# Low Carbon
# Two Wheeled Transport

## Report on the Sector and
## Opportunities for Realising Government Objectives

**Motor Cycle Industry Association**

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## *1. Introduction*

From January 2011, the Government will give a £5,000 subsidy for the purchase of low carbon vehicles. This grant, named the 'Plug In Grant', has survived the Coalition Government's spending review and is widely considered to be of both significant political and practical value; it underlines the Governments recognition of the embryonic electric transport sector whilst also giving the sector valuable 'pump priming' by making the purchase of an electric or hybrid vehicle a viable transport option for the general public.

To ensure that the Grant achieves its objectives, and is targeted towards what is considered to be 'appropriate' vehicle types and technologies, the following eligibility conditions have been put in place.

Eligibility for the Grant is based on a set of criteria which includes:

- Its fuel type – battery electric vehicles, plug in hybrid or hydrogen fuel cell
- A minimum of a 70 mile range on a full charge for electric vehicles
- A minimum of a 10 mile battery range for plug-in hybrid vehicles
- A maximum speed of at least 60mph
- Zero emissions for electric vehicles and a maximum CO2 emission rating of 75g/km for plug-in hybrids
- A minimum three-year/75,000 mile vehicle warranty and a minimum three-year extendable battery warranty
- Minimum safety requirements meeting internationally-recognised standards
- A reasonable degree of performance after a three-year period of normal use
- It must be a car, not a quadricycle such as the G-Wiz

Also included in the Government's plans is a £30 million fund for a network of electric vehicle hubs, called Plugged-In Places, to promote charging infrastructure in car parks, major supermarkets, leisure and retail centres, as well as on the street.

The first Plugged-In Places will be London, Milton Keynes and the north-east of England. In excess of 11,000 vehicle recharging points will be installed during the next three years.

However, notably absent from this new initiative is any support for electric powered two wheeled transport (ePTW). This omission is an oversight.

The Motor Cycle Industry Association (MCI) has held meetings with both the Office of Low Emissions Vehicles (OLEV) and with Ministers from the Department of Business Innovation and Skills (BIS) in relation to the new and developing ePTW sector. Ministers have indicated that they would appreciate a report on the sector which will help them consider policy and proposals for 'Stage Two' of the 'Plug In Grant'.

As requested by both BIS and OLEV, the purpose of this report is to 'scope' the electric motorcycle sector as it stands at the end of 2010, both in terms of its scale and nature, and also its potential for growth and development, especially in the area of new technologies relevant to this new transport sector.

## *2. Executive Summary*

The electric powered two wheeler (ePTW) sector is expanding rapidly, driven by a genuine enthusiasm for a greener, low emission transport alternative. Entrepreneurial by necessity, the sector has sought out its own solutions to the issues of design, manufacture and sales of a whole

new generation of electric powered two wheeled vehicles, creating a route to market that is fresh and new and designed to meet the demands of a new generation of commuters.

Design and technology are an important element of this growing transport sector. The slow pace of engagement by the major manufacturers has left the door open to smaller design houses and technology companies to seize the initiative and secure valuable market share. As demonstrated by companies like Intelligent Energy, the potential for 'UKPLC' to become a global technological 'hot house' is enormous.

However, by its very nature, the market for low emission vehicles is small and likely to remain so for the foreseeable future as financial constraints drive commuters to utilise cheaper current solutions.

The need to support the emerging low emission transport sector is recognised and demonstrated by Government through its 'Plug In Grant'. The Grant gives valuable financial incentives to purchase low emission vehicles, but also brings valuable publicity and media interest in the new sector.

The ePTW has been impacted on negatively by the Grant, insofar as the grant omits the ePTW, with this inadvertently placing the sector in the shade of their four wheeled counterparts.

The ePTW is a key component of a fully integrated and sustainable low emission urban transport strategy. It provides an affordable 'lifestyle' transport choice that avoids the issues of urban congestion and parking.

The sector has the potential for exponential growth if given the appropriate financial and promotional support.

## *3. The UK Low Carbon Two Wheeled Industry*

The UK Low Carbon Two Wheeled Industry is at a very early stage of development and is currently dominated by electrically propelled Powered Two Wheelers (PTW). Alternative power types, such as hydrogen fuel cells, are being developed by universities and researchers from the low energy sector (at least one concept in conjunction with a major motorcycle manufacturer) and are purely experimental at the moment.

The 'industry' currently combines a number of small specialist technology firms focusing on battery and control unit technologies and entrepreneurs with business links to Far East Manufacturers who import and retail road ready motorcycles.

### 3.1 Types of product

The majority of ePTWs on the UK roads are imported from the Far East and retailed via the internet or existing motorcycle/scooter dealerships. There are three distinct groups of electric PTW's:

**Electric 'Superbikes'**: branded 'electric superbikes', these machines generally use a donor chassis and suspension from a current internal combustion engine (ICE) bike and are designed to give power and performance characteristics similar to their ICE equivalent.

Mavizen Motorcycles are probably the most prolific in this sector, parent company TTXGP launching their 'brand' at an electric motorcycle race around the Isle of Man TT course in 2009.

Electric superbikes are designed primarily for recreational purposes where performance is one of the most important factors. These machines are still very niche and most of the design and production is based in the USA.

**Electric Scooters**: designed primarily as a short range urban transport solution, the e-Scooter is normally based on a generic ICE design, with an electric motor. The keys to success for e-scooters are range, recharge speeds, looks and design. Almost all e-scooter production is in China, but much of the design is European, indeed much is UK based. Current products mostly meet the range that commuters need for average daily travel mileages (National Travel Survey).

