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Green Energy On Sets – Roundtable
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Introduction to portable renewable energy technologies

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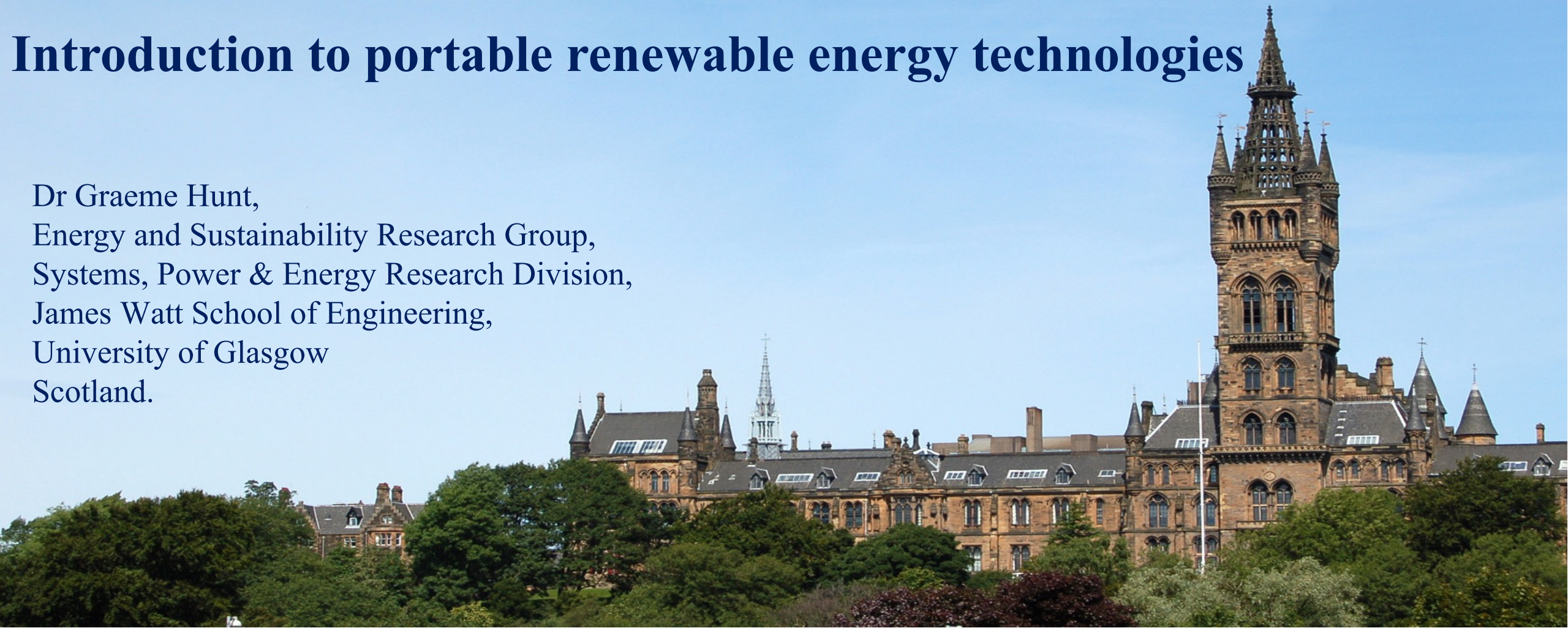


Contents:

- Drivers of climate change
- The Carbon cycle
- HVO (Hydrogenated Vegetable Oil)

