H2 as Opportunity for ZEHDVs

«2021 TTG ANNUAL MEETING»

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ENEA Energy Technologies and Renewable Sources Department
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A sustainable and fair path

2030 European Green Deal - 55% GHG emissions
2050 net zero GHG emissions

1997 Kyoto
2012 2020 Climate & Energy package
2015 Paris
2020 European Green Deal
2021 Fit for 55
2030
2050

Energy Transition

- Socially fair
- Economical sustainable
- Energetically reacheable
- Enviromentally friendly

The Just Transition Fund (JTF) to alleviate the socio-economic costs for communities across the EU that are heavily dependent on fossil fuels or greenhouse gas-intensive industries.

“We must show solidarity with the most affected regions in Europe, such as coal mining regions and others, to make sure the Green Deal gets everyone’s full support and has a chance to become a reality.”

Frans Timmermans, Executive Vice-President of the European Commission

H2 as Opportunity for ZEHDVs
The role of transportation: from national commitments to the territory

GHG emissions by transportation

- GHG Transportation: 29%
- GHG Road: 20.8%
- GHG Trucks & buses: 5.4%

Trucks & buses share on overall GHG emissions

Source: EEA

<table>
<thead>
<tr>
<th>Mode of Transport</th>
<th>GHG Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aviation</td>
<td>0.5%</td>
</tr>
<tr>
<td>Road transport</td>
<td>13.4%</td>
</tr>
<tr>
<td>Maritime</td>
<td>14.0%</td>
</tr>
<tr>
<td>Railways</td>
<td>71.7%</td>
</tr>
<tr>
<td>Other Road Transportation</td>
<td>0.0%</td>
</tr>
<tr>
<td>Other Transportation</td>
<td>6.5%</td>
</tr>
<tr>
<td>Cars</td>
<td>45.2%</td>
</tr>
<tr>
<td>Light duty trucks</td>
<td>8.5%</td>
</tr>
<tr>
<td>Heavy duty trucks and buses</td>
<td>18.7%</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>0%</td>
</tr>
</tbody>
</table>

EU28

Smog and Noise

Air pollution

H2 as Opportunity for ZEHDVs
ZeroEmission HDVs: transition or transformation?

2050 net zero GHG emissions

Transition

The process of changing from one system to another

Transformation

The process of changing completely the character or appearance of something in order to improve it

HDVs for 2050

Affordable
Sustainable
Safety
Resilient

EU Transportation Target

2050 - 90% GHG emissions

Climate
Technological
Operational

(HNeutrality)^3 =

Fossil fuels
Renewable energies

H2 as Opportunity for ZEHDVs
One recipe ... more ingredients

Green Energy

- Renewable sources
- Renewable hydrogen
- Bio-methane
- Bio-fuels e-fuels

Storage

- Batteries, chemical
- Gaseous, liquid, (solid)
- Liquid

Infrastructures

- Charging stations
- Electric network
- Refuelling stations
- Distribution network (pipe, trucks, ships,..)

H2 as Opportunity for ZEHDVs
The range for a battery HDV depends on battery size and weight of the vehicle.

The battery range for a typical battery freight vehicle is around 100–200 km on a single charge.

Some manufacturers claimed a range up 800 km.

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800 km ---> 1.25 kWh/km ---> 1 MWh battery capacity

### Battery weight & volume

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>Expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>5.7 ton (2020)</td>
<td>2.7 ton (2030)</td>
</tr>
<tr>
<td>Volume</td>
<td>3.3 m³ (2020)</td>
<td>1.3 m³ (2030)</td>
</tr>
</tbody>
</table>
Electric Battery HDV: the charging impact

3.5 MWh
Average annual electricity consumption of a household in EU

3 kW
Max load Power

1 truck charge = 1/3 annual household consumption

1 MW Ultra fast truck charge = 330 households

The question arises whether or not the renewable electric generation capacity and grid could cope with the new demand

The recharging time for a battery HDV depends on the type of charger, the battery capacity of each truck and battery technology

<table>
<thead>
<tr>
<th>Battery Capacity</th>
<th>Ultra Fast Charger</th>
<th>Fast Charger</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 MWh</td>
<td>350 kW</td>
<td>80 kW</td>
</tr>
<tr>
<td></td>
<td>4 hours</td>
<td>18 hours</td>
</tr>
</tbody>
</table>

10 HDVs
Grid power
3.5 MW
800 kW

H2 as Opportunity for ZEHDVs
Electric Road Systems to increase the electric range

Diesel powered (also fueled with bio-fuel) in cooperation with electric motor

Hybrid configuration consent to operate as a conventional truck but with reduced emissions.

Full electric with limited range

Zero emission range is limited by battery size.

