal education offers a diverse learning environment and a powerful vehicle to unlock emotions, build bonds within the society and unite people around a shared vision for the future. To that end, culture needs to be open to all. In this sense, digital culture and virtual museums can efficiently promote social sustainability and enhance equity for vulnerable communities. In this framework, within the Cave3 project, a multidisciplinary research team develop innovative mechanisms and a state-of-the-art digital environment (digital tools, open labs and serious games) for the case of the Petralona Cave and the Petralona Museum (Petralona, Chalkidiki, Greece), so as to deliver an interactive experience to the wide public. Using advanced digital methods and techniques, the research team is developing a unique virtual reality, interactive experience for the visitors of the cave and the museum. Digitization of culture can be easily transferred to areas other than the Petralona Cave and Museum in order to attract visitors or for educational purposes (especially in isolated, vulnerable areas).

**Keywords:** *Cultural sustainability, virtual reality, 3D scanning, human-computer interaction, open culture*

## SUSTAINABLE TOURISM DEVELOPMENT THROUGH ACCESSIBILITY AND EQUITY: NOVEL TOOLS FOR IMPROVING EASE OF ACCESS FOR ALL IN TOURISM DESTINATIONS

DIMITRIOS AIDONIS<sup>a</sup>, CHARISIOS ACHILLAS<sup>a</sup>, KIRIAKOS KORITSOGLOU<sup>b</sup>,  
IOANNIS FUDOS<sup>b</sup>, IOANNIS TSAMPOULATIDIS<sup>a,c</sup>, ALEXANDROS MOUROUZIS<sup>a,d</sup>,  
NAOUM TSOLAKIS<sup>a</sup>

<sup>a</sup> *Department of Supply Chain Management, International Hellenic University, Katerini, Greece,  
Email: [c.achillas@ihu.edu.gr](mailto:c.achillas@ihu.edu.gr)*

<sup>b</sup> *Department of Computer Science and Engineering, University of Ioannina, Ioannina, Greece*

<sup>c</sup> *Department of Urban and Regional Development and Planning, School of Architecture,  
Aristotle University of Thessaloniki, Greece*

<sup>d</sup> *National Confederation of Disabled People, Athens, Greece*

Human rights lie in the heart of sustainable development. Accessibility is a well-recognized human right and, thus, essential towards successful delivery of the UN Sustainable Development Goals. Although a number of initiatives have been put through at international level, tourism potential for people with disabilities remain underdeveloped in many areas around the globe. Inevitably, this represents a major obstacle for sustainability due to obvious social reasons (exclusion of people from places and points of interest), as well as economical ones, since people with difficulties (elderly people and people with limited mobility in general) represent a large fraction of the modern tourism industry. To that end, the accessible design of tourism destinations and the development of appropriate services may play a key role towards an inclusive and sustainable future for all. In this context, the Seek & Go project focus on the development of innovative digital products and services for accessible and safe mobility of senior and disabled tourists and citizens. The aim is to improve the capacity of tourism (and not only) destinations to better approach and efficiently serve individuals from special groups. More specifically, in the framework of the project, an ICT-based solution is developed, which will allow people with limited mobility to know in advance the accessibility status of a tourism destination, infrastructure and places of interest within an area, and finding the optimal routes to move from one place to the other based on their individual needs and taking into consideration the accessibility of pedestrian sections (inter-connections of pavements, crosswalks, obstacles, etc.). The Seek & Go application is validated through its pilot application in the main urban networks of Athens and Thessaloniki, based on real accessibility data from hundreds of field inspections, in an effort to become a catalyst towards improving the mobility of Greek citizens with disabilities, but also towards introducing Greece at global level as a unique destination for accessible tourism.

**Keywords:** *Social sustainability, ICT, accessibility, accessible tourism, tourism for all*

## FIRST EVIDENCE OF SUSTAINABILITY ASSESSMENT OF EDUCATIONAL BUILDING UNITS WITH THE USE OF BUILDING INFORMATION MODELLING TOOLS

PANAGIOTA KONATZII<sup>1a</sup>, EGLE KLUMBYTE<sup>2b</sup>, LINA SEDUIKYTE<sup>2c</sup>,  
PHOEBE ZOE MORSINK GEORGALI<sup>1d</sup>, PARIS A. FOKAIDES<sup>1,2 e\*</sup>

<sup>1</sup> School of Engineering, Frederick University, Cyprus

<sup>2</sup> Faculty of Civil Engineering and Architecture, Kaunas University of Technology, Kaunas, Lithuania

Email: <sup>a</sup> [res.pk@frederick.ac.cy](mailto:res.pk@frederick.ac.cy), <sup>b</sup> [egleklumbyte@gmail.com](mailto:egleklumbyte@gmail.com), <sup>c</sup> [lina.seduikyte@ktu.lt](mailto:lina.seduikyte@ktu.lt),

<sup>d</sup> [res.gp@frederick.ac.cy](mailto:res.gp@frederick.ac.cy), <sup>e</sup> [eng.fp@frederick.ac.cy](mailto:eng.fp@frederick.ac.cy)

The assessment of the sustainability of buildings is at the forefront of the environmental analysis of the built environment. The necessity of assessing the sustainability of different types of buildings with the use of advanced digitized tools, becomes imperative. This study presents some first evidence of the sustainability performance of educational building units, with the use of advanced tools, and specifically with the use of Building Information Modelling. For the purpose of this study, two case studies, located in northern and southern Europe, are examined. The building models of both units are digitized and analysed towards delivering their environmental performance with the use of advanced tools. Sustainable energy indicators, considering the whole life cycle of the building, are delivered and assessed, with different methodologies, including the recently launched Level(s) scheme of the European Commission.

Numerical results for each indicator are delivered. This study aspires to be a stepping stone, towards developing tailored sustainability schemes for educational units and green campuses.

**Keywords:** *Sustainability, Life Cycle Assessment, Building Information Modelling, Educational Building Units*

**INTERNATIONAL ENVIRONMENTAL AGREEMENTS WITH EMISSION,  
ABATEMENT AND ADAPTATION CHOICES****EFTICHIOS S. SARTZETAKIS<sup>1</sup>, STEFANIA STRANTZA<sup>2</sup>, EFFROSYNI DIAMANTOUDI<sup>3</sup>**<sup>1</sup> *University of Macedonia, Email: [esartz@uom.edu.gr](mailto:esartz@uom.edu.gr)*<sup>2</sup> *Thompson River University,*<sup>3</sup> *Concordia University*

The present paper examines the formation of stable international environmental agreements on net emission, considering countries' choice of mitigation and adaptation strategies. We assume that countries, before they decide to join or not the coalition, choose their level of emission, abatement and adaptation. The standard non cooperative leadership framework is employed. A coalition is considered stable when no signatories wish to withdraw while no more countries wish to participate. While abatement effort reduces emissions, adaptation effort reduces damages from emissions. We assume specific functions for benefits, damages and costs and we model coalition formation as a three stage game: In the last stage countries choose independently their level of adaptation activities, after observing global net emissions. In the second stage, countries choose their levels of emission and abatement and in the first stage countries choose whether or not to join a coalition that aims at controlling emissions. Within this framework we find that first, assuming adaptation is not very effective, the size of the stable coalition is always larger than in the case in which countries can choose only their emissions level. Second, the size of stable coalition increases as abatement becomes less costly. Finally, as the effectiveness of adaptation effort increases, the incentives to join the coalition decrease and for highly effective adaptation the size of the stable coalition returns to levels commonly reported in the literature without the abatement option.

## MINERAL DUST CONCENTRATION AND LIGHT ABSORPTION: REAL-TIME MEASUREMENTS IN CENTRAL LOS ANGELES

RAMIN TOHIDI, VAHID JALALI FARAHANI, CONSTANTINOS SIOUTAS

*University of Southern California, Department of Civil and Environmental Engineering, Los Angeles, California,  
USA, E-mail: [sioutas@usc.edu](mailto:sioutas@usc.edu)*

Mineral dust particles as a major component of PM<sub>10</sub> have been associated with adverse health effects worldwide. Dust aerosols can interfere with the Earth's radiative forcing due to scattering and absorption characteristics. We adopted a novel approach to measure the real-time concentration of mineral dust in Los Angeles by evaluating particle attenuation after a coarse particle virtual impactor (VI). This method minimizes the black carbon's light absorption impact, which dominates the PM<sub>2.5</sub> light absorption, on samples by increasing the concentration of coarse particles. The chemical components of collected coarse particles were evaluated by the Inductively Coupled Plasma Mass Spectroscopy method for 22 days in 3 seasons. Two Aethalometers calculated the absorption coefficients of concentrated coarse particles as well as ambient particles in two different lines of our setup. The mineral dust concentration was estimated using the enrichment factor of VI (~19) and the chemical components of collected coarse particles. The dust particles' light absorption coefficient in central Los Angeles was evaluated to be 2.7 and 0.41 1/Mm at 370 and 880 nm, respectively. While the mineral dust mass concentration showed significantly higher values for fall and winter due to higher wind speeds (i.e., 19.26 and 11.36 µg/m<sup>3</sup>, respectively), lower concentrations were observed during the summer campaign (i.e., 6.90 µg/m<sup>3</sup>). Additionally, the Absorption Angstrom Exponent (AAE) for coarse particles was determined using the light absorption values in two different wavelengths; the AAE value was ~2.18, indicating the presence of dust particles. This study showed the possibility of using light absorption properties and the efficiency of the virtual impactor in estimating the mineral dust mass concentrations in urban environments.

## DUTCH DISEASE IN EASTERN MEDITERRANEAN

GRIGORIS ZAROTIADIS, ODYSSEAS KOPSIDAS, DIMITRA GIANNOPOULOU

*Aristotle University of Thessaloniki, School of Economics, Greece*

*Email: [gzarotia@econ.auth.gr](mailto:gzarotia@econ.auth.gr)*

Mediterranean accounts for the 20% of global “blue economy” production, which makes it the fifth largest “economy” in the European area. Therefore, the well-known case of the so-called “Dutch Disease”, along with the priorities set in the UN 2030 SDGs strategy, forces us to raise specific concerns and alternative proposals against the prospects of marine mineral extraction in Eastern Mediterranean.

In the present paper we start with analysing three types of concerns: (i) the problems arising from economic “monocultures” and the crowding out of alternative industries, (ii) the environmental opportunity costs and the non-financial sustainability concerns, (iii) the international political imbalances.

In order to analyse these consequences in a theoretical approach, we modify the traditional Dutch Disease model according to the specificities of the certain region. Besides to the standard short-run inefficiencies due to the induced cross-industry restructuring, there are two additional effects arising: (i) “cleaning” and (ii) “dealing” costs. These two can result in long run worsening of the production possibilities frontier.

In the last part we conclude with an appeal for a better, thorough cost-benefit evaluation of the prospect to exploit these reserves. The theoretical analysis in the main part of the paper enables us also to propose specific aspects that should be considered so that such an analysis will be complete and useful.

**Keywords:** *Blue Economy, Marine Mineral Extraction, Dutch Disease, Mediterranean economy*

## TOWARDS METHODS AND PROTOCOLS FOR NANOPLASTIC AEROSOL GENERATION, CHARACTERIZATION AND IMPACT ASSESSMENT

ATHANASIOS G. KONSTANDOPOULOS<sup>1,\*</sup>, CHRYSA M. OIKONOMIDOU<sup>1</sup>,  
ROZINA E. METALLINO<sup>2</sup>

<sup>1</sup> *Aerosol & Particle Technology Laboratory, Department of Chemical Engineering, Aristotle University Thessaloniki, Greece, \*Corresponding author, Email: [agk@auth.gr](mailto:agk@auth.gr)*

<sup>2</sup> *SyNest PC, Thessaloniki, Greece*

Nanoparticle aerosols originating from polymer/rubber/plastic degradation and/or release from consumer, commercial and industrial products, have been recently identified as a potential environmental and health risk, due to their wide distribution over large geographical locations and due to their easy uptake in the body through the respiratory system.

In the present work we identify potential sources and mechanisms of aerosol nanoplastics emissions, with the goal to arrive at appropriate methods and protocols for the development of technology for nanoplastics detection, characterization and biological impact assessment. To this end we outline approaches for the development of standardized nanoplastic aerosols, their measurement technology and impact assessment, adapting and extending techniques developed for the generation, characterization, biological exposure assessment and abatement of combustion and engineered nanoparticle emissions. Unique challenges to the nanoplastics domain are identified and discussed along with potential mitigation approaches and new opportunities for advanced instrumentation are presented.

Overall addressing the issue of nanoplastics is very important for deployment of circular economy approaches, since under certain conditions increased emission of nanoplastics may occur by recycling and processing operations.

**Keywords:** *nanoplastics, aerosol, circular economy*

## TRACING WASTE TO ASSESS CIRCULAR ECONOMY GAPS FROM A GLOBAL PERSPECTIVE

PIERGIUSEPPE MORONE<sup>1</sup>, GÜLŞAH YILAN<sup>1,2</sup>, ANA GABRIELA ENCINO-MUÑOZ<sup>3</sup>

<sup>1</sup>*Bioeconomy in Transition Research Group (BiT-RG), UnitelmaSapienza University of Rome, Italy,*

*Email: [piergiuseppe.morone@unitelmasapienza.it](mailto:piergiuseppe.morone@unitelmasapienza.it)*

<sup>2</sup>*Department of Chemical Engineering, Faculty of Engineering, Marmara University, Turkey*

<sup>3</sup>*Universidad Nacional Autónoma de México, Mexico*

The circular economy is an alternative development model that promotes the reduction of the environmental impacts through the recirculation of products and material recovery to keep materials in use as long as possible and close the loop. This implies that products, components and materials can be reused or reprocessed to reduce environmental burdens as well as waste generated. However, different studies have highlighted some gaps in the circularity approach, especially regarding the waste-related aspects. Through the analysis of global material trajectories, it is possible to observe some issues linked to waste trade considering in terms of both waste content and geographical location. Some reports on waste treatment classify waste trade as an environmentally friendly practice and as an enabler of the circular economy. Nonetheless, by analysing this issue from a global perspective, it seems that circularity is not fully achieved. For example, generally Global North countries “trash” their waste to the South by shipping polluting substances and materials causing environmental degradation and exposing people to environmental and health risks. Despite the international agreements and the regulation of waste trade such as the Basel, Rotterdam and Stockholm conventions, there are important leakages that need to be addressed to encourage an effective circularity. Against this background, this paper analyses circularity gaps on three different types of products: second-hand clothing, electronic waste and plastics. Specifically, through a case study lens, we consider the case of UK, one of the most significant (if not the highest) contributors to the waste trade problem for clothing, electronics and plastics, e.g., for Chile, Turkey, and Nigeria, respectively. These countries share a common characteristic feature that they lack the required infrastructure to process imported waste in an environmentally and socially safe manner. We aim to discuss the waste trade in terms of a planetary justice perspective to highlight the need for preventive measures to avoid a superficial approach to circularity known as “circular washing” with the aim of identifying potential interventions to improve the current situation.

**Keywords:** *circular economy, global trade, planetary justice, waste trade*

## THE CLIMATE EXPOSOME

**D.A. SARIGIANNIS<sup>1,2,3\*</sup>, A. GOTTI<sup>4</sup>, A. GYPAKIS<sup>5</sup>, S. KARAKITSIOS<sup>1,2</sup>**

<sup>1</sup> *Aristotle University of Thessaloniki, Department of Chemical Engineering, Environmental Engineering Laboratory, Thessaloniki, Greece \*Email: sarigiannis@auth.gr*

<sup>2</sup> *HERACLES Research Center on the Exposome and Health, Center for Interdisciplinary Research and Innovation, Aristotle University of Thessaloniki, Greece*

<sup>3</sup> *School for Advanced Study (IUSS), Science, Technology and Society Department, Pavia, Italy*

<sup>4</sup> *EU CENTRE, Pavia, Italy*

<sup>5</sup> *Ministry of Development, General Secretariat for Research and Innovation, Athens, Greece*

The current state of play in the climate policy debate focuses on two key aspects: the relevance and proper extent of mitigation measures in order to avoid crossing the point of no return; and the necessity for adaptation measures considering the very different socio-economic state and dynamics across the globe. Proper assessment of the health benefits of policy measures geared towards adapting to the incumbent climate change is a key requirement for accurate impact assessment of the measures envisaged. Reliable quantification of direct and indirect impacts related to both climate change and to climate mitigation policies and measures is a sine qua non for further climate action. Lack of reliable data and comprehensive integrated assessment models hampers decision-making in government, industry and the financial sector.

