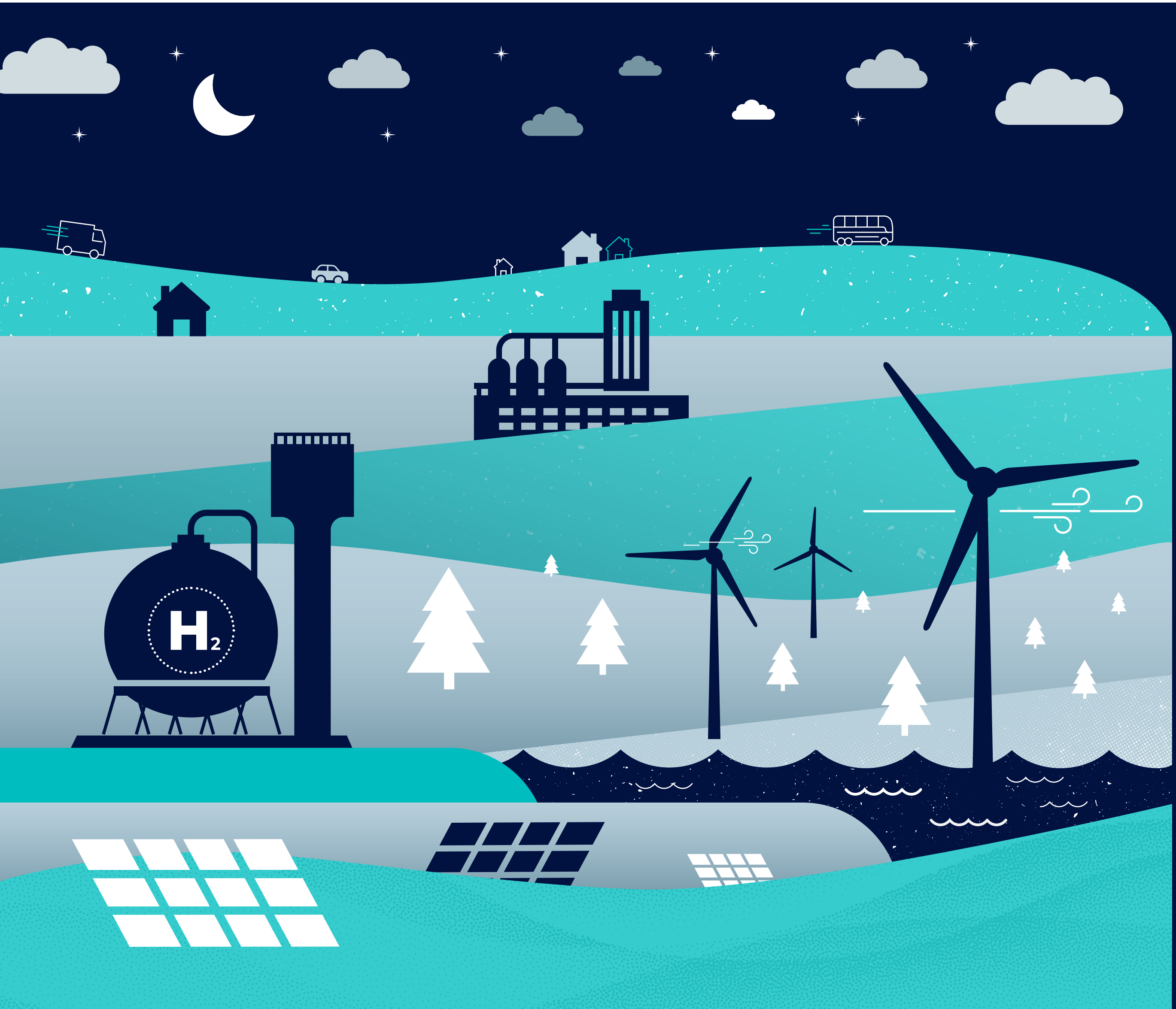
Interreg North-West Europe
GenComm
European Regional Development Fund

# $H_2$GO NEWS

## December 2020



# Pure Energy Centre circular economy work pays dividends

**As part of the GenComm renewable hydrogen project the Pure Energy Centre have been involved in analysing an innovative circular economy concept around an existing bio-energy plant that generates renewable hydrogen from municipal biodegradable waste. Surplus constrained renewable electricity within the anaerobic digestor plant is used to generate hydrogen and also oxygen for the island's fish farms for the farming of salmon. The digestate outputs from the anaerobic digestion process also yields nitrogen rich fertilisers for use with agriculture and horticulture.**

One of the main aims of the GenComm project is to enable remote communities to access renewable energy in the form of hydrogen, in a bid to tackle the ongoing and long-term challenge of constrained grid connections. As part of the Pure Energy Centre's work package deliverables, investigation of how biodegradable waste can be utilised to produce biogas and generate clean hydrogen and oxygen for capture and use has investigated.

