Enabling true green transport

Commercial vehicles de emissie-loze(!?) verbrandingsmotor
Biofuels and bioenergy

Bioenergy is seen as an important contributor to meeting the targets set by the Renewable Energy Directive (20% share of renewable energy over total EU consumption by 2020), and therefore complementary to other low carbon energy alternatives. The European Commission has also proposed that 10% of the transport sector’s final energy consumption in 2020 should come from renewable energy sources. Biofuels are expected to play an important role to achieve this target.

Commercial vehicles: the Dilemma

Direct Use of Electricity not foreseen for all modes

![Table showing coverage of transport modes and travel range by the main alternative fuels](image)

Figure 2.2 Coverage of transport modes and travel range by the main alternative fuels [Clean Power for Transport: A European alternative fuels strategy, 2013]
According to Hans-Dieter Schilling (Energie-Fakten), the average efficiency of all coal power stations in the world currently stand at around 31%, leaving a vast potential to reduce coal consumption and CO2 emissions.

Commercial vehicles an ‘inconvenient truth’

Electric transport is not green perse

![China's installed electricity capacity by fuel, 2011](image)

**Figure 4.43** Well-to-Wheel assessment of different production pathways and powertrain systems [Ricardo-AEA analysis]
Energy density of liquid fuels

Energy Density of batteries

Comparison of Energy Densities for Various Battery Chemistries

- Smaller
- Wh/kg
- Wh/l

- CNG
- Liquid fuels

Road towards green transport
Energy density of liquid fuels is needed. A road towards green transport.

Equivalent battery stack: 15-25 m³

45-60 tonnes
The road to green transport

Ultra-Clean and Ultra-Efficient Engines prepared for Low-Carbon Liquid Fuels

Local, (NOx/Soot)
- Clean Concepts
- Aftertreatment

Global (CO₂/CH₄)
- Efficient
- Low-Carbon Fuels
The road to green transport

Clean Engines (game changer)
The road to green transport

Clean Engines (game changer)

Dear Bert,

We were interested to hear about the initiative to start a research project on advanced combustion concepts leading towards a highly efficient engine. We believe that proposed idea is very innovative and could become a game-changer for future engine technology. The fundamental and applied components of the project will contribute valuable and essential understanding, and will also be very useful for industrial applications.

The proposed research as written down in the abstract is of great interest to us and it will help us increase our understanding of advanced diesel combustion and the impact of different fuels. Therefore, we will support the final project with an amount of 50 thousand euro as in-kind contribution. Key deliverables from Shell include:

1.) Shell will provide special and reference fuels including detailed fuel analyses using our in-house blending and laboratory facilities

2.) Shell commits to assist in defining fuel specifications and to support in interpretation of the fuel chemistry effects.

We hope that your proposal is successful, and we are looking forward to a fruitful collaboration.

Yours sincerely,

Dr.-Ing. Andreas Janssen
Fuels Technology

Hamburg, 01. July, 2015
The road to green transport

Clean Engines (visualization)

Classical Concept

- Hot burning soot

New Concept

- Cheminumilescence

Road towards green transport
The road to green transport

Ultra-Clean Engines (a paradigm shift)

Gasoline/Diesel
70-90%/30-10%
No Aftertreatment!
The road to green transport

*Ultra-Efficient Engines (a paradigm shift)*

59% reported in literature!

New Concept, Naphta blends

Vs

Classical Diesel
The road to green transport

Ultra-Fuel flexible Engines (a paradigm shift)

Fuel appetite

nm = 0.0000000001m
= 10^{-9} m
100nm = 0.1 micrometer

Low load

Medium load

High load

RON70 fuels
Primary Reference Fuels

Classical Concept

New Concept
The road to green transport

Clean Engines: its fuel appetite

Any gasoline-like fuel

Candidates

• Gasoline
• Less refined fuels (naphta)
• CNG/LNG (20% CO$_2$ benefit)
• Alcohols
• Lignin based fuels (waste from paper industry)
• Solar Fuels (H$_2$, H$_2$O/CO$_2$ to liquid), liquid electricity!

+ 5-20% diesel or bio-diesel, DME/FAME/FAEE/HVO
Sustainable Liquid Fuels Future

**Bio-fuels**
- **Alcohols**
- **Lignin based fuels (waste from paper industry)**
- **Bio-diesel**

New Concept
Sustainable Liquid Fuels

Solar-fuels

Differ (TU/e) ST/TN (TU/e)

Fischer-Tropsch fuels as Carbon Capture solution

New Concept
Enabling true green transport

Commercial vehicles

Locally

Globally

Low Carbon fuels (Bio/Solar fuels)
Some comments on CO2 neutrality of EV?

Electricity Generation Leads Growth

1000 BTU~1MJ
Quadrillion=10^{15}.
10^{15} J = Peta Joule
Some comments on CO2 neutrality of EV?

Which is why electric vehicles are NOT zero emission nor will they be in the near future.

Especially this guy.

6% growth scenario
Some comments on CO2 neutrality of EV?

### Specific Carbon Dioxide Emissions of Various Fuels

<table>
<thead>
<tr>
<th>Fuel</th>
<th>CO₂/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural gas</td>
<td>0.2</td>
</tr>
<tr>
<td>LPG</td>
<td>0.23</td>
</tr>
<tr>
<td>Refinery gas</td>
<td>0.24</td>
</tr>
<tr>
<td>Gasoline</td>
<td>0.25</td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.26</td>
</tr>
<tr>
<td>Crude oil</td>
<td>0.26</td>
</tr>
<tr>
<td>Diesel</td>
<td>0.27</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>0.28</td>
</tr>
<tr>
<td>Hard coal</td>
<td>0.34</td>
</tr>
<tr>
<td>Lignite</td>
<td>0.36</td>
</tr>
<tr>
<td>Peat</td>
<td>0.38</td>
</tr>
<tr>
<td>Wood</td>
<td>0.39</td>
</tr>
</tbody>
</table>

kg CO₂/kWh
Some comments on CO2 neutrality of EV?

Electricity from a coal plant
\[
\frac{380}{0.32} = 1004 \text{ gCO}_2/\text{kWh}
\]

from a gas plant
\[
\frac{240}{0.36} = 660 \text{ gCO}_2/\text{kWh}
\]

Direct use of HD engine
\[
\frac{270}{0.44} = 617 \text{ gCO}_2/\text{kWh}
\]
\[
\frac{270}{0.55} = 490 \text{ gCO}_2/\text{kWh}
\]
For more information, visit exxonmobil.com/energyoutlook

or download the ExxonMobil app