HEV TCP Task 27: Final report

Electrification of Transport Logistic Vehicles (eLogV)

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IEA Technology Collaboration Programmes
Hybrid and Electric Vehicles (HEV TCP)

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The HEV TCP aims to produce and disseminate balanced objective information about advanced electric, hybrid, and fuel cell vehicles for governments and local authorities with currently (July 2017) activities in [3], [4]:

- Light electric vehicle parking and charging infrastructure
- Plug-in electric vehicles
- Wireless power transfer for electric vehicles
- Electrification of transport logistic vehicles (eLogV)
- Home grids and V2X technologies
- Electric and automated vehicles
- Assessment of environmental effects of electric vehicles
- Fuels and energy carriers for transport
- Small electric vehicles
- Electric buses
- Batteries
- Fuel cell electric vehicles
- EV adoption and use patterns
- Ultra-fast charging
- E-Ships

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List of abbreviations

AC	Alternating Current
BEV	Battery Electric Vehicle
CNG	Compressed Natural Gas
CV	Commercial Vehicle
CERT	Committee on Energy Research and Technology
DOE	U.S. Department of Energy
DC	Direct Current
EVS	Electric Vehicle Symposium
EEVC	European Electric Vehicle Congress
ExCo	Executive Committee
EV	Electric Vehicle
EU	European Union
EUWP	Working Party on Energy End-use Technologies
EFV	Electric Freight Vehicle
ETN	IEA Energy Technology Network
eLogV	Electrification of transport logistics vehicles
FPCC	Fusion Power Co-ordinating Committee
FCEV	Fuel Cell Electric Vehicle
GVW	Gross Vehicle Weight
GHG	Greenhouse Gas
HEV TCP	Hybrid and Electric Vehicle Technology Collaboration Programmes
HEV	Hybrid Electric Vehicle
HDV	Heavy Duty Vehicle
IEA	International Energy Agency
IPCC	International Panel on Climate Change
ICE	Internal Combustion Engine
LowCVP	UK Low Carbon Vehicle Partnership
NGO	Non-governmental Organisation
OEM	Original Equipment Manufacturer
PEV	Plug-in Electric Vehicle
PHEV	Plug-in Hybrid Electric Vehicle
R&D	Research and Development

REWP	Working Party on Renewable Energy Technology
RFS	Road Feeder Services
RCO	Relevant Cost of Ownership
TCO	Total Cost of Ownership
ULEV	Ultra-Low Emission Vehicle
UK	The United Kingdom
USP	Unique Selling Point
V2X	Vehicle to Everything
WPFF	Working Party on Fossil Fuels
ZEV	Zero Emission Vehicle

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Management Summary

The Hybrid and Electric Vehicle Technology Collaboration Programmes (HEV TCP) is an international membership group collaborating under the International Energy Agency (IEA) framework and aims to produce and disseminate balanced objective information about advanced electric, hybrid, and fuel cell vehicles for governments and local authorities. As one of its activities, Task 27 named *'Electrification of transport logistics vehicles (eLogV)'* has the scope to investigate the potential and feasibility of electric freight vehicles (EFVs) for road freight transport and urban logistics with the objectives, to summarize the status of vehicle and infrastructure technologies, implementation and hurdles, to identify early niche markets and commercialization opportunities and to provide policy recommendations for further research and deployment activities. To manage the work the activity was split into three steps: (1) Investigate the status of EFVs, (2) Development opportunities of EFV transport logistics and (3) Engaging with policy in the area of EFV transport logistics. The project delivered four presentations at international events and three accompanying research papers targeted at key stakeholders in industry, R&D, academia, NGOs and government. In addition to the presentations and research papers, the activity also held four international workshops, the first in Stuttgart (DE), the second in Amsterdam (NL), the third in Vienna (AT) and the fourth in Coventry (UK). These workshops attracted key stakeholder involved with logistics, electric vehicle technology, policy, etc. The presentations at the international conferences, the discussions at the workshops and the continued engagement with stakeholders all focused around the support and dissemination of the desk based research activity. In addition, the activity resulted in a number of key deliverables: (1) Vehicle Database, which presents the key facts of EFVs available on the market or presented as prototypes, (2) Project Profiles, which present key facts of on-going or completed demonstration projects from the partner countries, (3) Workshop Presentations provided by stakeholders, and around which the discussion points noted were arrived at. The activities within the project reached a wide target audience and the results of these activities presents a valuable resource that collates activities regarding EFVs in transport logistics in the partner countries. All of the results remain accessible on the HEV TCP Task 27 website (http://www.ieahev.org/tasks/e-logistics-task-27/) to support stakeholders involved in the EFV transport logistics.

1 Introduction

This report is the final deliverable of Task 27 '*Electrification of Transport Logistic Vehicles (eLogV)'.* The objective was to investigate the potential and feasibility of the electrification of road freight transport and urban logistics. The work was part of the International Energy Agency's Hybrid and Electric Vehicles Technology Collaboration Programme (HEV TCP). This final report will be delivered as part of the activity and will summarise the work and provide guidance for further actions.

In order to minimize the negative environmental impacts, as described within the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), emissions of Greenhouse Gases (GHG) from all sectors of the global economy have to be reduced [5]. Not only national but also international actions have been implemented to target reduction in emissions from particular sectors of the economy. As an example, the European Union (EU) has set an ambitious target for reducing its GHG emissions and aims for an 80 % reduction in 2050 compared to 1990 levels [6]. The reduction target for the transport sector is 60 % over the same period.

Whereas across the EU overall emissions of greenhouse gases are on a declining trend, emissions from the transport sector continue to increase [7]. In particular, road freight transport is one of the fastest growing modes of transport and has an increasing share in the total GHG emissions of transport. Road freight transport accounts for approximately 25 % of GHG emissions from road transport [8]. Over the last decade, road freight transport emissions grew by around 25 % in EU 27, without significant changes to vehicle fuel consumption, resulting in an increase of emissions [9]. Worldwide, road-freight activity and energy use have almost doubled in the last two decades [10]. Furthermore, the available projections show further increase in freight activity [7], [11], [12], [13], [14].

Various technical and non-technical options exist for reducing the GHG emissions of road freight transport, such as improving the efficiency of freight logistic systems or incremental technology developments to reduce fuel consumption of conventional vehicles. However, combined with the increasing share of road freight transport these measures will not be sufficient to fulfil the GHG reduction targets of the EU.

Several pilot projects have therefore been initiated to investigate the potential of electric freight vehicles (EFVs). The common approach has been to prove feasibility in terms of vehicle requirements and logistic processes driven by the assumption that some vehicles follow specific routes and usually refuel at dedicated stations which may enable the application of alternative vehicle concepts. Therefore, one of the scopes of this Task 27 has been to investigate the potential and feasibility of EFVs for road freight transport and urban logistics.

2 Approach

The working method for the task is outlined in Figure 2-1. The data collection was to be undertaken by a combination of desk based activity – collecting information on the current status of EFVs and application to logistics – and direct engagement with stakeholders and actors by a series of themed workshops. The results of this activity would be communicated to the public and policy makers through a series of channels that include research papers, presentations and representation at conferences.

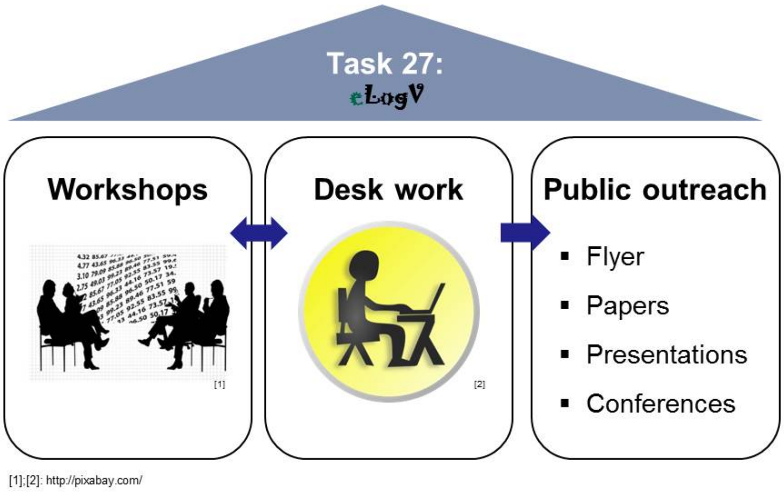

Figure 2-1: Task 27 working method

To manage the work, the approach was to split the activity into three steps.

Step 1: Investigate the Status of EFVs

In order to investigate the status of EFVs a vehicle database was developed. Based on inputs from Austria, Germany, Korea, Turkey, the Netherlands and the United Kingdom, information on vehicles of the category N according to the European classification scheme was collated. Category N vehicles are motor vehicles with at least four wheels designed and constructed for the carriage of goods and defined according to the following classification [15]:

- **Category N_1:** Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes
- **Category N_2:** Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes
- **Category N_3:** Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes

Due to increasing vehicle development activities, there is no claim for completeness of the database. It was the purpose to assemble sufficient information to enable comparative assessment both with existing fossil fuel vehicles and between the respective regions. This information would provide initial input into the workshops and also provide information for communication to interested parties via papers and conferences.