**Electric Off Road Bikes**: Zero and Quantya produce a range of e-motorcycles with off road capabilities. These are often targeted towards fleet users in the forestry/parks sector, or recreational off road parks. Many products have a battery range that is suitable for short range off road competition and motocross.

### 3.2 The Manufacturers

There are a number of brands of electric powered two wheeled vehicles being sold in the UK:

- Quantya – Swiss built off road motorcycles and off road styled road legal motorcycles.
- Mavizen – branded as the world's first Production electric superbike, the UK assembled bikes use an Indian built Agni electric motor and a KTM RC8 Chassis. The company also offer a 'build your own' option using a customer supplied donor chassis. The machines are sold on line.
- Brammo – a US based manufacturer of electric motorcycles, sold through Best Buy. A small number of machines have reached the UK market through the UK outlets of Best Buy.
- Zero Motorcycles – a US brand of electric road legal motorcycles and off road motorcycles. Distributed in the UK by on line retailer electricmotorcycles.co.uk.
- Love2scoot – an emerging UK based designer of electric bikes, around 18 months from manufacture and launch.
- Econogo- UK designed, Chinese built electric scooters with removable/interchangeable battery packs, distributed via web site.
- Epeds – Chinese built e-scooters at a budget price, sold via web site.
- Govecs – e-scooters designed and built in Europe, and sold in the UK via on line retailer.
- Plug-in Drive Tech – US and Israeli designed, Chinese built e-scooters. Sold world wide via a network of small distributors. The company also promotes the use of electric fleet vehicles.
- E-City Wheels – Sold via the web or through a London based retailer, these UK designed Chinese built e-scooters.
- E-Max **–** Spanish designed, Chinese built e-scooters sold via a European wide distributor network.
- Zepii – Chinese built scooters, sold on line via The London Electric Scooter Company.

### 3.3 The Market and trends

Currently, it is difficult to identify an existing sales 'market' for electric motorcycles, despite many products being within the needs and capacity of many urban commuters. Those operating within the sector have identified a number of reasons for this lack of engagement, the most significant of which is a general lack of publicity/awareness of the ePTW sector as a viable transport option, which seems related to the lack of engagement with all other kinds of PTW within UK public policy.

Where sales are being made, almost without exception these are to short distance commuters in urban environments, with London being the dominant market place.

As with ICE scooters, design is a key feature of a successful product and the best selling ePTWs are following the trends already established. The growth in European designed vehicles supports

this and more vehicles are being brought to market with design inspirations being taken from 'timeless' designs such as those manufactured by Vespa and Piaggio.

Each of the manufacturers/importers of the machines outlined in 3.1 has been working hard to create a market for its products but each has voiced a common concern regarding the lack of publicity around the ePTW alternative. Many of those in the sector believe that the public perception of 'low emission vehicles' is overly dominated by electric cars and the car-focused publicity surrounding the 'Plug In Grant' has only added to the problem for the ePTW sector.

### 3.4 Technology and innovations

Technology is the key to the 'electric transport revolution' both for cars and ePTWs.

As almost all of the current range of ePTWs, in the only part of the sector to have any demonstrably commercial viability, the commuter/utilitarian sector, are based on current ICE model/chassis design. As a result, there are no technological issues in relation to running gear or chassis. As previously mentioned, design is becoming a more important factor in making these vehicles saleable (lifestyle design) and many of those offered in the UK are from UK or European design houses.

All of the technological challenges for e-vehicles surround battery technology. For ePTWs the issue of batteries is exaggerated by the problem of weight and the physical size of any battery pack that can be carried. For cars this is less of a problem in absolute terms.

Many of the cheaper ePTW machines on offer currently have relatively low ranges (less than 30 miles) as a result of their 'low tech' battery technologies. Machines with ranges of less than 80 miles benefit from newer and more advanced battery technologies, but these come at a cost – often ten times that of a lower technology option.

China and India have enjoyed a rapid growth in electric motorcycle, bicycle and scooter use in the last decade but are today having to deal with significant quantities of disused lead acid batteries. The problem is severe; there are a number of reported cases of contamination of communities and water courses through improper recycling of the chemicals.

Clearly it is important to avoid this problem in the UK, and whilst the stringent recycling regulations already in place in the UK will address much of the problem, everyone recognises the problems inherent in a surge in low tech battery usage, both for cars and motorcycles.

Current 'State of the Art' technology in ePTW battery technology involves the use of Lithium-ion based chemistry.

Lithium-ion batteries use Lithium as their base chemistry and offer one of the highest energy densities available. With further refining, research and development they have the potential to offer even higher densities. They are also relatively light weight; essential for use in ePTWs where overall machine weight is critical to performance and practical handling on a day to day basis.

Additionally, Lithium-ion batteries do not have any of the charging issues endemic in many of the other nickel or lead based chemistries and, as such, can tolerate intermittent and irregular charging patterns.

Whilst battery size, weight and efficiency are clearly critical, another element of a battery's performance that will be central to the development of practical transport will be charge rate. The

ability to input a usable amount of charge to a flat or nearly flat battery in 30 minutes will be an important consideration for customers looking for a real world green transport option.

Weight and removable batteries (very important when the cost of batteries motivates theft of batteries from parked vehicles) will also become issues for the sector as sales grow.

However, all this performance and development has its cost and Lithium-ion battery stocks sell at substantial premiums to their lead-acid peers. Global lithium supplies may be finite. Therefore there are two challenges here for the Lithium-ion battery manufacturers, one of driving down costs and one of investing in product development. The contradiction is clear and not easily solved, with this challenge facing both the electric car and ePTW worlds.