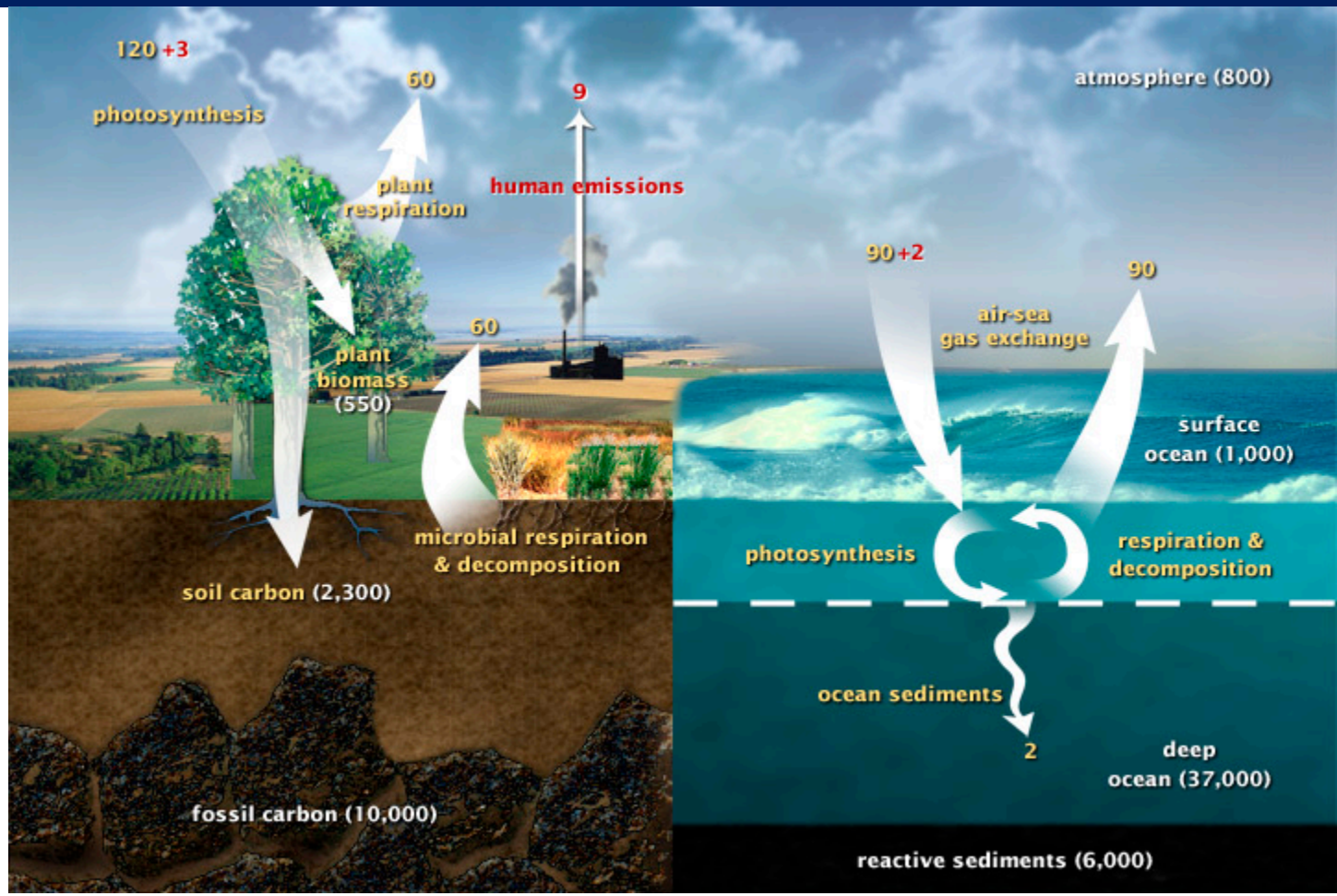
- Battery
- Hydrogen Fuel Cell
- Hybrid systems
- Closing thoughts

Drivers of climate change

- Methane, carbon dioxide, and chlorofluorocarbons (CFCs) don't condense, and they aren't particularly chemically reactive or easily broken down by light in the atmosphere. For these reasons, they remain in the atmosphere for anywhere from years to centuries or even longer, depending on the gas.
- Greenhouse warming potential (GWP) is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given timescale, relative to the emissions of 1 ton of carbon dioxide (CO_2). Carbon dioxide equivalent is also often used
- The larger the GWP, the more that a given gas warms the Earth compared to CO2 over that time-period. The time-period usually used for GWPs is 100 years
- GWPs of common Greenhouse Gases:
  - **CO_2 = 1,**
  - **Methane = 25-30**
  - **Nitrous Oxide = 270**
  - **CFCs, HFCs, HCFCs = 1,000- 10,000+**

