Electric freight vehicles – out of niche into mass market

Results of the IA-HEV Task 27 “Electrification of transport logistic vehicles”
3rd Workshop held in Vienna on October 19th, 2016

suggested citation format:
IA-HEV Task 27
Electrification of transport logistic vehicles

3rd Workshop: “Electric freight vehicles - out of niche into mass market”
October 19th, 2016
AustriaTech – Federal Agency for Technological Measures
Meeting room 3rd floor
Raimundgasse 1/6, 1020 Vienna

09:00 Registration

Moderation Martin Beermann, JOANNEUM RESEARCH

Welcome and Introduction

09:30 - 09:40 Welcome adress by the Austrian IA HEV ExCo representative
Sarah Krautsack, Ministry for Transport, Innovation and Technology bmvit

09:40 - 09:50 Introduction to Task 27
Florian Kleiner, DLR

Electric freight vehicles as pillar of sustainable logistics

09:50 - 10:15 Electric freight vehicles out of niche: experiences, requirements and expectations
Barbara König, Council for Sustainable Logistics CNL

10:15 - 10:40 GreenCityHubs - an enabler for electric freight vehicles?
Bartosz Piekarz, i-LOG Integrated Logistics GmbH

10:40 - 11:00 Coffee break

Governmental perspectives and implementation plans for electric freight vehicles

11:00 - 11:30 Facts and figures of the United Kingdom
Bob Moran, Department of Transport, Office for low emission vehicles (OLEV)

11:30 - 12:00 Facts and figures of Germany
Dominique Sevin, National Organisation Hydrogen and Fuel Cell Technology (NOW)

12:00 - 12:30 Facts and figures of Austria
Henriette Spyra, AustriaTech - Federal Agency for Technological Measures

12:30 - 13:30 Lunch break

Performance and limits of electric freight vehicles

13:30 - 14:00 Supermarket logistics with the electric truck fleet of Coop
Georg Weinhofer, Coop-Switzerland

14:00 - 14:30 Technology developments and experiences in the Netherlands
Eric Beers, RAI Vereniging (Platform of Sustainable Transport, NL)

14:30 - 15:00 Coffee break

eDrive system designs for electric freight vehicles

15:00 - 15:30 Electric fleet vehicle testing
John Farrell, National Renewable Energy Laboratory

15:30 - 16:00 Fuel Cell Range Extender - Zero emission vehicle concept for logistic applications
Markus Passath, Magna

16:00 - 16:10 Closure of the workshop day
Welcome address by the Austrian IA HEV ExCo representative
19th November 2016, Vienna
From the RTI strategy to sustainable solutions

BMVIT, Innovation

RTI strategy
RTI grants
RTI programme
Open calls

Impact orientation

Companies & research institutions

Innovation

R&D projects

Sustainable solutions for economy, environment & society
RDTI-Programmes

Lighthouse Programme for Electric Mobility

- Duration: 2009-2017
- Budget: approx. 5 million/year
- Development, Implementation
ERA-NET Cofund-Call “Electric Mobility Europe”

Overview

- **Objective**: Accelerate the time to market for solutions for integrating electric mobility in Europe’s (sub-)urban mobility systems

- **coming soon**: [www.electricmobilityeurope.eu](http://www.electricmobilityeurope.eu)

- **Budget**: 25 M € (incl. EC co-financing), AT: 1,5 M €

ERA-NET Cofund-Call “Electric Mobility Europe”
13 Member Countries

13 countries
- Austria
- Belarus
- Denmark
- Finland
- France
- Germany
- Hungary
- Italy
- The Netherlands
- Poland
- Spain
- Sweden
- Turkey

2 regions
- Catalonia (ES)
- Piedmont (IT)

Israel?
ERA-NET Cofund-Call “Electric Mobility Europe”
Thematic Key Areas

- 5 Thematic Key Areas:
  • System integration (transport, [sub]urban areas)
  • Integration of urban freight and city logistics in the e-mobility
  • Smart Mobility concepts and ICT applications
  • Public Transport
  • Consumer behaviour and societal trends

- Outcome: Highly visible demonstration and implementation projects!
Kontakt

Austrian Ministry for Transport, Innovation and Technology
Unit of Mobility and Transport Technologies

Sarah Krautsack
Responsible for Goods Transport
Sarah.Krautsack@bmvit.gv.at
T: +43 1 711 62 65 – 3211
Welcome to
IA-HEV Task 27
3rd Workshop
“Electric freight vehicles - out of niche into mass market”

Florian Kleiner, Martin Beermann, Bülent Çatay, Eric Beers, Huw Davies, Bob Moran, Ock Taeck Lim, Stephan A. Schmid

www.ieahev.org
International Energy Agency
Hybrid & Electric Vehicle Implementing Agreement

IA-HEV 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

www.ieahev.org
Need for alternative vehicles

**Ever increasing freight demand**
- Worldwide road-freight activity and energy use have almost doubled in the last two decades [IEA 2012]

**Challenges for Cities**
- Worldwide urbanization and online retailing activities are increasing inner city air pollution [UN 2011]; [RSS 2012]

Expected changes of the regulation framework:
- Emission free inner city delivery
- CO₂ limits for HDV

**Development and market introduction of alternative transport logistic vehicles is essential**
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 – current Outputs
(http://www.ieahev.org/tasks/e-logistics-task-27/)

• EVS28 (2015) paper:
  Comparison of country individual Relevant Cost of Ownership per ton-kilometers for light commercial vehicles

• EEVC (2015) paper:
  Status and trends for electrified transport logistic vehicles

• EL-MOTION 2016 conference presentation:
  International experiences within the IEA HEV Task 27 „Electrification of transport logistic vehicles“

• Project profiles:
  Key facts of ongoing or terminated demonstration projects from the partner countries

• 1st Workshop held in Germany (2015-03-19):
  “Electric transport logistic vehicle technology and its application”
  - Expert presentations regarding battery and fuel cell technology and real world data from electric transport logistic vehicles
  - Workshop session – Hurdles of implementation: Discussions about barriers, drivers, strategies and expectations

• 2nd Workshop held in Amsterdam (2016-04-12):
  “Experiences and prospects of electric freight vehicles”
  - Best practice experiences of pioneer cities
  - Experiences from early adopters of electric freight vehicles
  - Current status of charging infrastructure technologies for heavy duty vehicles

• Vehicle database:
  Key facts of electric commercial vehicles available on the market or presented as prototypes. Approx. 90 vehicles are listed up to now.
Contact details

**Operating Agent**

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German Aerospace Center  
Institute of Vehicle Concepts  
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**Co–Operating Agent**

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JOANNEUM RESEARCH  
LIFE – Centre for Climate, Energy & Society  
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8010 Graz  
Austria  
Office: +43 316 876 1313  
E-Mail: Martin.Beermann@joanneum.at
Electric freight vehicles out of niche: experiences, requirements and expectations

Barbara König
Council for Sustainable Logistics
Council für Nachhaltige Logistik (CNL)
Council for Sustainable Logistics

• founded in 2014
• 15 companies
• Goal: joint progress in the field of sustainable logistics
working programm

- Focus area: electric commercial vehicles
  - Projects aiming at implementation
  - Cooperation with manufacturers

- 3 task groups
  - E-truck
  - City logistics
  - Warehousing

- Service for members
  - Processing of ecological, social, political, legal and economical aspects
  - 4 events a year
  - NEWSletter
  - Homepage
  - Event schedule

Goal: TCO-neutral electric commercial vehicles
experiences, requirements and expectations
e-fahrzeuge.info

• comprehensive market overview
• BEVs and FCEV
• commercial vehicles and passenger cars
• CO₂-neutral delivery since 2011
• biggest e-mobility fleet in Austria
  • 238 e-cars, 181 e-mopeds, 593 e-bikes, 52 CNG-cars*
• Purchase of green electricity only and own solar plants: >1.300 kWp
• obstacles
  – availability of electric commercial vehicles
  – shipping space not big enough
  – low range of EV

* Nachhaltigkeitsbericht 2015 der Post AG
• Development of an e-VAN ready for serial production

• charging infrastructure for electric freight fleets

• new business model for fleet-operators
• fleet management, vehicle routing & charging strategy
Requirements

- 200 km
- equal payload
- shipping space min. 10m³ for 3.5 to
- TCO-neutral

from 3.5to e-van – 40to e-truck
TCO
electric commercial vehicles

- Charging Strategy
- Infrastructure
- Battery Capacity
- Funding/Monetary Incentives
- Non-Monetary Incentives
- OEM

IEA-Workshop „Electric freight vehicles - out of niche into mass market“
zero-emission city logistics

European Commission's Transport White Paper:

essentially CO$_2$-free city logistics in major urban centres by 2030
zero-emission city logistics

European Commission's Transport White Paper:

essentially CO$_2$-free city logistics in major urban centres by 2030

average exchange of vehicle after 8-10 years
zero-emission city logistics

European Commission's Transport White Paper: essentially CO$_2$-free city logistics in major urban centres by 2030

average exchange of vehicle after 8-10 years

start fleet exchange

2011  2016  2020  2030

CO$_2$-free city logistics
COOPERATION
key to success

• to achieve the 2030-goal of CO$_2$-free city logistics we need new forms of cooperation
  – cross-company
  – cross-sectoral
  – multi-institutional

• Council for Sustainable Logistics is a model example of this kind of cooperation
Objectives

• expand the CNL
  – New members

• Cooperation with OEMs

• Cooperation with the federal government and cities
CONTACT

DI Werner Müller – Project lead
DI Barbara König, BEd

Council für nachhaltige Logistik
Universität für Bodenkultur
Zentrum für Globalen Wandel und Nachhaltigkeit
Borkowskigasse 4/4
1190 Wien

E-Mail: CNL-Team(at)boku.ac.at
Telefon: 01 47654 99116

Web: www.councilnachhaltigelogistik.at
GREEN CITY HUBS

Project Presentation

Dr. Bartosz Piekarz
Head of Research & Development
bp@i-log.at

supported by FFG
#1
OUR RESEARCH ROADMAP
GREEN CITY HUBS
Concept for Sustainable Inner-City Last Mile Logistics

LEEFF: LOW EMISSION ELECTRIC FREIGHT FLEET
- 8 EV out of 20 vans in the total fleet
- 500,000 electric km to drive
- 40% planned CO2-reduction

DELIVERY ON DEMAND
New Business and Operating Model for Parcel Service
### Project Partners | An Interdisciplinary Approach

<table>
<thead>
<tr>
<th>Projektpartner</th>
<th>Kernkompetenz</th>
</tr>
</thead>
<tbody>
<tr>
<td>i-LOG Integrated Logistics GmbH Hörsching</td>
<td>Konsortialführerin; Projektmanagement, Logistik Know-How</td>
</tr>
<tr>
<td>Lehrstuhl für Produktion und Logistik (mit int. Schwerpunktsetzung) Universität Wien</td>
<td>Transportplanung; Logistische Netzwerkoptimierung</td>
</tr>
<tr>
<td>Tbw Research GesmbH Wien</td>
<td>Städtische Standortplanung</td>
</tr>
<tr>
<td>Institut für Fahrzeugantriebe &amp; Automobilentechnik TU Wien</td>
<td>Alternative Antriebstechniken LKW Einsatzprofile</td>
</tr>
<tr>
<td>Satiamo GmbH Eberstalzell</td>
<td>CO2-Monitoring; Know How Transport- / Dienstleistermarkt</td>
</tr>
</tbody>
</table>

### Praxispartner

![Rexel](image1.png) ![ADAMAH BioHof](image2.png) ![Schachinger](image3.png)
Award Winning Project “Research” | VCÖ Mobilitätspreis 2016
#2

PROJECT GOAL
**Project Goal**

Concept and feasibility study of a sustainable last mile delivery logistics

- based on several, inner-city logistic HUBs
- using delivery vehicles with alternative drive systems
- in the context of adapted transport planning
Implications through the Use of City-HUBs

- shorter delivery trips = reduction of driven kilometers in the city
- with higher potential for alternative drive systems
- thereby reducing CO2-footprint

- but with higher intensity of logistical infrastructure
**PROJECT BACKGROUND:** **CITY OF VIENNA**

Population: 1.85 Mio. (2029: > 2 Mio.)  
Vienna Region: 3.7 Mio.

