


## Developing high power fuel cell systems for automotive applications

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# Intelligent Energy (IE) Overview

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The image shows the Intelligent Energy logo and name embossed on a metallic surface. The logo is a circular emblem with a stylized 'IE' inside, and the words 'Intelligent Energy' are written in a sans-serif font below it.

- 30 years fuel cell experience**, experts in PEM technology
- Focus on **smaller** and **lighter** products
- Products for a range of markets**, including automotive and aerospace industries
- Privately-owned, headquartered in the UK**, with international commercial offices
- Proprietary high-power** fuel cell technology

# Intelligent Energy (IE): fuel cell solutions provided across multiple sectors supporting decarbonisation



IE-Soar™ fuel cell modules enables UAV fleets to fly significantly longer, with minimal downtime, improving productivity. The modules come in a range of power outputs.



IE Lift™ modules are self-contained, compact, power-dense zero emission power solutions. The modules come in a range of power outputs. They can be easily integrated into a range of static and motive applications including material handling.



IE-Drive™ is our proprietary, high power system designed for volume manufacturing, whilst delivering low temperature operability and simplified balance of plant. The result is a compact, modular, system with fewer components, improved reliability and overall reduced system cost.

# Fuel cells are back on the agenda for automotive OEMs

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- ❑ The opportunity for fuel cells in automotive applications is growing globally as manufacturers recognise the limitations of battery technology
  - ❑ Range vs weight
  - ❑ Utilisation – duty cycles – vehicle and fleet productivity
  - ❑ Sustainability & supply chain
- ❑ Not limited to the manufacturers with their own technology (Toyota & Hyundai); car OEMs like BMW, JLR, Stellantis and truck/bus OEMs (Volvo, NewFlyer) developing FC vehicles
- ❑ Recognition that for some challenging applications hydrogen fuel cells have strong benefits:
  - ❑ Large SUVs and Taxis
  - ❑ Heavy duty / long range commercial vehicles
- ❑ Challenges remain, most significantly the availability of infrastructure, cost and 'green-ness' of hydrogen as well as the cost and availability of fuel cells

# TCO is a key driver – fuel cells becoming cost competitive for automotive use?

## Passenger vehicle



- Hydrogen will outcompete BEVs by circa 2025 for vehicles with very high range (650 km)
- Next will come sub-segments such as SUVs and large passenger cars with range requirements of + 500km
- For the mid-size car with a 400 km range, FCEVs will reach cost competitiveness around 2030

## Truck



- Fuel costs are a significant component of the cost for trucks, up to 60 per cent of TCO, so a low hydrogen cost is key to uptake
- Fuel cell MDTs and HDTs could become lower-cost alternatives to comparable BEVs as soon as 2025
- Fuel cell trucks may break even with ICE before 2030 depending on the relative cost of hydrogen vs diesel

## Bus



- Fuel cell buses are expected to outcompete full battery buses by 2025 if the range exceeds 400 km
- By 2030, urban short-range fuel cell and electric buses reach cost parity
- For short-range buses the lowest-cost application will depend on local conditions - costs of electricity vs hydrogen & infrastructure

# Major automotive project – establishing IE’s UK fuel-cell capability for large passenger cars, buses and heavy-duty transport



## Project Esther



- ❑ Project ESTHER secures the UK's position at the vanguard of a global hydrogen fuel cell Electric Vehicle (FCEV) market and in the race to zero transport emissions
- ❑ Centred on the advantageous evaporatively cooled fuel cell system from IE, with Alexander Dennis and Changan as OEM partners
- ❑ A modular fuel cell system is being designed for manufacture, integrated and tested in the real world for the transport market
- ❑ Project Esther will set-up a UK fuel cell production capability to deliver large passenger car, bus and heavy-duty transport zero emissions drivetrain solutions.



