

Beyond Batteries: Hydrogen Fuel Cells for UAVs

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Intelligent Energy Ltd

- Privately-owned
- Experts in PEM fuel cell technology
- Technology range 650W to 120kW
- Headquartered in Loughborough, UK
- International commercial presence
- Circa 200 employees

Commercial offices

Loughborough, UK

HQ, main facility

Japan, Tokyo

Commercial Office

Regional representation

USA, South Korea and China



Class leading air cooled fuel cell technology

Features:

- Operation on dry hydrogen and ambient air
- Robust metal cell construction
- Ideal for hybridisation with battery and/or super-capacitors
- Proven durability and reliability for application environments
- Multiple configuration options providing modular and scalable solutions
- Range of stack options to fit different application requirements
- Low thermal and acoustic signature
- Series and parallel connections possible



Fuel cells for commercial UAVs



Huge increase in
**Operational
efficiency**



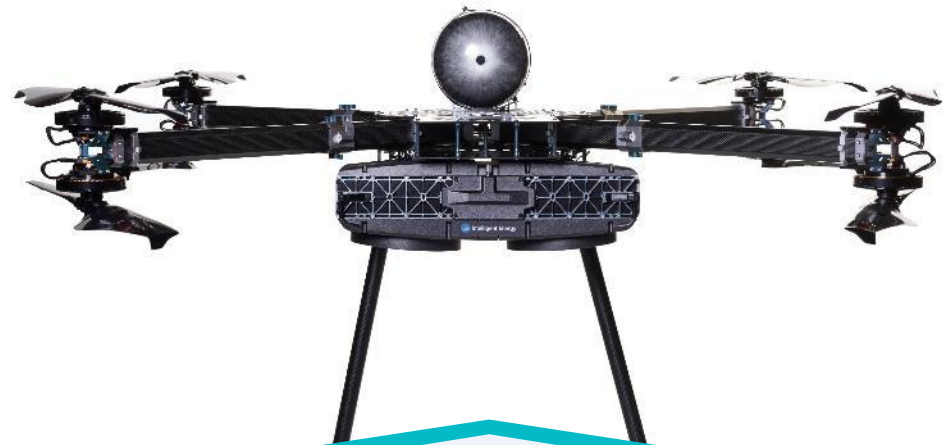
Application enabler.
BVLOS
range requires fuel cells



