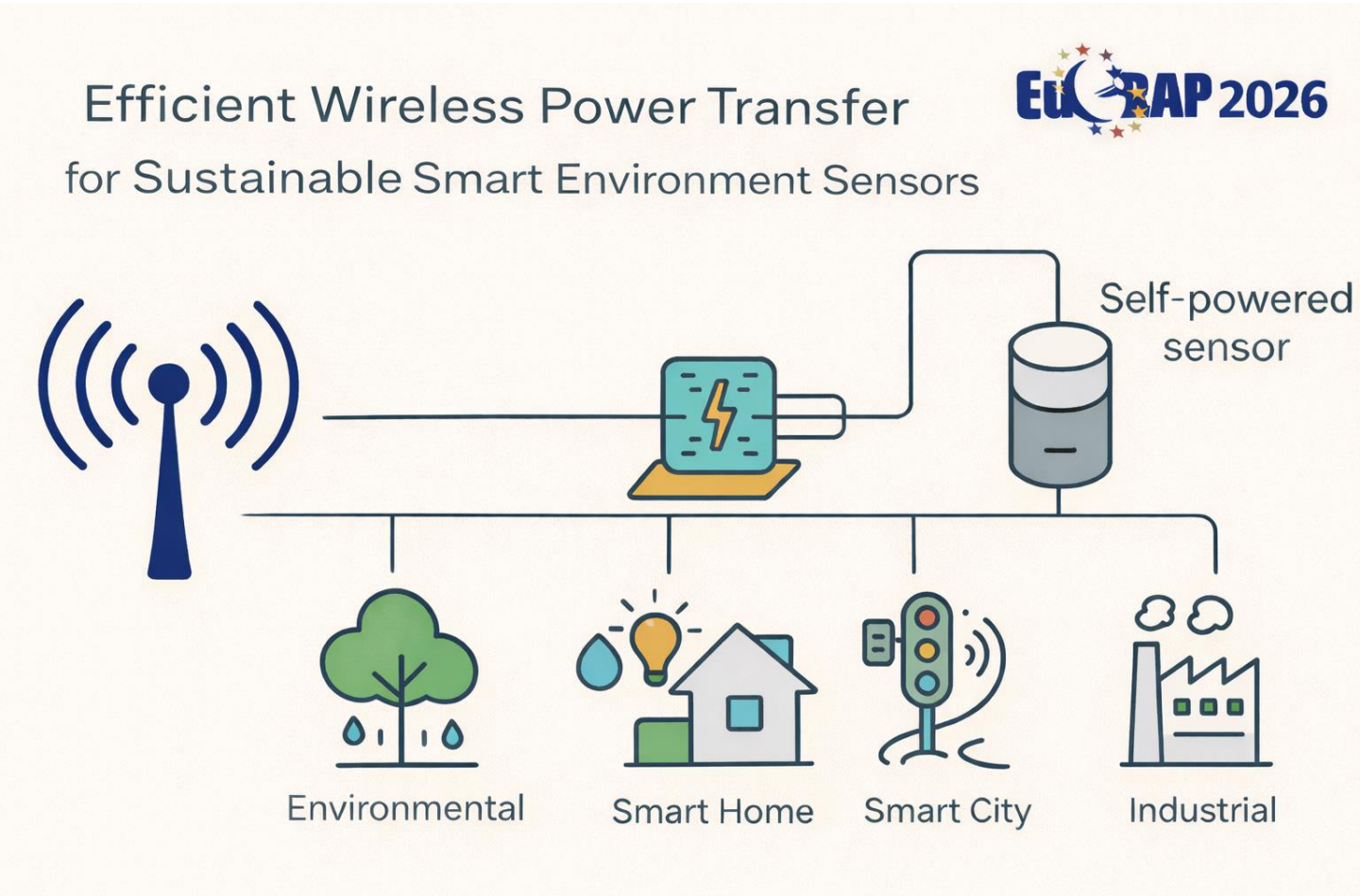
SW9 - Efficient Wireless Power Transfer for Sustainable Smart Environment Sensors

Abstract:

This workshop addresses self-powered sensors for smart environments to solve the strong sustainability problem of standard wireless sensors, which, as expected by the European Innovation Council-European Union, will require 80 million batteries to be changed daily by 2040. Challenges and opportunities of the different microwave wireless power transfer (WPT) subsystems (antennas, harvesting circuits, wireless sensing, and energy management) will be discussed with novel solutions towards making them suitable for various sensor systems, such as environmental monitoring and smart homes/cities. It will feature perspectives from both academia and industry, complemented by insights from the IEEE AP-S Environment Technical Committee.

Workshop outline:

The workshop will combine technical presentations, each followed by interactive discussions. Then, a panel with all speakers to foster collaboration within the community working on these domains.