Full electric with line connection

Electric energy from overhead line consent to operate battery charging and electric traction increasing full electric range.
Electric Road Systems (ERS): an Italian Case Study

The pilot project is based on the electrification of about 6 km stretch for each direction on Brescia-Bergamo-Milano motorway (A35) between Calcio and Romano di Lombardia exits. It is based on a German-Sweden technology.

Power supply by an overhead line contact (750 V DC)

On electrified road sections the truck is connected to the electrical overhead line - via pantograph - receiving the energy needed to run without polluting emissions and to recharge the battery thus to increase the zero emission range.

On roads without infrastructure or when overtaking, the vehicles continue, using their own hybrid drive engine.

For a small distance (i.e. city roads) the truck can run full electric, using electric drive engine only.

Hybrid HDV solution (SCANIA)
Battery vs. Hydrogen?

Energy Production
Transport
Storage
Distribution
Use

Refuelling
Recharging
Life span
Cost

Range

System application

Competition

Complementarity

H2 as Opportunity for ZEHDVs
H2: Production and final use in transportation

**H2 as fuel in transportation**
- Long haul
- No electrified railway
- On road public transportation
- Inland navigation and ferries

**Green**
Electrolysis of water using electricity from renewable energy

**Pink**
Electrolysis of water using electricity from nuclear energy

**Blue**
Steam reforming of methane with CCUS

**Turquoise**
Thermal splitting of CH4 with solid carbon as by-product

**Yellow**
Electrolysms using energy mix

**Grey**
Steam reforming by natural gas

**Brown**
From coal with no CO2 capture
H2 for HDV: first commercial vehicles
Hydrogen for road freight transport in Italy

Tab. V.4.2. - Trasporto merci su strada interno, internazionale e complessivo per titolo di trasporto(a) - Anno 2018

<table>
<thead>
<tr>
<th>Titolo di trasporto</th>
<th>Conto proprio</th>
<th>Conto terzi</th>
<th>Complessivo</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tonellate (migliaia)</td>
<td>Tonellate-km (milioni)</td>
<td>Tonellate (migliaia)</td>
</tr>
<tr>
<td>Trasporti interni</td>
<td>153.191</td>
<td>7.209</td>
<td>743.244</td>
</tr>
<tr>
<td>Trasporti internazionali</td>
<td>1.753</td>
<td>304</td>
<td>22.543</td>
</tr>
<tr>
<td>Trasporti complessivi</td>
<td>154.945</td>
<td>7.513</td>
<td>765.787</td>
</tr>
</tbody>
</table>

Annual H2 consumption x FCHDV: 8.400 – 13.200 kg

H2 specific consumption: 70-110 g/km

Renewable energy for H2 production:
- Solar: 23.19 TWh
- Wind: 20.03 TWh

Electric energy generation:
- 2019
- 2% freight fleet
- 20% freight fleet

Solar: 23.500 – 36.950 ton/year
Wind: 235.000 – 369,500 ton/year

2019 Electric energy generation

H2 as Opportunity for ZEHDVs

140,000 HDVs
16,800,000,000 vehicles*km

HDVs > 14 tons Km/year → 120,000

H2 specific consumption → 70-110 g/km

Annual H2 consumption x FCHDV: 8.400 – 13.200 kg

1.17 – 1.84 TWh
11.76 – 18.5 TWh

1.17 – 1.84 TWh
11.76 – 18.5 TWh
H2Ports: European Project on HDV

First application of hydrogen technologies in port handling equipment in Europe

Reach Stacker in MSC Terminal
- FC: 90-120 kW
- 2 years / 5000 h of operation

Mobile HRS
- Hydrogen supply logistics at ports
- Port regulatory framework
- Safety procedures

Port of Valencia

Yard Tractor in Valencia Terminal Europa
- FC: 85 kW
- 2 years / 5000 h of operation

H2 as Opportunity for ZEHDVs
H2Ports: European Project on HDV

Coordination:
FUNDACIÓN VALENCIAPORT

Public authorities
valenciaport
Autoridad Portuaria de Valencia

Research institutions
H Centro Nacional del Hidrógeno
ATENA

End users
MSC TERMINAL VALENCIA
GRIMALDI GROUP

Industry
HYSTER-YALE
BALLARD
enagás

H2 as Opportunity for ZEHDVs
H2Ports: European Project on HDV

4x4 FC Yard Truck @ Grimaldi Terminal

FCHJU funding € 1,100,000 approx.

ATENA, Grimaldi Group, Ballard, National Hydrogen Centre, Fundacion Valenciaport

Development and deployment a 4x4 Yard Tractor equipped with a Fuel Cells and test it in Valencia Terminal Europa (Grimaldi Group). It involves three tasks:

- Design of the new FCEV YT
- Assembling of new components in the YT
- Testing and Piloting of the FCEV YT in Valencia, Spain

www.h2ports.eu
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