scalable
technology

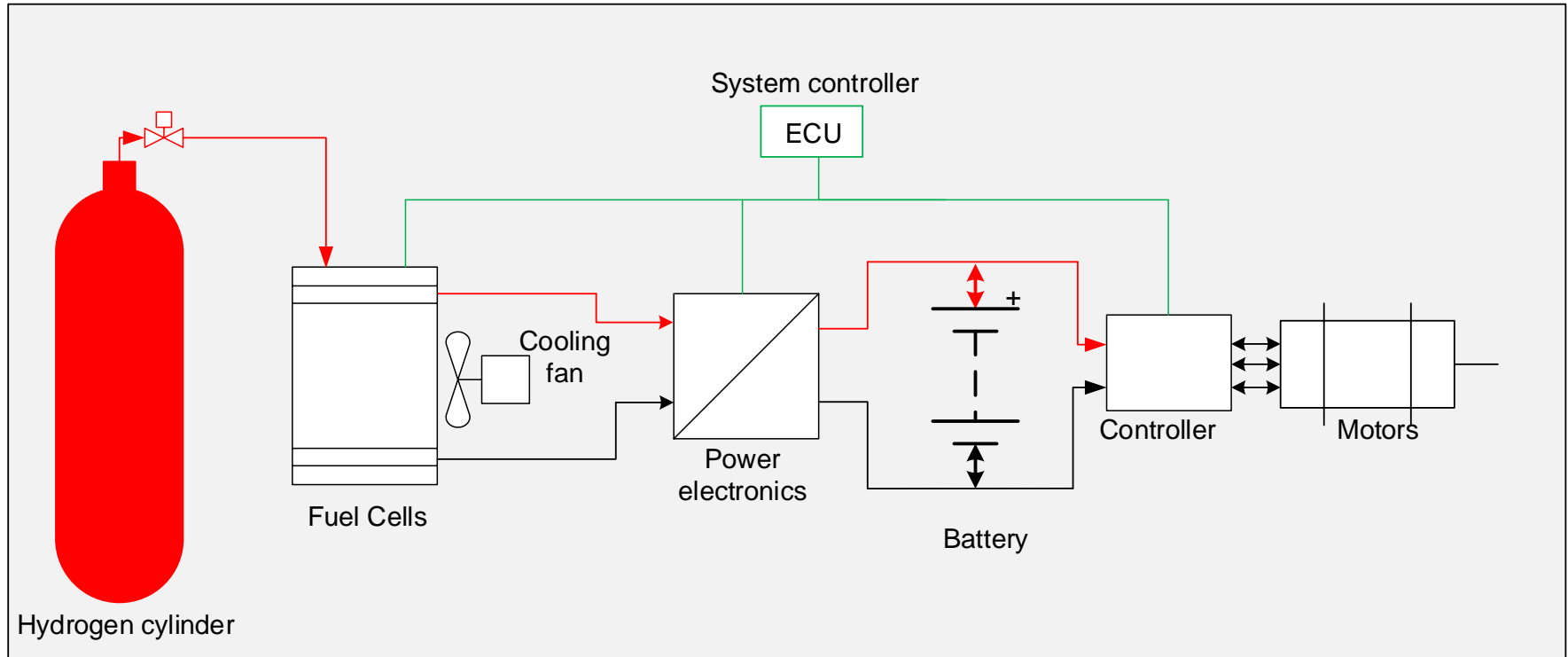


Significantly
longer flight
times



There are challenges to the acceptance of fuel cells, but the solutions are here now.

Fuel cell system



Fuel cells vs batteries for UAVs

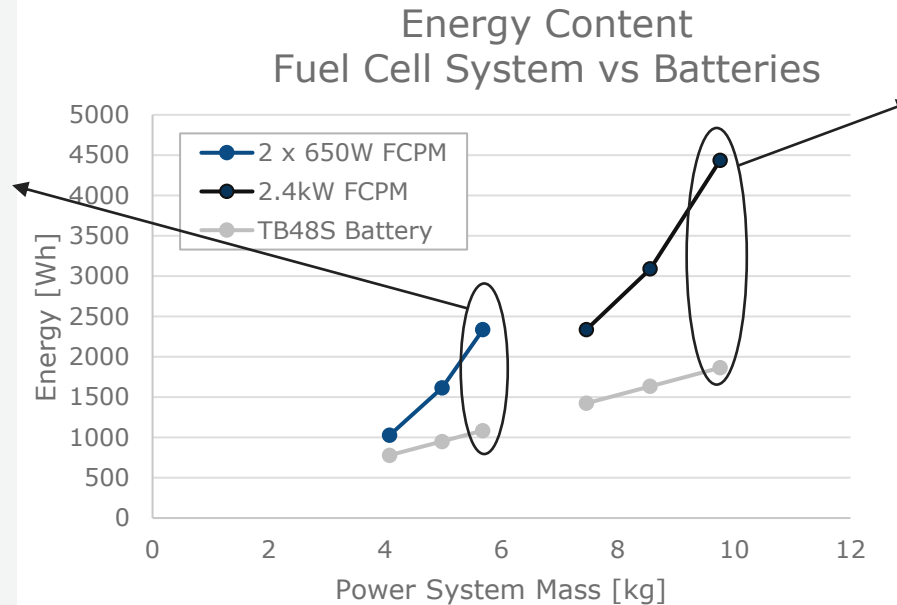
Compressed hydrogen contains more usable energy than a LiPo battery