Step 2: Development Opportunities of EFVs in Transport Logistics

The development potential of EFVs in transport logistics would be approached via the organisation of a number of themed workshops. These workshops would complement and add the necessary additional depth to the information collected from the desk based research activity.

Step 3: Engaging with Policy in the Area of EFVs in Transport Logistics

The final step and perhaps the most challenging, was to translate the input gathered into information with impact at the policy level. Therefore, the partnership provided status updates at international conferences throughout the duration of the project. Finally, this report will answer exemplary key questions regarding EFVs for road transport and urban logistics in order to strengthen discussions around the hurdles for deployment and enable policy recommendations:

a. Is there the product in place?
b. Is there the infrastructure in place?
c. Is there the policy support?

3 Current Status of EFVs in Transport Logistics

There is a lack of information about the status of existing EFVs [16]. To counteract this situation and to support relevant stakeholders with appropriate information it is crucial to understand the status of EFVs. In this context, vehicle availability, applicability and commercial viability are important aspects to consider. Essential for determining the applicability is the vehicle performance in terms of range and payload. Key for the commercial viability is the type of application and related Total Cost of Ownership (TCO). Therefore, the aim of this section is not only to summarize the status of EFVs with focus on vehicle performance (range and payload). Also a summary of experiences from different pilot applications and a Relevant Cost of Ownership Analysis undertaken for electric vehicles of the category N_1 is given.

3.1 Vehicle and Infrastructure Technology

For the purpose of data collection in order to understand the current status of EFV availability and current status of technology, a EFV database was created based on market inputs from different countries like Austria, Canada, France, Germany, Turkey, Italy, the Netherlands, Portugal, the United States of America, Sweden and the United Kingdom. The inputs were mainly based on information from vehicle fact sheets. Finally, the database includes about 123 EFVs of the different vehicle categories N_1, N_2 and N_3. A list of the EFVs in the database is attached to the Appendix 1: List of electric freight vehicles in the database. Relevant EFV characteristics are classified into general and specific data.

EFV general data collected were:

- **Market**
  Name of Country where the vehicle was presented or is commercially available
- **Producer**
  Name of the company producing or converting the vehicle
- **Name**
  Name of the vehicle
- **Powertrain technology**
  - *HEV (hybrid electric vehicle),*
  - *PHEV (plug-in hybrid electric vehicle),*
  - *BEV (battery electric vehicle),*
  - *FCEV (fuel cell electric vehicle)*
- **Type of powertrain**
  - *parallel hybrid,*

- *serial hybrid,*
- *pure electric,*
- *fuel cell electric*

- **Functionality**
  - *micro hybrid*
  - *mild hybrid*
  - *full hybrid,*
  - *plug-in,*
  - *range extended*

- **Production status**
  - *Prototype (vehicle used for research purpose),*
  - *e-conversion (conversion of conventional commercially available vehicle or electrification of conventional chassis),*
  - *close to series production (more than one vehicle has been produced and/ or as per producer announced commercially available)*

- **European vehicle category**
  - *N_1 (≤ 3.5t GVW),*
  - *N_2 (> 3.5t - ≤ 12t GVW),*
  - *N_3 (>12t GVW and Tractor Trailer)*

- **Year**
  Year of vehicle presentation to public or date of press release

The data collected allowed for a view to be gained about the current production status, the current manufacturers and current powertrain types. EFV specific data was collected in order to understand the current status of technology implemented and the key powertrain components configuration of the different powertrain types.

EFV specific data collected were:

- *Engine displacement in cm³*
- *Nominal performance in kW*
- *Max. Torque in Nm*
- *Gearbox type*
- *Type of electric machine*
- *Battery type*
- *Battery capacity in kWh*
- *Gross vehicle weight in tons*
- *Payload in tons*
- *Range in km*
- *Top speed in km/h*

The purchase price would be interesting to know but was not collected for two reasons. First, the production status of current vehicle models presented varies from prototypes to e-conversions to close to series production. Vehicle models produced at series conditions will have different purchase prices depending on production units. Second, the transport sector is very individual with a wide range of applications. Therefore, the purchase price is a matter of negotiation, depends on individual requirements and is only available on personal request.

As mentioned before, the production status of the current EFVs presented varies from prototypes to e-conversions to close to series production. Figure 3-1 shows that with about 51 % (63 vehicle models), most of the EFV models identified, are vehicle models of the category N_1. However, 26 % (32 vehicle models) and 23 % (28 vehicle models) of the total EFV models identified are vehicle models according to the vehicle category N_2 and N_3 respectively. The most frequently observed production status is close to series production followed by e-conversion.

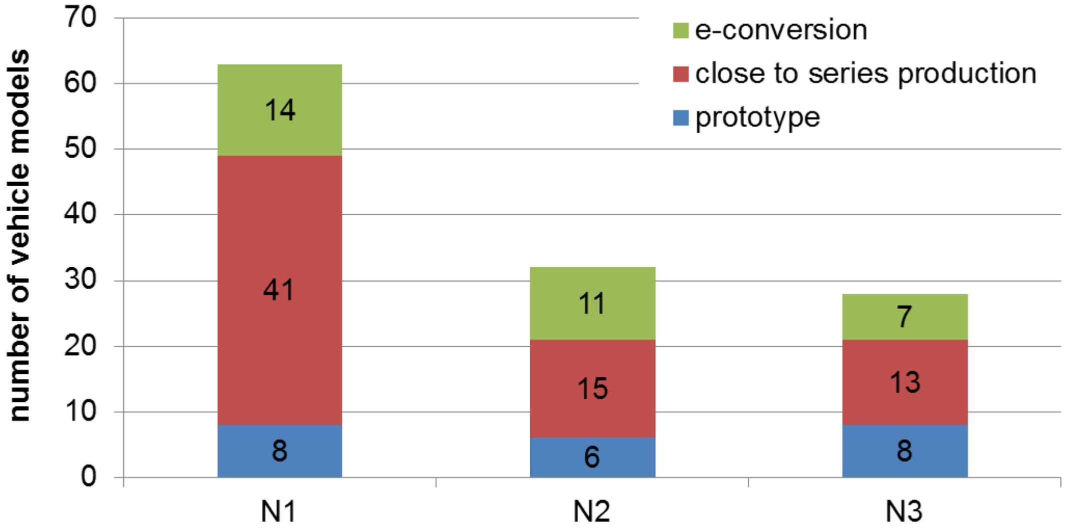

Figure 3-1: Number of EFV models identified (prototype, close to series production or e-conversion) with electrified powertrain (total number of EFV models is 123)

Battery electric vehicles (BEV) clearly dominate across all the vehicle categories (see Figure 3-2). The highest share of BEV can be observed within the vehicle category N_1 (>90 %). Nevertheless, there is a high share of BEV according to the vehicle categories N_2 (~75 %) and N_3 (~70 %). In comparison to the battery electric technology, only a small number of vehicle models with alternative powertrain technology like hybrid (HEV), range extender (REEV) or fuel cell (FCEV) can be observed.

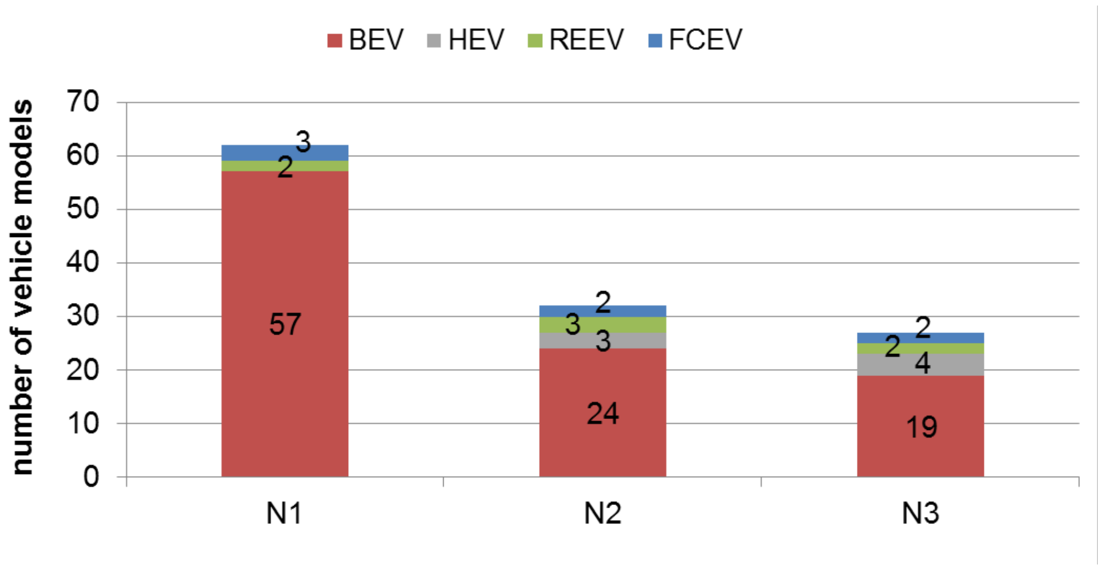

Figure 3-2: Identified powertrain types (total number of EFVs is 123)

In terms of the range current vehicle performance of N_1 category battery electric freight vehicles range from 35 km to 403 km with 118 km on average. Vehicle payload ranges from 230 kg to 1,900 kg with 800 kg on average. Regarding the range of N_2 category battery electric freight vehicles, the current driving range varies from 30 km to 223 km with an average of 120 km. Vehicle payload ranges from 2,000 kg to 5,990 kg with 2,900 kg on average. The range of N_3 category battery electric freight vehicles vary between 97 km to 325 km with 179 km on average. Vehicle payload ranges from 6,000 kg to 29,000 kg with 9,730 kg on average (see Figure 3-3).

