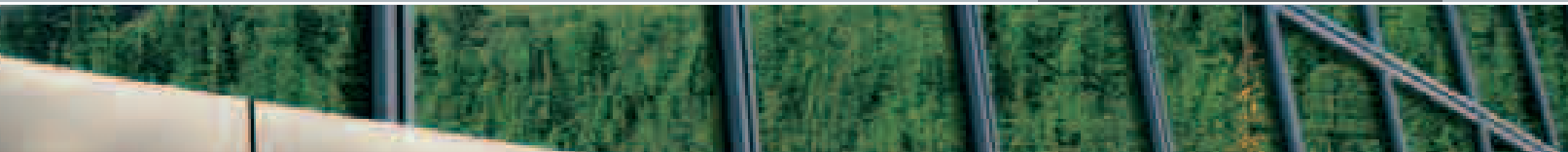
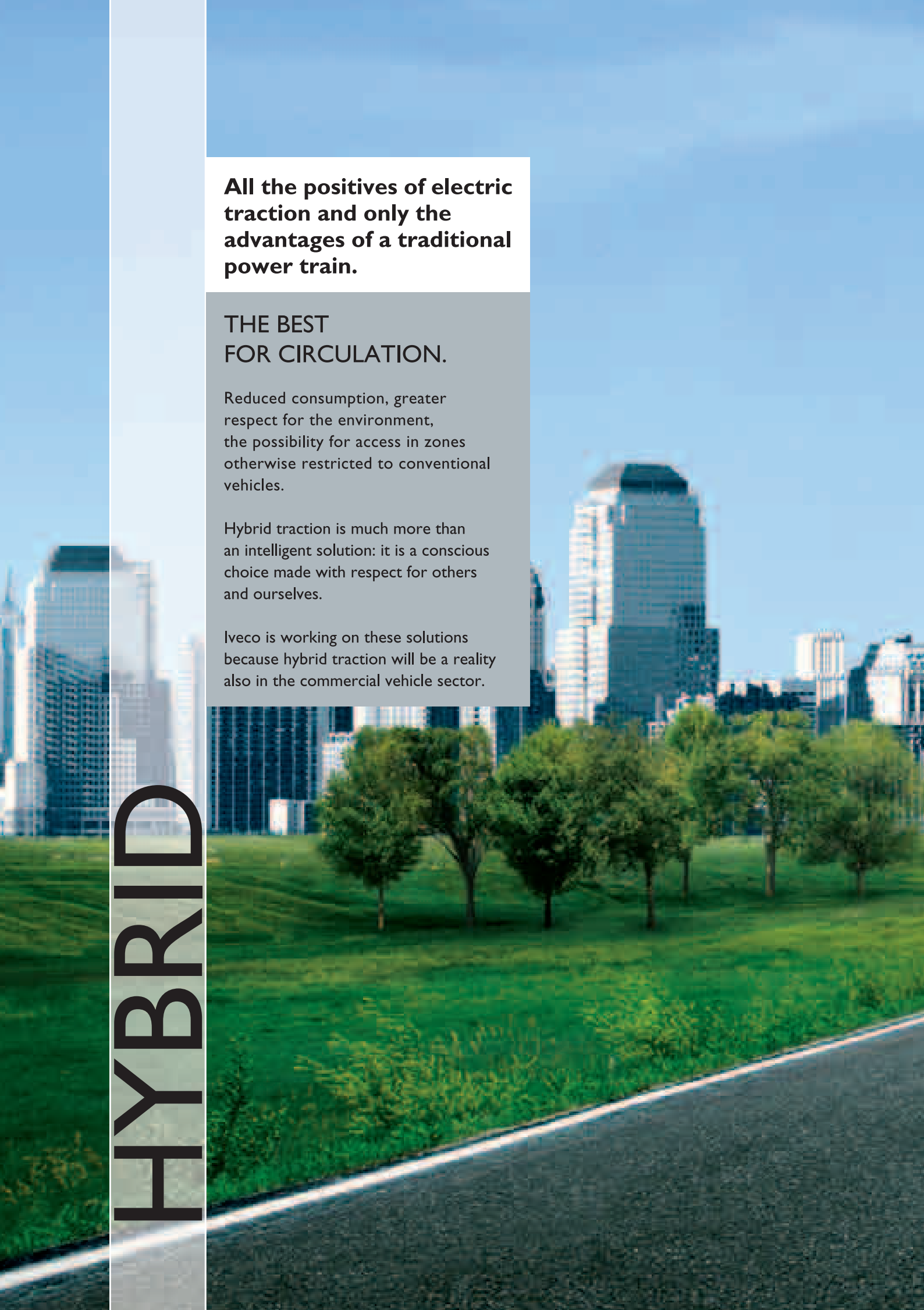
HYBRID VEHICLES:
THE INTELLIGENT ALTERNATIVE.