Clearly, cheaper battery technologies will continue to have their place in ePTWs for some time to come, at least until cheaper high performance Lithium-ion batteries are brought to market.

### 3.5 Involvement of traditional Internal Combustion Engine (ICE) manufacturers

The traditional ICE manufacturers, the Japanese (Honda, Kawasaki, Suzuki & Yamaha) and their European counterparts (BMW, KTM, Triumph, Piaggio etc.) are all showing interest in the development of the ePTW sector, but only the larger companies have taken any public steps into the arena.

**Honda:** already a significant player in the low-emission car market with both fuel cell and electric vehicles on the road, the Japanese giant Honda recently launched their first electric scooter, the EV-neo Scooter.

Honda started leasing the EV-neo to select customers in Japan in December 2010. The plan is to have at least 100 of the battery-powered scooters on the roads by next March, expanding to 1000 by the close of 2011.

The EV-neo is said to offer performance on a par with the company's 50cc ICE powered models with up to 18 miles of range from its Toshiba-supplied SCiB Lithium-ion battery pack. It has a top speed of less than 30 mph and comes with an optional quick charge system that will 'top up' the battery in as little as 20 minutes.

**Suzuki:** Suzuki have taken the view that the electric motorcycle revolution will be undermined by inadequate battery technology and have instead gone for electric with no battery – by using fuel cell technology. Developed in partnership with Intelligent Energy, a British company based at Loughborough University, the fuel cell power unit is designed around a Suzuki Burgman scooter. It has a range of over 200 miles and offers the refuelling and performance characteristics of an ICE powered motorcycle. This is a promising technology that faces the challenge of the lack of hydrogen refuelling infrastructure in the UK – at the moment.

**Yamaha:** Yamaha declared an interest in electric motorcycles in 2007 with the EC-02, an 18mph scooter with a 40 mile range, complete with an iPod dock!

It has now launched its EC-03. Equivalent to a 50cc ICE scooter, the EC-03 is powered by a 50V Lithium-ion Sanyo battery. The Yamaha EC-03 has an aluminium-alloy frame so it only weighs 56kg, which is 30 per cent less than a petrol-powered 50cc scooter. However, it only has a range of 26 miles on a single 6 hour charge. It costs around £2,000 but it is unknown whether it will be released outside Japan.

Of the European Manufacturers, only BMW and Piaggio have any significant plans to bring ePTWs to market in the near future:

**BMW:** A re-launch of their innovative C1 scooter called the C1e, this time fitted with the electric motor out of a previous Vectrix scooter (NB: Vectrix is now back in production with an updated design). BMW are also experimenting with a hydrogen powered concept e-cycle.

**Mini:** BMW owned car brand Mini have launched a concept electric scooter branded the Mini Scooter E-Concept. Although the German automotive giant has a successful standalone motorcycle division, it has chosen to launch its first foray into the ePTW market through its iconic urban Mini brand. This is a move that underlines the widely held view that the ePTW sector does not sit comfortably within the existing ICE motorcycle sector. That said, the styling of the Mini Scooter E-Concept draws heavily on another iconic urban two wheeler – the Vespa.

**Piaggio:** As arguably the undisputed kings of the ICE scooter market, Piaggio should be natural players in the ePTW scooter market. Indeed, during the mid 1990s, they marketed a hybrid scooter, the 'Zip and Zip'. The concept was too early to draw significant sales though. More recently, Piaggio have launched a three wheeled hybrid scooter named the MP3. Using both an ICE and electric engine, the MP3 claims to offer the ultimate transport solution – lower emissions without the cost and practicality issues of fully electric scooters.

### 3.6 Standardisation

Standardisation will be the key to the development of the sector for a number of reasons:

- **Component/battery cost** – as outlined in 3.4, the only way that ePTW specific battery technology development can be made commercially attractive to manufacturers will be through standardisation and therefore economy of scale.
- **Charging infrastructure** – as demonstrated by Suzuki with their hydrogen fuel cell scooter, the technology cannot be developed in the public mind without a refuelling infrastructure. However, without coordination and standardisation of charging plugs and charge rates (single or multi-phase), we are doomed to repeat the errors of the early days of the LPG fuelling, when cars and pumps all had a variety of filling nozzles and adapters were almost always needed. However, the consequence of incorrect or excessive charging for very expensive batteries can be catastrophic.

### 3.7 EU regulations (WVTA/Euro IV,V,VI)

**EU type approval requirements**

The report will make reference to both current EUTA requirements under Directive 2002/24/EC and those proposed under the draft Framework Regulation (FWR) due to apply to new type approvals from January 1st 2013.

**Table 1. Categories of electric vehicle**

| Current Type approvals 2002/24/EC | Under new FWR from 1/1/13 |
|---|---|
| | EAPC>250watts <1000 watts |
| Moped: <4kW<br>Certain exemptions for mopeds with a maximum speed of <25kmh (e.g. indicators) | Moped: <4kW<45kmh<br>NB the future of the current exemptions for mopeds<25kmh is uncertain |
| Motorcycle: >4kW<br><br>All references to power refer to maximum continuous rated power | Motorcycle:<br>A1 <11 kW, pwr/ratio <0.1kW/kg<br>A2< 35kW pwr/ratio <0.2kW/kg<br>A3>35kW |

**EU type approval**
Electric PTWs are subject to all the requirements in Directive 2002/24/EC, although 97/24 Chapter 5 (air pollution) is redundant as there are no gaseous emissions.

**EU Driving Licence requirements**
These apply in the same way as for ICE PTWs, depending on the category into which the test vehicle falls (moped/motorcycle). The licence achieved will be for an automatic transmission.

