

# Harnessing Offshore Wind for Hydrogen Power

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*A fossil-based economy has been driving our planet to its limits since the dawn of the Industrial Revolution. The finite and localised availability of fossil fuels has shaped continents and turned entire nations upside down. Moreover, the carbon dioxide emissions produced by using these fuels are bringing entire ecosystems to their knees. But how can we reduce emissions and avoid further impacts?*

In the last few decades, our knowledge of renewable energies has greatly improved. We learned how to harness the wind, generate electricity with turbines, and capture the power of the sun with photovoltaic cells. But these technologies create a new challenge: how does one store this energy?

Electrochemical storage using batteries is one solution. However, besides being extremely hard to recycle, batteries also rely on the mining of rare elements, which devastates entire regions and damages their social tissues and nature, as seen in lithium mines from Chile to South Africa. But there are other energy storage solutions, some of which are particularly suited for use in an offshore environment (see Buhagiar & Sant, 2017).

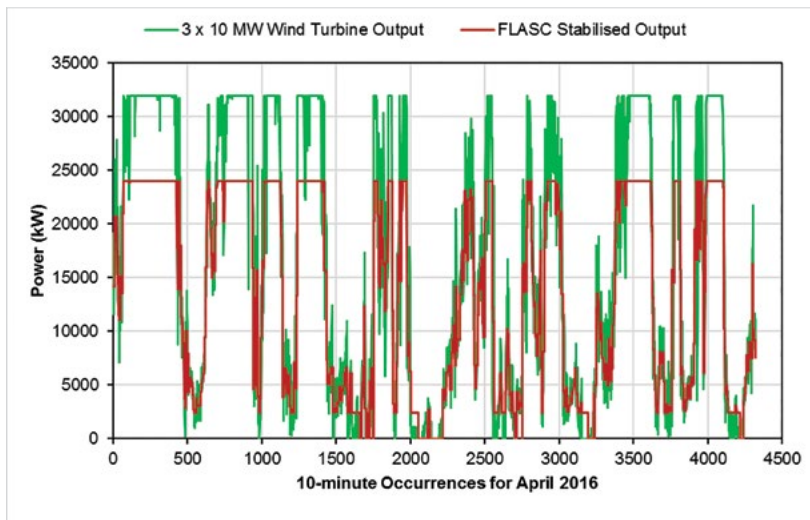
The UM researchers (Oleksii Pirotti, Diane Scicluna, Robert N. Farrugia, Tonio Sant, and Daniel Buhagiar) behind the Hydro-pneumatic Energy Storage for Offshore Green Hydrogen Generation project, or HydroGenEration, are developing a concept system that uses offshore wind farms and integrated energy storage to produce decarbonised – or ‘green’ – hydrogen.

## USING HYDROGEN FOR A MORE SUSTAINABLE FUTURE

Through the process of electrolysis, hydrogen can be produced in a relatively simple way by splitting water (H<sub>2</sub>O) into oxygen (O<sub>2</sub>) and hydrogen (H<sub>2</sub>). When used as fuel, hydrogen does not emit carbon dioxide, which can make it attractive as an alternative energy source for tackling

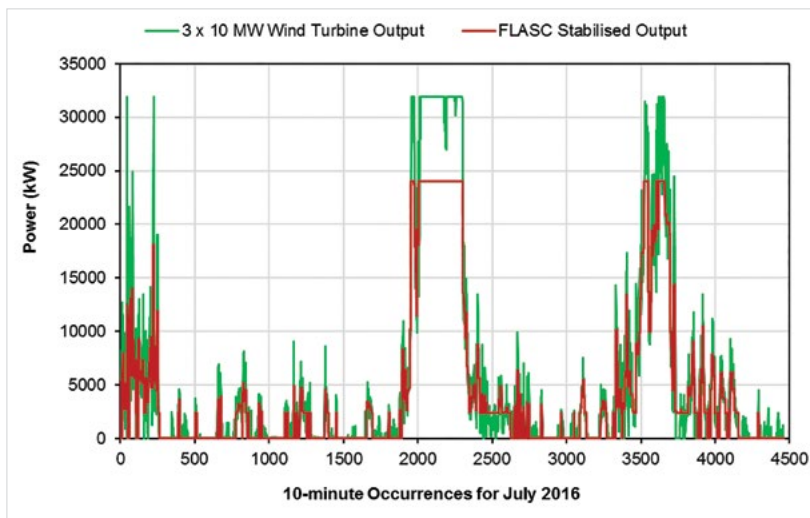
climate change and decarbonising our economy. However, the energy used to produce it must also be taken into account, because this can come from different sources, some of which may not be green. In fact, 95% of the hydrogen produced in the EU in 2023 was a result of the use of fossil fuels.

