Backstory
How a hydrogen start-up can contribute to the energy transition through the emerging hydrogen economy

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With an ever-increasing drive to grow the hydrogen economy, developing routes to store hydrogen is a key requirement to enable its wider use as an energy carrier at scale. At H2GO Power, we develop systems to store hydrogen in a safer, cheaper, and denser way when compared to conventional hydrogen storage routes. Conventional storage methods require extreme conditions, either very high pressures or very low temperatures; moreover, reaching these extreme conditions require substantial energy costs. Besides the high costs, safety concerns have also been raised when large quantities of hydrogen are stored at high pressures.

At H2GO Power we overcome these problems by storing hydrogen in a solid-state form, exploiting the chemical bond that hydrogen can form with either a solid or a liquid material with no need of extreme conditions. The pressures that we use are comparable to the pressures used in conventional household appliances such as coffee machines. The chemical reactions at the basis of our technology are reversible, meaning that we can store green hydrogen when the production exceeds the demand, and release it, by applying a small temperature gradient, whenever needed. These steps can be repeated tens of thousands of times making our patented technology unique.

Part of H2GO Power team. From left to right: Luke Sperrin, Manjot Chana, Lukas Malms, Enass Abo-Hamed, Joshua Ivanhoe, Federico Pesci, Peter Italiano. Copyrights H2GO Power Ltd. Reprinted with permission.
We are an international and multidisciplinary team currently working on three main products: two hardware products for stationary and mobility applications, and a software product that combines machine learning and artificial intelligence to optimize the production, the storage and the release of green hydrogen with the aim to maximize the operation and monetization of assets across the value chain (www.h2gopower.com).

Our hardware systems include a stationary product capable of storing hydrogen in a solid-state form at 1% the pressure and half the volume of compressed gas, for use in conjunction with wind or solar farms to store the excess energy produced. A second hydrogen storage product is a system used in drone applications, which allows a three times improvement of flight duration when compared with current battery-powered drones.

Further, over the last few decades, high levels of CO₂ emissions have been extremely detrimental for our planet and prominent scientists have warned the public to take actions to prevent further irreversible damage. Considering the decarbonization targets set by national and international governments for the next few decades, we hope to play a pivotal role toward reaching those goals using hydrogen. The multidisciplinary nature of the team allows us to fully develop our products and technology, from conceptualization to on-site integration and testing. We are a team of chemists, electrical and mechanical engineers, material scientists, physicists, and mathematicians, and each of us contribute with our unique set of expertise to the development of our products and to the growth of our company.

**MOTIVATION**

Elaborate on what is already on the market and how do you aim to touch upon everyday lives of the public

Conventional routes to store hydrogen have two main drawbacks: high processing costs and low safety. Storing hydrogen by physical means requires either extremely high pressures (up to 700 atm) if stored in...
its gas phase, or very low temperatures ($<-253^\circ C$) if stored in its liquid phase. Achieving these extreme conditions is associated with high costs. In addition to these costs, compressed gasses and cryogenic liquid represent a safety hazard. At H2GO Power we offer an alternative solution to store hydrogen, by bonding it to other materials and molecules exploiting their chemistry. By doing so, we overcome the need of using high pressures or low temperatures and doubling the volumetric storage capacity, simultaneously reducing the costs, and increasing the safety of our hydrogen storage solutions.

There are countless options for renewable technologies, why do you think the answer is hydrogen, and why now?

There are countless options for renewable technologies indeed. Over the last few decades researchers and industry have been able to develop and optimize methods to harvest energy from renewable sources which are easily accessible, abundant, and delocalized.

One of the major challenges remaining is how we can store the excess energy that we can produce from renewables. We can find the answers to these problems by looking at the periodic table of elements and selecting the chemistries that could help us achieve effective and efficient energy storage. The lighter an element and the higher its energy density, that’s why some of the most promising elements used in energy storage are the ones that we find in the top left region of the periodic table such as hydrogen (H) and lithium (Li).