Highest gross regional product in Austria  
(GRP per capita 47,200 EUR)

Economic Growth 2005–2013:+24%

**Key Sectors:**  
Life Sciences, Engineering, IT & Communication, Chemical Industry,..., Logistics
Karte 3.1

Bevölkerungsentwicklung 2014 bis 2024
Relative Veränderung der Bevölkerung

Quelle: MA 23, Kleinräumige Bevölkerungsprognose für Wien
Prognosegebiete: 250 Zählbezirke
Kartengrundlage: ViennaGIS
Bearbeitung: T. Tranum

Index (2014=100)
- unter 90
- 90 < 100
- 100 < 110
- 110 < 120
- 120 und mehr

Verkehr
- Straßen
- Grundstücksnutzung
- Gewässer
- Naturschutz

WIEN GESAMT

+10%
(+177.600)
#3
RESEARCH APPROACH
The Research Approach

Location Model
- Multi Level Decision Model

Energy Consumption Model
- Telematics-based simulation model

Planning Model
- Multi-Objective Assignment Problem

Control Panel
- Visualizer
- Decision Support Tool

Practical Experience
- Process Models
- Valid Cost Models
- Practical HUB locations
**Location Model**

**Area of Interest: Larger Urban Zone of Vienna**

- We defined a total of 21 urban logistics clusters.

- Each cluster was rated by the following indicators:
  - Suitability for long haul lines
  - Current land planning scheme
  - Present logistical intensity
  - Proximity to customers
  - Proximity to “sensitive zones”
LOGISTICS
ATTRACTIVENESS
INDEX
by the
“Real World”
Components of the Energy Consumption Model

- 7 types of vehicles (see chart)
- 3 scenarios of energy mix (Vienna, Austria und EU)
- additional factors like seasonality (summer, winter, etc.) and speed corridors
Planning Model

Impacts on Vehicle Routing

- short distances with heavy load at the beginning of the tour
- longer distances with low load at the end of the tour

Impacts on Fleet Structure

- vehicle replacement can lead to a significant CO2 reduction with relatively little investment
- electric vehicles should be used mostly in urban areas
Costs / Emissions Trade-Off Analysis

Initial Solution

10x

1x

Vehicle Replacement

8x

2x

1x

+ 30% Costs

- 63% Emissions
Costs / Emissions Trade-Off Analysis

Initial Solution

- 10x Diesel Vans
- 1x City Hub

Additional City Hubs

- 8x Electric Vans
- 2x City Hubs

- +100% Costs
- -77% Emissions

Trade off Kosten/Emissionen (Case Biokistl Zustellung, Szenario Strommix Österreich, 5 Tage)
Visualization & Simulation through an Integrated Online Tool
#4 KEY FINDINGS
**Key Findings**

1. There is a valid solution finding methodology available for complex urban / last mile distribution issues.

2. Traffic-induced emissions in urban areas result only for a low degree of driven mileage. To this extent, kilometers traveled are only a poor reference base for any city toll considerations.

3. 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.
#5
RECOMMENDATIONS
How much more does it cost?

Parcels delivered per day: 150 / van
Additional costs of an e-Van per month: € 250,-
Additional costs per parcel: € 0,08
#2 Only a “Restricted Access”-Solution makes Sense for Cities
#3 Total Gross Weight of a LCV should be raised to 4.25 tons.

..otherwise we might get in trouble with the police..
#4 Bottleneck: Availability of e-Vans & Innovative Business Models

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

pay-per-use
THANK YOU FOR YOUR ATTENTION!
GOING ULTRA LOW
UK government policy towards zero emission vehicles
Bob Moran
IA-HEV eLogV workshop in Vienna on 19 October 2016
CAN ELECTRIC VEHICLES SAVE THE WORLD? NO. But they might help …
Zero emission vehicles? FOUR key UK policy drivers.

- Inward Investment
- Carbon
- Air Quality
- Energy Security
Global trends …

By 2020, around 60% of the world’s population will live in cities.

* Brazil data 2008, all others 2010
Global trends …
... leading a once in a generation technology transition

- IC Engine and Transmission innovations
- Vehicle weight and drag reduction improvements
- Micro- / mild Hybrids
- Plug-in Hybrids
- Mass-market EVs
- Fuel Cell EVs

DATE: ???
UK Climate Change Act 2008 requires an 80% reduction in emissions in the UK by 2050 (against a 1990 baseline)

- Legally binding ‘carbon budgets’ to cap emissions of greenhouse gases (GHG) over rolling 5 year periods.
- Committee on Climate Change (CCC) and Adaptation Sub-Committee to advise on progress and direction.
- UK Government duty to deliver a UK Climate Change Risk Assessment report to Parliament every 5 years.
25%+ of UK total GHG emissions come from transport … up from 15% in 1990

- Road transport 18%
- Energy supply 33%
- Residential 13%
- Business 14%
- Agriculture 9%
- Other 6%
- International shipping 1%
- Non road transport 2%
- International aviation 5%
UK transport emissions - dominated by road vehicles >90%

Cars & Taxis, 54%
HGVs, 21%
Vans, 13%
Aviation & shipping, 3%
Buses and Coaches, 3%
Rail, 2%
Other incl. road, 3%
The government will spend more than £600m between 2015-16 and 2020-21 to support uptake and manufacturing of ultra-low emission vehicles (ULEVs) …and keep the UK on track for all new cars to be effectively zero emission by 2040.

‘Our aim is for almost every car and van to be a zero emission vehicle by 2050 and we will invest £500m over the next five years to achieve it.’
### Most comprehensive policy programme in the world?

<table>
<thead>
<tr>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>£400m+</td>
<td>Plug-in Car Grant</td>
</tr>
<tr>
<td>£20m+</td>
<td>Commercial vehicles / two-wheelers</td>
</tr>
<tr>
<td>£2m+</td>
<td><em>Go Ultra Low</em> comms campaign</td>
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<tr>
<td>£40m</td>
<td><em>Go Ultra Low Cities</em></td>
</tr>
<tr>
<td>£30m</td>
<td>Buses</td>
</tr>
<tr>
<td>£20m</td>
<td>Taxis</td>
</tr>
<tr>
<td>£35m</td>
<td>London</td>
</tr>
<tr>
<td>£30m+</td>
<td>Chargepoint infrastructure</td>
</tr>
<tr>
<td>£10m+</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>£15m</td>
<td>Highways England chargepoints</td>
</tr>
<tr>
<td>£125m+</td>
<td>Research and development</td>
</tr>
<tr>
<td>£10m</td>
<td>Battery prize</td>
</tr>
</tbody>
</table>
£600m support package 2015 - 2020

£20m+ Plug-in Van Grant

20% off an eligible van (up to £8,000)

- N1; UN-ECE 100.00 comp.
- <75g CO₂/km
- 10 – 60 miles ZEV range
- 50 miles top speed
- 3 year vehicle warranty
- 5 year battery warranty
Grow automotive by stimulating innovation, speeding up technology development and reducing emissions

£125m+  Research and Development

Forecast returns on UK investment

£1 invested  £8-14  £20-34
10 years  15 years
£125m+  Research and Development

- £11m part funded ~350 alternatively fuelled commercial vehicles demonstrating low carbon truck technologies in real-world settings and primed the UK market with a series of accessible gas refuelling stations.

- Generated a body of evidence to support fleet and government decision making.

- Consortia includes John Lewis, United Biscuits, Stobarts, Argos, DHL, Tesco, Wincanton and GasRec.

- Final stages of evaluation of carbon emissions, air quality impacts, costs and operational performance.

- Final data report to be published 2016 …
“Low Emission Freight Demonstration”

£125m+ Research and Development

- £19m+ to stimulate ‘real-world’ on-road demonstration trials of ‘near to market’ technologies for vans, HGVs.

- Encouraging greater focus on zero emission capability and urban delivery than previous truck trial,

- Funding associated publicly accessible infrastructure, especially that that could unlock alternatively fuelled vehicles for other users.

- Working closely with industry, operators and others.

- July 2016 launch for April 2017 start!

- www.gov.uk/olev
UK Government plans

- Incentives, infrastructure + R&D plans
- Autumn Statement 2016
- New Auto Sector Strategy
- UK position on EU vehicle CO₂ regs
- Focus on industrial strategy
- Carbon Budget plans
- Modern Transport Bill

Refreshed Government strategy for ultra low emission vehicles

ALL vehicles covered

2017 and beyond
Normalisation ...

Technology Adoption Curve

EVERETT ROGERS - DIFFUSION OF INNOVATIONS 1962

2.5% INNOVATORS
13.5% EARLY ADOPTERS
34% EARLY MAJORITY ADOPTERS
34% LATE MAJORITY ADOPTERS
16% LAGGARDS
Facts and Figures of Germany

### Structure and tasks

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromobility Model Regions programme</td>
<td>EU Directive on development of alternative fuels infrastructure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Coordination and implementation of policies adopted by BMVI, BMWi, BMU, BMBF, BmEL, and possibly further senior federal authorities</td>
<td>• Support of BMVI with development of MFS and CPT</td>
<td>• Cooperation and coordination regarding European and international initiatives, including the representation of public interests in relevant policy bodies</td>
<td>• Stakeholders and the general public</td>
</tr>
<tr>
<td>• Coordination of other programs of the federal government in relevant fields of technology</td>
<td>• Developing national strategy framework for hydrogen and electricity</td>
<td>• Monitoring as a basis for the analysis and evaluation of specific measures</td>
<td>• Networking</td>
</tr>
</tbody>
</table>

Development, coordination and implementation of national strategies and public-private initiatives in the technology field of sustainable propulsions systems on behalf of the federal government.
Objectives of German Federal Government:
Reduction of final energy consumption and CO₂ emissions

- 10% by 2020
- 40% by 2050

Final energy consumption in mobility sector

- 40/55/80-95%

CO₂ emissions by 2020/2030/2050

- 33.6 million tons

CO₂ emissions in mobility sector

Need for action in mobility sector!

