The Road to Electrification of Logistics

Results of the IA-HEV Task 27 “Electrification of transport logistic vehicles”
4th Workshop held in Coventry on April 26th, 2017

suggested citation format:
Results of the IA-HEV Task 27 “Electrification of transport logistic vehicles” 4th Workshop
held in Coventry on April 26th, 2017

www.ieahev.org
Dear ladies and gentlemen,

The task 27 partners cordially invite you to the workshop “Experiences and prospects of electric freight vehicles in the UK” on April 26th, 2017 at the Centre for Mobility and Transport Research of the Coventry University in Coventry.

The Workshop is organized by the Task 27 “Electrification of transport logistic vehicles” of the Hybrid and Electric Vehicle Technology Collaboration Program (HEV TCP) within the framework of the International Energy Agency (IEA) (www.ieahev.org/tasks/e-logistics-task-27). Its aim is to summarize and communicate on a global level:

- the status and prospects of transport logistic vehicle electrification
- early markets and hurdles of commercialization and
- policy recommendations for deployment and pre-competitive research

for road freight transport vehicles operating in city, urban or regional logistic applications.

Dedicated topics of the Workshop in the United Kingdom are:

- regional stakeholder approach to electrification of transport logistics
- planned and ongoing pilots supporting electrification of transport logistics
- overcoming the technical challenges to electrification of transport logistics

The workshop is targeted at policy makers and stakeholders from entrepreneurs in the transport and logistic sector, vehicle manufacturers, technology suppliers and research around the globe. Participation is free of charge.

The workshop is organized by the Coventry University. Please register for the workshop by sending your company name and contact details via email to Dr Huw Davies (ac2616@coventry.ac.uk, +44 2477 659137) until 19th April 2017. The number of participants is limited to 30 persons.

Yours faithfully,

Florian Kleiner
German Aerospace Center (DLR)
Institute of Vehicle Concepts
Germany
Operating Agent

Martin Beermann
JOANNEUM RESEARCH
Institute of Vehicle Concepts
LIFE – Centre for Climate, Energy and Society
Austria
Co-Operating Agent
### IA-HEV Task Force 27

**Electrification of transport logistic vehicles**

#### 4th Workshop: “The Road to EV Logistics”

April 26th, 2017

Centre for Mobility and Transport Research

Room EC1.21 Faculty of Engineering and Computing

Coventry University, Priory Street, Coventry, UK, CV1 5FB

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>09:00</td>
<td>Registration / Start of Workshop</td>
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<tr>
<td>09:30 - 10:00</td>
<td>Welcome</td>
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<tr>
<td></td>
<td>Professor Andrew Parkes, Centre for Mobility and Transport, Coventry University</td>
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<tr>
<td></td>
<td>Task 27 introduction and previous results</td>
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<tr>
<td></td>
<td>Florian Kleiner, DLR / Martin Breermann, Joanneum Research</td>
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<tr>
<td>10:00 - 11:00</td>
<td>Session 1: Regional stakeholder approach to electrification of transport logistics</td>
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<td></td>
<td>Facts and figures of the United Kingdom</td>
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<td></td>
<td>Dr Bob Moran, Deputy Head Office for Low Emission Vehicles</td>
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<td>EV logistics promotion - case studies from the UK and EU</td>
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<td></td>
<td>Tim Anderson, Senior Transport Advice Manager, Energy Saving Trust</td>
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<tr>
<td>11:00 - 11:30</td>
<td>Coffee break</td>
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<tr>
<td>11:30 - 12:30</td>
<td>Session 2: Planned and ongoing pilots supporting electrification of transport logistics</td>
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<td></td>
<td>Experience from London in running electric vehicle logistic pilots projects</td>
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<tr>
<td></td>
<td>Tanja Delle-Muenchmeyer, FREVUE Co-ordinator</td>
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<td></td>
<td>Electrification of heavy goods vehicles</td>
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<td>Harm Weken, FIER Automotive NL</td>
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<td></td>
<td>Experiences from running Electric Range Extended Vehicles</td>
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<td></td>
<td>David Thackray, TEVVA Motors Ltd</td>
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<tr>
<td>12:30 - 13:45</td>
<td>Networking Lunch</td>
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<tr>
<td>13:45 - 14:45</td>
<td>Session 3: Overcoming the technical challenges to electrification of transport logistics</td>
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<td>Microcab - Light Electric Fuel Cell Vehicles for Logistics</td>
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<td></td>
<td>Professor John Jostins, Centre for Mobility and Transport, Coventry University</td>
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<tr>
<td></td>
<td>Technology developments and experiences in the UK</td>
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<td></td>
<td>Jonathon Murray, Low Carbon Vehicle Partnership</td>
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<tr>
<td>14:45 - 15:00</td>
<td>Closure of the day</td>
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<tr>
<td>15:00</td>
<td>End of Workshop followed by tour of MicroCab</td>
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</table>

Please register interest for MicroCab visit (the MicroCab van will be on display outside EEC building during the day).

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**For information on MicroCab** [www.microcab.co.uk](http://www.microcab.co.uk)
Participating Nations and Organizations:

IEA Task 27 in the HEV IA is supported by the German Federal Ministry for Economic Affairs and Energy (BMWi), by the Austrian Ministry of Transport, Innovation and Technology (bmvIt) and by the Netherlands Enterprise Agency (RVO.nl).
Electrification of Transport Logistic Vehicles

presenting author: Florian Kleiner

Florian Kleiner, Martin Beermann, Bülent Çatay, Eric Beers, Huw Davies, Ock Taeck Lim
International Energy Agency
Hybrid & Electric Vehicle Technology Collaboration Programme

HEV TCP Mission

- Supply objective information to support decision making
- Facilitate international collaboration in pre-competitive research and demonstration projects
- Foster international exchange of information and experiences

Target audience

- Governmental bodies at national, regional and city levels
- Automotive industry
- Component suppliers
- Utilities
Why Task 27 “Electrification of Transport Logistic Vehicles”?

- transport sector heavily depends on fossil fuel
- freight transport activity is predicted to grow
- reduction in GHG emissions is required
- expect changes of the regulation framework

→ the electrification of transport logistic vehicles is essential

lack of information about the status of existing electrified logistic vehicles and possible fields of applications
Task 27 “Electrification of Transport Logistic Vehicles”

Objectives & Working Method

Objectives

1. Summarize the status of vehicle and infrastructure technologies, implementation and hurdles
2. Identify early niche markets and commercialization opportunities
3. Provide policy recommendations for further research and deployment activities

Working Method

Objectives are addressed in three ways:

- Workshops: To involve stakeholders and collect information
- Desk work: To establish the scientific foundations, input for workshops and papers
- Public outreach: To raise awareness in the broader community
**Task 27 Data Basis**

**Vehicle Database**
(includes about 120 electrified transport logistic vehicles: BEV, PHEV, FCEV / N₁, N₂, N₃)

<table>
<thead>
<tr>
<th>General data:</th>
<th>market, producer, name of vehicle, powertrain technology, type of powertrain, functionality, production status, vehicle category, year, source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical data:</td>
<td>engine power, battery type, battery capacity, gross vehicle weight, payload, driving range, top speed</td>
</tr>
</tbody>
</table>

