

Scotland's first smart hydrogen microgrid

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David Hogg, Technical Manager, Bright Green Hydrogen

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Overview

- Bright Green Hydrogen
- The Hydrogen Office Project
- Levenmouth Community Energy Project
- The Future of Hydrogen

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Bright Green Hydrogen (previously The Hydrogen Office Ltd.)

- Set up to showcase hydrogen energy storage
- Not-For-Profit SME
- Part of The Business Partnership
 - Midlothian & East Lothian Chamber of Commerce
 - Bright Green Business

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Bright Green Hydrogen (previously The Hydrogen Office Ltd.)

- Focused on 4 key areas
 - Technology Demonstration
 - Education & Training
 - Research & Development
 - Project Consultancy

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Bright Green Hydrogen (previously The Hydrogen Office Ltd.)

- Focused on 4 key areas
 - Technology Demonstration
 - The Hydrogen Office Project
 - Hydrogen Boiler installation with Fife Council
 - Limpet Climb assist system
 - Levenmouth Community Energy Project
 - Education & Training
 - Research & Development
 - Project Consultancy

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Bright Green Hydrogen (previously The Hydrogen Office Ltd.)

- Focused on 4 key areas
 - Technology Demonstration
 - Education & Training
 - Over 32000 children seen in 7 years
 - Work with Fife College on STEM activities, incl. Hydrogen Challenge
 - Developed a Hydrogen Awareness course with SDS
 - Research & Development
 - Project Consultancy

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Bright Green Hydrogen (previously The Hydrogen Office Ltd.)

- Focused on 4 key areas
 - Technology Demonstration
 - Education & Training
 - Research & Development
 - Worked on several academic papers
 - Hosted a PhD Student from Sevilla
 - Currently have an ETP PhD Student with University of Edinburgh
 - Project Consultancy

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Bright Green Hydrogen (previously The Hydrogen Office Ltd.)

- Focused on 4 key areas
 - Technology Demonstration
 - Education & Training
 - Research & Development
 - Project Consultancy
 - Knowledge and experience gained from two cutting edge hydrogen developments
 - Business Park blueprint from LCEP

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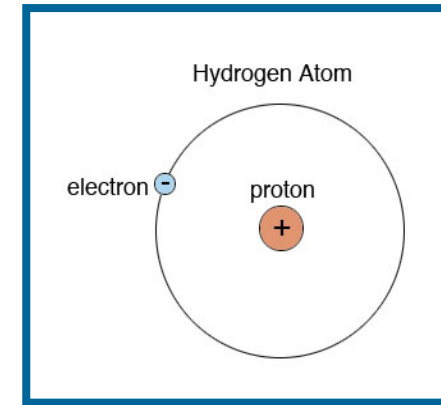
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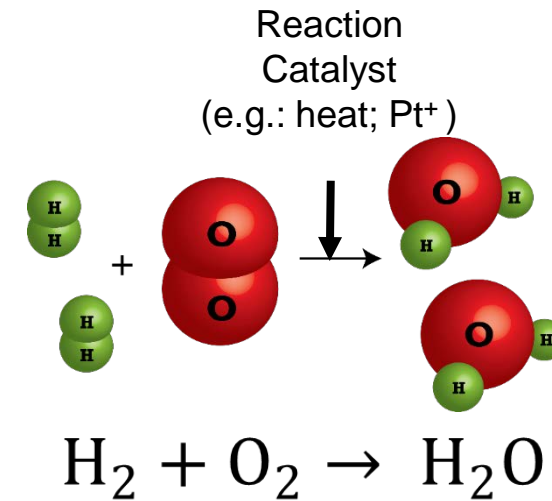
What is Hydrogen?

- Colourless, odourless, tasteless, non-toxic, non-metallic
- Lightest gas in the periodic table
- Highly combustible
 - (Flammable in air at 4% - 74% concentration)
- ...but it has some benefits!



Why Hydrogen

- Zero carbon energy cycle when produced with renewables
- Can be used to load balance excess wind and solar electricity
- Energy devolution from renewable electricity to renewable transport
- No compromise on vehicle range or refuelling time



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The Hydrogen Office Project

- The Hydrogen Office project, operated by Bright Green Hydrogen, demonstrates how excess renewable energy can be stored as hydrogen, encouraging the de-carbonisation of our energy supplies
- It acts as both a demonstration centre and an educational centre for this new technology