Carbon Cycle

- This diagram of the fast carbon cycle shows the movement of carbon between land, atmosphere, and oceans
- Fast Carbon cycle is about a human lifespan
- Slow carbon cycle is 100-200 million years
- Humanity is extracting carbon from fossil fuels. That carbon which would be released naturally (e.g., via volcanic activity) over 100's of millions of years is now released in mere decades
- During that long natural release process, the carbon released would be replaced, maintaining a balance

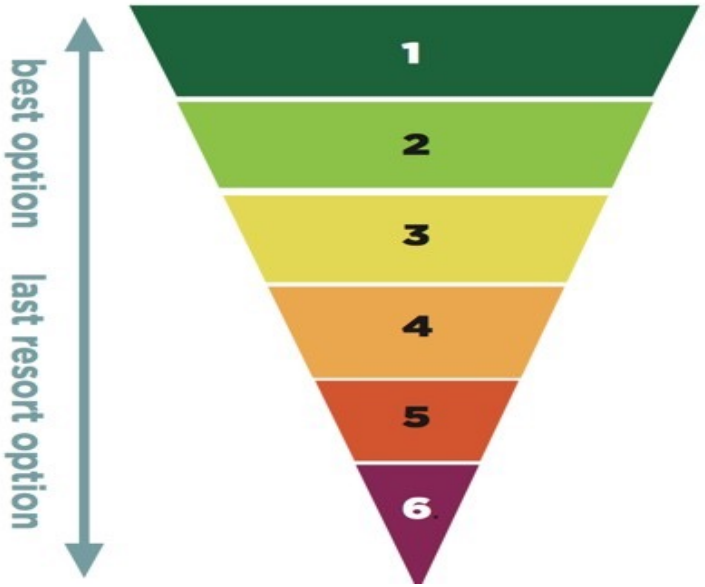


Fast Carbon cycle diagram (source: NASA) -Yellow numbers are natural fluxes, and red are human contributions in gigatons of carbon per year. White numbers indicate stored carbon.

Live Music Events:

- Live music events share much in common with location filming and learnings from one may be applicable to the other
- For example, Glasgow is famous worldwide as a live music venue city and is increasingly used as a filming location
- While much live music occurs in pubs, the O2, and the SEC Hydro and Armadillo, there are multiple outdoor music events ranging in size up the Riverside Festival and TRNSMT

Power required at multiple locations.
All using HVO powered generators.



Prevention - do you actually need power in this location/for this application?

Efficiency - use less power & use it in a more fuel efficient way

Sourcing - can you use mains instead of generators? Can you use renewables?

Hybrids - can the system be backed up or bolstered by battery technology?

Alternative fuels - can you use HVO or other sustainable fuels?

Diesel-fuelled generators only - where nothing else can be used

So, what do these options mean?

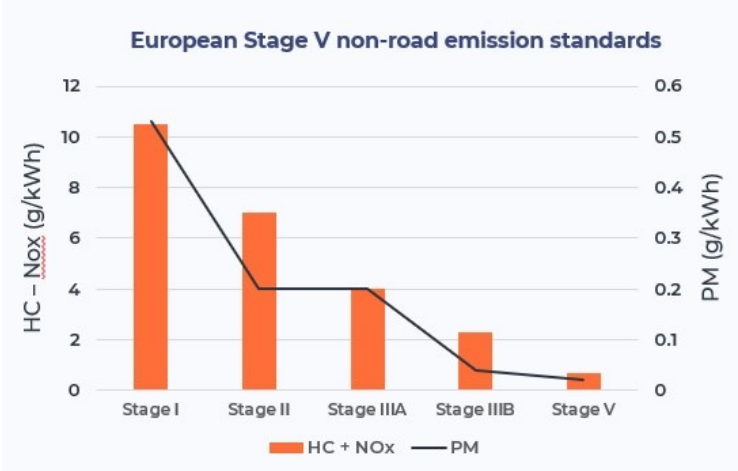
- Prevention- As is sounds, is the power actually required?
- Efficiency – many festivals over-spec the power requirements significantly out of fear of power shortfall and associated financial penalties
- Sourcing – Where possible mains power (generated from renewables) would be ideal. Though this often is not realistically feasible
- This is where it gets complicated, and we must look at these individually