**Project Profiles**
(info collection of pilot projects)

- Short description
- Stakeholder involved
- Actors involved
- Focus areas
- Contact
- Links
- Results

**Series of Workshops**
- Stuttgart 19.03.2015 ✓
- Amsterdam 12.04.2016 ✓
- Vienna 19.10.2016 ✓
- Coventry 26.04.2017

**Topics:**
- Electric transport logistic vehicle technology and its application
- Experiences and prospects of electric freight vehicles
- Electric freight vehicles - out of niche into mass market
- The Road to Electrification of Logistics
- Exchange of experiences with city administrations, battery and fuel cell producers, early adopters, research institutions
88 electrified transport logistic vehicles models; >50% in the N₁ vehicle category

- Battery electric vehicles clearly dominate across all vehicle categories
- Not surprisingly, the share of BEV is higher, the smaller the vehicle and battery
- A surprise is the high share of BEV in N₃-class
- Only a few vehicles from OEMs
- The database will be available for download in May 2017

http://www.ieahev.org/tasks/e-logistics-task-27/
Performance and Limits of Electrified Transport Logistic Vehicles

- category N₁: on average 106 km range and 700 kg payload
- category N₂: on average 110 km range and 3,400 kg payload
- category N₃: on average 200 km range and 10,100 kg payload

→ current performance limits operation

based on manufacturer’s data; in terms of range total number of vehicles considered is 46 for N₁, 16 for N₂ and 7 for N₃; in terms of payload total number of vehicles considered is 40 for N₁, 14 for N₂ and 7 for N₃
Experiences from Different Countries

- Urban logistic applications are generally seen as early niche markets from the operations point of view
- Vehicle performance varies between specific vehicle types and depends on a number of factors related to operational conditions, technology, infrastructure and cost
- Operability and the business case highly depend on country specific conditions and case of application
- Business cases are hardly provided
- Most experience has been made with battery electric vehicles related to vehicle category N₁ used for parcel and post deliveries → vehicles are well suited and competitiveness is almost given
- More experience is needed in order to identify suitable applications in urban goods distribution for N₂ and N₃ category vehicles
Contributions on the topics: R&D for Electrified Transport Logistic Vehicles, Possible Fields of Application for Electrified Transport Logistic Vehicles, World Café Discussion about Hurdles of Implementation

- Automated production for battery systems is achieved for the capacity of 20 MWh (ca. 200 buses), which can be upscaled
- Automated production for high volume fuel cell system manufacturing with an expected cost reduction of 50% ($/kW); offered warranty with a 15,000 operating hours (>10 years)
- About half of all outages are due to difficulties with the electric powertrain
- Economic efficiency is the key to success! Electric trucks are still NOT profitable
- The number of trips that could be electrically operated with vehicles which are already available is much higher than estimated
- There is a need to transfer the information from desktop to the “real life”
- Clear targets and standardised EU wide “zero emission” areas
- EV center for all questions and education
- …
WS held in Amsterdam (2016-04-12)
“Experiences and prospects of electric freight vehicles”

Contributions on the topics: Best Practice Experiences of Pioneer Cities, Experiences from Early Adopters of Electric Freight Vehicles, Infrastructure for Charging

- It is essential to give perspective for action. Put a dot on the horizon for e.g. environmental and congestion zones.
- Initial cost stays high, not enough advantages of privileges to close the financial gap → Reward frontrunners e.g. subsidies, parking and loading spaces, time windows for loading-unloading zones, etc. and build platforms for sharing knowledge.
- Everyone wants you to transport electrically, until you really try…road legislation stays hopelessly behind → Supportive government policy is still of high importance for the wider uptake of EFVs.
- Strong appeal to develop an integral European vision on electrical distribution.
- A better way to support the mass adoption of the alternatively fueled technology is to give them a long-term competitive advantage.
- Adjust driver license B to a maximum gross vehicle weight of 4,5 tones.
- European cities have to team up (learn from each other, mass potential in EV demand).
- …
WS held in Vienna (2016-10-19)
“Electric freight vehicles - out of niche into mass market”

Contributions on the topics: Electric Freight Vehicles as Pillar of Sustainable Logistics, Governmental Perspectives and Implementation Plans for Electric Freight Vehicles, Experiences from Early Adopters of Electric Freight Vehicles

Many existing strategies, projects and initiatives which are still not sufficient to reach targets set

In order to reach essentially CO₂-free city logistics in major urban centers by 2030 (White Paper) fleet exchange has to start at 2020 latest (average exchange of vehicle after 8-10 years)

New forms of cooperation is needed e.g. cross-company, cross-sectoral, multi-institutional

After-Sales-Service is not an issue for e-converter, if you are prepared in a way, that a local dealer takes on the responsibility

The costs of urban city hubs are still too high. Since the utilization of city hubs is limited to only 1-2 hours per day, “shared hub”-approaches appear to be more useful

Routing according payload is important → deliver heavy goods first

New technology has to be combined with an advanced business model (fleet integration advisory, on-demand availability/ provision of EV, integrated service & maintenance, training/info material)

Allow drivers with class B license to drive E-Vans up to 4.25t GVW

...
WS held in Coventry (2017-04-26)
“The Road to Electrification of Logistics”

- Contributions on the topics: Regional Stakeholder Approach to Electrification of Transport Logistics, Planned and Ongoing Pilots Supporting Electrification of Transport Logistics, Overcoming the Technical Challenges to Electrification of Transport Logistics

**Messages (ex extractions):**

- ...

**WE'RE LOOKING FOR YOUR INPUT!**
Task 27 Outputs

http://www.ieahev.org/tasks/e-logistics-task-27/

Presentations:
1) Electrification of transport logistic vehicles: Techno-economic assessment of battery and fuel cell electric transporter EVS28, Korea, May 3-6, 2015
2) Status and trends for electrified transport logistic vehicles EEVC, Belgium, 2nd - 4th December 2015
4) Current status of the electrification of transport logistic vehicles EEVC, Geneva, 14th – 16th March 2017

Papers:
1) Electrification of transport logistic vehicles: A techno-economic assessment of battery and fuel cell electric transporter EVS28, Korea, May 3-6, 2015
2) Status and trends for electrified transport logistic vehicles EEVC, Belgium, 2nd - 4th December 2015
3) Current status of the electrification of transport logistic vehicles - Early niche markets and commercialization opportunities EEVC, Geneva, 14th – 16th March 2017

- Vehicle database: Key facts of electric commercial vehicles available on the market or presented as prototypes. About 120 vehicles are listed.
- Project profiles: Key facts of ongoing or terminated demonstration projects from the partner countries. About 30 project profiles.
Thank you for your Attention

Florian Kleiner
German Aerospace Center
Institute of Vehicle Concepts
Research Group
„Vehicle Systems and Technology Assessment“
Pfaffenwaldring 38-40, 70569 Stuttgart
Tel: +49 (0) 711 6862 8120
florian.kleiner@dlr.de
Overview of I-CVUE

Aim:
I-CVUE aimed to reduce CO$_2$ emissions in urban environments by increasing the number of electric vehicles in large fleets in urban areas