Source: The Mobility and Fuels Strategy, 2013
German Ministry for Traffic and digital Infrastructure BMVI
Overview Funding Electric Mobility since 2011

### Funding Million € by BMVI as at 01/2016

<table>
<thead>
<tr>
<th>Category</th>
<th>Funding in Mio.€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individualverkehr</td>
<td>11</td>
</tr>
<tr>
<td>Gewerblicher Verkehr</td>
<td>10</td>
</tr>
<tr>
<td>ÖV Schiene</td>
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</tr>
<tr>
<td>Antrieb / Energieversorgung</td>
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<tr>
<td>ÖV Busse</td>
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<tr>
<td>Infrastruktur</td>
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<tr>
<td>ÖV intermodal</td>
<td>18</td>
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<tr>
<td>Studien</td>
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<tr>
<td>Internationalisierung</td>
<td>3</td>
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<tr>
<td>Organisation / PLS</td>
<td>3</td>
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<tr>
<td>ERANET</td>
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</tr>
<tr>
<td>Plattform</td>
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<tr>
<td>Luftverkehr</td>
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<tr>
<td>ÖV intermodal</td>
<td>18</td>
</tr>
</tbody>
</table>

Additionally:
- Internationalization = 5.74 Mio.€
- Accompanying Research = 5.5 Mio.€
- Verification of Technology = 20 Mio.€
Urban commercial traffic in Germany

Urban commercial transportation in German cities accounts for approx. 30-35% of total traffic

- **45%** Service & People Traffic
- **55%** Freight Traffic
EV urban freight: Strategic importance for German Government

- Action plan “Freight Transport and Logistics” by BMVI as at 2014 (update 2016)
  - Increasing importance of Electric Mobility
- High potential for reducing pollutant emissions (up to 29% Carbon dioxide emission savings)
  - preventing penalties for municipalities
- High potential for supporting market acceleration
  - Two thirds of new vehicle registration in Germany made in business sector
  - highest potential in sector light Utilities (< 3.5 tons, 72% share)

- Important role in Federal and regional funding programs!!!
Federal Ministry of Traffic and digital Infrastructure: Current Funding Guideline Electric Mobility

- Procurement of vehicles and building up of charging Infrastructure (funding 40 percent of “Innovation Delta”)
- Working out municipal concepts to boost electric mobility in cities and counties
- Research and development for further assistance towards market acceleration
## Guideline Funding Electric Mobility 2015: Sample calculation

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Price</th>
<th>Funding Amount (40% investment grant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW Golf (Golf 85 KW TSI CL)</td>
<td>€17,000</td>
<td>€4,800</td>
</tr>
<tr>
<td>VW eGolf</td>
<td>€29,000</td>
<td></td>
</tr>
<tr>
<td>Price difference</td>
<td>€12,000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Price</th>
<th>Funding Amount (40% investment grant)</th>
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</thead>
<tbody>
<tr>
<td>Renault Kangoo (diesel / 2-seats)</td>
<td>€13,500</td>
<td></td>
</tr>
<tr>
<td>Renault Kangoo Z.E. (2-seats)</td>
<td>€20,300</td>
<td>€2,600</td>
</tr>
<tr>
<td>Price difference</td>
<td>€6,500</td>
<td></td>
</tr>
</tbody>
</table>

* Approximate reference values: Actual promotion may vary depending on equipment.
EV urban freight:
Number light Utilities & EV Trucks in Germany (BEV & PHEV)

Number Vehicles

<table>
<thead>
<tr>
<th>01/01/2013</th>
<th>01/01/2014</th>
<th>01/01/2015</th>
<th>01/01/2016</th>
<th>01/04/2016</th>
<th>01/07/2016</th>
<th>01/10/2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,389</td>
<td>2,931</td>
<td>3,571</td>
<td>4,367</td>
<td>4,764</td>
<td>5,290</td>
<td>5,572</td>
</tr>
</tbody>
</table>

Private

Commercial (Percentage)

89% 89% 89% 89% 90% 90% 91%
Market Situation in Germany:
light e-Utilities & e-Sprinter (up to 3.5/4.25 tons)

- Citroën Berlingo Electric
- EcoCraft EcoCarrier
- Ford Transit Connect
- Daimler Vito E-Cell
- Iseki Megaworker
- Micro Vett Fiorino
- Nissan eNV200
- Peugeot Partner Electric
- Renault Kangoo Z.E. / Z.E. Maxi
- VW Abt E-Caddy
- Streetscooter Work
- emovum e-Ducato
- IVECO Daily Electric
- Smith Edison
- Mercedes Sprinter
- BEV
- BEV
- BEV
- BEV
- BEV / also available as 4.6 tons
- PHEV

Database: Own Research, October 2016, all information is provided without warranty
Market Situation in Germany:
e-Trucks (up to 7.5 tons, only BEV/REV)

Emoss Electric Dyna EV200 (BEV)

EFA-S P80 e (REV)

Framo e 180/280 (BEV)

Orten E 75 AT/TL (BEV)
Market Situation in Germany: e-Trucks (> 7.5 tons)

Scania G 360 4x2 Electric
Trolley Truck / diesel-hybrid

BEV
Emoss CM 10 / 12 / 16 /18
10 / 12 / 16 /18 t

Smith Newton
7,5 / 10 /12 t

Framo e 180/280
7,5 - 44,0 t

E-Force
Based on IVECO Stralis / 18 t

Database: Own Research, October 2016, all information is provided without warranty
Market Situation in Germany:
Announced e-Sprinter & e-Trucks

**VW e-Crafter**
- 4.25 tons
- BEV

**Fuso Canter E-Cell**
- Announced for 2017
- BEV

**Hyundai H350**
- Prototype presented on IAA Commercial Vehicles 2016
- FCEV

**Mercedes Urban e-Truck**
- Prototype presented on IAA Commercial Vehicles 2016
- BEV

**Nikola One**
- Expected 12/2016
- Range up 1,931 km / Hydrogen free for first 1 million miles
- FCEV

**Mercedes Future Truck 2025**
- Semi-autonomous prototype
- BEV
## Market Situation in Germany: Overview

<table>
<thead>
<tr>
<th></th>
<th>≤ 3.5 t/4.25 t</th>
<th>3.5/4.25 t to 7.5 t</th>
<th>7.5 t to 12.0 t</th>
<th>&gt; 12.0 t</th>
<th>Total Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
<td>8</td>
<td>12</td>
<td>5</td>
<td>8</td>
<td>30</td>
</tr>
<tr>
<td><strong>Thereof…</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BEV</strong></td>
<td>7</td>
<td>10</td>
<td>4 (+1*)</td>
<td>7</td>
<td>22</td>
</tr>
<tr>
<td><strong>REEV</strong></td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td><strong>FCEV</strong></td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* Trolley Truck

Due to constructions and battery size several models can be divided up in various categories.
Accompanying Research by BMVI: New working group „eLogistics“

**Vehicles**
- Light Utilities
- EV trucks (up to 18 tons)
- Special Vehicles

**Technology**
- Technology review (BEV, PHEV, FCEV)
- Market observation & analysis
- Concepts for charging infrastructure

**Practicality & Readiness**
- Supply chains
- Urban transport
- Distribution traffic
Market Incentives Electric Mobility: Decision by German Federal Government at 18/05/2016

**PURCHASE INCENTIVE**
- Environmental Premium (4,000€ for BEVs and FCEVs; 3,000€ for PHEVs)
- Financing 50% each by Government and OEMs
- Funding of vehicles with a maximum purchase price of 60,000€
- Total budget: 1.2 Billion € maximum until 2019

**CHARGING INFRASTRUCTURE**
- Total budget: 300 million €
- 200 million € promote fast charging (DC)
- 100 million € promote normal charge (AC)
- At least 15,000 charging stations will be set up
  - 10,000 normal
  - 5,000 fast

**TAX FUNDING**
- Tax free charging on working place for employee
- Extension of tax exemption for EVs from 5 to 10 years

**PUBLIC FLEETS**
- 20 % EVs in federally owned fleets
- Total costs of investments: 100 million €
Thanks for your Attention!

www.starterset-elektromobilitaet.de

Dominique Sévin

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dominique.sevin@now-gmbh.de
(+49) 30 - 311611640

NOW GmbH
National Organization Hydrogen and Fuel Cell Technology
Fasanenstraße 5
10623 Berlin / Germany

www.now-gmbh.de
Electric freight vehicles – out of niche into mass market
Facts&Figures Austria
IA-HEV Task 27 Workshop, 19 October 2016, Vienna
Henriette Spyra, AustriaTech – Federal Agency for Technological Measures
Agenda

- Who is speaking to you?
- Status Quo
- What will change? Upcoming challenges
AustriaTech is a national-level Transport Agency

- Agency of the Austrian Ministry for Transport, Innovation and Technology
- Focus on Innovation, ITS Deployment and E-Mobility
- NCP for implementation process of AFI DIRECTIVE 2014/94/EU

- Implementation of measures from the 2012 E-Mobility Implementation Plan
- Advisory & project support
- Advisory for national RDD programs
- Annual E-Mobility monitoring report for Austria
- Policy support and coordination during EU legislation processes
- Policy support and coordination during national transposition processes on behalf of bmviti (as currently ongoing for AFI Directive 2014/94/EU)
- Cooperation with regional and local authorities (cities, municipalities)
- Participation in international working groups (e.g. IEA-HEV IA, UNECE QRTV)
Status Quo Austria
E-Logistics in Austria – 2 things you’ll always hear

- Rail modal split above EU average – 32% of goods transported by railway system (objective: 40% by 2025)
- Austrian Postal Service, as one of the most important logistics providers, has the largest electric fleet of the country: > 1.300 E-Vehicles (cars, scooters, E-Quads, E-Bikes)

...but a lot of work needed to reach 2030 goal of CO₂-free logistics in urban areas...
Status Quo: Vehicle Registrations (Q3/2016)

<table>
<thead>
<tr>
<th>Vehicle Type, Fuel Type / Energy Source</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016 [Q3]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars M1</td>
<td>328.563</td>
<td>356.145</td>
<td>336.010</td>
<td>319.035</td>
<td>303.318</td>
<td>308.555</td>
<td>252.178</td>
</tr>
<tr>
<td>Petrol incl. Flex Fuel</td>
<td>159.740</td>
<td>159.027</td>
<td>143.325</td>
<td>134.276</td>
<td>126.503</td>
<td>122.832</td>
<td>101.104</td>
</tr>
<tr>
<td>Diesel</td>
<td>167.130</td>
<td>194.721</td>
<td>189.622</td>
<td>180.901</td>
<td>172.381</td>
<td>179.822</td>
<td>144.493</td>
</tr>
<tr>
<td>Battery-Electric (BEV)</td>
<td>112</td>
<td>631</td>
<td>427</td>
<td>654</td>
<td>1.281</td>
<td>1.677</td>
<td>2.919</td>
</tr>
<tr>
<td>Plug-In-Electric (PHEV)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>184</td>
<td>434</td>
<td>1.100</td>
<td>879</td>
</tr>
<tr>
<td>Hydrogen (FCEV)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>New Electric Vehicle Registrations M1</strong></td>
<td>112</td>
<td>631</td>
<td>427</td>
<td>83</td>
<td>0.03%</td>
<td>0.18%</td>
<td>0.13%</td>
</tr>
<tr>
<td><strong>Share of EVs in new M1 Registrations</strong></td>
<td>0.03%</td>
<td>0.18%</td>
<td>0.13%</td>
<td>0.26%</td>
<td>0.3%</td>
<td>0.18%</td>
<td>0.13%</td>
</tr>
<tr>
<td>Other Battery Electric Vehicles of Classes L, M, N</td>
<td>1.225</td>
<td>979</td>
<td>1.400</td>
<td>792.13</td>
<td>919</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorbikes/Trikes/Quadricycles (class L)</td>
<td>1.206</td>
<td>923</td>
<td>1.094</td>
<td>585</td>
<td>672</td>
<td>651</td>
<td>919</td>
</tr>
<tr>
<td>Busses (class M2 and M3)</td>
<td>8</td>
<td>5</td>
<td>14</td>
<td>15</td>
<td>1</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Duty Vehicles Class N1 (&lt; 3.5 t)</td>
<td>11</td>
<td>51</td>
<td>292</td>
<td>191</td>
<td>203</td>
<td>267</td>
<td>380</td>
</tr>
<tr>
<td>Duty Vehicles Class N2, N3 (&gt; 3.5 t)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