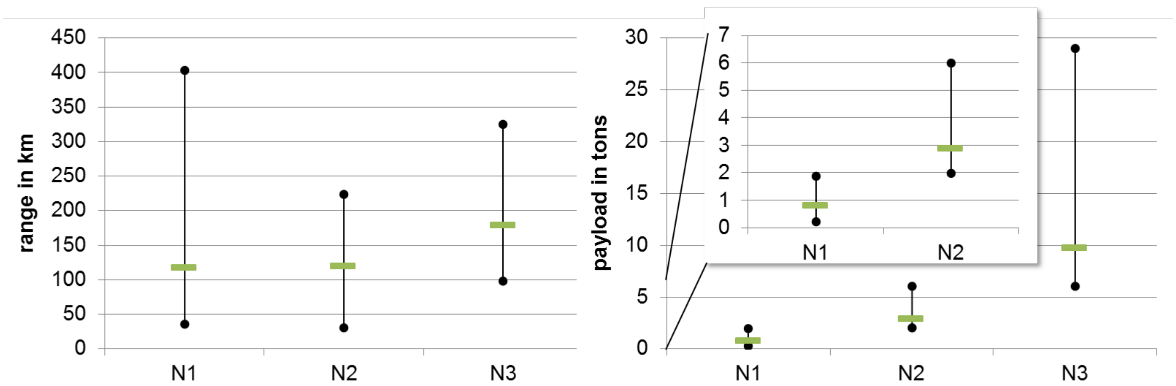

Figure 3-3: Bandwidth of current vehicle performance[1)] – regarding range (on the left) and payload (on the right)

Looking at the vehicle manufacturers it can be observed that the majority of the vehicle models presented are produced for niche applications and offered by new players.

The Task 27 vehicle database contains further detailed information regarding the EFV models identified as listed above. The database is available for download via the task webpage: http://www.ieahev.org/tasks/e-logistics-task-27/

The most common concept for charging is plug-in electric slow charging with a charging power of ≤ 22 kW AC. In addition, fast charging stations with charging power of 50 kW DC is another common charging concept. The idea of Electric Road Systems (ERS) is to provide continuous or dynamic power transfer to the truck as it is driving. Principally, there are two different technology approaches to install electric road systems. By the use of overhead transmission technology an active, conductive-based, pantograph connects and disconnects the truck to the contact lines at all speeds and transfers energy directly from the overhead contact wires to the electric motor to the eDrive-System of the truck. The proof of concept was achieved in 2010. The system is currently tested on public roads in Sweden and will be tested on public roads in Germany in 2018 [17], [18]. By the use of ground-based transmission technology either conductive or inductive solutions are possible. Via a physical pick-up, the truck is conductively connected to an electrified rail in the road. Using wireless power transfer from a coil in the road to a pick-up in the vehicle, power transfer takes place inductively. Inductive solutions are currently tested, e.g. the PRIMOVE System of Bombardier is often mentioned related to stationary and dynamic inductive charging systems for e-buses and e-trucks with a state of the art charging power of 200 kW [19]. Battery swapping for automated guided vehicles (AGV) was successfully developed and brought into service via a pilot project in Germany named “B-AGV”. Additionally, an implementation of a battery swapping system for commercial vehicle application took place within another German pilot project called “NaNu!”. A sufficient network of hydrogen refuelling infrastructure is currently missing. However, only a very small number of EFV powered by hydrogen are in operation and commercially available.

3.2 Pilot Applications and Business Models

In order to summarise the experiences of the current usage of EFVs in transport logistics, experiences from pilot applications performed in Austria, Germany, Turkey and the Netherlands were gathered. The findings are based on public information provided by relevant projects identified (see Appendix 2). In addition key results are documented via 16 individual prepared project profiles which are available for download via the HEV TCP Task 27 webpage. In the following, a summary of the findings is given.

The aims of the pilot applications vary widely, e.g. testing the deployment of electro mobility, proving practical feasibility, developing new logistic concepts, etc. (see Figure 3-4). For detailed information please see the individually prepared project profiles available via the task webpage: http://www.ieahev.org/tasks/e-logistics-task-27/

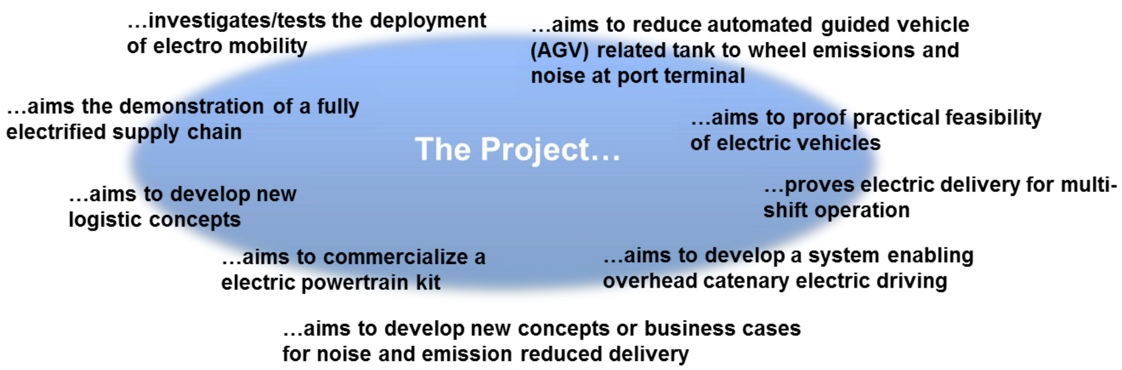

Figure 3-4: Aims of the pilot applications (extraction)

Generally, three different fields of operation, urban delivery, regional delivery and others were differentiated.

Urban logistic applications which cover the distribution in cities or suburban sites of consumer goods/parcels from a central store to selling points/recipients, e.g. "last-mile" deliveries, are generally seen as early niche markets for EFVs from the operations point of view. Reasons for that are limited route lengths, low travel speed and frequent stop-and-go movements in urban areas. In addition, vehicles used within urban areas are going to be faced with tightened emission requirements. However, vehicle performance varies between specific vehicle types and depends on a number of factors related to cost, operational conditions, technology and infrastructure. Therefore, the operability and the business case highly depend on country specific conditions and the case of application. Battery electric vehicles of the vehicle category N_1 are mainly used for urban delivery transport application. Most experiences have been made with battery electric vehicles used for parcel and post deliveries. Results of a cost analysis for an urban delivery application show that battery electric vehicles are (almost) competitive throughout the countries of investigation. Fuel cell electric vehicles are by far currently not an economic solution mainly based on high costs of the fuel cell system and the high hydrogen prices per MJ energy carrier in comparison to the electricity and diesel fuel prices (see Figure 3-5) [20].

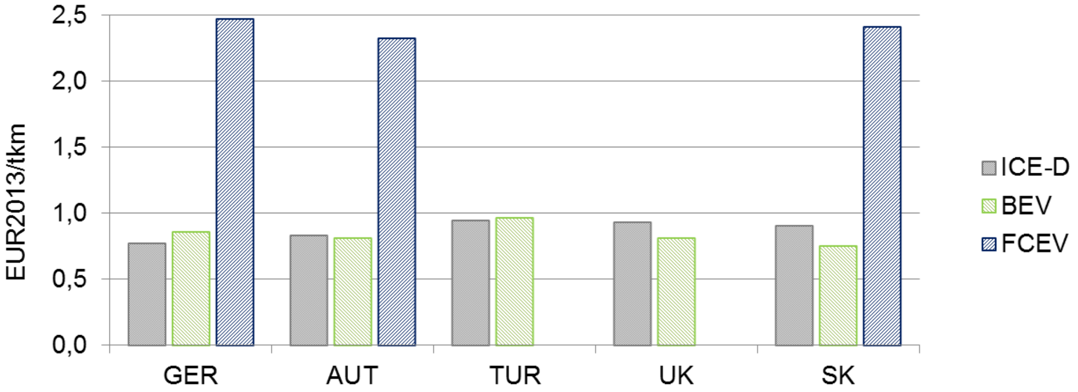

Figure 3-5: Comparison of country individual Relevant Cost of Ownership per ton-kilometres for battery and fuel cell electric vehicles of the vehicle category N_1

The cost evaluation is based in theoretical data input given in [20]. Unfortunately, business case information out of practice, e.g. regarding the pilot applications, are not provided or publicly available.

Whereas the applicability of category N_1 battery electric vehicles seems to be given for urban logistic applications, it is still unclear for vehicles of category N_2 and N_3. In addition, the applicability of EFVs within regional logistic applications covering the delivery of consumer goods from a central warehouse to local stores, e.g. “first-mile” deliveries, is not sufficiently proven yet. Other applications like waste collection and airport or port terminal operation seems to be very promising for which reason, e.g. for airport terminal operation, a follow-up project was initiated.