Example fuel cell system

Fuel cell – 2.48kg
 Battery – 0.46kg
 Cylinder – 3.2kg

Total mass 6.14kg and contains 2336Wh
 = 411Wh/kg
 Typical FT = 108mins

6.14kg of batteries contains 1085Wh
 = 176Wh/kg
 Typical FT = 49mins



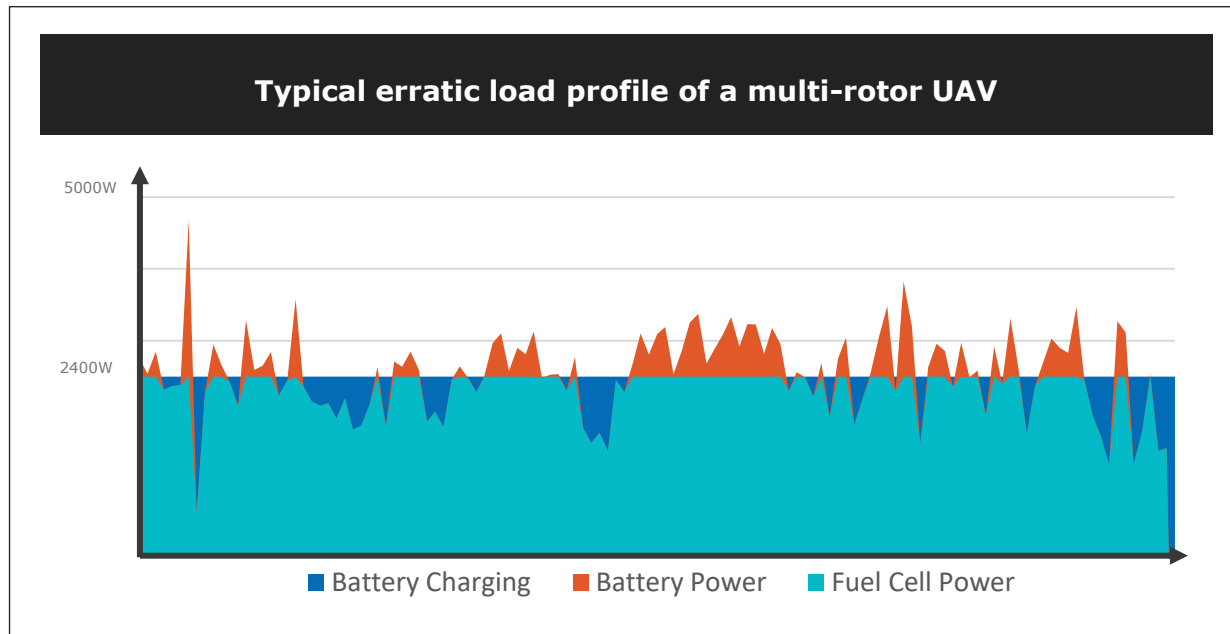
Example fuel cell system

Fuel cell – 3.25kg
 Battery – 0.76kg
 Cylinder – 5.5kg

Total mass 9.5kg and contains 4435Wh
 = 450Wh/kg
 Typical FT = 110 minutes

9.5kg of batteries contains 1800Wh
 = 189Wh/kg
 Typical FT = 45 Minutes

Peak power and battery hybridisation



Peak Power (>2400W) will come from the hybrid battery

While load is less than 2400W, hybrid batteries can be **recharged in flight.**

Hybrid battery cannot be switched out of the circuit, meaning it also acts as **power system redundancy.**

Technology advantages

⊕ At point of use



Quick refueling – typically **less than 2 minutes**

Near **silent operation**

Battery performance with ICE range

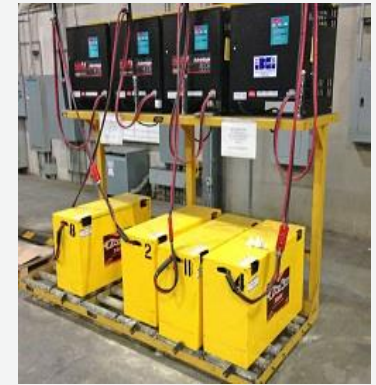
Built in **power system redundancy**

⊕ For your operation

Increased **efficiency**

Enables applications previously impossible with battery UAVs – e.g. **BVLOS range**

Reduced TCO



Significantly longer flight time!

