Making an impact on the clean energy transition

TRANSPORT

FUEL-CELL BREAKTHROUGHS FOR HYDROGEN AVIATION

©HEAVEN, 2021

Innovations for low-carbon flight

Aviation needs to decarbonise as part of the EU vision for low- or zero-carbon transport by 2050. Aircraft fuelled by hydrogen, which would produce no in-flight CO_2 emissions, could help Europe to achieve this goal. However, first there is a need for high-energy fuel cells that meet the specifications of the aeronautic sector and for tanks that can store hydrogen efficiently as part of an aircraft fuel system.

A PEM-based aeronautic-grade fuel cell system is being developed in FLHYSAFE to replace current turbine-based back-up power systems for aircraft. Components are being optimised to reduce the weight of the system, to make it easy to install and maintain, and to give it a cost-effective lifetime. Meanwhile, HEAVEN is developing liquid hydrogen tanks that can produce almost double the energy of existing compressed-hydrogen storage systems. This storage system, which is being fine-tuned for an existing small hydrogen aircraft, will be joined by a 90-kW high-power fuel cell currently under development in the project.

Adaptable comfort and power

Building on the achievements of the FCH JU project HYCARUS, the modular FLHYSAFE fuel cell is intended to reduce costs and to be sufficiently flexible to be included in existing and innovative future aircraft designs. It could also provide a quiet, low-emission alternative to aircraft power unit (APU) systems that currently run in-flight services from aircraft engines. The HEAVEN system brings zero-carbon flight even closer. The high-energy fuel system is being designed for the experimental HY4 2-4-seat aeroplane but could contribute to future regional, small and medium hydrogen aircraft as the technology progresses.

Low-emission flight is taking off thanks to two FCH JU projects. A commercially viable fuel cell for zero-carbon emergency and in-flight power is being developed in FLHYSAFE, while HEAVEN is designing compressed-fuel tanks and a high-power fuel cell for fully hydrogen planes.

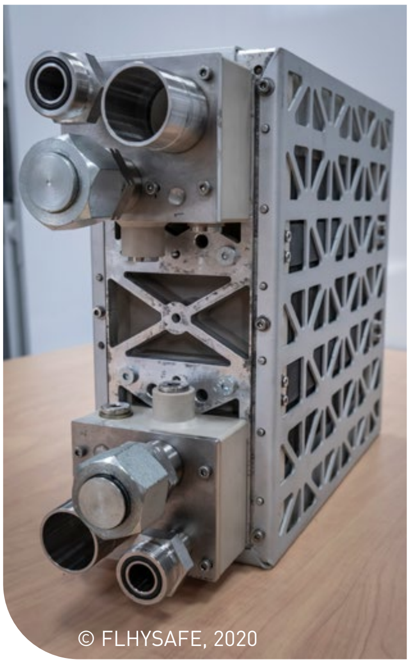
© FLHYSAFE, 2020

PIECES FOR THE AIR-TRAVEL PUZZLE

Critical aircraft components are still needed for hydrogen flight to take off as a greener form of air travel.

CLEAN-ENERGY COMMERCIAL AIRCRAFT

Projects are developing hydrogen fuel cells, storage tanks and power systems for hydrogen passenger aircraft. **The goal?** European aeronautics manufacturers, SMEs and researchers are joining forces under the FCH JU umbrella to design and demonstrate solutions for piloted hydrogen flight. **Key results?** Promising steps towards commercially viable emergency hydrogen-power generation and more electrical aircraft, and towards the first demonstrations of a liquid hydrogen storage and fuel cell propulsion system for passenger aircraft.



KEY ACHIEVEMENTS

FLHYSAFE

3 HOURS
target operating time

150 kg
APU weight

60 dBA
APU noise

HEAVEN

5 000 HOURS
stack lifetime

90 kW
system power

15 %
storage-system gravimetric density

2.7 kW/kg
stack power density

IMPACT

FLHYSAFE

HYDROGEN EMERGENCY POWER UNIT
foreseeable for commercial aircrafts

SAFE, RELIABLE
system for existing and future aircraft designs

LOWER CO_2 EMISSIONS
from in-flight services

MEETING COMMERCIAL DEMAND
for a greater share of electric power generation in aircraft

HEAVEN

AERONAUTIC-GRADE LIQUID-HYDROGEN TANK
close to trials in a piloted aircraft

FIRST TIME
a fuel cell and a liquid hydrogen tank combined in a piloted platform

PAVES THE WAY
for low-temperature, high-density hydrogen storage for passenger flights

EUROPEAN LEADERSHIP
in emerging technology to reduce climate impacts of flying

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
https://www.flhysafe.eu/
https://heaven-fch-project.eu/

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

A partnership dedicated to clean energy and transport in Europe

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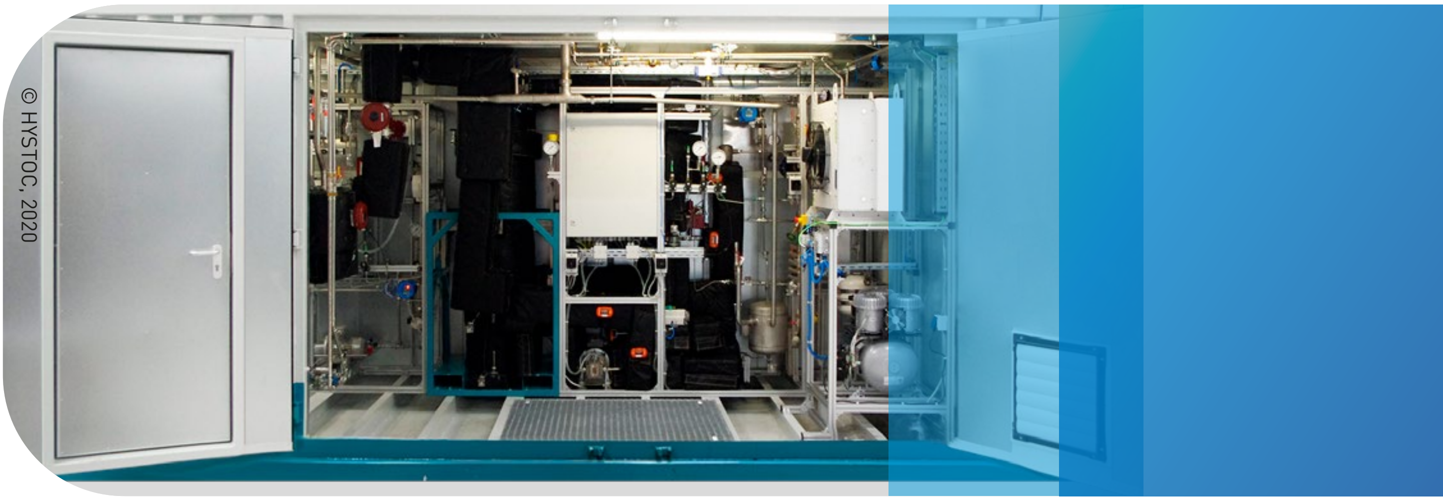
Making an impact on the clean energy transition

TRANSPORT

SCALING UP LIQUID HYDROGEN ORGANIC CARRIERS FOR DECARBONISATION



Simpler transport

Hydrogen is a volatile and low-density gas. When not generated on-site, producers must transport it to customers in high-pressure equipment – an inefficient and expensive task. Liquid hydrogen organic carriers (LHOC), which trap hydrogen in a liquid chemical, could allow the use of standard oil tankers and infrastructure to deliver the gas.

An experimental system to store and release hydrogen from LHOC is being scaled up in HySTOC, with FCH JU support. The system, which uses a purification unit developed by HyGEAR in the project, stores hydrogen from a 300-bar pipeline in dibenzyltoluene and releases it in a hydrogen refuelling station at 30 bars. With a 'StorageBox' installed at a hydrogen-generation plant in Woikoski and a 'ReleaseBox' at the VTT research centre, both in Finland, the system has successfully produced its first kilogrammes of hydrogen-saturated carrier. HYSTOC is now ready to test hydrogen transport and release.

Cost and energy savings

Dibenzyltoluene is not classified as a dangerous compound, is barely flammable and can store up to five times as much hydrogen as standard high-pressure technology. Its use could cut hydrogen transport costs by up to 80 %. A life-cycle assessment and economic comparison with other carriers have shown promising results. To make further savings, HySTOC is investigating the viability of other carriers from the same chemical family that are less energy-intensive, while another FCH JU project, SHERLOHCK, is looking into catalysts that could speed up hydrogen release.

The use of hydrogen as an energy vector must become widespread if Europe is to meet its climate targets. The FCH JU project HySTOC is scaling up a system to transport hydrogen in liquid chemicals as a safe and cost-effective way for producers to supply demand.

SCALING UP LIQUID HYDROGEN ORGANIC CARRIERS FOR DECARBONISATION

DISTRIBUTION SOLUTION

With the right technology, LHOC could be a safe, cost-effective way for hydrogen distribution to decarbonise major industries.