*Credit to: A 6 STEP APPROACH TO PLANNING FOR EFFICIENT POWER PROVISION -Tim Benson, Zap Concepts

Diesel-fuelled generators only - where nothing else can be used

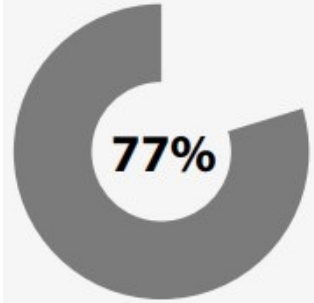
Stage V generators:

- Current industry standard
- Significant improvement on previous generation (not just on Carbon)
- Still diesel though
- As if diesel wasn't bad enough…

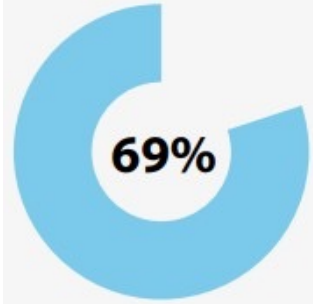


Generators Efficiency:

- In Holland, Watt-Now
- This data correlates strongly with recent data from Glastonbury Festival and the University of West of England (UWE)Still diesel though
- A good rule of thumb is that around 75-80% load is perfect (optimum). Going downwards, anything between 50-75% load is still good as reductions in efficiency are marginal, but as you go down to 25-50% efficiency reduces significantly. A load below 25% is low efficiency and is wasteful of both fuel and costs



of generators have an average load of less than 20% of their capacity.



of generators have twice the capacity of the peak demand.

HVO

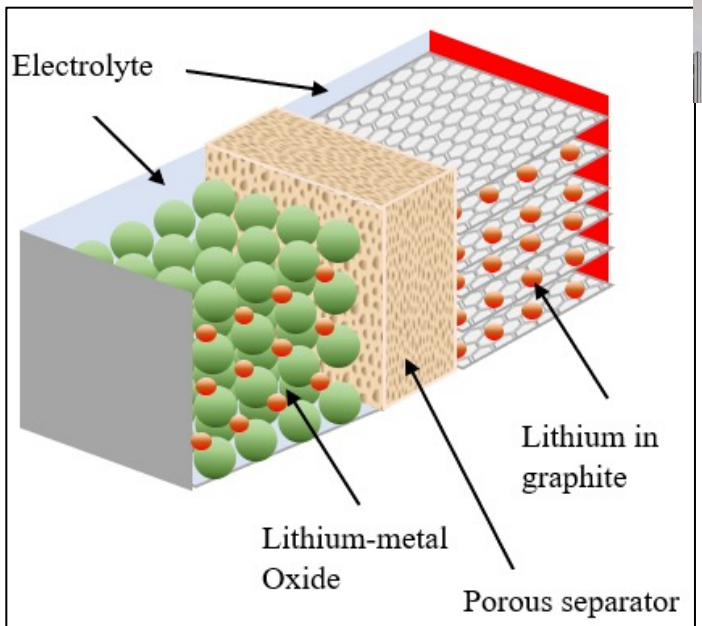
Alternative fuels - can you use HVO or other sustainable fuels?

- 1st generation fuels such as Biodiesel (aka FAME (Fatty Acid Methyl Esters)) produced via esterification of oils with methanol. **Not to be confused with HVOs**. Biodiesel is hygroscopic (it can absorb moisture) therefore can be attacked by microbes or oxygen. Thus, they have limited shelf life.
- HVO is second generation (i.e., the feedstock from which it is made can be waste 1st generation) produced via a hydrotreatment to yield a chemical similar to oil derived diesel containing no esters. Hydrotreatment uses hydrogen to remove oxygen from fats, thus splitting the molecules (Triglycerides) into individual hydrocarbons. This means it has a much greater (up to 10 years typically) shelf life.
- HVO is interchangeable with oil derived diesel. Whereas biodiesel is usually only up to 7% mix with regular diesel (B7 fuel) (7% bio diesel, 93% diesel). HVO can be used for generators, plant, and fleet.
- Burning HVO produces far fewer greenhouse gas emissions than conventional diesel because some of the carbon emitted is cancelled out by the carbon dioxide absorbed from the atmosphere when the feedstock was growing. It also produces fewer air pollutants (e.g., NOX, particulate matter) than biodiesel
- **HVO is only truly sustainable if it is produced from a waste-derived feedstock that doesn't contribute to deforestation**

Hybrids - can the system be backed up or bolstered by battery technology?

