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Powered Lightweight Vehicles:
Challenges and Opportunities for Low Carbon L-Category Vehicles in the UK

Introduction to L-Category PLVs

Final Report
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Powered Lightweight Vehicles: Introduction

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Project Brief:

The L-Category vehicle sector has been identified as offering economic, environmental and societal benefits. However, the UK currently lags behind other countries in exploiting the advantages of this transport sector. Following a LowCVP seminar and workshop on the subject, it was agreed that further work would be worthwhile, to explore L-Category vehicles' potential in greater detail. The primary focus was to be around the larger three and four-wheeled L-Category vehicles, dubbed **Powered Lightweight Vehicles**, as powered two-wheelers (PTWs), such as motorbikes and mopeds, are already established markets in the UK.

A consortium of specialists from seven UK universities have come together to produce a series of reports, pro bono, in conjunction with the LowCVP's Innovation Working Group and including input from stakeholders to ensure relevance.

These reports are not intended as an end in themselves, but instead to act as a spur to action: to build the UK's capability in ultra-light automotive engineering and to provide conditions which support the market for powered light vehicle uptake.

For more information about the LowCVP and the Partnership's work on Powered Lightweight Vehicles visit:

LowCVP.org.uk/PLV

Introduction

Powered Light Vehicles (PLVs) is a collective term for a range of two, three and four-wheeled vehicles that can transport either passengers or cargo. Under the classification system used by the European Union, these vehicles are referred to as 'L-Category', which is based on the broader UNECE classification of vehicle types ('M-Category' vehicles for the carriage of passengers (i.e. cars and buses) 'N-Category' used for the carriage of goods (i.e. vans and trucks)). L-Category vehicles are subdivided into seven groups, determined by mass, power, top speed, number of wheels etc. They range from the familiar light mopeds and motorbikes up to four-wheeled enclosed quadricycles.

FIGURE 1.1, OVERVIEW OF L-CATEGORY

Other regions of the world have their own vehicle categorisations for similar vehicles. For example, in Japan there is what is known as Kei cars, while in the USA the new 'autocycle' category came into force in 2016 for enclosed three-wheelers with steering wheels.

1.1 Applications of Powered Light Vehicles

The most important consideration for Powered Light Vehicles is the areas that they can be used in and, more importantly, the markets they are currently involved in. The range of applications for L-category PLVs is particularly wide due to the diversity of the sub-categories which result in vehicles that are suitable for a range of different activities. Across the whole category however, there are three application themes:

1. Personal mobility. In both urban and rural settings
2. Leisure activities (eco-tourism for example)
3. Light commercial use. ("Last Mile" logistics, local food deliveries)

Light commercial use is becoming very popular. More precisely, last mile delivery in urban areas as demonstrated by Gnewt Cargo, a delivery company in London (Figure 1.2). While most of their vehicle fleet consists of electric N1 vans, they have also employed a range of electric L-category vehicles in trials that cover the majority of the sub-categories from L1 to L7.

FIGURE 1.2. EXAMPLE OF SOME VEHICLES IN THE GNEWT CARGO RANGE. 1

1.1.1 L1e and L2e

TABLE 1.1. L1E AND L2E REQUIREMENTS (EUROPEAN UNION, 2013)

Classification	Requirements
L1	• Two-wheel vehicles. • Max speed of 46km/h. • Cylinder capacity less than 60 cm^3 or maximum rated power no more than 4 kW.
L2	• Three-wheel vehicles. • Max speed of 46km/h. • Cylinder capacity less than 60 cm^3 or max rated power output of 4 kW.

Sub-Categories: L1e-A (powered cycle), L1e-B (two-wheel moped), L2e-P (three-wheel moped for passenger transport), L2e-U (three-wheel moped for utility purposes).

L1e and L2e form the moped category which includes low powered two and three-wheel vehicles. Mopeds are well known; however, this section also includes lesser known vehicles such as powered cycles (distinct from EAPCs or pedelecs which are legally pedal bicycles) and three-wheel mopeds which can be optimised for passengers or other, more commercial, uses. A good example of the potential for commercial uses is the IEV Postmaster which is used for postal services or delivery of goods and offers a large payload of 230kg which competes with many conventional vehicles (Figure 1.3).

FIGURE 1.3. IEV POSTMASTER (image source: www.ieve.dk)

The bulk of the vehicles in this section revolve around personal urban transport due to the low speed cap of the vehicles which restricts them from accessing national road networks. This is interesting because there is a specific sub-category detailing utility-based moped categorisation.

One rare example of a utility-based L2e is from Segway who have been developing two and three-wheel vehicles with the intention of being used for light goods delivery, commercial use and also for police/security patrol vehicles (Figure 1.4).