April 2014 - March 2017

Funded by the Intelligent Energy Europe
Overview of I-CVUE

Project partners:
10 partner organisations from across Europe, including: UK, The Netherlands, Germany, Norway, Austria, Spain and Belgium

Advisory Board members:
Fleet World    Alex Grant
Lease Europe   Richard Knubben
Leaseplan      Ronald de Haan
RWS           Peter Wilbers
Barcelona LIVE Angel Lopez
Main objectives

- Identify business cases for fleets, looking at:
  - whole life cost analysis
  - emission data
  - information on the expected commercial benefit

- Regional authority support framework to set up incentive programs:
  - according to the specific socio-economic conditions of the city, region or country

- Decision Making Tool:
  - for policymakers and fleet operators to evaluate the effectiveness of various incentives
Mentoring model

5 mentoring partners:

- EST - UK
- RACC - Spain
- FIER – The Netherlands
- AEA – Austria
- IRU – Belgium
The business case

Identify the vehicle opportunity
- Vehicle profiles / duty cycles that appear to work
- Vehicles where there is an appropriate alternative

Understand the costs & benefits
- Carry out whole life cost analysis vs ICE
- Factor in grants and tax benefits

Operational considerations
- How and where to re-charge
- Duty cycle and route optimisation

Driver acceptance
- Ensure drivers are educated, informed and enthusiastic!
- Consider specific efficient driver training to improve range
Case studies - Rijkswaterstaat (RWS)

- Large fleet mixed van and car fleet.

- After analysis was done, results showed:
  - 30% of fossil fuel powered fleet could be replaced with EVs.
  - the EVs already in the fleet could also be used to a higher potential
  - users were ‘nervous’ of the new technology

- End result:
  - 400 vehicles will be replaced in 2017, of these 25% will be EVs
  - Exploring new ways of providing guidance and training

I-CVUE played a key role in this decision making process
Case studies - Transports Metropolitans de Barcelona (TMB)

Extremely positive feedback to the mentoring service

- Increased the fleet managers awareness of EVs
- The recommendations given will feed into the future business plan for the fleet

<table>
<thead>
<tr>
<th>Number of EVs prior to the I-CVUE support</th>
<th>0</th>
</tr>
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<tbody>
<tr>
<td>Number of EVs since to the I-CVUE support</td>
<td>15</td>
</tr>
<tr>
<td>Estimated number of EVs/PHEVs by end of 2017</td>
<td>15 additional purchase will take place in 2018</td>
</tr>
<tr>
<td>Estimated number of EVs/PHEVs by end of 2020</td>
<td>25</td>
</tr>
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</table>
Case studies - Manchester Metropolitan University

Strongly agreed that the mentoring support they received will lead to an increased introduction of Electric Vehicles to the fleet

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<tbody>
<tr>
<td><strong>Number of EVs prior to the I-CVUE support</strong></td>
<td>0</td>
</tr>
<tr>
<td><strong>Number of EVs since to the I-CVUE support</strong></td>
<td>12</td>
</tr>
<tr>
<td><strong>Estimated number of EVs/PHEVs by end of 2017</strong></td>
<td>16</td>
</tr>
<tr>
<td><strong>Estimated number of EVs/PHEVs by end of 2020</strong></td>
<td>20</td>
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</table>
Achievements

- **50 fleets** have been mentored
- Supported a **wide range of organisations**: public, private, governmental, taxis
- **Increased awareness** of EV use in European cities
- I-CVUE has positively contributed in the decision to purchase **916 new EVs** (final evaluation still being collected)
- Fleet mentoring **business model** developed and refined
- New stakeholder **network** with partners and advisory board
Conclusions

• Demand is increasing
• There are large opportunities to support fleets
• EV adoption is linked closely to a number of factors including:
  o Total Cost of Ownership
  o Incentives
• Need for variety of EV model – to meet fleet needs – new product arriving all the time
• Driver training is important to ensure a positive experience
Lessons learnt and going forward

Lessons learnt
• Circumstances change – governments, policies, costs
• Change within organisations can be slow
• Seek senior buy-in from within the fleet early on
• Take a flexible approach to mentoring

After the lifetime of the project:
• Continue mentoring fleets – partners and wider
• Capacity Building Workshop – exploring wider opportunities
• Mentored fleets to become champions for EVs
Is any ongoing support available?

Fleet support is available in England and Scotland
• DfT and Transport Scotland funded
• Full review of current fleet and opportunities for EVs
• TCO analysis of EVs v ICE vehicles
• Support accessing grants and incentives

• Contact EST for more information.
• [www.est.org.uk](http://www.est.org.uk)
Thank you for your attention

Tim Anderson
Energy Saving Trust
Tim.anderson@est.org.uk
Freight Electric Vehicles in Urban Europe
The Road to Electrification of Logistics
IA – HEV Task 27 eLogV
Coventry, 26 April 2017

Tanja Dalle-Muenchmeyer, FREVUE Co-ordinator
Objectives

Demonstrate suitability of electric freight vehicles for urban last-mile deliveries

Underpin future uptake of these vehicles

Provide evidence for policy intervention

Project to be finalised in September 2017
Consortium

City + Policy
- Cross River Partnership (Co-ordinator)
  - City of Amsterdam
  - City of Lisbon
  - City of Madrid
  - City of Milan
  - City of Oslo
  - City of Rotterdam
  - City of Stockholm
  - Swedish Transport Adm.
  - EMEL
  - Transport for London

Co-ordination and Dissemination
- Hyer
- Polis

Research
- Imperial College London
- TNO (NL)
- SINTEF (NO)

Logistics
- TNT
- UPS
- Heineken
- Emilio B. Pascual
- Arup
- CTT Correios
- Breytner
- Seur
- Fer y Cia

Vehicle Manufacturers
- Smith
- Nissan

ICT Partners
- Itene
- Atos

Grid Operators
- Fortum
- UK Power Networks

Freight Electric Vehicles in Urban Europe
FREVUE Vehicles
Output

- Key reports
  - Technical suitability
  - Economics of EVs for city logistics
- Transport and environmental impacts
  - Social and attitudinal impacts
- Policy and governance
- Guidelines / recommendations
Technical suitability

Data

• Dynamic vehicle data with state-of-charge from 10 operators and 83 vehicles

• Covering 757,000 km – 19 times around the Earth at the equator

• Data collection framework developed as part of the project
Technical suitability
Km per kWh, temperature and weight group

![Graph showing the technical suitability of electric vehicles in urban Europe, with Km per kWh on the y-axis and temperature range on the x-axis. The graph demonstrates the impact of temperature and weight group on the km per kWh efficiency.](#)
Technical suitability
Km per kWh, average speed

![Graph showing the technical suitability of electric vehicles in terms of Km per kWh and average speed across different speed ranges and vehicle weight categories. The graph includes data points for speed ranges of 5-10, 10-15, 15-20, 20-25, 25-30, 30-35, 35-40, 40-45, 45-50, 50-60, and 60+ km/h, with vehicle weight categories of < 3.5 t, 3.5 t - 7.5 t, and > 12 t. The graph highlights the efficiency of electric vehicles across various conditions.](image-url)
Economics of EVs for City Logistics