In a conventional renewable hydrogen scenario wind, solar, wave or tidal energy is typically utilised to create 'green' hydrogen via electrolysis. Moreover, by-product oxygen from the electrolysis process is vented to atmosphere. However, the analysis undertaken in GenComm has examined the potential to not only utilise the by-product oxygen, but also integrate the hydrogen production and oxygen capture with the anaerobic processing of municipal organic waste.

GenComm team members Paul McCormack, Wulf Clemens, Bodo Groß and Elizabeth Johnson at the PEC Installation

Analysis of operations have shown that a modestly sized 30kW electrolysis system powered by biogas from anaerobic digestion via an integrated CHP has the potential to produce up to 12kg of Hydrogen per day. At the lower heating value (LHV) the hydrogen produced contains around 33.3kWh/kg, and at the Higher Heating Value (HHV) hydrogen contains around 39kWh/kg. Therefore, in simple terms the electrolysis has the potential when operated at 100% annual capacity to capture the equivalent of circa 146MWh equivalent LHV and 171MWh equivalent HHV as hydrogen gas.

The GenComm team and Associate Partners at a project meeting in Stornoway on the island of Lewis and Harris

*As a road fuel equivalent, the total displaced diesel potential equates to approximately 13,611 Litres which is on average the equivalent of driving almost 129,000 miles in a typical UK Diesel car on 100% mineral diesel. In environmental terms, when working at maximum capacity, this has the potential to save 35.7T CO2e/annually[1].*

Moreover, it is suggested in literature that an average pine tree in the course of its life, might absorb roughly 10 kilograms of CO2 per year when planted in appropriate ground so as not to dry out peat moor. Assuming a standard density of tree planting might be considered around 1000 trees per hectare, it could therefore be said that a hectare could absorb around 10 tons of CO2 per year.

**Therefore, in unit measurement of equivalent trees the potential maximum saving in diesel burn would be the equivalent of planting 3570 'average' pine trees, or in land mass the same as 3.57 hectares of tree plantation of your average pine tree.**

Ross Gazey
Pure Energy Centre

[1] kgCO2e/kWh figures based on UK Government GHG Conversion Factors

WANTED

# Industrial Partner required for H2020 Green Deal call

**The GenComm team are currently developing a tool to optimise Green Hydrogen from Renewables and are seeking an industrial partner for the upcoming H2020 Green Deal Call, which closes on 26th January 2021**

*The Hydrogen Optimisation Support Tool (HOST)* will optimise hydrogen production, storage and use, and maximise green energy outputs. This will be a techno economic tool that will enable users to validate P2X H2 technologies that can be deployed in individual scenarios and to develop long-term strategies for the advancement in adoption of hydrogen technologies. This tool will also enable the mapping of Energy Navigation Routes for the transition of the EU energy system from fossil fuel dependence to green destination.

*'Hydrogen is the catalyst driving Europe's energy transition. Optimising this journey by fortifying the hydrogen supply chain, production, storage and the new developing markets is key to creating a successful Hydrogen Europe.'*

HOST
Hydrogen Optimisation Support Tool

**Creating the *Hydrogen Optimisation Support Tool* (HOST)**

1. **Optimising** hydrogen production, storage and use.
2. **Actualising** the CH2F to maximise the green energy outputs
3. **Evaluation** parameters of performance and benefits realisation
4. **Validating P2X** H2 technologies to be deployed in emerging scenarios
5. **Developing** long term strategies for the advancement in adoption of hydrogen technologies
6. **Mapping** Energy Navigation Routes for the transition of the EU energy system to the green destination
7. **Marketing** – identifying key user inputs to ensure an accurate user decision making process

*Our proposal – 'We are looking for an industrial/commercial partner/consortium who would have the capacity and foresight to take advantage of the opportunities identified within the HOST development tool'.*

**We will also 'Book End' the project by providing critical front & back end support**

**Front End**
- Exploring Stakeholders' perceptions
- Identifying key factors for public/user acceptance
- Establishing public participation strategies
- Moderation of decision-making processes

**Back End**
- Optimising Value P2€
- Delivering Long Term Effects
- Supporting data informed decision
- Creating optimal supply chain opportunities

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Hydrogen enAbled Zero Emission suppLy chains

# HAZEL webinars

**Tuesday 17th November was the last of the Autumn series of the HAZEL webinars.**

This Autumn series of five hydrogen based webinars were all centred on the innovative work Belfast Met and their partners are delivering in the HAZEL portfolio of projects, addressing the 4 core pillars of hydrogen production, sustainability, application & use , safety innovation and entrepreneurship.