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Agenda:

Time Slot	Speakers (Affiliation)	Topic
08:30 – 08:40	Kerlos Atia Abdalmalak (Universidad Carlos III de Madrid, Spain) George Shaker (University of Waterloo, Canada)	Welcome and Workshop Scope Insights from the IEEE AP-S Environment Technical Committee.
08:40 – 09:05	George Shaker (University of Waterloo, Canada)	Fluid-Activated Matter: Toward Battery-Free Intelligence and Universal Connectivity
09:05 – 09:30	Kerlos Atia Abdalmalak (Universidad Carlos III de Madrid, Spain)	Compact Liquid Dielectric Antennas for Wireless Power Transfer
09:30 – 09:55	Will Whittow (Loughborough University, England)	3D printed RF devices and optically transparent antennas and metasurfaces
09:55 – 10:10	Panel with all speakers	Discussion / Q&A
10:40 – 11:05	Daniel Segovia-Vargas (Universidad Carlos III de Madrid, Spain)	Miniaturized Microwave Wireless Power Transfer Systems
11:05 – 11:30	Mahmoud Wagih (University of Glasgow, Scotland)	Making RF Wireless Power Sustainable? From Quantifying Impact to Circular Electronics
11:30 – 11:55	Spyros Daskalakis (Green IoT Solutions Ltd, Scotland) Manos Tentzeris (Georgia Tech, USA)	Green IoT Solutions and Global Environmental Responsibility
11:55 – 12:10	Panel with all speakers	Discussion / Q&A
12:10 – 12:20	Chairs	Wrap-Up and Outlook

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Speakers:

Dr. Kerlos Atia Abdalmalak (Organizer) is an assistant professor at Universidad Carlos III de Madrid, Spain. He has authored 1 book chapter and 80+ reviewed papers. Participated in 21 R&D and industrial projects (total fund +3.2 M€) where he led two of them. Co-organizer of European School of Antennas (ESoA) fundamental-of-the-Antenna course in 2025.

Dr. Abdalmalak received several prestigious awards (examples in last 4 years): best Ph.D. Thesis in the aerospace by Madrid City Council, best Ph.D. thesis in signal processing and communications in Spain from IEEE Spain Section, finalist in EuCAP Best-Paper, IEEE/AP-S Postdoc Fellowship, MDPI Symmetry Travel-Award, IEEE/AESS Young Professionals Travel Grant, and Fulbright short-stay for young doctors.

Prof. George Shaker (Co-organizer) is the lab director of the Wireless Sensors and Devices Laboratory at the University of Waterloo, where he is an adjunct associate professor with +200 peer-reviewed publications and +35 patents/patent applications. He has +20 years industrial experience with many commercial products available from startups and multinationals includes Apple, Amazon, Google, and Blackberry. He is currently an IEEE AP-S Distinguished Industry Speaker and IEEE Sensors Council Distinguished Lecturer. Received multiple awards, including IEEE/AP-S Best Paper Award, IEEE/AP-S Honorable Mention Best Paper Award (4 times), IEEE/MTT-S Graduate Fellowship, IEEE Sensors most-popular-paper award, NASA Tech-Briefs-HM Award, and Nature-Communications-Engineering Top25-downloaded-papers.

Prof. Will Whittow FIET, AFWES, SFHEA, SMIEEE (WW) is Professor of Radiofrequency Materials and leads the Wireless Communications Research Group at Loughborough University. He is a named PI/CI on grants totalling > £17m: 3D Metamaterials (SYMETA) (PI, EP/N010493/1), Anisotropic metasurfaces (ANISAT) (PI, EP/S030301/1); and Transparent metasurfaces (PI, EP/W037734/1). He has > 350 peer-reviewed publications (~ 130 journal papers) (> 6,500 citations, h-index = 41): including metasurfaces; dielectric lenses, and dielectric characterisation. He is an IEEE Distinguished Lecturer in Additively Manufactured RF Devices. WW won the inaugural Women's Engineering Society (WES) Men As Allies Award (2017) for outreach.

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Speakers:

Prof. Daniel Segovia-Vargas is a full Professor at Universidad Carlos III de Madrid, Spain and the Chair of the Radiofrequency, Electromagnetics, Microwaves and Antennas Group (GREMA) and a former head of Telecommunications Engineering. Has authored or co-authored more than 350 publications in scientific journals and international conferences. His areas of research include antennas, active antennas, metamaterials, energy harvesting, and THz technologies. He was a Treasurer of the European Microwave Conference2018 and EuCAP2022, the Chairperson of URSI2011. He has organized several international workshops and chaired courses in European School of Antennas since 2013. He has chaired more than 90 R&D projects.

Dr. Mahmoud Wagih is a reader at the University of Glasgow, leading the Green RF-Enabled Electronics Lab, holds a UKIC Fellowship from the Royal Academy of Engineering, and is the Founder of RX Watt Ltd. His interests cover RF-enabled sustainable systems for energy harvesting, sensing, and wearable applications. He has published 130 journal and conference publications and 3 patents and has been principal/co-investigator on over £15M research projects. He is an IEEE Distinguished Microwave Lecturer, received 20+ awards, including multiple IEEE Best Paper, EurAAP Per-Simon Kildal, 2 URSI Young Scientist Award, and was listed in Forbes 30 Under 30 in 2024.