SIMPLER DECARBONISATION

SME, industry and scientific partners from three European countries are developing a LHOC-based system to distribute hydrogen cost-effectively, easily and safely. **The goal?** Manufacturing, materials production, maritime transport and many other sectors could all decarbonise more easily with better access to hydrogen. **Key results?** Proof of a commercial-scale blending and release system as a step towards a viable hydrogen refuelling network.

KEY ACHIEVEMENTS

5 TIMES HIGHER TRANSPORT CAPACITY
compared to 200-bar tube trailers

3 TIMES HIGHER TRANSPORT CAPACITY
compared to 500-bar tube trailers

EUR 85/kg
cost of project system – over four times lower than the target cost

80 %
reduction in operating costs

1 300 kg
capacity of the hydrogen transport trailer

99.95 %
hydrogen purity

6.23 %
gravimetric capacity

750 TIMES
carrier cycling capacity

IMPACT

DATA AVAILABLE FOR BUSINESSES AND POLICY
from a preliminary life-cycle assessment

LOWER TRANSPORT COSTS AND IMPACT
thanks to higher capacity

LOWER INVESTMENT COSTS
from option to use standard oil-tank infrastructure

EASIER TRANSPORT
as handling of hydrogen possible under ambient conditions

GREATLY REDUCED RISK
since hydrogen is bound to a carrier rather than free gas

HIGHLY USEFUL HYDROGEN
thanks to high purity of the released gas

INCREASED ACCESS TO RENEWABLE ENERGY
stored in the hydrogen carrier

DECARBONISATION GAME CHANGER
for industry and transport

CAN ENHANCE PUBLIC ACCEPTANCE
of hydrogen mobility

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
https://www.hystoc.eu/

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

A partnership dedicated to clean energy and transport in Europe

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FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Making an impact on the clean energy transition

TRANSPORT

DRIVING FORWARD A HYDROGEN REFUELLING NETWORK

© H2ME, 2021

Accessible H_2 mobility

If hydrogen vehicles are to prove a viable alternative to petrol and diesel cars and trucks, drivers must be able to refuel at convenient locations at a reasonable price when travelling. A growing network of hydrogen refuelling stations (HRS) and effective expansion strategies can drive down operational costs and support streamlined licensing by public authorities, making hydrogen more accessible for drivers.

The H2ME project (June 2015 to November 2020) and expansion project H2ME 2 (May 2016 to June 2022) have built new HRS to test different network-growth strategies in Germany, France, Denmark and the United Kingdom. Fleets of fuel cell cars, vans and trucks have also been deployed across Europe to assess real-world use. The projects have found that the skeleton network in Germany of over 90 HRS – from FCH JU and other funding – enables fuel cell vehicles to travel across the country, while in France, HRS roll-out coordinated with fleet availability has encouraged drivers to adopt hydrogen mobility.

Roll-out groundwork

H2ME 2 partners are also looking at the impact of connecting the refuelling stations to the live online European HRS Availability System (https://h2-map.eu/), which includes 149 stations to date. This encourages organisations to develop HRS location apps, such as H2.live and FillnDrive, helping consumers to find their nearest available station and, in turn, making fuel cell vehicles more attractive. HRS are already present in 14 countries in Europe. Project results strengthen the business case to expand the network and inform licensing and supportive public policies so that refuelling coverage can grow with demand.

With around 150 sites in operation, Europe has the largest network of public hydrogen refuelling stations in the world. Almost half of them have resulted from FCH JU projects, such as H2ME and H2ME 2. These two projects alone have financed and analysed 37 new refuelling stations to accelerate the uptake of hydrogen vehicles.

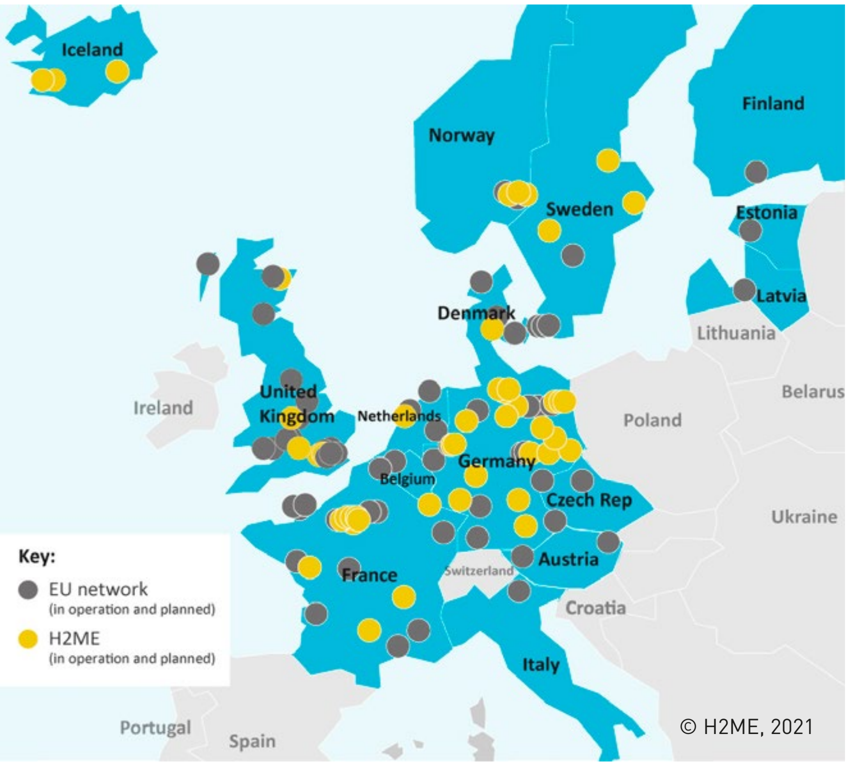
©H2ME, 2020

INFRASTRUCTURE THAT SUPPORTS DEMAND

To adopt hydrogen vehicles, drivers must be confident that refuelling stations will be available on their journey.

TRIED-AND-TESTED EXPANSION

FCH JU projects have rolled out fuel cell vehicles and hydrogen refuelling stations across Europe, analysing consumer, commercial and policy lessons for a shift to hydrogen mobility. **The goal?** Almost 50 SMEs, research organisations, manufacturers and public authorities have contributed to expanding the viability of private and business hydrogen transport. **Key results?** A significant increase in hydrogen refuelling stations, fuel cell vehicles on the roads and better understanding of strategies supporting full commercial roll-out of hydrogen vehicles.



KEY ACHIEVEMENTS

H2ME

27 HRS
deployed across Europe

99.99 % HYDROGEN PURITY
in participating stations

300 FUEL CELL ELECTRIC VEHICLES
in operation

14.5 MILLION km
driven by project vehicles

H2ME 2

9 HRS DEPLOYED
out of a possible 20

95 % AVAILABILITY
of the deployed HRS

1 000 FUEL CELL ELECTRIC VEHICLES
planned – 313 deployed

IMPACT

Contributes to the 149 HRS
connected to the European HRS Availability System

Increases potential network coverage
in and beyond existing countries

SUPPLIES GROWING DEMAND
106 tonnes of hydrogen were delivered from H2ME 2 stations in 2019-2020

BOOSTS FUEL CELL VEHICLE USE
shown by the almost 56 000 refuelling operations within the projects in 2019-2020

STRENGTHENS THE BUSINESS CASE
for hydrogen refuelling infrastructure

SUPPORTS A SWITCH TO HYDROGEN MOBILITY
to consumers, businesses and public services

CREATES A LEVEL PLAYING FIELD
with other low-carbon vehicle industries

REDUCES TRANSPORT EMISSIONS
even more so when using green hydrogen

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
https://h2me.eu
https://h2-map.eu
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Making an impact on the clean energy transition

SHIFTING GEARS TO H2-POWERED PUBLIC TRANSPORT

TRANSPORT

© JIVE, 2021

Making the change

Hydrogen produced from 'green' sources can play a vital role in zero-emission mobility and achieving Europe's aim of being carbon neutral by 2050. Fuel cell buses (FCB) provide a quieter and smoother ride than their diesel counterparts and produce only heat and water as by-products. Significant progress on the additional costs to operators of buying and running FCB and hydrogen refuelling stations has been achieved, which remain the main barriers to the introduction of this new technology.
National and EU emission reduction targets require operators and public authorities to change to clean transport. FCH JU demonstration projects are increasing the visibility of FCB and promoting the shift from grant funding to self-sustaining commercial finance arrangements.