What about batteries?

- Regardless of load profile, lithium-ion battery systems are designed to offer a robust and highly mobile solution
- Good at dealing with uneven load profiles
- Can handle prolonged periods of low load
- They are quiet compared to diesel generators, though there can be some fan noise
- Little to no vibration
- But… While not producing any carbon, Lithium-ion batteries obviously require Lithium, the extraction of which is not environmentally friendly.
- There is much ongoing research into finding a more sustainable and less harmful replacement for Lithium while retaining functionality.
- Also need to consider lifecycle impact



Hybrids - can the system be backed up or bolstered by battery technology?

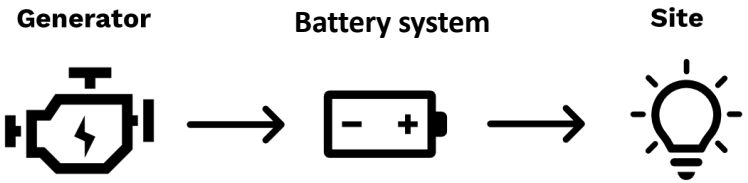
Battery repurposing

Reuse of batteries

- Once an EV battery has degraded past a certain point, it can no longer last the required mileage on a single charge
- A new battery is required to allow the EV to continue operating its full route
- Whilst no longer suitable for the demanding requirements of the EV, the original EV battery still has a lot of life left
- This can be unlocked by **repurposing** the battery and deploying it in different applications – the battery's second life
- These batteries from EV's can be used in the events industry as they still have sufficient power for this new purpose.

Batteries included...?

Hybrids - can the system be backed up or bolstered by battery technology?

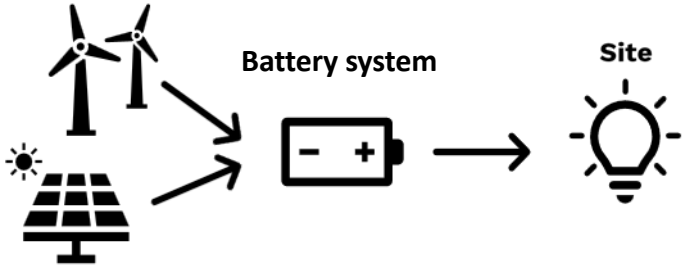


Without Battery system – Generator runs 24/7 to power site, often with very low loads
With Battery system – Generator can be controlled by computer to run only at efficient rates with significant savings

Diesel Off-Grid

A battery system can form island grid when no grid connection available. System can be implemented with generator in a hybrid system