**VED**
Electric PTWs must be registered but are currently exempt from VED.

### 3.8 UK laws in relation to use

ePTW vehicles come in a large variety of shapes and sizes and it is important to stress the difference between an electrically assisted pedal cycle (EAPC) and an electrically powered scooter (moped) or electrically powered motorcycle.

The legislative requirements for certain types of Electrically Assisted Pedal Cycle (EAPCs) are defined by European Community Directive 2002/24/EC. This came into force on 9 November 2003 and this has resulted in uncertainty regarding the use and construction of EAPCs in Great Britain.

An Electrically Assisted Pedal Cycle which complies with the technical requirements in SI 1983/1168 (an "EAPC") is not considered to be a motor vehicle within the meaning of The Road Traffic Act 1988. An EAPC is not required to be registered, have a vehicle licence or a nil licence, pay vehicle excise duty (road tax) or be insured as a motor vehicle. An EAPC cannot be ridden by anyone under the age of 14 years.

The Regulations apply to bicycles, tandem bicycles and tricycles fitted with pedals by means of which it is capable of being propelled. If the vehicle is to be regarded as an EAPC, the motor assistance must be provided by an electric motor and not by an internal combustion engine. The electric motor must not be able to propel the machine when it is travelling at more than 15mph.

Furthermore, in order to be an EAPC within the meaning of SI 1983/1168, the vehicle must also meet the following requirements:

Maximum kerbside weight (not including rider) shall not exceed:

- bicycle - 40kg
- tandem bicycle -60kg
- tricycle - 60kg

Maximum continuous rated power output of the motor shall not exceed:

- bicycle - 0,2kW
- tandem bicycle - 0,25kW
- tricycle - 0,25kW

The Pedal Cycles (Construction and Use) Regulations 1983 (SI 1983/1176) imposes construction and use requirements for pedal cycles and EAPCs.

However, it should be stressed that the above regulations have yet to be tested in court and may be open to a degree of interpretation.

The situation with electric scooters and motorcycles is far clearer.

**Electric Sit-On Scooters (Mopeds)**
Electric Sit-On Scooters are classed as mopeds in UK law and require a registration document, number plate, MOT at 3 years, insurance and a valid tax disc. A "moped" is defined as a 2 or 3 wheeled electric vehicle with a maximum design speed of 50 km/h (31 mph) that has lights and indicators. Riders must be at least 16 years old, wear an approved helmet, and have category "P" on their driving licence. If you only have provisional category "P" then you must display "L" plates and have a valid DL-196 certificate of completion of CBT issued by an approved training body.

**Light Electric Sit-On Scooters and Motorcycles**
Light electric sit-on scooters and motorcycles are classed as light motorcycles in UK law and require a registration document, number plate, MOT at 3 years, insurance and a valid tax disc. A "light motorcycle" is defined as a 2 or 3 wheeled electric vehicle with a maximum output of 11kW that has lights and indicators. Riders must be at least 17 years old, wear an approved helmet, and have category "A1" on their driving licence. If you only have provisional category "A1" then you must display "L" plates and have a valid DL-196 certificate of completion of CBT issued by an approved training body.

**Standard Electric Sit-On Scooters and Motorcycles**
Standard electric sit-on scooters and motorcycles are classed as standard motorcycles in UK law and require a registration document, number plate, MOT at 3 years, insurance and a valid tax disc. A "standard motorcycle" is defined as a 2 or 3 wheeled electric vehicle with a maximum output of over 11kw that has lights and indicators. Riders must be at least 17 years old, wear an approved helmet, and have category "A" on their driving licence.

## *4. Technology and Economic Prospects*

It is clear that there are significant technological challenges to be faced and overcome by this embryonic transport sector over the coming years, and with these challenges will come equally significant commercial technology and IP opportunities. Whether through the development of battery technology and chemistry, energy capture, power regeneration control units or associated software, or simply design, the potential rewards for those who can find the solutions to the power/range/charge rate/cost equation will be significant.

An example of where a small technological innovation can lead to a significant market advantage has come out of the recent genesis of ePTW racing. After the first 'world class' event (TTXGP) in 2009 at the Isle of Man TT races, there has been a 'gold rush' of innovation to push the performance envelope even further, chasing the Holy Grail of comparable performance with an ICE superbike.

2010 race winner MotoCzysz Ep1c (http://www.motoczysz.com/) used an innovative oil cooled motor capable of sustained levels of high power output. The machine set a new outright lap record during the race and a race average speed of 98mph.

American electric bike race pioneer and racer Chip Yates's SWIGZ.com Pro Racing has developed an electric superbike with a new and innovative Kinetic Energy Recovery System (http://www.youtube.com/watch?v=RIMQ0c7JKIU&feature=player_embedded#)

Both of these American machines used their own highly developed battery management software to enable them to run at these levels of performance. This demonstrates quite clearly that whilst larger scale manufacturing may have moved East, the heart of this transport revolution, small scale hi-tech R&D, is most certainly still centred in the West.

### 4.1 UK as Technological Centre of Excellence

There is no question of the UK being able to compete globally in the vehicle manufacturing sector as this moment in time. As with ICE vehicles, much of the Electric Vehicle (EV) manufacturing takes place in China, India or the US. At a component level, the same is true of batteries and control units. The manufacture of these components on increasingly industrial scales has already been mastered by many Chinese and Indian firms, many of whom have invested heavily in production line technology to service their contract with the computer/phone sector. The crossover from the manufacture of increasing hi-tech computer and phone batteries to automotive batteries for EVs will not be that significant.

That said, at least one company is poised to start manufacturing complete electric motorcycles in the UK during the next 18 months.