Paving the way

By bringing together transport operators, public authorities and FCB suppliers, FCH JU co-funded projects are preparing the entire FCB value chain – from regulations and permits to supply of fuel, operation and maintenance of buses. At least nine demonstration projects, including CHIC, JIVE, JIVE 2 and MEHRLIN, have shown that buses and refuelling infrastructure can perform as well as diesel in various urban and climatic conditions. Suppliers involved in JIVE 2 have met the target cost of EUR 625 000 per standard 12 m bus. Data monitoring and assessment performed during JIVE and JIVE 2 will help inform the next steps, while international zero-emission bus conferences are raising awareness about decarbonising public transport.

Hydrogen-powered buses are contributing to cleaner air in cities, reducing emissions of greenhouse gases and other harmful pollutants and meeting growing demand for public transport. Several FCH JU-funded projects are helping the technology evolve from demonstration scale to full commercial use by proving its benefits to the public and authorities.

©JIVE 2, 2021

© JIVE, 2021

REDUCING COSTS, IMPROVING RELIABILITY

Deployment of fuel cell buses must happen on a larger scale to encourage competition among manufacturers and reduce the cost of FCB, refuelling stations and hydrogen fuel.

DRIVING LONG-TERM DEMAND

Public funding is helping to ensure that the cost of hydrogen and vehicles is low enough to stimulate demand. JIVE demonstrated that joint procurement processes – although not without problems – can help to achieve sufficient scale. Encouraging operators and public authorities to consider the total cost of ownership keeps the focus on the long-term benefits of clean transport. **The goal?** To increase demand for FCB and governments to regulate for zero-emission public transport to motivate more manufacturers to enter the market. **Key results?** Deployment has evolved from tens of buses in early demonstration projects, such as CHIC, High V.Lo-City, HyTransit and 3Emotion, to hundreds in ongoing projects like JIVE, JIVE2 and H2Bus Europe. With economies of scale, the cost of non-articulated single-deck fuel cell buses fell from over EUR 1 million in 2009 during CHIC, to below EUR 500 000 under the H2Bus Europe consortium, formed in 2019. CHIC showed that HFC buses can match the cost of diesel versions by 2030.

KEY ACHIEVEMENTS

471
buses in total since 2001

310
buses to be deployed by JIVE (142) and JIVE 2 (168) by 2023

65
buses delivered to Cologne, Wuppertal and Aberdeen (JIVE) and Pau (JIVE 2) are in service, the rest have been ordered

>98%
availability of the buses already operational

85 %
Well-to-Wheels emission reductions compared to diesel buses achieved by CHIC FCB

5
hydrogen refuelling stations are operational in 5 out of 17 participating cities in JIVE and JIVE 2 projects

25
Member States foresee the development of hydrogen-powered mobility

EUR 15.5 BILLION
EU investments are foreseen to build hydrogen infrastructure in transportation by 2030

IMPACT

10 YEARS OF OPERATIONS
planned by most projects, compared with 2-3 years in earlier demo projects

CAPEX TARGET
of <EUR 650 000 (JIVE) and <EUR 625 000 (JIVE 2) per non-articulated bus met by several suppliers

ORIGINAL EQUIPMENT MANUFACTURERS
in Europe are responding to growing demand, with 12 now offering fuel cell buses

TRAINING
drivers, technicians and first responders in the new technology (CHIC)

OPERATING RANGE
of over 350 km, similar to diesel buses, achieved by HFC buses in CHIC

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
https://www.fuelcellbuses.eu/
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Making an impact on the clean energy transition

TRANSPORT

THE SHAPE OF HYDROGEN FUEL TANKS TO COME

© TAHYA, 2018

Thinking inside the box

Hydrogen storage in vehicles has long been a challenge. The gas is typically kept in high-pressure cylinders that are heavy, bulky and expensive, complicating car designs and commercialisation. Other constraints relate to efficiency, safety and the reliance on costly carbon fibre to reinforce the tanks.

FCH JU projects are powering solutions. TAHYA, for example, developed a safe and efficient tank comprising carbon fibre and a plastic liner that is cheaper than conventional ones because it uses less material. The THOR project created a thermoplastic tank that uses less carbon fibre, is recyclable and therefore also more sustainable. SH2APED, meanwhile, has designed a conformable tank that is rectangular and fits into the flat space of car underbodies.

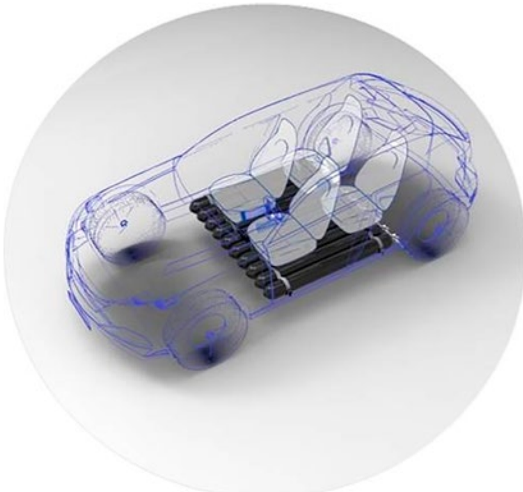
Brand and business boosters

With clean mobility gaining momentum, the projects have sparked interest – and helped partners win new contracts. This, in turn, has benefitted European excellence and manufacturing.

In May 2021, French automotive supplier Plastic Omnium, involved in TAHYA and SH2APED, announced a partnership with Hopium to develop a storage system for the Māchina, set to become the first French hydrogen-powered car. This followed a major order for 10 000 hydrogen bus tanks from a German manufacturer in late 2019.

French automotive technology company and THOR coordinator Faurecia saw success with a significant June 2020 deal to supply hydrogen-storage systems – including 10 000 tanks – for Hyundai trucks.

FCH JU projects are optimising hydrogen tanks for vehicles with a bold new approach to shapes, materials and manufacturing. Results have boosted business for industry partners and highlight how research and innovation are key to driving this critical fuel cell technology forward.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FROM INNOVATION TO OPTIMISATION

To facilitate the large-scale production and adoption of hydrogen-powered vehicles, European research and innovation are needed for tank designs, materials and manufacturing.

NEW SPIN ON STORAGE

Experts from across the European supply chain have collaborated to improve hydrogen fuel tanks, boldly rethinking designs, materials and production processes to better meet the needs of the automotive industry. **The goal?** To optimise hydrogen fuel tanks with alternative materials such as thermoplastics, improved manufacturing and space-saving shapes, while cutting costs and monitoring sustainability. **Key results?** Cost-effective storage systems that are efficient, durable, safe, easily integrated into cars – and recyclable.

KEY ACHIEVEMENTS

TAHYA

3 patents

Cost-competitive H_2 storage system (500€/kg H_2) with mass production capability

100 % recyclability

THOR

Development of an optimised design for the first 64-litre thermoplastic tank that includes a winding pattern and bosses.

First tank prototypes produced to be used for burst and rupture tests

SH2APED

Box-like tank that fits into a rectangular space

IMPACT

PROMOTION OF EUROPE AS A PREMIER HYDROGEN TANK PRODUCER

TAHYA

Updates expected to GRT13 and EC79 safety standards based on project test results

THOR

Unlocked potential of thermoplastics

SH2APED

Cost reductions expected for Type IV conformable hydrogen tanks

© CETIM, 2021

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
http://hycarus.eu
https://www.flhysafe.eu
https://heaven-fch-project.eu/index.php

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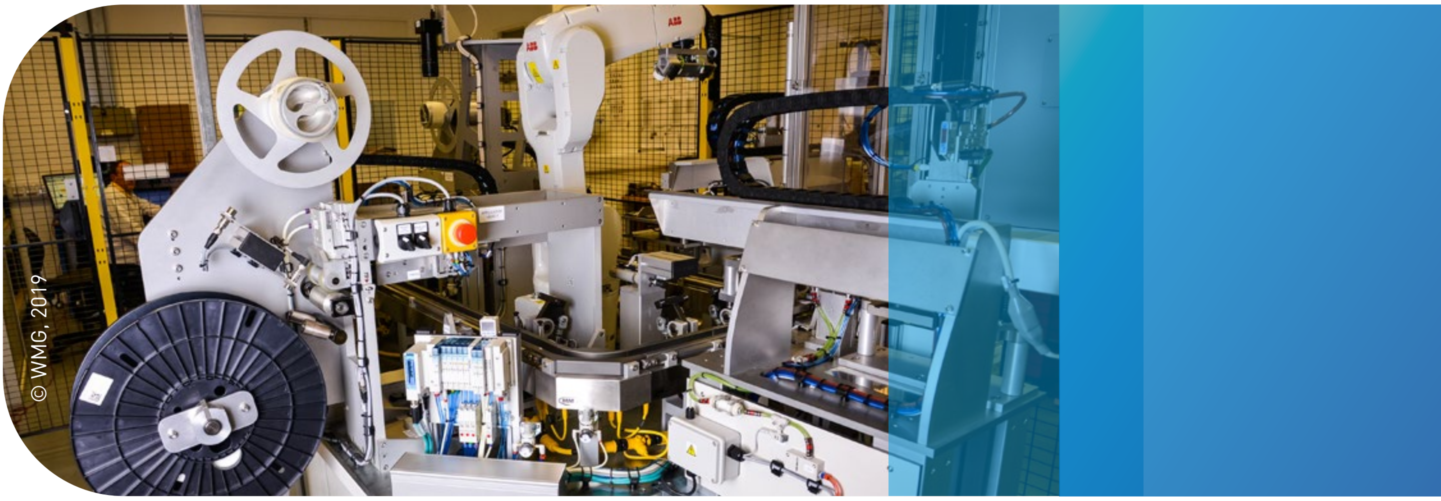
Making an impact on the clean energy transition