Informed by industry with speakers from leading industrial champions including BOSCH, Dillinger Huttenwerke AG and Energia, complemented with 10 academic and public sector speakers the webinars provided a rich insight into the current and potential applications for hydrogen. Each webinar was developed on a public, theory and application theme and outlined specific opportunities, strategies and case studies from Europe highlighting that Green Hydrogen is technically doable, economically viable and socially advantageous.

The webinars were timed to coincide with the EU Green Deal project call and were designed to inform, assist, direct and act as a call to other potential partners in building collaborative bids for H2020 funding. The webinars represent the vision of the Belfast Met GenComm team and are a bold statement of intent stressing the importance of hydrogen as an energy solution in reducing the carbon footprint of industry, transport and heat networks across Europe. The work within GenComm and HAZEL is closely aligned with the aims and objectives of the EU, its Green Deal, driving growth and recovery post COVID. To decarbonise Europe, clean renewable power production must become the main source of energy. Building on the empirical the HAZEL project seeks to develop the full spectrum of applications in the Power to X technology solutions for green hydrogen. An estimated increase in offshore wind capacity in Europe from 22 GW today to 240 440 GW by 2050 presents a huge opportunity for a new European Fossil Free Energy Equation.

**Hydrogen will play a central role in the global energy decarbonisation transition journey and has the potential to stimulate energy transformation across the entire energy supply chain.**

**DOWNLOAD ALL HAZEL WEBINARS**

Click here to view all presentations and recordings on the GenComm website.

Paul McCormack
GenComm

**WEBINAR ONE – Tuesday 22 September**
**Industrial Sector-Coupling using a Connected eH2-Cycle**
BOSCH. IZES and DCU – Federal State Ministry of Economic Affairs, Employment, Energy and Transport, Saarland, Germany

**WEBINAR TWO – Tuesday 6 October**
**H2 Sustainability H2-DxNET – Hydrogen injection into natural gas distribution networks**
Gas Networks Ireland, USAA, Dillinger Huttenwerke AG and TU Graz

**WEBINAR THREE – Tuesday 20 October**
**H2 Safety –Practical and theoretical analysis of H2 & development of H2 sensors**
Mecadi, European H2 Association, CNI-ITM and University South Wales

**WEBINAR FOUR – Tuesday 3 November**
**H2 Application & usage - Hydrogen in a net zero energy system & H2 powered hybrid heat pumps.**
Energia, Ulster University, Energy Systems Catapult, and AVL List GmbH

**WEBINAR FIVE – Tuesday 17 November**
**Marketable hydrogen innovations - entrepreneurship of innovation of Energy Carriers through academia & industry alliances**
Interreg NWE, IECE Macedonia, Belfast Met, Pure Energy Centre and Kemijski institute Slovenia

# Hydrogen in a net zero energy system

**Hydrogen is expected to play a significant role in our future net zero energy system. This means creating an entire new energy sector within 30 years, delivering energy volumes which in the UK could reach up to 300TWh by 2050, equivalent to that of our power sector today[1]. Creation of a UK hydrogen economy also has the potential to manage energy import dependency and presents opportunities for exporting any surplus green hydrogen[2].**

There are multiple possible end-uses for hydrogen across industry, transport (including heavy duty land vehicles, rail, shipping and aviation) electricity generation and heating. Hydrogen could provide a valuable resource for managing peak electricity demand in an energy system with significant amounts of installed renewable generation capacity. Biomass gasification with carbon capture and storage (CCS) which can deliver negative emissions, and steam methane reforming with CCS (at 99% capture rate) offer potentially valuable sources of hydrogen production. Innovation will be critical to achieve the high carbon capture rates needed from blue hydrogen production by steam methane reforming. Demonstrating green hydrogen production from electrolysis at industrial scale in the 2020s is a priority given implementation risks with steam methane reforming and carbon capture and the importance of reducing costs and improving performance. Early demonstration of 100% hydrogen networks and boilers is needed to prove the safety case and maintain this as an option for decarbonising heat alongside large-scale deployment of district heating, electric and hybrid heat pumps which could provide a valuable option for using both zero carbon electricity and gas[3].