The exposome accounts for the totality of exposures over an individual's life course, focusing inevitably on age windows of increased susceptibility. Making use of the exposome for comprehensive health risk assessment on the population scale requires development of advanced statistical and biochemical/pathology models based on a combination of environmental and high dimensional biological data, enhanced by machine learning and big data analytics. In addition, agent-based models help capture the changing socioeconomic dynamics that influence societal vulnerability to climate-induced health stress. Considering the change in environmental pressure and human exposure to health stressors linked to climate change would allow us to construct the climate exposome: namely, the exposome of human population subgroups considering the climate change aspects relevant to the ca. 80 years of the human life course.

Herein we present the methodological framework for unraveling the climate exposome with examples demonstrating its applicability and usefulness in climate decision-making are given. The ultimate objective at this point is to start the scientific discussion on the new generation of integrated assessment models. This entails a model scheme based on enhanced data fusion and on the concept of ensemble modelling, supported by big data analytics for filling data gaps. The climate exposome methodological framework is applied in two EU projects, ICARUS and URBANOME, aiming at exploring win-win solutions for minimizing environmental and health impacts in urban areas through the development of integrated tools and strategies in support of air quality and climate change governance in EU cities. Technological and non-technological measures have been proposed, taking into account societal dynamics and motivating citizens

towards adoption of environment-friendly alternatives with a positive impact on their health. The ICARUS and URBANOME methodology has been applied in eight EU cities, including Athens and Thessaloniki. Among the investigated scenarios, in the Greater Athens Area, the scenario with the highest emission reductions for all pollutants is the promotion of sustainable mobility through eco-driving, cycling and walking, as well as an enhanced usage of public transportation in Athens metropolitan area, while in Thessaloniki, highest reductions of air pollutants has been obtained for transport related measures such as promotion of green vehicles and promotion of public transport and the use of metro by building an integrated urban mobility system.

## ASSESSMENT OF THE ECONOMIC IMPACT OF ACTIONS TARGETING CLIMATE RESILIENCE IN GREECE

IOANNIS SEBOS<sup>1,\*</sup>, DIMITRIOS STAMOPOULOS<sup>2</sup>, PETROS DIMAS<sup>2</sup>,  
DIONYSIOS ASSIMACOPOULOS<sup>1</sup>

<sup>1</sup> *Laboratory of Industrial and Energy Economics, National Technical University of Athens, Greece.*

<sup>2</sup> *School of Chemical Engineering, National Technical University of Athens, Greece.*

*\*Email: [isebos@mail.ntua.gr](mailto:isebos@mail.ntua.gr)*

Climate change (CC) is the defining crisis of our time and a threat to both current and future generations. In addition to adopting low carbon strategies, more and more countries are developing strategies and action plans to adapt to CC impacts by increasing their resilience and enhancing their adaptive capacity. According to the Adaptation Committee established under the UNFCCC, rising adaptation costs are likely to range globally from USD 140 billion to 300 billion per annum by 2030, and could reach values between USD 280 billion and 500 billion per annum by 2050. In Greece, the adaptation measures and actions needed to adapt against the effects of CC are defined at the regional level, through the Regional Adaptation Action Plans (RAAPs) of the 13 administrative regions established in the country (Law 4414/2016). The indicative budget of these measures for the current programming period of the RAAPs (7 years' duration, until 2027 or 2028) averages over two hundred million euros per region. The present work attempts to assess the economic impact of a series of monetary shocks to the Greek economy that result from the financing of the adaptation measures proposed in the RAAPs. We focus on the structural effects of these shocks on a series of socioeconomic indicators, including GDP, employment, wages, government income (through taxes), and capital formation. Our approach builds on an input-output framework to allocate the planned financing of adaptation projects to the corresponding economic sectors through a composite industry approach. The region of the South Aegean is analyzed as a case study to demonstrate the approach.

**Keywords:** *Climate Change, Climate Resilience, Adaptation Action Plans, Input-output analysis*

## RETHINKING EU ENERGY LANDSCAPE AT THE BASIS OF ETHICAL AND SOCIAL CONCERNS

NIKOLAOS M. KATSOUKAKOS

*Aspropyrgos Academy of Merchant Navy*

*Email: [katsoulakos@metal.ntua.gr](mailto:katsoulakos@metal.ntua.gr)*

The EU considers climate change and environmental degradation as major, existential threats. So, the well renowned European Green Deal has been adopted, which sets ambitious goals for the Union. One basic aim is to have no net emissions of greenhouse gases by 2050. The pathway to climate neutrality passes through decarbonization of the economy, which mainly demands minimization of fossil fuels in the energy sector. The corresponding European energy strategy is supposed to “provide secure, affordable and clean energy for EU citizens and businesses”.

However, many households in Europe face difficulties in covering their energy needs. Despite the expansion of renewable energy use and the increase in energy efficiency of residences and devices, 8% of the EU population stated that they were unable to keep their home adequately warm, according to the last relative survey. This is rather worrying for one of our planet's regions that is considered to have high standards of living. Issues like energy poverty, inevitably, raise social and ethical concerns over energy transition policies. The present paper aims at highlighting these concerns and exploring ways to overcome them, in order to ensure a sustainable energy future. Some special references are made to the case study of Greece, which due to a long economic crisis presents particular characteristics.

More specifically, some important quantitative data regarding the energy sector in the EU and Greece are firstly highlighted. Data regarding energy pricing and energy poverty are also presented together with evidence between energy prices and factors like energy market liberalization and the operation of the emission trading system. Then, some plausible questions related to ethics and justice are raised and controversies are highlighted. So, it is attempted to investigate ways to a new energy future that ensures social cohesion and overcomes ethical concerns.

We need to overcome anthropocentrism, which includes the treatment of environment and natural resources solely as means for economic growth and human well-being. However, the dominant production patterns should be changed without causing intensified inequalities. Market-based approaches seem to have failed towards this aim. The benefits of the use of renewable sources have not been diffused to the society. Hence, it is necessary think over energy as a social good rather than as stock market product. Considering social and ethical aspects of energy transition and a radically different energy market are not groundless visions. On the contrary, without effective actions against current problems, such as energy poverty, EU declarations about a sustainable future are in danger of being left as a wish list.

**Keywords:** *energy transition; energy poverty; ethical concerns; social inequalities*

## THE POTENTIAL OF FUTURE FLOATING WIND FARMS FROM A SOCIO-ECONOMIC AND FINANCIAL PERSPECTIVE IN VIEW OF A GREEK ISOLATED AND NON-ISOLATED TOURIST AND INDUSTRIAL AREAS

ANN WOLTER, ABDUL SALAM K. DARWISH, PETER FARRELL

*Bolton University, United Kingdom*

*Email: [aw1res@bolton.ac.uk](mailto:aw1res@bolton.ac.uk)*

Wind technology has advanced rapidly in recent years, thanks to new platforms. Due to the logistical, value chain, ecological and capacity advantages, offshore wind technology began to overtake onshore wind technology. Evidence demonstrates that floating wind farm technology is rising in popularity among investors and governments. It is expected to be the dominant form of wind energy in the future. However, the financial and economic elements are still in the development process. A major component of determining the feasibility of such innovation adoption is socio-economic factors. This article is analysing the economic impact of a floating wind farm on three different regions, isolated tourists, not isolated areas, and industrial areas. The value chain is analysed in conjunction with the national economy, and the results are compared to industrial regions and fixed foundation technologies. The results showed that the value chain is the leading capability for these technologies. It may be adjusted depending on the wind data available for high power generation at the chosen site. The investigation covers geography, economics, and constraints over time. The feasibility of a wind farm depends on the geographical area where the wind farm is to be constructed and the number and size of installed wind turbines, according to the research results. These factors appear to have a direct impact on cost-effectiveness. Finally, this paper highlighted important aspects such as the offshore floating wind farm's high feasibility in the Greek offshore market, making it a powerful future technology to be a prime source of clean energy in this country. It supports all efforts to achieve the United Nations' Sustainable Development Goals, which look at sustainable cities and human resilience.

**Keywords:** *Floating Wind Farm, Offshore wind Farm, Socio-economic, Value Chain, Sustainable Development Goals (SDGs)*

## NON-TECHNOLOGICAL PARAMETERS OF THE SUSTAINABLE DEVELOPMENT OF OFFSHORE WIND AND WAVE POWER GENERATION

THEOCHARIS TSOUTSOS

*Renewable and Sustainable Energy Lab, School of Chemical and Environmental Engineering,  
Technical University of Crete, University Campus, 73100 Chania, Crete, Greece  
Email: [theocharis.tsoutsos@enveng.tuc.gr](mailto:theocharis.tsoutsos@enveng.tuc.gr)*

The decarbonization of energy power generation is the main ambition globally. Due to land-use conflicts, in this new era, along with the increasing demand for onshore green energy, the yet unexploited offshore wind and wave potential will play a dynamic and vital role.

However, this is not enough for sustainable (economic, environmental, social) development; in addition to the energy potential, critical non-technology parameters exist for the further development of offshore wind and wave parks.

This paper reviews the existing experience of the Renewable and Sustainable Energy Lab (#resel\_tuc) on:

- Visual impact from new parks
- the role of the social acceptability
- non-technology parameters (Natura 2000 areas, navy and defence uses, Posidonia fields)
- the examination of wind and wave power systems in combination with the rest of onshore renewable energy power.

In the end, tested examples from the island of Crete are shown and discussed.

**Keywords:** *Offshore Wind Farms, Wave Energy Converters, Visual Impact, Sustainable Siting*

## CLEAN-GREEN SOLUTION FOR REMOTE ISLANDS. THE CASE STUDY OF NISYROS

JOHN K. KALDELLIS<sup>1,\*</sup>, DAVIDE ASTIASO GARCIA<sup>2</sup>, ATHANASIA ANDRIANOPOULOU<sup>3,1</sup>,  
AGGELOS KALDELLIS<sup>1</sup>, EMILIA M. KONDILI<sup>4</sup>

<sup>1</sup> *Lab of Soft Energy Applications & Environmental Protection, UNIWA, Greece*

<sup>2</sup> *Dept of Planning, Design, Technology of Architecture, Sapienza University of Rome*

<sup>3</sup> *Nisyros Municipality, 85303 Nisyros, Greece*

<sup>4</sup> *Optimisation of Production Systems Lab., University of West Attica, Greece*

A particular feature of the Greek geography is the extensive number of islands (exceeding 2,500), among which about 230 are inhabited. Nisyros island is a unique volcanic Greek island located in the center of the island complex of Dodecanese. The population of the island is slightly above 1000 people and the local society covers its electricity needs as part of the “Kos-Kalymnos” autonomous micro-grid, based mainly on two oil-consuming thermal power stations (APS). These APSs provide electrical energy to Nisyros island through two subsea cables that are terminated at the north part of the island. According to available data during the last years the annual electricity consumption of Nisyros is approximately 6,000MWh<sub>e</sub>, while the corresponding peak load demand varies between 1200-1400kW.

Moreover, Nisyros island has severe issues concerning its water resources adequacy, while its economic activities are also strongly based on the island’s seawater RO desalination units’ operation, absorbing more than 10% of the islands total electricity consumption.

On the other hand, Nisyros island is characterized by abundant solar and geothermal energy potential, the combined and environmental friendly (mild) exploitation of which seems favorable for the amelioration of the island’s current energy status and economy. As far as the island’s available wind energy potential is concerned, it can be also considered of medium to high quality.

The proposed analysis aims to investigate the clean-green solutions that can be implemented in Nisyros island to improve its energy autonomy, in view of the Interreg-MED Prismi Plus research program. Actually, using the available excellent RES potential that characterizes the island one may develop the relevant energy solutions to satisfy the island’s energy requirements and enhance its energy security. To this end, RES-based configurations have been introduced for both the power generation and transportation sectors, taking into consideration land availability and first installation cost issues. The analysis carried out indicates that the total annual energy requirements of Nisyros island could be satisfied on an annual basis by the combined utilization of the available RES, while any possible excess energy could support clean water production and encourage the electro-mobility option.

**Keywords:** *Energy autonomy, Desalination, Electric Vehicles, Land Use*

## CULTURAL AND NATURAL HERITAGE OF NISYROS AND CLIMATE CHANGE; EFFECTS AND THE NEED OF PROTECTION AND SUSTAINABILITY

MARINA PANAGIOTA P. NASTOU

*School of Applied Arts and Sustainable Design, Hellenic Open University, 26335, Patra, Greece*

*Email: [nastou.marina@ac.eap.gr](mailto:nastou.marina@ac.eap.gr)*

The island of Nisyros in Dodecanese of Greece is a place with unique cultural heritage, which includes its particular geology. As nowadays climate change is a fact and an ongoing condition, the heritage of the island, both cultural and natural, seems to be threatened by the effects of climate change. The stakeholders have to consider and interpret the special meaning of this place and in the meantime to assess mitigation and adaptation techniques. Especially local communities are part of the character of the island, as they transmit the intangible heritage of knowledge and tradition to the next generation and they should incorporate the contemporary need of preservation and heritage management for the adaptation to climate change effects.

More particularly, the architecture of Nisyros is an instance of typology and morphology of Dodecanese, with a variety of residences from the small traditional house to a more luxurious one even with neoclassical features. At the courts and the open public spaces there are delicate floors with rich themes and decorative and natural designs and forms and made by local craftsmanship. There is connection between culture and nature, expressed by the continuous inspiration of built heritage creations in a characteristic environment. Actually, the villages of the island present typical form of Dodecanese with condense structure with interesting squares and open spaces across the streets, all of them are part of the daily routine of the inhabitants, who respect the public spaces and consider them as a sequence of their private space. An important fact showing the outstanding value of the villages of Nisyros, is that the villages of Mandraki, Emporios, Pali and Nikia are characterized as Historical Places, designated for conservation (article 52 of the 1469/1950 & Ministerial Decision 1018/45813/24-6-81, ΦΕΚ 455/Β/3-8-81). Simultaneously, as the land of the island is of unique character with the volcano and the special geology, there is combination of built heritage with natural heritage- geopark and georoutes. The aforementioned imply that nature and culture constitute a heritage unity deserving conservation and equivalent management for the necessary protection of the effects of climate change.

Therefore, the cautious study of the materiality, the structural conjunctions and the smooth spatial and intangible continuity of private and public spaces are threatened by the fluctuation of climate parameters, stemming from the global climate change. As the former factors design the identity of the place, immediate heritage management actions should be adapted aiming to the protection and sustainability of the place.

**Keywords:** *Culture, Nature, Climate Change, Sustainability*

## CLEAN ENERGY TRANSITION OF NISYROS ISLAND, THROUGH RENEWABLE ENERGY PRODUCTION: SIMULATIONS AND ENERGY MANAGEMENT

A. KARTALIDIS, G. ZISOPOULOS, N. NIKOLOPOULOS

*Centre for Research & Technology Hellas / Chemical Process and Energy Resources Institute,  
6th km Charilaou-Thermis, GR 57001 Thermi, Greece*

*Email: [kartalidis@certh.gr](mailto:kartalidis@certh.gr), [zisopoulos@certh.gr](mailto:zisopoulos@certh.gr), [n.nikolopoulos@certh.gr](mailto:n.nikolopoulos@certh.gr)*

Island regions are facing an important challenge in the light of the energy transition towards a non-fossil fuel era, with the increase of renewable energy systems (RES) and the electrification of energy demand domains, such as heating and transportation. Nisyros island is selected in the present study as the reference, for which common RE production systems such as PV and Wind turbines are explored. Nevertheless, owed to the fact that these systems are not dispatchable, storage and demand side management techniques are as well explored, to increase production and consumption synchronization and minimize the energy transfers between Nisyros and Kalymnos-Kos Archipelagos; all interconnected.

A range of technical solutions, contributing to the reduction of the associated CO<sub>2</sub>eq emissions towards near zero ones, are investigated, while also addressing challenges related to electricity curtailments and grid stability issues.

This study is based on a simulation model representation, using commercial software, for energy production and consumption assets, allowing the estimation of the various impacts of the suggested solutions on supporting Nisyros in its green transition.

**Keywords:** *Energy System Analysis; Zero Emission Island, Renewable Energy Integration; NESOI*

## NEW AND FLEXIBLE MODES OF ELECTROMOBILITY IN SOUTHERN AEGEAN, NEMO

EVANGELOS BEKIARIS

*Hellenic Institute of Transport (HIT), Centre for Research and Technology Hellas (CERTH),  
6th km Charilaou-Thermi Rd, GR 57001 Thermi, Thessaloniki, Greece, E-mail: [abek@certh.gr](mailto:abek@certh.gr)*

Traffic congestion is an unsolved issue causing multiple problems in modern societies. The multifaceted problems caused require solutions, such as alternative forms of energy, driving autonomy, interconnected vehicles, car, bicycle and skate sharing. Both in Europe and around the world, private car owning is gradually replaced by alternative means of transport, such as micromobility. In particular, micromobility services include small means of transport, such as bicycles (electrified or not) and scooters moving at low speeds, usually <25km/h.