A lot of experiences were gathered throughout the different pilots. Unfortunately, for some of the pilot projects, key results have not been publicly available. However, beside country individual experiences described within [21], common experiences across countries are:

- Current development stage of battery electric vehicles limits operation
- Availability and choice of EFVs is low
- Technology is well accepted by the drivers
- Practical business cases are hardly provided
- Business case highly depends on the local conditions

4 Accelerating Deployment of EFVs in Transport Logistics

Through a series of themed workshops, external experts were invited from industry, research organizations, and policy institutions around the world to refer and discuss about the four different topics:

- EV Technology and its Application to Logistics
- Experiences and Future Prospects for EFVs
- Moving EFVs from the Niche to the Mass Market
- The Road to Electrification of Logistics

These activities complement and add the necessary additional depth to the information collected from the desk based research activity (see section 3). All the presentations are available for download via the Task 27 webpage: http://www.ieahev.org/tasks/e-logistics-task-27/

4.1 EV Technology and its Application to Logistics

The initial workshop was held in Germany and hosted by the Institute of Vehicle Concepts of the German Aerospace Center on March 19th, 2015. The theme of this workshop was '*EV Technology and its Application to Logistics*' with the intention to understand the state of battery and fuel cell technology for transport logistic vehicles. In addition, the workshop also sought to collect more general background information on experiences made by demonstration projects in Germany. Furthermore, an open discussion regarding barriers, drivers and strategies for the operation of EFVs took place.

The workshop started with the story of Hytruck, a company providing customized electric truck solutions, presented by the Dutch task partner Eric Beers from Hytruck.

Session 1: R&D for EFVs

The first of the three sessions covered the latest R&D developments for EFVs with presentations from Felix von Borck (Akasol), focused on developments of battery systems, and Sebastian Wider (Ballard representative), focused on developments of fuel cell systems. The key messages from this session were as follows:

- Automated production of battery systems is achieved for the capacity of 20 MWh (one-shift operation; ca. 1,000 battery electric cars or 200 e-buses), which can be upscaled in units of 20 MWh.
- Production quality of battery cells and modules is crucial for the robustness of the battery system.
- Operating temperature, cell chemistry, cell design and the number of charging processes influence the battery's life-time by factor 3, 4, 4 and 5, respectively.
- High potential of life cycle cost reduction through reduction of installed battery capacity combined with an optimal re-charging strategy in order to use the cyclic life-time within the calendric life-time.
- Quality of the battery system, e.g. life time or energy density, is significant for the market penetration of heavy duty vehicles (HDV)
- Automated production of fuel cell systems for high volume manufacturing with an expected cost reduction of 50 % ($/kW).
- Fuel cell system warranty offered is about 15,000 operating hours.

In summary, the conclusion of this session was that there are viable products in place. However, further improvements regarding technical performance and costs are required in order to boost the attractiveness of these technology solutions and to ensure adequate product durability, security, robustness and power density.

Session 2: Possible Fields of Application for EFVs in Transport Logistics

The second of the three sessions addressed the user experiences of EV in transport logistics. Presenters where Dr. Sebastian Stütz (Fraunhofer IML), presenting real world data from electric delivery vehicles and their implications for EFV transport logistics, and Prof. Bernecker (Heilbronn University), presenting the results of the Mannheim case study "Electric heavy duty vehicle for urban environment". The key messages from this session are outlined below:

- Procurement decisions require precise and reliable range information of EFVs which is non-existent yet.
- Authorities lack experiences with EFVs, prolonging the process of technical examination and registration.
- About half of all problems are due to difficulties with the electric powertrain.
- Technical problems with charging have not been recorded.

- General reliability of EFV is highly volatile.
- Lack of technical support for EFVs leads to longer downtimes compared to ICE vehicles.
- Conservative calculations lead to estimated cost savings of about > 70 % per km when holding electricity vs. diesel fuel consumption.
- Corporate fleet operators have their own charging points at loading bays or inside their terminals and usually charge their vehicles at night when off duty. Charging en route is considered as impractical and time-consuming. Therefore, fleet operators are rarely interested in an extensive network of public charging points.
- Economic efficiency is the key to success. Much higher vehicle investment compared to conventional diesel vehicles is seen as a main barrier for application of EFVs.
- Overcautious dispatch and route planning keep EFV from reaching full and optimal utilisation.
- Uncertainty about technical and economic potential pushes EFVs out of fleet planning and procurement.
- Groupage operations: Nearly all trips < 300 km could be operated with the electrically driven vehicle „E-Force”. Resting time (4 p.m. to 7 a.m.) is sufficient for recharging.
- Road Feeder Services (RFS) in air cargo: All trips can be operated with the electrically driven vehicle „E-Force“. A heavy commercial vehicle with a maximum mass exceeding 18 tonnes – as it is used at present – is not available yet. Breaks of about an hour are not sufficient for re-charging the batteries completely; thus a battery-exchange system is needed.
- The number of trips that could be electrically operated with vehicles which are already available is much higher than estimated. According to the real life cases up to 75 % of all truck operations with heavy commercial vehicles in the Rhine-Neckar area could be operated electrically, but operating electric trucks in the selected cases is still not profitable.
- Additional real life cases should be evaluated to get more information on the existing possibilities of electric driving.

In summary, the sessions covered a number of pilots in operation in Germany. These pilots have provided information on usage of EV and the suitability of the technology. There is a large potential for heavy duty transport tasks in urban areas, mainly in local distribution, but also in semitrailer transport operated by electric tractor units within the city. However, current battery electric heavy duty vehicle product availability is very limited and not profitable. Together with the existing lack of knowledge and experience the technology penetration is difficult.

Session 3: Open Discussion regarding Barriers, Drivers and Strategies for the Operation of EFVs

During the final "World Café" session, simultaneous discussions on four tables and in four sessions with representatives out of industry, public and science took place. The results, from the participants discussed and identified "Barriers", "Drivers" and "Strategies" are outlined below:

- **Barriers** for the operation of EFVs
  - Vehicle range
  - Limited infrastructure availability and too many standards
  - No business case for OEMs
  - Lack of information / specs
  - Technology cost, availability and reliability
  - Lack of public awareness / interest
  - Limited public procurement
  - Less flexibility in multi-purpose logistics tasks / fleet
  - Limited warranty / lack of trained personnel for maintenance & repair
- **Drivers** for the operation of EFVs
  - The rising awareness on climate change and, therefore, increasing demands for all electric vehicles.
  - Addressing all-electric vehicle usage in city transportation policy (low emission vehicle in terms of noise, CO_2 and pollutants).
  - Making progress in standardization issues, e.g. charging infrastructure.
  - Benchmarking: Information transparency regarding technical, economical and acceptability issues of vehicle operation, e.g. driving experiences, vehicle performance, etc.

- Further developments in battery technology, e.g. enhancing specific power / energy density to improve operating performance, e.g. driving range.
- Autonomous driving
- Second-life concepts for battery usage
- Purpose design of the vehicle especially matched to requirements of the transport task and to the requirements of the drivers.
- Using the positive image of all electric vehicles as unique selling point (USP).
- New business model by offering grid power of the all-electric vehicle fleet.
- Driving restrictions within high polluted areas.
- Clear and stable boundary conditions – low risk for the investment in all-electric vehicles.
- Availability of all-electric vehicles
- Reduced payback periods through multi-shift operations.

* **Strategies** for the operation of EFVs
  - EV centres for all questions and education
  - More awareness for the end customers by advertising and TV commercials.
  - Strengthen awareness for overall change of mind towards CO_2 goals.
  - More real life tests and demo projects and a good communication around it.
  - By involving end customer in supporting CO_2 – neutral logistics (involve the whole chain)
  - Easy and clear / transparent subsidies
  - Incentives for EV trucks on EU base
  - Transparent and publicly available analysis of practical business cases
  - Clear targets: 2025 => X number of EV trucks : 2035=> Y number of EV trucks
  - Bring together customer demands for larger quantities and lower vehicle costs.
  - EU wide standardized “zero emission” areas
  - Longer battery warranty and full mobility solution services

In summary, the discussion session showed that there are still existing barriers for the operation of EFVs. Nevertheless, the identified barriers can be overcome by addressing the drivers named and the implementation of individual strategies listed above. Especially, the urban framework conditions e.g. zero emission areas, seems to be a central element in introducing EFVs in transport logistics. Generally, there is a need to transfer the information from desktop to “real life”.

4.2 Experiences and Future Prospects for EFVs

The second of the workshops was held in Amsterdam on April 12th, 2016. The theme of the workshop was *‘Experiences and Future Prospects for EFVs’* and the aim was to collect information on the experiences of the operation of EFVs both from a Dutch perspective and more generally. The intention was to use this understanding to identify prospects for the electrification from a user perspective.

The opening speech was delivered by Stephan Schmid from the German Aerospace Center (DLR), scientific delegate of Germany to the HEV TCP Executive Committee (ExCo), who provided general information about the Task 27. Next, Hans Quak from TNO (Netherlands Organisation for Applied Scientific Research) presented facts and figures about the air quality problem in Dutch cities; highlighted the role of urban freight transport on emissions, congestion, noise, and traffic safety; and provided the motivations towards electro mobility in logistics and the challenges as well. Frank Rieck from the Rotterdam University presented an analysis of national and international electric vehicle pilot projects in transport logistics, discussed their findings, and summarized the key factors underlying success and failure.