TRANSPORT

STACKING THE ODDS IN HYDROGEN'S FAVOUR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The incredible lightness of hydrogen

The transport sector accounts for almost a quarter of Europe's greenhouse gas emissions and causes most of the air pollution in cities. While hydrogen fuel cells can help achieve the EU's 2050 climate-neutral goal, they need to be produced in greater quantities, to strict quality standards, and at lower cost. To get there, the DIGIMAN and Fit-4-Amanda projects increased automation in the manufacturing process and simplified the design of fuel cell stack parts. DIGIMAN has taken a proton exchange membrane (PEM) fuel cell production line from semi- to full automation. The Fit-4-Amanda consortium built a scalable mass-manufacturing machine. Projects such as INLINE and INN-BALANCE assessed current manufacturing processes and redesigned several components to enable easier production.

One step closer to mass production

The FCH JU has invested EUR 31 million in eight complementary manufacturing projects that bring together research institutes, universities and vehicle makers to ensure that manufacturing improvements are commercialised. The blueprint for a fuel cell assembly production line developed by DIGIMAN allows production to be scaled up to 50 000 fuel cell stacks per year. The project raised the design's manufacturing readiness (MRL) to level 6, the pre-production stage. Meanwhile, the project consortium is continuing to disseminate the results of its work.

Vehicles powered by clean, efficient hydrogen fuel cells can make a vital contribution to reducing greenhouse gases and pollution. Several FCH JU-funded projects are developing the technology to mass produce cell stacks in response to market demand, while ensuring they meet strict quality standards.

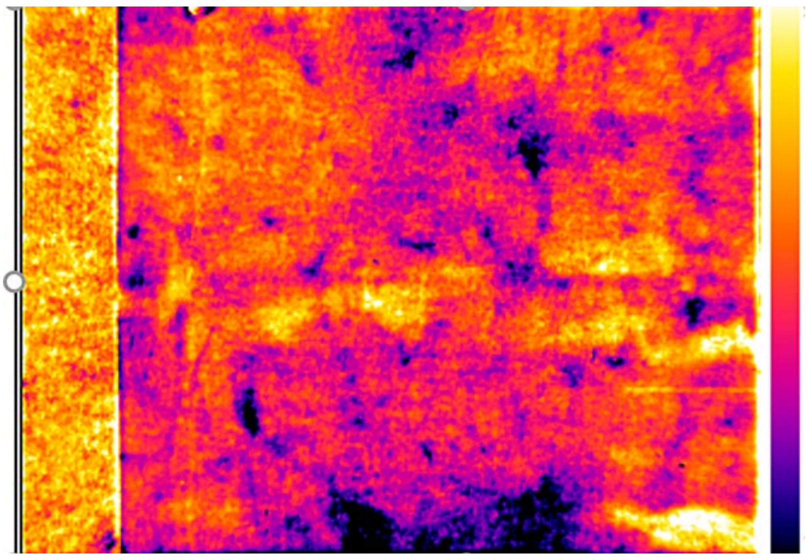
© Freudenberg, 2018

MORE, BETTER, FASTER

To meet the growing demand of zero-emission vehicles, fuel cell stack production capacity has to increase from tens of thousands of units per year to hundreds of thousands, along with millions of components. Quality control methods to identify flaws that could affect stack performance need to be integrated into production.

BRIDGING THE GAP

The fuel cell market is making the transition from time-consuming manual, laboratory-based manufacture to mass production. These projects are helping to bridge this gap by developing scaleable, adaptable production technology that European manufacturers can add to as demand increases, avoiding the need for massive initial investments. Reducing the waste of materials, integrating quality control into production to save time, and simplifying the design of stack components is part of this process. **The goal?** To accelerate commercialisation of fuel cells for vehicles by improving manufacturing processes and lowering production costs. **Key results?** Digitised and automated production, in line with Industry 4.0 standards, has improved the design and performance of fuel stack parts and made it easier to determine the relationship between the two. This has provided a basis for further scientific and technical progress. The fuel cell manufacturing supply chain has been improved and DIGIMAN project partner Intelligent Energy now has a better production line, enabling greater output of PEM fuel cells.



KEY ACHIEVEMENTS

50 000
fuel cell stacks per year can be manufactured by DIGIMAN's blueprint for a fully automated production line

4
companies, one of which is an SME, are introducing innovations, thanks to DIGIMAN

5 SECOND
cell assembly time achieved by DIGIMAN, down from 22 seconds

ELIMINATION OF OPERATOR HEAD COUNT
from 4 to none, as the DIGIMAN cell assembly process has been raised from semi- to fully automated

IMPACT

PRE-PRODUCTION READINESS
or manufacturing readiness level 6, achieved by the DIGIMAN production line design

FIVE-FOLD
improvement in cell assembly time at DIGIMAN project partner Intelligent Energy

IMPROVED CHARACTERISATION
of the gas diffusion layer with the use of inline quality control hardware and big-data techniques

STRONGER
supply chain for the fuel cell manufacturing market, especially for DIGIMAN partners Intelligent Energy and Freudenberg

SEAMLESS INTEGRATION
of digital manufacturing techniques with advanced automated production technology achieved by DIGIMAN

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
https://digiman.eu/
https://fit-4-amanda.eu/partners/
https://www.inline-project.eu/
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Making an impact on the clean energy transition

ENERGY

INNOVATIVE ELECTROLYSERS GREENING EUROPEAN INDUSTRY

© voestalpine, 2019

More productive technology

Hydrogen is essential to processes in sectors such as refining, fertilisers and manufacturing. Yet over 90 % of the hydrogen that industry uses comes from CO_2-emitting natural gas – 'grey' hydrogen. Large-scale electrolysers that extract hydrogen from water using renewable energy – 'green' hydrogen – could significantly reduce industry CO_2 emissions as part of the EU goal of 40 GW of green electrolysers in Europe by 2030.

Four FCH JU projects have been scaling up electrolyser cells and adding cells to electrolyser stacks to boost capacity, building on the achievements of the HyBalance demo project. Demo4Grid and DJEWELS have produced 4-MW single stacks and 20-MW systems for alkaline electrolysis and increased current density three-fold, from 0.3 A/cm^2 to 1.0 A/cm^2. H2FUTURE and REFHYNE have produced 0.5-MW proton exchange membrane (PEM) stacks that deliver hydrogen at atmospheric pressure of 20 bar in scalable modular units of 6 and 10 MW, respectively.

Real-world viability

Demo4Grid and DJEWELS are installing their electrolysers in food and green fuel factories in Austria and the Netherlands to produce hydrogen for ovens, transport, methanol production and nearby industries. In addition, the projects demonstrate that the higher productivity of the alkaline electrolysers reduces their size and CAPEX requirements. H2FUTURE and REFHYNE are placing PEM electrolysers in steel and oil refineries in Austria and Germany. Although the equipment meets only a small percentage of current production demand, it demonstrates that the technology can reliably reduce steel plant or refinery emissions, in readiness for future PEM capacity increases.

FCH JU projects are scaling up electrolysers that generate hydrogen from renewables and installing them in large refineries and factories. The demonstrations aim to show that the technology is a reliable, viable alternative to hydrogen production from natural gas, decarbonising industries and connected businesses in emerging 'hydrogen valleys'.

© voestalpine, 2019

HYDROGEN FOR HARD-TO-ABATE INDUSTRIES

Refineries and factories use hydrogen for many processes, yet much of this is produced from natural gas, making it difficult to reduce industry CO_2 emissions.

CONFIDENCE TO GO GREEN

Refineries, large-scale manufacturers and public organisations are cooperating in FCH JU projects to develop and demonstrate electrolysers that produce low-carbon hydrogen for industry. **The goal?** Electrolysers which produce high-purity hydrogen on-site, creating confidence that the technology is suitable for other companies, industries and surrounding businesses. **Key results?** Alkaline and PEM electrolysers that generate green hydrogen in refineries and factories, demonstrating that the technology is a practical and viable way to reduce CO_2 emissions in many industries.