Micromobility abruptly made its appearance all over the world with the introduction and circulation of electric scooters. This new transportation mean, i.e.the use of shared scooters for urban routes has also found particular resonance in Greece. This project focuses on capturing the real needs and mobility requirements of the residents and visitors/tourists of the island of Rhodes, as well as their expectations regarding the introduction and promotion of shared electric scooters, in order to meet existing and future travel needs. A survey was carried out using an online questionnaire aimed at residents, visitors and tourists of the island and was carried out within the framework of the nationally-funded NEMO project. The results of the survey reflect the positive acceptance of electric scooters on the island of Rhodes. The use of electric scooters are expected not only to contribute to the relief of traffic, and the promotion of a more environmentally friendly mean of transport and the sustainability of the island, but also to

- Reduction of e-scooter accidents, • Develop new mobility services and tourism experiences,
- Minimization of traffic congestion in the city of Rhodes, • Controlled use of e-scooters in urban streets, • Route recording and e-scooter localization in real time, • Boosting of local economy and • Contribution on region's islands competitiveness as touristic destinations.

Introducing and promoting e-scooters as a micromobility solution in the island of Rhodes is expected to:

- Introduce a new service of ecological and safe transportation, with speed control and proper adaptation to the specific road environment, with Geofencing technology as well as provision of training for ensuring the right use of the service. • Assist in decongestion of heavily congested streets. • Improve quality of life by contributing to the reduction of traffic noise and pollutant emissions. • Form new and sustainable business models. • Develop personalized offers and services for the tourists of the island. • Contribute to the development of satellite businesses.

**Keywords:** *Micromobility, Shared Electric Scooters, Travel Sustainability, Geofencing*

## AN HOLISTIC ENERGY PLANNING PLATFORM SUPPORTING ENERGY TRANSITION AND SMARTIFICATION OF GEOGRAPHICAL AND ENERGY ISLANDS

NIKOLAOS TAGKOULIS<sup>1</sup>, ANDREAS SEITARIDIS<sup>2</sup>, IOANNIS MAMOUNAKIS<sup>3</sup>,  
NIKI SKOPETOU<sup>4</sup>, PETROS ILIADIS<sup>5</sup>, DIMITRIOS-SOTIRIOS KOURKOUMPAS<sup>6</sup>,  
KOMNINOS ANGELAKOGLOU<sup>8</sup>, NIKOLAOS NIKOLOPOULOS<sup>7</sup>

*Centre for Research & Technology Hellas/Chemical Process and Energy Resources Institute (CERTH/CPERI),  
52, Egialias str., Maroussi, Athens, GR 15125, Greece*

<sup>1</sup> *n.tagkoulis@certh.gr*, <sup>2</sup> *a.seitaridis@certh.gr*, <sup>3</sup> *mamounakis@certh.gr*, <sup>4</sup> *n.skopetou@certh.gr*,

<sup>5</sup> *iliadis@certh.gr*, <sup>6</sup> *kourkoumpas@certh.gr*, <sup>7</sup> *n.nikolopoulos@certh.gr*, <sup>8</sup> *angelakoglou@certh.gr*

Urbanization leads to increasing environmental pressures and practical concerns, that call for new methods and tools which are able to evaluate the sustainability of the continuously evolving energy systems at wider spatial scales (e.g. neighborhoods/districts to cities/islands). Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) are commonly accepted methods that can be utilized to assess environmental/cost-related impacts. Additionally, in order for results to efficiently reflect the on-going energy transition, the utilization of reliable grid operation data, able to indicate daily energy usage in high accuracy, is crucial considering the upward trend of distributed energy sources, electrification and the formation of energy communities. With a view to address these issues, the key objective of this paper is to introduce a highly innovative energy planning platform building upon the combination of two software tools developed by CERTH namely: 1) Virtual Integrated on Life Cycle Analysis – District (VERIFY-D) and 2) INTEgrated Energy MANagement – grid (INTEMA.grid). VERIFY-D is a web-based LCA/LCC tool, which goes beyond the typical inventory and/or assumption based computations, being also capable to utilize “real-time” data (e.g. through IoT sensors) to extract environmental and cost-related impacts of energy infrastructure elements. VERIFY-D can be applied in multiple temporal (covering short to long-term periods) and spatial scales, ranging from the level of building, up to district and even city/island level, performing multi-sector LCA analysis, considering the integrated impact of: i) private and public buildings, ii) transportation infrastructure, iii) energy production (both RES and non-RES technologies), iv) distribution infrastructure and consumption units, and v) energy storage systems. INTEMA.grid is a dynamic modeling and simulation tool for energy systems of high renewables shares and distributed generation. This tool considers: i) passive grid assets (buses, lines, transformers, loads), ii) conventional generation systems (gas, hydro, steam, etc.), iii) RES technologies (e.g., photovoltaics, wind turbines), and iv) energy storage systems (e.g., flywheels, electrochemical batteries). Simulations calculate a number of synthetic data with high temporal resolution (minute-based). INTEMA.grid results can serve as input data for VERIFY-D, sent through HTTP request in JSON format to ensure seamless integration. The combination of these tools and respective functionalities, under a common platform, unlocks more accurate power flow analyses and environmental assessments, in line with eco-design principles. Results presented in this study are expected to be of very high interest for: (i) policy and decision makers, managers and public administrators overseeing public services, (ii) scientists aiming at sustainability assessments studies for e.g. cities/islands, (iii) SME's with the purpose of using it as a basis for improving current or future energy sustainability plans.

**Keywords:** *Platform, Sustainability Assessment, Life Cycle, Energy Modeling and Simulation*

## SIMPLIFIED MODEL ON SUSTAINABLE MOBILITY PLANNING IN SMALL INSULAR TOURISM DESTINATIONS. THE CASE OF PLATANIAS, CRETE

STAVROULA TOURNAKI

*Renewable and Sustainable Energy Lab, School of Chemical and Environmental Engineering,  
Technical University of Crete, University Campus, 73100 Chania, Crete, Greece  
Email: [stavroula.tournaki@enveng.tuc.gr](mailto:stavroula.tournaki@enveng.tuc.gr)*

Sustainable urban mobility planning is a challenging task, especially in the context of smaller cities, where resources, data availability, and planning autonomy are limited. At the same time, small cities can face significant challenges in their mobility systems, especially the ones being popular tourist destinations.

Even though numerous guidelines and advanced design tools are available, a simplified approach in mobility planning, non-intensive in terms of data analysis, funds and human resources, is needed in these cases.

This work presents experiences and lessons learned from new simplified mobility planning approaches tailored to the needs of small insular cities with seasonal tourism and tested in Platania on the island of Crete. The extreme variation of the population between summer and winter forces mobility and urban planners to consider residents and visitors and the thousand seasonal workers in their planning.

The approach focuses on the analysis of mobility and behaviour patterns of citizens and visitors, in combination with mobility and environmental indicators, and tests GIS-based analytical tools by exploiting open data sources to support decision-making in a highly co-created engagement process for the development of the city's first Sustainable Urban Mobility Plan.

**Keywords:** *Sustainable Mobility, Tourism, Small City, Behavioural*

## MODELLING OF AIR POLLUTION IN MEDITERRANEAN COASTAL CITIES DUE TO MARINE TRAFFIC

E. CHEVET, O. BOIRON, F. ANSELMET

*École Centrale de Marseille, Institut de Recherche sur les Phénomènes Hors Équilibre,*

*Aix-Marseille University, CNRS*

*Email: [elliott.chevet@centrale-marseille.fr](mailto:elliott.chevet@centrale-marseille.fr)*

Maritime traffic is constantly increasing and is unlikely to decrease in the years to come. However, merchant and tourist ships still use fuels with a high pollutant content, particularly in the Mediterranean sea where regulations are more flexible than those applied in northern European waters. These pollutant emissions in the Mediterranean basin have an all-the-more significant impact on the population since the busiest ports are generally located in the heart of the major Mediterranean cities. The pollutants of interest in this work, which include particulate matter (PM<sub>10</sub>, PM<sub>2.5</sub>), NO<sub>2</sub>, SO<sub>2</sub> and ozone, are responsible for respiratory diseases such as asthma and airway irritation, but also for cardiopulmonary and lung cancers.

The purpose of this study is to estimate the impact of marine traffic on the air quality of the overall city in case of high occupancy scenarios of the port. In order to do so, we have parameterized a numerical weather forecasting model that also allows the inclusion of chemistry and atmospheric transport equations. The model used, WRF (Weather Research and Forecasting), offers a great flexibility concerning the parameterization and proposes many physical models, which makes it easier to adapt the model to the given problem as well as to the characteristics of the studied region.

Three types of data are required as inputs to run the model. 6-hourly GFS/FNL data (Global Forecast System) are used as coarse meteorological initial and boundary conditions, with a horizontal resolution of 27 km. WRF then performs a downscaling, reaching a resolution of about one kilometer. The chemical model takes yearly chemical emission data from EDGAR-HTAP inventory. Hourly coefficients are then applied accordingly to the method implemented by Crippa et Al. (2020)<sup>1</sup>. For ship traffic, AIS data provides position, speed and time at berth of any given boat as well as its main features. Methodology to estimate ship emissions from its characteristics and its state (navigating, maneuvering, hosteling), is derived from both EPA and EMEP reports.

The relative difference in concentration between a situation with and without ship traffic allows us to evaluate the influence of ships on air quality. The effect of seasonality is also analyzed, by running 4 simulations of 72 hours for each season. The dates are chosen to best represent their respective period in terms of local weather. Centre de Calcul Intensif d'Aix-Marseille is acknowledged for granting access to its high performance computing resources.

When compared to the values presented in Viana et Al. (2014)<sup>2</sup>, the model seems to underestimate the contribution of the shipping sector to urban pollution. However, these results are provisional and some points of improvement still need to be explored, especially concerning emission data.

**Keywords:** *Atmospheric Pollution, Ship Traffic, Numerical Weather Prediction, Chemical Emissions*

## MONITORING THE ENVIRONMENTAL IMPACT OF TRANSPORT AND PROMOTION OF ELECTROMOBILITY IN ISLAND AREAS

DIMITRIS MARGARITIS, EVANGELOS BEKIARIS,  
MARY PAPANDREOU, PANAGIOTIS LIAPIS

*Centre for Research and Technology Hellas/Hellenic Institute of Transport  
Email: [dmarg@certh.gr](mailto:dmarg@certh.gr), [abek@certh.gr](mailto:abek@certh.gr), [mpapandreou@certh.gr](mailto:mpapandreou@certh.gr), [pliapis@certh.gr](mailto:pliapis@certh.gr)*

Environmental pollution in the urban areas remains a major issue with serious implications for the health of citizens. Exposure to air pollution, particularly within the microenvironment of roads, is associated with cardiopulmonary diseases, increased risk of carcinogenicity and neuro-related disorders. In addition, increased noise level (from road traffic and other sources) is an important parameter which, apart from the disturbance and the mental burden, is associated with cardiovascular diseases. The aforementioned phenomena may be more intense within large urban centers when occurring on a continuous basis, but also in the island regions where the environmental burden is caused by the arrival of large number of tourists in a short period of time, leading to mid-term health implications to permanent residents.

The main goal of the ELEKTRON project is the establishment of a Lab of Excellence, which, studies, elaborates, develops and proposes smart solutions for energy savings both through the application of modern technologies in transport and through the pilot production of renewable energy, with a focus on solar energy leading to minimization of carbon footprint implications.

The Lab consists of its premises in the island of Rhodes, Greece. It is equipped with three portable/mobile units that monitor environmental and meteorological parameters as well as noise for indoor and outdoor places. Three high-end fully electric vehicles are used for conducting pilot tests with the involvement of end-users and local operators. The laboratory is also equipped with a small solar power plant (3KW) and with two electric vehicle chargers of 25KW each to facilitate the electro mobility scheme. A grid simulation model is being developed to assess the impact of the seasonal energy demand generated during the tourist period.

ELEKTRON project does not only provide equipment and software for research activities but it plans to produce its own tools, which will make available for use to local operators. These concern: i. an info library on optimal electromobility and energy saving solutions and ii. a digital tool for the initial design of scenarios for improving the current situation and the estimation and planning of future energy demand through the application of electric mobility.

The project seeks to implement some of the best practices for creating "Smart Cities" in island regions, so as to develop and create "Smart Islands". It also aims to the expansion of renewable energy sources use with a view to meet the future power supply needs in the transportation sector. The implementation of new "smart" solutions, such as electromobility, will significantly contribute to the growth of the islands' by creating new permanent jobs in existing and new local economy sectors.

**Keywords:** *Electric Mobility, Energy Monitoring, Pollution Monitoring, Smart Islands*

## PROBLEMS OF SUSTAINABILITY INFORMATICS DEVELOPMENT

**HORST JUNKER**

*IMBC GmbH, Beckerstr. 6a, 12 157 Berlin*

*Email: [horst.junker@imbc.de](mailto:horst.junker@imbc.de)*

Due to the definition of sustainability as an integrative model of the pillars economy, ecology and social affairs it seems likely to investigate initially to which extend it is succeeded to establish comprehensive business informatics as well as a holistic environmental informatics. This question shall be examined first concerning the production integrated environment protection for - in case of a positive result – to integrate the third pillar of sustainability.

As business-oriented software (e.g. ERP and also production, planning and control systems) and CEMIS in principle cover the same area, namely production, such CEMIS can be designed on the basis of the add-on model, expansion model or integration model. The integration model is portrayed as being particularly powerful. This model calls for a software architecture design which takes equal account of economic and ecological interests. However, as yet, no such system has been implemented on the basis of this model. If the expansion model were to be implemented, the existing functionalities of a production, planning and control system or ERP system must be added as environmentally oriented additions. Thus, integration in this case does not take place at the system level, but through the development of add-ons at the individual function level. Such systems are likewise as yet unknown to exist. If the add-on model were to be pursued, this would signify the development of a separate CEMIS for production, independent of existing production, planning and control systems or ERP systems. A model of this nature has serious disadvantages. Firstly, the same data may have to be stored in both systems, infringing the principle of entering data only once and multiple evaluations. Secondly, users would likely be confronted with different processing results, since such CEMIS must fulfil different objectives compared to production, planning and control systems or ERP systems.

Due to the till this day existing unavailability of software systems for the production integrated environment protection at least one of the three pillars of sustainability can not attend. Therefore it will be necessary to choose a different innovative approach for the development of sustainability information systems.

Companies have to submit the postulate of sustainability. Therefore, they necessarily need comprehensive support by efficient information for remaining competitive taking sustainability into account. But such type of information systems are neither existing in practice nor are they treated scientifically in a comprehensive manner. Merely, concerning sustainability mission statements and reporting knowledge and results are available. But this will describe but not support or force sustainability. Sustainability is defined as the optimization of not only its three components but also its mutual integration. Strategic information management suggests strategic situation analysis, strategic target planning, strategy development and strategic information system planning as sequence of process steps for developing corporate relevant portfolio of

information systems. Precondition for an individual design of such a portfolio is the availability of a common sustainability target system. Therefore, it will be necessary to prepare a hierarchical target system for each of the three components of sustainability and to examine the relationships between all identified target elements in how far they are harmonic or whether it will be possible to harmonize them. By the availability of such a harmonized integrative sustainability target system precondition are given to develop a portfolio of sustainability information systems.

**Keywords:** *Sustainability, Sustainability Informatics, Production Integrated Environment Protection, Information Management*

## NUMERICAL INVESTIGATION OF THE THERMAL PERFORMANCE OF A SOLID BIOFUEL BOILER

THEOKLITOS KLITOU<sup>1a</sup>, PARIS A. FOKAIDES<sup>1,2 b\*</sup>

<sup>1</sup> *School of Engineering, Frederick University, Cyprus*

<sup>2</sup> *Faculty of Civil Engineering and Architecture, Kaunas University of Technology, Kaunas, Lithuania*

<sup>a</sup> [res.kt@frederick.ac.cy](mailto:res.kt@frederick.ac.cy), <sup>b</sup> [eng.fp@frederick.ac.cy](mailto:eng.fp@frederick.ac.cy)

The use of solid biofuels as a source of domestic heating, is an established methodology, which is developing in the recent years. Due to the fact that the physics of solid fuels combustion are much more complex compared to liquid and gaseous fuels, numerical simulation on the topic of investigating the performance of solid biofuels boilers are limited. It is a fact though, that numerical simulations are more than imperative for improving and optimizing solid biofuels boilers, with regard to their main features. This study presents the numerical investigation of the thermal performance of the combustion chamber of a solid biofuel boiler, with the use of finite elements. In terms of this study, the heat transfer solver of Solidworks was employed. The study reveals aspects of geometry optimization of the boilers combustion chamber, towards reducing heat losses and achieving higher levels of efficiency.