Session 1: City and Country Perspectives

The first session included three presentations providing various perspectives from different cities / countries. Eric Regterschot from Sustainable Mobility of Amsterdam presented their EFVs implementations and experiences in Amsterdam. Jos Streng FREVUE Rotterdam outlined the need for EFVs implementation in leading European cities. Finally, Prof. Ock-Taeck Lim from the Ulsan University presented the recent activities related to the development of small EFVs in South Korea. The key discussion points from this session are outlined below:

- The experiences revealed that it is essential to put a target on the horizon and give perspective for action. A good example is the introduction of congestion zones.
- The initial costs of EFVs are still high and the advantages of privileges provided are not sufficient to close the financial gap. The remedy may include:

- Rewarding the frontrunners through subsidies, parking and loading spaces, time windows for loading-unloading zones, etc.
    - Building platforms to share experiences and disseminate the acquired knowledge.
- Procurement policies are needed for delivered goods and services as well as the fleets.
- The current subsidies for EFVs in Amsterdam are as follows:
    - 5.000 EUR for N_1 category vehicles
    - 40.000 EUR for N_2 and N_3 category vehicles
- Supportive government policy is still of high importance for the wider uptake of EFVs.

Session 2: Early Adopters of EFVs

Two presentations were delivered in the second session by early adopters of EFVs. Edwin Vermeer from TNT Rotterdam outlined their company's vision and shared their experiences within the FREVUE Project. He also highlighted the challenges they were faced with and the steps to take next to deliver their services in an energy neutral way. Bert Roozendaal from TransMission introduced cargohopper, a 'quick and easy' solution for electrified city distribution. The key messages from this session are outlined below:

- TNT addresses electro-mobility at their corporate responsibility commitments.
- The benefits of investing in EFVs for TNT can be summarized as follows:
    - Improved operational efficiency and acquired privileges through collaboration with city authorities.
    - Financial savings through fuel reduction; reduced tailpipe emissions, and noise.
    - New experience and skills gained with motivated drivers.
    - Public exposure
    - Customer acquisition / competitive edge
- B-class driver license should be adjusted to permit driving EFVs with a maximum weight of 4.5 tons.
- The electric trucks are not cost-effective because the transport sector operates with low profit margins.

- Cargohopper is designed to deliver more volume with fewer trucks in the inner city.
- Cargohopper uses lead-acid batteries which cost about 85,000 EUR.
- Road legislation stays behind the practice.
- There is a strong appeal to develop an integral European vision on electrical distribution.

Session 3: Infrastructure for Charging

The two talks in the third session focused on the charging infrastructure. Hasso Grünjes from Siemens AG presented the current status and outlook on the eHighway system, an electrified road network for heavy-duty transport. Daniel Dörflinger from IPT Technology outlined their efforts in inductive charging technology. The key discussion points from this session are outlined below:

- Zero-emission trucks are possible with renewable energy, but well-to-wheel efficiency varies greatly:
  - 77 % Electric Road Systems
  - 62 % Battery
  - 29 % Hydrogen
  - 20 % Power-to-Gas
- Potential application fields for the eHighway system:
  - Short term: shuttle and mine transport
  - Long term: long-haul freight transport
- In Germany
  - 60 % of heavy duty vehicle emissions occur on 2 % of the road network, that is, on the autobahns (total length of 12,394 km)
  - The most intensely used 3,966 km handle 60 % of all ton-km on the autobahns
- Investment cost of the eHighway system varies between 1 - 2.5 Mio. EUR/km for both directions depending on local situations.
- Inductive charging technology will break-even after 6 – 12 years and strongly depends on individual application.
- Positive business cases for inductive charging are possible for vehicles driving periodic routes.
- Short inductive charging may extend the battery lifespan up to 10 times.

- Inductive charging system weights nearly 100 kg.

Session 4: Panel Discussion on "Plan of action for EFV market penetration: Out of Niche - Into the Mass Market!"

The last session was a panel discussion on the action plan for EFV market penetration. The key messages are outlined below:

- The majority of fleet managers declare a period of 3 – 4 years as the period of amortization in which they expect to recover the purchase price of an EFV.
- Product market combination differentiation is essential.
- Recently, non-monetary incentives appear to be very important as financial ones are not sustainable in the long term.
- A better way to support the mass adoption of the alternatively fuelled technology is to give them a long-term competitive advantage.
- Even frontrunner companies stress that they cannot compete without a means to bridge the financial gap in the business case for EFVs.
- It is essential for the European cities to team up in order to share information and learn from each other:
    - What is the potential demand for EFVs?
    - How the solutions are valid in different climate and policy environments?
- 15 % of the world's total battery capacity belongs to the mobility sector and 85 % belongs to consumer electronic devices.
- Main challenges:
    - Technology reliability
    - Daily range / flexibility
    - Duty cycle / charging
    - Driver acceptability / driver training
    - Fitting of telematics to monitor vehicle performance remotely
    - Suitable charging infrastructure in place
    - Positive business case to invest in EFVs

4.3 Moving EV Freight Vehicles from the Niche to the Mass Market

The third workshop was held in Austria and hosted by JOANNEUM RESEARCH on October 19th, 2016. The theme of this workshop was *'Moving EV Freight Vehicles from the Niche to the Mass Market'*. The four sessions focused on ways and experiences on how to bring the vehicle technologies and the user requirements together to move EFVs from the niches and current pilot activities into the wider commercial market.

Session 1: EFVs as Pillar of Sustainable Transport Logistics

After the welcome address by Sarah Krautsack from the Austrian Ministry for Transport, Innovation and Technology (bmvit), and a Introduction to Task 27 by Florian Kleiner from the German Aerospace Center, two presentations in session 1 presented ongoing activities with the objective to implement EFVs as enabler for sustainable transport logistics in Austria. The first presentation was held by Barbara König from the Austrian Council for Sustainable Logistics (CNL), an association with currently 17 Austrian major logistic and retail companies. During the second presentation held by Dr. Bartosz Piekarz from the Austrian research project GreenCityHubs in the field of last mile urban logistics based on combining inner-city hubs and EFVs was introduced. The key messages from this session were as follows:

- Cooperation - cross-company, cross-sectoral and multi-institutional - is in the current phase key to success to achieve the 2030-goal of the European Commission, reaching a substantially CO_2-free city logistic.
  - The CNL association in Austria provides an example for cooperation of major logistic and retail companies, OEMs, federal government and city administrations as well as research institutions.
  - The cooperation provides support, network exchange and lobbying in relation to ecological, social, political, legal and economical aspects of implementing EFVs.
- The CNL partner companies start operating 9 MAN battery electric heavy duty trucks as test vehicles starting from November 2017. Small series production of approx. 250 MAN e-trucks (TGM type, 12 to 26 tons) in the production facility Steyr (Austria) is planned starting end of 2018, with a full series production starting in 2021.
- Achieving the 2030-goal of reaching a substantially CO_2-free city logistic requires the fleet exchange of diesel with electric vehicles to start already 2020. Many existing strategies, projects and initiatives which are still not sufficient to reach the targets set.
- Lack of support by Austrian city administrations – no Austrian city has so far put electric freight transport on its political strategy agenda.

- City hubs as inner-city last-mile hubs support the implementation of EFVs for last-mile delivery as the driving range is reduced.
- Due to still high costs, shared hubs appear to be a solution. However, the varying logistic systems of different companies are a major challenge for city-hub sharing.
- City hub sharing is a topic in the EU project NOVELOG (http://novelog.eu/)
- Additional costs of an e-van per month, based on 150 parcels delivered per day in Austria are about 250 EUR per month.
- To support the implementation of e-vans, "restricted access" areas in cities should charge diesel vans with the additional costs of e-vans (min. 250 EUR).
- Payload - gross vehicle weight of driving license type B (limit 3.5 ton of GVW): should be raised to 4.25 to for e-vans in Austria.
- New technology has to be combined with an advanced business model (Fleet integration advisory, on-demand availability / provision of electric vehicles, integrated service & maintenance; installation and maintenance of charging infrastructure, training / informational material)

Session 2: Governmental Perspectives and Implementation Plans for EFVs

Two presentations in session 2 presented "facts and figures" related to governmental plans to implement EFVs in Austria and Germany. The first presentation was held by Dominique Sevin from the National Organisation for Hydrogen and Fuel Cell Technologies (NOW, Germany), the second presentation was held by Henriette Spyra from the Austrian Federal Agency for Technological Measures (AustriaTech). The key messages from this session were as follows:

- EV in urban freight transport has a high strategic importance for the German government and regional funding programs.
- Current funding options by German Federal Ministry of Traffic and Infrastructure:
  - 40 % of additional costs for commercial e-vehicles and charging infrastructure (no limits to purchase price or payload)
  - Municipal concepts to boost electric mobility, linked to compulsory implementation
  - Environmental Premium (4,000 EUR for BEVs and FCEVs; 3,000 EUR for PHEVs); Financing 50 % each by Government and OEMs; Funding

of vehicles with a maximum purchase price of 60,000 EUR; Total budget: 1.2 Billion EUR maximum until 2019