# The EU-funded STASHH project is aiming to standardize fuel cells for heavy duty applications

## Developing an open standard for fuel cell modules:

- Size,
- Interfaces,
- Control,
- Test protocols

## 9 OEMs from key sectors including:

- Road,
- Off-road,
- Rail,
- Maritime & inland waterway

## 11 fuel cell manufacturers (inc. IE)



Towards a standardised fuel cell module

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under Grant Agreement № 101005934. This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation programme, Hydrogen Europe and Hydrogen Europe Research.

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# H2GVMIDS – Feasibility study for trials of 43t fuel cell trucks

- ❑ The UK's Department for Transport's Zero Emission Road Freight programme is funding a feasibility study for hydrogen fuel cell powered heavy goods vehicles (HGVs)
- ❑ The consortium 'H2GVMids', was developed by the Energy Research Accelerator, with support from EDF & the Midlands Engine. IE is the UK fuel cell partner.
- ❑ With 90% of the UK's people and businesses within four hours travel time, the Midlands is the focal point of the freight and logistics sector
- ❑ The partnership will prepare the ground for a green-hydrogen fuelled 44-tonne truck demonstration programme in the Midlands







# Extending into Aero, alongside Auto sectors for fuel cell platforms

## Collaborating to develop a ground-breaking hydrogen propulsion system powering **Zero Emissions Aircraft**

### H<sub>2</sub>GEAR HOW IT WORKS



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In partnership with:



Global Technology Centre Bristol



### THE BENEFITS

**£54M+**  
initial investment  
(£27.2M Gov, matched by industry)

**FURTHER  
£200M+**  
R&D investment  
to follow

**UNLOCKING  
a market worth  
£16.8Bn**

**3,120**  
jobs created in the  
**UK**

**ZERO**  
**CO<sub>2</sub>** emissions  
air travel

**100%**  
**UK** system  
content

**2026**

First potential  
entry into  
service



“ Working with our partners, and made possible by Government investment, GKN Aerospace will develop and industrialise the breakthrough technology to fly aircraft with zero CO<sub>2</sub> emissions by the mid-2020s. ”

Russ Dunn, CTO GKN Aerospace

# IE Drive: Two high power fuel cells, with common technology

## IE-Drive HD

### Bus and truck



Compact self-contained unit to allow easy integration for heavy duty vehicle applications

50-80kW continuous power ideal for bus and truck applications

Modular: multiple systems can be operated in parallel to achieve 500kW+

## IE-Drive P100

### Passenger car and light commercial



Engine block' format means the system is ideal to fit into existing vehicle designs

>100kW peak power matched to passenger and light commercial vehicle applications

Up to 70kW continuous power output depending upon chosen vehicle cooling system design

