ZERO EMISSION PUBLIC TRANSPORT

The London taxi is an iconic vehicle, with currently over 21,000 in operation in London alone. A fleet of diesel vehicles this size that operates for many hours of the day inevitably makes a substantial contribution to traffic emissions, not just of CO_2 but also nitrogen oxides, hydrocarbons and particulates. Changing to a zero emission taxi would have a marked effect on the pollution levels in London.

While the taxi looks and drives like an iconic London black taxi, the fuel cell black cab is powered by an Intelligent Energy hydrogen fuel cell system hybridised with lithium polymer batteries; allowing the vehicle to operate for a full day without the need for refuelling. The taxi is capable of achieving a top speed of over 80 mph (128 km/h), refuels in about five minutes and produces no emissions other than water vapour.

Lotus Engineering has packaged the full propulsion system including the fuel cell and has designed control systems to optimise performance of both the fuel cell and electric drive systems.

VEHICLE SPECIFICATION

Overall Length:	4,580 mm
Overall Width:	2,036 mm
Overall Height:	1,834 mm
Weight:	2,180 kg
Motor:	3-phase (100 kW)
Fuel Cell:	PEMFC (Intelligent Energy)
Fuel Storage:	Pressurised hydrogen tank (350 bar)
Battery:	Lithium-ion polymer battery (14 kWh)
Range:	160 miles (257 km)
Top Speed:	80 mph (128 km/h)
Acceleration:	0-60 mph (0-97 km/h) 15.5 seconds

HYDROGEN FUEL CELL

The configuration of the propulsion system for this vehicle is Intelligent Energy's fuel cell system with high pressure hydrogen storage, connected via a DC-DC converter and high voltage battery pack to an electric motor, which powers the rear wheels through a single speed transmission.

The hydrogen powered fuel cell acts as the range extender to the electric drive system. This allows a smaller battery pack and creates a total powertrain with zero tailpipe emissions. With an appropriate hydrogen distribution network in place, the fuel cell could be replenished quickly in service, unlike charging the battery of a pure electric vehicle.

