2050 DECARBONISATION VISION

27 NOVEMBER, 2018
BRUSSELS

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LARGEST CLIMATE PROBLEM...

- Industry: 22.7%
- Agriculture: 9.6%
- Transport & Bunkers: 27%
- Public Electricity & Heat: 22.7%
- Buildings: 14.7%
- Waste: 3.1%
- Transport: 20.7%
- Bunkers: 6.6%
...AND GETTING WORSE
NEED OF LONG-TERM STRATEGY
STUDIES PUBLISHED

Roadmap to climate-friendly land freight and buses in Europe
June 2017

Roadmap to decarbonising European aviation
October 2018
STUDIES PUBLISHED

Roadmap to decarbonising European shipping
October 2018

Roadmap to decarbonising European cars
November 2018
How to decarbonise European transport by 2050
November 2018
GENERAL CONSIDERATIONS

• Natural gas is a fossil fuel
• Biomethane in sectors using fossil gas today

• Sustainable advanced biofuels, limited availability
• To be used in sectors without alternative (aviation)
## Demand Management + Modal Shift

<table>
<thead>
<tr>
<th>Sales of Zero Emission Vehicles</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycles &amp; mopeds</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>15%</td>
<td>40%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Vans</td>
<td>20%</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Urban buses</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Coaches</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>HGVs (&lt;16t)³</td>
<td>10%</td>
<td>30%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>HGVs (&gt;16t)⁴</td>
<td>5%</td>
<td>30%</td>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>Rail (passenger and freight)⁵</td>
<td>70%</td>
<td>80%</td>
<td>90%</td>
<td>100%</td>
</tr>
</tbody>
</table>
EVEN NOT ENOUGH
AVIATION

How electrofuels can reduce CO2 emissions of European departing flights

- BaU (1% p.a. fleet fuel efficiency gain)
- 0.2% p.a. improvement conventional fleet
- Gen II aircraft from 2040
- €150/tCO2 carbon price
- Advanced biofuels uptake (7500 ktoe)
- Electrofuels

Electrofuel consumption by European departing flights

- Remaining energy demand, covered by PtL
- Reduction from electrofuel uptake
- Reduction from advanced biofuels uptake (7500 ktoe)
- Reduction from Gen II aircraft from 2040
- Reduction from 0.2% p.a. improvement conventional fleet
SHIPPING

Additional power demand compared to 2015 EU electricity production

- Extra EU outbound
- Intra EU
- Domestic

Additional electricity demand for maritime (2050)

- H2 fuel cell
- H2 ICE
- Ammonia fuel cell
- Ammonia ICE
- Battery-electric
- Technology mix
- e-methane ICE
- e-diesel ICE

Renewable electricity production 2015

1,032 TWh
1,109 TWh
1,110 TWh
1,192 TWh
798 TWh
350 TWh
1,354 TWh
1,718 TWh
966 TWh
## EFFICIENCY FIRST

<table>
<thead>
<tr>
<th></th>
<th>Direct charging (battery electric vehicle)</th>
<th>Hydrogen (fuel cell vehicle)</th>
<th>Power to liquid (conventional vehicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel production efficiency</td>
<td>95%</td>
<td>61%</td>
<td>44%</td>
</tr>
</tbody>
</table>

### Tank to wheel

- **Charging equipment (EVSE)**: 5% energy losses
- **Battery charge efficiency**: 5% energy losses
- **H2 to electricity conversion**: 46% energy losses
- **Inversion DC/AC**: 5% energy losses
- **Engine efficiency**: 5% energy losses

### Well to tank

- **Electrolysis**: 5% energy losses
- **CO₂ air-capture FT-synthesis**: 22% energy losses
- **Transport, storage and distribution**: 22% energy losses
- **44% energy losses**

### Overall efficiency

- **77%**
- **30%**
- **13%**

Source: WTT (LBST, IEA, World bank), TTW (IEA, DOE, Transport & Environment calculations)

