

GOING GREEN WITH GRAPHENE

GREENER POSSIBILITIES FOR A SUSTAINABLE FUTURE

By: Letizia Diamante



WATER

In line with [SDG 6](#), which aims to ensure availability and sustainable management of water and sanitation for all, Graphene Flagship researchers are investigating various applications of graphene to improve water filtration and contaminant detection technology. Furthermore, graphene-based membranes could potentially purify sea and wastewater, making it suitable for consumption and agriculture.

Since many common water contaminants are resistant to conventional purification techniques, Graphene Flagship researchers are working on new graphene-enriched water filters. These filters could remove toxins and contaminants from European water, and they could also contribute to water conservation programmes in arid regions in the Global South.

AFFORDABLE, POINT-OF-USE WATER TREATMENT

Graphene-enriched water filters favour the absorption of organic and inorganic contaminants, so they are a great candidate for next-generation water filtration technology. Scientists at [Medica SpA](#), Italy, lead the recently established Spearhead Project [GRAPHIL](#), which seeks to develop micro-filtration membranes that can be directly connected to a household sink. The commercial product should be ready for the market in 2023.



The Graphene Flagship, hand-in-hand with many institutions, enterprises and governments around the world, have pledged to work towards the United Nations' [2030 Agenda for Sustainable Development](#) and the [EU Green Deal](#).

Our sustainable research across Europe is diverse in both discipline and scale, and aims to solve a broad range of important societal and environmental challenges – from the development of low-cost, handheld graphene-enabled water quality sensors, to the establishment of the world's first graphene-enabled solar farm in Greece. Overall, our projects contribute to 11 of the 15 [UN Sustainable Development Goals](#) (SDGs), and we believe that graphene and layered materials will play a key role in the green revolution.

But with less than ten years to go before 2030, the need for new technologies to ensure sustainable access to energy and water has never been greater. To this end, the Graphene Flagship is paying more attention to sustainability than ever, focusing many of our industry-led [Spearhead Projects](#) and a broad range of our research initiatives and commercial endeavours to develop innovative solutions for a greener, more sustainable future. Among them, several concentrate on SDGs 6 and 7: [clean water and sanitation](#) and [affordable and clean energy](#).

MEMBRANE FILTERS FROM INDUSTRIAL SCRAPS

Researchers at [CNR, Italy](#), and [Chalmers University of Technology, Sweden](#), envisioned a new technique to [produce water filters](#) from graphene oxide (GO) and a waste product from the industrial production of polysulfone membranes. The graphene-coated membrane combines the unique properties of both materials and works simultaneously as a filter and as an adsorbent.

"Our method can not only be applied to commercial membranes, which are already manufactured on large scales, but also to scraps derived from their fabrication," explains Vincenzo Palermo from Chalmers University of Technology, Vice Director of the Graphene Flagship. "This is a great advantage, and a step forward towards a circular economy."

CONTAMINANT SENSING FOR SAFE WATER

Low-cost graphene-based sensors developed by the Graphene Flagship can detect bacteria, viruses, proteins, oligonucleotides, toxins and metal ions. These easy-to-prepare sensors also show promising sensitivity.

"We are developing paper or plastic platforms with graphene-based electrodes. They can become cheap lateral flow devices, with structures similar to pregnancy tests or simple microfluidic devices," explains Arben Merkoçi from the [Catalan Institute of Nanoscience and Nanotechnology \(ICN2\)](#).

Recently, Merkoçi and colleagues in the Graphene Flagship's [Sensors Work Package](#) created a sensing platform, based on reduced GO, to detect harmful toxins originating from fungi that are frequently found in agricultural products like wheat and corn. Farmers could use these graphene-enabled [sensing platforms](#) to protect their crops and help their agricultural businesses to thrive.

TOXICITY TESTING FOR RESPONSIBLE RESEARCH

We recognise that it is vital for the Graphene Flagship to study the effects of graphene and layered materials on health and the environment, in addition to those of our research and the industrial and commercial processes we enable.

To this end, the Graphene Flagship's [Health and Environment Work Package](#) works tirelessly to conduct environmental toxicity tests – in line with the [OECD Guidelines for Sustainability](#) – and determine appropriate methods for the disposal, treatment and recycling of products containing graphene and related materials.