Fuel usage is reduced by up to c.80%

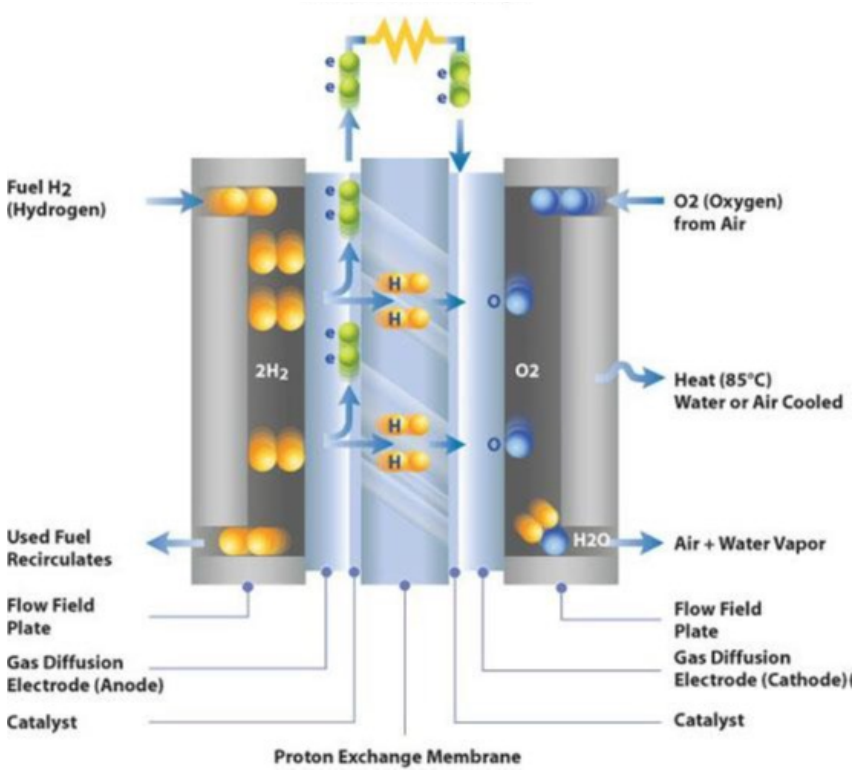


Clean Off-Grid

System can also be recharged from renewables in a hybrid system

Hybrids - can the system be backed up or bolstered by battery technology?

- Like batteries, fuel cells contain an electrolyte and positive and negative electrodes. Also, both fuel cells and batteries generate DC current.
- Unlike batteries the electrodes in fuel cell do not go under electrochemical reactions. Additionally, batteries are discharged but fuel cells run until their supply of fuel and oxidiser (air) is exhausted.
- Hydrogen generates zero (Carbon) emissions; the only exhaust is unused air and water.
- The membrane is impermeable to electrons but lets protons (hydrogen ions) go through.
- The break down of hydrogen molecules happens on the surface of a platinum catalyst.
- **Hydrogen is not a readily available fuel**, and if a fuel cell is equipped with a fuel processor to generate hydrogen some emissions are generated, including CO_2. In general, these emissions are lower than those of comparable conventional energy conversion technologies.
- **A large proportion of hydrogen available is still extracted from fossil fuels**.
- It is also possible to make hydrogen powered internal combustion engines with little to no NOX produced and exhausts of mainly water vapour.



Hydrogen Power Generation

Hybrids - can the system be backed up or bolstered by battery technology?

Combusting hydrogen emits pollutants impacting on air quality. Since this is a combustion process, NOX is still produced. This impact can be mitigated when emissions control technologies are used.

