Intelligent Energy

IE-Soar UAV Fuel Cell Product line update

IE-Soar™ fuel cells

- **3 to 5 times** the flight time over batteries
- **Long lifespan estimate –** 1,000 flying hours or one-year commercial warranty. 1500–2500-hour lifespan.
- Electrical fans **only moving parts** – no mechanical maintenance required and no risk of mechanical failure
- **Negligible noise** from fans
- **No tuning necessary** for varying season or environmental conditions
- **Minimal maintenance** (10 mins/month assuming UAV flown at least twice a month)
- **2-3 minute refueling**
- **Zero emissions**

About Intelligent Energy

Our Mission

To design and manufacture commercially viable fuel cell products to unlock the benefits of hydrogen, enabling our customers to have class leading, reliable and affordable zero emission products.

- Intelligent Energy (IE) is a privately-owned fuel cell engineering company
- Experts in PEM fuel cell technology
- Approximately 190 employees
- Products for automotive, stationary power, Materials Handling Equipment and Aerospace markets
- Intelligent Energy Ltd. is credited with Quality ISO 9001:2015, Environmental ISO 14001:2015 and Occupational Health & Safety ISO 45001:2018

Commercial offices

Loughborough, UK, HQ, main facility

Japan, Tokyo, Commercial Office

Regional representation

USA, Korea and China

Key facts about fuel cells

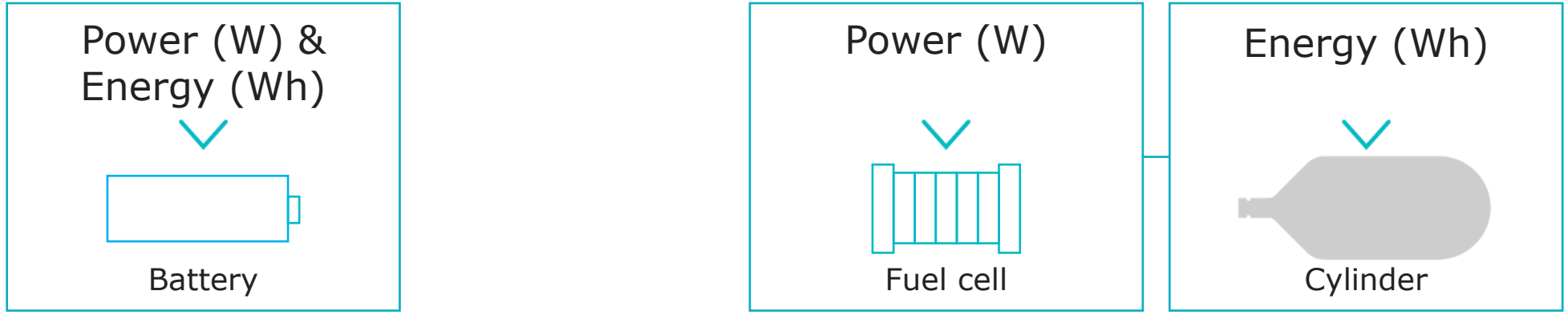
A fuel cell is not a battery!

- Fuel cells **generate** electrical energy from chemical energy
- Energy is produced through an **environmental friendly** electrochemical reaction (it operates quietly and requires minimum maintenance)
- The fuel is **hydrogen**. It is combined in the fuel cell with oxygen from the air to produce electricity and pure water
- As long as you provide hydrogen to the fuel cell, you can keep generating **electricity**

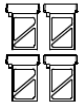
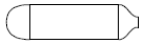
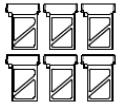
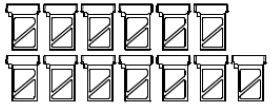
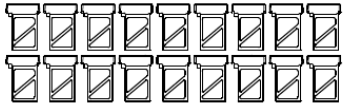
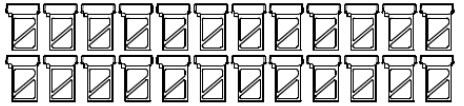
Power vs energy

Power	>	This relates to the lifting capability of the power system. The battery equivalent is discharge rating (C-rating) or discharge current (A). A battery has a continuous discharge limit (peak power).
Energy	>	This is how long you can stay in the air. The battery equivalent is capacity, for example mAh or Wh.

A battery has both power and energy limits in the same hardware.
In a fuel cell system these are separate.