In addition, our [SafeGraph](#) Spearhead Project formulates strategies to help our other projects comply with all the relevant safety regulations and legislation, helping Graphene Flagship-enabled products reach the market in a safe, cost efficient and timely manner.



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ENERGY

To cope with the ever-increasing global demand for energy, Graphene Flagship researchers are searching for new renewable and sustainable options. Graphene-enabled batteries, supercapacitors, solar cells and other new energy-saving solutions could bolster the European Union's efforts to reduce our dependence on fossil fuels.

Two of our Work Packages, dedicated to [Energy Generation](#) and [Energy Storage](#), and several of our [Spearhead Projects](#) address [SDG 7](#) to ensure access to affordable, reliable, sustainable and modern energy for all.

CREATING THE WORLD'S FIRST GRAPHENE SOLAR FARM

The Graphene Flagship's Solar Farm Spearhead Project established the world's first graphene-enabled solar farm in Crete, Greece. In 2019, our Italian partners the [Italian Institute of Technology \(IIT\)](#), the [University of Rome Tor Vergata](#) and spin-off [BeDimensional](#) collaborated to produce large-area graphene-enriched perovskite solar cells, which achieved excellent power conversion efficiencies of 15.3%.

Now, our industry-led [GRAPES](#) Spearhead Project includes partner companies such as [Greatcell Solar](#) and [Siemens](#), and aims to surpass this figure with new solar cell configurations. Beyond flexibility, transparency and low-light responses, graphene-enabled solar cells could reduce the cost of photovoltaic energy below €20/MWh – cheaper than fossil fuels.

SAVING WEIGHT, FUEL AND ENERGY IN CARS AND PLANES

Lightweight graphene-based composites can save significant amounts of energy in the automotive and aerospace industries. An industrial collaboration between partner companies [Avanzare, Spain](#), and [Nanesa, Bioage SRL, SPAC SpA](#) and [Fiat-Chrysler Automobiles, Italy](#), aims to replace the metal in conventional vehicle dashboards with graphene-based materials. The Spearhead Project [G+BOARD](#) will reduce the weight of vehicles, lowering their fuel consumption and CO₂ emissions.

In addition, our Spearhead Project [GICE](#), which comprises several key partners in the aeronautics industry, including [Airbus](#) and [Sonaca](#), is studying graphene-enabled systems to remove ice or prevent ice accumulation in helicopters and planes. Thanks to the outstanding properties of graphene, thermoelectric de-icing or anti-icing systems can be lighter and more fuel-efficient, saving up to 90% of the energy required for conventional hot air alternatives.

To learn more about the Graphene Flagship's contributions to the aeronautics industry – and to find out about our recently appointed Aeronautics Champion, [Airbus' Elmar Bonnaccuso](#), and his commitment to new and existing innovations in the field – please turn to page 34.



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GREENER TECHNOLOGIES FOR ENERGY STORAGE

Worldwide demand for battery-based energy storage will significantly increase by 2025, and graphene and layered materials could play a vital role in meeting this higher demand.