- Charging infrastructure: Total budget: 300 million EUR; 200 million EUR promote fast charging (DC); 100 million EUR promote normal charge (AC); At least 15,000 charging stations will be set up: 10,000 normal and 5,000 fast
- Tax free charging on working place for employee
- Extension of tax exemption for EVs from 5 to 10 years
- 20 % EVs in federally owned fleets

- German information platform providing practical advice and recommended actions for municipalities willing to start with electro-mobility: www.starterset-elektromobilitaet.de
- Incentives for e-mobility in Austria
  - Klimaaktiv mobil and regional funding as direct funding incentives
  - Tax exemptions (registration, insurance, company car tax)
  - Green public procurement
  - Municipal incentives (exemption from parking fees, reserved parking)
  - No specific measures for EFVs

Session 3: Performance and Limits of EFVs

Two presentations in session 3 presented practical experiences with electric trucks in Switzerland and the Netherlands. The first presentation was held by Georg Weinhofer from COOP Switzerland, the second presentation was held by Eric Beers from the Dutch Platform of Sustainable Transport. The key messages from this session were as follows:

- COOP Switzerland operates five E-Force e-trucks (one since 2014, four since 2016) for good transport to supermarkets and for delivery wholesale.
- Profitability compared to diesel truck:
  - Investment is 220 % of diesel, operating costs 10 % of diesel
  - E-truck is more profitable compared to diesel after 220.000 km (in Switzerland, mainly due to exemption from road toll).
- Conclusions from operation:
  - (+) No constraints regarding transported volume and disposition

- (+) Total substitution of a comparable diesel truck (solo use in city / metropolitan area)
- (+) Low noise, good acceleration
- (–) Use on tours with autobahn not so good (less recuperation)
- (–) Use with a trailer is not possible

- In Amsterdam EV trucks are subsidized as most cost efficient use of public money in order to reduce urban emissions from traffic. From 2020 an environmental zone for truck traffic is planned, privileges for e-trucks are already in place.
- Subsidy needed on zero emission trucks or clear regulations on (future) emission zones in cities.

Session 4: eDrive System Designs for EFVs

Two presentations in session 4 presented activities related to electric truck testing and development. The first presentation was held by John Farrell from the U.S. National Renewable Energy Laboratory (NREL) related to Electric fleet vehicle testing, the second presentation was held by Markus Passath from Austrian company Magna Steyr related to their Fuel Cell Range Extender concept, a zero emission vehicle concept for logistic applications. The key messages from this session were as follows:

- The objective of NREL is to evaluate the performance of alternative fuels and advanced technologies in medium- and heavy-duty fleet vehicles - in partnership with commercial and government fleets and industry groups' vehicles.
- NREL provides a common data storage warehouse for medium- and heavy-duty vehicle data across the U.S. Department of Energy (DOE) activities and labs: www.nrel.gov/fleetdna
- Drive Cycle Data Library – NREL DriveCAT: provides a common, publically available, easy to use site for standard and custom drive cycles for medium- and heavy-duty vehicles: https://www.nrel.gov/transportation/drive-cycle-tool/
- The Fuel Cell Range Extender Electric Vehicle by Magna is a vehicle platform to develop a vehicle with
  - Zero tailpipe emissions, long driving range, fast refuelling time, all-wheel powertrain

- The vehicle architecture consists of a 25 kW fuel cell, 3 kg H_2 (70 MPa) hydrogen storage, 16 kWh Li-ion battery, 75 kWp (front) and 50 kWp (rear)

4.4 The Road to Electrification of Logistics

The final of the four workshops was held in the UK and hosted by the Centre for Mobility and Transport of the Coventry University on April 26th, 2017. The theme of this workshop was '*The Road to Electrification of Logistics*' and built upon the previous three workshops by providing a holistic overview from the policy support to business models and future technologies. As for the previous workshops there was also a focus on understanding the host country's approach to electrification of logistics.

Session 1: The UK Approach to Electrification of Transport Logistics

After a short welcome by Prof. Andrew Parkes (Centre for Mobility and Transport, Coventry University) and an introduction to Task 27 by Florian Kleiner (German Aerospace Center), the first of the three sessions covered the UK approach to the electrification of transport logistics. Bob Moran (UK Office of Low Emission Vehicles (OLEV)) focused on the UK facts and figures and Tim Anderson (Energy Savings Trust) focused on case studies. The key discussion points from this session are outlined below:

- From the UK government perspective, supporting the ultra-low emission vehicle (ULEV) market creates growth, makes transport cleaner and reduces CO_2. Successive UK Governments have been interested in investing public funds to encourage new road vehicles to be zero emission. At the time of writing the funding available from 2015-2020 for the ULEV Programme was +£850m. The focus has primarily been on passenger cars as they are viewed as the major contributor to CO_2 emissions. However, there are incentives are in place for N_1 (£8,000) and N_2/N_3 (£20,000) category PEV vehicles. There is also a 'freight carbon review'.
- Whilst customers are perceived to want low carbon vans and CV, the overall demand for all vans and CV is not to the level of the demand for passenger cars. For passenger cars 2020 (3 %-7 % new cars ULEVs); 2040 (100 % new cars ZEVs); 2050 (nearly all cars ZEVs). For vans and CV there is not the product in place to make the move to low carbon.

- There is a developing policy framework in place that in turn is supported by regulation. The approach needs to be to leverage that framework – so focus on where EV could work and overcome any inertia (perceived risk). It is also important to continue to develop that framework in a positive direction and the close coupling between stakeholders is important – need to feedback experience into development of government framework.
- In the UK funded research projects play a key role in raising the awareness for the potential of EV fleet integration. From these projects, mentoring support will become available for other actors in the logistics sector and lead to an increased introduction of EVs in fleets

In summary, the conclusion of this session was that within the UK there is a framework in place for promotion and support of EVs. As this is a dynamic environment, there is a need to understand how it is evolving and how to work best within that evolving framework. Whilst there is an acknowledgement that present focus is on passenger cars this is not a problem per se, if experiences can be disaggregate and related to vans and CV challenges.

Session 2: Planned and On-Going Pilots Supporting Electrification of Transport Logistics

The second of the three sessions turned towards the user experiences of EV in transport logistics. Presenters where Tanja Dalle-Muenchmeyer from the FREVUE project, which supported demonstration projects in the UK and also across the EU, and David Thackray from TEVVA motors, which has a range extended electric N_2 vehicle in operation in the UK. In addition, there was a presentation from the Netherlands by Harm Weken from FIER Automotive focused on electrification of N_3 heavy goods vehicles. The key discussion points from this session are outlined below:

- The key point for all the pilots was the business case. For the smaller vehicles it could be shown that there was a positive business case for the move to EV, certainly for the smaller and medium vehicles, but for larger vehicles this remains challenging.
- However, the way costs are considered is not always transparent. There needs to be a more integrated approach – true cost and managing costs. Certainly in the UK there is an argument that the offset (between the cost for EV and existing approaches) is actually lower than is perceived by the operator

especially if considering penalties associated with low emission zones (so high initial cost is offset by saving). This could be presented to customer in a positive way if the costs are built into leasing arrangements (so actual monthly cost would be actually less).

- In addition, within the pilots it was noted that there was a societal attitude towards EV that resulted in over specifying of vehicles (such as larger than required battery) or not using vehicle to its absolute capability. This raised the TCO and made the business case for EV less than realistic. A Range Extender could minimize overcautious planning. Further to this it was also noted that to overcome a TCO deficit requires methods/approaches for higher intensive use such as sharing or more operational years and more kilometres covered.
- It was noted that HGV routes are in areas that require lower emissions for societal benefit so favouring EV for societal benefit (the main arterial routes into and out of cities are generally home to the more vulnerable in society – less able to move away from the pollution). However, for the larger N_3 vehicles it was noted that the challenge is to create a positive business case. This has led to a divergence in approaches (with the UK approach of CNG) and whether this diversification in approach helps or hinders? If the EU does not to provide a suitable framework to encourage the development of EFV solutions for HGV and it becomes commoditised by others then the value in the intellectual property development is lost to outside of the EU.
- Whilst for these pilots it was determined that range issues are not really the case, more general use of EV for logistics would require greater interaction with infrastructure. However, charging is still considered a moving target for larger vehicles with changes from fast charging to other methods mooted (catenary, etc.). Could the infrastructure requirements be developed around bus fleet and provide infrastructure for later use by HDV?)

In summary, the sessions covered a number of pilots in operation both the UK and across the wider EU. These pilots have provided information on usage of EV and the suitability of the technology. There is a nervousness relating to new technology and we are not utilising the advantages of this technology and being overly cautious leading to higher costs and perceived market disadvantage. Further education of the capability of the technology is required so that were there is a positive business case it can be identified and promoted as such. Hybrid solutions for heavy EFVs are required that respond to needs that may exist in the short to medium or even longer term. So diversification of the fleet (multiple solutions) may be expected.