Map from Google Maps





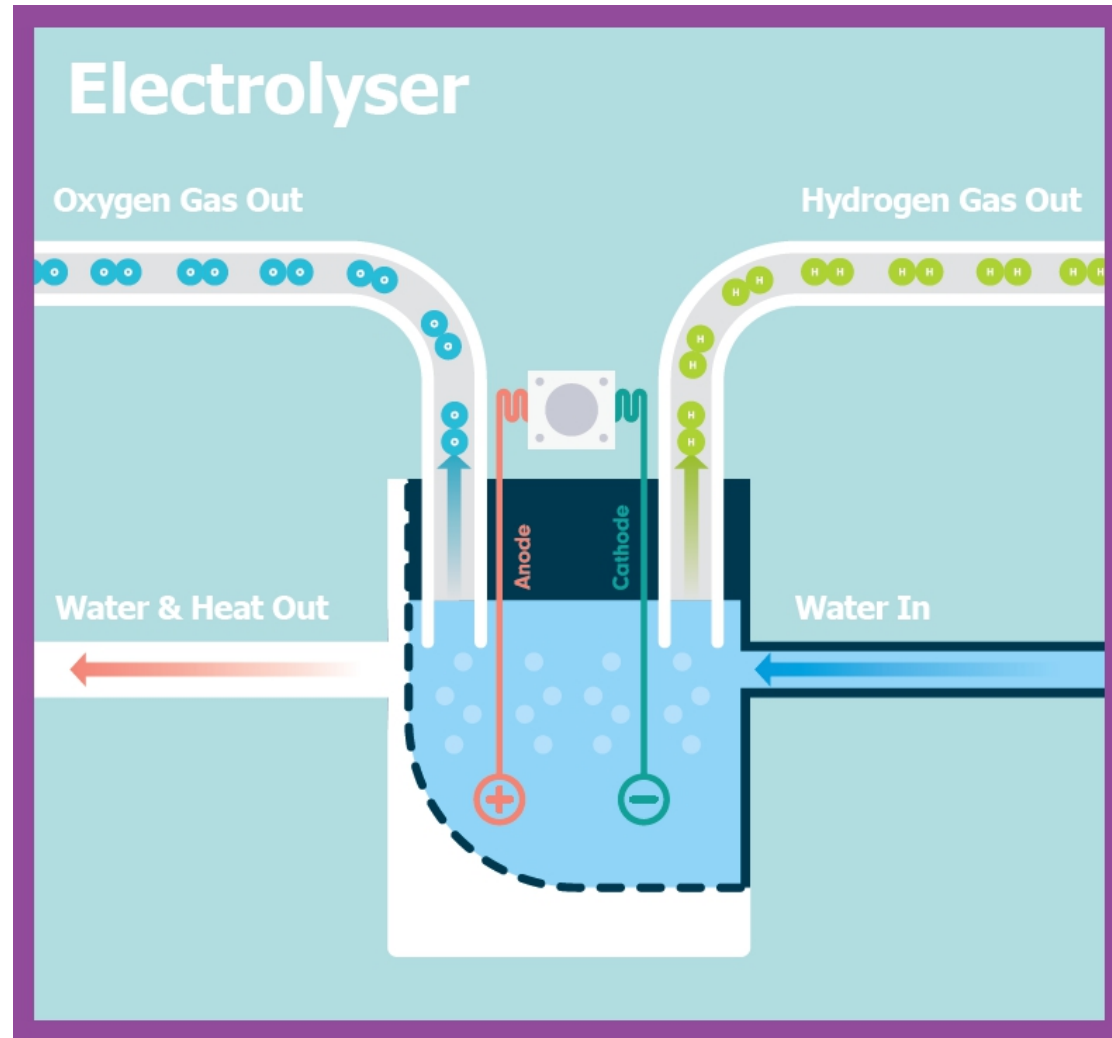
Our Wind Turbine

- GWP 47 turbine, designed by Norwin
- 750kW rated power
- Provides electricity for our innovative micro-grid
- Excess wind energy sent to the hydrogen storage system



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THO Electrolyser

- 30kW Erre Due Alkaline Electrolyser
- Produces ~ 0.45kg of hydrogen per hour
- Efficiency ~ 50%
- Combined purifier gives hydrogen purity ~ 99.995%



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THO Hydrogen Storage

- Tank stores 11kg hydrogen at 12bar ~ 350kWh
- Hydrogen would supply the demonstration centre for approximately 2 weeks
- 2 weeks of storage capacity would likely require a significantly larger battery system