KEY ACHIEVEMENTS

H2FUTURE

>1 200 Nm³/h
hydrogen produced

99.9 %
hydrogen purity

77-82 % HHV
rated system electrical efficiency

10 m²/MW
electrolyser footprint

REFHYNE

< EUR 1 000/KW installed
target CAPEX

DEMO4GRID AND REFHYNE

2 s
from standby to full power

DJEWELS

TRL 7 TO TRL 8
with pilot stacks of 1 MW

0.72 %/year
target efficiency degradation

IMPACT

ADDS TO ELECTROLYSER CAPACITY
already 100-fold greater in FCH JU projects in eight years

CONTRIBUTES TO LOWER SUBSIDY PER KW
reduced by a factor of 50 in FCH JU initiatives since 2012

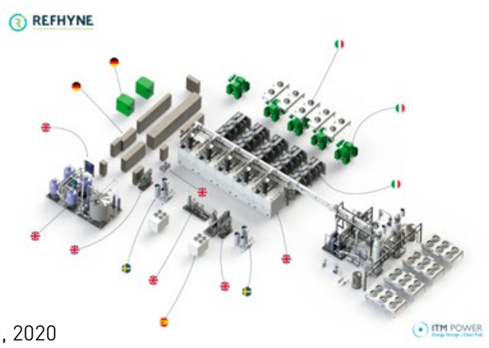
REDUCES ELECTROLYSIS POWER DEMAND
– approaching 52 kWh/kg H_2 in DJEWELS and REFHYNE

ADDRESSES A MAJOR BARRIER
to cutting industry emissions by enabling renewable energy to enter industrial facilities through hydrogen

BOOSTS 'HYDROGEN VALLEYS'
around industries, to extend hydrogen use to the wider business community

CREATES CONFIDENCE
in green electrolysis technology, driving adoption

INCREASES HYDROGEN SECURITY
by reducing dependence on natural gas imports



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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

A partnership dedicated to clean energy and transport in Europe

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Making an impact
on the clean
energy transition

ENERGY

GAME-CHANGING COMPONENTS FOR NEXT-GENERATION ELECTROLYSERS

Two FCH JU projects are pushing the limits of PEM electrolyser performance, aiming at a current density of 6-8 A/cm2 and operating pressure of 100 bar. The lower footprint and energy consumption for commercial-level output make the technology cheaper to install and operate, increasing its appeal to industry.

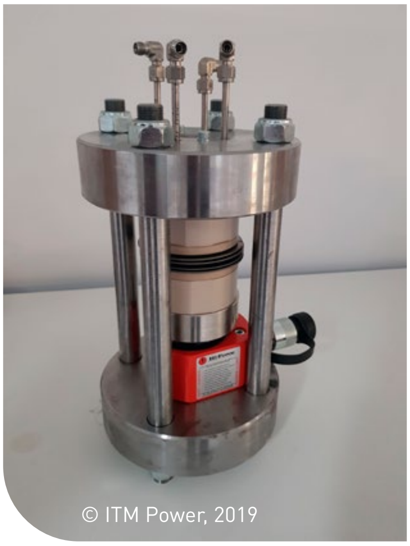
Higher pressure and current densities

Existing high-pressure proton exchange membrane (PEM) electrolysers produce hydrogen at 20-30 bar, which requires operators to use a mechanical compressor to store and transport the gas efficiently. As industrial electrolyser current density is only 2-3 A/cm^2, the footprint of electrolysers is high, taking up large areas of valuable space.

Technology for compact PEM electrolysers that operate at 100 bar and higher current densities is being developed in the FCH JU projects NEPTUNE and PRETZEL. NEPTUNE will use novel polymers, along with thin membranes that withstand large pressure differentials and a safety recombination catalyst, enabling stacks to operate at a base load of 4 A/cm^2 at nominal power and 8 A/cm^2 at high power. Meanwhile, PRETZEL is placing stacks inside a high-pressure chamber and improving membrane electrode assemblies, the porous current distributor and bipolar plates, among other components. The project has also used low-cost coatings to optimise current collectors and has designed innovative pressurising and cooling for durable operation at 4-6 A/cm^2.

Efficiency for industry

Both projects pave the way for electrolysers that deliver hydrogen at high pressures for industry applications and injection without further compression to natural gas (NG) transmission grids. Once these concepts have been proven at a scale of 10-100 kW, the next step is to scale up the electrolysers. NEPTUNE and PRETZEL will also compare the investment and operating costs of the new 100-bar electrolysers with those of existing lower-pressure electrolysers operating with a compressor, strengthening the case for industry investment.



INCREASING ELECTROLYSER ATTRACTION

For electrolysers to be attractive to industry, they must produce hydrogen at a higher rate relative to their footprint and at pressures that allow for direct transport and storage.

A COST-EFFECTIVE CASE FOR HYDROGEN

Collaborations between energy and specialist manufacturing and research organisations are improving electrolyser components. **The goal?** To make electrolysers more efficient and the resulting hydrogen easier and more cost-effective for industries and gas distributors to integrate into their operations. **Key results?** Electrolysers that produce hydrogen at a ready-to-store 100 bar and with higher current densities that increase their productivity, enhancing the business case for industry to adopt green hydrogen.

KEY ACHIEVEMENTS

NEPTUNE

< 50 kWh/kg H_2
target nominal energy consumption

< 1.75 V AND < 2.0 V
cell voltages at 90 °C, at 4 A/cm² and 8 A/cm², respectively

100 bar
output pressure for current densities ranging from 0.2 to 8.0 A/cm²

50 %
of beneficiaries are SMEs and received > 50 % of project funding

PRETZEL

500 cm²
membranes developed and ready to test in stacks

4.5 m³/h HYDROGEN EXPECTED
at target electrical power consumption of 25 kW

90 °C
maximum feedwater temperature

IMPACT

INCREASES PRODUCTION RATE
for a higher return on investment

REMOVES NEED FOR COMPRESSORS
thanks to higher output pressure

SAVES VALUABLE MATERIALS
through innovative component solutions

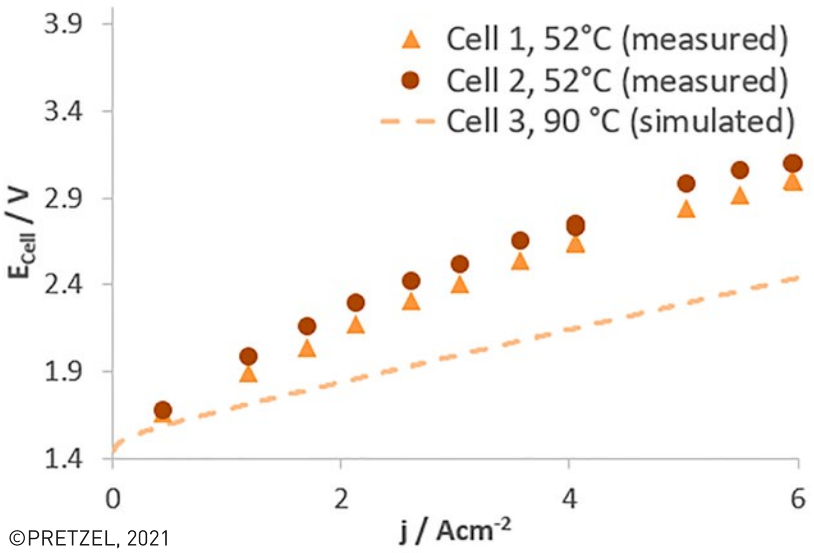
SHRINKS FOOTPRINT
of electrolysers for more efficient use of floor space

STRENGTHENS BUSINESS CASE FOR GREEN HYDROGEN
to promote carbon savings in industry

SUPPORTS RENEWABLE ENERGY
with production pressures suitable for injection into the NG grid

EXPANDS MARKET FOR ELECTROLYSERS
for new opportunities for manufacturers

SHOWCASES EUROPEAN INNOVATION
in commercially attractive green technology



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www.fch.europa.eu/page/fch-ju-projects
https://neptune-pem.eu/en/activities-en
http://pretzel-electrolyzer.eu/

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

A partnership dedicated to clean energy and transport in Europe

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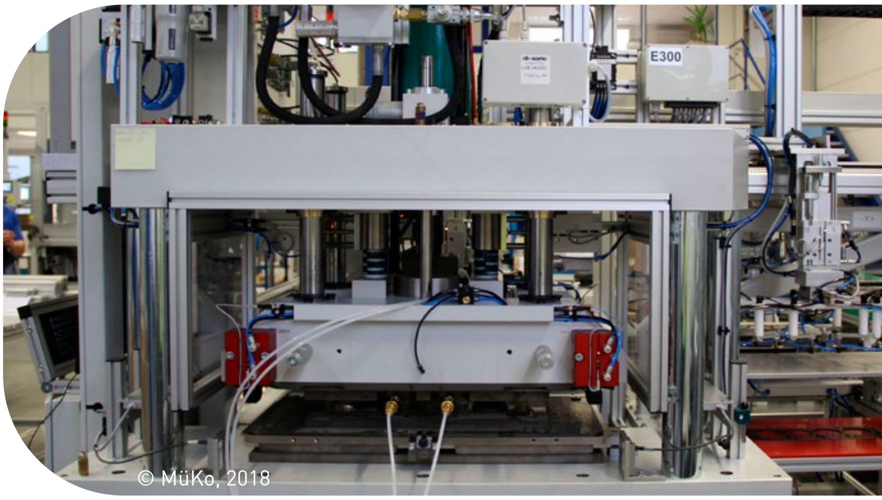
Making an impact on the clean energy transition

ENERGY

MID-SIZED SOFC SYSTEMS BREAK PRODUCTION-COST BARRIERS



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Innovation to demonstration

Solid-oxide fuel cells (SOFCs) enable households and businesses to produce low-carbon electricity and heat. FCH JU projects, such as ENE.FIELD and PACE, have helped the development of affordable mass-produced small 0.5-1.5 kW SOFCs. Larger systems of 50 kW or more must be researched and improved now to become competitive.