Lithium-ion batteries for example, have had an impact on everyday life. But they are met with challenges such as sourcing, disposal, recycling, performance enhancement, and scaling up for certain applications.
This is why hydrogen can be a game changer. Apart from extremely dry lands, we can find hydrogen well distributed and accessible around the globe; we should consider that the major source of hydrogen is water, which covers 71% of the Earth’s surface. Electrolysis of water is known to be an energetically costly process; however, if the electricity used to split water into its two elemental components (hydrogen and oxygen) is sourced from renewables, the process becomes carbon neutral. The hydrogen produced from water using renewable sources of energy is known as “green hydrogen” and can be used directly into a fuel cell to produce electricity to power a variety of things, from small single appliances to larger entire buildings. Considering the intermittent nature of the natural resources such as wind and sunlight, it is of fundamental importance to maximize their utilisation by storing the excess energy produced. This can be done in periods in which the electricity demand is low, but the energy produced by renewables is still high, by splitting water and producing hydrogen that can be temporarily stored and used when needed.

In our program named HyAI, we demonstrate how software integrated with hydrogen hardware can make intelligent and data-driven asset management decisions in real time and optimise renewable energy integration into the UK energy grid. This is one example for a use case we’ve looked at and there are many more in the pipeline.

**PROXIMITY**

***Who are the key players in this project, and how did you bring everyone together? Are your team, work, topics interdisciplinary?***

Members of our team come from different backgrounds, which give us the possibility to look at things from different perspectives and therefore optimise our outcomes. We have two separate, but at the same time extremely interconnected, teams working on machine learning and hardware products development.

Our backgrounds span from pure chemistry and theoretical physics to mechanical and electrical engineering. This wide and complementary range of expertise allows us to develop our products and software from conceptualisation to full development and deployment. I am personally involved in the characterisation of the materials we use to store hydrogen, with the aim of optimising their performances. However, as well as working on materials characterization, I am also involved in design and optimization of experimental setups and integration of our hydrogen storage reactors into a
final product. This is possible thanks to the close collaboration that I have with other members of our team including Luke Sperrin, our CTO, Peter Italiano, head of product development, and Manjot Chana, senior integration engineer.

Our software team, composed by Joshua Ivanhoe, Dr. Lukas Malms and, Dr. Carlo Corsaro, alongside the development of a software to make intelligent and data-driven asset management decisions, is also involved in validating the operation of our hardware systems and optimizing their performances. Our young and enthusiastic CEO and co-founder, Dr. Enass Abo-Hamed, has built a team of fantastic individuals, who are very collaborative and hold a strong belief in the company mission statement. The frequent meetings that we have between the two teams are a unique opportunity to define targets and find a common working ground toward mutual growth.

Did you encounter any challenges or any benefits of working with people from different backgrounds and expertise? How did you bridge the language or other gaps among different disciplines?

Rather than encountering challenges in working with people with a different expertise, I have found several benefits which are contributing to my personal and professional development. I have a background in chemistry with a wide experience in employing spectroscopic techniques to characterize and understand the factors that shape the properties of materials. During my PhD and postdoctoral research studies I have always been involved in multidisciplinary projects which have allowed me to keep an open mind. Alongside pure chemistry research, I have designed and built proof-of-concept devices and instrumentation, trying to learn new skills in fields out of my comfort zone. I have to thank my mum and dad, as since I was a child, alongside many practical skills, they taught me how to be curious toward things and how to listen and learn from people with different backgrounds. This is extremely beneficial for a personal and professional growth, and it is possible in a start-up company where everybody needs to work at a fast pace to reach a shared goal.

RESEARCH METHODS
Did this project require tailoring your (or existing) research methods to adjust to working interdisciplinary?

Sure it did. As mentioned, I have an academic background, and research in academia is quite different. Talking about materials science, the focus of academic research is to investigate the properties of a material to understand its behavior on a larger scale. This is very important to enable targeted engineering of materials and allow their use in practical devices. Some of the most important discoveries that humankind has done have been made in academic environments. However, the use of materials in commercial devices is often done by industry. In industry, the research methods are mostly aimed at the development of a product and the focus is more on the overall performance of a device, exploiting the properties of materials, with the aim to create a market-ready product. In academia, on the other hand, you tend to focus your attention on details and often on the problems that limit the performances of a material.