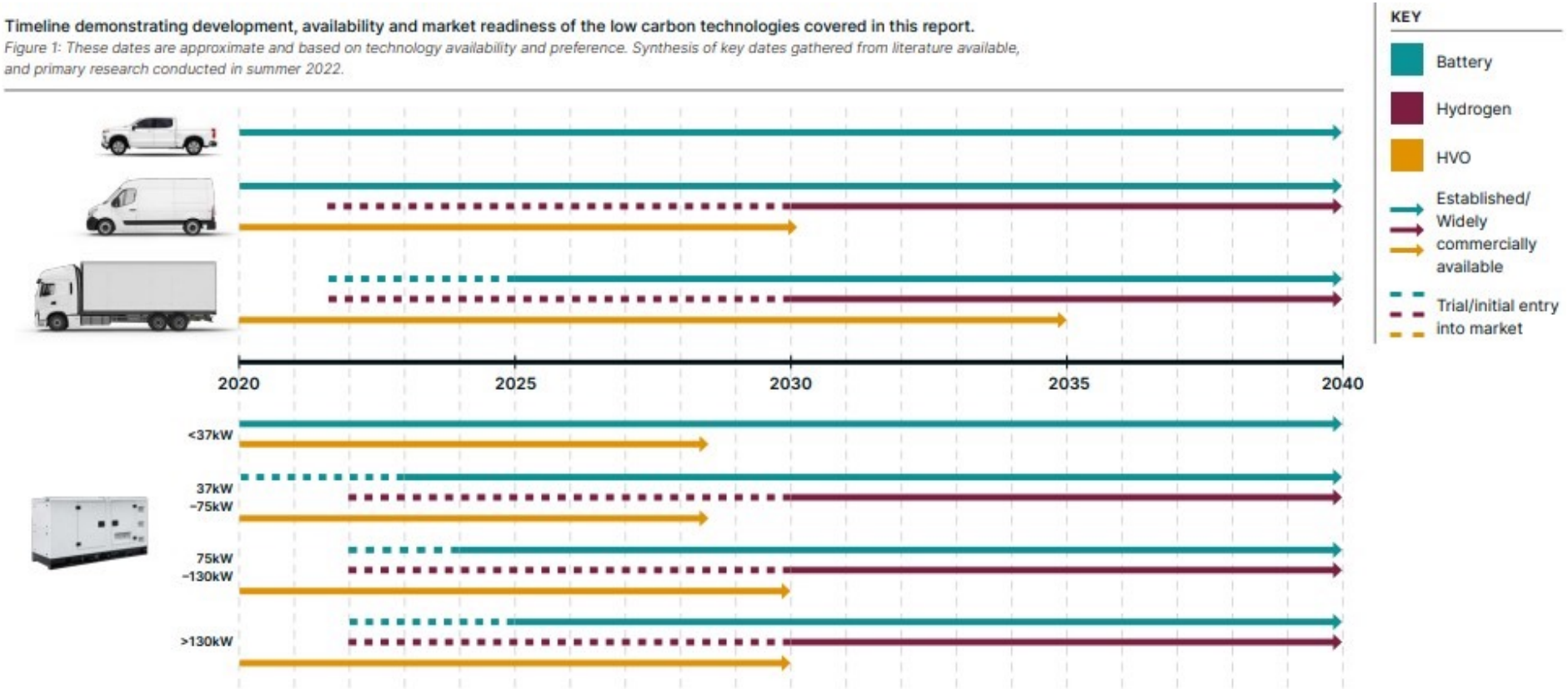
Hydrogen fuel cells on the other hand power electric drivetrains, therefore emitting no air pollutants into the atmosphere. The only emission from the exhaust is pure water that does not impact climate change at this level. A fuel cell system also requires a battery, so similar environmental concerns must be considered as with battery electric technology

When the LCA is considered, the operation of hydrogen systems will lead to an 80% reduction in greenhouse gases compared to the retail diesel equivalent. **This reduction relies on the adoption of 100% green hydrogen.** Currently, the UK market is dominated by grey hydrogen sourced from natural gas.

Current and future market

Timeline demonstrating development, availability and market readiness of the low carbon technologies covered in this report.

Figure 1: These dates are approximate and based on technology availability and preference. Synthesis of key dates gathered from literature available, and primary research conducted in summer 2022.



Need to also consider the transport of goods such as the generators themselves and any other items required for the event. The fleet of vehicles required to accomplish the supply of even a small festival is significant. Thus, it is vital to ensure any savings in CO2 (and equivalent) are not then lost in logistics.

Closing thoughts

- There is a significant role for battery and hydrogen technologies, more narrowly now and more vastly in the future.
- Putting a stop to overestimation of power needs can have an immediate impact on both the cost and environmental impact of location filming even in the absence of other interventions.
- While these technologies continue to develop, HVO is a necessary lower-emission stop gap. However, it must then end as it will always contribute to CO2 emissions.
- Production suppliers are key to unlocking rapid emission reductions. Greater availability will permit wider scale adoption and help break the mistrust of non-traditional power generation methods
- It is vital to support the understanding of the significant impact the next investment choices will have on the net zero ambitions of the industry.

Useful Resources:

BECTU Vision Sustainable Screen Production in Scotland:

https://padlet.com/BECTUVision/bectu-vision-sustainable-screen-production-in-scotland-cnyiyadhmvke13tk

Film London Creative Zero: The Fuel Project report:

https://s3.eu-west-1.amazonaws.com/filmlondon/The-Fuel-Project-Supplier-Guidance-Report-V1.pdf

The Powerful thinking guide 2017 and The Power guide:

https://www.powerful-thinking.org.uk/resources/powerful-thinking-guide-2017/
https://www.powerful-thinking.org.uk/wp-content/uploads/The-Power-Guide_Edition3.pdf

Thank you for your attention