In the same way that suppliers and component manufacturers for the old British industry of the 1920s to the 1960s survive and thrive to this day, now supplying modern motorcycle manufacturers, it can be expected that these manufacturers are in a strong position to support the ePTW sector as it develops.

However, the 'hi-tech' end of the design and manufacture of batteries is not dominated by China, and India. Much of the battery R&D is still done in Japan and the USA, where investment is still strong.

An example of the UK's potential for embracing the high technology end of the new EV market is the partnership of UK Technology firm Intelligent Energy (IE). IE are global leaders in Fuel Cell technology and are examples of how the UK can dominate this embryonic sector if the appropriate policy support is put in place at the right time.

### 4.2 Inward investment

In terms of creating a wider, world class EV technology centre in the UK, IE provide an excellent case study of what is possible.

The Company started life in the Department of Chemistry and the Department of Aeronautical and Automotive Engineering at Loughborough University in 1995 designing the UK's first Fuel Cell. Using proton exchange membrane (PEM) fuel cell technology, the first Kilowatt-level Cell was constructed in 1995 and, realising the commercial possibilities, a 'Spin Out' company named Advanced Power Sources Ltd (APS Ltd) was formed. APS Ltd was the first UK Company to specifically address the development and commercialisation of PEM fuel cells.

APS worked on the early prototyping of fuel cell products and on the pre-commercial development of its proprietary fuel cell technology, funded by UK Government bodies as well as through joint development programmes with other commercial entities.

In 2001 Intelligent Energy was founded and attracted private finance capital upon the acquisition of APS. As a new company based both in Loughborough and in a new London office, it secured an irrevocable, worldwide licence to exploit all of both APS's and the University group's fuel cell related know-how, in addition to all the key staff from both entities.

Cleary, the role of UK Government funding was key to the ability of APS to design and develop these innovative technologies to the point where they were able to successfully attract inward investment. Without this early support and seed funding it is arguable that the potential of the early PEM Fuel Cell would have never left the University and the position of the UK in the potentially massive new energy market would have never been achieved.

Fuel Cell technology is just one example of how foresight and recognising commercial potential has placed a UK firm at the centre of an emerging global energy technology.

The same can be true in the EV sector, specifically in the areas of battery chemistry, management systems, motor technologies and machine design.

### 4.3 Export potential

In the same way that IE have become global players in the Fuel Cell market, there are considerable opportunities for similar innovation in the EV power sector. Japanese manufacturing giant Suzuki have recognised the expertise in IE and have commissioned them to develop their own branded Fuel Cell technology. As the infrastructure of hydrogen fuel grows around the world, so IE technology will become an exporter of UK expertise.

As outlined above, once the technology is brought to market, manufacturing will inevitably move East to where the technological production lines are already in place. As such, the export potential for UK PLC will come through the export of Intellectual Property and technology/know how, rather than hard product.

### 4.4 Higher Education relationships

The natural home for high technology R&D is the UK's Higher Education Establishments. Once again IE Ltd demonstrates perfectly how R&D can make the evolution to high tech business through identifying a potential market and securing R&D Government funding.

Many universities are now embracing the emerging EV market and have projects working on EVs, particularly ePTWs. The development of micro-KERS (Kinetic Energy Recovery Systems) is one area of development that has attracted particular interest and many students are producing dissertations on battery chemistry and engine/power management.

In researching this report, Automotive and Mechanical Engineering Course Directors at Coventry and Loughborough were interviewed and both stressed their Department's interest in developing technology around EVs.

Both of these universities have well established R&D relationships with UK based OEMs (Jaguar/Landrover and Aston Martin) and are working on well advanced EV technology projects.

### 4.5 Interface with emerging electric infrastructure

In the same way that the evolution of Fuel Cell technology will be dependent on refuelling infrastructure, so the growth and take up of EVs will, to a large extent, be governed by the roll out of charging points.

The roll out of charging points across the UK is mixed. With over 50 points in London, the capital is relatively well served. Scotland has only a hand-full and Wales has none at all. A list of points can be found at: http://www.electriccarsite.co.uk/electric-car-charging-points

Note that this list is not exhaustive and new points are being added continually.

There are also a number of centrally funded electric car charging schemes being rolled out across the UK at the moment. The Cambridge scheme, run by Chargemaster PLC, is now in operation and similar schemes for London and Milton Keynes are in the pipeline.

Currently the most common public charging points in the UK are 'Elektrobays'. These shoulder-high posts have a plug socket mounted near the top. The bays have a yellow coiled power lead

which will supply 240 volts AC at 13 amps. This is compatible with most electric vehicles and uses a standard 3pin plug.

They are suitable for installation indoors or out in the street and are supplied by a company called Elektromotive. The socket has a cover which is unlocked and opened by an RFID (radio-frequency identification) tag. This will be kept somewhere near the charging bay usually by a car park attendant or by shopping centre facilities management etc. In return for the tag you may be required to show some form of ID and / or leave a deposit.

These are slowly being replaced by POD points, a new charging point which allows the use of the vehicle's own cable.

There are a number of issues that need to be overcome as the charging technology rolls out.

First, whilst the use of 240volts/13amps and a three pin plugs is good insofar as it allows vehicle charging in a domestic environment, it does impose limits to any rapid charging of batteries.

A more advanced system, using three phase charging and seven pin plugs which will enable rapid charging of batteries safely, is now replacing the older system. This will require all vehicles to either be fitted with a three phase seven pin system or carry an adaptor to allow the use of the new charging points.

Secondly, it is vital that a vehicle's charging system can cope with three phase rapid charging. The battery will be one of the most important and expensive components on the vehicle and can be easily and irrevocably damaged by incorrect charging.