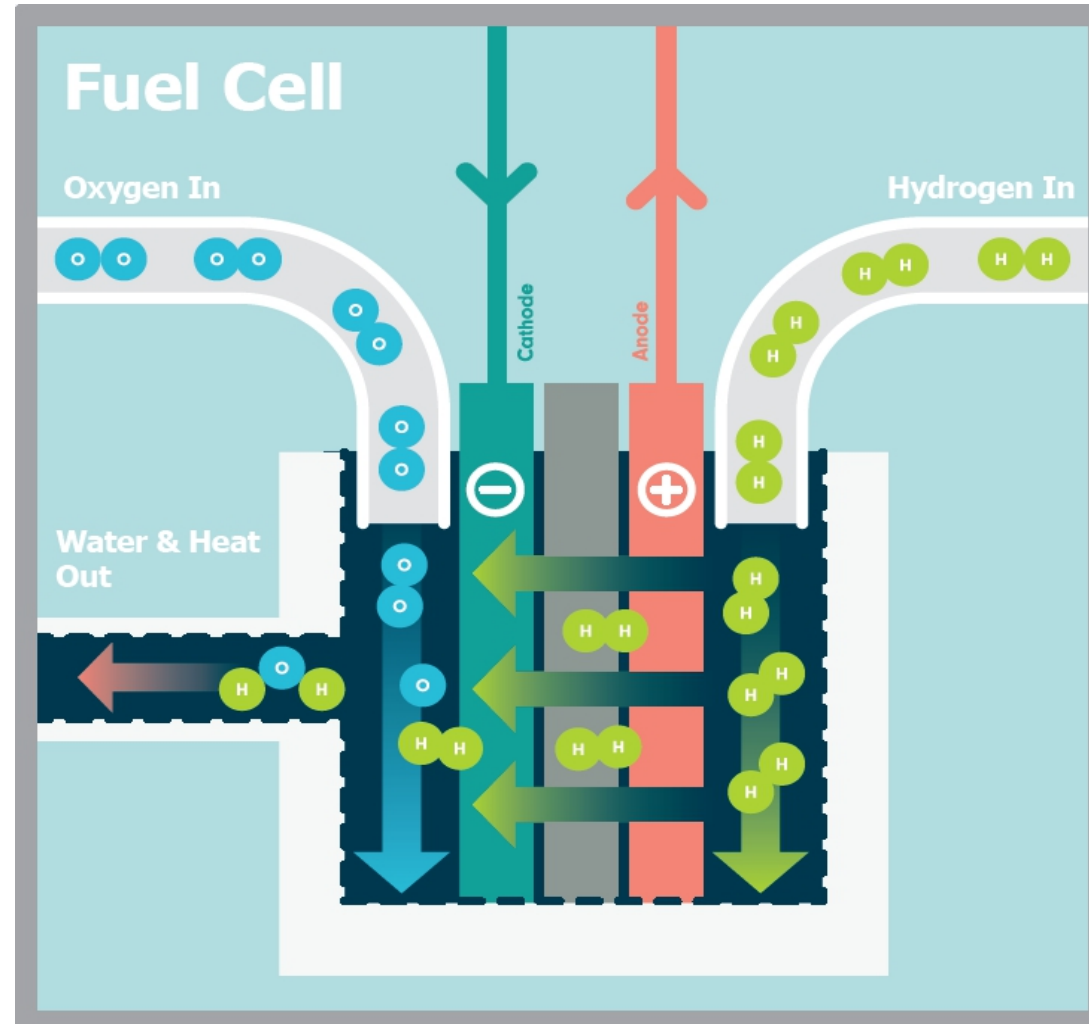
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THO Fuel Cell

- Two 5kW PEM fuel cell stacks from Alteryg
- Hydrogen from storage used, oxygen comes from the air
- Efficiency ~ 45%
- Also works as an Uninterruptible Power Supply in the event of grid failure



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Low Carbon Transport

- First 100% green public charging point in the UK
- Formerly used to charge Fife Shopping and Support Services van
- It was perfect for 100% green local deliveries in Methil area



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LES Challenge Fund 2015

- Set up to demonstrate the value of localised, low-carbon economies;
- Projects needed to be Innovative, Ambitious, Transformational and Community focused;
- Other successful projects include:
 - ACCESS: DSM on Mull
 - EASTHEAT: Heat storage in central Scotland
 - Surf 'n' Turf: Hydrogen storage in Orkney
 - SMART Fintry: Linking generation to demand

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LES Challenge Fund 2015

- Seeking a major expansion of its activities, BGH set up a consortium of organisations in 2014, involving principally Fife Council and Toshiba
- The group successfully passed both stages of the LES Challenge Fund during 2014 and 2015, resulting in a grant of £4.4m to the project
- Much-expanded, new and innovative facilities are being installed, which are scheduled for completion this summer

The Partners

- BGH
- Fife Council
- Toshiba
 - New Energy Project Division
- Others include SHFCA, Fife College, Green Business Fife

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Levenmouth Community Energy Project

- Based in Methil, Fife
- Builds on The Hydrogen Office Project
- Showcases Energy Storage of renewable energy in the form of hydrogen
- Facilitating Sustainable Transportation in Levenmouth and Fife

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Levenmouth Community Energy Project