Dr. Spyros Daskalakis is co-founder of Green IoT Solutions Ltd (UK) and Assistant Professor at Heriot-Watt University, UK, specializing in radio electronics for sensors and wireless communications. His research focuses on environmental sensing, batteryless sensors, RF energy harvesting, ambient backscatter communications, ultra-low-power embedded systems, and agricultural IoT applications, with over 8 years dedicated to design, integration, fabrication, and testing of hardware for wireless sensing devices and RF applications. He serves as Associate Vice President of Conferences for IEEE Council on RFID (2025-2027) and vice chair of Subcommittee 17, WiSNet—Wireless Sensors for IoT Applications, Radio and Wireless Week 2026 (RWW2026).

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ABSTRACTS:

Fluid-Activated Matter: Toward Battery-Free Intelligence and Universal Connectivity

As billions of sensors blanket our built environment, battery dependency emerges as an unsustainable paradigm, burdening ecosystems with toxic waste, costly replacements, and recycling complexities. Batteries further introduce fire hazards in thermally dense AI data centers and detectable thermal signatures compromising military concealment. We present a self-powered water leak detection platform harvesting hydroelectric energy for perpetual, maintenance-free operation. Remarkably, this harvested energy powers wireless radios from short-range to satellite connectivity over Low Earth Orbit constellations. This battery-free architecture unlocks transformative applications across residential towers, industrial facilities, military installations, and smart city grids, envisioning a future of resilient, self-sustaining, planet-scale monitoring.

Compact Liquid Dielectric Antennas for Wireless Power Transfer

This presentation addresses self-powered sensors to solve the strong sustainability problem of standard wireless sensors, which, as expected by the European Innovation Council-European Union, will require 80 million batteries to be changed daily by 2040. The focus will be directed to antennas working at lower frequencies (<1GHz) for far-field Microwave wireless power transfer (WPT) systems. Novel solutions for compact high-gain designs will be discussed, such as constructing high-permittivity liquids to be injected into 3-D-printed shells, along with a WPT demo based on these liquid solutions. This provides sufficient power over larger distances, required for various applications such as environmental monitoring, smart homes/cities, and industry.

3D printed RF devices and optically transparent antennas and metasurfaces

3D printing not only allows control of the external shape, the local relative permittivity can be tailored to precise specifications by controlling the internal geometry and hence varying the ratio of air and filament. The local relative permittivity can then be graded in all three axes for extra degrees of freedom. This can be exploited to create flat grade index lenses as well as hybrid lenses. By using specialist printers and careful control of the settings, filaments with relative permittivities up to 15 can be printed. The talk will demonstrate how these RF materials can be used to create artificial dielectrics, filters, metamaterials, and bespoke antennas. The talk will also cover the challenges of measuring dielectric properties. A current ongoing project is exploring optically transparent conductors to fabricate antennas and metasurfaces.

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ABSTRACTS:

Miniaturized Microwave Wireless Power Transfer Systems

The development of miniaturized wireless power transfer (WPT) has recently attracted huge interest, especially for implantable antennas. Thus, a miniaturized dual-band implantable antenna, combining meandered line and spiral techniques to achieve wide impedance bandwidths, is proposed. Furthermore, the proposed WPT system achieves a power transfer efficiency (PTE) of 1.15% by improving the coupling between the receiving (Rx) and transmitting (Tx) antennas using magnetic-based designs, thereby reducing human tissue losses. Finally, the measured results obtained inside minced pork show a high degree of agreement with the expected performance, validating the system's performance in realistic biological environments.

Making RF Wireless Power Sustainable? From Quantifying Impact to Circular Electronics

RF power delivery to rectennas could enable battery-free devices, but its environmental impacts are not clearly understood. This talk will review the sustainability of different RF power delivery scenarios and more broadly the underpinning components' sustainability, through Life Cycle Assessment (LCA). Efficiency improvement approaches and also associated antenna-IC co-design will be discussed. Finally, fabrication processes and materials for zero-waste and fully recyclable antennas and RF power harvesting frontends will be introduced.

Green IoT Solutions and Global Environmental Responsibility

Batteries are one of the biggest barriers to large-scale wireless sensor deployment, they need replacing, they fail, and they create waste. This talk presents work from Heriot-Watt University, Green IoT Solutions Ltd, and Georgia Tech on sensors that run without batteries, harvesting energy from ambient RF and solar sources. We cover the underlying RF energy harvesting and backscatter communication techniques, as well as real-world deployments in precision agriculture and environmental monitoring. The goal is simple: sensors that just work, indefinitely, with no maintenance, and a smaller environmental footprint to match the "green" in Green IoT.