# Evaporatively cooled HD fuel cells from Intelligent Energy

## De-ionised water is pumped directly into the fuel cell stack

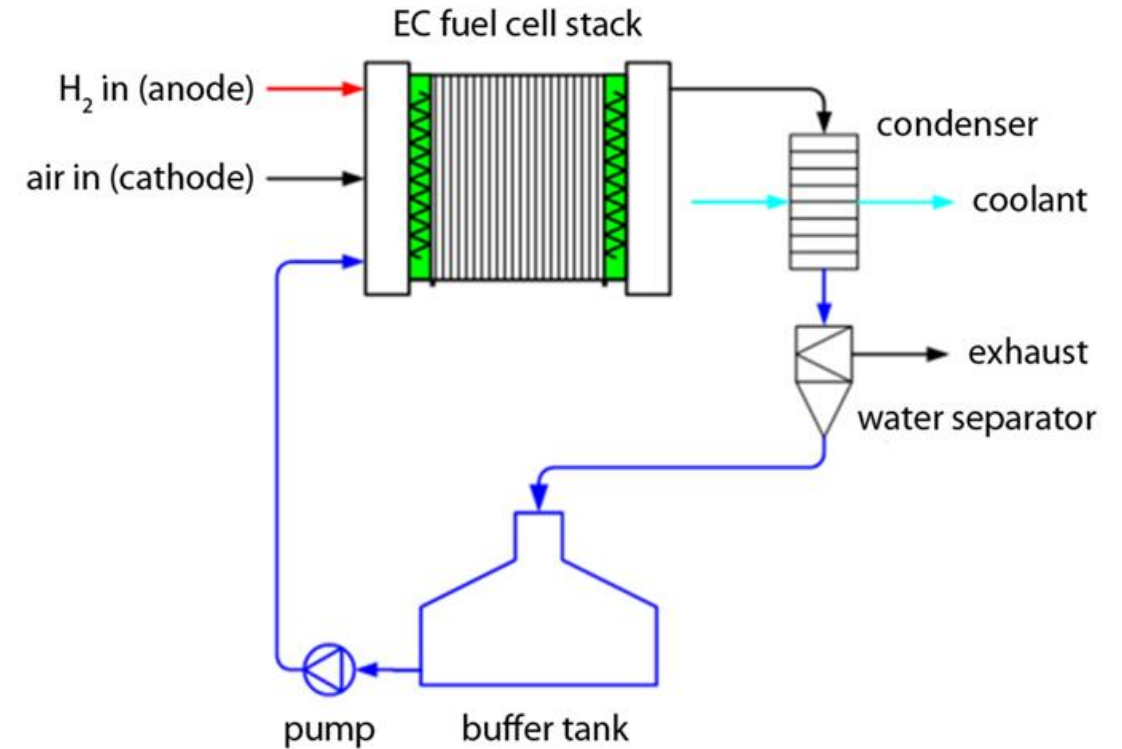
- Humidification
- Extraction of heat through evaporation
- No separate cooling plates
- No external humidifier

## Liquid water is recuperated from the cathode exhaust gas

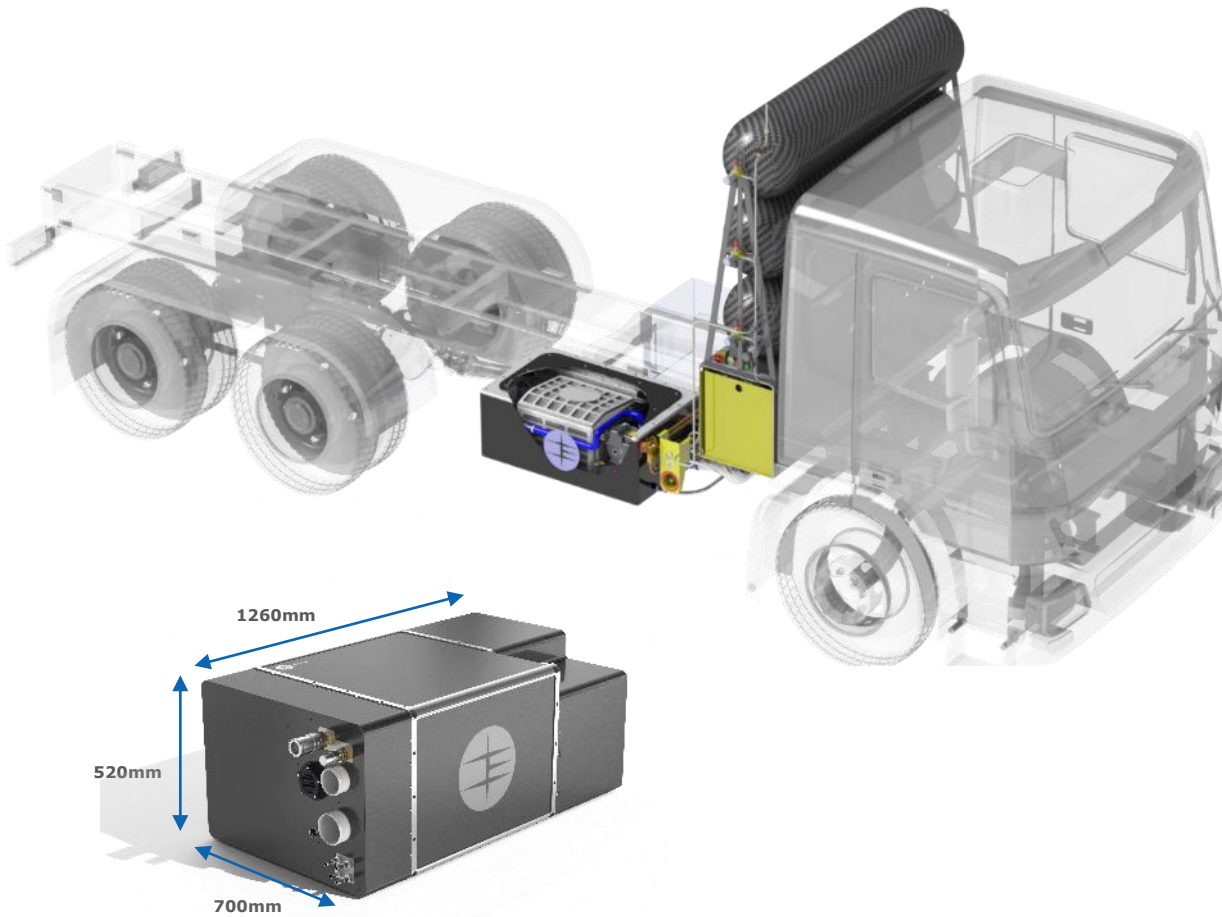
- Using a condenser
- Condensate is extracted via a water separator
- Water returned to a buffer tank