**Richard Halsey**
Director Energy Systems Catapult

[1] https://es.catapult.org.uk/wp-content/uploads/2020/03/ESC_Innovating_to_Net_Zero_report_FINAL.pdf
[2] https://ore.catapult.org.uk/?orecatapultreports=offshore-wind-and-hydrogen-solving-the-integration-challenge
[3] https://es.catapult.org.uk/reports/decarbonising-heat-understanding-how-to-increase-the-appeal-and-performance-of-heat-pumps/

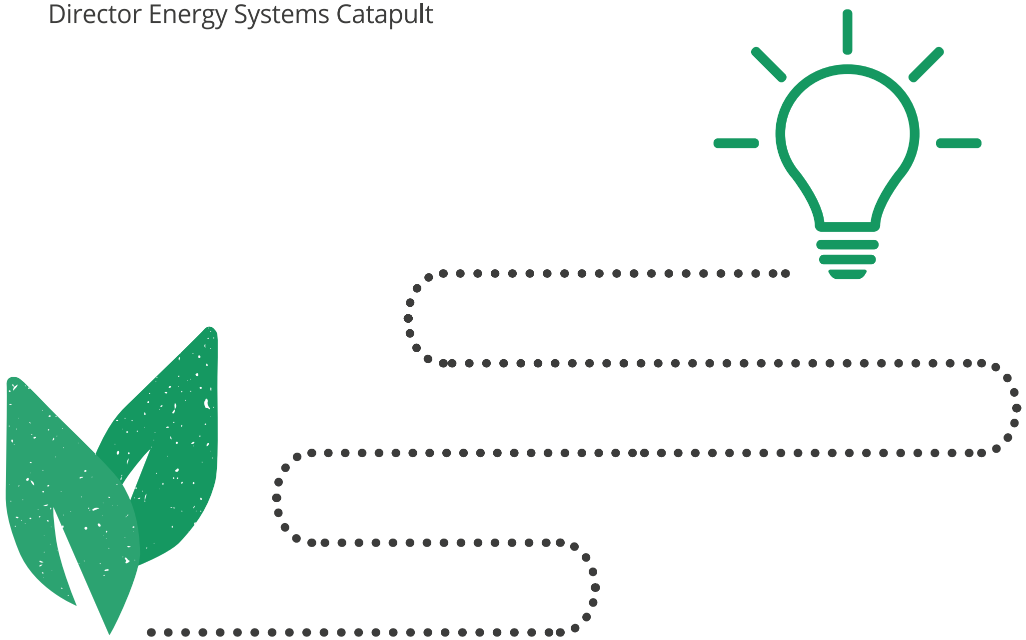
There is a clear need to improve the planning and design of smarter local energy systems to build better evidence on local options and choices for decarbonised heat, power and transport and help inform national decisions[4]. This can ultimately mobilise public and private investment and enable local delivery of the right low carbon heating, energy generation and storage technologies and infrastructure, in the right place at the right time[5]. We must engage communities and citizens in the race to net zero and understand how new low carbon products and services including use of hydrogen can deliver people and businesses the comfort and mobility they need and value.

*The UK can play a leading role in the development of hydrogen technologies given the significant renewable energy potential for green and domestic gas reserves for blue hydrogen production alongside the UKs strong supply chain capability. To realise this potential, we must increase investment in R&D and industrial scale demonstration programmes or risk being overtaken with major technology development and demonstration happening elsewhere.*

**The sector requires a clear hydrogen strategy and a focal point to drive innovation and enable effective coordination across sectors as part of the whole energy system from production to storage and distribution and ultimately end use of low, zero and negative emission hydrogen.**

CATAPULT Energy Systems

**Richard Halsey**
Director Energy Systems Catapult



[4] https://es.catapult.org.uk/impact/projects/milford-haven-energy-kingdom/
[5] https://es.catapult.org.uk/wp-content/uploads/2018/12/Local-Area-Energy-Planning-Supporting-clean-growth-and-low-carbon-transition.pdf

# Hybrid Heat Pumps development

**Decarbonisation of space heating is a significant challenge. The UK Clean Growth Strategy (2018) stated that heating in buildings and industry represented 32% of total UK emissions.**

The Committee on Climate Change (UK Housing: Fit for the Future, 2019) noted that decarbonisation of our existing and proposed new housing stock would require a decarbonised heating supply. Again, referring to the UK Clean Growth Strategy, such decarbonisation was seen to emerge from (a combination of) an electrification pathway, a hydrogen pathway and an emissions removal pathway requiring carbon capture, use and storage. The electrification pathway for space heating already exists in the form of heat pumps, typically air source for retrofit and ground source for new build. Queries have been raised over their use and the subsequent challenge to the existing electricity distribution network capacity. However, such challenges could be alleviated by hybrid system use (or the use of low temperature district heating – a separate discussion).