BEV registrations (+138.9%)

Very few freight vehicles (380 N1)
## Status Quo: Vehicle Population (08/2016)

<table>
<thead>
<tr>
<th>Vehicle Type, Fuel Type / Energy Source</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016 (08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>1.988.079</td>
<td>2.506.511</td>
<td>2.570.124</td>
<td>2.621.133</td>
<td>2.663.063</td>
<td>2.702.922</td>
<td>2.738.029</td>
</tr>
<tr>
<td>Battery-Electric (BEV)</td>
<td>353</td>
<td>989</td>
<td>1.389</td>
<td>2.070</td>
<td>3.386</td>
<td>5.032</td>
<td>7.710</td>
</tr>
<tr>
<td>Plug-In-Electric (PHEV)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>408</td>
<td>776</td>
<td>1.512</td>
<td>2.391</td>
</tr>
<tr>
<td>Hydrogen (FCEV)</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>3</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Electric Vehicle - Change on Previous Year</td>
<td>58,3%</td>
<td>180,2%</td>
<td>40,4%</td>
<td>78,4%</td>
<td>68,1%</td>
<td>57,3%</td>
<td>-</td>
</tr>
<tr>
<td>Share of EVs in M1 population</td>
<td>0,01%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- > 10,000 EVs
- ~0,2% of car population

### Other battery electric vehicles of classes L, M, N

<table>
<thead>
<tr>
<th>Class</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016 (08)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorbikes/Trikes/Quadricycles (class L)</td>
<td>3.034</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.532</td>
</tr>
<tr>
<td>Busses (class M2 und M3)</td>
<td>113</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>138</td>
</tr>
<tr>
<td>Duty Vehicles Class (&lt; 3.5 t)</td>
<td>69</td>
<td>135</td>
<td>428</td>
<td>619</td>
<td>819</td>
<td>1.069</td>
<td>1.449</td>
</tr>
<tr>
<td>Duty Vehicles Class (&gt; 3.5 t)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Very few duty vehicles (~1.500 N1)
Top 10 PEV (M1) market share Countries in the European Union

New registrations 01-08.2016

Austria among Top 10 in Europe

M1 stock 08/2016

© EAFO (including figures from Jan - Aug 2016)
Status Quo: Charging Infrastructure (07/2016)

1,327 normal power CPs
316 high power CPs
Status Quo: CNG and Hydrogen Infrastructure

171 CNG filling stations
3 H2 filling stations
## Incentives for E-Mobility

<table>
<thead>
<tr>
<th>Status Quo Incentives E-Mobility</th>
<th>Purchase Incentives</th>
<th>Taxes</th>
<th>Innovative/green public procurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct purchase incentives for companies, public authorities etc. (klimaaktiv mobil and regional funding)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NoVA exemption (registration tax) Exemption engine-related insurance tax <strong>NEW FROM 2016: changes in company car taxation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large scale public tender for EVs currently in preparation by Federal Procurement Agency BBG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purchase Incentives</td>
<td>Taxes</td>
<td>Innovative/green public procurement</td>
<td></td>
</tr>
<tr>
<td>Electric Mobility Flagship Projects Model regions electric mobility Mobility of the Future Urban E-Mobility</td>
<td>e.g. parking management, exemption of EVs from restrictions with or without reduced (free) parking fees; additional parking space</td>
<td>e.g. adaptation of building regulations for easier installation of charging infrastructure</td>
<td></td>
</tr>
<tr>
<td>Research, Development &amp; Demonstration</td>
<td>Municipal incentives</td>
<td>Regulatory frameworks</td>
<td></td>
</tr>
</tbody>
</table>
E-Logistics Support @ bmvit

FTI Support

Deployment Support
What will change? Upcoming challenges
National Policy Framework Clean Power for Transport

- Art. 3: National Policy Framework for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure
- Public sector to set “measures necessary to ensure that ... objectives contained in the national policy framework are reached”
National implementation process: build on existing strategies and use process to drive change

<table>
<thead>
<tr>
<th>Erstes Jahr Nationale Umsetzung 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Österreichweite Online-Konsultation Saubere Energie im Verkehr</td>
</tr>
<tr>
<td>• WS Elektrizität, CNG, LNG, H2 05/2015 – 09/2015</td>
</tr>
<tr>
<td>• WS Bundesländer 06/2015 - 10/2015</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zweites Jahr Nationale Umsetzung 2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Workshops Graz, Salzburg, Innsbruck</td>
</tr>
<tr>
<td>• Erstellung des Nationalen Strategierahmens:</td>
</tr>
</tbody>
</table>

NPF 18.11.2016

Implementation + further measures!
Relevant objectives in Austria’s NPF

- Explicit recognition that massive change in mobility system is needed and that diesel/petrol use needs to decrease significantly
- Transition to low- and zero emission vehicles
- Change needed to fulfil already existing legal and political objectives on air quality, decarbonisation etc.
- Explicit objectives in Austria’s regions, e.g. new Styrian E-Mobility strategy assumes that by 2030 95% of new vehicle registrations will be EVs
## Some relevant measures in Austria’s NPF

<table>
<thead>
<tr>
<th>Planned adaptation</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road law</strong></td>
<td>Objective: reserve parking space at charging stations</td>
</tr>
<tr>
<td></td>
<td>Symbol and EV definition in road law</td>
</tr>
<tr>
<td><strong>Vehicle classification &amp; labelling</strong></td>
<td>Unified labelling of clean vehicles (L, M1, N1), includes BEV, PHEV with at least 50km electric range, FCEV; evaluation to increase electric range</td>
</tr>
<tr>
<td><strong>Law on driving licences</strong></td>
<td>Objective: allow drivers with class B license to drive E-Vans up to 4.25t</td>
</tr>
<tr>
<td><strong>Procurement</strong></td>
<td>• Continue purchase support for duty vehicles</td>
</tr>
<tr>
<td></td>
<td>• Establish public procurement objective for low emission vehicles &amp; obligatory use of TCO approach</td>
</tr>
<tr>
<td><strong>Industry dialogue</strong></td>
<td>Establish industry dialogue together with CNL aimed specifically at increasing use of E-duty vehicles in cities and building up necessary infrastructure</td>
</tr>
</tbody>
</table>
The challenge: Many existing strategies, projects and initiatives...

...which are still not sufficient to reach Paris or 2030 objectives though!
**Open issues – the big picture**

### GHG emissions: EU targets & Austria

**EU 2020 targets (-20% CO₂-Emissionen to 1990)**  
Ö-Effort Sharing: 2020 (-16% CO₂-Emissionen to 2005)

<table>
<thead>
<tr>
<th>EU 2030 targets (-40% to 1990)</th>
<th>Red -%</th>
<th>(to 2005)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETS</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>Non-ETS</td>
<td>30%</td>
<td></td>
</tr>
</tbody>
</table>

**Austria**  
Possible national sectoral target for transport (non-ETS): 36% (to 2005)

Transport: Increase of CO₂-Emissions 1990-2013 58%

- 1990: 13.7 Mio tCO₂e  
- 2005: 24.6 Mio tCO₂e  
- 2008: Record high 21.9 Mio tCO₂e  
- 2009: 21.3 Mio tCO₂e (Mandatory biofuel substitution scheme - FQD)  
- 2010: 22.1 Mio tCO₂e  
- 2011: 21.3 Mio tCO₂e (Rising fuel prices)  
- 2012: 21.2 Mio tCO₂e  
- 2013: 22.2 Mio tCO₂e  
- 2014: 21.7 Mio tCO₂e  
- 2015: 22.3 Mio tCO₂e  
- 2016: 22.1 Mio tCO₂e  
- 2017: 22.0 Mio tCO₂e  
- 2018: 21.9 Mio tCO₂e  
- 2019: 21.8 Mio tCO₂e  
- 2020: 21.7 Mio tCO₂e  
- 2030: 15.7 Mio tCO₂e  

- **Possible necessary national sectoral target** - 28%

**Possible measures:**

- **Backcasting** based on final reduction targets (COP21, post EU 2030 effort sharing decision)
- Backcasting for 2030 and 2050
- **Long term planning perspective** for businesses & European industry
- **100% zero emission** registration targets/quotas for different vehicle classes:  
  - 2030 range: Passenger cars, LDV  
  - 2040 range: HDV

**Worldwide CO₂ budget:**

- 1000 gigatons of CO₂

**Austria’s share:** 1 per mille

† 1000 million tonnes of CO₂

† Approx .14 years with current emission levels left (~75 tCO₂e p.a) -> beyond that overshooting of 2°C target

† Every ton saved now until 2030 gives leeway for post 2030

**MINUS 25/30% CO₂-emissions in the transport sector by 2030 (within 14 years)**  
- despite forecasts of growing transport volumes, ...

**Virtually zero CO₂-emissions in road transport by 2050**
IA-HEV Task 27 Workshop
Supermarket logistics with electric trucks

Dr. Georg Weinhofer
Vienna, October 19th 2016
Coop (Switzerland): revenue of 27 billion CHF in 2015 with retail, wholesale and production
Coop exercises its responsibility for climate protection

CO₂ neutral by 2023

- Until 2023 the annual CO₂ emissions will be reduced as much as technical possible and economical suitable. After 2023 the remaining CO₂ emission will be offset externally.