Session 3: Overcoming the Technical Challenges to Electrification of Transport Logistics

The final session looked at the technology options available. Presentations were provided by Prof. John Jostin from the Coventry University spin-out MicroCab that promotes hydrogen as a fuel for EFVs in the N_1 class and by Jonathan Murray from the UK Low Carbon Vehicle Partnership (LowCVP) that promotes low carbon transport technologies in all sectors, including transport logistics, on behalf of its members. The key discussion points from this session are outlined below:

- Hydrogen has benefits beyond transportation and the integration means that benefits can be realised in both transport market place and other markets (clean energy). Hydrogen infrastructure is developing and has the advantage that it can be integrated with the generation and supply side of energy (so development of a hydrogen vehicle fleet goes hand in glove with other problems that we observe beyond the transport arena).
- Operators are highly sceptical of technology manufacturer performance claims. The issue is that vehicles are used for a range of operations (driving cycles) and testing for every situation is prohibitive. Although LowCVP has a Certification Scheme for Aftermarket Technologies, there is no widely accepted process to test technology and validate claims.
- Funding is required to develop business models around new technologies to resolve this. The higher profile of air quality problems will drive support for this – the LowCVP will restart the CV working group.

In summary, the session on technology showed that there are options and technologies that are available and under development. The issue is the mismatch between the technology claims and how these may translate to a sector that has significant diversity in terms of vehicle types and use cases. It is important to clearly show the benefits of the technology to the customer based on real and not on theoretical data. In addition, the benefits may extend beyond the immediate transport logistics sector and support other sectors such as energy generation and supply. The question is how to capture this and there are initiatives proposed that look for better policy to support disruptive technology. The final workshop enabled the participants to gain an understanding of the UK market place with regards to electrification of transport logistics. The workshop brought together the experiences of the previous actions and presented a holistic view from the user, infrastructure and vehicle provider, with a view on soliciting thoughts for future developments in this sector.

5 Engaging with Policy

It was the objective of the HEV TCP activity '*Electrification of Transport Logistic Vehicles (eLogV)'* to investigate the potential and feasibility of the electrification of road freight transport and urban logistics. The results of this activity were communicated to the public and policy makers through a series of channels that include research papers, presentations and representation at conferences. The activities within the project reached a wide target audience and the results of these activities remain accessible on the HEV TCP website (http://www.ieahev.org/tasks/e-logistics-task-27/) to support stakeholders involved in the EFV transport logistics.

5.1 Presentations / Papers

The project delivered a number of presentations at international events and targeted at key stakeholders in industry, R&D, academia, NGOs and government.

- The first presentation was at the 28th Electric Vehicle Symposium held in Korea from the 3rd to 6th May 2015. The World Electric Vehicle Symposium and Exhibition (EVS) attracts academic, government and industry leaders from around the world interested in exploring and understanding the technical, policy and market challenges to the paradigm shift toward the use of electric transportation technologies. The focus of the presentation and accompanying research paper was a techno-economic assessment of EFVs.
- The second presentation was at the European Electric Vehicle Congress (EEVC) held in Brussels from the 2nd to the 4th November 2015. The EEVC is positioned as global platform to foster exchange of views between R&D, industry, authorities, end-users and NGO's actors, so as to develop synergies in the field of e-mobility. The focus of the presentation and accompanying research paper was to report on the status and trends for EFVs in transport logistics.
- The third presentation was at the Elmotion Congress held in Austria from the 27th to the 28th January 2016. The Elmotion is a central platform for new technologies and business models in the field of electro mobility with focus on commercial transport. The focus of the presentation was to report on the international experiences gathered within the scope of the Task 27 activities.
- The fourth presentation was at the European Electric Vehicle Congress (EEVC) held within the framework of the Geneva International Motor Show from the 14th

to the 16th March 2017. As for the 2015 event, the 2017 running of the EEVC is an enabler for exchange of views between R&D, industry, authorities, end-users and NGO's actors. The focus of the presentation and accompanying research paper was early niche markets and commercialization opportunities for EFVs in transport logistics.

5.2 Workshops

In addition to the presentations and research papers, the activity also held four workshops in total. These workshops attracted key stakeholder involved with transport logistics, electric vehicle technology, policy, etc. At each of the workshops a presentation on the status of the Task 27 activities was provided. A discussion about the content and outcomes of workshops can be found in the previous section.

5.3 Key Deliverables

The presentations at the international conferences, the discussions at the workshops and the continued engagement with stakeholders all focused around the support and dissemination of the desk based research activity. The activity resulted in a number of key deliverables that are described below:

- Vehicle Database: This database, available from the HEV TCP Task 27 website, presents the key facts of EFVs available on the market or presented as prototypes. The database has around 128 vehicles listed.
- Project Profiles: These profiles present key facts of on-going or completed demonstration projects from the partner countries. There are at present about 16 project profiles.
- Workshop Presentations: The presentations provided by stakeholders, and around which the discussion points noted in section 4 were arrived at, are also provide on the HEV TCP Task 27 website and presents a valuable resource that collates activities regarding EFVs in transport logistics in the partner countries.

6 Conclusions and Discussion

a. Is there the product in place?

The electric freight vehicle (EFV) market is still in an early stage. Availability and choice of EFVs is low. New and established suppliers offer alternative powertrains as well as complete electric vehicles for niche applications. The original equipment manufacturers accelerate their activities regarding electric freight vehicle development. The number of trips that could be electrically operated with vehicles which are already available is much higher than estimated. Especially urban logistic applications which cover the distribution in cities or suburban sites of goods/parcels from a central store to selling points/recipients, e.g. “last-mile” deliveries, are generally seen as early niche markets for EFVs. Most of the EFV models identified via a comprehensive market research are vehicle models of the category N_1 not exceeding a gross vehicle weight of 3.5 ton in which vehicle category battery electric vehicles (BEV) clearly dominate. However, also BEV according to the vehicle categories N_2 (not exceeding a gross vehicle weight of 12 ton), and N_3 (exceeding a gross vehicle weight of 12 ton) are available on the market. Compared to conventional diesel driven vehicles, range and payload of EFVs is limited and reliability is highly volatile. Nevertheless, EFVs show a good technical performance. Companies using EFVs are satisfied, especially the drivers. Adaption to EFV operation is needed in order to deal with the performance limits. However, there are still some barriers which need more attention and efforts in order to overcome. The initial costs of EFVs are still high and the advantages of privileges provided are not sufficient to close the financial gap. In addition, uncertainty about the impairment in value and a lack of qualified and reasonably priced aftersales support exist. Therefore, from a total cost of ownership perspective, EFVs are not cost effective compared to conventional diesel driven ones and is one major reason for inhibiting the wider uptake of EFVs. However, vehicle performance varies between specific vehicle types and depends on a number of factors related to cost, operational conditions, technology and infrastructure. Therefore, the operability and the business case highly depend on country specific conditions and the case of application. Results of a cost analysis for an urban delivery application showed that EFV of the category N_1 are almost competitive. The competitiveness is expected in the medium term, if battery system prices drops as estimated. In principle, TCO deficits of EFVs can be overcome through higher intensive use. Multi-shift operation or vehicle sharing approaches allow for more kilometres to drive and thus to better exploit the potential of EFVs. Unfortunately, business case information in practice, e.g. regarding the pilot applications is not provided or publicly available. Whereas the applicability of category N_1 battery electric vehicles seems to be given for urban logistic applications, it is still unclear for vehicles of category N_2 and N_3. In addition, the applicability of EFVs within regional logistic applications covering the delivery of consumer goods from a central warehouse to local stores, e.g. “first-mile” deliveries, is not sufficiently proven yet. Other applications like waste collection and airport or port terminal operation seems to be very promising. Viable products are in place which requires further improvements regarding technical performance and costs in order to boost the attractiveness of these technology solutions and to ensure adequate product reliability.

b. Is there the infrastructure in place?

The most common concept for charging is plug-in electric slow charging with a charging power of ≤ 22 kW AC. In addition, fast charging stations with charging power of 50 kW DC is another common charging concept. Generally, corporate fleet operators have their own charging points installed at their depots and usually charge their vehicles once a day over night time. Charging en route is considered as impractical and time-consuming. Therefore, fleet operators are rarely interested in an extensive network of public charging points. Private charging infrastructure becomes an issue, if a total EFV fleet need to be charged at the same time which requires an expansion of the installed performance. However, for heavy EFVs which were not able to recharge overnight due to the high battery capacity installed, different systems like the electric road system, stationary and dynamic high power inductive charging systems or batter swapping systems are under investigation. A sufficient network of hydrogen refuelling infrastructure is currently not in place. However, only a very small number of EFV powered by hydrogen are in operation and commercially available. Additionally, supportive dealer-networks and a lack as well as a reasonably priced aftersales support are missing.

c. Is there the policy support?

Within several countries is a developing policy framework in place for the promotion and the support of EFVs. For example, several countries have been changed the regulation that driving of EFVs with a maximum weight of 4.25 ton is permitted with a

B-class driver license. Tax exemptions for electric vehicles are in place or monetary purchase incentives are often given to encourage the electric freight vehicle uptake. Public funds are spent on the installation of publicly available charging infrastructure and funded research projects play a key role in raising the awareness for the potential of EFV fleet integration. Generally, there are many existing strategies, projects and initiatives. However, it is expected that all the existing strategies, projects and initiatives are not sufficient enough to reach the targets set. A transparent, obligatory and target-orientated strategy for the wider uptake of EFVs is not apparent. Only in some countries, EFVs in urban freight transport has a high strategic importance for the government and regional funding programs. In other countries there is a lack of support by city administrations which have not put EFVs on their political strategy agenda so far. However, in order to achieve the 2030-goal of reaching a substantially CO_2-free city logistic requires the fleet exchange of diesel with EFVs has to start already by 2020. It has to be mentioned, that the developing policy framework for the promotion and the support of a wider electric vehicle uptake is mainly focused on passenger cars.

d. Policy recommendations

There is a need for sufficiently detailed and reliable data bases in terms of logistics structures and processes, user behaviour and related EFV requirements. Unfortunately, information from real world activities, e.g. regarding the pilot applications is rare and hardly provided or publicly available. Having access to such data would be highly recommended in order to better transfer the findings from desktop to “real life”. Additional real life cases should be evaluated to get more information on the existing possibilities of electric freight driving. Especially, the research on the applicability of heavy EFVs in regional delivery and long-distance haulage should be intensified.