## The condenser may be cooled with any suitable media

- Air cooled arrangement has lowest thermal inertia



# Working with Tri-Ring: integrating IE-Drive HD



## IE-Drive HD

### Supplied in the main FC module

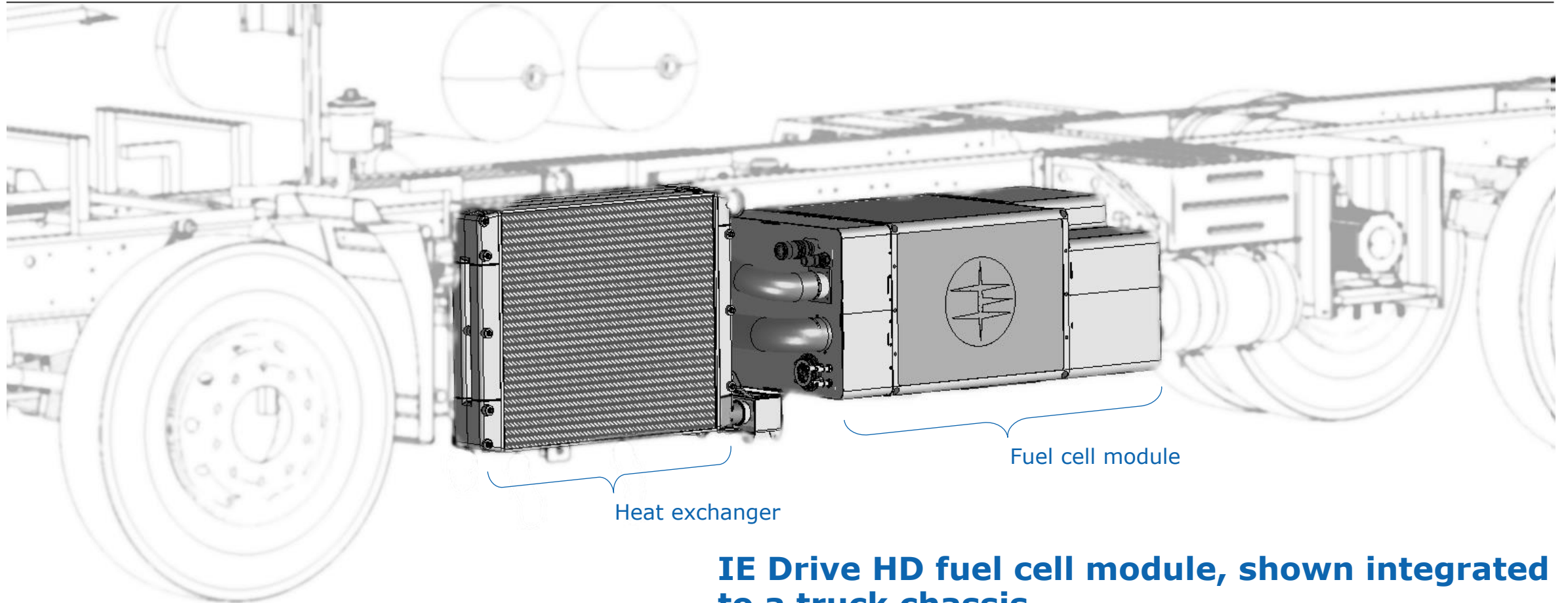
- Fuel Cell Stack Module
- Primary Coolant Module
- Hydrogen subsystem
- Fuel Cell Control Module
- Air Delivery Module (including compressor)
- High Voltage Module