FIGURE 1.4. SEGWAY SE-3 PATROLLER (image source: segway.com/products/segway-se-3)

Toyota has produced a concept vehicle called the i-Road (Figure 1.5) that is designed to fit into the L2e category that is unlike any of the other mentioned here. The Toyota i-Road is of a stylish, futuristic design which aims to provide the exciting ride of a motorcycle with the safety of a car. While not (yet) on general sale to the public, vehicle sharing schemes in France and Japan include i-Road fleets and demonstrate perfectly that the L2e category can also be filled with stylish commuter vehicles, not only rickshaw-type vehicles.

FIGURE 1.5. TOYOTA I-ROAD USED IN THE CITÉ LIB BY HA:MO PROJECT, GRENOBLE, FRANCE (Image source: www.toyota-global.com)

1.1.2 L3e and L4e

Sub-Categories: L3e-A1 (low performance motorcycle), L3e-A2 (medium performance motorcycle, L3e-A3 (high performance motorcycle). These three categories then each divide into Enduro motorcycles or Trial motorcycles.

L3e and L4e encompass motorcycles which are much more powerful than mopeds with no limit on speed and an engine capacity 2.6 times that of mopeds. This increased flexibility that is exhibited in this category means that L3e and L4e vehicles can be used for travel on national roads as well as urban travel and also allow for transportation of heavier goods than would be available in the previous two categories. Despite the increased power, there are still size limitations for what goods can be transported. In the case of L4e, the sidecar allows for an extra passenger or increased goods carrying capacity.

Motorcycles are not considered in this report because they are associated with their own developments.

TABLE 1.1. L3E AND L4E REQUIREMENTS (EUROPEAN UNION, 2013)

Classification	Requirements
L3	Two-wheel vehicles without a sidecar fitted with an engine having a cylinder capacity of more than 126cm^3
L4	Two-wheel vehicles with a sidecar fitted with an engine having a cylinder capacity of more than 126cm^3.

1.1.3. L5e

L5e is split into two categories: tricycles and commercial tricycles. Tricycles are explicitly defined as intended for carrying up to 5 passengers whereas commercial tricycles have fewer seats but more of an emphasis on utility and transportation of goods.

While tricycles are not very common, commercial tricycles see a relatively large amount of use throughout Italy, France and Spain with the main usage being for deliveries. Piaggio's 'Ape Classic' is an example of a commercial tricycle and is specified to be able to carry 390kg which is sufficient to replace the majority of deliveries that businesses require (Figure 1.6).

FIGURE 1.6. PIAGGIO APE

TABLE 1.2. L5E REQUIREMENTS (EUROPEAN UNION, 2013)

Classification	Requirements
L5	Three wheels that are symmetrically arranged. Cylinder capacity of more than 50cm^3 and/or a maximum speed of more than 45km/h.

Sub-Categories: L5e-A (Tricycle) and L5e-B (commercial tricycle).

While tricycles are uncommon in the UK at present, there is the potential for them to become a staple in urban or rural commuting. Compared with four-wheelers trikes are lighter, require fewer components, use less space (including turning circle) and have lower rolling resistance with commensurately reduced tyre noise. These features offer environmental, societal and cost benefits.

In the UK, certain vehicles (e.g. Reliant's Robin) have historically given three-wheelers, especially those with the delta layout of a single front wheel, a reputation of lacking stability. However, when the weight is distributed correctly (unlike the Robin) both delta and "tadpole" (two front wheels, one rear) offer good handling. An electric three-wheeler, such as SAM has been designed to use the battery as ballast for even better road handling.

1.1.4. L6e and L7e

Sub-Categories: L6e-A (light on-road quad), L6e-B (light quadri-mobile), L7e-A (heavy on-road quad), L7e-B (heavy all terrain quad), L7e-C (heavy quadri-mobile).

Both L6e and L7e are perhaps the most interesting of sections due to the versatility of the vehicles that are present and their similarity to the M-category vehicle that is so common. For clarification, the specifications for an M-category vehicle are summarised in Table 1.4 and it can be seen that the M-category covers the majority of vehicles that will be seen in day-to-day life. The L6e and L7e categories each have many sub-categories which depend on whether the vehicles are designed for carriage of passengers or for the carriage of goods.

TABLE 1.3. L6E AND L7E REQUIREMENTS (EUROPEAN UNION, 2013)

Classification	Summary of Requirements
L6e	• Quadricycles and quad-bikes with a mass in running order no more than 426kg, excluding batteries in the case of electric vehicles. • Maximum two seats (including driver). • Maximum speed 46km/h. • Maximum power 4kW (quad-bike) or 6kW (enclosed quadricycle). • Further requirements depend upon the sub-category of vehicle.
L7e	• Quadricycles, buggies and quad-bikes other than those in category L6e, with a m.i.r.o not more than 400kg (or 500kg for goods) and excluding batteries in the case of electric vehicles. • Maximum speed 90km/h in most cases. • Maximum power 16kW in most cases. • Further requirements depend upon the sub-category of vehicle.

