

MECA0527 ELECTRIC, HYBRID, AND FUEL CELL VEHICLES

Environmental Context and Challenges for Automotive Industry

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### OUTLINE

- Context
- From societal megatrends to automotive trends
- Environmental challenges for automotive industry
  - Resource depletion
  - Global Warming
  - Air quality
  - Safety and road accidents
  - Traffic congestion
- Strategies to reduce energy consumption and emissions
  - Roadmaps
- Conclusion
  - Autonomous Driving





# CONTEXT







- The automobile is freedom"!
  - The automotive industry has undergone a remarkable development over the last century and especially in the last decades.



- The automobile is an essential component of economic life:
  - mobility of goods and people
  - characteristic of developed countries
  - condition / consequence of the development
  - Economical growth calls for more mobility
- Automobile is also a partner of our social life and lifestyle:
  - individual mobility for work and leisure
  - response to a deep aspiration for freedom of movement



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- The automobile is a victim of its success
  - Development of road traffic and increase of the vehicle fleet
  - Growth in travel routes and distances
  - Congestion in major urban centers
  - Road transport consumes 70% of the European Union's oil consumption.
- The sustainability of the transport sector is questionable
  - Sufficient energy supply and at what cost?
  - Local air pollution
  - Increase in greenhouse gas emissions
  - Increase in noise pollution





# FROM SOCIETAL MEGATRENDS TO AUTOMOTIVE TRENDS



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## WORLD IS CHANGING DEEPLY & QUICKLY

#### Urbanization



Individualization of Mobility Needs



Population ageing



Climate change



#### Accident



Congestion



Criminality



Air pollution







Digitalization



#### Healthcare





Sensors and big data



Connectivity

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Limited Resources





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#### Waste et recycling





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



- Health, wellness and wellbeing
- 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



## ENVIRONMENTAL CHALLENGES FOR AUTOMOTIVE INDUSTRY



### CHALLENGE OF 21<sup>st</sup> CENTURY FOR A SUSTAINABLE AUTOMOTIVE INDUSTRY

- Steadily increasing number of automobiles on the road
- Road transport is strongly dependent on petrol (>90%) that is 70% imported 70% outside EU
- Scarcity and cost of petrol resources
- Global warming of the planet due to intensive use of fossil fuels





CO2 emissions by sector in 2009





### Growth of car fleet around the world





Towards the one billion vehicles on the road in the world...



### CONTEXT: DOMINATION OF RAOD TRANSPORT











Evolution of the car fleet in Belgium (source: FEBIAC)







### CHALLENGE: CAR FLEET EVOLUTION



Evolution of the average car mileage in Belgium (source: FEBIAC)



### DEPLETION OF PETROL RESSOURCES



Resources of petrol ~ 35 to 40 years

Reserves of petrol ~ 60 years





### REDUCING CO<sub>2</sub> EMISSIONS





- Global warming related to human activities and use of fossil fuels
- Transport is one major contributors to CO<sub>2</sub> 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%





- For about ten years, the reduction in average vehicle consumption in Europe has been achieved by the massive dieselization of new vehicles (about 45%).
  - uses direct injection (+15% yield)
  - downsizing thanks to turbocharging
- This trend will continue partially but is levelling off.
- New technological developments cannot be avoided in order to achieve the longer-term objectives.





### REDUCE CO<sub>2</sub> EMISSIONS





- After Kyoto treaty, volunteer commitment of car manufacturer to target
  - 140gCO2/km in 2008
  - 120 gCO2/km in 2012 → FAIL

### New constraining target of EU

- 2012: average of the sold fleet < 130 g CO2/km (65% of the least polluting vehicles)
- 2015: average fleet sold < 130 g CO2/km (100% of vehicles)
- 2020: average of 95 g CO2/km



### PRESSURE OF EU REGULATIONS ON CO<sub>2</sub> EMISSIONS



#### Fleet CO2 emission reduction objectives converge towards binding targets



[1] China's target reflects gasoline fleet scenario. If including other fuel types, the target will be lower. [2] US and Canada light-duty vehicles include light-commercial vehicles.

#### Source: ICCT

Remark: Recalculation in ICCT July 2012 report indicates level of 93g for passenger cars only for the US in 2025. EU's targets are comparitively more stringent. Vehicle definitions are different in the US and EU, and not directly comparable.



Source: https://www.acea.be/industry-topics/tag/category/co2-from-cars-and-vans

### PRESSURE OF EU REGULATIONS ON CO<sub>2</sub> EMISSIONS

#### Fleet objectives are putting pressure on all manufacturers and particularly on the premiums.

Distance to 2012 target by individual manufacturers in 2011 (only manufacturers registering >100 000 vehicles in Europe).





