SOCIETAL MEGATRENDS & TRENDS IN VEHICLE TECHNOLOGIES

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OUTLINE

- Introduction: From societal megatrends to automotive trends

- Alternative fuels
  - CNG and LNG
  - Electric and hybrid vehicles
  - Fuel cell and hydrogen

- Autonomous Driving

- Conclusion
INTRODUCTION
From societal megatrends
To automotive trends
WORLD IS CHANGING DEEPLY & QUICKLY

Urbanization
Individualization of Mobility Needs

Accident
Congestion

Artificial Intelligence
Digitalization
3D printing

Sensors and big data
Connectivity
Limited Resources

Population ageing
Criminlity

Healthcare
Waste et recycling

Climate change
Air pollution

Cost of fuel
GLOBAL MEGATRENDS

- Acceleration factor of **Technologies** and ubiquitous presence of **Digital World** with a growing importance of **Health**

**POWER OF TECHNOLOGY**
- “Innovation to zero”
- Ambient technology
- Robotics and AI
- Miniaturization
- 3D printing...

**DIGITAL WORLD AND CONSUMER TRENDS**
- Connected objects
- Using instead of owning
- Augmented and virtual reality
- Demand for security

**HEALTH**
- Thinner boundary between living and non-living
- New health issues
- Elderly people
- Health, wellness and well-being
- eHealth
Continued focus on **Energy Efficiency** and growth of **Digital World** with impact on **Mobility**

**ENERGY EFFICIENCY**
- Low emission regulation
- Powertrain electrification
- Renewable energy
- E-vehicle as a smart grid component
- Lightweight materials
- Recycling

**CONNECTED CAR**
- Big data
- Safety and remote services
- Navigation, location based services
- Infotainment services
- Mobility services
- Payment and e-commerce services

**MOBILITY**
- Multimodal mobility
- Car sharing
- Car pooling
- Autonomous driving
- Integrated mobility ecosystems
- Low emission zones
REDUCING CO₂ EMISSIONS

- Global warming related to human activities and use of fossil fuels
- Transport is one major contributors to CO₂ emissions
- Reduction of emissions by 50% by 2030 (ERTRAC):
  - Substituting petrol fuels by fuels with low carbon emissions or fuels with low LCA emissions (biofuels)
  - Improve the powertrain fuel efficiency
  - Reduce the mass, which often antagonistic with the demand for greater safety, comfort, etc. → 6% to 12% per 10%
Air pollution is now considered by OMS "the world's largest single environmental health risk," with more than three million people dying every year as a result.
NATURAL GAS (CNG & LNG)

- Natural Gas is an excellent alternative fuel:
  - Easy adaption of classic internal combustion engines
  - Large reserves of natural gas are available
  - Reduction of CO₂ emissions (-10%) and air pollution (PM: -95%)

- Target: optimization of engine efficiency: allows a reduction of 5 to 10% of CO₂ emissions compared to Diesel engine

- Target by EU: substitution: 10% in 2020
### Questions to be solved

- **Emissions of CH\(_4\) and development of specific after treatment to be developed**
- **Refueling station network still under construction:** 68 stations in Belgium mostly in Flanders
- **CNG (200/350/800 bar)**: Volume per unit of energy content still high ➔ Limited autonomy: 300 to 400 km
- **LNG (3 bars @ -143°C / 8 bars @-130°C):** Volume reduced by 2.4 ➔ Extension of autonomy to 700 to 800 km and over

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#### Energy per storage volume for common fuel

<table>
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<tr>
<th></th>
<th>Density kg/m(^3)</th>
<th>LHV kJ/kg</th>
<th>Energy MJ/m(^3)</th>
<th>Volume (for same energy)</th>
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<tbody>
<tr>
<td>Gasoline</td>
<td>750</td>
<td>42 690</td>
<td>32 020</td>
<td></td>
</tr>
<tr>
<td>Diesel fuel</td>
<td>835</td>
<td>42 770</td>
<td>35 710</td>
<td>+11% × 0.9</td>
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<tr>
<td>Gaseous methane</td>
<td>0.716</td>
<td>50 010</td>
<td>36</td>
<td>−100% × 889</td>
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<tr>
<td>1013 hPa, 273 K</td>
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</tr>
<tr>
<td>Gaseous methane</td>
<td>173 (AGA8)</td>
<td>50010</td>
<td>8 652</td>
<td>−73% × 3.7</td>
</tr>
<tr>
<td>20 Mpa, 293 K</td>
<td></td>
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</table>

*(1 MPa = 10 bars)*
ELECTRIC VEHICLES
AND HYBRID ELECTRIC VEHICLES
ELECTRIC VEHICLES

- Advantages
  - Nicely fitted to urban driving
    - Zero local emission
    - Great driving comfort
  - High energy efficiency
    - Lower energy cost: 20 kWh/100 km

- Drawbacks: the batteries!
  - New customer habits to develop
    - Charge time (1 to 6 hours)
    - Autonomy between 130 km and 300 km (strongly dependent on the weather conditions)
  - Smaller size vehicles
  - Reliability is still to be fully demonstrated
ELECTRIC VEHICLE

- **Urban applications** are targeted
  - Driving comfort and efficiency
  - Low emission zones (LEZ)
  - Night delivery

- **Charging infrastructure** is currently growing but still limited:
  - Public charging infrastructure v.s. company private charging stations

- **Batteries**: new developments
  - Temperature sensitivity
  - Recycling
  - **Graphene batteries**: +45% capacity / charging 12 times faster...
  - When will the technology be available??