Both of these points may present specific challenges to the more budget ePTWs and eventually preclude all but the most modern EVs from using public charging points.

A key task for industry will be to ensure a level of compliance harmony amongst the importers of ePTW machines.

### *5. Two Wheeled Low Carbon Strategy*

In 2007, the Government launched a Low Carbon Transport Innovation Strategy (LCTIS) as part of its wider commitments to reducing UK carbon emissions.

The report was clear in its motivation in looking at emissions from the transport sector:

"The road sector is the largest source of carbon emissions from transport in the UK. It is also the transport sector with probably the greatest potential to reduce carbon emissions in the coming decades. In developing the LCTIS the Government therefore asked E4tech to examine how the innovation system was functioning for some of the key technologies central to carbon reduction in the road sector.

Those technologies with the clearest potential to contribute in the near future include:

- continued incremental improvements to petrol and diesel engines
- a range of new and emerging lightweight materials
- nearer market hybrid petrol-electric or diesel-electric vehicles
- first generation biofuels (bioethanol made from sugar or starch crops and biodiesel made from oil crops and wastes)

Those technology options which may become very significant over longer timescales are:

- "plug-in" hybrids which can be re-charged from the electricity grid
- fully electric vehicles
- second generation biofuels, manufactured from a wide range of biomass sources
- hydrogen powered vehicles and fuel cells

The key attraction of these latter technologies is the possibility they offer of delivering very substantial carbon reductions from road transport over the longer term – including potentially achieving the almost total de-carbonisation of road transport. However in general they are not yet ready to be applied to mass markets in the road sector, either because costs are prohibitively high and/or significant technological progress is required to bring down costs and overcome performance issues likely to be important to consumers."

(Source: http://www.dft.gov.uk/pgr/scienceresearch/technology/lctis/lowcarbontis?page=3#a1003)

Combined with European pressure on OEM vehicle manufacturers to reduce emissions to unprecedented levels over coming years (New Car CO2 Regulation), the intention to push the low carbon agenda could not be clearer.

Already offering a low emission transport option in their existing ICE power format, PTWs have a clear role to play in delivering Government 'sustainable transport' targets.

However, where PTWs can excel is by bringing affordable and practical low emission technology to market earlier than any other form of transport. The entrepreneurial nature of the sector has seen rapid growth in the number of electric scooters and motorcycles already available to the 'green' consumer – over 30 different models ranging in price from £425 to £8000 (http://www.atob.org.uk/electricmotorbikes.htm)– against the nine listed vehicles eligible for the 'Plug In Grant' and three more vehicles (G-Wiz type) that are not.

Also, given the current rate of development, it is likely that this trend will continue and more ePTW options, each more advanced, powerful and durable than their predecessors will come to market in the next 5 years.

The obvious flexibility of the PTW, its ability to provide a viable transport solution that does not in any way contribute to levels of urban congestion, take up large areas for parking and its associated journey time savings, clearly demonstrate the ePTWs potential. It was therefore surprising that there were no references to ePTWs in Lord Andrew Adonis's 2009 report "Low Carbon Transport – a Greener Future", and that the first phase of the Government's 'Plug In Grant' for EVs excluded PTWs.

EPTWs, along with their four-wheeled counterparts, offer an opportunity to create public awareness and critical mass if promoted in those areas which benefit from the Electric Plugged In Places grant, as part of a strategy for 'electric cities'. Government should not ignore the potential of ePTWs in achieving such an end.

### 5.1 Government Policy (Central and regional, i.e. London)

Driven by its wider objectives of reducing the UK 'Carbon Footprint', UK Government transport policy is transparent and focused totally on emissions. As outlined in LCTIS, the Government is aiming to shift UK transport to a low carbon model through more efficient ICE vehicles whilst nurturing new technologies through R&D.

However, since the ICTIS was published in 2007, the ground has shifted and what was an aspiration of "…potentially achieving the almost total de-carbonisation of road transport" has become an objective and a goal: "Most commentators agree that meeting the UK's longer-term climate goals will require the almost complete decarbonisation of road transport." (http://www.dft.gov.uk/pgr/sustainable/olev/)

It continues,

> "To help achieve this aim, the Government has announced provision of over £400 million to support measures designed to promote uptake of a next-generation of ultra-low emission vehicle technologies. Electric, plug-in hybrid, and hydrogen fuelled vehicles can all help to reduce emissions from road transport, whilst allowing drivers to retain all the benefits associated with private car usage.
>
> The Office for Low Emission Vehicles (OLEV) is a cross-Whitehall team that has been established to manage this programme of measures. Comprising people and funding from the Departments for Transport; Business, Innovation and Skills; and Energy and Climate Change; OLEV is responsible for taking forward a national policy on this shared agenda.
>
> OLEV is not only concerned with ultra-low emission vehicles. Technological developments are also delivering significant efficiencies in the fuel economy of conventionally fuelled vehicles; and OLEV is also responsible for managing the regulatory framework that is driving emissions from road transport down."
>
> The announcement of funding towards the purchase of a new electric car, called the 'Plug In Grant', is also supported by another scheme called Plugged-In Places.
>
> In February 2010, the government announced the next stage of its roll-out of a network of electric vehicle hubs, called "Plugged-in Places", which will see a charging infrastructure appearing in car parks, major supermarkets, leisure and retail centres, as well as on the street. The first Plugged-in Places are London, Milton Keynes and the North East, and between them they will be installing over 11,000 vehicle recharging points during the next three years.
>
> The Plugged-In Places will provide the charge points to support 'Plug-in Cars' - pure electric vehicle (EVs), plug-in hybrid electric vehicles (PHEVs) and hydrogen cars.
>
> The experiences of the first three Plugged-In Places will be used to inform the future development of a national charging infrastructure. The first round of Plugged-in Places funding, out of a total of £30m, was open to bids from consortia in England, Scotland, Wales and Northern Ireland made up of local authorities, businesses, electricity distributors and suppliers and other organisations like Regional Development Authorities. Each consortium had to demonstrate why their area was best suited to be at the forefront of the EV market, for example, through use of local incentives: Milton Keynes, for instance, will be offering ultra-low carbon car drivers in their region free parking and electricity, and London will be waiving the congestion charge."