CO₂ reduction of goods transport

- Goods transport (Coop and third party) accounts for 40% of CO₂ emissions.
- Until 2023 the annual CO₂ emission of goods transport should be reduced by 20% compared to 2008.
measures to reduce $\text{CO}_2$ emissions of goods transport

- transport shift from street to rail
- electric trucks
- fuel from organic waste
- energy efficient trucks
idea and realization in 2013

idea

- 18 tons electric truck for same use as conventional diesel truck
- usual container and cooling system
- electric powered cooling system

realization

- bought electric truck «E-Force»
- container installed by Frech-Hoch
- Cooling system with Thermoking and Fröhlich Transklima adapted and installed
technology of electric truck «E-Force»

**CHASSIS**
IVECO Stralis

**ENGINE**
2 engines á 150 kW (total 408 PS)

**BATTERIES**
2 blocks á 285 Ah (120 kWh) 
each 1.3 tons, LiFePO₄ 
recharge in 6 hours with 400V/63A/44kW

**WEIGHT**
empty weight: 8 tons 
weight for container an cargo: 10 tons

**COOLING**
Thermoking (powered from electric system of truck)
since January 2014: goods transport to supermarkets

- cargo load: 6.1 tons
- truck is used on normal solo-tours (no trailer) in metropolitan area Zurich on six days a week
- net power consumption: 1 to 1.3 kWh per km
- range: up to 240 km (without recharge)
- so far 80'000 km use (35'000 km in 2016)
four more «E-Force» bought in 2016
since April 2016: use also in delivery wholesale

- challenges compared to supermarket logistics:
  - higher number of unloading stations
    (lifting platform is more often in use)
  - transport of non-cooled, cooled and frozen products at the same time

- cargo load: 6.0 tons
- truck is used on normal delivery tours in metropolitan area Zurich
- net power consumption: 1 to 1.3 kWh per km
- range: up to 240 km (without recharge)
- so far 10'000 km use
- from December 2016 on there will be a further truck in use for deliveries in Berlin
### Profitability of Electric Truck «E-Force»

<table>
<thead>
<tr>
<th>Category</th>
<th>Diesel Percentage</th>
<th>Electric Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chassis</td>
<td>100%</td>
<td>340%</td>
</tr>
<tr>
<td>Container + Cooling</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Investment Costs</td>
<td>100%</td>
<td>220%</td>
</tr>
<tr>
<td>Fuel</td>
<td>100%</td>
<td>20%</td>
</tr>
<tr>
<td>Service</td>
<td>100%</td>
<td>25%</td>
</tr>
<tr>
<td>Charge for street use</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Tax</td>
<td>100%</td>
<td>80%</td>
</tr>
<tr>
<td>Operating Costs</td>
<td>100%</td>
<td>10%</td>
</tr>
</tbody>
</table>

### Graph

- **Diesel**
- **Electric**

The graph compares the costs of diesel to electric trucks based on distance in kilometers. The costs are measured in CHF (Swiss Francs), with diesel costs generally higher than electric costs at lower distances, but the efficiency gap narrows and electric costs become more favorable at higher distances.
Conclusion of use of electric truck «E-Force»

+ no constraints regarding transported volume and disposition
+ total substitution of a comparable diesel truck (solo use in city / metrop. area)
+ low noise, good acceleration

– use on tours with autobahn not so good (less recuperation)
– use with a trailer not possible

I do not drive another truck anymore!

Coop truck driver
project "mobility in a closed water circle"

- water vapor
- hydraulic power station
- fuel cell vehicle
- electrolysis
- hydrogen station
- transport of hydrogen
construction of a fuel cell electric truck (use from 11/2016)
construction of a fuel cell electric truck (use from 11/2016)
Thank you for your attention!
Start of HyTruck in 2006
### Aantal geregistreerde elektrische voertuigen in Nederland

<table>
<thead>
<tr>
<th>Type voertuig</th>
<th>Aantal per</th>
<th>31-12-2014</th>
<th>31-12-2015</th>
<th>30-04-2016</th>
<th>31-05-2016</th>
<th>30-06-2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personenauto (BEV)</td>
<td></td>
<td>6.825</td>
<td>9.368</td>
<td>10.566</td>
<td>10.690</td>
<td>11.041</td>
</tr>
<tr>
<td>Personenauto (E-REV, PHEV)#</td>
<td></td>
<td>36.937</td>
<td>78.163</td>
<td>80.464</td>
<td>81.124</td>
<td>81.887</td>
</tr>
<tr>
<td>Personenauto (FCEV)</td>
<td></td>
<td></td>
<td></td>
<td>23</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Bedrijfsauto ≤3500</td>
<td></td>
<td>1.258</td>
<td>1.460</td>
<td>1.553</td>
<td>1.496</td>
<td>1.522</td>
</tr>
<tr>
<td>Bedrijfsauto &gt;3500</td>
<td></td>
<td>46</td>
<td>50</td>
<td>56</td>
<td>58</td>
<td>61</td>
</tr>
<tr>
<td>Bus *</td>
<td></td>
<td>80</td>
<td>94</td>
<td>101</td>
<td>105</td>
<td>104</td>
</tr>
<tr>
<td>Quadricycles (vh driewielig)</td>
<td></td>
<td>769</td>
<td>872</td>
<td>900</td>
<td>939</td>
<td>957</td>
</tr>
<tr>
<td>Motorfiets</td>
<td></td>
<td>196</td>
<td>268</td>
<td>311</td>
<td>314</td>
<td>319</td>
</tr>
<tr>
<td><strong>Totaal op de weg</strong></td>
<td></td>
<td><strong>46.111</strong></td>
<td><strong>90.275</strong></td>
<td><strong>93.974</strong></td>
<td><strong>94.749</strong></td>
<td><strong>95.915</strong></td>
</tr>
<tr>
<td>Bromfietsen</td>
<td></td>
<td>3.441</td>
<td>3.610</td>
<td>3.682</td>
<td>3.682</td>
<td>3.728</td>
</tr>
<tr>
<td>Snorfietsen</td>
<td></td>
<td>23.850</td>
<td>28.459</td>
<td>29.820</td>
<td>30.265</td>
<td>30.708</td>
</tr>
<tr>
<td>Brommobielen</td>
<td></td>
<td>172</td>
<td>219</td>
<td>236</td>
<td>240</td>
<td>239</td>
</tr>
<tr>
<td><strong>Totaal inclusief brom/snoriets/brommobielen</strong></td>
<td></td>
<td><strong>73.574</strong></td>
<td><strong>122.563</strong></td>
<td><strong>127.712</strong></td>
<td><strong>128.936</strong></td>
<td><strong>130.590</strong></td>
</tr>
</tbody>
</table>

* Inclusief trolleybussen en een aantal hybride bussen; # Exclusief volledig hybride voertuigen
Charging-points

Laadpunten (exclusief private laadpunten)

<table>
<thead>
<tr>
<th>Jaren</th>
<th>Aantallen</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-06</td>
<td>6.075</td>
</tr>
<tr>
<td>2015-12</td>
<td>7.395</td>
</tr>
<tr>
<td>2014-12</td>
<td>5.421</td>
</tr>
<tr>
<td>2013-12</td>
<td>3.521</td>
</tr>
<tr>
<td>2012-12</td>
<td>2.782</td>
</tr>
<tr>
<td>2011-12</td>
<td>1.258</td>
</tr>
<tr>
<td>2010-12</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Commercial vehicles in urban traffic

- Commercial vehicles (vans and trucks) account for about 15% of urban traffic
- Varies slightly between cities (especially ratio trucks – vans)

Source: Vehicle fleet scan Amsterdam (TNO, 2014)
Urban freight transport

Total CO₂ emissions city traffic in the Netherlands

Estimated total emissions per year per vehicle type for all urban traffic in the Netherlands (TNO, 2015)
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)
Urban freight transport

Total PM10 emissions city traffic in the Netherlands

Estimated total emissions per year per vehicle type for all urban traffic in the Netherlands (TNO, 2015)
2. Give subsidies for EV trucks

NOT: the polluter earns BUT: reward frontrunners

And: € for trucks is far more cost efficient than for passenger cars
2016: Clean air for Amsterdam

- Expansion of the fast charger network
- Agreements with business owners about emission-free delivery of supplies
- Privileges for electric vehicles
- From 1,700 charging points to 4,000 by 2018
- Clean taxi rank near Amsterdam Central Station
- Additional charging points in parking structures
- No new parking permit for most polluting cars
- Agreements with taxi companies on emission-free taxis
- Emission-free municipal vehicle fleet
- Subsidy scheme for electric vehicles
- Coaches covenant
- Location-specific measures for final bottlenecks to good air quality
- From 3 to 5 cargo hubs for clean urban distribution

Visit amsterdam.nl/physicalplanning/sustainability
3. LEZ: an infrastructure to secure your ambition
4. Privileges for EV Trucks
50 kilometres, daily 5 days a week

- Cargohopper operates in Amsterdam and Enschede
- 5 self developed vehicles do up to 70 drops a day covering 50km,
- 1,100,000 kg annually
- Beloved in the city: Cargohopper is Amsterdam!
- We have a perfect solution to distribute copier paper, but..
- We haul construction materials
Ook in bestelauto's:
More VANS
Heavy trucks
Vele mogelijkheden:
City distribution

- 340km
- 81.7 km
- 68.8 km
- 76.4 km
- 212 km

Zero, Oslo 2016-02-03
Emoss serie:

- Based on DAF LF serie from 12-19 tons rigids
- Battery package between 120-240kWh
- Range of 150-240 km
- 44 kW chargers on board (4-6 h charging)
- Incl chargingpiont (380V 63Amp)
- Incl Cab heather
- Incl datalogger and online connection
REEEV tractor unit
Performance and specs

- Daf LF 19 tons chassis
- Payload 9200 kg
- Range 200km (200kWh)
- 44 kW chargers, 4-5 h charging
- Distribution in and round Utrecht, daily between 200-240 km
Performance and specs

- Daf LF 19 tons chassis
- Payload 9850 kg
- Range 160 km (160 kWh)
- 44kW chargers on board
- Daily distribution in Rotterdam (80-100km)
Performance and specs

- DAF 16 tons chassis
- Payload 6000 kg
- Range 200 km (200kWh)
- Charging 4-6 h
- Moving company surrounding of Amsterdam
Performance and specs

- Daf LF 12 tons chassis
- Payload ±3000kg
- Range 120 km (160kWh)
- Cooling machine
- 44kW chargers
- Citydistribution in Amsterdam (Bio Fruts)
* MAN 19 tons chassis
* Freezing box and electric cooler
* 240 kWh battery
* Range 200 km
* Supermarket delivery
Cost and savings

* **Costs:**
  * Chassis price 3-4 times a normal diesel chassis
  * Charging points at your company
  * Training of mechanics and drivers
  * (Cost / km +€ 50,- per day)

* **Savings:**
  * Fuel: ±60% lower “fuel” cost (Dutch figures)
  * Maintenance (?)
Electric city distribution

* Clean, quiet and energie efficient
* Pleasure to drive
* Extra cost can be reduced by privileges and city rules
* No public charging required
6. Procurement: practice what you preach
2015 - 2020

- Subsidy needed on 0-emission trucks
  - Niche product, high costs
  - In interest of total community

- OR: (statement:)

- Clear regulations on (future) emission zones (CITIES)
  - Investment in vehicles for long term
  - Regulations stimulate development
Mercedes at the IAA sept 2016
Outlook

- 3 kW (6 kW)
- 22 kW
- „50 kW“
- 100 kW
- 200 kW
- 300 kW
The core of the system is an intelligent pantograph combined with a hybrid drive system.
Hydrogen in near future

* Bigger range >500 km
* Heavier specs >25 ton
* Fast filling (max 10 min)
* Light weight icw batteries

* New projects are starting up in Holland
* Using the existing electric chassis as bases
* Both tractor and rigids
* Several suppliers for fuelcell systems
Scania test vrachtwagens op waterstof

Scania slaat de handen ineen met Asko, één van de grootste transportbedrijven van Noorwegen, om vrachtwagens te testen die worden aangedreven door elektrische energie vanuit waterstofgas.
Thank you for the attention:
eric@beers.nl
Mob: +31651587696
Medium and Heavy Duty EV Activities
NREL Update

John Farrell
Kenneth Kelly & Kevin Walkowicz
National Renewable Energy Lab

IA-HEV Task 27 – Electrification of Transport Logistic Vehicles
3rd Workshop on Electric Freight Vehicles
October 19th, 2016
NREL Vehicle RD&D Activities

**Vehicle Thermal Management**
- Integrated Thermal Management
- Climate Control / Idle Reduction
- Advanced HVAC

**Vehicle Deployment / Clean Cities**
- Guidance & Information for Fleet Decision Makers and Policy Makers
- Technical Assistance
- Online Data, Tools, Analysis

**Regulatory Support**
- EPAct Compliance
- Data & Policy Analysis
- Technical Integration
- Fleet Assistance

**Infrastructure**
- Vehicle-to-Grid Integration
- Integration with Renewables
- Charging Equipment & Controls
- Fueling Stations & Equipment
- Connected and Autonomous

**Advanced Combustion / Fuels**
- Advanced Petroleum and Biofuels
- Combustion / Emissions Measurement
- Vehicle and Engine Testing

**Vehicle and Fleet Testing**
- MD/HD Field Testing & Analysis
- MD/HD Chassis Dyno Testing
- Duty Cycle Analysis
- Data Collection, Storage & Analysis
- Vehicle Systems Modeling

**Advanced Power Electronics and Electric Motors**
- Thermal Management
- Advanced Heat Transfer
- Thermal Stress and Reliability

**Advanced Energy Storage**
- Thermal Characterization / Management
- Life/Abuse Testing and Modeling
- Computer Aided Engineering
- Electrode Material Development
Medium- and Heavy- Vehicle Field Testing and Evaluations

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.