• Work in progress
• Can say that positive business case is achievable for small and medium EFVs
• For large EFVs this remains difficult
Transport and environmental impacts

• Three level analysis:

   1. **Direct impacts** from FREVUE project

   2. Modelling of **larger uptake**

   3. Impact **monetisation**
Direct impacts - Local air pollution

• Strong benefits of NOx and PM savings

• **NOx savings** comparing between EFVs and Euro III/3 ICEVs: equivalent to total road transport NOx emissions in the City of London for three days in 2013

• **PM savings** comparing between EFVs and Euro III/3 ICEVs: equivalent to total road transport PM emissions in the City of London for two days in 2013
Direct impacts - CO$_2$ emissions

• Carried out both at the local level (direct GHG emissions) and the total environmental load (using Well-to-Wheel analysis)

• WTW emission reduction ranging from 10% to 99%

• In total, the FREVUE project has led to:
  • local GHG savings of 385 - 400 tonnes CO2e
  • total environmental GHG savings of 176 - 190 tonnes CO2e, i.e. approx. 45%
  • equivalent to total road transport GHG emissions in the City of London for about one day in 2013
Direct impacts - FREVUE London demonstrator

- UPS 7.5t vehicles and Clipper 10t Smith Electric

- Based on Euro IV comparator vehicles:
  - NOx reduction of 437kg
  - PM reduction of 9.4kg
  - Local GHG savings of 93 tonnes CO$_2$e
  - Total environmental GHG savings of 32 tonnes CO$_2$e
Wider uptake – forecasted LGV/HGV traffic London

Spatial distribution of freight traffic, AM peak, LGV and HGV, 2021

Trip length distribution, AM peak, LGV and HGV, 2021
Wider uptake and monetisation

London

• Low penetration level (10%), 2021:
  • NOx reduction of 402Kt
  • PM reduction of 3.8t
  • Local GHG savings of 284Kt CO$_2$e

• Monetisation, low penetration level, 2021:
  • £881 million savings from NOx reductions
  • £13.5 million from GHG savings
Other preliminary findings

- Vehicle supply
- Local electricity supply constraints
- Maintenance and repair
- Good acceptance
Next steps

• Wider deployment
  • ‘Declaration of Intent’
  • Further funding requirements

• Final event London 21 June 2017

• Innovate UK co-funded Smart Electric Urban Logistics project
For further information please contact:

Tanja Dalle-Muenchmeyer
FREVUE Coordinator
Cross River Partnership

tanjadallemuenchmeyer@crossriverpartnership.org

www.frevue.eu
Heavy duty electric truck deployment in Europe
Workshop, Road to Electrification of Logistics
Task27 IEA-HEV

26th of April 2017

Harm Weken
Managing Partner
Harm Weken: Managing Partner of FIER Automotive
- Chairman of the board, Foundation Limburg Electric
- Member of the Council of Advisors:
  - Drive Oregon, US
  - EU Center for Sustainable Mobility, FH Aachen, D
- Ambassador for EVU, Electric Vehicle Union
- Board director of EASN, platform for automotive clusters and regions (2007-2015)
FIER Automotive & Mobility

- Business development for Dutch e-mobility sector:
  - Missions to EU countries, China, India, US etc
  - 3-year program on German market

- Business planning and funding applications: smart- and e-mobility test labs, Automotive Campus Helmond (follow-up campus co-development)

- Clean vehicle fleet projects for governments

- Realisation and expansion of corporate / private e-car sharing programs together with Foundation Limburg Electric

- Strategic planning and mapping of future-proof charging infrastructure

- International benchmark and technology / supplier search for electric bus consortium

- Business development and grant applications for electric trucks (incl. PHEV & hydrogen) for distribution, garbage and container transport

- Boardmemberships / advisory rolls: Drive Oregon, EU Center for Sustainable mobility FH Aachen, Electric Vehicle Union, EASN
## Electric Mobility: European projects

### I-CVUE
- EV fleet monitoring and analysis
- Transferability of Best Practice
- Market-Potential supported by Predictive Tools

### e-GLM
- 10 full electric trucks (45t) with network of fast charging points in a cross border project (Germany – Netherlands) for
- Innovative logistic concepts for regional container distribution

### FRevue
- Support the uptake of electric freight vehicles in eight of Europe’s largest cities
- Demonstrating and evaluating innovative urban logistics solutions
- New concepts and business models

### ENEVATE
- Electric Vehicle Supply Chain Development
- Strategic implementation & infrastructure roll-out plan
- Market drivers and mobility concepts
- E-car sharing pilot project

### BATTERI
- Intermodal, smart technologies & Alternative Fuels
- Policy & Behaviour
- Pilots
3 big polluters

Urban freight transport
Total NOx emissions city traffic in the Netherlands

Estimated total emissions per year per vehicle type for all urban traffic in the Netherlands (TNO, 2015)
Electric mobility, future or past
the future is now
Electric Mobility Projects Heavy Duty

- Support companies for application electric trucks (30+)
- Technical, economical and finance support
- ICOVA, Hoogwout, Lidl, etc.

- Support the uptake of electric freight vehicles in eight of Europe’s largest cities (Milan, Rotterdam, London)
- Demonstrating and evaluating innovative urban logistics solutions
- New concepts and business models

- 2014: Feasibility study and preparation for FULL electric truck e Green Last Mile Netherlands - Germany
- 9 fully electric trucks (45t) with network of fast charging points in a cross border project (Germany - Netherlands) for
- Innovative logistical concepts for regional container distribution

Others to be Announced...
Amsterdam electric truck support

Peeters Vervoerscentrale
- Inner-city distribution
- Goal of full electric fleet in 5 years
- Electric DAF
  - GVW 12,000 kg
  - 120 kWh Lithium-Ion
  - 150 km NEDC

Albert Heijn
- Delivering of online ordered grocery’s
- Electric VW Crafter
  - GVW 3,500 kg
  - 80 kWh Lithium-Ion
  - 150 km NEDC

ICOVA
- Garbage collectors for the inner-city
- Electric FIAT Ducato
  - GVW 6,900 kg
  - 80 kWh Lithium-Ion
  - 150 km NEDC

LIDL, VsdV
- Distribution from DC to multiple supermarkets
- Electric MAN TGM
  - GVW 17,990 kg
  - 200 kWh Lithium-Ion battery
  - 225 km NEDC

Hoogwout Berging
- Road service and towing
- Electric IVECO
  - GVW 8,000 kg
  - 160 kWh Lithium-Ion
  - 160 km NEDC
Freight Electric Vehicles in Urban Europe

Logistics companies

2013 - 2017
Challenges experienced in FREVUE eTrucks >12ton

Economic feasibility

- High purchase costs
- Negative TCO ≠ -€30,000 and -€75,000 in 8 - 10 years
- Decisions made for marketing reasons / pilots

Vehicle supply

- Technical possible but not many suppliers / mainly conversions

Risks / uncertainties e-Trucks:

- Residual value / second life
- Repair and maintenance
- Reliability, lifecycle of battery and second use of battery

≠ TCO e-Truck needs: more operational years and more kilometres
eGLM electric Green Last Mile
eGLM legacy by the end of 2020

3,5 years experience:
- 9 full electric container trucks (40ton)
- 2 mln electric kilometres
- Efficient fast charging on smart charging locations – open for public (other e-trucks, busses e.g.)
- Innovative logistic concept for truck sharing, increased mileage per day and increased capacity utilisation

5 companies, ready and well positioned for a future in sustainable transport, ahead of competition!