Intelligent Energy's UAV fuel cell product offering

650W and 800W Fuel Cell Power Modules



- **FCC** and **CE** certified
- Includes **all** fuel cell stack management yielding simple “**plug and play**” solutions
- Standard UAV interfaces for **power** and **communications**

2.4kW Fuel Cell Power Module

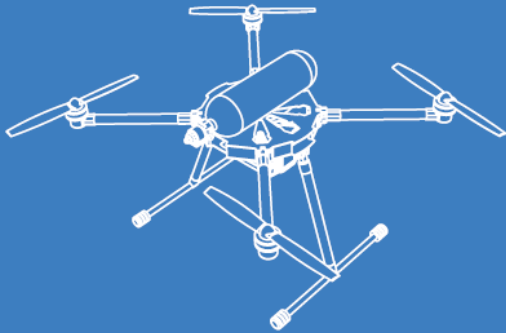


- 2.4kW **covers majority of bespoke and COTS UAVs**, while being light enough to significantly increase flight time
- Two stack design concept allows **flexible configuration** options for UAV mounting
- **FCC** and **CE** certified

Example UAV use case – Typical UAV specification

7kg AUM

1kg payload – **60 minute** flight time



Compact and lightweight UAV designed for up to 1.2kg payloads. Balances good manoeuvrability with excellent lift efficiency. Lighter payloads can fly for upwards of 90 minutes.

25kg AUM

7kg payload – **90 minute** flight time



A medium sized hex rotor, designed to stay within the 25kg (55lb) category. Balances the redundancy of a hex rotor and the lift efficiency suited to long flight times and larger payloads.

Hydrogen challenges for UAVs

- A fundamental part of ensuring fuel cells are adopted by the commercial UAV market is enabling **straightforward access to fuel**
- Additionally, commercial uptake by non fuel cell experienced users can be **constrained by perceptions** around handling of hydrogen
- It is key, that as an industry, with the established gas companies, we need to ensure potential end-users are fully **aware of the facts and educate appropriately**



Hydrogen solutions

- It's not a 'one-size-fits-all' approach and the most suitable solution depends on frequency of refill, portability and size of fleet
- For a captive fleet of fuel cell powered UAVs, a back to base scenario could be applied & fuel cell MHE model is established and proven
- Manual solutions for UAV user to fill smaller cylinders with a compressor
- Passive solutions where cylinders can be delivered ready filled
- NanoSun has developed an automated fill station that offers a connect and button press to simply fill your cylinders on site, minimising downtime
- Refuelling systems can be portable
 - E.g. flight case in the back of a van holding a week's worth of instant fuel



Nanosun.co.uk

Specific example – Power line inspection

- 160,000 miles of power transmission lines in the US.
- Individual transmission lines have to be inspected every 5 years and are done so by helicopter.

Line of sight

\$500/mile

100 miles /month per crew

- Two operators required, including overheads
- **High percentage of downtime**
- Familiarity of equipment and operations

BVLOS

\$65/mile

1000 miles/month per crew

- Single operator
- **More time in the air**
- Increased initial CAPEX

Fuel cells significantly extend range capability

IE fuel cell UAV British customer - ISS Aerospace

- ISS Aerospace designs, builds and operates cutting edge UAVs for a wide range of international clients
- Their systems are designed to collect data under challenging conditions
- ISS developed the SENSUS UAVs, which are fuel cell powered
- Rugged, MIL-SPEC platforms capable of operations in harsh conditions
- IE's 800W and 2.4kW FCPMs were selected by ISS Aerospace to power their UAVs



Market leading UAV applications by Intelligent Energy

MetaVista

- World record flight time achieved of over 12 hours
- Used IE's 800W Fuel Cell Power Module
- MetaVista used a 6-litre liquid hydrogen cylinder



ISS Aerospace

- Completed inspection and detection work for its customer in the Oil and Gas industry
- Used IE's 800W Fuel Cell Power Module
- UAV was also able to complete site safety monitoring throughout the inspection work



Robodex

- Signed a distributor agreement with IE in April 2020 for the resale and maintenance of IE UAV Fuel Cell Power Modules
- One of the first customers to purchase the 2.4kW module following successful trials with the 800W module



2.4kW launch

- Launched to the market in May 2019
- Two 2.4kW modules can also be linked in parallel to provide up to 4.8kW of power without the need for additional hardware



Summary – Fuel cells can transform your operations

Fuel cells behave like batteries, but operate as **long as they have hydrogen supplied**

Increased specific energy density compared to batteries means you can operate for longer

Quick, simple and easy refuelling

Fuel cells **can offer longer flight times with increased payload due** to their increased energy density

Scalable technology applicable to **UAVs and UAM**

Reduced TCO



Fuel cells can transform your operations

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