By contrast, green hydrogen, produced using renewable energy sources and resulting in no CO<sub>2</sub> emissions, is the key to a sustainable future. The HydroGenEration project focuses on using offshore wind turbines coupled with co-located energy storage to reduce the intermittency of renewable sources in the Central Mediterranean. Project HydroGenEration has also closely followed developments in local renewable energy policies by the Continental Shelf Department



**Figure 1: Power output from a three 10 MW wind turbine cluster (green) compared to the power output after being stabilised by the FLASC energy storage system (red) for the months of April (Top) and July (Bottom), for the year 2016**

*Images courtesy of the HydroGenEration Team*



(Preliminary Market Consultation – For the Proposal of Economic Activities within Malta’s Exclusive Economic Zone, 2022) and the Energy and Water Agency (EWA, National Policy for the Deployment of Offshore Renewable Energy – A Draft for Public Consultation, 2023).

## PRODUCING GREEN HYDROGEN FOR MALTA

The use of renewable energies comes with its challenges. Infrastructure such as wind turbines and solar panels require swathes of land, and even though the wind is widely available in Malta, onshore space is scarce. This prompted the

researchers to look to the sea, where there is ample space and the winds are even better quality. Offshore wind energy production is widespread in the North Sea as wind resources in that region are undeniably better. However, implementing this technology in the Mediterranean brings a new level of difficulty due to its comparatively deeper seas. As Sant puts it: ‘To make it viable in the Mediterranean, floating wind turbines become necessary.’ Floating platforms are already in use in the oil and gas industry, and the same kind of infrastructure is being adapted to deep-water floating offshore wind farms.

Another challenging problem is the irregularity of the wind. Sudden changes in its velocity result in a variable and unpredictable energy output from wind turbines. This can reduce the efficiency of the hydrogen production process and drastically impact the lifetime of the system’s components.

This problem was overcome by using a Floating Liquid-piston Accumulator using Seawater under Compression (FLASC) system: an innovative energy storage technology developed in Malta by Daniel Buhagiar, Tonio Sant, and Robert N. Farrugia (check out **THINK** Issue 22). The FLASC hydro-pneumatic energy storage (HPES) technology compensates for the irregularity of the wind, or any fluctuating source for that matter, by storing the excess energy produced in moments of wind surplus and releasing that energy when there is less wind and hence less energy being produced.

Thanks to funding from the EWA, this team of investigators from UM, together with its preceding spin-out company, FLASC B.V., is building on the earlier work of the WIND4H2 project (see Settino et al., 2022). And by means of Project HydroGenEration, they are investigating the possibility of improving the hydrogen production process in the local context by stabilising the power produced by offshore wind farms through co-located HPES (see Pirotti et al., 2023). ▶