Collect, analyze and publicly report data:
- Drive cycle and system duty cycle analysis
- Operating cost/mile
- In-use fuel economy
- Chassis Dynamometer emissions and fuel economy
- Scheduled and unscheduled maintenance
- Warranty issues
- Reliability (% availability, MBRC)
- Implementation issues/barriers
- Subsystem performance data & metrics (ESS, engine, after-treatment, hybrid/EV drive focus)

Data stored in FleetDNA for security and limited public accessibility

Frequent interactions and briefings with stakeholders – fleets, technology providers, researchers, and government agencies

Fleets

UPS, FedEx, Coke, Frito-Lay, Foothill Transit, PG&E, Long Beach Transit, Miami-Dade, Verizon, Walmart, Waste Management...

Vehicle & Equip Mfg’s

†

Proterra, BYD, Odyne, Parker-Hannifin, Cummins, Volvo, Peterbilt, Smith EV, Eaton, Allison, BAE, EDI, Altec, Navistar, PACCAR, Oshkosh, ...

Useful Data, Analysis and Published Reports
NREL Field Data, Testing, & Analysis Tools

Data from Field Evaluations helps populate FleetDNA database

DOE Fleet Tools (DRIVE, FASTSim, A Fleet, etc.) used to analyze and investigate impacts – data used to validate and improve tools

Published information and data used by fleets, industry, DOE and other research programs, and other agencies

Collect Lab and Field Data
Capture, Store and Analyze
Laboratory Testing
Explore & Optimize
Communicate & Inform
Identify Barriers, New R&D Opportunities, Validate Efforts

Data from Field Evaluations helps populate FleetDNA database

DOE Fleet Tools (DRIVE, FASTSim, A Fleet, etc.) used to analyze and investigate impacts – data used to validate and improve tools

Published information and data used by fleets, industry, DOE and other research programs, and other agencies

Partnership with Fleets and Technology Providers = Relevant Results & Optimized Solutions for Real World Applications
# NREL Technology Evaluation Projects

## DOE Current/Planned Fleet Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Non-DOE Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UPS HHV</strong></td>
<td><strong>SCAQMD</strong></td>
</tr>
<tr>
<td>Renewable Diesel</td>
<td>- S.C. Fleet DNA</td>
</tr>
<tr>
<td>Extended Range</td>
<td>- Zero Emissions</td>
</tr>
<tr>
<td><strong>Long Beach Transit BYD</strong></td>
<td><strong>CA Air Resources Board (CARB)</strong></td>
</tr>
<tr>
<td><strong>EV Transit Bus w/ WPT</strong></td>
<td>- Heavy Hybrid Vehicle Analysis</td>
</tr>
<tr>
<td><strong>Miami-Dade HHV</strong></td>
<td>- Aerodynamics Testing</td>
</tr>
<tr>
<td>Refuse Trucks</td>
<td><strong>EPA</strong></td>
</tr>
<tr>
<td><strong>Foothill Transit</strong></td>
<td>- Heavy-Duty Phase II GHG</td>
</tr>
<tr>
<td><strong>Proterra Fast Charge</strong></td>
<td>- Drive Cycle Development</td>
</tr>
<tr>
<td><strong>EV Transit Bus</strong></td>
<td><strong>TARDEC</strong></td>
</tr>
<tr>
<td><strong>Duke Energy</strong></td>
<td>- Autonomous vehicle data collection</td>
</tr>
<tr>
<td><strong>Odyne PHEV utility trucks</strong></td>
<td>- analysis</td>
</tr>
<tr>
<td><strong>Fleet Platooning</strong></td>
<td><strong>Nat’l Park Service</strong></td>
</tr>
<tr>
<td><strong>Duke Energy</strong></td>
<td>- Data collection and recommendations</td>
</tr>
<tr>
<td><strong>Odyne PHEV utility trucks</strong></td>
<td></td>
</tr>
<tr>
<td><strong>EV - V2G School Bus</strong></td>
<td></td>
</tr>
<tr>
<td><strong>EDI PHEV Utility Truck w/export power</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Frito Lay Smith Electric</strong></td>
<td><strong>Includes electrified vehicles</strong></td>
</tr>
<tr>
<td><strong>EV delivery</strong></td>
<td></td>
</tr>
<tr>
<td><strong>PG&amp;E Electrified Utility Trucks</strong></td>
<td></td>
</tr>
</tbody>
</table>
Objectives:
- Capture and quantify drive cycle and technology variation for the multitude of medium- and heavy-duty vocations
- Provide a common data storage warehouse for medium- and heavy-duty vehicle data across DOE activities and labs – www.nrel.gov/fleetdna
- Integrate existing DOE tools, models, and analyses to provide data driven decision making capabilities

For Government: Provide in-use data for standard drive cycle development, R&D, tech targets, and rule making

For OEMs: Real-world usage datasets provide concrete examples of customer use profiles

For Fleets: Vocational datasets help illustrate how to maximize return on technology investments

For Funding Agencies: Reveal ways to optimize impact of financial incentive offers

For Researchers: Provides a data source for modeling and simulation

www.nrel.gov/fleetdna
Data and Information Exchange

Vehicle Technology Evaluation Projects

DOE Programs
- Energy Storage
- Power Electronics
- Hydrogen and Fuel Cells
- 21st Century Truck
- National Clean Fleet Partners
- EV Everywhere
- INTEGRATE

Industry Partners
- Extensive fleet and industry partners

Other Agencies
- US EPA
- National Park Service
- DOT - Volpe
- TARDEC
- SCAQMD
- CARB / CEC

Research Orgs
- ORNL, INL, LLNL, ANL
- Clemson, Ohio State,
- U of Michigan, Auburn,
- Georgia Tech...

International Collaborations?
Fleet DNA Data Highlights:

- 9.5 M miles of on-road 1Hz GPS and CAN data
- **5.3 M EV miles from Recovery Act medium-duty EV projects**
- 2.4 M miles from heavy-duty industry through IAG with EPA

### Fleet DNA – Current Data Status

<table>
<thead>
<tr>
<th>Category</th>
<th>Vehicles</th>
<th>Days</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Delivery</td>
<td>419</td>
<td>123,166</td>
<td>3,069,150</td>
</tr>
<tr>
<td>Line Haul</td>
<td>85</td>
<td>5,213</td>
<td>2,107,655</td>
</tr>
<tr>
<td>Food &amp; Beverage Delivery</td>
<td>227</td>
<td>66,732</td>
<td>1,779,335</td>
</tr>
<tr>
<td>Package Delivery</td>
<td>186</td>
<td>32,688</td>
<td>834,764</td>
</tr>
<tr>
<td>Regional Haul</td>
<td>29</td>
<td>1,243</td>
<td>452,471</td>
</tr>
<tr>
<td>Tanker</td>
<td>25</td>
<td>1,067</td>
<td>377,207</td>
</tr>
<tr>
<td>Other Class 8 Trucks</td>
<td>73</td>
<td>5,549</td>
<td>270,367</td>
</tr>
<tr>
<td>Mass Transit</td>
<td>50</td>
<td>2,386</td>
<td>234,955</td>
</tr>
<tr>
<td>Utility</td>
<td>120</td>
<td>7,970</td>
<td>122,364</td>
</tr>
<tr>
<td>Drayage</td>
<td>34</td>
<td>805</td>
<td>85,574</td>
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<tr>
<td>School Bus</td>
<td>247</td>
<td>1,466</td>
<td>85,454</td>
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<tr>
<td>Refuse Pickup</td>
<td>82</td>
<td>1,474</td>
<td>70,747</td>
</tr>
<tr>
<td>Vehicle Platform</td>
<td>Vocation</td>
<td>Project Type</td>
<td>Date Range</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------</td>
<td>-------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Navistar eStar</td>
<td>Class 3 Delivery Van</td>
<td>Data Collection</td>
<td>7/12 – 6/14</td>
</tr>
<tr>
<td>Smith Newton G1</td>
<td>Class 6 Delivery Truck</td>
<td>Data Collection</td>
<td>11/11 – 6/14</td>
</tr>
<tr>
<td>Smith Newton G2</td>
<td>Class 6 Delivery Truck</td>
<td>Data Collection &amp; Fleet Evaluation</td>
<td>1/13 – 6/15</td>
</tr>
<tr>
<td>Odyne PHEV Utility</td>
<td>Class 4+ Utility Trucks</td>
<td>Data Collection</td>
<td>12/14 – 6/15</td>
</tr>
<tr>
<td>Proterra FC Transit Bus</td>
<td>Class 7 Transit Bus</td>
<td>Fleet Evaluation (Ongoing)</td>
<td>7/14, 10/14, 1/15, 4/15</td>
</tr>
<tr>
<td>TransPower Electric Drayage</td>
<td>Class 8 Port Tractor</td>
<td>Data Collection (Ongoing)</td>
<td>10/14 – Present</td>
</tr>
</tbody>
</table>
**EV V2G School Bus**

**Lead:** Mike Lammert, NREL

**Partners:**

**Goals/Objectives**

- Demonstrate and document that the total cost of ownership of EV school buses with V2G capability
- Contribute EV bus optimization efforts through the duty cycle characterization of current conventional and hybrid vehicles in service.