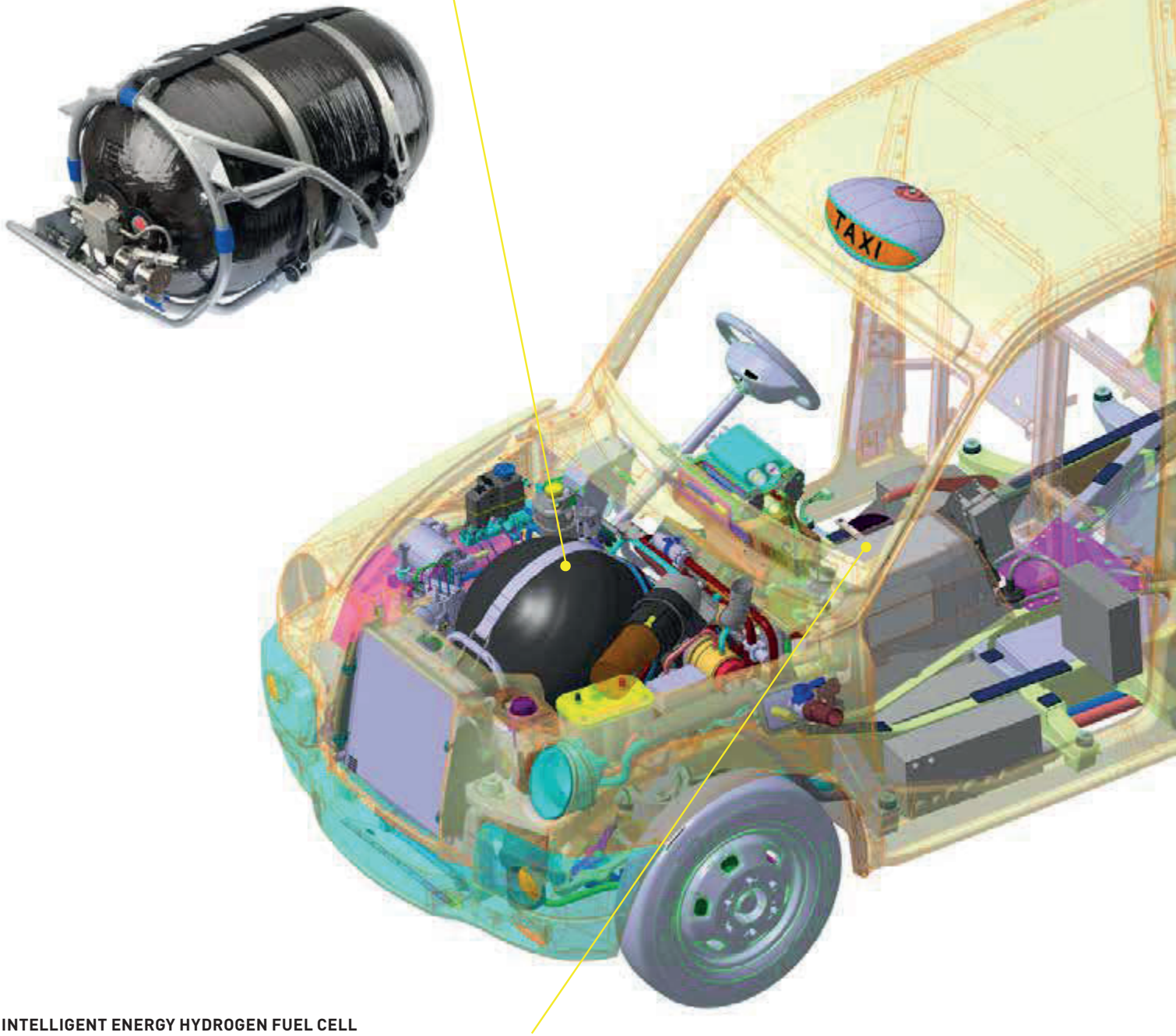
In the normal operation mode of the vehicle, the power for the electric motor comes from the battery pack. When required, the fuel cell operates on the most efficient part of its cycle to charge the battery pack. This can occur whilst the vehicle is in motion or stationary waiting on a taxi rank.

HYDROGEN FUEL CELL TAXI
OVERVIEW

HYDROGEN STORAGE TANK

Packaged into the front of the vehicle is the hydrogen storage tank. At this stage a 350 bar system has been chosen, with a tank capacity of 3.7 kg. This pressure rating is compatible with the existing UK hydrogen refuelling facilities and the size of tank sufficient to exceed the 155 miles (250 km) target range.

The installation design has been protected for a 700 bar tank, which could be used with higher pressure refuelling stations and would give the vehicle a greater range.



INTELLIGENT ENERGY HYDROGEN FUEL CELL

The fuel cell system is a development of two Intelligent Energy single stack evaporatively cooled modules which together provide an output of 30 kW. A single air delivery subsystem reduces system losses and is mounted remotely from the main fuel cell power module to aid packaging.

A bespoke liquid/liquid plate heat exchanger enables the heat generated to be used in conjunction with waste heat from other electrical components to heat the vehicle cabin. This is then coupled to a conventional radiator located at the front of the vehicle to remove excess heat.