Contribution in CO2 reduction of 1.900 ton as well as other hazardous emissions. As a modest first start!
CO2 reduction – Air quality improvements – Lower noise

Lower costs, stronger competitive strength
eGLM Project partners

CTV Multimodal Container Transport
Köppen
Klijnen Logistics Group
Samskip
Eulenberger
LIOF
provincie Limburg
Nordrhein-Westfalen
Conceptual designs

Unique and innovative

Recognisable design

Quick coupling

Ergonomic design

Easy to get in/out

40t tractor  Flexibility  Sharing
Charging Infrastructure

- AC slow charging via a plug
- DC fast charging via a plug
- Induction charging
- Overhead charging (pantograph)
- Battery ‘swap’
- Conductive plate
Feasibility study eGLM

- Technical feasibility of trucks
- Technical feasibility of fast charging
- Logistic & organizational, operational feasibility
- Financial-economic feasibility
De Groene Cockpit

Analyses | Financial feasibility

- "(s) afschrijving, onderhoud en financiering laadinfra"
- "(s) totaal wegenbelasting"
- "(s) totaal verzekeringspremie"
- "(s) onderhoudskosten alle trucks"
- "(s) totale brandstofkosten"
- "(s) financieringskosten trucks totaal"

<table>
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<th>Year</th>
<th>Diesel VI (10)</th>
<th>LNG (10)</th>
<th>Elektrisch (10)</th>
<th>Elektrisch (10)</th>
<th>Diesel VI (10)</th>
<th>LNG (10)</th>
<th>Elektrisch (10)</th>
<th>Elektrisch (10)</th>
<th>Diesel VI (10)</th>
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<td>€ 285k</td>
<td>€ 225k</td>
<td>€ 202k</td>
<td>€ 285k</td>
<td>€ 225k</td>
<td>€ 202k</td>
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<td>€ 225k</td>
<td>€ 202k</td>
<td>€ 292k</td>
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<td>€ 225k</td>
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<tr>
<td></td>
<td>€ 0.09</td>
<td>€ 0.09</td>
<td>€ 0.09</td>
<td>€ 0.08</td>
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<td>€ 360B</td>
<td>€ 270B</td>
<td>€ 270B</td>
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<td>€ 0.0,-</td>
<td>€ 0.0,-</td>
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<tr>
<td>2016</td>
<td>€ 1,-</td>
<td>€ 1,-</td>
<td>€ 1,-</td>
<td>€ 1,-</td>
<td>€ 1.7kW</td>
<td>€ 1.7kW</td>
<td>€ 1.7kW</td>
<td>€ 1.7kW</td>
<td>€ 1.7kW</td>
<td>€ 1.20</td>
<td>€ 1.20</td>
<td>€ 1.20</td>
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<td>€ 1,20</td>
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<td>€ 0,8</td>
<td>€ 0,8</td>
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</table>

Legend:
- Green: "(s) afschrijving, onderhoud en financiering laadinfra"
- Orange: "(s) totaal wegenbelasting"
- Yellow: "(s) totaal verzekeringspremie"
- Brown: "(s) onderhoudskosten alle trucks"
- Red: "(s) totale brandstofkosten"
- Purple: "(s) financieringskosten trucks totaal"
Summarising, Why eGLM

- Reduce CO2 emissions, NOx and particle’s and noise pollution from transport
- Create broad cooperation in region for transport innovation and increased competitiveness
- Kick-start the market for electric trucks and create urgency at OEM’s. Realise (first step towards) critical mass
- Transport companies get a head start in testing and applying electric trucks as well as new logistics models for increased capacity utilisation
- Increase the economic and environmental sustainability of logistics sector in the region
## Overall conclusions on deployment of Heavy Duty EV

Already many e-trucks / pilots on the road in Europe

- Positive feedback from companies and drivers
- Decisions made for marketing reasons / pilots

<table>
<thead>
<tr>
<th>Economic not feasible yet</th>
<th>Technical feasible</th>
<th>Risks / uncertainties:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ÿ High investment Ÿ negative TCO</td>
<td>Ÿ Trucks available however still conversions</td>
<td>Ÿ Residual value &amp; second life of e-trucks</td>
</tr>
<tr>
<td>Ÿ Low daily distance Ÿ conservative planning &amp; long slow charging</td>
<td>Ÿ Range is in many applications not an issue</td>
<td>Ÿ Repair and maintenance</td>
</tr>
<tr>
<td>Ÿ Improved economics</td>
<td>Ÿ Fast charging solutions available, not yet standardized</td>
<td>Ÿ Reliability, lifecycle of battery and 2nd use of battery</td>
</tr>
<tr>
<td>Ÿ In right application</td>
<td>Ÿ Reliability needs improvement</td>
<td>Ÿ Technology innovation: Increased range, lower investments, improved reliability</td>
</tr>
<tr>
<td>Ÿ Adapted logistic models</td>
<td></td>
<td>Ÿ Traditional “one-truck-fits-all approach”</td>
</tr>
<tr>
<td>Ÿ Fast(er) &amp; opportunity charging</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Zero Emissions Where it Matters
Technology – Outline and Key Advantages

BENEFITS: Unlimited range; minimised emissions with zero emissions where most needed; lower operating and lifetime costs

On-board charging system means any 3-phase power socket can be used

Small engine or fuel cell (range extender) drives on-board generator to recharge the batteries

Cloud-based software monitors vehicle and controls use of range extender to ensure zero emissions where most needed

Wheels driven only by electric motor

Batteries charge primarily from the mains
Tevva Tecnology Detail and Schematic

Cloud-based software
Tevva patented Predictive Range Extender Management System (PREMS)

Range Extender/Generator
Current range extender uses standard car engine driving generator only. RE operates at constant RPM maximizing efficiency and removing 100% of ‘transient’ emissions (which are the main cause of NOx). PREMS ensures that RE operates for the absolute minimum period daily – minimizing emissions and maximizing financial savings.