FCH JU projects are addressing this need. NELLHI developed components and stack properties to boost manufacturing rates and reduce the cell price of a high-performance 1 KW stack. qSOFC then enhanced manufacturing and automated quality control, making costs of EUR 1 100/kW possible for the production of 10 MW/year or more. Following on, INNO-SOFC integrated the NELLHI stack into a second-generation version of a system from earlier project DEMOSOFC to create a high-efficiency, long-lasting 50 kW system that can be mass-produced at below EUR 2 000/kW. Finally, ComSos is building on these projects, with European manufacturers, to demonstrate next-generation commercial-size systems and to test business models.

A commercial future

The projects contribute to a European supply chain for affordable, reliable mid-sized SOFC systems. European specialist supplier SMEs received 63 % of the available funding from INNO-SOFC and 87 % from ComSos. A machine-vision inspection system and interconnection and coated-steel materials production from qSOFC are already being commercialised. Meanwhile, INNO-SOFC results are being used in a system in a smart grid in Finland and have been modelled for other applications (see results tab). Overall, the innovations pave the way to better quality control and scaled-up manufacturing and production capacities, enabling competitive full-cell CHP systems. Third-generation systems are now being developed in projects CH2P and SWITCH.

A 60 kW (C60) hydrogen heating and power system developed from a range of FCH JU-funded projects costs less to build than existing models and has a fully European supply chain. Demonstrations of the systems in real applications are boosting manufacturing volumes and supporting the business case for their application.


© qSOFC, 2019

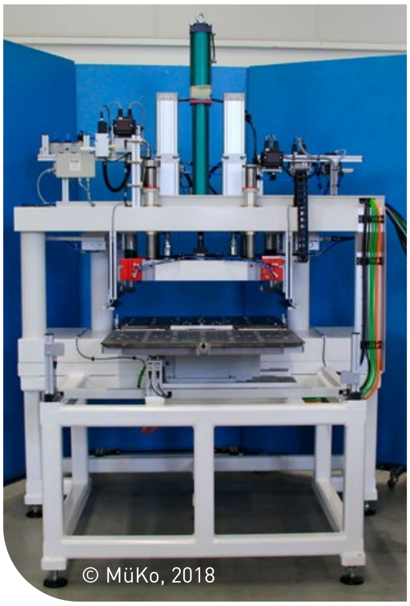
MID-SIZED SOFC SYSTEMS BREAK PRODUCTION-COST BARRIERS

AFFORDABLE MID-SIZED SOFC

SOFC heating and power systems of up to 60 kW (C60) are currently expensive to manufacture and buy, limiting access to the technology and related jobs in Europe.

GREENER ENERGY AND JOBS

FCH-JU-funded collaboration between European specialised companies and research institutions have improved components and assembly of mid-sized SOFC stacks and systems. **The goal?** To develop reliable technology that is cost-efficient and with fast manufacturing processes. **Key results?** Systems, components, materials and production technology have been improved and are ready for commercialisation or development to the next generation.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KEY ACHIEVEMENTS

qSOFC

50 MW/year
production volumes possible from advanced cell manufacturing

10-µm scale
of visual inspection for defects at 10 s/cell

NELLHI

74 %
stack electrical efficiency at 1-kW scale

650 ºC
operating temperature

INNO-SOFC

61.4 %
system electrical efficiency

60 kWe
second-generation SOFC system

ComSos

20 FUEL CELLS
to be deployed; with total installed capacity of 500 MW

3 EUROPEAN MANUFACTURERS
are joining forces

IMPACT

ENABLES FULL EUROPEAN SUPPLY CHAIN
for affordable, efficient, adaptable SOFC of up to 60 kW

qSOFC

HIGHLIGHTS POTENTIAL OF THE TECHNOLOGY
– project awarded the EU's Innovation Radar Prize 2019

REDUCES MANUFACTURING COSTS
through advanced interconnects, conditioning and inspection technology

NELLHI

CONFIRMS EUROPEAN LEADERSHIP
in SOFC technology, with first stack electrical efficiency of 74 %

INNO-SOFC

PROMOTES TAKE-UP OF LOW-EMISSION HEATING AND POWER
by enabling competitive systems that can be tailored to local needs

ComSos

EXPECTED TO DE-RISK SCALE-UP INVESTMENT
in a high-potential emerging market

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects

http://www.qsofc.eu/
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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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Making an impact on the clean energy transition

ENERGY

BRINGING CLEAN POWER TO ISOLATED LOCATIONS


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Taking renewable energy further

While zero-carbon energy sources such as wind and solar are useful in remote areas, their effectiveness either depends on the weather, or their output is curtailed by insufficient grid capacity. Hydrogen fuel cell systems can overcome these limitations and totally or partially replace diesel generators.
REMOTE is demonstrating two types of hydrogen fuel-cell-based energy-storage solutions in three locations: on a milking facility in the Canary Islands, Spain; an agri-food processing unit in Agkistro, Greece; and a fish farm and homes in Rye, Norway.

People living and working in off-grid areas often have to rely on noisy, polluting diesel generators for electricity. The FCH JU-funded REMOTE project is showing how hydrogen fuel cells offer a cleaner alternative that is technically and economically viable.

Getting off the grid

The REMOTE demo has avoided the need to build a 20-km transmission line connected to the main grid in Agkistro. This would have been considerably more expensive than the hydrogen option. In addition, fuel-cell- and hydrogen-based power-to-power (P2P) systems have medium- to long-term storage capacity which is more viable than battery systems that only store energy over the short term. The milking facility in La Aldea de San Nicolás, on Gran Canaria, is surrounded by nature reserves, which means that the grid cannot be expanded. A local hydroelectric power plant will be used to produce hydrogen which will be stored and used to power the farm when the hydroelectric plant cannot meet demand.
Lessons learnt from the REMOTE demos will help improve the technology so that the solution can be replicated effectively in other off-grid areas.

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CUTTING COSTS, BOOSTING PERFORMANCE

In addition to the need for performance improvements, the cost of hydrogen production and conversion technology has to be reduced through economies of scale to make it more attractive than fossil-fuel-powered alternatives.

EASY TO REPLICATE

The FCH JU-funded demos are designed to be easily replicable and adaptable to demand. With more than 10 000 inhabited islands and 30 000 off-grid telecoms towers worldwide, powered largely by diesel generators requiring expensive, imported fuel and regular maintenance, the market potential for greener technology is huge. **The goal?** To help suppliers and users gain experience with such systems, to be applied in the next generation of designs. Demonstrating to the energy community and decision-makers how fuel-cell-based H_2 energy-storage solutions are more efficient and require less maintenance than fossil-fuel-powered technology will help boost their use. **Key results?** REMOTE has defined the technical and business cases for the demonstration sites, along with the value chain. The regulatory framework has been analysed and technical specifications for each demonstration site have been developed. The first algorithm needed to help run the technology has been developed and can be used in future applications of these P2P solutions. In addition, the project was named best renewable energy project in the innovation section at the European Sustainable Energy Week 2020.