Considering Northern Ireland as an example and its continued deployment of a natural gas distribution network with potentially a 40-year payback, it may be prudent to ask what such a network may carry in a 2050 (or sooner) decarbonised space heating scenario. A brief analysis of the natural resources of Northern Ireland reveals that about 20% of our current gas usage could be obtained through the injection of biomethane derived from local anaerobic digestion from animal and other biowastes and existing fuel crops. Given our gas usage could virtually double as the intention is to grow the gas network of Northern Ireland to reach over 500,000 homes by 2022, the bio-derived gas would appear to be insufficient. New bio-resources can be added of course but Brexit has added a dimension of food security in the "food versus fuel" debate. Ulster University's experimental development of hybrid heat pumps (an air source heat pump combined with a natural gas boiler) trialled in its Terrace Street facility of family occupied homes revealed that recent winter operations would require about 36% of the space heating load to be delivered by natural gas when operating with a hybrid heat pump.


**Professor Neil Hewitt**
Ulster University

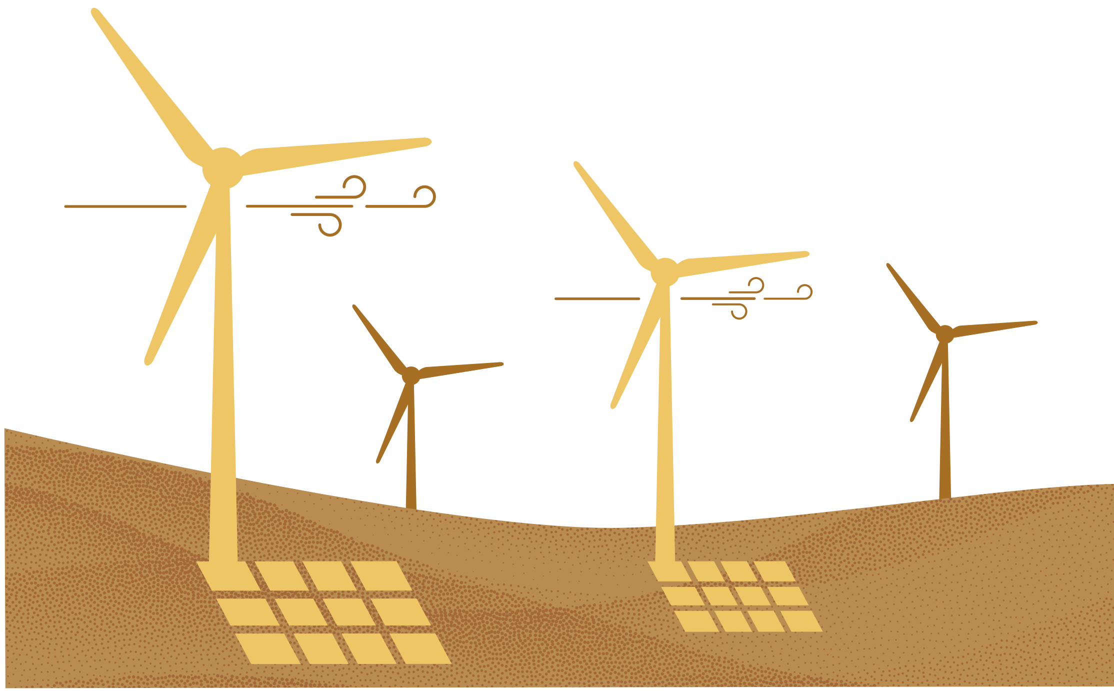
Therefore, given the growth in natural gas usage coupled with (potentially) improved building thermal performance, there is still a need for additional space heating gas to be stored (potentially in the existing network) for use in winter months. The role of biogas has been discussed and the addition of up to 20% by volume of hydrogen (6% energy at current gas distribution network pressures) therefore could have a vital role in ensuring our successful space heating during the winter months. Such hydrogen could be green hydrogen (derived through electrolysation of water with excess renewable energy) that is primarily developed and used for higher value commercial vehicle operations. Seasonal excesses would be then delivered and stored for winter use, provided energy tariffs were appropriate. Greater volumes of hydrogen require equipment changes to boilers and to reduce the flexibility of the system to address both needs of hydrogen and the use of farm and other biowastes that whose use will ultimately improve our overall environment.