Motor/Generator
Currently fitted motor rated at 150kW and 2000Nm torque. 200kW option available ‘off the shelf’

Battery/ Battery Management System
Battery comprised of multiple Lithium Iron Phosphate (LiFePO4) cells – safer and more durable than Lithium Cobalt Oxide found in consumer electronics. BMS is Tevva proprietary technology. Tevva now supplies or licenses technology to McLaren, NextEV and motorsport

Regenerative Braking
Produces approximately 30% of battery electric charge used each day
Fleet Trial at UPS

UPS P80 truck retrofitted by Tevva Motors and delivered to UPS UK in October 2015

Truck has successfully covered 11,238 km on road in 9 months

Operational period extended by 6 months – UPS needed capacity and Tevva prototype proved robust

Truck has successfully completed operations under optimal and non-optimal battery SOC

Feedback has been very positive

Truck was be used as a daily fleet vehicle from October 2015 to January 2017

Purchase order received for a further 15 Vehicles to be delivered December 2017 – January 2018

RETROFIT PROTOTYPE
37 Updates Made During Trail Period Bringing Significant Performance Uplift

<table>
<thead>
<tr>
<th>Software Level</th>
<th>Distance travelled (km)</th>
<th>Fuel Used (l)</th>
<th>Fuel Cost (£)</th>
<th>Electricity charged (kWh)</th>
<th>Electricity cost (£)</th>
<th>Cost per kilometre (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Vario</td>
<td>4,950</td>
<td>1,040</td>
<td>873</td>
<td>0</td>
<td>0</td>
<td>£0.18</td>
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<tr>
<td>Initial</td>
<td>7,457</td>
<td>880</td>
<td>739</td>
<td>1,974</td>
<td>196</td>
<td>£0.13</td>
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<tr>
<td>Final performance</td>
<td>3,781</td>
<td>208</td>
<td>149</td>
<td>1,408</td>
<td>141</td>
<td>£0.08</td>
</tr>
<tr>
<td>12/7/2016 Performance</td>
<td>111.8</td>
<td>3.13</td>
<td>2.63</td>
<td>55.8</td>
<td>5.58</td>
<td>£0.07</td>
</tr>
</tbody>
</table>
Next Moves

Broadening the application

- Higher weights
- Integration of ancillary loads

New Technologies

- High Density Switched Reluctance Motor
- ZE Range Extender

Source: Transport for London, Ultra Low Emission Zone Supplementary information, October 2014
Next Moves

HDRSM
Q4 2017 – Q1 2018

7.5 & 14 tonne GVW
Temperature Controlled Body
Q4 2017 – Q1 2018
Software

Autumn 2017

- Leeds City Council
- Integration of PREMS into Smart City traffic systems
Specific Markets

Madrid

US West Coast

Heathrow
Adoption Barriers

Few and Manageable

- Residuals
- Initial outlay (smaller fleets)
- Perceived technical risk (larger fleets)
  - Status of OEM warranty
- Uncertainty re. whether R&M savings will be achieved
- Uncertainty re. future fuel costs

Solutions

- Full R&M Contract hire option
- Lifetime drivetrain and battery warranty
Market Evolution

Frenetic

- December 2016 - Paris, Madrid, Athens and Mexico City announce full diesel bans from 2025
- December 2016 Announcement of 1st ever joint public procurement in US – SFO, LA, Portland & Seattle -24,000 EVs
- Feb 2017 above expanded to include 26 cities – 114,000 EVs
- Jan 2017 Oslo begins temporary diesel ban
- Feb 2017 Stuttgart announces ban of older diesel cars from City
- Feb 2017 Sadiq Khan announce London T Charge from the Autumn and pulls forward London ULEZ date
- April 2017 Govt of India announces aim to achieve 100% of all vehicles nationwide as EVs by 2030
Thank You
T27 workshop
Microcab project

Coventry University
26 April 2017

John Jostins
Managing Director, Microcab Industries Ltd.
Prof. Sustainable Transport Design, Coventry University

Working in partnership with Coventry University

copyright Microcab 2017
Microcab background

SME, founded 2004
- The UK’s innovative fuel cell vehicle maker.
- 14 years of pioneering fuel cell vehicle design

Mission statement
- Developing sustainable, integrated solutions for the New Mobility and Circular Economy

Recent growth:
- Commercial order for vehicles
- Extensive portfolio of grant funded programs
- Job creation – 3 new employees in last 12 months
H2EV platform

Chassis, built by Lotus
Bonded aluminium, laser cut flat sheet

• Hydrogen cylinder weight 41kg
• Chassis weight 80kg
H2EV powertrain

1.8kg H2 storage, 350bar
1 kg H2 = 33.3KWh

3-5kW fuel cell & DC/DC converter

4kWh lithium battery

Twin 72v DC motors,
13kW each
Single speed
Belt drive to front wheels

Twin motor controllers
Top speed 88kph
Van variant development – Royal Mail

- 2007 started work with Royal Mail
- Interested in zero emissions
- Very large fleet
- Looking at potential of Hydrogen power
- FC and ICE
- Plan to generate hydrogen at delivery depots
- Adopted a Microcab in van variant
- Used for mail delivery at University of Birmingham
- Royal Mail now privatised
H2EV platform – light van

- 2009 H2EV design started
- Used Royal Mail light van spec.

- Payload:
  - 1 cubic metre
  - 250kg

- Plug Fuel Cell
- Range 240 – 280km
SWARM trials: FCH-JU
New hydrogen station

Brussels
• Air Liquide, first HRS in Belgium
• Opened Zavantem, 2016
• M-cab V4 delivered University Libre
• Testing and data collection
• Operating in Brussels

copyright Microcab 2017
Hydrogen refuelling UK
Hydrogen refuelling

- Possibilities for on site generation
- Water electrolysis
- Move to decentralised energy
- Supports the energy storage agenda
- Generate hydrogen with surplus renewable energy
- Very low carbon possibilities

- Pics: ITM Power HRS, Sheffield with wind turbine
Conclusions

• Delivery vehicles operate in large numbers – diesel
• Internet shopping increases demand for deliveries
• Air Quality dominates still
• HFCs offer benefits of zero emissions and very low carbon
• Hydrogen gives quick fill and long range
• Infrastructure is expanding – buses lead the way

Thanks to all staff at Microcab and Coventry University.

https://www.youtube.com/watch?v=0ykWf3R8xZ4
Technology developments and experiences in the UK

26 April 2017

Jonathan Murray
Policy & Operations Director
Public Private Partnership

"To accelerate a sustainable shift to low carbon vehicles and fuels in the UK and thereby stimulate opportunities for UK businesses".
Commercial goods vehicles: The next big (low) carbon opportunity?
There are many technical options to reducing vehicle CO2 and improving air quality. All have challenges and are suitable to different applications. We are likely to need all of them.

Low carbon vehicles achieved through improved efficiency and/or low carbon fuels:

- Conventional Vehicle
- Reduce Carbon in Fuel
- Improved Vehicle Energy Efficiency
- Low Carbon Vehicle
- Combustion Engine/Battery Hybrid
- Lightweighting
- Next Generation ICE + Heat Recovery
- 2nd & 3rd Generation Biofuels
- Combustion Engine/Flywheel Hybrid
- Super Efficient Engines
- Battery Electric (Low Carbon Electricity)
- Hydrogen Fuel Cells (Low Carbon H₂)
- Natural Gas/Biogas
- Plug-in Hybrid (Low Carbon Electricity)

Source: Ricardo analysis
A number of technology roadmaps have been developed for CVs. The Automotive Council UK’s provides the UK consensus view driving investment.
Battery electric vehicles are seen as being limited to duty cycles with lower range and GVW.
Electric commercial vehicles are available up to 12t GVW and benefit from lower taxes and running costs.