Energy comparison: Hydrogen cylinder vs DJI M600 TB48S battery

Cylinder Size [L]	Cylinder Mass	Usable Energy		DJI TB48S Wh Equivalent	TB48S Mass
1.5L	**0.97**kg	**482**Wh			**2.5**kg
2.0L	**1.25**kg	**780**Wh			**4.1**kg
4.7L	**2.56**kg	**1614**Wh			**8.4**kg
6.8L	**3.3**kg	**2336**Wh			**12.2**kg
9.0L	**4.0**kg	**3091**Wh			**16.2**kg
10.8L	**4.3**kg	**4209**Wh			**23.5**kg

IE-Soar™ UAV fuel cells – the most power dense certified fuel cells available on the market

Manufacturer	Doosan	Horizon Energy Systems	Plug Power	Honeywell	BM Power /Hypoint	Intelligent Energy
Model	DP30	Aerostack 1500	ProGen 1kW	FC1200U	N/A	IE-Soar™ 2.4kW
Rated Power (kW)	2.6	1.5	1.0	1.2	2	2.4
Weight (kg)	7.3	2.8	3.5	4.0	4.4	4.4
Cooling	Air-Cooled	Air-Cooled	Air-Cooled	Liquid-Cooled	Air-Cooled	Air-Cooled
Temperature Range (°C)	0-35	0-35	?-40	-20-45	-40-55	-5-40
Lifespan Estimate (hrs)	?	?	3000	3000	?	2000
Altitude (m)	?	?	5000	4500	?	3500
Specific Power (W/kg)	**356**	**536**	**286**	**300**	**454**	**545**






IE-Soar™ customer applications

ISS Aerospace

- Sensus 4 quadcopter. 90 minutes flight time with a 1kg payload.
- Serves inspection markets
- Applications include surveying, pipeline inspection and H_2S gas detection

MetaVista

- Broke a Guinness World Record in 2019 for longest flight time on a multi-rotor UAV using the IE-Soar™ 800W Fuel Cell
- Achieved 12 hours and 7 minutes flight time with a 6L LH_2 cylinder

Delair

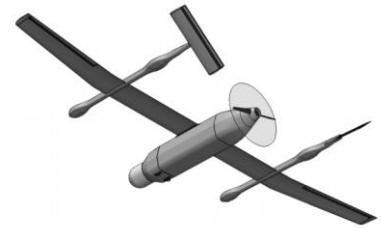
- Developed a fixed wing 'Hydrone' powered by the IE-Soar™ 800W Fuel Cell
- Applications: agriculture inspection and military

Harris Aerial

- Developed a mutli-rotor Hydrone with the IE-Soar™ 2.4kW fuel cell.
- 90 minutes flight time with a 10lb payload.
- Applications: oil and gas pipeline inspections and LiDAR scanning

Zepher Flight Labs

- Developing the fuel cell powered Z1 VTOL fixed wing UAS under a US Army contract.
- Powered by 2 x 800W IE-Soar™ Fuel Cells



UAV power supply comparison

Attribute	IE-Soar™ 2.4kW Fuel Cell	Internal Combustion Engine	LiPo Batteries
UAV Endurance	High	High	Low
Maintenance	10 mins/month of power cycling	Overhaul every 75-100 hours	Charge cycles every 50 cycles or 3 months
Lifespan estimate	2,000 hours	300 hours	200-300 charge cycles
Pollution	Zero	High	Zero
Vibration	Negligible	High – dampers required	Zero
Noise signature	Negligible	High	Zero
Environmental tuning	N/A	High - carburettor tuning depending on operating altitude and season	N/A
Ease of use	Straight forward after training	Straight forward after training	Easy
Power supply redundancy	Yes	Yes	No
Total Cost of Ownership	Medium	High	Medium

Intelligent Energy's certified IE-Soar™ product range

- FCC and CE Certified
- Integrated with Ardupilot flight controller software
- **World leading specific power density** fuel cell modules enabling **world leading fuel cell energy density solutions**

2nd place in NIST US First Responder UAS Endurance Challenge Finals

The National Institute of Standards and Technology (NIST) UAS Endurance challenge scored over 40 UAS solutions against a series of criteria including:

- Safety
- Endurance
- Technical and handling inflight
- Set up time
- System cost