The interdisciplinary nature of my job allows me to constantly learn new skills and use my problem-solving experience on practical issues resulting in a very rewarding experience.

GOVERNANCE
How did the decision of branching out from your (academic) fields come about? What implications did it have on your careers? (recognition, funding, etc.?)

Since my PhD, I have been researching energy materials, first on hydrogen production and then on CO2 reduction via photo electrochemical water splitting. I then moved my research interest on 2D materials such as graphene and TMDs, also used in water splitting. Before joining H2GO Power Ltd., I was a postdoctoral research associate in Imperial College London, working on lithium-metal batteries to understand and overcome some of the major problems associated with the use of metallic lithium anodes.
Although academic research allowed me to fully explore and gain a deep understanding of materials and their properties, it was not enough applied to lead to the development of a product. After several years in a pure research setting, I got to a stage in my career where I felt it was time to work in a product orientated environment with the aim to have an impact on society and I therefore decided to join a company to work in a more commercial environment.

However, H2GO Power being a very dynamic company, I still have the opportunity to keep up with the literature and collaborate with our academic partners in several projects, so many aspects of academic research are still present in my current job.

**PUBLICATION**

*When patenting or publishing this or any interdisciplinary patent or paper, how do you decide which community/venue to target? What are the challenges during publication of this or any such research?*

The broader the community is, the more visibility a company gets. However, it depends on the type of publication and the reason behind it. When patenting our technology, we are of course very specific. At H2GO Power, we have a portfolio of patents, some are granted and others are pending. The aim of our research is to develop a product and, with it, to create intellectual property. We are nonetheless still involved in peer-reviewed papers thanks to projects with our academic partners.

We also participate in conferences and events targeted to both the general and the specialized public to engage in conversations, explain how we translate pure research into a complete product, and put valuable research findings to use.

*What initiative (by publishers, funders, etc.) would make communicating interdisciplinary research easier/more effective?*

Venues where we can engage with others that are not traditionally involved with hydrogen research are very beneficial for us. I am finding it very useful when academic and industrial representatives engage in conversations as they can help each other in translating ideas into products.

Besides specialized conversations, I believe in the importance of engaging with the public to stimulate their interest in renewable energies, energy storage systems and how every individual can contribute to a cleaner and more sustainable world. We do this by taking part in events that are not solely aimed at a specialized public, such as the Royal Institution Christmas Lecture 2020 where our CEO presented one of our plug & play systems.

We are also active on social media platforms such as LinkedIn, which give us the opportunity to reach out to a broad audience.

**FINAL THOUGHTS**

*What did you learn about interdisciplinary research from the project and what tips would you give to anyone considering undertaking such work? Are there any other challenges you encountered that aren’t discussed here?*

Over the last decade I have learnt the importance of interdisciplinary research and how this can help us in having a broader understanding of what surrounds us by using critical thinking. Working in a multidisciplinary environment has enabled me to build a unique set of skills, which could be used in different fields of research.

I extremely enjoyed my time in academia, and I think that pure research gave me a unique mindset that is of great importance for personal and professional development. When I joined H2GO Power, I found my previous experience in academia very beneficial, and this has allowed me to quickly adapt to the new
environment and research style. Currently, I am extremely enjoying my time in a start-up as it gives me the feeling of working towards a goal that could have an impact on hundreds of thousands of people and I feel the excitement of being involved in a game-changing technology.

To anyone considering a move from academia into industry, I would remind you of the importance of the unique experience built in a research lab that could easily enable you to carry out a wide range of jobs and tasks in a more product-oriented environment. Therefore, if your desire is to work towards something that could have an immediate long-term impact on our society and to be in a multidisciplinary and fast-paced environment, I highly recommend joining a start-up company which I personally find very rewarding.