KEY ACHIEVEMENTS

EUR 410/MWh UNIT COST
for the hydrogen-based power-to-power solution in Agkistro over 10 years, compared to EUR 864/MWh for a new 20-km cable connection to the grid

67 %
of the electricity stored in the hybrid H_2 battery system at the Agkistro demo site can be retrieved for use (known as round-trip efficiency)

48 TO 57 TONNES
of CO_2 production saved per year (projected) from reduced use of diesel generators at the Gran Canaria demo site

AROUND 60 %
of local renewable energy generation is provided to users through the P2P system at the Rye demo site, which would otherwise be lost because of the mismatch between RES generation and demand

IMPACT

OPERATION IN ALL-WEATHER CONDITIONS
including self-starting in low temperatures

LOW OPERATING COSTS
due to long lifetime and minimal need for regular or predictive maintenance – long-term potential for total cost of operation less than that of diesel generators

HIGHER OPERATING EFFICIENCY
for combustion and storage, and extended run times compared to conventional technologies

FEWER REGULATORY HURDLES
when setting up hydrogen power infrastructure in environmentally protected areas

EMISSION SAVINGS
of 1.5 gigatonnes of CO_2 per year (4 % of global emissions) could be achieved if the world's 750 million islanders were to replace their diesel generators with hydrogen power

REPLICATION
of the REMOTE concept in off-grid areas could provide an estimated potential capacity of 2 gigawatts annually for an investment of EUR 340 million per year

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
https://www.remote-euproject.eu/

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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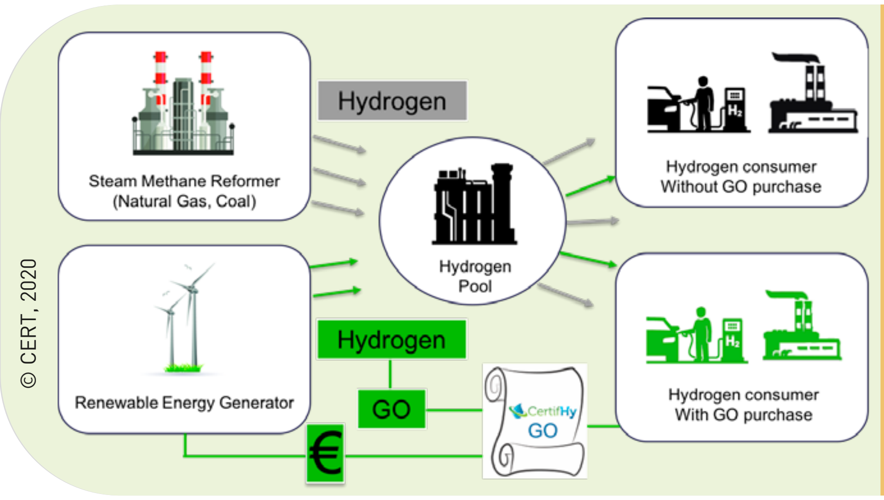
Making an impact on the clean energy transition

MARKET UPTAKE

TOWARDS A SUSTAINABLE AND CIRCULAR HYDROGEN ECONOMY



Impact analysis and action

With growing interest in hydrogen comes the need to ensure the sector's technology – and its economy – are as sustainable as possible. That means developing tailored environmental impact tools and greening everything from design to disposal.

FCH JU-funded projects have long promoted such a comprehensive approach. Providing a solid basis, FC-HYGUIDE developed guidance, training materials and courses on how to use Life Cycle Assessments (LCA) to holistically determine a hydrogen technology's environmental footprint. That initial framework is now being expanded by the SH2E project to include economic and social dimensions, while close collaboration with the European Commission's Joint Research Centre (JRC) is fostering further critical advances.

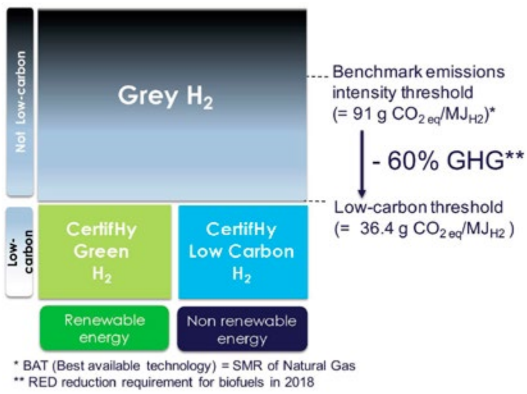
With recycling strategies, eco-design, life-cycle-thinking tools and much more, the FCH JU is boosting the sustainability and circularity of hydrogen technology, preparing the sector and its economy for a planet-friendly roll-out as part of Europe's clean energy transition.

Recycle, redesign, GO!

How best to dispose of defunct technology and bolster circularity? With their focus on recycling and dismantling strategies, as well as the recovery and reuse of resources such as platinum, this is where the HYTECHCYCLING and BEST4HY projects come in.

EGHOST, meanwhile, is working on eco-design guidelines to promote efficiency, finding ways to refurbish older technologies and include environmentally friendly design criteria early on in the development of new ones.

Advancing sustainability through truthful sourcing, CERTIFHY created the first EU-wide Guarantee of Origin (GO) scheme for green and low-carbon hydrogen. The project's current third phase includes building a market for GO trade.



TOP-NOTCH GREEN TECHNOLOGY

Hydrogen technology must deliver excellent performance on the one hand and sustainability and circularity on the other, promoting an economy that minimises environmental impact and encourages the reuse of resources.

CIRCULAR AND SUSTAINABLE

Encouraging collaboration between industry and research experts to foster the greening of hydrogen technology, from start to finish. **The goal?** To promote a sustainable and circular hydrogen economy that supports the EU's Green Deal and strategy on energy integration while contributing to the Sustainable Development Goals and Paris Agreement. **Key results?** Tools to assess the impact of hydrogen technologies; advances in recycling, dismantling and resource recovery; a hydrogen-sourcing scheme and steps to develop eco-design guidelines promoting sustainability and circularity.

KEY ACHIEVEMENTS

CERTIFHY

First EU-wide Guarantee of Origin scheme for green and low-carbon hydrogen
Pilot projects throughout Europe on **production pathways**

FC-HYGUIDE

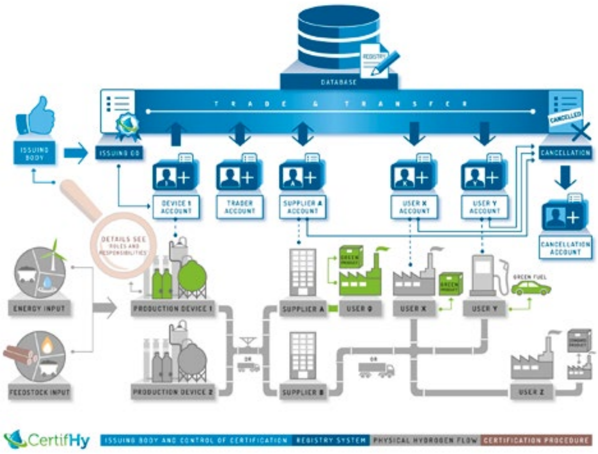
Guide and reporting template for hydrogen-specific LCAs
Life Cycle Inventory (LCI) data for hydrogen and fuel cell technologies

HYTECHCYCLING

Identification of critical materials and components in hydrogen technology products
Mapping of existing and new recycling technologies

JRC COOPERATION

Expert workshop on LCAs of hydrogen technologies
Review of LCAs for **70+** FCH JU projects



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IMPACT

CERTIFHY

New & transparent clean hydrogen market
Enhanced business case for green hydrogen

FC-HYGUIDE

Tailored resources for measuring hydrogen technology's environmental footprint
Bolstered sustainability awareness through broad dissemination of materials

HYTECHCYCLING

New strategies and roadmap for recycling and dismantling
Harmonisation and regulatory proposals related to recycling and dismantling

JRC COOPERATION

Informed decision-making on sustainability due to continuous monitoring activities
Strengthened links and data sharing with the European Platform on Life Cycle Assessment

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
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Making an impact on the clean energy transition

MARKET UPTAKE

STRONGER STANDARDS FOR HYDROGEN

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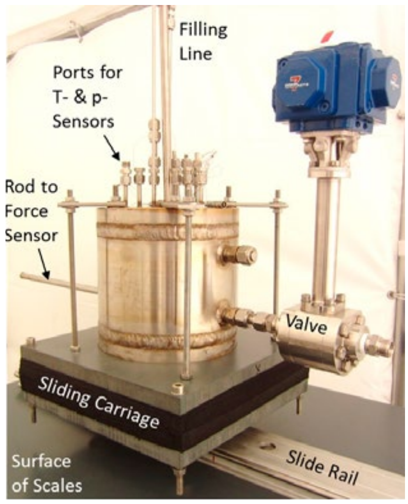
Research and international cooperation

The hydrogen sector needs a clear set of strong and harmonised standards to commercialise and bolster its reputation as a clean and safe alternative. The FCH JU is contributing to this with a science-based approach alongside close cooperation with the Joint Research Centre and European standardisation bodies CEN and CENELEC.
Focused on standards across the board, the FCH JU currently funds 10 projects with safety, central to building trust, paramount. To that end, for example, PRESLHY has proposed a new international standard on the safe use of liquid hydrogen while HyTunnel-CS recommendations are expected on ensuring a high degree of safety for hydrogen-powered vehicles in tunnels and similar spaces.

From trucks to stress tests

PRHYDE is working on the standardisation of hydrogen refuelling protocols for medium- and heavy-duty hydrogen vehicles such as trucks. Out to sea, E-SHYIPS aims to define guidelines for powering passenger ships with hydrogen.
While HYDRAITE has issued standardisation recommendations on hydrogen fuel quality and more, THyGA is tackling standards linked to bringing hydrogen and natural gas blends to homes and businesses. HIGGS is striving to fully assess the impact of high amounts of hydrogen on the natural gas pipeline network. MultHyFuel, meanwhile, is focusing on integrating hydrogen into existing refuelling stations. That leaves ID-FAST and AD-ASTRA, which deal with degradation and stress-testing protocols for fuel cells.