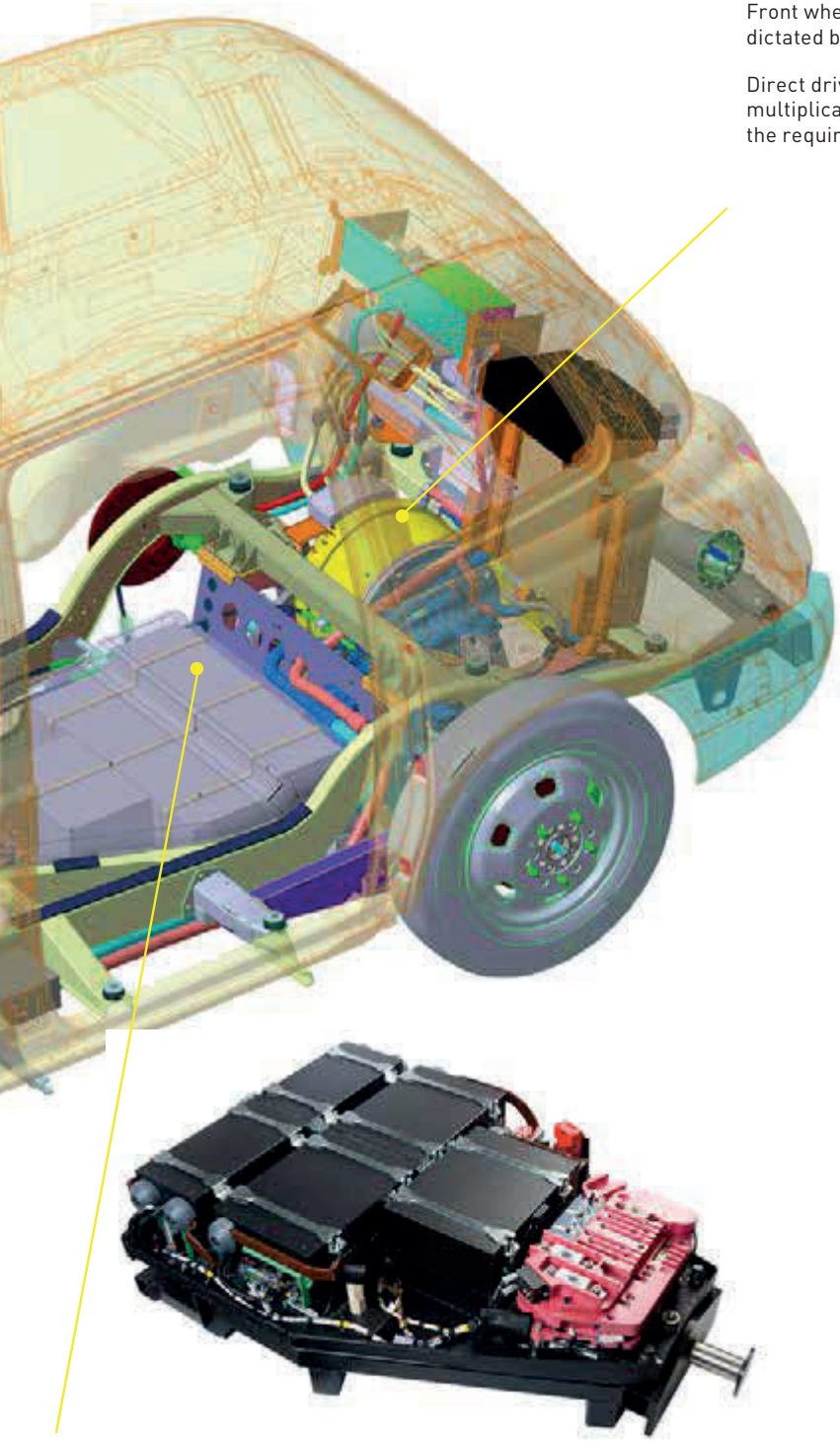
The stacks are housed within the fuel cell power module which is positioned in a modified vehicle transmission tunnel.