IVECO





HYBRID

All the positives of electric traction and only the advantages of a traditional power train.

THE BEST FOR CIRCULATION.

Reduced consumption, greater respect for the environment, the possibility for access in zones otherwise restricted to conventional vehicles.

Hybrid traction is much more than an intelligent solution: it is a conscious choice made with respect for others and ourselves.

Iveco is working on these solutions because hybrid traction will be a reality also in the commercial vehicle sector.

Two traction systems working in harmony offer optimum results from every point of view.

THE UNION PROVIDES THE FORCE.

Hybrid vehicles are those equipped with more than one power source.

Hybrids can be **parallel**, in which both power units are directly linked to the driving wheels or **series** where only one power unit is directly linked to the driving wheels, the other providing electrical power generation for vehicle traction.

A hybrid vehicle usually has an electric motor and a second engine; usually but not necessarily an internal combustion engine.

> **Hibrid vehicles**
> Light and medium range vehicles for the transport of goods or passengers – the ideal application for hybrid technologies.

Hybrid vehicles are not new. A moped is an example of a so called parallel hybrid vehicle in which the vehicle is propelled by an internal combustion engine and by the rider's pedals to give extra power for starting from rest or under arduous conditions.

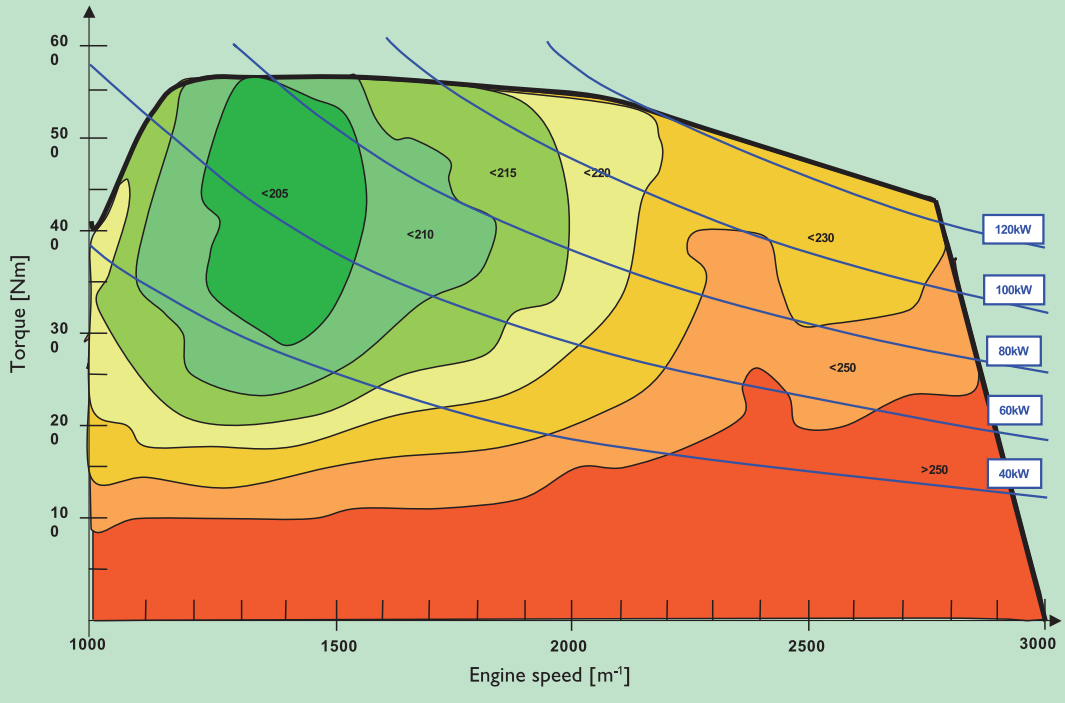
A Diesel electric locomotive is an example of another hybrid configuration, a series hybrid where the Diesel engine has no physical connection to the driving wheels but is connected directly to an electricity generator. The electricity is used to drive the train as if it were an electric train.