**Background and Value**

- Leverages investment of CGI technical and project team with funding from CEC and SCAQMD and many cost share elements
- Collaboration between Fleet Test and Vehicle Grid Integration
- Contribute data to FleetDNA database & knowledge base on school bus duty cycles and electrification potential

**Cost Share:**

**EV V2G Partnership** $1.4M CEC / $2.2M SCAQMD

**School Districts** – access to EV and baseline buses, chargers, and facilities for instrumentation / data collection

**TransPower** – information/data on EV system; 1 Hz data on EV school buses

**EV Bus Configuration**

- 6 EV buses deployed in 3 CA school districts – Napa Valley, Torrance, Edison
- EV buses began service 2016-17 school year
- NREL collecting in-use data throughout the school year

<table>
<thead>
<tr>
<th><strong>Chassis</strong></th>
<th>International / Blue Bird DT466 retrofits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>System Integrator</strong></td>
<td>TransPower</td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td>150 kW peak / 110 kW continuous</td>
</tr>
<tr>
<td><strong>Battery</strong></td>
<td>115 kWh LiFePO4</td>
</tr>
<tr>
<td><strong>Bi-directional inverter</strong></td>
<td>EPC Power Epic 150 150kW inverter / 70kW charger</td>
</tr>
</tbody>
</table>
## Baseline School Bus Duty Cycle Data

**Daily Average Driving Speed vs. Kinetic Intensity for School Buses**

Small circles are daily averages from field data.

### Test Cycle Performance

<table>
<thead>
<tr>
<th>Test Cycle</th>
<th>OCTA Max Speed (mph)</th>
<th>RUCSBC Max Speed (mph)</th>
<th>HHDDT Max Speed (mph)</th>
<th>NREL Custom School Bus Max Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Speed (mph)</td>
<td>40.6</td>
<td>49.7</td>
<td>59.3</td>
<td>49.9</td>
</tr>
<tr>
<td>Average Speed (mph)</td>
<td>15.7</td>
<td>26.6</td>
<td>35.6</td>
<td>22.6</td>
</tr>
<tr>
<td>Stops per Mile</td>
<td>4.7</td>
<td>1.4</td>
<td>0.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Kinetic Intensity (1/mile)</td>
<td>3.6</td>
<td>1.7</td>
<td>0.2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

**Graphs**

- **High KI Low Speed Cycle**
- **Existing School Bus Cycle**
- **NREL Representative Cycle**
- **Low KI High Speed Cycle**
Initial Chassis Dynamometer Results

Preliminary EV Field Data
Avg. 0.74 miles/kWh

Energy Consumption (Miles/kWh)

Industry Average Diesel
0.19 miles/kWh

OCTA  RUCSBC  HHDDT  NREL Custom School Bus
Plan Forward...

• Report on IEEE testing of bi-directional inverter

• In-use vehicle performance data collection from all 6 EV buses 2016-17 school year – 1 Hz GPS and EV component data (motor, battery, inverter – voltages, currents, temperatures, etc)

• Collect data on facility and EVSE electrical power demands

• Develop validated FASTSim EV school bus model to investigate battery sizing requirements and route selection

• Evaluate total operational costs including electricity usage, demand charges, managed charging strategies, and grid services (V2G)

• Interim and final technical reporting (2017)
Zion National Park – Visitor Shuttle

• Zion National Park currently operates a fleet of 14 propane-power shuttle buses
• Data collection and analysis of drive-cycle characteristics of baseline shuttle buses duty cycle
• NPS is working with NREL to use this drive-cycle information to optimize the conversion of 14 of its propane buses to run on electricity.
• Leveraging existing tools and capabilities, NREL supplied the NPS with data and information to be used in their upcoming EV shuttle bus retrofit solicitation.
Zion National Park – Visitor Shuttle Route

16 mile round trip / 500 ft elevation gain / 10-15 trips per day
Passenger capacity : 105
Typical Daily Drive Cycle

<table>
<thead>
<tr>
<th>Bus #</th>
<th>Operation</th>
<th>Mean Dwell Time (Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days in Use</td>
<td>Trips</td>
</tr>
<tr>
<td>41</td>
<td>9</td>
<td>76</td>
</tr>
<tr>
<td>42</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>43</td>
<td>10</td>
<td>76</td>
</tr>
<tr>
<td>44</td>
<td>11</td>
<td>87</td>
</tr>
<tr>
<td>45</td>
<td>7</td>
<td>63</td>
</tr>
<tr>
<td>46</td>
<td>9</td>
<td>74</td>
</tr>
<tr>
<td>47</td>
<td>9</td>
<td>74</td>
</tr>
<tr>
<td>48</td>
<td>11</td>
<td>95</td>
</tr>
<tr>
<td>49</td>
<td>10</td>
<td>76</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>696</td>
</tr>
</tbody>
</table>
Zion National Park – FAST Sim Model

Baseline Powertrain Simulation: Total Work 34.1kWh

EV Powertrain Simulation: Net Work 28.7 (include energy recapture)
Battery Size Requirements

Baseline Vehicle
- Empty: 37,220 lbs
- GVWR: 53,000 lbs
  - Capacity: 15,780 lbs
  - Passenger Capacity (150#): 105

Electric Shuttle – battery sized for overnight charging – 400 kWh
- Empty: 37,220 lbs
- GVWR: 53,000 lbs
  - 400 kWh ESS: 5,870 lbs
  - Capacity: 9,910 lbs
  - Reduced Passenger Capacity: 66

Electric Shuttle – battery sized for single round trip with on-route fast charging – 40 kWh
- Empty: 37,220 lbs
- GVWR: 53,000 lbs
  - 40 kWh ESS: 587 lbs
  - Capacity: 15193 lbs
  - Reduced Passenger Capacity: 101
NPS currently reviewing EV shuttle bus retrofit proposals

Fact sheet and website describing data collection and analysis
http://www.nrel.gov/transportation/fleettest_electric_zion.html

Upcoming Publication:
“Analysis of In-Route Wireless Charging for the Shuttle System at Zion National Park” - IEEE Workshop on Emerging Technologies: Wireless Power

Application of methodology with other Parks and agencies
- Yosemite National Park
2016-17 EV / PHEV Evaluation and Development Projects

UPS / Workhorse Extended Range Hybrid

Long Beach Transit / BYD EV Transit Bus with WAVE wireless charging and managed depot charging

Duke Energy / Odyne PHEV utility truck with export power

Cummins – Class 6 Medium-duty Extended Range Hybrid for Urban Delivery

Bosch – Class 4 Medium-duty Extended Range Hybrid Parcel Delivery
NREL Medium and Heavy-Duty Fleet Testing and Technology Evaluations

Supported by:
U.S. Department of Energy
Vehicle Technologies Office
Vehicle Systems Program
– Lee Slezak and David Anderson

For more information:
Kenneth Kelly
National Renewable Energy Laboratory
kenneth.kelly@nrel.gov
phone: 303.275.4465

NREL Fleet Evaluations Website
http://www.nrel.gov/transportation/fleettest.html

Fleet DNA Website
www.nrel.gov/fleetdna

DriveCAT
www.nrel.gov/transportation/drive-cycle-tool

www.nrel.gov
Drive-cycle Rapid Investigation, Visualization and Evaluation (DRIVE) Tool

• Created to help fleets and OEMs analyze vehicle usage data for proper vehicle placement, design and testing
• Combines large amounts of user data then filters, creates new cycles & identifies best fitting existing cycle
• Quickly processes and analyzes data:
  • Over 250 metrics
  • Histograms
  • Scatter plots
  • Creates custom cycle
  • Recommends standard cycles
Drive Cycle Data Library – NREL DriveCAT

- Provide a common, publically available, easy to use site for standard and custom drive cycles for medium- and heavy-duty vehicles
- Capture, quantify and compare drive cycle variation across the spectrum of medium- and heavy-duty vocations
- Allows users to download raw time series data of drive cycles for their own use

www.nrel.gov/transportation/drive-cycle-tool
### EV Vehicle and Component Data – 1Hz

#### Vehicle Data Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle ID</td>
</tr>
<tr>
<td>Vehicle weight or mass</td>
</tr>
<tr>
<td>Payload</td>
</tr>
<tr>
<td>Door Status</td>
</tr>
<tr>
<td>Timestamp</td>
</tr>
<tr>
<td>Operation state</td>
</tr>
<tr>
<td>Shifter position</td>
</tr>
<tr>
<td>Transmission gear state (if applicable)</td>
</tr>
<tr>
<td>Accelerator position</td>
</tr>
<tr>
<td>Brake pedal on state or applied pressure</td>
</tr>
<tr>
<td>Vehicle speed</td>
</tr>
<tr>
<td>Distance driven</td>
</tr>
<tr>
<td>GPS latitude</td>
</tr>
<tr>
<td>GPS longitude</td>
</tr>
<tr>
<td>GPS elevation</td>
</tr>
<tr>
<td>Ambient temperature</td>
</tr>
<tr>
<td>Air conditioner state</td>
</tr>
<tr>
<td>Air conditioner compressor power</td>
</tr>
<tr>
<td>Heater state</td>
</tr>
<tr>
<td>Air compressor status / pressure</td>
</tr>
</tbody>
</table>

#### Component Data Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery current</td>
</tr>
<tr>
<td>Battery voltage</td>
</tr>
<tr>
<td>Battery pack SOC</td>
</tr>
<tr>
<td>Battery pack min cell voltage</td>
</tr>
<tr>
<td>Battery pack max cell voltage</td>
</tr>
<tr>
<td>Battery pack balance mode state</td>
</tr>
<tr>
<td>AC charging current</td>
</tr>
<tr>
<td>AC charging voltage</td>
</tr>
<tr>
<td>Battery pack bulk temperature</td>
</tr>
<tr>
<td>Battery pack min cell temperature</td>
</tr>
<tr>
<td>Battery pack max cell temperature</td>
</tr>
<tr>
<td>Battery pack max cell temperature</td>
</tr>
<tr>
<td>Motor temperature</td>
</tr>
<tr>
<td>Power electronics/charger temperature</td>
</tr>
<tr>
<td>DC/DC voltage</td>
</tr>
<tr>
<td>DC/DC current</td>
</tr>
<tr>
<td>Motor speed</td>
</tr>
<tr>
<td>Motor torque</td>
</tr>
<tr>
<td>Motor power (electrical)</td>
</tr>
</tbody>
</table>
Baseline Data Channels – 1Hz 75+ Channels