Supportive government policy in the timeframe 2017 – 2025 is still of high importance for the wider uptake of EFVs, especially, to reach the 2030-target of “essentially CO_2-free city logistics”. Therefore, the policy framework in place needs to be further developed in a positive direction being transparent, obligatory and target-orientated by a close coupling between all relevant stakeholders. The coupling between all relevant stakeholders enables to include feedback experience into development of the government framework. An integral European vision with a more integrated city management approach is necessary on electrical distribution. The implementation of standardized European wide “zero emission” areas with clear regulations might be the key to the wider EFV implementation and emission target achievements. Therefore, it would be essential for the European cities to team up in order to share information and learn from each other in terms of the potential demand for EFVs and how the solutions are valid in different climate and policy environments for example.

Rewarding frontrunners through subsidies, parking and loading spaces, time windows for loading-unloading zones for examples are important, because even frontrunner companies stress that they cannot compete without a means to bridge the financial gap in the business case for EFVs. Non-monetary incentives which allow for a long term advantage of EFVs appear to be very important as financial ones are not sustainable in the long term.

To strengthen and to support cross-company, cross-sectoral and multi-institutional cooperation is in the current phase key to success. For example by building platforms or competence centres to share experiences and disseminate the acquired knowledge.

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Appendix 1: List of electric freight vehicles in the database

ID	producer	name
1	MAN	TGL 12.220 Hybrid
2	MAN	Metropolis Abfallsammelfahrzeug
3	Daimler	Vito E-Cell
4	Daimler	Sprinter
5	Daimler	Atego BlueTec
6	Daimler	Econic Blue Tec 2629
7	Volkswagen	e-load up
8	Orten	ELC1
9	FAUN	Dualpower
10	e-Wolf	Omega-1.4 Cargo
11	e-Wolf	Omega-Mini
12	e-Wolf	Omega-0.7
13	Terberg Nordlift	YT-EV
14	EFA-S	New E-Master
15	EFA-S	UPS P80-E
16	Multicar/e-Wolf	FUMO E1
17	Volkswagen	e-Caddy Maxi
18	Street Scooter	Work
19	Volkswagen	eT
20	EMOSS	CM 10 (DAF LF 45)
21	EMOSS	CM 12 (DAF LF 45)
22	EMOSS	CM 16 (DAF LF 55)
23	EMOSS	CM 18 (DAF LF 55)
24	EMOSS	EV200 (Dyna chassis)
25	Peugeot	iOn Cargo
26	Peugeot	Partner Electric
27	Ford	Transit Connect Electric
28	Citroen	Berlingo electrique
29	Iveco	Daily electric 35S/C
30	Renault	Kangoo Maxi Z.E.
31	Canadian Electric Vehicles Ltd.	isuzu npr electric truck
32	Canadian Electric Vehicles Ltd.	Might-E Truck
33	Mitsubishi Fuso	Canter 3S13
34	Freightlliner	M2 Hybrid
35	Goupil Industry	G3
36	SFL	ELI
37	HET	EMF Citylog
38	Piaggio	Porter Electric

ID	producer	name
39	ALKE	ATX 110 E
40	ALKE	XT320 E
41	EH Line	ECN01 Wumbo
42	MP Ecodrive	Golia
43	MP Ecodrive	SmilE
44	Aixam Mega	eWorker
45	Aixam Mega	Mega Multi-Truck
46	Klingler	EPSI 2094
47	Klingler	MAFI 200/20D
48	UTV	50DUTV
49	Elektro-Mobil Manufaktur	E-Scout 1000
50	Elektro-Mobil Manufaktur	E-Garbage Vehicle G2
51	Elektro-Mobil Manufaktur	Apollon 1500
52	Loyds Industri	Paxster
53	Mia Electric	K
54	Indimo Motor Group	Freedom Van Lang
55	Indimo Motor Group	Electric CoolCar
56	BDOTO	E-Fiorino
57	BDOTO	E-Scudo
58	BDOTO	E-Traffic
59	BDOTO	E-Ducato
60	Renault	Twizy Cargo
61	MP Ecodrive	ecoMILE
62	Allied Electric Vehicles	Peugeot Boxer
63	MP Ecodrive	Jolly
64	Doll-Fahrzeuge	E-Cat
65	Nissan	e-NV200
66	ZeroTruck	ZeroTruck
67	German e-cars	Plantos
68	Mitsubishi Fuso	Canter 7c15 Eco Hybrid
69	Smith	Edison
70	Smith	Newton
71	Iveco	Daily Electric
72	Proton Motor	Smith Newton FC
73	E-Force	One
74	Renault	Maxity D Elektro
75	HS Bochum	Bomobil
76	Hytruck	C8HE
77	Vision Motor Corp.	Tyrano
78	Vision Motor Corp.	Zero-TT
79	Renault	Maxity FC

ID	producer	name
80	Symbio Fcell	Kangoo FC
81	Volvo Trucks	FE 340
82	E-Trucks Europe	E-Truck H
83	H2Logic	Comet 3 FC
84	ECN	HydroGEM
85	Balqon Corporation	Nautilus XE-20
86	Balqon Corporation	Nautilus MX-30
87	Motive Power Systems	All-Electric Refuse Truck
88	Spykstaal Elektro B.V.	Ecotruck 7500
89	Spykstaal Elektro B.V.	Elektro-Kastenwagen 1000
90	Hytruck	C12E
91	Hytruck	C16E
92	Hytruck	C18E
93	EcoCentre Electric Cars	Eco Van
94	EcoCentre Electric Cars	Eco Truck
95	EFA-S	UPS P45-E
96	Electric Vehicles International	Walk-In Van
97	Electric Vehicles International	Light Duty Vehicle
98	Electric Vehicles International	Medium Duty Truck
99	German e-cars	eCAT
100	emovum	E-Ducato
101	FRAMO	e 75
102	FRAMO	e 120
103	FRAMO	e 180
104	FRAMO	e 260
105	FRAMO	e 260 SZM
106	Orten	E75 TL
107	Orten	E75 AT
108	Orten	ET 35 M
109	Volkswagen	e-Crafter
110	MAN	e-TGS
111	Scania	P320 Hybrid
112	Daimler	Vision Van
113	Daimler	Urban E-Truck
114	Fuso/Mitsubishi	E-Canter
115	Street Scooter	Work L
116	Hyundai	H350
117	ABT sportsline	eCab
118	Renault	ZOE Fiskal-LKW
119	Voltia	eVan K3 L3H3
120	Ginaf	E21114

ID	producer	name
121	All Green Vehicles	E-TGL
122	Tevva Motors	n.a.
123	Goupil Industry	G5
124	Paneltex Electric Vehicles	Paneltex Electric Vehicles
125	Imecar	Electric Citroen Jumper
126	Ginaf	E2104
127	Addax Motors	MT10
128	Addax Motors	MT15

Appendix 2: List of relevant projects

ID	country	name of the project	project profile provided
1	Germany	E-City-Logistics	✓
2	Germany	E-Lieferung-Allgäu	✓
3	Germany	KV-E-CHAIN	✓
4	Germany	Elmo	✓
5	Germany	NaNu!	✓
6	Germany	Urban logistischer Wirtschaftsverkehr	✓
7	Germany	B-AGV	✓
8	Germany	efleet	✓
9	Germany	ElektroAES	✓
10	Germany	ELENA II	✓
11	Germany	SMART-E-USER	✓
12	Germany	komDRIVE	x
13	Germany	EMIL	✓
14	Germany	ENUBA	x
15	Germany	ENUBA II	x
16	Germany	EMKEP	x
17	Germany	DisLog	✓
18	Germany	eCanter for Stuttgart	✓
19	Germany	GeNaLog	x
20	Germany	Elektrische Schwerlastlogistik im urbanen Raum	x
21	Germany	IKONE	x
22	Austria	E-LOG Klagenfurt	x
23	Austria	E-mobility POST	x
24	Austria	EMILIA-Electric Mobility for Innovative Freight Logistics in Austria	x
25	Austria	LEEFF-Low Emission Electric Freight Fleets	x
26	Turkey	Aras Kargo 100% Electric	✓
27	Turkey	E-courier in Istanbul by TNT Express	✓
28	Turkey	Electric delivery in Istanbul by Sürat Kargo	x
29	Turkey	Migros electric grocery delivery	x
30	The Netherlands	Electric garbage trucks by Van Gansewinkel	x
31	The Netherlands	Electric urban delivery by Combipakt	x
32	The Netherlands	Electric urban delivery with Hytrucks	x
33	The Netherlands	Meshed urban distribution by UPS	x
34	The Netherlands	Rotterdam test electric driving	x