WHY HYBRID?

Motor vehicles have existed in history for little more than one hundred years during which time they have evolved at a tremendous pace. In the more recent past, in the face of increasing fuel costs and concerns regarding the environmental implications of an ever increasing number of motor vehicles on our roads, fuel consumption has become a major consideration for both vehicle users and legislators. In fact, for industrial vehicles the issue of fuel consumption is of greater importance because it represents an unwanted cost to the business operating the vehicle.

The improvements made to engines and power trains with the objective of reducing fuel consumption have been considerable but ultimately there is a compromise between vehicle performance and fuel consumption.

ISO-COMSUMPTION MAP



The figure represents a property of an internal combustion engine regarding its thermal efficiency as a function of engine torque and engine speed.

The coloured islands represent areas of constant specific fuel consumption (g/kWh).

The position of the green area demonstrates that the more the engine is under load the better is the performance in terms of fuel consumption and hence the thermal efficiency.

> **The advantages**
To reduce fuel consumption and respect the environment: a promise kept.

An internal combustion engine operates more efficiently from a fuel consumption point of view under high load conditions; that is to say when the engine is working hard. Under most circumstances, urban driving or at constant modest road speeds for example, the engine is not working hard, so to speak. It has reserves of power to enable acceleration and to provide a higher road speed, even while climbing a gradient. The compromise is providing an engine suitable for normal use but with the capacity for the high vehicle performance desired under certain occasions by vehicle users.

WORKING IN PAIRS IS BETTER.

Hybrid vehicles have two principal strong points: reduced fuel consumption due to a down sized engine that serves to meet a modest vehicle performance and the possibility to improve energy efficiency by conserving the kinetic energy possessed by the vehicle in motion.

The internal combustion engine used in a parallel hybrid vehicle is effectively working harder than that of a conventional power train equipped vehicle as a result of its down sizing. Additional power required under more arduous conditions, rapid acceleration or maintaining high speeds up an incline for example, is met by the electric motor working with the internal combustion engine.

> **Maximum efficiency**
Kinetic energy provided by the internal combustion engine is not lost but transformed to electrical energy and used to charge the batteries.

Hybrid traction is a choice that wins - always.

The energy conservation aspect of the parallel hybrid vehicle is brought in avoiding the conversion of its kinetic energy of motion to heat energy in its braking system, and subsequently lost, when the vehicle is brought to rest.

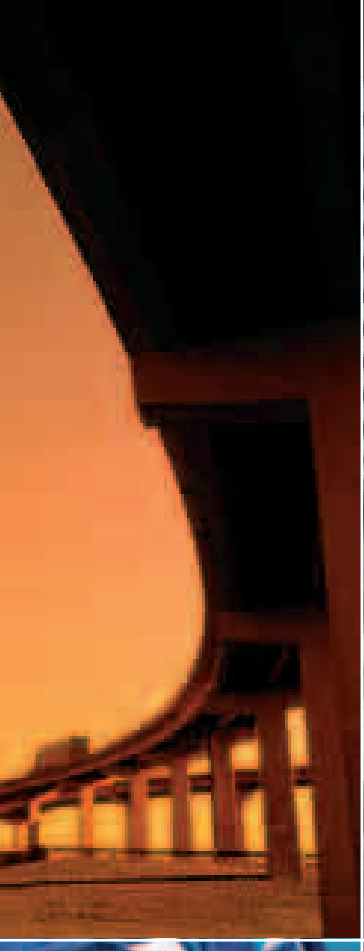
Under conditions of deceleration, the internal combustion engine may be disconnected and the electric motor functions as a generator. In this way the kinetic energy is no longer lost as heat energy but, subject to some energy losses, the energy will be transformed to a higher state of charge of the electricity storage batteries.