**Finally, Imperial College in their report to the Committee on Climate Change on the "Analysis of Alternative UK Heat Decarbonisation Pathways" (2018) noted the hybrid pathway to net zero emissions was the least expensive and perhaps the above decarbonisation vision will lead Northern Ireland to net zero in a financially sustainable manner.**

Ulster University

Professor Neil Hewitt
Ulster University

*"A brief analysis of the natural resources of Northern Ireland reveals that about 20% of our current gas usage could be obtained through the injection of biomethane derived from local anaerobic digestion from animal and other biowastes and existing fuel crops."*



# GenComm welcome hydrogen bus trials

**GenComm, the Belfast Metropolitan College led European hydrogen project has welcomed the Hydrogen Fuel Cell Electric vehicle bus trials that commenced on November 10 in Dublin.**

The bus will be operated on different routes by CIÉ Group bus companies Bus Éireann and Dublin Bus as well as by Dublin City University (DCU) and Dublin Airport over a number of weeks in November and December, albeit carrying limited passengers due to the current Covid restrictions.

The zero emissions Caetano 'H2.CityGold' pre-production bus will run on green hydrogen (H2) produced in Dublin by BOC Gases Ireland Ltd using renewable electricity and water. The fuel cell electric bus is refuelled in minutes, similar to a conventional bus and its electric motive power is obtained when the Hydrogen molecules from its fuel are combined with Oxygen molecules from the air in the Fuel Cell.

At the launch of the Hydrogen Fuel Cell Bus on the road, Hydrogen Mobility Ireland Chairman Mark Teevan (Toyota Ireland) said *"This should be viewed as an important event, not because it's the first H2 bus on the road; but because it is a first step into the future for Ireland, enabling us to begin to envisage the practical solutions that will allow us to fully decarbonise road transport. We are all very conscious of the Environmental challenge we face in meeting our 2030 targets and the need to find zero-emissions solutions that will satisfy the varying needs of different users; public transport, haulage, van delivery, taxi or private car. FCEV's are Electric Vehicles, providing specific benefits that include very quick refuelling, long range, and a particular suitability for heavy and long-distance requirements. We are delighted that Dublin has been selected to host the very first trial of the Caetano RHD prototype fuel cell bus*".

CaetanoBus, part of the Salvador Caetano Group and Mitsui & Co, is the most important manufacturer of buses and coaches in Portugal. In 2019, the Company presented its latest development, the H2.City Gold – the new hydrogen-powered Caetano electric bus. In the beginning of this year Caetano started its commercialisation phase and, in the 2nd, quarter-initiated fuel cell bus production plans.

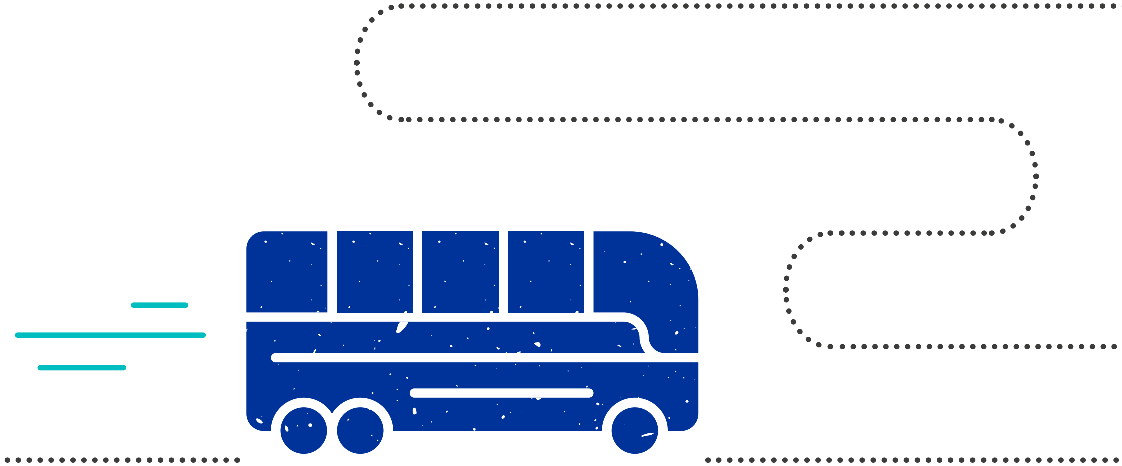
The trial will allow the partners to test this technology in everyday driving conditions and at a challenging time of the year in terms of weather, thereby gaining valuable information about the potential for large scale introduction of this technology in Ireland. DCU/CIE also intend to obtain insights and feedback from passengers on the bus. This news will be followed early next year by a National Transport Authority trial involving a number of Double Decker FCEV buses while in Northern Ireland HMI Member and GenComm partner Energia will shortly commence the production of H2 for road transport at a windfarm in Co. Antrim which will be used as fuel for FCEV buses in Belfast. The increasing rate of developments is a visible confirmation that hydrogen for road transport is beginning to move into the delivery phase.