**Keywords:** *Solid biofuels, combustion, numerical simulation, finite elements, heat transfer*

## SENSOR TECHNOLOGY ENABLES SUSTAINABLE WORK

THOMAS PIETSCH

*HTW Berlin, Business Informatics, Treskowallee 8, 10318 Berlin*

*Email: [thomas.pietsch@htw-berlin.de](mailto:thomas.pietsch@htw-berlin.de)*

The process of digitization that is currently pervading industries around the world has the potential of being a game changer not only for manufacturing industry, but across the entire economy. And it does not only affect single businesses and supply chains, but also has an impact on society and environment as a whole. This also creates opportunities in many areas of application to reduce the consumption of resources and to operate more sustainably. Such a use case, its analysis, research and development of an environmentally friendly solution are described in this contribution. It is a project for development and implementation of an Internet of Things (IoT) solution using sensors and monitoring software. The project was carried out together with a company that operates 23 car washes and our common goal was to find out how the use of sensor technology can make the company's work more resource-efficient and sustainable. Car washes consume a lot of resources, especially water and electricity, which are recorded by central meters of the energy supplying companies. They also wash off oils and greases from the cars, which must be collected, measured and disposed of. Each individual car wash has a large number of meters, but they don't track the point of time of the energy consumption or the individual energy-consuming machine and their counters have no predictive warning about the amount of pollutants collected. But above all: Energy meters are usually read manually and the meter readings are documented by hand. The manual entry of consumption data into the software, no targeted time- and device-related consumption determination and analysis functions as well as no forecast features cause a lack of opportunities for targeted measures to reduce resource consumption and improving sustainability. For these reasons, the analog meter readings should be digitized using IoT sensors and the readout and consumption check should be automated with the help of a monitoring and analysis software, which has been selected for this project. In our contribution we will present how we processed and tested our ideas and the proof-of-concept for the desired solution with models made of LEGO® bricks. After that, we show and explain our sensor-based solution after 2 years of analysis, research and development. Using the example of the car wash project we will then show the impact of digitization on an environmental and business level in a company that does not produce physical products. In this case sensors and cloud-based monitoring and data analysis built the basis for a in the future more sustainable working company. Finally, we will highlight the main positive changes for the environment with the implementation of intelligent digitized solutions that we anticipate in the aftermath of the implementation in order to motivate companies for the changes to come.

**Keywords:** *sustainability, resource efficiency, digitization, sensor technology*

## FUTURE OF WORK – A MIND GAME ABOUT USE CASES WITH AR, VR AND XR

**CARSTEN DOMANN**

*Fachhochschule des Mittelstands (FHM) GmbH - University of Applied Sciences – FHM Berlin*

*Email: [carsten.domann@fh-mittelstand.de](mailto:carsten.domann@fh-mittelstand.de)*

Techno-technological innovations in the form of products, integrated as processes in services, and last but not least as thought-provoking novel models of action are important building blocks for sustainable developments. Too often, foresight about future positive tendencies and the realization of these fantasies puts the initial steps on the sidelines. Questions about ideation, questions about feasibility, questions about acceptance, and questions about moving through the learning curve must be recognized and answered. Sustainability in the sense of understanding resources, in the sense of being application-oriented across disciplines, and in the sense of being a path-breaking learning and knowledge tramp must be answered.

Augmented and virtual realities were initially a short-term fad that did not really overcome the status of a game function. However, it is through the past few years (triggered by the pandemic) that they have returned to the focus of industry and academia. Online connections have taken over entire industries virtually overnight and have also shed new light on didactic approaches to learning and knowledge transfer at universities. The author will draw on two different EU projects in the areas of AR, VR, and XR and use selected examples to trigger and run through a thought experiment on the prerequisites of digital learning formats (content vs. technology), application scenarios (remote vs. travel effort), effects (model vs. simulation), and other parameters.

The main goal of the paper is to raise the awareness of the auditorium that it is not only the technology but the conscious, thoughtful and collaborative approach that leads to sustainable business models with environmental, ecological and social positives. Reflection on existing learning and knowledge transfer formats, as well as redefinition and reassessment, are prioritized to support the use of limited resources with the best paradigms, practices and strategies at local, Mediterranean, European and global levels.

## FUTURE OF WORK IN MOROCCO IN ARTIFICIAL INTELLIGENCE AGE

NAIMA EL HAUD, ZINEB BACHIRI

*Scientific Engineering of Organizations Laboratory, University Hassan II- ENCG C, Casablanca-Morocco  
Email: [n.elhaoud@encgcasa.ma](mailto:n.elhaoud@encgcasa.ma)*

In the context of “artificial intelligence revolution”, Morocco quickly understood the importance of artificial intelligence and took initiatives aimed at putting AI at the heart of public debate. However, while developing artificial intelligence, we must also pay enough attention to the problems it may cause. Employment is one of the most worrying issues. Indeed, future advances in artificial intelligence were set to be even more dramatic and may transform work worldwide (Brynjolfsson and McAfee, 2012; Ford, 2016; Boston Consulting Group, 2015; McKinsey, 2017). Our paper aims to determine the future impacts of AI on general employment in Morocco, referring to theories related to “technical unemployment” (Keynes, 1930; Malthus, 1962; Say, 1963; Arai, 2010; Graetz and Michaels, 2015). Based on the methodology of Frey and Osborne (2017) we showed that 66.31% of workers will be impacted by AI, men are exposed to higher risks than women, and that there is a correlation between the level of education of workers and the risk of disappearing from their professions. To face this shock, we believe that the key is the implementation of new public policies to tackle the structural problems of the labor market and the training of workers in the trades that will be most in demand in order to “technical unemployment”.

**Keywords:** *Artificial intelligence, Automation, Employment, Labor market, sustainable development*

## LIFE-CYCLE ASSESSMENT OF FOREST ECOSYSTEM IN PORTUGAL FOR ROUNDWOOD PRODUCTION: EUCALYPTUS GLOBULUS

FILIPA FIGUEIREDO<sup>1,2,3</sup>, JOÃO NUNES<sup>1,2</sup>

<sup>1</sup> Associação CECOLAB – Collaborative Laboratory Towards Circular Economy,  
Rua Nossa Senhora da Conceição, nº. 2. Lagares da Beira 3405-155 Oliveira do Hospital, Portugal

<sup>2</sup> Centre Bio R&D Unit, Association BLC3 – Technological and Innovation Campus,  
Rua Nossa Senhora da Conceição, nº. 2. Lagares da Beira 3405-155 Oliveira do Hospital, Portugal

<sup>3</sup> Centre for Environmental and Marine Studies (CESAM), Department of Environment and Planning,  
University of Aveiro, 3810-193 Aveiro, Portugal

\* Email: [filipa.figueiredo@cecolab.pt](mailto:filipa.figueiredo@cecolab.pt)

Roundwood production and forest management represent an important sector in the Portuguese economy. In 2019, Portugal remained the 3rd largest European producer of pulp, with a 7,2% market share, just behind Sweden and Finland, and ahead of Germany. This article presents an LCA of Portuguese forest ecosystem dedicated for roundwood production by *Eucalyptus globulus* specie. The delivered at the pulp production plant gate, incorporating a sensitivity analysis of *Eucalyptus* transportation at the pulp production plant. The input and output data of the Life-cycle inventory (LCI) were collected by the authors for the Portuguese forest reality, complemented with background data from Ecoinvent database 3.1. The functional unit adopted was 1 m<sup>3</sup> of *E. globulus* at pulp production plant gate.

A Life-Cycle Impact Assessment of *E. globulus* produced in Portugal calculated with ReCiPe method version v1.1 was performed for four impact categories: Climate Change (CC - GHG intensity, 100-year), Terrestrial Acidification (TA), Marine Eutrophication (ME) and Freshwater Eutrophication (FEW). The main results show that transport has little influence on the ME and FWE categories, unlike CC and TA. For distances greater than 90 km, transport represents for the CC and TA categories the life-cycle phase with the greatest environmental impacts. Land preparation, planting and maintenance represent more than 95% of the total impacts for FWE and ME, and 40% and 34% for CC (with a transport distance of 30 km and 60 km, respectively). Finally, for TA the life-cycle phase with the higher impacts depends on transportation distances. A comparative analysis with other agriculture crops was performed and has shown that *E. globulus* roundwood production present lower GHG emissions per ha than sunflower, soybean and rapeseed (raw-material commonly used for food and/or bioenergy production). For future work it was considered pertinent to evaluate the following: i) a multifunctionality approach that considers the valorisation of branches and other biomass residues into bioenergy or land use soil (substituting fertilization) and/or the valorisation of the bark in the paper production plant that could uses it for energy production; and ii) a sensitivity analysis of the soil carbon stock, when considering forwarding roundwood for pulp and paper production.

**Keywords:** *Life-cycle inventory, Environmental Impacts, Eucalyptus Globulus, ReCiPe*

## CIRCULAR UTILIZATION OF POST-CONSUMER PLASTIC WASTE VIA 3D PRINTING – A PRELIMINARY STUDY

NIKOLAOS EFKOLIDIS<sup>1</sup>, KYRIAKI G. SAKELLARIOU<sup>2</sup>, PERIKLIS KAFASIS<sup>2</sup>,  
PRODROMOS MINAOGLOU<sup>1</sup>, PANAGIOTIS KYRATSIS<sup>1</sup>

<sup>1</sup> *University of Western Macedonia, Department of Product and Systems Design Engineering,  
Kila Kozani, GR50100, Greece, Email: nefkolidis@uowm.gr*

<sup>2</sup> *DIADYMA SA Waste Management of Western Macedonia, 6th km Ptolemaida - Kozani Rd.,  
Kozani, GR50100, Greece*

3D printing technology (additive manufacturing) consists a revolutionary tool for product design and manufacturing industry. It is a cost-effective and time-saving technology that is applied for the development of conceptual models and functional prototypes, letting designers and engineers to check their designs in real-time and find the best solution. The capability of producing models with complex external and even more unusual internal geometries is particularly valuable. Furthermore, 3D printing is continuously evolved from a method of producing prototypes to a technology able to manufacture end-use parts. At the same time, one of the key issues in waste management and environment protection is based on the reuse and upcycling of post-consumer plastic waste. The development and implementation of new closed-loop schemes in view of the 3Rs (Reduce, Reuse, Recycle) principle are enhancing plastic waste upcycling via new valorisation routes leading to new products. The aim of the present study is to emphasize the management of recyclable plastic and investigate its processing into new products within the framework of circular economy. To this end, the feasibility of recycling HDPE plastic waste from mineral water bottle caps is studied and their transformation into recyclable HDPE filament is examined. Plastic bottle caps are specially processed in order to form PLA/ recycled HDPE mixtures with the aim to obtain new recyclable 3D printing filaments. After their collection, the plastic caps are shred into plastic bits followed by extrusion of the newly produced recycled material into a 3D printing filament offering additional advantages. The new more environmentally friendly filament is going to be used for the development of new 3D printed products in the context of circular economy, thereby, minimizing the environmental impact and promoting simultaneously the whole green effort.

**Keywords:** *Circular economy; 3D printing; plastic waste; recycled filament*

## THE USE OF DIAPERS SCRAP IN THE MANUFACTURE OF CLAY BRICKS

SH. K. AMIN<sup>1</sup>, M.F. ABADIR<sup>2</sup>, M.A. GADALLA<sup>3</sup>, F.H. ASHOUR<sup>2</sup>

<sup>1</sup>*The National research Center, Cairo, Egypt*

<sup>2</sup>*The Chemical Engineering Department, Faculty of Engineering, Cairo University*

<sup>3</sup>*The Chemical Engineering Department, Faculty of Engineering, Port-Said University*

*Email: [fhashour@eng.cu.edu.eg](mailto:fhashour@eng.cu.edu.eg)*

The diaper industry produces large amounts of scrap that is normally shredded and dumped. The use of shredded diaper waste was investigated to substitute clay in the preparation of building bricks. The recycle of this priceless waste not only decreases the negative effects of its disposal but can also contribute to decreasing the running cost of the produced bricks. Suggested mixtures were prepared by the addition of both wastes to the clay in levels varying from 0 to 3% by weight. The brick samples for each mixture were formed, dried, and then fired at temperatures ranging from 700oC to 900oC. Results showed that bricks containing 1.5% diaper waste and fired at 700oC displayed a boiling water absorption of 18.6%, a saturation coefficient of 0.78 and a compressive strength of 13.3MPa, thus abiding by ASTM C62 Standards for normal duty building bricks.

**Keywords:** *Diapers, Scrap, Clay, Bricks*

## OPTIMIZATION OF METHYL ORANGE REMOVAL FROM TEXTILE WASTE WATER BY ELECTRO-COAGULATION CELL USING RSM

SARAH MOHAMED ELHOSARYA, MAGDI F. ABADIRA, NOURA FATHY ADEL SALAM

*Chemical Engineering Department, Faculty of Engineering, Cairo University, Giza, 12613, Egypt*

*Email: [nourafathy@eng.cu.edu.eg](mailto:nourafathy@eng.cu.edu.eg)*

Wastewater treatment processes are urgently needed to adapt to rising water and energy demands, climate variability, and resource scarcity. In the present study, the performance of the electrocoagulation (EC) in the treatment of synthetic wastewater containing textile dyeing such as methyl orange (MO) was investigated using the Response Surface Methodology (RSM) in 33 full factorial design experiments. Electrolysis of wastewater was carried out by means of iron electrodes under different operating conditions of initial dye concentration, applied voltage and electrolysis time at room temperature and pH=7. The results showed that using EC has proven to be a promising method in the color removal from textile dyeing wastewater. The maximum color removal efficiency was 96.77% at an applied voltage of 15 V, an electrolysis time of 30 minutes and at an initial dye concentration of 50 mg/L. Under these conditions the corresponding Electrical Energy Consumption (EEC) was 23.7 kWh.m<sup>-3</sup>. Most of the color removal occurred in the first 20 min whereby 87.5-91% of the color was removed.

**Keywords:** *Electrocoagulation, Iron electrodes, Dye removal, Textile, Wastewater*

## RECYCLING OF END-OF-LIFE TYRES VIA PYROLYSIS AND CATALYTIC VAPOUR UPGRADING

STYLIANOS D. STEFANIDIS, ELENI PACHATOURIDOU, ELENI HERACLEOUS,  
ANGELOS A. LAPPAS\*

*Chemical Process and Energy Resources Institute, Centre for Research and Technology Hellas,  
57001 Thessaloniki, Greece, \*Email: [angel@certh.gr](mailto:angel@certh.gr)*

A large number of tyres from road vehicles are retired annually, entering the pool of end-of-life tyres (ELTs) that presents a large, untapped potential for material recovery. Tyres are complex composites made up of elastomers, fillers, reinforcement materials, chemicals and plasticisers, many of which are produced from non-renewable sources. While ELTs can be treated to be repurposed for various applications, today's treatment processes are not circular and do not result in many raw materials that can be reused in new tyres. The aim of this study, which is part of the EU project BlackCycle, was to develop a technology for the recycling of ELTs into raw materials that can be used for the production of new tyres, effectively reducing the use of composites from non-renewable sources and drastically mitigating CO<sub>2</sub> emissions associated with new tyre manufacturing. Towards this goal, pyrolysis of an ELT feed was carried out to obtain pyrolysis oil and recycled carbon black; pyrolysis oils with a high content in aromatics can be utilised for the production of carbon black, a major tyre component used as filler. Particular focus was placed on the coupling of pyrolysis with catalytic vapour upgrading in order to catalytically convert the tyre-derived compounds in the pyrolysis vapours to aromatics and maximise the aromaticity of the produced pyrolysis oils.

The pyrolysis temperature was first optimized in a bench-scale fixed bed reactor to obtain a maximum pyrolysis oil yield of ~53 wt%. This was followed by a pre-screening of various acidic zeolites and low-cost mineral oxides with the aim to identify promising catalysts that produce highly aromatic pyrolysis oils. A significant increase in the aromaticity of pyrolysis oils was observed with USY and ZSM-5 zeolite-based catalysts, accompanied by only a moderate reduction of the pyrolysis oil yield to ~42 wt%. Modification of the catalysts with transition metals evidently promoted dehydrogenation reactions, which favoured the formation of di- and tri- aromatic compounds over monoaromatics, and resulted in pyrolysis oils with increased average MW that are more suitable for the production of carbon black. The results were verified by further testing of the most promising catalysts in a continuous medium-scale unit with cascading bubbling bed reactors, as well as in a continuous pilot-scale plant with a circulating fluidized bed reactor with continuous catalyst regeneration. The maximum aromatic content achieved in the pyrolysis oil in this work was ~87 wt% with a USY catalyst, while the maximum total aromatics yield achieved was ~38 wt%.