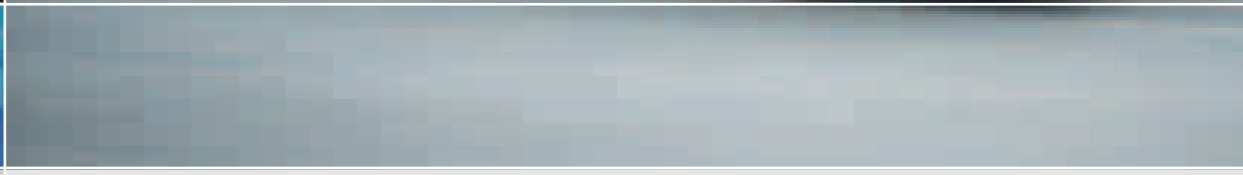
IN PERFECT HARMONY.

In many ways, with such a parallel hybrid vehicle, the driver does not directly control the engine and braking system but uses the accelerator and brake pedal to signal his intention to go faster or to slow down. It is a necessary aspect of hybrid vehicles to have a sophisticated management system to control the drive and braking systems.

With a robotised or automated transmission, starting from rest can be achieved using only the electric traction motor and as the vehicle speeds up the internal combustion engine can be started, often by the electric traction motor during the period between gear changes.
The management system decides when to start the internal combustion engine depending on the state of charge of the electricity storage battery and the acceleration demand indicated by the driver's action in depressing the accelerator pedal. Under internal combustion engine drive conditions the electric motor functions as an electric generator to provide battery charging.

Under deceleration, the internal combustion engine can be disengaged and shut down with the management system deciding how much electrical energy to generate. If the brake pedal is applied, the actuation of the service brakes will depend upon the degree by which the driver applies the brake pedal so indicating whether he wishes to stop abruptly or not.





> **Effective control**
A sophisticated control system integrating traction and the braking system controls the hybrid traction system optimising environmental performance.

THE COMPONENTS OF THE PARALLEL HYBRID POWER TRAIN

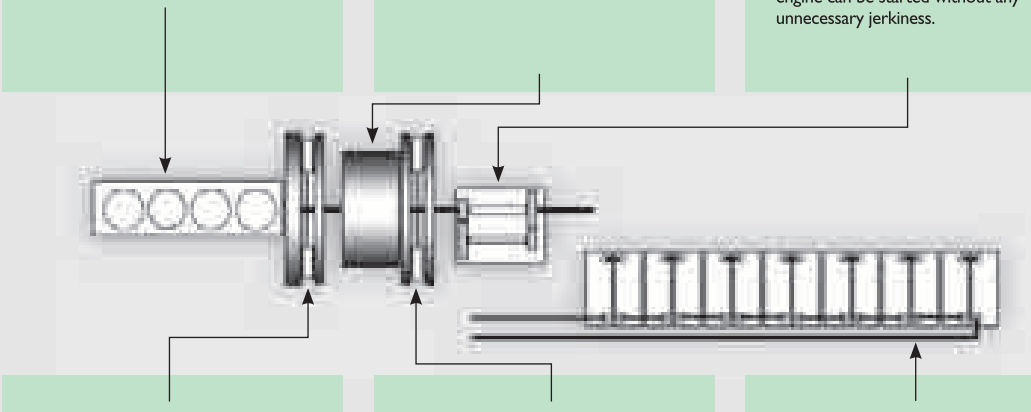
Internal combustion engine

Electric traction motor/generator

Used to provide power to assist the internal combustion engine and as a generator to charge the batteries and to utilize the kinetic energy for potential electrical energy.