UAS CHALLENGE 2021
ELEVATE • ENDURE • SUPPORT

https://www.firstresponderuaschallenge.org/

Gryphon UAV powered by IE-Soar 2.4kW FCPM

IE Soar™ 2.4kW FC powered Gryphon drone

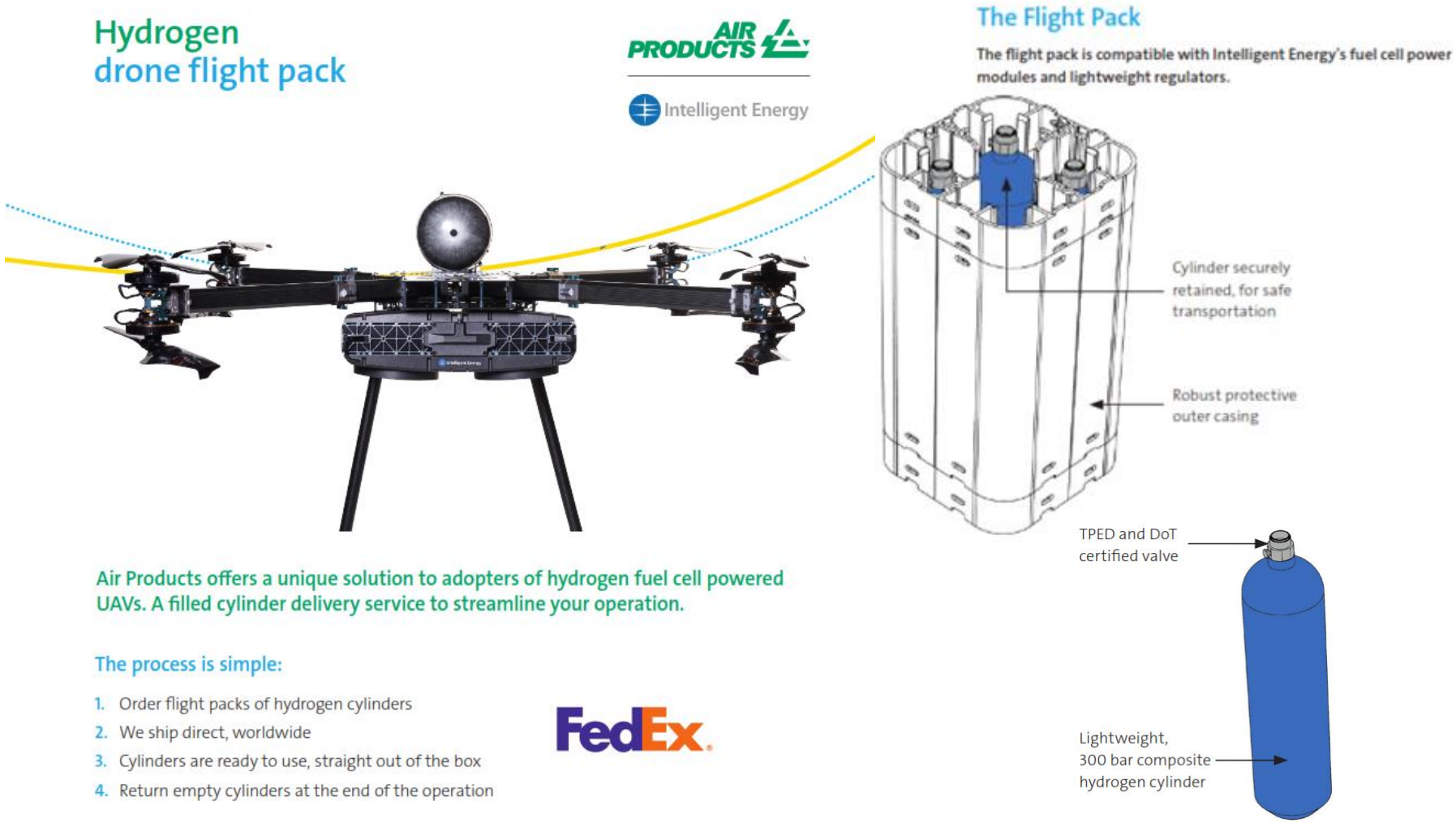
- Up to **120 minutes flight time** with **5kg/11lb payload** at 23kg/54lb MTOW
- Commercially available from IE's integration partners

Hydrogen refuelling – booster pump

- Refilling booster pump equipment (air driven or electric driven options) - $15k
- Two flights per h_2 cylinder from local gas supplier
- Booster pump lifespan – approximately two million pressure cycles

Hydrogen refuelling – global UAV hydrogen cylinder delivery service

- 4 x filled hydrogen cylinders in a ‘flight pack’ (c. 90-120 minutes flight time per cylinder)
- Shipping to any physical address in the world within 72 hours.
- Delivery service includes delivery and collection of cylinders.



IE-Soar™ 2.4kW safety case and reliability

- CE and FCC certified product
- Dual power system redundancy
- 1000-hour commercial warranty
- Full safety and reliability analysis to IEC 61508
- DOT certified hydrogen cylinders – bullet and drop tests

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