**Keywords:** *Tyres, Recycling, Carbon black, Aromatics*

## A CRITICAL GLOBAL ANALYSIS OF BIOECONOMY VISIONS IN BIOECONOMY POLICIES

MARIA PROESTOU, NICOLAI SCHULZ, PETER H. FEINDT

*Humboldt-Universität zu Berlin, Agricultural and Food Policy Group,  
Berlin, Germany*

*Email: maria.proestou@hu-berlin.de, nicolai.schulz@hu-berlin.de, peter.feindt@hu-berlin.de*

Bioeconomy is considered as a political and societal project that aims at transforming the fossil-based to a bio-based, resource-efficient and circular economy. A rapidly growing number of national and international organizations and actors see the transformation towards a sustainable and resilient bioeconomy as an important approach to address various problems and conflicts of our time (e.g. food security, poverty, climate protection, health risks, sustainable energy supply, biodiversity conservation), thereby contributing to the achievement of the Sustainable Development Goals and the post-COVID-19 recovery. Accordingly, bioeconomy-related policies have been published in more than 50 countries and scholars have increasingly studied bioeconomy from different angles. As part of this, several studies have identified different visions (i.e. the key goals, ideas, and ambitions) characterizing bioeconomy and its related policies (Bugge et al. 2016, Dietz et al. 2018). Usually, however, these studies have identified bioeconomy visions at a highly aggregated level. More detailed descriptions of bioeconomy visions across all 50 countries with bioeconomy-related policies are missing. To address this gap, building on a policy design approach (Howlett 2014), we conduct a systematic qualitative content analysis of 78 policy documents from 50 countries to study the visions reflected in their policy goals. Specifically, we first inductively identify and code 227 distinct policy goals throughout all documents. Based on this, we generate detailed descriptive statistics of the salience of certain goals and their overarching categories in bioeconomy-related policies. We further group these goals based on existing literature-based bioeconomy vision typologies to map patterns of bioeconomy visions across the globe. Overall, we find that bioeconomy policy visions are largely oriented towards (bio)technology, economic growth, biomass, research and innovation, whereas promotion of ecological and social questions tends to be of only secondary importance. We indicate that the prevailing techno-centric visions of bioeconomy policies appear problematic considering the desired transformation and achievement of the Sustainable Development Goals. This is of primary importance for a sustainable bioeconomy understood as a societal project expected to contribute to facing climate and biodiversity challenges and solving systemic economic, poverty, and health crises (IACGB 2020, FAO 2018). These findings contribute to a better understanding of the notion and ambition of current bioeconomies and call for further critical research on bioeconomy visions, and particularly their manifestation in public policy.

**Keywords:** *Bioeconomy, Sustainability, Policy Visions, Policy Goals*

## SALIENCE OF RESILIENCE CHALLENGES IN BIOECONOMY POLICIES: A COMPARATIVE ANALYSIS

MARIA PROESTOU, NICOLAI SCHULZ, PETER H. FEINDT

*Humboldt-Universität zu Berlin, Department of Agricultural Economics,  
Agricultural and Food Policy Group*

*Email: [maria.proestou@hu-berlin.de](mailto:maria.proestou@hu-berlin.de), [nicolai.schulz@hu-berlin.de](mailto:nicolai.schulz@hu-berlin.de), [peter.feindt@hu-berlin.de](mailto:peter.feindt@hu-berlin.de)*

The resilience of social-ecological systems (SES) has become a major concern in environmental policy. Aiming to address resilience and sustainability challenges of the fossil-based economy, over 50 countries around the globe have promulgated policies promoting the transformation towards a bio-based economy. The success of this transformation, in turn, depends on the resilience of the SES, bio-based production systems (BBPS), and particularly agricultural production systems on which the bioeconomy rests. The continued delivery of desired functions of these systems is, however, challenged by economic, social, environmental, and institutional short-term stresses such as interruption of seasonal labor supply and adverse weather conditions as well as long-term stresses such as increasing resource competition, climate change, decline of pollinators, and changing consumer preferences. Despite the importance of such resilience challenges for a sustainable bioeconomy transformation, it remains unclear and underexplored to what extent they are addressed in bioeconomy policies. To fill this gap, we study the salience of resilience challenges in bioeconomy policies applying the Resilience Policy Design (RPD) framework (Feindt et al. 2020), which combines resilience thinking with the 'new' policy design perspective. Specifically, we conduct a systematic content analysis of 78 bioeconomy-related policy documents across 50 countries to map the text share that addresses resilience challenges and identify the resource systems, units, uses, and functions challenged. We further describe and categorize the specific short- and long-term stresses mentioned and the policy goals and instruments directly targeted at addressing the challenges recognized. Based on this, we employ correlational analysis to identify potential political, economic, social, and environmental country context conditions affecting policy design spaces that might explain variation in salience of resilience challenges in bioeconomy strategies across countries. Overall, these analyses contribute to a better understanding of the role and origins of resilience concerns in global bioeconomy policy making.

**Keywords:** *Bioeconomy Transformation; Resilience; Sustainability; Policy Design*

## SUSTAINABLE INNOVATIONS. EMPIRICAL EVIDENCE FROM THE BIOECONOMY SECTOR

MAGDALENA WOJNAROWSKA<sup>1\*</sup>, MARIUSZ SOŁTYSIK<sup>2</sup>, CARLO INGRAO<sup>3</sup>

<sup>1</sup> *Department of Technology and Ecology of Products, Cracow University of Economics, Rakowicka 27, 31-510 Cracow, Poland, Email: [wojnarom@uek.krakow.pl](mailto:wojnarom@uek.krakow.pl)*

<sup>2</sup> *Department of Management Process, Cracow University of Economics, Rakowicka 27, 31-510 Cracow, Poland*

<sup>3</sup> *Department of Economics, Management and Business Law, University of Bari "Aldo Moro", Italy*

The current development trends indicate the need to modernize the economy, taking into account the notions of sustainable development, which is understood as a social model that cannot be attributed to any single scientific discipline. Sustainable development issues are very complex and despite numerous studies and publications in recent times, they are still poorly understood.

The implementation of sustainable development in the enterprise is related to ecological innovations, which play an important role in the process of sustainable transformation. According to the publicly available literature, enterprises play a central role in the process of research on sustainable development because they are direct users (consumers) of natural resources. The significant impact of increased pro-ecological activities on the part of enterprises is also visible in the change of consumer attitudes towards the environment, as well as in the environmental strategies of individual competitors. The development of ecological and / or sustainable entrepreneurship is of key importance for the economy, because by taking various pro-ecological activities at the enterprise level, it is possible to create the right conditions for the sustainable development of a given economy.

Bioeconomy is one of the areas supporting sustainable development and is an interdisciplinary branch of the economy that can be defined as the sustainable use of renewable biological resources to create goods and services. An economy based on new biological technologies is conducive to the creation of an innovative, resource-efficient, and competitive economy seeking to ensure food security using renewable resources for industrial purposes. In addition, the industries related to it are becoming one of the largest employers. Many factors influence the development of the bioeconomy, including regulatory conditions, intellectual property, human resources, social acceptance, market structure, and business models.

This allows for the formulation of the research thesis that sustainable development at the basis of the bioeconomy is perceived as a source of new entrepreneurial opportunities stimulating the development of innovative enterprises in the context of solving social and environmental problems.

The main goal of this study is to identify factors both supporting and inhibiting the development of innovation in enterprises on the example of the bioeconomy sector in Małopolska. Our research will have both theoretical and practical contributions. The theoretical implications will focus on explaining the role of innovation in sustainable entrepreneurship by focusing on internal

and external factors that support and hinder the development of innovation in bioeconomy enterprises. From a practical point of view, our research will be able to provide more detailed guidance for managers on how to identify and implement improvements in the environmental and economic performance that influence the innovation of enterprises.

**Keywords:** *Sustainable Innovations, Bioeconomy, Sustainable Development, Enterprises*

# BALANCING TECHNOLOGY AND NATURE: WATER MANAGEMENT RESTORATION TECHNIQUES APPLIED TO AGRIVOLTAICS AND THEIR CLIMATIC IMPACT COMPARED WITH CONVENTIONAL PHOTOVOLTAIC SYSTEMS

AMALIA TZIANOPOULOU

*MSc student in Water Biosphere and Climate Change, National and Kapodistrian University of Athens, Greece – International Hellenic University – UNESCO Con-E-Ect*

*Email: [amatz4444@gmail.com](mailto:amatz4444@gmail.com)*

Renewable energy is growing rapidly and the governments make more commitments to increase the sustainability of energy systems. While this transition to a stronger reliance on cleaner sources of energy will play a key role in global reduction of greenhouse gas emissions, there is always a question about land productivity and biodiversity impacts. Instead of choosing separately between energy solutions and land use for food and animal feed production, dual use concepts like agrivoltaics are combining both types, promising a new balance between nature and technology. There are also ways to safeguard biological diversity in solar parks, introducing wild flowers and herbs, pollinators, bird and bat cages. Sheep grazing controls plant height for the effective solar park operation and enhances soil health and soil carbon sequestration at the same time. In agrivoltaics the panels perform at a higher level, because of the plant's cooler microclimate, while plants are protected from sunburn, frost and dehydration. Panels could also be used for rainwater restoration. The combination of agrivoltaics and water management restoration techniques could be an effective measure against desertification. This could give a solution both to energy, agriculture and water management problems for arid and semi-arid regions. Restored rainwater can be reused for cleaning the panels and irrigation, while the installation of water filters could give an option for people to accessing clean water. The Standard Precipitation Index (SPI) spatial distribution is recording the evolution of the drought phenomenon, while changes in the atmospheric circulation with ongoing climate change accelerate arid conditions in South-East Mediterranean. The purpose of this study is balancing photovoltaic parks operation with green land uses in Greece and make agrivoltaics with water management restoration techniques an option against the increased aridity over Greek areas.

**Keywords:** *Agrioltaics, Water Restoration, Aridity, Biodiversity*

## TOWARDS ZERO FOOD WASTE AND LOSSES: DEVELOPMENT OF SUSTAINABLE INNOVATIVE SOLUTIONS FOR ARTISANAL MEAT SAUSAGES VALUE CHAIN IN PORTUGAL

FILIPA FIGUEIREDO<sup>1,2,3</sup>, RITA SANTOS<sup>1,2</sup>, PATRÍCIA VIEIRA<sup>1,2</sup>, JORGE A. P. PAIVA<sup>1,2</sup>,  
RITA PONTES<sup>2</sup>, SÓNIA RIBEIRO<sup>2</sup>, JOÃO NUNES<sup>1,2,\*</sup>

<sup>1</sup> Associação CECOLAB – Collaborative Laboratory Towards Circular Economy,  
Rua Nossa Senhora da Conceição, nº. 2. Lagares da Beira 3405-155 Oliveira do Hospital, Portugal

<sup>2</sup> Centre Bio R&D Unit, Association BLC3 – Technological and Innovation Campus,  
Rua Nossa Senhora da Conceição, nº. 2. Lagares da Beira 3405-155 Oliveira do Hospital, Portugal

<sup>3</sup> Centre for Environmental and Marine Studies (CESAM), Department of Environment and Planning,  
University of Aveiro, 3810-193 Aveiro, Portugal

\* Email: [joão.nunes@blc3.pt](mailto:joão.nunes@blc3.pt)

The Sustainable and Circular Bioeconomy in Europe is a key option for economic and social development. Reduction of food losses are one of the main priorities and challenges identified in the European guidelines for a Sustainable and Circular Bioeconomy. Thus, there is critical to developed new innovative solutions reduce residues from food processing and food waste, and to increase food shelf-life. The agri-food sector in Portugal represents about 4 million ha of the entire territory, with around 141 939 companies, a turnover of 17 560 million Euros and 900 982 jobs, characterized by a SME ecosystem. In Portugal, the meat sector represents around 34,2% in terms of turnover in the food sector, where meat transformation occupies an important place (represent 33% of the meat sector turnover). Sausage Portuguese production is considered a strategic option to valorize meat processing waste, with a gross added value of 209 million Euros, where sausage production represents around 30% of meat transformation sector. Nevertheless, sausage sector is continually throwing up new challenges and risks to the health and interest of EU. Among these challenges and risks there is the continuous need of innovation on ecofriendly packaging and on the use of natural preservatives dimensions. These dimensions that can extend the shelf-life of the products (24-36 days) but also maintaining the traditional organoleptic characteristics of the artisanal sausage products.

At Beirlnov project (CENTRO-01-0247-FEDER-113492), different Ecodesign solutions, with important commercial potential of scalability, are being to develop increase shelf-life of sausage products and more sustainable and circular food packaging. The main solutions studied at Beirlnov were:

- (i) the introduction of antimicrobial bioactive molecules at the inner surface of food preservation coatings in contact with the sausages or at the surface of sausages; and
- (ii) development of new bio-based and advanced packaging material derived from lignocellulosic biomass residues integrating bioactive compounds in the packaging, allowing to increase shelf-life of sausage products by 20 to 30%.

The results already obtained are very promising, as these innovative solutions will allow meat processors to improve food quality, freshness and safety, of the artisanal sausage products,

without compromising the organoleptic characteristics of this traditional products. In addition, these solutions will allow to reduce environmental impacts (either by increasing shelf-life of products, reducing and preventing food waste, or by the different sources of raw material used for the production of packaging and its biodegradability potential).

**Keywords:** Circular Economy, Bioeconomy, Ecodesign and Food Waste

## HEALTH RISK ASSESSMENT DUE TO SOME VEGETABLE CULTIVATED ON A FORMER MSW LANDFILL

MANIRAKIZA NORBERT<sup>1,2</sup>, NDIKUMANA THÉOPHILE<sup>2</sup>, JUNG C. GISÈLE<sup>3</sup>

<sup>1</sup> *Department of Natural Sciences, Higher Teacher School, Bujumbura, Burundi*

<sup>2</sup> *Center for Research in Natural and Environment Sciences, University of Burundi, Bujumbura, Burundi*

<sup>3</sup> *Faculty of Applied Sciences, 4MAT Service, Université Libre de Bruxelles, Belgium.*

*Email: [celine.gisele.jung@ulb.be](mailto:celine.gisele.jung@ulb.be), [manorbert84@gmail.com](mailto:manorbert84@gmail.com), [theo.ndikumana@gmail.com](mailto:theo.ndikumana@gmail.com)*

Heavy metals constitute a problem in both developed and developing countries due to their health impacts. This study shows that these micropollutants from anthropic origin do contaminate ground water by lixiviation and some plants cultivated on this soil to finally generate human health diseases through the food chain.

In developing countries, the growing of the population in big cities is forcing some of the population to find a location to live and the site of the former MSW landfill of Buterere is one being chosen by people of the city of Bujumbura. These recent inhabitants do cultivate their vegetables on a soil contaminated with heavy metals. These results have been published in recent research on the soil of the Buterere site\*. The soil showed a high level of heavy metals exceeding WHO permissible values. These results did induce a new part of the research dealing with the contamination of leafy vegetables. For this purpose, 60 representative samples of six types of leafy vegetables were collected from 10 different plots cultivated on the former Buterere landfill, respectively at the different sampling sites and analysed. Standard analysis protocols had been used to determine the concentration of heavy metals in various samples of vegetable samples. These results are showing a specific high level in Ni and Cr.

The comparison of the detected levels of heavy metals with the WHO and FAO acceptable limits shows that the levels of the analysed samples of vegetables are exceeding the guide values and could be harmful to the health of consumers.

A study of the assessment of health risks due to the consumption of these vegetables is performed and shows both carcinogenic and non-carcinogenic chronic pathologies could be affecting the population exposed on this site.

In order to find a sustainable solution, initial trials of phytoremediation of Ni have been carried out using *Panicum Maximum* as first trial presented in this work. The results show the performance of this species adapted to the local climate. Other species of vegetables are planned to be study.

Perspectives of the development of this remediation are encouraging and recommendations are suggested to the local authorities although further measures need to be implemented to raise awareness and avoid the diseases that may result.