Robotised or automated transmission

The specification of this type of transmission allows the driver to simply press the accelerator and go. It also has pauses in drive, unlike a hydrodynamic transmission, during which time the internal combustion engine can be started without any unnecessary jerkiness.



Friction clutch 1

Used to connect the electric motor/generator to the internal combustion engine for operation together or to separate them for electric motor/generator application only. Control is by the management system.

Friction clutch 2

Used for starting from rest and for gear changing. Control is by the robotised or automated transmission and is the 'normal' clutch present in a conventional power train.

Electricity storage batteries

Electricity storage batteries to power the traction motor and charged by the traction motor in generator mode. May be nickel-metal hydride or more advanced, lighter weight, lithium-ion. Super capacitors provide an alternative with a greater capacity to absorb electrical energy from braking.

Two alternative systems working together to achieve an improved productivity - always.

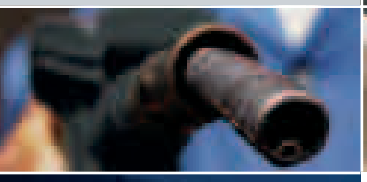
PRODUCTIVITY ALWAYS.

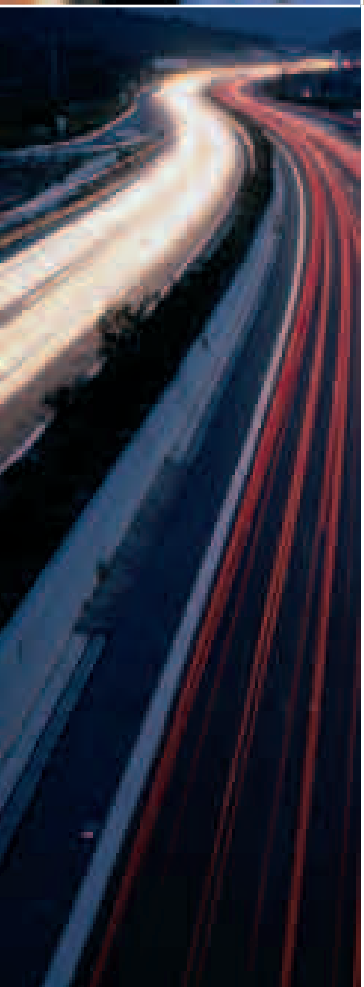
The technology is applicable to passenger cars and commercial vehicles. Without doubt there will be an incremental cost and weight effect but the former may well be offset by the reduced fuel consumption. The weight effect is to some extent a function of any electric only range requirement demanding electricity storage batteries.

While hybrid vehicles do exist in quite large numbers as passenger cars, their application in commercial vehicles is less common. This is largely due to the cost and weight implications of hybrid vehicles which is also related to any electric only operation of the vehicle required.

However, they do have a useful potential, especially for application in urban areas where a fully electric vehicle could operate but with operation outside of the urban area for which the fully electric could not operate.

> **No working restrictions**
Traffic limited zones? Maybe no longer a problem: with electric traction access is allowed and work goes ahead.





Typical of such vehicles are parcel distribution vans working from an out of town distribution centre to deliver and collect parcels in town. Out of town they must perform as a conventional vehicle but in town a degree of electric only operation is possible. The hybrid solution is appropriate for this application where loading volume is generally more important than loading mass.

The increased cost of a hybrid is compensated for by reduced fuel consumption and a greater operating potential in zones subject to increasing limitations to commercial traffic.

IVECO HYBRID TECHNOLOGY.