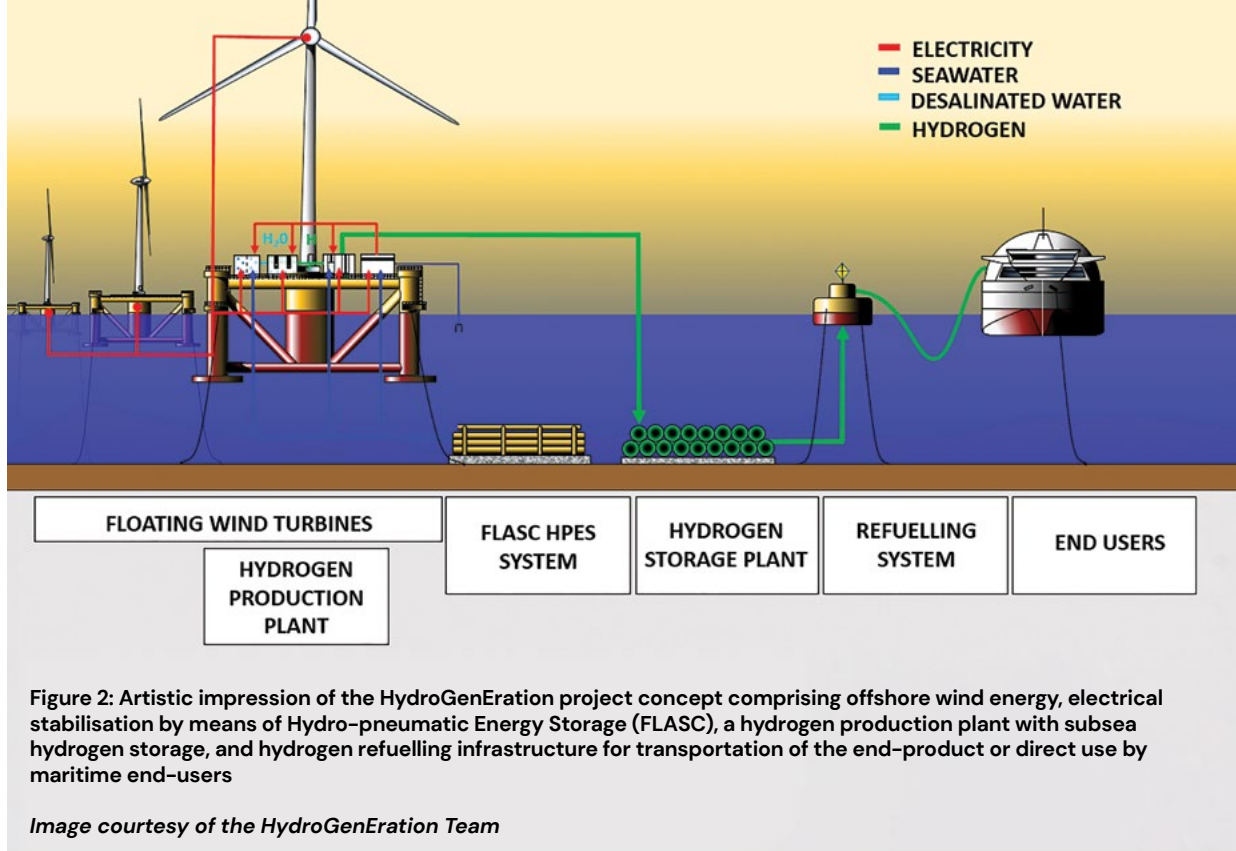


Figure 2: Artistic impression of the HydroGenEration project concept comprising offshore wind energy, electrical stabilisation by means of Hydro-pneumatic Energy Storage (FLASC), a hydrogen production plant with subsea hydrogen storage, and hydrogen refuelling infrastructure for transportation of the end-product or direct use by maritime end-users

Image courtesy of the HydroGenEration Team

## AN OVERVIEW OF THE HYDROGENERATION CONCEPT

The HydroGenEration project used coastal LiDAR wind data collected by UM to model the behaviour of the concept HydroGenEration system. In Figure 1, the green line represents the fluctuations of the wind turbine power outputs with time for typically hotter and cooler months. These lines are marked by peaks and drops in the output power due to the highly variable wind behaviour. On the other hand, the red lines show how the use of the FLASC HPES system stores and dispatches the power and thus smoothens the renewable power outputs, delivering a more consistent amount of energy to the hydrogen production system.

Without energy storage, the power being fed to the hydrogen production system would be turned off and back on again more frequently, which would reduce the electrolyser’s lifespan. As Farrugia explains, ‘When you turn the electrolyser on after a shutdown due to an insufficient power supply, it will

not be instantly up and running, as it has to ramp up to full capacity over several minutes,’ making the HPES storage component one of the biggest innovations of the project concept. With the FLASC system in place, the power supplied to the electrolyser is considerably more stable – even when the winds are more irregular, such as in the Mediterranean region – resulting in fewer energy losses, ‘more efficient hydrogen production, and an improvement in the lifecycle of the equipment which reduces the cost of the project,’ states Pirotti.

A visual representation of the HydroGenEration modular concept for the high seas can be seen in Figure 2, comprising floating wind turbines with a power rating of 10 Megawatts each to charge the FLASC energy storage system, which will be located partly on the floating platform and partly on the seabed. A steadier energy output from the FLASC HPES will then feed the water purification and electrolysis processes, leading to green hydrogen production. Since the platform is located at sea, water is widely available and only needs to be

desalinated and purified to be turned into hydrogen. This all happens in the floating hydrogen production unit, which is located topside on the wind turbine floater. Following this, the hydrogen is compressed and stored in the subsea hydrogen storage array pending collection by an H<sub>2</sub> carrier or for the refuelling of seafaring vessels.

The maritime sector’s big share of CO<sub>2</sub> emissions continues to grow. The shipping industry alone accounts for 3% of global emissions. There is an urge to decarbonise the sector, and HydroGenEration serves as a beacon of hope in the creation of a greener future. As the first H<sub>2</sub>-powered boats are being tested, the potential for the use of hydrogen in decarbonising the maritime sector is promising. Since the HydroGenEration project stores the hydrogen produced on-site, such ships can refuel off-shore, becoming the end-users for the produced H<sub>2</sub>. This eliminates the economic and environmental costs of transporting the fuel to land and can become a pivotal point in the future of shipping.

HydroGenEration has been ongoing since June 2022. In these



1. Dr Oleksii Pirotti
2. Ms Diane Scicluna
3. Prof. Ing. Robert N. Farrugia
4. Prof. Tonio Sant
5. Dr Daniel Buhagiar

*Photos by James Moffett  
(Last photo courtesy of  
Dr Daniel Buhagiar)*



past two years, different settings and combinations of equipment have been studied to zoom in on the ideal project concept. The latter stage will now focus on calculating the cost of hydrogen production using the conceptualised system. **T**

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*The HydroGenEration project team acknowledges the support of the University of Malta's Project Support Office, the Corporate Research and Knowledge Transfer Office, and the Marketing, Communications and Alumni Office.*

Further Reading:

Buhagiar, D., & Sant, T. (2017). Modelling of a novel hydro-pneumatic accumulator for large-scale offshore energy storage applications. *Journal of Energy Storage*, 14(2), 283-294. <https://doi.org/10.1016/j.est.2017.05.005>

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Pirotti, O., Scicluna, D., Farrugia, R. N., Sant, T., Buhagiar, D., & Settino, J. (2023). A Preliminary Analysis of the Generation of Hydrogen from a Floating Offshore Wind System. *Proceedings of the 7th Offshore Energy & Storage Symposium, IET Conference Series*, 124-132. <https://doi.org/10.1049/icp.2023.1562>