**Keywords:** *Landfill, Heavy Metals, Contamination, Human Health, Phytoremediation.*

## LCA OF GREEN HYDROGEN PRODUCTION AND LIQUEFACTION

J. INCER-VALVERDE, S. SENTHILKUMAR, G. TSATSARONIS, T. MOROSUK

*Institute for Energy Engineering*

*Technische Universität Berlin, Marchstr. 18, 10587 Berlin, Germany*

*Email: [jimena.incervalverde@tu-berlin.de](mailto:jimena.incervalverde@tu-berlin.de), [sudheep.senthilkumar@campus.tu-berlin.de](mailto:sudheep.senthilkumar@campus.tu-berlin.de),  
[georgios.tsatsaronis@tu-berlin.de](mailto:georgios.tsatsaronis@tu-berlin.de), [tetyana.morozyuk@tu-berlin.de](mailto:tetyana.morozyuk@tu-berlin.de)*

The goal of the Paris Agreement has been voluntarily embraced and ratified by many countries. Industries have also started contributing to the energy transition by means of carbon neutrality and sustainability goals. Hydrogen is seen as a key energy vector towards decarbonization. However, many questions on environmental impact of green hydrogen should be answered. The proper quantification of the environmental impact of green hydrogen production and liquefaction should be studied. This research is the Life Cycle Assessment (LCA) study. An LCA model, with the supply of wind-based electricity was developed using cradle to gate as the system boundary. The LCA models were created and simulated using the software GaBi version 9. Global warming potential, acidification potential, eutrophication potential and water footprint were evaluated in the study. The environmental profile is dominated by the source of electricity in the production stage of hydrogen, whereas the use and end of life were not considered in the scope of this study. According to the study, production stages are of significant environmental importance. The future research will focus on the exergoenvironmental analysis of green hydrogen.

**Keywords:** *Green hydrogen, Life Cycle Assessment, Environmental Impact*

## SUSTAINABILITY ASSESSMENT OF INCUMBENT AND EMERGING TECHNOLOGIES FOR WASTE VALORIZATION FROM THE JUICE INDUSTRY

PANTELIS MANAKAS<sup>1</sup>, ATHANASIOS T. BALAFOUTIS<sup>2</sup>, CONSTANTINA KOTTARIDI<sup>1</sup>,  
ANESTIS VLYSIDIS<sup>3</sup>

<sup>1</sup> *University of Piraeus, Department of Economics, 80, M. Karaoli and A. Dimitriou Street, Piraeus, PC: 18534, Greece*

<sup>2</sup> *Institute of Bio-Economy & Agro-Technology, Centre of Research & Technology Hellas, Dimarchou Georgiadiou 118, Volos, 38333, Greece*

<sup>3</sup> *School of Chemical and Environmental Engineering, Technical University of Crete, Chania, 73100, Greece*

*Email: [avlysidis@isc.tuc.gr](mailto:avlysidis@isc.tuc.gr), [manakaspa@gmail.com](mailto:manakaspa@gmail.com)*

Circular economy and sustainable development are terms which are increasingly attracting attention among policies and practices driven by nations and communities worldwide. While society is trying to fight environmental pollution and scarcity of natural resources to meet the Sustainable Development Goals by 2030, significant quantities of waste are produced from the food manufacturing industries causing severe environmental problems and loss of potential raw materials. Solely, in the EU, around 30.6 Mt of food waste is generated every year at the processing and manufacturing stage of the food supply chain. Fruit processing industries, primarily consisting of the juice industries, share a large portion of this amount. This waste that mainly contains peels, internal tissue, seeds and pomace is usually rich in organic compounds such as carbohydrates, proteins and lipids. Their traditional treatment/utilization technologies, limited to animal feeding, landfilling and incineration, are not viable and sustainable solutions both from an environmental and economic point of view as they fail to obtain value from each fraction of this waste.

Biorefinery development via integrated waste valorization technologies through fractionation and/or (bio-)conversion of organic waste streams, can result in a spectrum of products such as high value-added bioactive materials, biofuels, biochemicals and bioplastics. This study is a meta-analysis of the available technologies developed at different scales that give value to waste streams derived from the orange and apple juice industries. Initially, a detailed methodology is applied via material flow analysis to systematically determine the available waste quantities in the EU countries. A comprehensive sustainability analysis of the available valorization technologies is then implemented by assessing the most critical circularity, environmental and socio-economic indicators. The analysis is conducted both for emerging and incumbent valorization technologies and specific conclusions are deduced highlighting all favorable valorization routes.

**Keywords:** *Waste Valorization, Sustainability Assessment, Juice Industry, Biorefinery Development*

## AGRI WASTE TO ENERGY IN ENERGY IN CIRCULAR BIOECONOMY: OBSERVATIONAL EVIDENCE OF THE THESSALY REGION IN GREECE

D. FYTILI, A. ZABANIOTOU

*Biomass and Bioenergy group, Department of Chemical engineering, Engineering School,  
Aristotle University of Thessaloniki  
Email: [azampani@auth.gr](mailto:azampani@auth.gr), [desfytili@yahoo.gr](mailto:desfytili@yahoo.gr)*

Advancing a Circular Waste Bioeconomy (CWBE) should be a priority over business-as-usual, entailing sustainable resource use in early and late stages of industrialization processes. The present paper is both descriptive and prescriptive. Firstly, it aims to explore the main barriers, challenges, opportunities, and the context within agro-biomass and agro-industrial waste valorization can accelerate a low carbon economy, in the Thessaly region of Greece, where agricultural production and agro-industrial business are the prevailing economic sectors. Secondly, organizational, societal, knowledge and skills capacity actions are suggested as the most likely to change the business-as usual scenarios. A SWOT analysis performed to draw useful conclusions about the extent to which CWBE principles can be integrated into the economic, social, and environmental life of the Thessaly region, and recommendations made of what it is needed. One of the key insights is how to leverage emerging low carbon circular economy for regional regenerative future. The results showed that waste is managed inefficiently in the region and there is a lack of synergies and collaborations between different stakeholders. The milestones of accelerating a low carbon CWBE for regional development, and employment are a) the territorial cohesion and regional symbiosis, b) increasing the financial market opportunities for small and critical projects, c) promoting awareness, public knowledge, skills, and the responsibility of young scientists and citizens.

**Keywords:** *Circular Waste Bioeconomy; Agro-waste; Thessaly region; Greece*

# MEDITERRANEAN WETLANDS TO MITIGATE THE EFFECTS OF CLIMATE CHANGE. THE CASE OF AGHIOS MAMAS NATURA 2000 SITE, HALKIDIKI, GREECE

ATTILIO TORRE<sup>1</sup>, CHARIS CHRISTODOULOU<sup>2</sup>

<sup>1</sup> Architect, PhD Candidate, Department of Urban and Regional Planning and Development, School of Architecture, Faculty of Engineering, Aristotle University of Thessaloniki; 54124 Thessaloniki, Greece; Email: [attitorr@arch.auth.gr](mailto:attitorr@arch.auth.gr)

<sup>2</sup> Associate Professor, Research Unit for South European Cities, School of Architecture, Faculty of Engineering, Aristotle University of Thessaloniki; 54124 Thessaloniki, Greece; Email: [christodoulou@arch.auth.gr](mailto:christodoulou@arch.auth.gr)

Wetlands are natural elements with crucial importance in the conservation of biodiversity and in the capacity to mitigate climate change effects; the benefits they can offer include their role in the carbon cycle and, in coastal areas, their natural defense against sea-level rise, floods, and extreme storms associated with climate change. The Mediterranean area is considered a hot spot for climate change: the reduction of rainfall in the winter, and the heating and significant drought during the summer with more frequent and intense fires, are some of the most evident phenomena that emphasize the need to take urgent adaptation and mitigation measures. Despite their importance in this context, wetlands are subject to progressive degradation and destruction globally. In the Mediterranean, wetlands have been destroyed for decades and continue to face numerous threats today, due to a general tendency to ignore their ecological value and view them as an impediment to economic development. They were therefore considered as areas to be drained, destroyed, and converted into land for profitable uses: agricultural development, residential or industrial construction, and tourism infrastructure in coastal areas. The ecological network Natura 2000, the most ambitious EU initiative for the protection of natural habitats and wildlife, includes the protection of many Mediterranean wetlands, however, there are numerous critical issues in terms of protection and management. In addressing the issue of the protection of wetlands within the Natura 2000 system, this document presents the case of the wetland of Agios Mamas and the nearby estuary of the Olinthyos River on the coast of Halkidiki, in the region of Central Macedonia. This empirical study is part of a broader research focusing on the protection and management of natural landscapes and elements of cultural heritage conducted over the past two years. The methodology uses literature review, analysis of local planning documents, field explorations, interviews with stakeholders and members of the local community.

The study explored the status of the protection and management of the elements of the natural heritage of the area and highlighted a weak and incomplete protection system that has only partially succeeded up to now in preventing the degradation of the area, in favoring the involvement of the local community to promote nature conservation and sustainable development based on local natural and cultural values. Rather, economic interests that are incompatible with nature conservation seem to prevail, favored by local administrations and by the inertia of the national nature protection system.

The results indicate the need to take urgent conservation and restoration measures in the wetland of Agios Mamas and the estuary of the Olinthyos River, however, without the broad understanding and participation of citizens and communities, it will be difficult to achieve nature conservation objectives and, consequently, nature-based solutions for climate change mitigation.

**Keywords:** *Wetlands, Nature Conservation, Nature-Based Solutions for Climate Change Mitigation, Community Awareness*

## TOWARDS A CIRCULAR ECONOMY ERA – INTEGRATED AND INNOVATIVE MANAGEMENT OF USED COOKING OILS THROUGH DIGITAL TOOLS – THE CASE OF WESTERN MACEDONIA

PERIKLIS KAFASIS<sup>1</sup>, ATHANASIOS GENTIMIS<sup>2</sup>

<sup>1</sup> DIADYMA SA Waste Management of Western Macedonia, 6th km Kozani-Ptolemaida Rd., Kozani, P.C. 50150, Greece, Email: [pkafasis@diadyma.gr](mailto:pkafasis@diadyma.gr)

<sup>2</sup> SYMBIOLABS Circular Intelligence LC, Artemidos 6 str., Marousi 15125, Greece, Email: [thanasis@symbiolabs.gr](mailto:thanasis@symbiolabs.gr)

The challenge of a sustainable management system for Used Cooking Oils (UCO) coming from households is more than necessary. Taking into consideration that from app. 1.660.000 tones of UCO's that are produced each year in European level more than 50% are coming from households, and only 5,6% is collected it is more than necessary to address the problem at source.

Reward schemes have been implemented in European cities to increase participation in waste management practices. This approach has proven to be very efficient, as rewards can motivate citizens to be more proactive and diligent. In this respect, we introduced a system designed to facilitate the collection of UCO from households.

The collection of UCO with the use of innovative tools and digital platforms is a cost-effective technology accomplishes separation at source of specific waste streams and promotes reuse and recycling of post consumer UCO. It is also characterized by simplicity in use, interoperability with other initiatives, cooperation with a collection network, scalability and ease of operation and maintenance.

The system includes the use of innovative collection machines (called UCO's ATMs) and its operation is supervised through a digital platform. The platform is simple to use. Users/households register and receive personalised barcodes that must be applied to the bottle before depositing it in one of the specific UCO collection points. When the bottles are collected for further processing and valorisation, the operator scans the barcode and then reward points are assigned to each user depending on the quantity of UCO in the bottle. The more the collected UCO is, the more points are assigned. The digital platform allow users to redeem their points on benefits/discounts in local businesses or for entertainment (e.g. cinema or concert tickets).

Through the operation of such a system, the quantities of UCO that are discarded without being recycled are significantly reduced, while at the same time they are used to create new products of higher value. Finally, the implementation of such a reward scheme can be transferred to other types of waste in Western Macedonia as well and become the base for the transition to a circular economy era.

**Keywords:** Used Cooking Oils, Recycling, Innovative, Digital Platforms

## SUSTAINABLE URBAN DEVELOPMENT: THE CONCEPT OF HOME AND COMMUNITY COMPOSTING

P.G. SARANTI\*, Y.J. STEPHANEDES

*Department of Civil Engineering, University of Patras, Greece*

*\*E-mail: [psaranti@upatras.gr](mailto:psaranti@upatras.gr)*

### ABSTRACT

Sustainable urban development has been expanding to include the set of urban strategies adopted by an increasing number of governments and local authorities worldwide. Starting with the fundamental EU objective of sustainable urban development, Municipal Solid Waste (MSW) management schemes are increasingly adopted by municipalities. The implementation of such schemes is a basic step in the transition from industrialized cities to sustainable and smart cities.

This work focuses on the concept of composting as an alternative Municipal Solid Waste management scheme. Composting is a highly environmentally friendly technology for management of organic municipal solid waste or biowaste, allowing its material valorisation. Within waste recovery, the source separation and on-site treatment of urban organic waste can resolve major urban economic issues along with the environmental and social objections to landfilling. Composting has become increasingly important for solid waste disposal because it provides an efficient and environment - friendly method that can be used to reduce the volume of waste. The composting process also can detoxify harmful organic substances and pathogens, and provides a material of agricultural importance.

This research further analyses the concepts of home and community composting in waste management, and the major differences between centralized and decentralized composting. With Greece as an example of case study, the national legal framework of municipal solid waste and composting is presented as well as best practices including community and home composting that can offer municipalities social, environmental, and economically favourable alternatives to centralized composting and landfills.

The research also aims to showcase the benefits of integration of home and community composting within urban agriculture, leading to new ways that can be adopted by cities and communities in order to master recent social, economic, and ecological challenges. This is critical for effective strategy and policy planning, especially as future growth limits call for sustainable, smart, and inclusive urban development within the circular economy.

**Keywords:** Waste Management, Composting, Environmental Sustainability, Urban Organic Waste

## MAPPING OF AGRI-FOOD AND BIO-BASED INDUSTRIES IN THE REGION OF W. MACEDONIA FOR POTENTIAL VALORIZATION OF AGRI-FOOD RESIDUAL STREAMS INTO HIGH-ADDED VALUE PRODUCTS

K.G. SAKELLARIOU<sup>1\*</sup>, E. PAPISTA<sup>2,3</sup>, D. SILIKAS<sup>2</sup>, A. GIANNAKOULA<sup>1</sup>, N. NTAVOS<sup>2</sup>,  
Y. FALLAS<sup>2</sup>, P. KAFASIS<sup>1</sup>

<sup>1</sup>DIADYMA, Waste Management of Western Macedonia, GR-50150, Kozani, Greece

<sup>2</sup>Cluster of Bioeconomy and Environment of Western Macedonia, GR-50100, Kozani, Greece

<sup>3</sup>Department of Mechanical Engineering, University of Western Macedonia, GR-50100, Kozani, Greece

\*Email: [ksakellariou@diadyma.gr](mailto:ksakellariou@diadyma.gr)

Climate change, along with the growing need to reduce greenhouse gases (GHG) emissions and eliminate the use of fossil fuels, as well as the corresponding societal challenges, are the key drivers behind the adoption by the European Union of several approaches for the development of the concepts of Circular Economy and Bio-economy. These latter aim at promoting new strategies and policies, thus contributing to a more viable social, financial and technological model.

Among the priority areas of the EU Circular Economy Action Plan, the reuse of food waste is a key issue, promoting the transition to a more sustainable scheme. The valorisation of food processing by-products and their transformation into a spectrum of marketable products (food, feed, materials, chemicals) and energy (fuels, power, heat), has been enhanced by the integrated "biorefinery concept" through several different policies and funding opportunities. However, the variability in quantity and composition of residual streams, as well as the lack of information regarding the operation and viability of the bio-industries, render the management of the residual streams rather challenging.

Towards this direction, the European project Model2BIO develops and validates an innovative model-based decision support tool that predicts the physico-chemical characteristics of the residual streams generated in the agri-food sector, explores all the available alternatives for their valorization as feedstock in the bio-industry and selects the most appropriate options considering social, economic, environmental and regulatory criteria (including logistics).

The Region of Western Macedonia serves as one of the test beds for the development of the tool, since it has significant potential in agricultural, dairy and wine-making sectors' residues, the majority of which remains unexploited. In this context, the present study aims to detect and report the existing agri-food (meat, cheese, wine and pepper) and bio-based industries, in order to determine several parameters of the residual streams (type, volume and physicochemical characteristics) and to assess the sustainability of a biorefinery in the area. Considering the transitional period Western Macedonia undergoes since 2020 due to the termination of the lignite mines operation for power production, such a venture would be of a high importance for the Region, which prioritizes alternative, greener and more sustainable pathways.