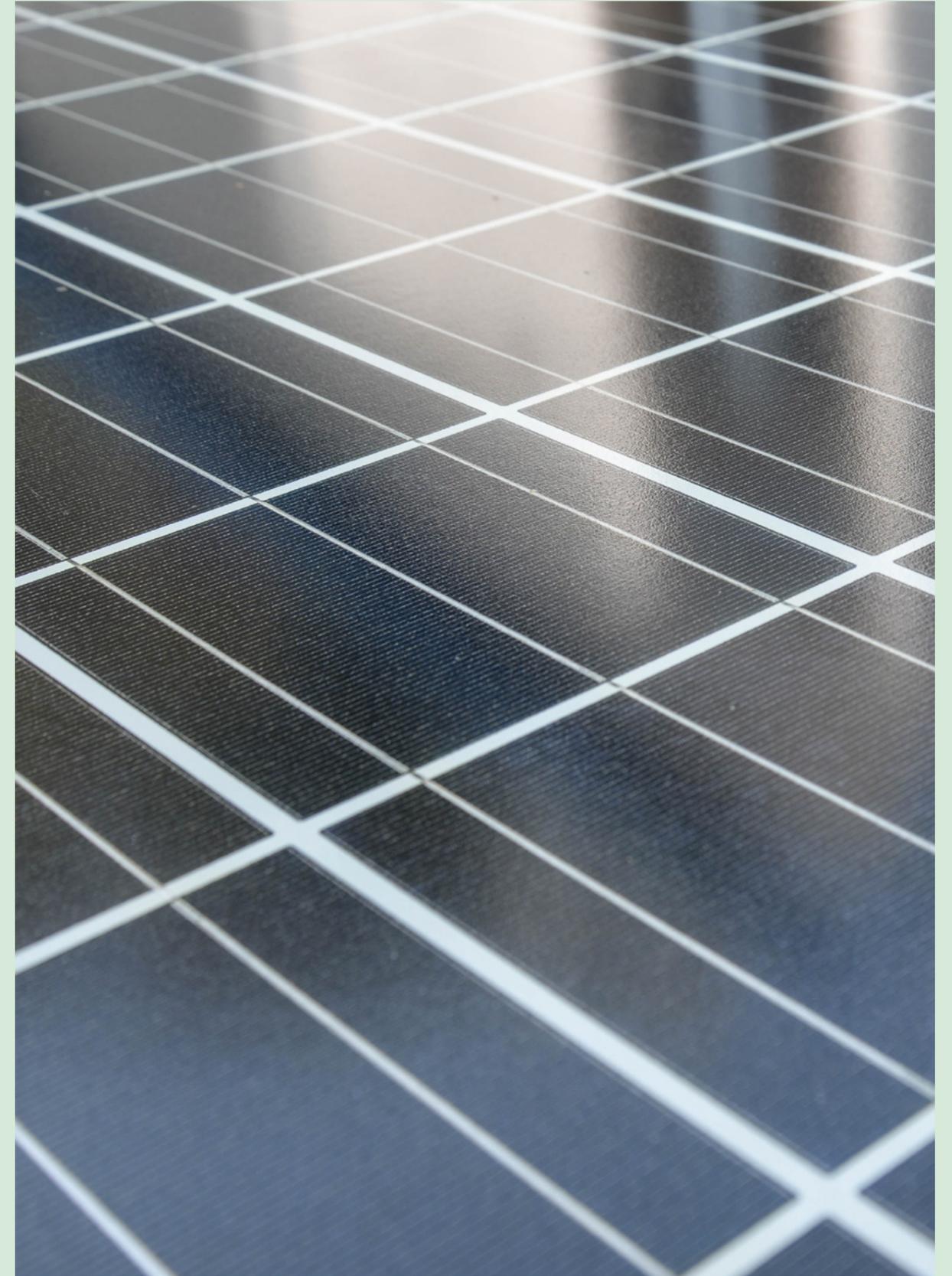
Due to its light weight and high surface area, electrical conductivity, chemical stability and mechanical flexibility, graphene can increase the energy capacity, charge rate and nourishing stability of lithium-ion batteries. In practice, this means graphene-enabled batteries for electric vehicles, mobile phones, laptops and more could have longer lifespans and faster charge times.

The Graphene Flagship Spearhead Projects [Batteries](#) and [GreenBAT](#) aim to provide innovative energy storage solutions to significantly increase the energy density of lithium-ion and post-lithium batteries – not only for portable and automotive applications, but also for the decentralised storage of renewable energy.

PAIRING SILICON AND GRAPHENE

In March 2020, Graphene Flagship researchers at [VARTA Micro Innovation GmbH, Austria](#), and [BeDimensional](#) and the [Istituto Italiano di Tecnologia \(IIT\)](#), Italy, announced a new prototype of graphene-enabled lithium-ion batteries with capacities more than 30% higher than any currently available alternative. With graphene, batteries can overcome some of the mechanical limitations of silicon. Christoph Stangl, from [VARTA Micro Innovation GmbH](#), has a clear goal: “Now, we want to quickly push this exceptional battery technology towards commercialisation.”

When it comes to sustainability, be it in terms of green energy, clean water or beyond, the future of graphene and layered materials is bright. Thanks to the Graphene Flagship's push for innovation, we are confident that graphene and layered materials will have a vital role to play in the move to a sustainable future.



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