GenComm Programme Manager, Paul McCormack, said: *"We are delighted that the bus is on trial and that the it will be on the Bus Eireann route for a number of weeks. The fact that it will also be on routes for Dublin bus, DCU and Dublin Airport shows the amount of interest and buy in to seek alternatives to fossil fuels for public transport. Ireland's first hydrogen fuel cell bus trial is a major innovative step which will contribute to both the country's climate challenge and public transport".*


**Dr James Carton**
Assistant Professor in Energy Sustainability and Hydrogen , DCU, with the hydrogen bus.

Stephen Kent, Chief Executive Officer, Bus Eireann said: *"Bus Éireann is committed to supporting the delivery of the National Climate Action Plan, with a focus on reducing vehicle emissions. We are targeting for half of our vehicles to be zero emission by 2030 with the remainder being low or ultra-low emission. The additional range offered by hydrogen fuel cell vehicles make them especially relevant and interesting to Bus Éireann, given our mix of longer commuter, stage carriage and intercity services.*

*"We are delighted to be part of the HMI trial, and look forward to the experience of operating this bus over four weeks on a route from Dublin to Ashbourne. The research and experience from this trial is an important prelude to a more extensive pilot deployment that Bus Eireann will be leading on with the National Transport Authority in early 2021. When Covid restrictions ease, we will be very excited to welcome Bus Éireann passengers to be among the first in Ireland to travel by hydrogen".*



# Cummins Continues to Make Hydrogen-Based Energy Storage a Reality Worldwide

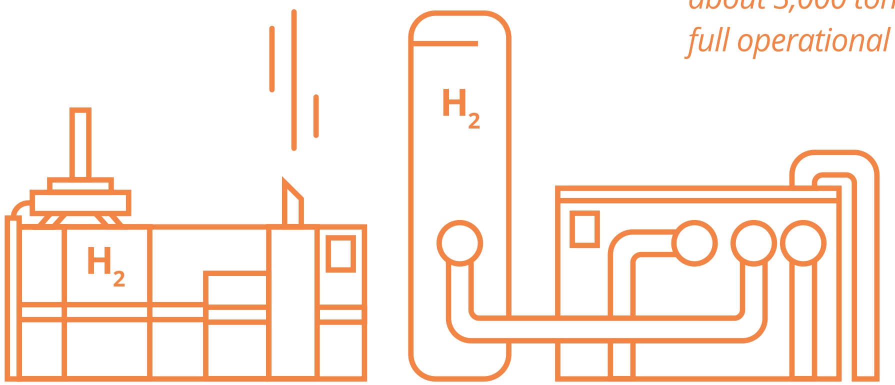
**Wind and solar technologies are key renewable energy sources to help decarbonize the energy market. However, integrating these intermittent energy sources into the power grid is highly challenging due to the increasing need for grid flexibility and energy storage solutions.**

Hydrogen as a power storage medium is well positioned to address these grid challenges and enable wind power to be more easily utilized outside the electric grid like fuel for fuel cell vehicles, storage, or even to supplement natural gas for heating.

In September 2019, Cummins Inc. acquired Hydrogenics, one of the world's premier fuel cell and hydrogen production technologies providers, strengthening Cummins' fuel cell capabilities with their expertise and innovative approach.

Just as Cummins recognized it could transform diesel into a reliable, everyday power source 100 years ago, the company recognizes the potential that hydrogen has to play in a decarbonizing world. Cummins' ability to further innovate and scale hydrogen technologies across a range of markets combined with Hydrogenics' more than 70 years of experience in providing hydrogen-based products will help usher in more opportunities for renewable energy storage, and fuel for fuel cell applications.