However, recent local authority budget cuts have started impacting on the aim of a low carbon UK transport infrastructure; the funding available for charging points in London has been slashed by 65%. But, with only 2,000 electric cars in the UK at the moment, this will probably provide more than enough points for current demand in the capital.

### 5.2 Potential impact on UK economy

The impact on the UK economy of the work of OLEV, through its 'Plug In Grant' and Plugged-In Places programmes, will be significant, if only as a way of ensuring that the UK transport sector keeps pace with its European counterparts. France, Spain, Italy, Germany and Portugal have all announced extensive investment in charging infrastructure, often working in partnership with existing utility suppliers.

A developed low emission support infrastructure, including fuel cell fuelling, will significantly enhance customer confidence in low emission vehicles and in turn encourage uptake of the new vehicles.

The 'Plug In Grant' of £5,000 will have a less immediate impact on the uptake of electric vehicles, simply because of the high purchase cost of qualifying cars – typically around £30,000. However, the publicity and press generated at the launch of the grant has awoken many people to the potential of these new vehicles.

Arguably, the rapidly increasing levels of tax on carbon fuels may ultimately have a greater persuasive power than both OLEV schemes.

In terms of securing the UK as a technology centre for low emission technologies (including ePTWs), the influence of the 'Plug In Grant' is arguable. Whilst the Government has expressed a desire to attract inward investment for electric car manufacturing, this does not necessarily attract anything more than a change of use of existing facilities, such as Nissan's use of its Sunderland plant. The question mark for the Grant's impact on inward investment rests upon the qualification criteria for qualifying cars meaning that probably only vehicles produced by volume OEMs, all of whom have advanced R&D divisions already established outside the UK, will benefit. It may be that some OEM's with UK based R&D Divisions will engage in the development of new Low Emission technologies and there is evidence of ongoing work at Landrover Jaguar and Aston Martin in this area. However, it is still not known if either manufacturer will ultimately produce qualifying vehicles.

### 5.3 Potential impact on the ePTW sector

The ePTW sector has been damaged by the 'Plug In Grant' because the press and PR coverage has focused exclusively on the electric car sector, casting a shadow over an already small market.

All of the representatives of the ePTW sector were very critical of the 'Plug In Grant', not only because it didn't include PTWs, but because it drew attention and public awareness away from the two wheeled option.

ePTWs have an important place within any low emission transport strategy and need to be included in any funding mechanism. In a congested urban environment, like any of the UK's major conurbations, ePTW transport is arguably more relevant in terms of road space taken in relation to the number of people travelling, parking space required, energy used and as a consequence needed to be replaced, and, ultimately, practicality.

Most of the sector experts who were surveyed for this report said that they felt that launch of the 'Plug In Grant' not only sucked the oxygen of publicity from ePTWs but also marginalised them as a viable green transport option. Also, they felt that the launch of the Grant redefined the low emission transport landscape in such a way as to give unfair market advantage to the large OEMs who could now capitalise on the public appetite for green vehicles – an appetite that was largely created by the smaller companies (including G-Wiz) and who now find themselves made irrelevant.

However, these same respondents are unanimous in their belief that a similar scheme for ePTW machines in phase two of the Grant roll out would have the opposite effect and invigorate the market to the extent that the quality ePTW sector would see rapid expansion in sales, especially in the 'ultra-urban' environments such as central London and Manchester/Birmingham. Such an expansion of awareness of the potential of ePTWs and subsequent sales would have a significant impact on the sector, in terms of sales and also a growth in the number and variety of outlets which sell these machines.

### 5.4 Potential impact on UK transport

In many ways, Government policy in relation to Low Emission vehicles is as much following, and responding to, a growing international agenda as dictating or setting a domestic agenda. It is difficult for the UK Government not to recognise or mirror green investment by its neighbours. As the major European car makers invest in EVs and launch them into their local markets, they will demand that those same markets invest in the relevant infrastructure to ensure that a sustainable market is created.

With significantly less Motorcycle OEM investment in ePTWs the European market conditions are far less favourable. Much of the R&D work is undertaken by smaller companies who rely on independent manufacturers in the Far East and then import and try and sell the finished product. The result is a smaller market, but also a significant potential for the UK to position itself as an R&D ePTW Technology world leader.

## *6. Sector Sustainability*

Any sector must have sustainability as a central element of its make up if it is to survive in a global market place. This is especially true of a sector that calls upon Public money in the shape of seed funding or purchase subsidy.

### 6.1 EPTW as part of overall environmental automotive strategy

The key to a sustainable transport strategy is diversity. An over reliance on one type of fuel or energy has fragility in it's make up and no long term future. Our experience with carbon based fuels is case study of such an over reliance.

A transport strategy that combines ICE-fossil fuels with renewable bio-fuels, in increasingly efficient power units, combined with EVs, hybrids and even Fuel Cells, will ultimately provide the perfect environment for market forces to select the best and most sustainable way for people and goods to get around.