## EXPERIMENTAL STUDY ON THE GASIFICATION OF INDUSTRIAL WASTES WITH STEAM OR CARBON DIOXIDE FOR SYNGAS PRODUCTION

D. VAMVUKA, E. AFTHENTOPOULOS, I. CHATZIFOTIADIS

*School of Mineral Resources Engineering, Technical University of Crete, 73100 Chania, Greece*

*E-mail: [vamvuka@mred.tuc.gr](mailto:vamvuka@mred.tuc.gr)*

Thermal treatment of industrial wastes, especially those produced from municipal solid waste management units, for energy production, destroying pathogens and other pollutants, is an attractive solution in view also of global energy crisis. Gasification technologies offer the advantages of higher efficiency and reduced emissions, as compared to incineration. A two-stage process, where the first step is pyrolysis generating bio-oil and gas as sources of energy and chemicals and the second step is the reaction of charcoal with a gasifying agent, could be beneficial, because of the lack of tar in product gas and the higher reactivity of biochar. In this work, two industrial wastes, sawdust and refused derived fuel (RDF) were pyrolyzed at 600°C and subsequently gasified up to 950°C under steam or carbon dioxide atmosphere, using a fixed bed reactor and a thermal analysis system. Solid, liquid and gaseous products were characterized by proximate analysis, ultimate analysis and calorific value, while the composition of both pyrolysis and gasification gas mixtures was analyzed by a quadrupole mass spectrometer. Thermal behavior of the fuels, reactivity and conversion were determined. The gasification process occurred above 700°C. Conversion of organic matter under either steam or carbon dioxide was almost complete, whereas the reactivity of sawdust was higher and correlated to the porous structure of char. Upon carbon dioxide gasification the main product was CO with small amounts of H<sub>2</sub>O<sub>v</sub> and H<sub>2</sub>. Upon steam gasification the gas mixture consisted mainly of H<sub>2</sub>, CO, lower amounts of CO<sub>2</sub> and minor quantities of CH<sub>4</sub> and hydrocarbons. The H<sub>2</sub> yield of sawdust biochar was about 60% and that of RDF biochar 44.4%. The higher heating value of the syngas produced was about 10MJ/m<sup>3</sup>, while the values corresponding to pyrolysis products were high (up to 14.5MJ/m<sup>3</sup> and 39.2MJ/kg for gas and oil, respectively) and were very satisfactory for the energy requirements of char production.

**Keywords:** *Industrial Wastes, Gasification, Steam, Carbon Dioxide*

## THE ENERGY PROFILE OF HOUSEHOLDS IN MOUNTAINOUS AREAS. THE CASE OF METSOVO

ANASTASIOS BALASKAS<sup>1</sup>, IOANNA KARANI<sup>2</sup>, NIKOLAS KATSOULAKOS<sup>3</sup>,  
DIMITRIS KALIAMPAKOS<sup>4</sup>

<sup>1</sup> Ph.D. Student, School of Mining & Metallurgical Engineering, National Technical University of Athens,  
E-mail: [balaskas@metal.ntua.gr](mailto:balaskas@metal.ntua.gr)

<sup>2</sup> MSc Student, School of Rural, Surveying and Geoinformatics Engineering,  
E-mail: [iwannakaranh@gmail.com](mailto:iwannakaranh@gmail.com)

<sup>3</sup> Associate Professor, Aspropyrgos Academy of Merchant Navy,  
E-mail: [katsoulakos@metal.ntua.gr](mailto:katsoulakos@metal.ntua.gr)

<sup>4</sup> Professor, School of Mining & Metallurgical Engineering, National Technical University of Athens,  
E-mail: [dkal@central.ntua.gr](mailto:dkal@central.ntua.gr)

### ABSTRACT

While energy is generally considered a basic human need, providing adequate, reliable, and affordable energy is a prerequisite for meeting these needs. Given its strong links to economic growth and social goals, energy services are the cornerstone of development, especially in mountainous and isolated areas. The energy identity of the mountainous areas is clearly different from that of the lower altitude areas, mainly due to changes in climatic conditions as a function of altitude. Altitude is the second most important factor in shaping the climate after latitude. In general, in the mountains of the Mediterranean region, as the altitude increases, the average temperature decreases, the rainfall increases and the relative humidity decreases. The “energy profile” of mountainous areas is outlined, which is characterized by particularly increased thermal energy needs.

In the present paper, the area of study is the settlement of Metsovo which is a small town in the Region of Epirus at an altitude of approximately 1,150m – 1,200m with a population of 2,500 permanent residents. Quantitative data were collected from households in the settlement of Metsovo, related to the electricity consumption as well as to the temperature and humidity data in three different rooms of each house. The results from the deployment of loggers were combined with the technical characteristics of the houses and the heating systems as well as with the socioeconomic characteristics of the households. Moreover, socio-economic data from a primary survey in Metsovo on a sample of 300 households were also used. The aim of the current research is to draw conclusions about the profile of household electricity consumption and the thermal comfort conditions of households. Various problems related to the level of thermal comfort are identified. The need for a specialised energy policy for mountainous areas is highlighted, in order to reduce the vulnerability of local populations to energy poverty.

**Keywords:** *Energy Profile, Mountain Areas, Households, Energy Needs, Energy Costs, Energy Poverty*

## BRIDGING THE GAP BETWEEN THE CULTURAL PILLAR AND OTHER PILLARS OF SUSTAINABILITY

CHARISIOS ACHILLAS<sup>a,b</sup>, CHRISTOS VLACHOKOSTAS<sup>a</sup>, ALEXANDRA MICHAILEDOU<sup>a</sup>,  
SAVVAS KOLTSAKIDIS<sup>a,c</sup>, KONSTANTINOS TSONGAS<sup>d</sup>, DIMITRIOS TZETZIS<sup>a,c</sup>,  
VASILIS EFOPOULOS<sup>e</sup>, VASILIS GKONOS<sup>d</sup>, NICOLAS MOUSSIOPOULOS<sup>a</sup>

<sup>a</sup> *Laboratory of Heat Transfer and Environmental Engineering, Department of Mechanical Engineering, Aristotle University Thessaloniki, Thessaloniki, Greece, Email: c.achillas@ihu.edu.gr*

<sup>b</sup> *Department of Supply Chain Management, International Hellenic University, Katerini, Greece*

<sup>c</sup> *Digital Manufacturing and Materials Characterization Laboratory, School of Science and Technology, International Hellenic University, Themi, Greece*

<sup>d</sup> *Teloglion Foundation of Arts – Aristotle University Thessaloniki, Thessaloniki, Greece*

<sup>e</sup> *Tessera Multimedia S.A., Pefka, Thessaloniki*

Cultural sustainability is considered as a central pillar towards sustainable development. The role of culture is often neglected in comparison to the other three pillars of sustainability, namely environmental, economical and social. This is the key reason why culture has been recently categorized as a separate pillar of sustainability (not within the social one), taking also into consideration that its importance and impact is fast growing in modern societies. Culture needs to be open to all, bringing together high-quality cultural and educational media for the international lifelong learning community. To that direction, ICT advancements provide the ground for the opening of culture to the society, directing towards the four critical values of culture's role, namely openness, impact, speed and autonomy. Towards this direction, a multidisciplinary scheme of three organizations representing culture, academia, and ICT business have joined forces in the framework of the ARTECH ("digitAlize aRt and cULtural hEritage for personal experienCe via innovative tecHnologies") project, with the aim to promote the permanent collection of the Teloglion Fine Arts Foundation to the wide public and also to specialized groups of visitors. Through digital tools and state-of-the-art technologies (e.g. virtual reality, 3D scanning, additive manufacturing, gamification techniques, etc.), the public can have access to important artworks of Modern Greek and European art, constituting Teloglion Fine Arts Foundation an extroverted, open, and -most of all- interactive Museum that combines research, education, art, culture, and science.

**Keywords:** *Cultural Sustainability, Digital Culture, Experiential Education, Virtual Museum, Open Culture.*

## KYKLOS 4.0: DEVELOPING A CIRCULAR MANUFACTURING FRAMEWORK

**CHRISTOS KOIDIS<sup>a</sup>, JASON MANSELL REMENTERIA<sup>b</sup>, EIDER ITURBE ZAMALLOA<sup>b</sup>,  
MARIA LAMPRIDIS<sup>c</sup>, DANAI KAZANTZI<sup>a</sup>, NIKOLAOS SAKKOS<sup>a</sup>**

<sup>a</sup>*Engineers For Business S.A., Thessaloniki, Greece*

<sup>b</sup>*Tecnalia, Basque Research and Technology Alliance (BRTA), Donostia-San Sebastián, Spain*

<sup>c</sup>*Institute for Bio-Economy and Agri-Technology, Centre for Research & Technology Hellas (CERTH), Volos, Greece*

*Email: [c.achillas@ihu.edu.gr](mailto:c.achillas@ihu.edu.gr), [ck741@efb.gr](mailto:ck741@efb.gr)*

Circular economy is a key systemic solution towards sustainability, and also closely related to the digital transition. Besides technologies, circular economy requires innovative enterprises, investment on research and development, involvement of research institutions, and a motivating policy environment. In brief, in order circular economy to prosper, a technology ecosystem is a prerequisite. There is a strong belief that circular economy cannot dominate without the 4th industrial revolution. In this light, the challenge lies on the integration of digital methodologies and technologies into the systemic approach towards sustainability.

To that end, the KYKLOS 4.0 project aims at providing a technology ecosystem which creates and supports the configurations, methodologies, production techniques, decision and actions at all different levels and stages of the manufacturing value chain to achieve increased energy efficiency, decreased use of raw materials (second use of parts or materials), customer centricity, and on-demand manufacture. The project delivers an advanced configuration variants' framework and a state-of-the-art production paradigm, embedding key technologies into a unified platform ecosystem to manage live product innovation.

KYKLOS 4.0 platform demonstrates the transformative effects of a batch of Industry 4.0 related technologies and methodologies, such as Circular Production System, Product Life Management, Life Cycle Assessment (LCA), Augmented Reality and Artificial Intelligence, to the Circular Manufacturing Framework. KYKLOS 4.0 technology involves a set of intelligent tools for real-time analytics prediction, and recommendation systems, all integrated into the KYKLOS 4.0 configuration environment. As an example, LCA Simulations Engine monitors the resource consumption in all the product life cycle and identifies processes not performing optimally from the resource consumption point of view and can recommend further improvement on the processes.

KYKLOS 4.0 is expected to address several business-related and technical challenges towards building a circular economy, promote low-cost and easy-to-use tools and data platforms for SMEs to adopt Circular Economy principles with limited investments, accelerate businesses' digital transition to boost their advancement and recovery, incorporate a set of components that support the production, post-production and assembly phases by modernizing the functionalities of shop floors in the adoption of circular manufacturing principles, and also identify processes not performing optimally and recommend further improvements.

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**Keywords:** *Circular Economy, Circular Manufacturing, Industry 4.0, KYKLOS 4.0 Project*

## LIFE CYCLE-BASED HEALTH RISK ASSESSMENT OF PLASTIC WASTE

D.A. SARIGIANNIS<sup>1,2,3\*</sup>, A. GOTTI<sup>4</sup>, S. KARAKITSIOS<sup>1,2</sup>

<sup>1</sup> Aristotle University of Thessaloniki, Department of Chemical Engineering, Environmental Engineering Laboratory, Thessaloniki, Greece, \*Email: sarigiannis@auth.gr

<sup>2</sup> HERACLES Research Center on the Exposome and Health, Center for Interdisciplinary Research and Innovation, Aristotle University of Thessaloniki, Greece

<sup>3</sup> School for Advanced Study (IUSS), Science, Technology and Society Department, Pavia, Italy

<sup>4</sup> EUCENTRE, Pavia, Italy

The plastics crisis has induced several jurisdictions to pose bans on use of plastic bags and enhance plastic recycling in the respective municipal waste management systems. To date, however, landfilling remains the most common waste management practice in Greece despite enforced regulations aimed at increasing recycling, pre-selection of waste, and energy and material recovery. Yet, there is a limited number of studies focusing on the adverse human health effects of plastic products and waste, the ubiquitous nature of plastic material notwithstanding. Thus, in this study we present an innovative tool for integrated health risk assessment of plastic waste. The INTEGRA LCA software couples the integrated external and internal exposure assessment capabilities of the INTEGRA computational platform with life cycle impact assessment. The integrated software platform allowed us to perform a first-of-its-kind analysis of adverse health outcomes attributable to chronic exposure to persistent organic pollutants associated with plastic material use and disposal. Our analysis focused on plastic waste generated in the two main metropolitan centers in Greece, Athens and Thessaloniki. A comprehensive review of up-to-date information on plastic products and plasticizers used by the urban population was performed to build up the application-specific release/emissions inventory. This review included both plastic products (e.g. PET bottles, PVC material, polycarbonate products) and plasticizers used in food packaging. Compounds of interest in this regard include bisphenol A, phthalates such as DEHP and its metabolites, DINCH, di-(2-ethylhexyl)adipate. Integration of all human exposure routes and pathways to the toxic compounds contained in plastic was done at the level of systemic internal dose, that was linked with adverse health outcomes reported in the literature to quantitatively assess the related health risk. Our analysis highlights that landfilling is the worst waste management strategy on a global scale. At the same time, the investigated options for waste treatment coupled with energy and material recovery would result in very important benefits in terms of greenhouse gas emission reduction. However, not all options are equally benign to the local environment and to the health of the local population, since both the former and the latter are still affected by non-negligible local emissions. Regarding public health impacts, adverse effects on the endocrine system with cascade impacts on human reproduction, metabolic syndrome and, even, neurotoxicity after chronic exposure to the persistent organic chemicals found in plastic products and waste were estimated. The coupled integrated exposure and life cycle assessment methodology developed in this study and translated into the INTEGRA LCA platform is a significant step towards the direction of comprehensive, precise and transparent

estimation potential health risks associated with use, management and disposal of plastics in urban settings. The incorporation of life cycle analysis produces different conclusions than a simple environmental impact assessment based only on estimated or measured emissions. Taking into account the overall life cycle of both the waste streams and of the technological systems and facilities envisaged under the plausible scenarios analyzed herein, alters the relative attractiveness of the solutions considered and enhances the robustness of the health impact assessment.

## POWERING ELECTRIC VEHICLES' CONNECTION TO BUILDING INFRASTRUCTURES: THE FUTURE OF ENERGY AND MOBILITY

D.V. CHONDROGIANNI<sup>1\*</sup>, P.G. SARANTI<sup>2</sup>

<sup>1</sup> *Dr. Civil Engineering, Architect, University of Patras, Ellinos Stratiotou 98, 26441,  
Email: [dimitra.chondrogianni@g.upatras.gr](mailto:dimitra.chondrogianni@g.upatras.gr)*

<sup>2</sup> *PhD Candidate, Civil Engineering, University of Patras, Ypatias 1, Rio, 26500*

Over the next five years, EV sales are expected to at least quadruple in the EU-27 plus the United Kingdom and more than double in the United States, resulting in the adoption of more than 50 million passenger vehicles and more than four million commercial vehicles in China (Hoover, 2021). Buildings play a crucial role in satisfying the needs of electric vehicles (EVs) and in the shift towards e-mobility. Over 80% of EV charging takes place around buildings, either at home or at the workplace. This highlights the need to equip buildings with EV charging infrastructure which will help to make EVs the preferred choice for families and commuters (ChargeupEurope, 2021). At the same time, the EVs revolution offers tremendous climate benefits, though it requires policymakers to manage the resulting increase in electricity demand.

The accelerated deployment of energy efficient technologies in buildings connected to EVs charging stations works as a cost-effective alternative to support the future of e-mobility. In this framework, the current research aims to identify the rising benefits of electric vehicle charging in buildings and the numerous challenges to be addressed to meet the energy and mobility needs of tomorrow. The research focuses on presenting the existing knowledge and the best practices to this direction while the rising concerns regarding these technologies are discussed. Moreover, in this research the important role of policy makers is showcased and the need for additional policy recommendations is examined, in order to achieve a stronger commitment on charging requirements in the private building stock.

**Keywords:** *Electric Vehicles, Energy Efficiency, Building Refurbishment, Charging, E-Mobility*

## ENVIRONMENTAL EDUCATION AND CLIMATE CHANGE: ACTIONS IN SCHOOLS OF THE 3RD PRIMARY DIRECTORATE OF ATHENS

ELENI NIARCHOU

*Coordinator of Environmental Education for the 3rd Primary Directorate of Athens*

*Email: [elniarchou@gmail.com](mailto:elniarchou@gmail.com)*

Environmental Education is an active - participatory Pedagogy that is based on ecological thinking and opposes the pathological characteristics of the traditional school. It is a critical intervention and innovation in the educational process that can form friendly attitudes towards the environment of the Greek reality.

Its Methodology - a key component of its characteristics - is derived from the New Pedagogy as it was formed and characterizes a school. It is open to society, where the experience is transformed into knowledge, participatory, where the individual and the team hold a primary position, where student and the team discovers - invents knowledge. The learning outcome is not offered ready but is built by the team step by step, cultivates and exercises a variety of skills, focuses his efforts on a specific goal, consciously uses a process - strategy, method that will lead to the realization of the purpose.

In this context, in schools of the 3rd Primary Directorate of Athens, educational activities are implemented in order to inform and update teachers and students to deal with the climate crisis. The point is to mobilize everyone for action and adoption of activities that help reduce the ecological footprint to protect our planet. Education is a vital tool for raising awareness and equipping future generations with the appropriate skills and knowledge needed to face climate change. Therefore, the objectives of the actions include empowering students with knowledge, skills, positive attitudes and motivation to take action, prevention and solution of environmental problems through appropriate teaching approaches and materials.