TABLE 1.4 M-CATEGORY REQUIREMENTS (TRANSPORTPOLICY.NET, 2014)

Classification	Requirements
M1	• Designed and constructed for the carriage of passengers. • No more than eight seats (including driver's seat). • Maximum mass of 3.5 tonnes.
M2	• Designed and constructed for the carriage of passengers. • More than eight seats (including the driver's seat). • Maximum mass of 5 tonnes
M3	• Designed and constructed for the carriage of passengers. • More than eight seats (Including the driver's seat). • Maximum mass exceeding 5 tonnes

The carriage of up to three passengers in L7e-C vehicles is permitted. Several French manufacturers (e.g. Aixam) produce four-seaters.

Major OEMs have been exploring two-seater L7s, most notably Renault's Twizy or Opel's 'RAK e' (concept/prototype). Given the high single-occupancy rate of many car journeys, the ability to carry only one passenger is unlikely to be a significant drawback to uptake. In respect of speed: the ability to travel at 80 km/h (50 mph) in the Twizy and up to 120 km/h (75 mph) in the 'RAK e' makes them ideal not only for urban commuting but they also have the potential for travel on national roads if required.

The first L7e vehicle made for mass production was the REVAi (known as G-Wiz in the UK) with production starting in 2001 (Figure 1.7). By the time production was stopped, 4,600 REVAi had been sold globally but were criticised for their lack of safety, lack of power and old-fashioned design. The REVAi perhaps was too early to be successful, but paved the way for vehicles such as the Twizy, which is produced to much higher safety standards and a much more attractive design.

FIGURE 1.7. REVAI (AKA THE G-WIZ)

While the commuting possibilities of L6e and L7e are impressive, the carriage of goods is where the category shines. L7e category goods vehicles in particular have the potential to fill many roles such as last mile delivery, industry vehicles and as a general workman's van. Mega Van offers an impressive array of utility vehicles from French manufacturer Aixam, that can be utilised in a variety of situations. One such vehicle is the Mega Chassis which boasts a payload potential of over 500kg.

1.1.5. Kei Cars

Kei cars (Figure 1.8) are a class of vehicle in Japan that bear many resemblances to the heavy quadricycles in the L-category (L7e), with the largest difference being that most Kei cars fall out of the L-category weight limit by about 100kg. Despite their small size and low power, in 2011 over half of the vehicles sold in Japan were Kei cars (Green Car Reports, 2011).

FIGURE 1.8. SUZUKI TWIN KEI CAR

The relevance of Kei cars is that they are very successful in Japan and that has been the case since the late 1940s. Initially, Kei cars were introduced as a category to allow the Japanese to purchase low cost vehicles while also starting the Japanese automotive industry. Over time, the initial purpose of Kei cars has been succeeded by a new role of environmentally friendly, urban vehicles. Current benefits for owning a Kei car from the Japanese government are several tax breaks.

The success of the Kei car serves as an indication of the impact that well implemented L-category vehicles and small cars can have.

Kei cars were initially successful largely because they were the only automobiles available to Japanese motorists, but their continued success can be broken down into a few factors:

- High fuel economy. Honda's N Box is just short of 70mpg
- An increasingly urban lifestyle coupled with small roads and limited parking spaces
- A preference for smaller vehicles over larger ones.

Even with current Kei cars proving popular there are still efforts to improve and push Kei cars further to be lighter, smaller, and more fuel-efficient. One such example is the electric 'Coms' vehicle by Toyota Auto Body, in service on Koshiki Island, Japan

FIGURE 1.9. TOYOTA AUTO BODY 'COMS'(licensed under CC BY-SA)

1.1.6 The Powered Light Vehicle Market

L-category vehicles are largely comprised of two categories: goods vehicles (e.g. Piaggio Ape or Goupil G3) and passenger vehicles (e.g. SAM or Twizy).

1.5 million light commercial vehicles (LCVs) were registered in the EU during 2014 which is very large when compared to the 300,000 heavy commercial vehicles. Obviously, LCVs present a larger market, so L-category PLVs with sufficiently high specifications, such as payload and top speed, could actively compete with traditional M-category LCVs (ACEA, 2016).

The European passenger vehicle market reported 12.5 million new registrations in 2014, of which 4 million are small (A+B segment) vehicles. Over half of the market is dominated by small and medium vehicles. Despite the progressive use of smaller vehicles, the number of vehicles utilising alternative fuels such as electricity is still very small with only 2.7% of passenger vehicles utilising them (which has grown from 1.7% in 2011). With larger automotive manufacturers turning their efforts to electric vehicles it is likely that this percentage will continue to rise (ACEA, 2016).

The large number of small vehicles present in the automotive market in Europe bodes well for the future of L5e, L6e and L7e vehicles as the public begins to see the financial, lifestyle and environmental benefits of smaller vehicles in an increasingly urban lifestyle. L7e vehicles in particular are the likely beneficiaries of this large market due to their many similarities with the A+B segment vehicles.

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