<table>
<thead>
<tr>
<th>Date</th>
<th>EngSpeed</th>
<th>EngSpeedAtIdlePoint1</th>
<th>EngOilPress</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>Aftertreatment1IntakeNOx</td>
<td>EngPercentTorqueAtIdlePoint1</td>
<td>ParkingBrakeSwitch</td>
</tr>
<tr>
<td>BoxT</td>
<td>Aftertreatment1IntakeO2</td>
<td>EngSpeedAtPoint2</td>
<td>WheelBasedVehicleSpeed</td>
</tr>
<tr>
<td>BoxV</td>
<td>Aftertreatment1OutletNOx</td>
<td>EngPercentTorqueAtPoint2</td>
<td>BrakeSwitch</td>
</tr>
<tr>
<td>Acc_Lat</td>
<td>Aftertreatment1OutletO2</td>
<td>EngSpeedAtPoint3</td>
<td>PTOState</td>
</tr>
<tr>
<td>Acc_Long</td>
<td>DslPrtcltFilter1SootLoadPercent</td>
<td>EngPercentTorqueAtPoint3</td>
<td>EngFuelRate</td>
</tr>
<tr>
<td>Acc_Vert</td>
<td>DslPrtcltFltr1TmSncLstActvRgnrtn</td>
<td>EngSpeedAtPoint4</td>
<td>BarometricPress</td>
</tr>
<tr>
<td>gps_Time</td>
<td>DslPrtcltFltrActvRgnrtnFrcdStts</td>
<td>EngPercentTorqueAtPoint4</td>
<td>AmbientAirTemp</td>
</tr>
<tr>
<td>gps_Lat</td>
<td>Afrtrtmnt1DslPrtcltFltrInt_0001</td>
<td>EngSpeedAtPoint5</td>
<td>EngAirInletTemp</td>
</tr>
<tr>
<td>gps_Long</td>
<td>Afrtrtmnt1DslPrtcltFltrDffPrss</td>
<td>EngPercentTorqueAtPoint5</td>
<td>EngTurboBoostPress</td>
</tr>
<tr>
<td>gps_Quality</td>
<td>Afrtrtmnt1PrtclTrpOtltGasTemp</td>
<td>EngSpeedAtHighIdlePoint6</td>
<td>EngIntakeManifold1Temp</td>
</tr>
<tr>
<td>gps_NbSatellite</td>
<td>Aftertreatment1ExhaustGasTemp1</td>
<td>EngGainOfEndspeedGovernor</td>
<td>EngAirInletPress</td>
</tr>
<tr>
<td>gps_Altitude</td>
<td>Afrtrtmnt1DslPrtcltFltrInt_0000</td>
<td>EngReferenceTorque</td>
<td>EngExhaustGasTemp</td>
</tr>
<tr>
<td>gps_Speed</td>
<td>EngExhaustGasTempRightManifold</td>
<td>EngTripFuel</td>
<td>BatteryPotential</td>
</tr>
<tr>
<td>AccelPedalPos1</td>
<td>EngExhaustGasTempLeftManifold</td>
<td>EngTotalFuelUsed</td>
<td>EngFuelRate_1</td>
</tr>
<tr>
<td>EngPercentLoadAtCurrentSpeed</td>
<td>Afrtrtmnt1SCRCCatalystTankLevel</td>
<td>EngCoolantTemp</td>
<td>EngineSpeed</td>
</tr>
<tr>
<td>ActMaxAvailEngPercentTorque</td>
<td>EngExhaustGasRecirculation1Temp</td>
<td>EngFuelTemp</td>
<td>TotalVehicleDistance</td>
</tr>
<tr>
<td>EngTorqueMode</td>
<td>NominalFrictionPercentTorque</td>
<td>EngOilTemp1</td>
<td>*Aftertreatment channels not available on all vehicles due to proprietary messaging</td>
</tr>
<tr>
<td>DriversDemandEngPercentTorque</td>
<td>EstEngPrsticLossesPercentTorque</td>
<td>EngIntercoolerTemp</td>
<td></td>
</tr>
<tr>
<td>ActualEngPercentTorque</td>
<td>ExhaustGasMass</td>
<td>EngFuelDeliveryPress</td>
<td></td>
</tr>
</tbody>
</table>
Medium and Heavy-Duty EV Data and Publications

- NREL Field Test and Evaluations team has extensive EV and PHEV data and publications that has been posted on the Electric and Plug-In Hybrid Electric Fleet Vehicle Testing web site.
  
  [Webpage](http://www.nrel.gov/transportation/fleettest_electric.html)
  - California school district electric school buses
  - Foothill Transit electric buses
  - Frito-Lay electric delivery trucks
  - Odyne plug-in hybrid electric utility trucks
  - PG&E plug-in hybrid electric utility trucks
  - SCAQMD electric drayage trucks
  - Smith and Navistar electric and plug-in hybrid electric vehicles
  - Zion National Park propane-to-electric shuttle buses

- EV Data Summaries
  - Navistar eStar EV Cumulative EV data report - [http://www.nrel.gov/docs/fy14osti/61899.pdf](http://www.nrel.gov/docs/fy14osti/61899.pdf)
NREL Drive Cycle Analysis - Clustering

**Characteristic Acceleration vs Aerodynamic Speed**
- Cluster 1
- Cluster 2
- Cluster 3
- Cluster 4

**Cluster 1: Creep/Queue Drive Cycle**

**Cluster 2: Port/Near Dock Drive Cycle**

**Cluster 3: Local Drive Cycle**

**Cluster 4: Metro Highway Drive Cycle**
Fuel Cell Range Extender – Zero emission vehicle concept for logistic applications

Markus Passath
Senior Technical Engineer Alternative Mobility
MAGNA STEYR
### MAGNA Steyr Locations
#### Worldwide Presence / Worldwide Network

- **~10,225 People**
- **33 Countries**
- **9** Manufacturing / Assembly
- **24** Engineering / Product Development / Sales
- **2** Engineering Services
- **8** Engineering Services
- **2** Fuel Systems
- **1** Fuel Systems
- **2** Sales
- **8** Sales

**Headquarters:** Graz

**Europe**
- **Engineering Services**
  - Graz, Böblingen, Cologne, Ingolstadt, Mühlhausen, Munich, Rüsselsheim, Sailauf, Sindelfingen, Wolfsburg, Etupes, Paris, Turin, Gothenburg
- **Vehicle Contract Manufacturing**
  - Graz, Hambach
- **Fuel Systems**
  - Graz, Sinabelkirchen, Weiz, Grevenbroich, Neumarkt, Schwäbisch Gmünd
- **Sales**
  - Graz, Cologne, Munich, Rüsselsheim, Sindelfingen, Wolfsburg, Paris, Turin, Warwick

**North America**
- **Sales**
  - Auburn Hills

**Asia**
- **Engineering Services**
  - Changchun, Shanghai, Shenyang, Wuhan, New Delhi, Pune, Shin-Yokohama
- **Fuel Systems**
  - Changchun, Shanghai
- **Sales**
  - Shanghai, Pune, Shin-Yokohama, Seoul

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10/27/2016

M.Passath / MAGNA Steyr

August 2016
MAGNA Steyr
Product Portfolio

Engineering
From systems and modules to complete vehicle engineering

Contract Manufacturing
World Class flexible solutions from niche to volume production

Fuel Systems
Energy storage systems made of steel, plastic and aluminum

Flexible and global solutions customized for the OEM
Magna’s Innovation Pillars

**SMARTER**
Comfort, Convenience and Connectivity

**CLEANER**
Efficiency and Sustainability

**SAFER**
Active and Passive Safety

**LIGHTER**
Lightweight Material and Science

**AFFORDABLE**
Development and Manufacturing Efficiency

for future HMI demand, interior concepts will be completely changed

lots of different legislation targets lead to different approaches

Advanced Driver Assistance Systems (ADAS) enable semi autonomous driving

improve driving performance, CO₂ & fuel economy, Total Cost of Ownership (TCO)
xEV TECHNOLOGY COMPARISON

Pros and cons on each technology leads to purpose oriented solutions
25-30 kW Fuel Cell Power will be sufficient for Charge sustaining mode
HOW MUCH SPACE IS NEEDED?

Volumetric Comparison of Energy Sources

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Volumetric Energy Density kWh / l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>8.80</td>
</tr>
<tr>
<td>CNG (20 MPa)</td>
<td>2.41</td>
</tr>
<tr>
<td>CH2 (70 MPa)</td>
<td>1.32</td>
</tr>
<tr>
<td>Li-Ion Batterie</td>
<td>0.225</td>
</tr>
</tbody>
</table>

β Basic Energy Source
β Energy Storage System
Energy Storage Systems

How much range is possible?

Driving distance including powertrain efficiency

Powertrain:
- Gasoline: ICE
- CNG: ICE
- CH₂: Fuel Cell EV
- Li-Ion Battery: BEV

Comparison factor to Gasoline – ICE vehicle

Big challenge in the target conflicts between Range-Space-Weight
FUEL CELL RANGE EXTENDED ELECTRIC VEHICLE

VEHICLE TARGETS:
• Zero emission
• Long driving range
• Fast refueling time
• AWD powertrain

SPECIFIED SYSTEMS ‡
Wireless Charging

Conductive Charging

Fuel Cell System
25kW net.

Electric Rear Axle
50kW peak / 200Nm

Electric Front Axle
75kW peak / 280Nm

HV Li-Ion Battery
12.8kWh usable
(~16kWh installed)

Hydrogen Storage System
3kg H₂ @ 70MPa

HV Wiring

FC-auxiliaries
(Pumps, Compressor,..)
HV ARCHITECTURE

**HV BATTERY**
- 400 V
- 16 kWh installed

**Electric Front Axle**
- EM1 400 V
- DC/AC1 (75 kW)

**Electric Rear Axle**
- EM2 400 V
- DC/AC2 (50 kW)

**Fuel Cell System**
- FCCU
- DC/DC2 100V/400V (30 kW)
- Fuel Cell 70 – 100 V (30 kW)

**HV PTC**
- A/C Comp.

**Wireless Charging** (6 kW)

**AC Charger** (6 kW)

**AC Charging Plug**
LOW-TEMPERATURE COOLANT CIRCUIT

- HV Battery
- DC/DC2<sub>FC</sub>
- Heat Exchanger
- Intercooling (Air/Air)
- Air Compressor

HIGH-TEMPERATURE COOLANT CIRCUIT

- Fuel Cell Stack
- DC/AC2
- EM2
- DC/AC1
- EM1
- DC/DC1
- HV-PTC
- Cabin Heat Exchanger

---

2 CIRCUIT COOLANT-SYSTEM FULFILLS FULL RANGE OF COMPONENT DEMANDS

- COMBINED ELECTRIC FUEL CELL AND CABIN HEATING
- FUEL CELL WASTE HEAT USAGE FOR CABIN HEATING

10/27/2016
M. Passath / MAGNA Steyr
WHEN TO USE BATTERY AND FUEL CELL?

Smart operating strategy combines efficiency and drivability.

Energy Management

VEHICLE SPEED / DRIVER DEMAND

USABLE BATTERY SOC

FUEL CELL OFF

INTELLIGENT FUEL CELL ACTIVATION AND BATTERY CHARGING

FUELL CELL ON

WHEN TO USE BATTERY AND FUEL CELL?

Smart operating strategy combines efficiency and drivability.
ENERGY MANAGEMENT

TORQUE DISTRIBUTION: e4x2 vs e4x4

Energy demand depending constant all-wheel distribution at NEDC and WLTP

Schemes of an energy-optimized all-wheel

Torque Distribution between front and rear axle

Efficiency based torque distribution schemes

EFFICIENCY BASED TORQUE DISTRIBUTION
VEHICLE OPERATION

STUTTGART - VIENNA
DISTANCE: ~700 km

START

DESTINATION

Gasoline
No refueling 7 h
EV 30 kWh
EV 65 kWh
FC REX
FC REX

50 kW 50 kW 50 kW 50 kW 50 kW
50 kW 50 kW

7 ¼ h <9 h

50 kW 50 kW 50 kW 50 kW
50 kW

9 ½ h 10 ½ h

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M. Passath / MAGNA Steyr
R&D-ID: MSE-016
SUMMARY

VEHICLE TARGETS:

• Zero emission
• Long driving range
• Fast refueling time
• All wheel drive

FIELDS OF APPLICATIONS...

Source: www.dpd.com/de/home/ueber_dpdp/resse_center/
Source: http://www.ukh2mobility.co.uk/news-media/

PKW / MPV > C-segment
READY FOR A RIDE / VISIT…

PROJECT PARTNERS:

PROJECT LEAD: MAGNA STEYR
CONTACT: Helfried Müller, Head of Alternative Propulsion Systems – R&D