It is clear that ePTWs have a role to play in such a strategy, coming into their own in the urban commuter and urban fleet user/delivery sector.

### 6.2 Role of ePTW in transport strategies

As outlined above, an effective transport strategy must be as diverse and multifaceted as the communities and business it seeks to serve. From public and private transport to transport for business and courier/freight sector, a combination of conventional ICE, Hybrid and full EVs can work together to create a truly sustainable and fit for purpose transport strategy.

ePTWs have a key role to play in such a strategy, particularly in the urban commuter sector and also, potentially, in the light weight urban commuter industry.

For solo commuters, the ePTW offers an emission free, congestion proof, time saving and more efficient transport option. With an average urban commute of 9 miles, and no requirement to

exceed 40mph, 75% of the current crop of ePTWs is capable of matching the needs of the today's urban commuter. Future developments, technological and design will only improve this situation and make the ePTW even more relevant.

The recent trend towards more Euro-styling, driven by the use of European design houses has led to more 'life style' retro designs mirroring the 'timeless' Vespa and Lambretta designs that have proved so popular amongst younger City commuters.

### 6.3 Types of Gvmt support indicated

The most appropriate and effective type of Government support for the ePTW sector revolves around three main options:

- **Cash purchase subsidy**: similar to the current 'Plug In Grant', a cash purchase grant, set at a similar percentage of RRP would certainly help. Based on an average purchase price of £5,000, a grant of £500 would, it is felt, have the same effect on the ePTW market. As with the 'Plug In Grant', a set of quality and performance criteria would be required to focus the grant on the higher quality/technology end of the market.
- **Low Cost Finance**: a purchase incentive built around the availability of low cost finance would probably have more impact on sales and growth of the market than a cash incentive. A performance and quality criteria would be set as above.
- **Mainstreaming ePTW**: An important, but missing, aspect of the green transport debate is the role of PTWs as zero congesting, time saving, efficient urban transport. In the case of ePTWs we can add zero emissions to the list of benefits. Therefore the total absence of recognition for ePTWs in Government policy and related documents is an extremely worrying oversight which needs correcting. The addition of ePTW to the list of recognised clean transport offers the buying public (which still needs persuading about zero emission transport) a mode of transport which offers immediate personal daily benefits on top of environmental responsibility.

### 6.4 Government Exit Strategy

The most straightforward exit strategy from an ePTW support programme would be a timed, phased withdrawal with a published exit date.

It is widely acknowledged that as sales volumes increase, so unit costs will fall, much as has been seen in the IT sector, and indeed the modern IEC sector. So, having stimulated the market, a phased withdrawal against a background of falling unit costs and increased technology will see the inertia generated by the initial support carry the sector forward unaided.

## *7. The UK motorcycle industry and ePTW*

### 7.1 MCI background and e-MCI development

The Motor Cycle Industry Association (MCI) was created just over 100 years ago as a 'union' of cycle and motorcycle manufacturers to represent the interests of the two wheeled industry. In 1973, the cycle industry formed its own stand-alone Association, leaving the MCI to focus on representing the motorcycle industry.

Today, the MCI represents over 125 member companies from the supply side of an industry which is worth over £7billion and employs 62,000 people in 6,300 businesses. The Association works to ensure an environment where motorcycling can flourish. The MCI works to protect its members' future trading, actively promotes the many positives of motorcycling and seeks to expand the market to the benefit of members, including those who are developing ePTWs and other zero emission technologies.

With manufacture groups representing almost every aspect of the industry, the MCI can gather fully rounded market data and opinion to truly understand its members' businesses.

However, it was recognised that many ePTW sector representatives required a voice and profile which enabled it to deal exclusively with emerging technology and marketing matters to a range of public audiences. MCI therefore established an alternative powered PTW structure which draws its members from new technology and ePTW importers, in addition to traditional ICE manufacturers who are entering the ePTW sector. This will be developed into a new sister association, the eMCI. Each of the key players in the ePTW sector were asked if they would be interested in becoming members of the new e-MCI and each confirmed that they would be very keen to join and help steer the sector.

As outlined in 3.5 of this report, the vast majority of major manufacturers of ICE motorcycles have an interest in the development of the ePTW sector. Whilst technically, certainly for at least the next decade, ICE PTWs will still dominate the UK market, in the long term all of the major players will need to create a suite of products to satisfy the growing demand for low emission vehicles.

## *8. Conclusions and Recommendations*

The ePTW sector is perfectly placed to transform the urban low emission transport landscape.

Targeted, timed and strategic government support through phase two of the 'Plug In Grant' will provide the necessary catalyst to enable the sector to achieve its critical mass and establish itself as a key player in the UK's urban transport future.

Financial support is important. Proportional to the purchase cost, a subsidy of between £300 and £500 would help make the purchasing decision, but more importantly demonstrate Government recognition of the value of the sector and help generate valuable publicity.

It is clear from the diversity and range of ePTWs available at the moment that the technological opportunities are far greater in this sector than in the car sector. As demonstrated by IE at Loughborough, with appropriate support the UK is perfectly positioned to become a global leader in low emission fuel technology, battery chemistry and regenerative systems. The window of opportunity will not stay open for long, with advances in the USA and India on a weekly basis.

The UK is on the verge of a low carbon urban transport revolution. However, a combination of the current economic climate and the high purchase cost of electric cars mean that the country is in serious danger of falling well behind its global rivals, both in terms of its shift to a low carbon transport economy, and of its ability to seize the technological opportunities that the new sector now presents. Electric PTWs offer the perfect engagement tool for urban commuters, allowing the UK to grow the critical sector mass to stimulate the interest in the technological challenges presented by the low emission revolution.

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