- 910kW renewable generation
- 8 building parallel microgrid
- Toshiba H2EMS Smart Grid control
- 250kW electrolyser/100kW fuel cell ESS
- 2 x 10kg per day hydrogen refuellers
- 17 vehicle fleet
- Study into rural hydrogen production

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Our Solar PV

- Solar PV designed by Forster Energy
- 160kW rated power
- Provides top-up electricity on days when there is little or no wind
- FiT changes caused serious project issues



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Our Micro-Grid

- Toshiba designed hydrogen Energy Management System
- 8 building micro-grid
- Active management of when buildings can switch to micro-grid
- Determines how much energy is stored through the hydrogen system

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Linking Smart Grid to Transport

- Excess renewable electricity fed into transport
- Smart system's first priority is to ensure there is enough hydrogen for the fleet
- Electric vehicle charging also available onsite

Linking Smart Grid to Transport



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Hydrogen Equipment – System Design & Install

- All 3 hydrogen systems designed and installed by Edinburgh based Logan Energy
- Specialists in hydrogen infrastructure
- All hydrogen equipment from Hydrogenics

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Hydrogen Equipment – Electrolyser

- 250 kW PEM electrolyser, made in Canada
- Produces circa 100kg of hydrogen per day at full power
- Supplies hydrogen storage needs



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Hydrogen Storage

- One tank stores 25kg of hydrogen at 30 bar – energy 750 kWh
- A second tank stores 20kg of hydrogen also at 30 bar – 675 kWh



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Hydrogen Equipment – Fuel Cell

- A 100kW PEM fuel cell, made in Canada
- Recombining hydrogen from storage, and oxygen from the air
- Can be used to supply the whole business park if there is no wind



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Hydrogen Equipment – Refuellers

- Two further electrolyzers for refueling – both 60 kW – one PEM technology, one alkaline technology
- These allows cross-comparison of performance and economics
- Each produces circa 24kg of hydrogen per day at full power
- Hydrogen is stored at 450 bar on refueller roof
- Produces hydrogen for vehicles

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Hydrogen Refuellers



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Management of Refuelling Hydrogen

- Vehicle refueling with green hydrogen will take place at the Methil site
- Refueling will also take place at the Council vehicle depot at Bankhead in Glenrothes, but without hydrogen production;
- The contract for the refueling station there has recently been awarded to BOC

Transport of Hydrogen between the Two Sites

- Contractors have been identified to conduct the transportation of the hydrogen between sites (Galt Transport, Dumbarton)
- The MCPs have been procured by Calvera.



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Our Benefits

- Zero carbon energy cycle
- Makes use of more renewable energy locally
- Electricity supplied for times there is no wind
- Energy devolution from renewable electricity to renewable transport

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Our Disadvantages

- Not Combined Heat & Power
- High capital cost of hydrogen equipment
- High operational costs
- These result in a high cost of hydrogen, especially when compared to current diesel prices

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Our Vehicles

- 10 Renault Kangoo converted by Symbio FC (leased by BGH)
- 5 Ford Transit converted by ULEMCo (operated by Fife Council)
- 2 Refuse Collection Vehicles converted by ULEMCo (operated by Fife Council)



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Other LCEP Outcomes

- A study has been conducted on the economics of producing hydrogen on farms, especially with stranded electricity assets
 - Report available on request
- A mechanism has been set up to pass any surplus project income towards tackling fuel poverty in the local economy

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Key Lessons

- This innovative project has proved to be complex and testing within the time available
- There have been a number of policy changes that have affected project economics e.g. cuts in renewable support
- There has been some slippage due to the development of first-time designs e.g. some of the hydrogen equipment
- Local Energy Scotland has proved highly supportive partner throughout

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Existing Hydrogen Infrastructure

- Pure Energy Centre – Shetland
- Stornoway hydrogen refuelling station
- Aberdeen hydrogen bus project



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Future Hydrogen Projects

- Hydrogen refuelling station at Bankhead in Glenrothes through Transport Scotland
- Orkney Surf & Turf and Big HIT projects
- Leeds City Gate

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Future Plans & Opportunities

- Hydrogen production at Bankhead
- Increased storage in Methil could allow for an increase in fleet size
- Including heating into the system

Conclusions

- Hydrogen is a technologically viable way to decarbonise the energy system
- Further cost reductions and technology improvements are still required
- The Levenmouth project has several world leading hydrogen applications
- Hydrogen vehicles are here to stay (No matter what Elon Musk says!)

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2050 Climate Group – www.2050.scot

- Spawned from 2020 Climate Group
- Focus on leadership development & climate action for young people
- Engage, educate and empower the leaders of tomorrow
- Change the world!

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- David Hogg, *Technical Manager*
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