Note: values displayed here are on the higher side (optimistic) of the ranges found in the bibliography.
## ADDITIONAL CLEAN ELECTRICITY NEEDED

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Electricity Generation for electric vehicles (TWh)</th>
<th>Hydrogen/Ammonia&lt;sup&gt;5&lt;/sup&gt; (TWh)</th>
<th>Electrofuels</th>
<th>Synthetic fuels (diesel, petrol, gas and kerosene) (TWh)</th>
<th>Optimal pathway (TWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorbikes</td>
<td>34 (1.1%)</td>
<td>90 (2.8%)</td>
<td>203 (6.3%)</td>
<td>34 (1.1%)</td>
<td></td>
</tr>
<tr>
<td>Cars</td>
<td>475 (14.7%)</td>
<td>1236 (38.3%)</td>
<td>2187 (67.6%)</td>
<td>475 (14.7%)</td>
<td></td>
</tr>
<tr>
<td>Vans</td>
<td>146 (4.5%)</td>
<td>381 (11.8%)</td>
<td>672 (20.8%)</td>
<td>146 (4.5%)</td>
<td></td>
</tr>
<tr>
<td>Buses</td>
<td>119 (3.7%)</td>
<td>310 (9.6%)</td>
<td>547 (16.9%)</td>
<td>119 (3.7%)</td>
<td></td>
</tr>
<tr>
<td>Trucks (&lt;16t)</td>
<td>112 (3.5%)</td>
<td>292 (9.0%)</td>
<td>515 (15.9%)</td>
<td>112 (3.5%)</td>
<td></td>
</tr>
<tr>
<td>Trucks (&gt;16t)</td>
<td>364 (11.2%)</td>
<td>949 (29.4%)</td>
<td>1676 (51.8%)</td>
<td>364 (11.2%)</td>
<td></td>
</tr>
<tr>
<td>Trains</td>
<td>145 (4.5%)</td>
<td>219 (6.8%)&lt;sup&gt;§&lt;/sup&gt;</td>
<td>NA</td>
<td>145 (4.5%)</td>
<td></td>
</tr>
<tr>
<td><strong>Total land transport:</strong></td>
<td><strong>1395 (43.1%)</strong></td>
<td><strong>3479 (107.6%)</strong></td>
<td><strong>5799 (179.3%)</strong></td>
<td><strong>1395 (43.1%)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Shipping</strong></td>
<td><strong>350 (11%)</strong></td>
<td><strong>1032-1192 (32-37%)</strong></td>
<td><strong>1718 (53%)</strong></td>
<td><strong>798 (25%)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Aviation</strong></td>
<td>N/A</td>
<td>N/A</td>
<td><strong>912 (28.2%)</strong></td>
<td><strong>912 (28.2%)</strong></td>
<td></td>
</tr>
</tbody>
</table>
## Carbon Budget?

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>Share of EU emissions in 2016</th>
<th>Carbon Budget from 2018 (Mt CO₂ eq.; 66% probability)</th>
<th>Cumulative emissions 2018 to 2050 (Gt CO₂ eq)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1.5°C</td>
<td>2°C</td>
</tr>
<tr>
<td>Motorbikes</td>
<td>0.23%</td>
<td>89</td>
<td>227</td>
</tr>
<tr>
<td>Cars</td>
<td>11.90%</td>
<td>4564</td>
<td>11628</td>
</tr>
<tr>
<td>Vans</td>
<td>2.32%</td>
<td>891</td>
<td>2269</td>
</tr>
<tr>
<td>Trucks &amp; buses</td>
<td>5.16%</td>
<td>1979</td>
<td>5041</td>
</tr>
<tr>
<td>Trains</td>
<td>0.14%</td>
<td>55</td>
<td>139</td>
</tr>
<tr>
<td>Aviation</td>
<td>3.64%</td>
<td>1395</td>
<td>3553</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23.39%</strong></td>
<td><strong>8972</strong></td>
<td><strong>22857</strong></td>
</tr>
</tbody>
</table>
HOW TO GET THERE?
BUT FIRST...