From quality control to refuelling protocols, FCH JU research and cooperation with key players is supporting the development and updating of standards across the hydrogen sector. The goal? To shape rules and regulations, build consumer confidence – and ensure a smooth roll-out.



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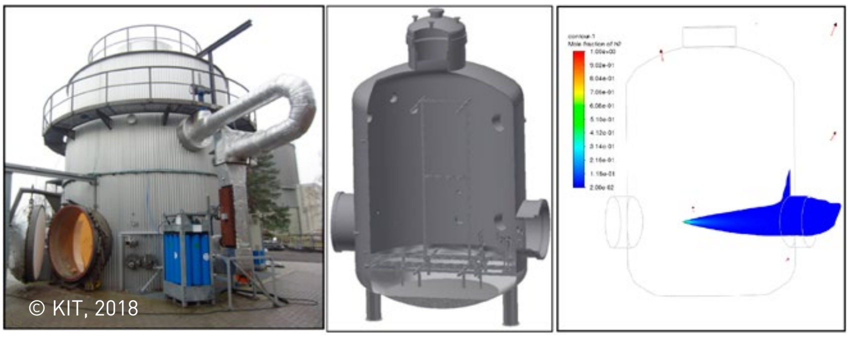
STANDARDS BREED SUCCESS

A lack of suitable, hydrogen-specific and performance-based standards – as well as clear rules and regulations – is holding back the development of mass-market hydrogen products and risk hampering the sector's overall success.



LETTING SCIENCE LEAD

To advance standardisation in the hydrogen sector, the FCH JU funds pre-normative research projects to identify and fill in knowledge gaps in a wide range of areas. **The goal?** To bring new, science-based facts to the table to develop and update hydrogen-sector standards. This will generate positive public perception, ensure a safe and smooth hydrogen roll-out, and spur commercialisation. **Key results?** A proposed new international standard on the safe use of liquid hydrogen in addition to boosting knowledge in areas including hydrogen-powered transport, quality control, as well as refuelling and stress-testing protocols.

KEY ACHIEVEMENTS

HYDRAITE

ISO recommendations on hydrogen fuel quality, quality assurance, sampling

3 European labs to analyse hydrogen quality

PRESLHY

New international standard proposal on the safe use of liquid hydrogen in non-industrial settings

Guidelines for safe design and operation of liquid hydrogen infrastructure

New Handbook of Hydrogen Safety chapter on liquid hydrogen

JRC COOPERATION

EU harmonised terminology and tests for low-temperature water electrolysis for energy-storage applications

Enabling framework for market uptake

EU harmonised protocols for PEM fuel cell testing for automotive applications

IMPACT

HYDRAITE

New European infrastructure for the hydrogen sector

HYTUNNEL-CS

Tunnel safety recommendations expected for hydrogen-powered vehicles

PRESLHY

Boosting liquid hydrogen safety knowledge and awareness

JRC COOPERATION

EU harmonised tests supporting the European hydrogen sector

CEN-CENELEC COOPERATION

Strengthened European hydrogen sector through filled-in knowledge gaps

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3 analytical laboratories ready for Hydrogen quality ISO 14687

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Making an impact
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MARKET
UPTAKE

COMMUNITIES ENJOY CARBON-FREE LIVING IN HYDROGEN VALLEYS

© BIG HIT, 2018

An integrated solution

The benefits of hydrogen as an energy source are greater when it is used for a range of applications, serving several industries and sectors in a territory, while complementing existing renewable energy sources. 'Green' hydrogen can be produced by electrolysis with excess electricity from renewable sources that cannot be absorbed by the grid. The hydrogen can be stored and used to produce electricity via fuel cells when renewable energy supply dips below demand.

On the Scottish Orkney islands, the BIG HIT demonstration project built an integrated hydrogen-based energy system that serves the whole community. Although the HEAVENN and GREEN HYSLAND projects only started recently, their ambition is to create hydrogen hubs in the northern Netherlands and on the Spanish island of Mallorca, respectively, by cooperating with several international partners.

Creating hubs of hydrogen production, distribution and use can help regions become energy self-sufficient and reduce carbon and greenhouse gas emissions. Three FCH JU-funded demonstration projects are showing how these 'hydrogen valleys' can be replicated and contribute to economic growth.

Building replicable models

In BIG HIT, energy curtailment from wind and tidal turbines on the Orkney islands of Eday and Shapinsay is used to produce up to 50 tonnes per year of 'green' hydrogen through electrolysis. This heats a local school and is transported by sea to the largest town of Kirkwall, where it powers a 75-kW fuel cell providing heat and power for harbour buildings, a marina and three ferries, and supplies a hydrogen refuelling station for 5 delivery vans.

GREEN HYSLAND, launched on Mallorca in February 2021, will be the first southern European hydrogen flagship project. It aims to generate, distribute and use at least 360 tonnes of hydrogen per year, produced from solar energy. The project will create skilled jobs and economic growth in the energy sector, helping the island recover from the COVID-19 pandemic.

© BIG HIT, 2018

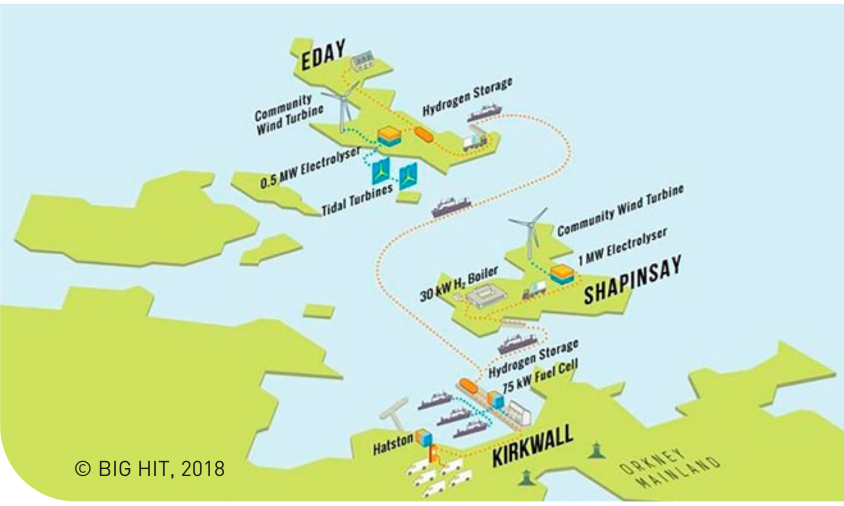
A TRIPLE BURDEN

Lack of regulations, access to funding and presenting a viable business case are the three main hurdles hydrogen valley projects face in their preparatory stages.

STRONGER TOGETHER

Whereas most hydrogen projects are individual initiatives, valleys combine several clusters, ensuring greater efficiencies, more off-take commitments and ultimately more support for the technology. HEAVENN spans six locations focused on four hydrogen-based areas of application: industry, homes, storage and infrastructure, and green mobility.

The goal? To support deployment of integrated fuel cell and hydrogen technologies across Europe, leading to decarbonisation, innovation, skills development and job creation. Interregional cooperation between public and private partners encourages information sharing and strengthens the business case for hydrogen and fuel cell (HFC) technologies. **Key results?** Hydrogen valleys develop local supply chains and expand the market for renewables. Their greatest benefits are energy self-sufficient communities and substitution of fossil fuels, resulting in cleaner air. The replicability of BIG HIT has led to the creation of the Hydrogen Territories Platform which includes a modelling tool enabling public entities and decision-makers to assess their business models for implementing HFC technologies.



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KEY ACHIEVEMENTS

65 %
of the hydrogen valley projects are located in the EU

7
valleys are large-scale projects, with investments over EUR 500 million

2
valleys will each produce more than 500 H_2 tonnes/day

77 %
of hydrogen valley projects in Europe plan to expand their current scope

80 %
of Europe's hydrogen valleys are based on a power-to-mobility business model

EUR 10 MILLION
grant from the FCH JU for GREEN HYSLAND is the second-largest grant to a 'green' hydrogen project

IMPACT

FULLY-INTEGRATED
and functioning hydrogen valleys serve as a blueprint for replication

'Green' hydrogen
is used across the entire value chain, from production and supply to end-users

VALLEYS MAXIMISE
integration and use of renewable energy sources

BIG HIT
is a pioneering hydrogen fuel cell energy system resulting from international cooperation

GREENHOUSE GAS
emissions reduced by 330 tonnes per annum CO_2 equivalent by BIG HIT

FIND OUT MORE

www.fch.europa.eu/page/fch-ju-projects
http://h2territory.eu/
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www.bighit.eu

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