**Electric Vehicles**
- **Concept:** Vehicle which is driven by a battery powered electric motor.
- **Base Functioning:** Vehicle is driven by an electric motor powered by batteries which are charged from mains electricity. The vehicle has no other power source other than the battery.
- **CO₂ Benefit:** Tailpipe CO₂ emissions are 0g/km and overall emissions are estimated to be 40% lower than conventional diesel, but this is dependent on fuel source used to generate electricity.
- **Costs:** Smiths Newton electric 7.5t vehicle (very similar to medium duty benchmark) is between £78,387 and £80,886.
- **Environmental Benefit:** Electric vehicles have societal benefits in that they reduce road noise.

**Safety and Limitations**
- Less stressful driving
- Lower maintenance and servicing requirements
- Lower vehicle payload than comparable diesel vehicle
- Limited to GVW of 12t
- Low residual vehicle values
- Operation limited to central depot based fleets
- Reduction in road noise needs to be handled carefully to ensure no adverse effects for vulnerable road users

**Technology Applicability**
- Limited to vehicles up to 12t
- Best suited to vehicles operating from a single depot and with daily mileage of <100 miles
- Greatest benefit for urban applications where exemption from congestion charge and low emission and noise operation is beneficial

**Powertrain**
- CO₂ Benefit
- Technology costs
- Environmental costs
- Safety & Limitations
- Technology Maturity

**Visualisation**
- Picture: Smith Newton from sev-us.com

Greater opportunities for electrification of the drive train are anticipated through hybrid and range extender technologies.
Hybrid and range extended vehicles offer high CO2 reductions in urban applications but are expensive and require maintenance training.

**Hybrid Powertrains – Full Hybrid**

- **Concept**: A powertrain which can use more than one fuel source to provide energy to propel the vehicle.
- **Base Functioning**: Typically implemented as hybrid electric vehicles where electrical energy is stored in batteries which can be used to drive an electric motor to power the vehicle or supplement engine power.
- **CO2 Benefit**: Ranges significantly dependent upon vehicle operation but averages 20% for medium (urban) and 7% for heavy duty (long haul) applications.
- **Costs**: Significant technology on cost of additional hybrid components. Some environmental impact in terms of battery manufacture and disposal.

**Powertrain**

- CO2 Benefit: 9 (best)
- Technology costs: 2
- Environmental costs: 5
- Safety & Limitations: 3
- Technology Maturity: 6

**Safety and Limitations**

- Lower brake wear due to use of regenerative braking – leads to lower maintenance costs.
- Makes use of existing fuel infrastructure.
- Vehicles have better acceleration.
- Some vehicles have a reduction in payload.
- Engine stop/start unsuitable for some applications.
- Requires training of maintenance staff to safely work with high voltage systems.

**Technology Applicability**

- Greatest CO2 reduction potential for vehicles operating over an urban duty cycle.
- CO2 savings still possible for long haul applications but business case requires more consideration.

**Visualisation**

Picture: DAF LF Hybrid

Source: OEM corporate websites and press releases – Full sources available on detail shots in the attached annex.
There are also opportunities for electrification in delivering efficiency gains in ICEs and electrification of ancillaries.
Waste heat recovery can provide moderate CO2 benefits – electrical turbocompounding

**Waste recovery systems – electrical turbocompound**

- **Concept:** Exhaust gas energy recovery
- **Base Functioning:** Exhaust turbine in combination with an electric generator / motor to recover exhaust energy
  - Recovered energy can be stored or used by other electrical devices
  - Motor during transients to accelerate
- **CO2 Benefit:** Fuel economy benefit of 10 % achievable at maximum power point\(^1\). Real world benefit closer to 3% depending on duty cycle. ETC perhaps best suited to off-highway applications like plopping tractor which runs a long time at max power
- **Costs:** Increasing costs for turbocompound system

**Safety and Limitations**

- Moderate potential in reduction of fuel consumption and CO2 emissions
- Primary for new engine designs
- Added complexity for energy storage, control
- Increased costs generator turbine, energy storage, crank mounted motor
- High voltage system

**Technology Applicability**

- Electric turbocompounding systems for medium and heavy duty application in development phase
- Fuel / CO2 benefits confirmed

**Powertrain**

<table>
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<tr>
<th></th>
<th>1 (worst)</th>
<th>10 (best)</th>
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<tr>
<td><strong>CO2 Benefit</strong></td>
<td>3</td>
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<tr>
<td><strong>Technology costs</strong></td>
<td>4</td>
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<tr>
<td><strong>Environmental costs</strong></td>
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<tr>
<td><strong>Safety &amp; Limitations</strong></td>
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<td>4</td>
</tr>
<tr>
<td><strong>Technology Maturity</strong></td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**Visualisation**

Picture: John Deere- Bowman Power turbogenerator
Source: http://www1.eere.energy.gov DEER 2006

*Source: Ricardo Research, Ricardo Evaluation, 1) http://www1.eere.energy.gov /*
Refuse trucks are being developed that use electric motors to drive hydraulic lifting and compacting mechanisms.

**Electric/ Alternative Fuel Bodies**

- **Concept:** Replacement of existing power sources for vehicle bodies which use diesel for power.
- **Base Functioning:** Electrification or use of an alternative power source, e.g. nitrogen to drive systems requiring power instead of diesel.
- **CO₂ Benefit:** Varies between 10% and 20% depending on the body power system being replaced.
- **Costs:** Up to 15% vehicle on cost, but some systems are lower cost.

**Safety and Limitations**

- No limitations on vehicle usage.
- Electric and nitrogen systems offer quieter and smoother operation.
- Electric and nitrogen systems have low operating and maintenance costs.
- Nitrogen system, unlike mechanical – will not ‘top freeze’.
- Safety of nitrogen system.

**Technology Applicability**

- Suited to applications where electrical motors have sufficient torque to drive load.
- For use in hybrid vehicle applications where hybrid battery can be used to power trailer.

**Vehicle**

- CO₂ Benefit (rating: 9/10)
- Technology costs (rating: 6/10)
- Environmental costs (rating: 6/10)
- Safety & Limitations (rating: 7/10)
- Technology Maturity (rating: 6/10)

**Visualisation**

*Picture: Volvo Hybrid Refuse Truck (gizmag)*

VECTO – HDV CO2 tool

The EC has developed a computer simulation tool, VECTO, to measure CO2 emissions from new HDVs.

The EC will use VECTO to propose legislation which would require CO2 emissions from new HDVs to be certified, reported and monitored.

Vecto has three purposes

1. OEM – robust and objective tool to assess vehicles
2. Legislator – to assess emissions and develop measures to improve CO2 from HDV
3. Member states – to implement additional measures for more energy eff vehicles

Likely to be simulation approach (VECTO) for certification, but conformity and post validation see vehicle testing benefits
Carbon saving technologies face a major hurdle to penetrate the market.