*Cummins has developed and installed more than 1500 hydrogen generation systems globally since 1948, including the first-to-market scalable proton exchange membrane (PEM) electrolysis electrolyzer. In 2019 Cummins received a major order from Air Liquide to design, build and install a 20-megawatt PEM electrolyzer system for hydrogen production located in Becancour, Quebec, Canada. Considered the world's largest electrolyzer, the PEM elecrolyzer will produce about 3,000 tons of hydrogen annually, becoming full operational at the beginning of 2021.*



So how do these electrolyzers integrate into the current green economy? Power-to-Gas is a highly effective way of integrating these renewables. It can provide a rapid, dynamic response to the Grid Operator's signal to adjust to the variations in renewable generation output. The siting of a Power-to-Gas facility can be deployed wherever the power and gas grids intersect.

To date, Cummins has participated with four power-to-gas projects throughout Europe including the world's first demonstration project that injected hydrogen into a natural gas grid in Falkenhagen, Germany using renewable wind energy to power the system in 2013. In November, Cummins announced that their Enbridge power-to-gas facility, located in Canada, received approval to inject hydrogen, making it the first demonstration project of its kind in North America.

It is this diversity and range that differentiates Cummins. As one of the only hydrogen companies that specializes in both sides of the hydrogen equation, Cummins offers generation systems which produce hydrogen as well as fuel cells that convert the hydrogen back to electricity for a variety of applications.

Angus Brown
Marketing Manager, Cummins Inc


HyLYZER® 230-30 – dual stack in Hobro, Denmark

# Low-Temperature Fuel Cell research

**AVL is the world's largest independent company for the development, simulation and testing of powertrain systems (hybrid, combustion engine, transmission, electric drive, batteries, fuel cell and control technology) for passenger cars, commercial vehicles, construction, large engines and their integration into the vehicle.**

The company has decades of experience in the development and optimization of powertrain systems for all industries. As a global technology leader, AVL provides complete and integrated development environments, measurement and test systems as well as state-of-the-art simulation methods.

For nearly two decades AVL has been working on the development of fuel cell technology and has been concerned with fuel cell system development and engineering, fuel cell test systems, and fuel cell simulation.

AVL is developing fuel cell powertrain systems, portable and stationary power generators based on two types of fuel cell technologies, Low-temperature Polymer Electrolyte Membrane Fuel Cells (PEMFC) and Solid Oxide Fuel Cells (SOFC). AVL is also exploring other applications and is, among others, extending its research efforts to developing stationary SOFC Combined Heat and Power (CHP) generators that can be used to provide continuous power on-site and on-demand. This means power for homes, factories, data centres and other high-demand buildings.

**The benefits of PEMFC make it the ideal power source for electrified propulsion systems. Long driving ranges and short refuelling times make it a convenient technology. Some of the biggest obstacles faced by PEMFC are being tackled with a simulation-based development approach. For light-duty vehicle applications of PEMFC one such challenge is to maximize performance and the life expectancy of the fuel cell.**

**Dr. Reinhard Tatschl**
AVL

To deal with these kinds of tasks AVL has developed the AVL FIRE™ M modelling tool. AVL FIRE™ M offers dedicated multi-physics simulation capabilities that consider the relevant physical and electrochemical processes of PEMFC operation. From analyzing PEMFC-related multiphase flow, thermal and electrochemical processes, including degradation on both cell and stack level, AVL FIRE™ M is a proven and versatile tool. It delivers the ability to optimize flow field design to avoid local fuel starvation and liquid water accumulation, which can be damaging to the cell, and allows the modelling of cell degradation to therefore maximise the fuel cell's lifespan.

**In addition to AVL FIRE™ M another valuable tool that is helping to realize the establishment of fuel cell technology is AVL CRUISE™ M. This simulation tool offers dedicated multi-physics modelling capabilities that can support the optimization of entire fuel cell systems and their different parts, such as balance of plant (BoP) and coolant circuit components. Transient load pick-up response, system efficiency under real operating conditions and start-up and shut-down behaviors can all be modelled in AVL CRUISE™ M to set and meet development targets.**

Having access to simulation tools such as these enables virtual testing to begin early on in the development process, before the first hardware has even been built. And as components become available, a combination of virtual testing in the office and hardware testing on the testbed can be applied in an approach that is flexible, cost effective, and saves valuable time in the race to market.

AVL

**Dr. Reinhard Tatschl**
AVL

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