The main objectives for the members of the educational communities and the wider society are to acquire the necessary knowledge, skills, abilities regarding climate change, focusing on the future impact in Greece. The issue of climate change requires a transformation of our way of thinking and acting and an urgent change in our way of life. To achieve such a change, we need to adopt new values, skills and attitudes that will lead to more sustainable societies. Consequently, Education should focus on raising awareness and cultivating the ability of students and schools to take action on mediation, adaptation to climate change, reduction of the consequences and early prevention.

## EFFECTS OF FLEXIBLE HEAT, FUEL AND ELECTRICITY-PRODUCING FACILITIES ON FUTURE GERMAN ELECTRICITY PRICES

ELISA PAPADIS<sup>a,b</sup>, GEORGE TSATSARONIS<sup>a</sup>

<sup>a</sup> Technische Universität Berlin, <sup>b</sup> Corresponding author

Faculty III – Process Sciences and Engineering, Chair of Energy Engineering and Environmental Protection  
Berlin, Germany, E-mail: [elisa.papadis@tu-berlin.de](mailto:elisa.papadis@tu-berlin.de)

In order to meet the climate target, the energy system already undergoes a significant transition and will continue to do so in the future. With a declared phase-out of coal-fired power plants possibly in 2030, and an aspired goal of reaching climate neutrality until 2045, Germany needs to accelerate the transition to secure an uninterrupted energy supply and fulfil the targets. This transition requires new, carbon-neutral, heat, fuel and electricity-producing facilities, such as power-to-heat (direct electric boilers and heat pumps), power-to-gas (water electrolyzers) and an increasing capacity of renewable energy plants to supply the above facilities with renewable generated power. Although on the one side these facilities provide the necessary flexibility to the electricity system (acting as electricity consumers in times where the feed-in from renewable energy is high), on the other side they also have an increasing effect on electricity demand and hence electricity prices.

These described effects are modelled and evaluated in a mathematical model of the German electricity market. Among other fossil-fueled and renewable electricity generation plants, district heating systems (combined heat-and-power plants and power-to-heat plants), and power-to-gas plants are represented. Electricity prices are calculated for future years while considering exogenously defined renewable and conventional energy capacity expansion, the phase-out of coal-fired power plants, and further flexibility enhancement. The relation between demand, electricity price and the balancing reserve price is examined in this paper, and the CO<sub>2</sub> reduction is compared to the national targets. It can be examined that flexibility options have a smoothing effect on future electricity prices and counteract zero electricity prices in many hours of the year.

**Keywords:** *Renewable Energy, Electricity Market, Flexible Electricity Demand, Electricity Prices*

## EVALUATION OF URBAN AND INDUSTRIAL WASTES FOR ENERGETIC USES THROUGH GASIFICATION WITH CARBON DIOXIDE STREAMS. A TG-MS STUDY

D. VAMVUKA, K. ZACHEILA

*School of Mineral Resources Engineering, Technical University of Crete, Chania, Greece*

*E-mail: [vamvuka@mred.tuc.gr](mailto:vamvuka@mred.tuc.gr)*

Given the European Union policies for recycling, reuse and valorization of wastes, as well as market needs for diversification in view of global energy crisis, thermal treatment of solid waste materials for energy recovery is becoming more attractive as a disposal option. As an alternative to incineration emitting hazardous species to the environment, gasification is a flexible route of converting waste materials to syngas, utilized for power generation, or synthesis of biofuels and chemicals. When carbon dioxide from flue gases is used as the reactant gas the process offers a potential solution to the greenhouse gas problem. In this context, present work aimed at investigating the gasification of urban wastes, such as demolition wood and industrial wastes, such as MDF (medium density fibreboard) and their mixtures under carbon dioxide atmosphere up to 1000°C. Following the characterization of raw materials by proximate analysis, ultimate analysis and calorific value, a two-stage process was applied, where the first step was pyrolysis in a fixed bed unit producing biooil and gas up to 600°C and the second step was the reaction of biochar with carbon dioxide in a thermobalance system up to 1000°C, coupled with a quadrupole mass spectrometer. The bulk of the gasification process occurred between 800°C and 950°C, with main product the CO and small amounts of H<sub>2</sub>O and H<sub>2</sub>. Decomposition of demolition wood biochar occurred earlier, but with a much lower rate and conversion of about 60%. On the other hand, the reactivity of MDF fuel was higher and conversion reached 96%. When demolition wood was blended with MDF at percentages up to 50%, its thermochemical reactivity was enhanced and its conversion to fuel gas increased, reaching a value of 73%. The thermal behavior of blended fuels followed that of parent materials in more or less an additive manner.

**Keywords:** *Demolition Wood, MDF, Gasification, Carbon Dioxide*

## UTILIZATION OF FOOD WASTE TOWARDS A CIRCULAR ECONOMY IN THE CONTEXT OF THE SUSTAINABLE DEVELOPMENT IN GREECE

**KONSTANTINOS PAPAMONIOUDIS**

*Agias Sofias 73, Thessaloniki, 54633, Greece*

*Email: [kpapamo8@gmail.com](mailto:kpapamo8@gmail.com)*

This research aims to investigate the habits of the Greek citizens regarding the management of their household food waste and their familiarisation with circular economy and sustainable development.

For that purpose, a questionnaire was designed and delivered online to the participants. Initially, the concept of the circular economy, the national strategy and the actions that Greece intends to carry out for the transition from the linear to the circular economy model are studied.

The multidimensional problem of food waste management and its economic, social, and environmental impact are presented below. Through the questionnaire and the literature review, the solution of the problem, which is inextricably linked to the implementation of the food waste hierarchy and the measures taken by the state for its prevention, reuse, and recycling, is investigated.

The literature review showed that Greece is the first country in Europe in the annual per capita production of food waste (142kg), thus the dimension of the problem is quite big for the country. From the 1565 responses collected in the context of the survey by Greek consumers and the statistical analysis of the results with the IBM SPSS Statistics 27.0 program, it was indicated that the largest percentage is aware of the existence of the problem but does not fully understand the gravity of the matter. However, it is worth noting that the citizens stand ready to recycle their food waste without anything in exchange, while most look for advice on the reduction of the food they reject.

Finally, from the seventeenth question of the questionnaire, some information is collected about the food that is expelled more often from the Greek homes. After that, the possibility of its utilization for energy recovery as well as the production of value-added products is explored.

**Keywords:** *Circular Economy, Food Waste Biorefinery, Food Waste, Sustainable Development*

## THE BASIC NEED FOR CLEAN WATER: HOW A SCHOOL PROJECT CAN REACH THE CONCEPT OF SUSTAINABILITY

MARIA CHANOUMIDOU

*Leontos Sofou 10, Drama, 66131, Email: [maria.chan.gr@gmail.com](mailto:maria.chan.gr@gmail.com)*

In this current abstract it will be presented the way young pupils attempt to approach sustainability in the basis of children's rights. How is this possible? During a mini school project in the Primary School of Egialis, Amorgos, 11-year-old students came across the Fundamental Human Rights. They focused their attention on the Children's Rights. After a very initial conversation focusing on the rights all children a priori must enjoy, none of the students could deny that the right for food and clear water are of most importance and should not be deprived from anyone. Following that, they watched a short film called "My letter to the oilmen", where the contamination of the Niger river due to oil disposal comes up through the eyes of a young boy who is trying to claim his right for clear water.

The main goal of the project was students to understand the unequal distribution of power rich and poor countries exists upon key sources such as the water and what kind of decisions must be made by those who have the power to affect the fair distribution of pores alongside the world. That's why, students undertook three main roles: representatives of the inhabitants of the contaminated area, representatives of the United Nations and representatives of the company which is responsible for the contamination. Students had to investigate a bit upon their roles in small groups so as a debate to be implemented. This experiential process gave the opportunity to students to take a very close look at how a natural source as water is used by different people in different countries and the way this use affects a lot of other people around the globe.

**Keywords:** *Debate, Children Rights, Sustainability, Water*

## MODELING EXERGETIC EMISSION ALLOCATION IN LINEAR OPTIMIZATION PROGRAMS

MERLIN SEBASTIAN TRIEBS<sup>a,b</sup>, GEORGE TSATSARONIS<sup>a</sup>

<sup>a</sup> Technische Universität Berlin, <sup>b</sup> Corresponding author

Faculty III – Process Sciences and Engineering, Chair of Energy Engineering and Environmental Protection,  
Berlin, Germany, E-mail: [triebs@tu-berlin.de](mailto:triebs@tu-berlin.de)

Modeling the pathway to renewable energy systems requires a metric to measure the emission intensity of a product. While allocating environmental emissions for single-fuel-single product systems is relatively easy, it is more challenging for systems with multiple products, for example, in combined heat and power plants. Common methods in legislature and linear programming rely on substitution or credit methods, as these can be applied easily. However, in science, substitution methods are criticized as their application could result in negative emissions for one of the products. One step to overcome this is to use partitioning methods. For energy-related products, the relevant partitioning variable should be the product's thermodynamic value - namely, the exergy content of the product. Unfortunately, the partitioning method requires non-linear equations and cannot be used directly in linear programming to calculate the emissions for different products model-endogenously. Therefore, specific model features, such as keeping the emissions associated with a product below a certain minimum, cannot be implemented.

This work introduces a simple approach to consider the emissions associated with a product model-endogenously, relying on exergy as the partitioning variable. Important model features for combined heat and power plants, such as part-load efficiency drops or component startups, and the resulting emissions are also included in this approach. The approach is implemented in a unit commitment model for district heating systems. Different kinds of heat extraction in combined heat and power plants, such as backpressure turbines, extraction condensing turbines, and stand-alone gas turbines, are considered. Comparing the model-endogenously emissions to the exact calculation in post-processing shows an average deviation of one percent.

**Keywords:** *Allocation Methods, Exergy, Linear Programming, Combined Heat and Power plants*

## ADOPTION OF AI IN HIGHER EDUCATION USING THE STRUCTURAL EQUATIONS MODEL: THE CASE OF MOROCCO

NAIMA EL HAUD<sup>1</sup>, OUMAIMA HALI<sup>1</sup>, BRAHIM SABER<sup>2</sup>

<sup>1</sup> *Scientific Engineering of Organizations Laboratory, University Hassan II- ENCG C, Casablanca-Morocco*

<sup>2</sup> *Cady Ayyad University, Poly-disciplinary Faculty of Safi. INREDD (Innovation, Responsibilities and Sustainable Development)*

*Email: [n.elhaoud@encgcasa.ma](mailto:n.elhaoud@encgcasa.ma)*

The academic world cannot remain in different to the profound changes that our world is undergoing, nor can it ignore the debates that mark the evolution of society. As several authors have stated, universities and business schools are organizations in touch with society; consequently, they have the right, if not the obligation, to question their own responsibility, their practices, the nature of the knowledge they provide and the intrinsic quality of the human resources they train. One of the factors that could influence human resources in general and the academic world in particular is Artificial Intelligence, AI. This will change the way we work, the way we learn and the way we live.

The objective of this paper to study the attitude of human resources (faculty, students and administrators) in higher education in Morocco to the adoption of AI. To do this, the structural equation modeling (SEM) method was adopted to quantitatively describe the impact of each factor on the attitude of acceptance (AI) as well as the mutual influence relationships between the factors. In this study the variables Perceived Risk (PR), Expected Performance (EP), Expected Effort (EA), Facilitating Conditions (FC), and Attitude (ATT) were in corporate into the Integrated Model of Technology Adoption (UTAUT, Unified Theory of Technology Acceptance and Use).

The results show that AI applications in the higher education system would easily enrich the stakeholders of higher education institutes. Perceived risk (PR), expected performance (EP) and expected effort (EA) impact the attitude of stakeholders in Moroccan higher education institutions to adopt AI and facilitating conditions would also help users to show acceptable and favorable intention to use AI in the higher education system and facilitating conditions would positively affect the effort expectation of users.

**Keywords:** Artificial Intelligence, Higher Education, New Technology Acceptance Models, UTAUT, Structural Equations Model, Sustainable Development.

## NUMERICAL ASSESSMENT OF SOLAR ASSISTED PLASTICS PYROLYSIS FOR SUSTAINABLE UTILIZATION OF PLASTIC WASTE

MARIA MELA<sup>1a</sup>, PARIS A. FOKAIDES<sup>1,2 b\*</sup>

<sup>1</sup> School of Engineering, Frederick University, Cyprus

<sup>2</sup> Faculty of Civil Engineering and Architecture, Kaunas University of Technology, Kaunas, Lithuania

Email: <sup>a</sup> [res.mam@frederick.ac.cy](mailto:res.mam@frederick.ac.cy), <sup>b</sup> [eng.fp@frederick.ac.cy](mailto:eng.fp@frederick.ac.cy)

Plastic waste constitutes one of the main and most difficult to manage streams. Adopting sustainable practices of recycling and recovering of plastic waste, remains as of today a best practice for the scientific community. At the same time, life cycle assessment studies, reveal that the heating stage in the thermochemical waste treatment of plastic waste, remains the process with the most negative environmental impact in numerous aspects. This study presents a numerical model for investigating the suitability of a solar assisted method for plastic waste management, namely solar assisted pyrolysis. In terms of this study, a numerical model under Aspen Plus was developed. The model was fed with solar energy produced by a CSP unit, the performance of which was calculated with the use of the SAM tool. For this study the feedstock was comprised of polyethylene terephthalate, polypropylene and polystyrene and the desired products were mainly benzene and ethane. The findings of the study reveal aspects of process improvement and optimization, as well as the perspectives of solar assisted pyrolysis, as a reliable plastic waste management method.

**Keywords:** *Plastic waste, solar assisted pyrolysis, numerical assessment, circular economy*

## ANAEROBIC DIGESTATE EXPLOITATION FROM BIOGAS PLANTS ORIGINATED IN WESTERN MACEDONIA

V. PROSKYNIPOULOU<sup>1,2</sup>, S. LORENTZOU<sup>1</sup>, K. PLAKAS<sup>1</sup>, K. SAKELLARIOU<sup>3</sup>,  
P. KAFASIS<sup>3</sup>, E. PAPISTA<sup>4</sup>, Y. FALLAS<sup>4</sup>, D. SILIKAS<sup>4</sup>, N. NTAIVOS<sup>4</sup>, K.D. PANOPOULOS<sup>1</sup>

<sup>1</sup> Chemical Process and Energy Resources Institute (CPERI), Centre for Research and Technology Hellas (CERTH),  
Thessaloniki, Greece, Email: [panopoulos@certh.gr](mailto:panopoulos@certh.gr)

<sup>2</sup> Department of Chemistry, Aristotle University of Thessaloniki, Thessaloniki, 54124, Greece

<sup>3</sup> Anonymi Etaireia Diacheirisis Aporrimmaton per Dytikis Makedonias (DIADYMA SA),  
6th km Kozani – Ptoleimada, Kozani, 50100, Greece

<sup>4</sup> Cluster of Bioeconomy and Environment of Western Macedonia (CluBE), ZEP Area, Kozani, 50100, Greece

Anaerobic digestion could play a vital role in the future of circular bio economies, especially in decentralized areas, where biogas plants could utilize local organic residues for the production of biogas and valuable by-products for local reuse. Biogas industry accelerated in Greece over the last few years, particularly in areas where livestock and agriculture are predominant with the technologies focusing on anaerobic digestion. Specifically, in Western Macedonia, an area in transition, it is estimated that more than 250 ktn of manure is produced every year from livestock activities. Currently, only 4 biogas plants are operating in this region, using livestock and agricultural residues as a feedstock, with a total capacity of 1.470 kWe corresponding to a mere 1% of the overall potential of the region. This indicates that there are huge prospects for future development of new biogas plants during the transition of the region in the post lignite period.

On the other hand, the by-product of the anaerobic digestion, the digestate, is already a major concern due to numerous legislative and operational/management issues. Post-processing of digestate in small biogas plants for recovering valuable constituents leading to added value products such as fertilizers, falls under the scope of regulations, requiring high installation costs and energy consuming processes. Finding a viable solution is therefore critical in ensuring digestate is fully exploited and circular economy practice is established.

The present work aims in recovering nutrients and antibiotics-free water from the liquid fraction of digestate produced from biogas plants located in W.Macedonia region using a compact technology. The developed technology combines filtration units, electro dialysis for nutrient recovery, advanced oxidation process for antibiotics elimination and fertilizer formulation integrated into a system that collects digestate produced from decentralized anaerobic digestion plants. The nutrients product streams are mixed in specific compositions formulating solid fertilizers with the target to replace mineral fertilizers. The produced materials will be used in field experiments for lettuce cultivation in the region and the water derived from the process will be used for irrigation.

**Keywords:** *Nutrients Recovery, Digestate, Circular Economy, Western Macedonia*