- Operators are highly sceptical of technology manufacturer performance claims
- There is no widely accepted process to test technology and validate claims
- Vehicles are used for a range of operations (driving cycles) and testing for every situation is prohibitive.
LowCVP Certification Scheme for Aftermarket Technologies

The scheme will help to build the market for low carbon HDVs

**Evidence**
- Operators get reliable, trustworthy and relevant information on likely effectiveness for their duty cycles
- Suppliers can demonstrate realistic savings, independently evaluated

**Recognition**
- Suppliers gain marketing opportunities, able to distinguish themselves from the snake oil salesmen
- Innovative and genuinely effective products encouraged
- Certificate issued for products that meet the mark

**Incentives**
- Win-win for suppliers and operators via increased sales and fuel savings
- Government can properly target support mechanisms towards genuinely effective products
What are the schemes objectives?

- The Scheme will be designed, managed and run for the benefit of UK operators – collaboration and co-operation with them are key guiding principles. Credibility is paramount.
- The Scheme will support UK Government policy and the achievement of CO2, air quality and energy security targets.
- The Scheme will add value to the development of a market for low carbon HGVs by addressing one of the key existing market failures – operators don’t have a ‘go-to’ source of reliable information about technologies that might be useful to them and are reluctant to believe everything a supplier tells them.
Millions of charge points (mostly residential) will be needed to support widespread EV deployment, with uncertainty over charging technologies.

**Infrastructure roadmap**

<table>
<thead>
<tr>
<th>Year</th>
<th>Sites</th>
<th>Cost (m)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Many sites but variable offer</td>
<td>£20-40m</td>
<td>Rollout of primarily conductive rapid (40-kW) charging points in short term</td>
</tr>
<tr>
<td>2020</td>
<td>c. 500</td>
<td>£130-230m</td>
<td>Solutions to provide certainty of access to homes w/o off-street parking</td>
</tr>
<tr>
<td>2025</td>
<td>c. 1,100</td>
<td>£300-530m</td>
<td>Potential rollout of alternative power delivery systems e.g. dynamic charging on highways, battery swap or overhead cables</td>
</tr>
<tr>
<td>2030</td>
<td>c. 2,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>Dependent on BEV/ PHEV split and charging rates</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend**

- Cost
- Investment in electricity networks (transmission & distribution) – cumulative from 2015
- Total CPs
- Technical

**Plug-in electric vehicles stock**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cars (thousand)</th>
<th>Vans (thousand)</th>
<th>HDVs (thousand)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>300</td>
<td>60</td>
<td>&lt;5</td>
</tr>
<tr>
<td>2025</td>
<td>1,500-2,500</td>
<td>250-400</td>
<td>10</td>
</tr>
<tr>
<td>2030</td>
<td>4,000-8,000</td>
<td>700-1,300</td>
<td>20</td>
</tr>
<tr>
<td>2050</td>
<td>20,000-25,000</td>
<td>3,400-4,000</td>
<td>130</td>
</tr>
</tbody>
</table>

Projections are based on policy-led uptake scenarios presented on page 25.

Data supported quantification of infrastructure requirements.

Dashed lines represent high uncertainty.

Major milestone / enabler.

Cost estimates are cumulative costs from 2015.

CP = Charge point.
Solutions to facilitate overnight charging will be required across residential areas and depots

Depots / workplaces and fleets

- Fleet operators of HDVs are likely to be faced with high local network reinforcement costs (already observed) – an investment in assets not own by the fleet operator: an unfamiliar risk and procedure

Recommendations

- Local gov.: facilitate the interface between DNOs and fleet operators and prediction of ‘demand cluster’ for optimised investment; socialise early adopter case studies to share lessons learnt

- Central gov. and regulator: align EV uptake ambition with network reinforcement needs to allow/encourage ‘top-down’ strategy (upfront investment in advance of need)

- R&D bodies: support trial of new technologies (e.g. inductive, ultra fast conductive, ‘automatic plug-in’ etc.) that would be more practical for fleets than current technologies
Mitigating the impact of electric vehicles on the network will require new technologies and new commercial arrangements

Impact on electricity network

• Without management of the charging time, **EVs will require large investment in new distribution infrastructure (substations, cables) and possibly new generation / interconnection capacity.** The Smart Grid Forum estimate that ‘smart’ technical and commercial solutions could **save in the order of £15bn** on distribution network reinforcement costs by 2050

• **DNOs will need information on EV location and uptake to plan investment** and smart solutions rollout accurately

• Research is needed to **understand relative impact of different charge point deployments** (3kW, 7kW or more)

• Although less studied **benefits to the grid could also be available**: as flexible loads, recharging EVs could provide important grid balancing services to maintain grid frequency, to manage supply and reduce renewable curtailment

Recommendations

• Central Gov. & regulators: support DNOs to access geographically disaggregated EV uptake data;

• Installers and DNOs: improve platform for compiling charge point installation notifications (as stipulated by IEC)

• Regulators, electricity suppliers and DNOs: develop new commercial arrangements and tariffs required for the uptake of smart charging solutions and for customer engagement [Ofgem’s Low Carbon Fund already supports these activities]

• On-going trial programs: disseminate findings on local network management solutions to DNOs and related stakeholders

• R&D bodies & DNOs: Investigate network related topics: charging/demand management technologies, Vehicle-2-Grid, impact on battery life, co-locating energy storage devices with rapid charge points to alleviate strain on weak grid
In summary

• Increasing numbers of CVs, particularly LCVs, increasing source of GHG and impact on air quality.

• Range of technologies which are capable of reducing GHG and improving air quality.

• Electrification of powertrain focused on light and medium duty applications, opportunities for electrification of ancillaries and energy recovery.

• Accreditation scheme for vehicles and components can provide marketing opportunity for manufacturers, confidence for fleet operators and metric for Govt to set incentives against.

• Electrification of CVs will increase pressure on electricity distribution network and need for reinforcement or demand side management.

• Electric vehicles offer opportunities for demand levelling and V2G.

• To make most of electrification of vehicles will require a level of information flow between vehicles, recharging infrastructure and networks which is unprecedented.
Thank you!

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www.lowcvp.org.uk
Links to key studies on LowCVP website

- Market background study
- Technology Roadmap
- Technology Testing study
- Technology accreditation
- HGV Simulation tool
- LowCVP report on recommendations to accelerate the market for Low Carbon HGVs
- Auto Council Commercial and Off-highway Technology Roadmap
- Opportunities for low emission HGVs Report
- Infrastructure Roadmap Final Report
- Infrastructure Roadmap - Electricity
- Infrastructure Roadmap – Hydrogen
- Accreditation Scheme for Aftermarket Technologies - Sample Certificate (Updated 29.06.16)
- Development of test cycles and measurement protocols for a low carbon truck technology accreditation scheme. (Updated 29.06.16)
- Test Procedure for Measuring Fuel Economy and Emissions of Trucks Equipped with Aftermarket Devices. (Updated 29.06.16)
Low Carbon Emission Bus market

Number of LCEBs in service in the UK (Jan 2017)

- **Hydrogen**: 10
- **Flywheel Hybrid**: 20
- **Biomethane**: 112
- **Electric**: 180
- **Efficient Diesels**: 1322 (+212)
- **Hybrid**: 3091 (+723)

4,743 LCEBs in service with 6 distinctive technologies.

Producing a 30% GHG savings vs Euro III diesel equivalent bus

Hybrids most popular, 65% of LCEBs.

Efficient diesels models second popular: 28%.