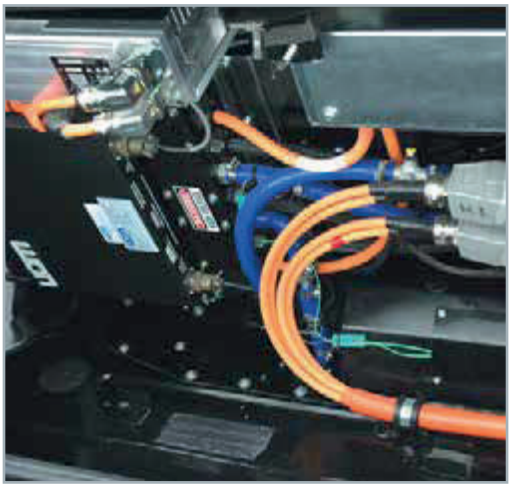
ELECTRIC MOTOR AND GEARBOX

An AC brushless electric motor, with a peak power of 100 kW providing continuous power of 50 kW. This drives the rear wheels through a single speed transmission.

Front wheel drive was considered but rejected because of the wheel angle dictated by the turning circle requirements of a registered London taxi.

Direct drive hub motors on the rear were also considered but without the multiplication factor from a gear box, existing hub motors could not provide the required torque to enable the taxi to meet its performance targets.





BATTERY STORAGE

The 400 V, 14 kWh battery back is constructed from lithium polymer cells with a battery management system to monitor charge, discharge and control voltage balancing of the cells.

Modular construction allows it to be packaged into the chassis beneath the passenger compartment without raising the floor or causing any reduction in ground clearance.

ELECTRIC PROPULSION

A taxi's operating cycle of stop/start in city traffic makes it ideally suitable for an electric drive system with the ability to recover energy through regenerative braking. A large proportion of London taxis spend the day just operating in the centre of London, but if requested they will go further afield.

A taxi needs a range of 150 miles (241 km), the normal distance covered in a shift but also the ability to be refuelled quickly to get it back out mid-shift for the next fare.

For these reasons, a battery electric propulsion system alone is too limited. The size, weight and cost of the battery packs would be prohibitive for the range required and the recharging time would also limit the practicality in taxi applications.

A series hybrid configuration using the hydrogen powered fuel cell developed by Intelligent Energy acting as the range extender is the solution in this collaboration.

The drive system is an AC brushless electric motor, with a peak power of 100 kW and a continuous power of 50 kW. This drives the rear wheels through a single speed transmission.

PACKAGING

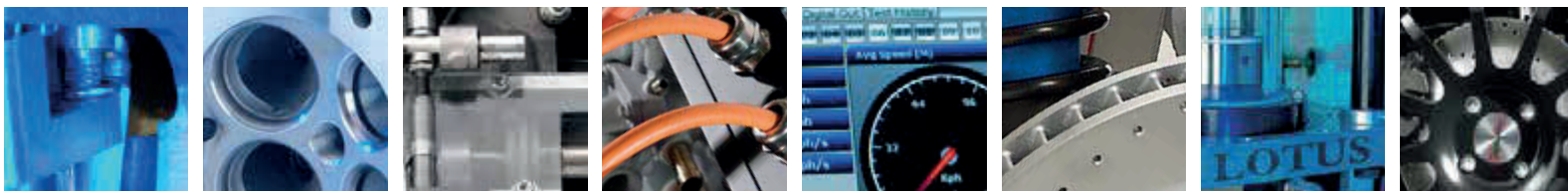
Careful packaging has been necessary to maintain the current forward luggage storage compartment and preserve the existing passenger space, providing capacity for five occupants and wheel chair use.

The fuel cell module and heat exchanger are chassis mounted and installed from underneath the vehicle. Packaged into the front of the vehicle is the hydrogen storage tank. At this stage a 350 bar system has been chosen, with a tank capacity of 3.7 kg.

The electric motor and gearbox are housed under the rear floor of the taxi, where the live rear axle is normally located and are mounted on their own subframe.

A fully independent trailing arm and lateral link system has been designed to fit in the package space available without any modifications to the vehicle structure.

Apart from minor revisions to the centre console in the driver's compartment, the interior of the taxi remains unchanged from the standard vehicle. Two in-car displays have been incorporated into the vehicle, one to give the driver information about the electrical systems and a display in the passenger compartment informing them of the way the vehicle is operating.



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