- **Future research**:
  - Fast inductive charging
  - Electrified highway by Siemens
HIGHERY VARIABLE OPERATING CONDITIONS

- Major difficulty of propulsion systems: the highly variable operating conditions (torque, regime)
  - Target: sizing to average power consumption!
  - Approach: store the energy ➔ Batteries
  - Recover energy: Two energy converters

Hybrid vehicles combine two sources of energy, energy storage, and energy conversion systems.

Source G. Coquery, INRETS
HYBRID ELECTRIC VEHICLES: CHARGE SUSTAINING VS PLUG-IN

- **Charge sustaining:**
  - Energy is produced on-board by engine only.
  - Easy adaptation of users
  - Limited energy efficiency improvement
  - Petrol dependency

- **Plug-in hybrid:**
  - Energy is either produced on-board or by using plug-in capacity to the network.
  - Long range and low emission performance
  - Energy consumption: l/100km and kWh/100km ➔ access to renewable energy sources

*Source: Toyota*
HYBRID VEHICLES: ABOUT THE USEFULNESS OF PLUG-IN STRATEGY

Source: www.green propulsion.be

Renault Kangoo Hybrid
Green Propulsion
FUEL CELL VEHICLE
FUEL CELL PRINCIPLE

- Fuel Cell carries out a direct conversion of the fuel chemical energy into electrical energy
- Electrochemical reaction (oxide-reduction) without flame
- The hydrogen H₂ – O₂ fuel cell: inverse reaction of water electrolysis
- High fuel efficiency (>50%)
- Major issues:
  - Cost related of electrodes made of precious metal, membranes
  - Reliability
- Hydrogen technology: a real start?
FUEL CELL POWERED VEHICLES

- **Zero emission vehicle:**
  - No pollutant emission except $\text{H}_2\text{O}$
  - Nearly silent operation

- **Powertrain layout based on series hybrid architecture**
  - Energy storage based on batteries or supercaps
  - Recovery of braking energy
  - Autonomy of 400 to 500 km

- **Hydrogen production & distribution**
  - \( \text{H}_2 \) or plug-in hybrid on electrical network
  - \( \text{H}_2 \) production and distribution?
AUTONOMOUS DRIVING
AUTONOMOUS VEHICLES: IN THE TRACK OF ADAS


PASSIVE SAFETY
- Side airbag
- Side impact protection
- Active seat belts
- Airbags
- Deformation elements
- Compound glass
- Seat belts
- Safety cell

ACTIVE SAFETY
- Automatic Emergency call
- Night vision enhancement
- Collision avoidance
- Lane departure
- Emergency brake
- Night vision
- Driver assistance

SMART ADAPTIVE CONTROLS
- Rollover
- Precrash action
- Emergency brake
- Automatic
- Emergency call
- Night vision
- Driver assistance

AUTONOMOUS DRIVING
- Smart adaptive controls
- Autonomous driving

AVS
- ABS
- ESP
- BAS
- ETC

DRIVER ASSISTANCE
- AutoPilot
- CoPilot
- Pilot

10 8 6 4 2 0
AUTONOMOUS VEHICLES: THE CROSSROAD

2018

2010
Automated system features: cruise control, parking and lane keeping assistance.

2015
Automated system features: accelerating, braking & steering.

Within limited environments [such as freeways], driver can safely turn their attention away from driving tasks.

2025
Automated system features: accelerating, braking & steering. System recognises its performance limits and requests driver to resume control within a sufficient time margin.

>2020?
No driver intervention required after setting destination and starting the system. Fully autonomous.

LEVEL 0
DRIVER ONLY

LEVEL 1
ASSISTED

LEVEL 2
PARTIAL AUTOMATION

LEVEL 3
CONDITIONAL AUTOMATION

LEVEL 4
HIGH AUTOMATION

LEVEL 5
FULL AUTOMATION
AUTONOMOUS VEHICLES: THE NEW PLAYERS

- Key element of autonomous vehicles: New technologies
  - Artificial intelligence, Machine learning algorithms,
  - Vision, mapping...
- Arrival of new players: Google, Apple...
CONCLUSION
SOLUTIONS DEPEND ON USAGE PROFILE!

Source: ERTARC
**SHIFT IN POWERTRAIN TECHNOLOGIES**

- **Powertrain shift:**
  - Diesel drops but remains for low cost and long haul vehicles
  - CNG and LNG provide an alternative fuel route
  - EV gaining momentum first for urban applications waiting for new batteries
  - Plug-In Hybrid Vehicles for premium

*Source: VALEO*
CHALLENGES IN AUTOMOTIVE INDUSTRY

Mobility and ownership models will diversify
New players are emerging
QUESTIONS
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