### Supplied as separate modules

- Thermal module (condenser) including water capture
- Exhaust Module
- Air filter
- DCDC (optional)

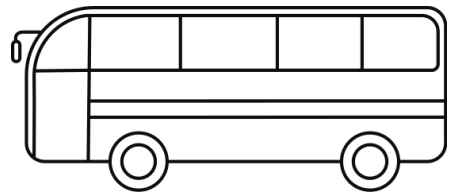


# Working with Tri-Ring: integrating IE-Drive HD

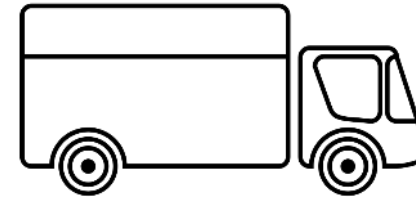




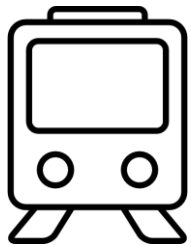
# IE-Drive HD: a modular system applicable to a range of applications



Bus / coach



Truck / van



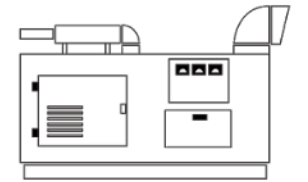
Rail



Marine



Construction /  
Off-highway



Stationary

# IE-Drive HD: Specification



## Complete fuel cell system including balance of plant

- Continuous (net) power output 50 to 80kW
- Peak power output 97kW
- Peak efficiency 55%
- Mass <250kg
- Volume 460l
- Environmental IP67 rated
- Interfaces Can 2.0b  
SAE J1939

# IE scaling up: planned 2GW global manufacturing centre, supporting the UK's fuel cell supply chain

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- Fuel cell manufacturing facility with expanded presence (UK/Europe/ global)
- State-of-the-art Gigafactory facility (2GW pa) to support volume manufacture of IE fuel cells
- Covering fuel cell stack modules and fully integrated powertrain systems across all application areas; targeting >75% UK supply chain content
- Utilising the capabilities of a UK-centric supply chain; IE personnel growth to 800 staff and indirect supply chain growth of 1,000+ personnel

# Summary

IE-Drive HD is supplied as a complete, fully integrated fuel cell system **making integration easier**

**UK manufacturing base** for cells, modules and systems - scaling to **GW scale**

Our innovative technology means our **FC system is smaller and lighter**

**Competitively priced** today with a roadmap for **significant cost reduction**

Our fuel cells are designed to provide the **power, range, and efficiency** that our customers need

We tailor our **warranty** and **support** package to meet our customers requirements



## Confidence to deliver

30 years fuel cell development experience

Proven experience within automotive

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