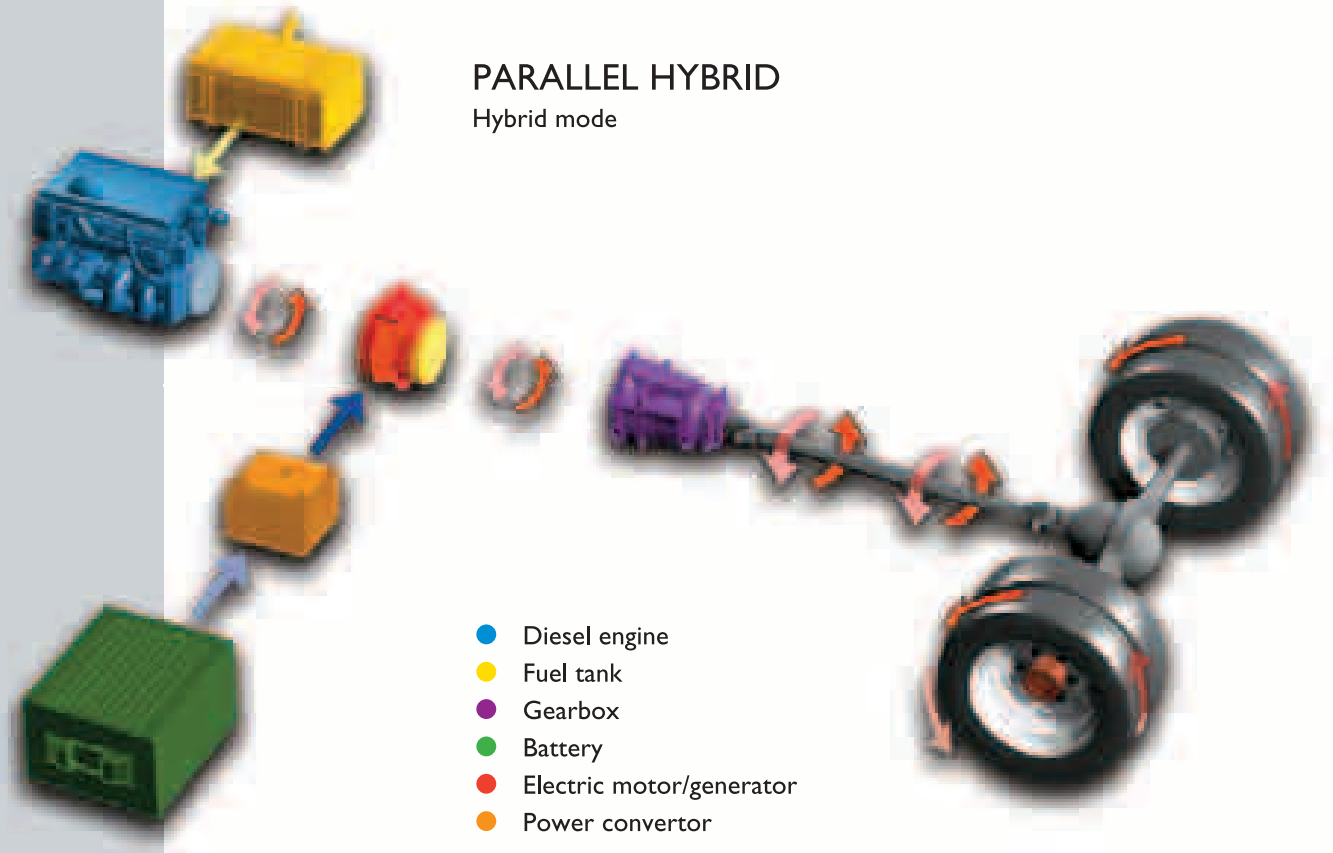
Iveco has a great deal of experience in the production of both electric and hybrid traction systems used in urban bus applications.

Iveco is applying parallel hybrid technology to the Daily range in response to the specific needs of some important customers while a specific hybrid application is under evaluation for the Eurocargo range.

The task is to develop parallel hybrid solutions for light and medium commercial vehicles meeting the diverse needs of vehicle users, providing the same versatility of use which they are used to with conventional vehicles.

PARALLEL HYBRID

Hybrid mode



- Diesel engine
- Fuel tank
- Gearbox
- Battery
- Electric motor/generator
- Power convertor

> **Innovation continues**
> Iveco is working to make hybrid commercial vehicles a reality – in every area of application.

Iveco S.p.A.
Via Puglia, 35
10156 Turin - Italy
www.iveco.com

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