Source: https://www.eea.europa.eu/highlights/most-car-manufacturers-on-track



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### AIR POLLUTION IS AND REMAINS A WORLD WIDE ISSUE



AQI – Thursday 07th Nov. 2016– 09:14 French Time Extract from AQICN website - www.aqicn.org

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.

AQI	PM2.5 concentration µg/m³	AQI category
0 to 50	0 to 12	good
51 to 100	12 to 35	MODERATE
101 to 150	35 to 55	UNHEALTHY FOR SENSITIVE GROUPS
151 to 200	55 to 150	UNHEALTHY
201 to 300	150 to 250	VERY UNHEALTHY
300 to 500+	250 to 500	HAZARDOUS

### AIR POLLUTION IS AND REMAINS A GLOBAL PROBLEM



The invisible killer: According to the WHO, air pollution is considered "the single greatest environmental threat to health" with more than three million people dying each year. This is more than double the number of deaths in road accidents each year.





A top priority for China: More than 50% of the respondents in China place air quality in the place where they live as a major concern and qualify it as quite poor/poor/very poor (Europe 25% - USA 17%).



3 out of 4 Chinese seek information on the environmental conditions of their living.



### LOCALIZED POLLUTION IN URBAN CENTERS

- Transportation contributes mainly to NOx and CO
- High exposure of Europeans to local pollution: 80% of Europeans live in medium and large cities.
- Noise pollution (noise) is also becoming a major problem.









Contribution of the Transportation Sector to Overall EU Pollutant Emissions (2001)

### TIGHTENING OF EMISSION NORMS IN EU

#### >> 1971- 2005 : DES NORMES ANTIPOLLUTION TOUJOURS PLUS STRICTES





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### EMISSIONS IN EU, USA, AND JAPAN









- Technological developments
  - Improvement of fuel quality: benzene content, aromatic compounds, sulfur content, etc.
  - Avoid the formation of pollutants:
  - Electronic control of the engine, injection, ignition and air supply
- High pressure direct injection for diesel engines
- Combustion Improvement
- Catalytic post-treatment systems for pollutants. 3-way catalysis allows the simultaneous reduction of CO, NOx and HC with 99% efficiency.



REDUCTION OF LOCAL POLLUTION: EURO



- Strengthening the emission norms for passenger cars and heavy-duty vehicle since 1996
- The total amount of pollution emitted by vehicles has been constantly reduced (factor 10!)
  - The global emission of CO<sub>2</sub> is still increasing



### NETWORK CONGESTION AND ROAD SAFETY

- Network congestion
  - Urban areas, network
  - Trans-European
  - Cost: 1% GNP in 2010

- Road safety
  - 41,000 deaths per year on the roads in the EU
  - Cost: 2% of GDP
  - 2010 target to reduce the
  - number of fatalities per 2.







### CHALLENGE OF 21ST CENTURY FOR A SUSTAINABLE AUTOMOTIVE INDUSTRY

- Mobility is considered as a right of citizens
  - People are very proud of their personal mobility
- Efficient transportation systems have a large impact on:
  - Economic growth
  - Social welfare
  - Environment
- Sustainable Transport aims at matching simultaneously
  - 1/ Societal needs
  - 2/ Economic requirements
  - 3/ Environmental constraints



### TARGET FOR 2030 – 50% BETTER ENERGY EFFICIENCY



 Main contributions of European Car Industry to tackle Global Warming and energy challenge:



- Improvement of energy efficiency of transportation systems:
  - Higher energy efficiency of engines for vehicles and transportation systems
  - Better usage of alternative transportation means (not only vehicles) and common transportation systems, especially in urban area
  - Making a better usage of new possibilities offerte par ICT technologies (V2I, V2V)
- Increase of share of renewable energies in transportation systems
  - Bio fuels
  - Renewable energy sources in electricity production for electric vehicles





### TARGET FOR 2030 – 50% BETTER ENERGY EFFICIENCY







## STRATEGIES TO REDUCE FUEL CONSUMPTION AND EMISSIONS



### REDUCING CO<sub>2</sub> EMISSIONS







- To reduce the emissions, several approaches
  - Substituting petrol fuels by fuels with low carbon emissions (per energy release) or fuels with a life cycle giving rise to low emissions (biofuels)
  - Improve the fuel efficiency of the energy plant (the most direct action)
  - Reduce the mass, which often antagonistic with the demand for greater safety, comfort, etc.
  - Internal friction and losses reduction: downsizing strategy = keep same performance with a lower cylinder displacement
  - Reduction of aerodynamic drag
  - Improve drivetrain efficiency



### ALTERNATIVE CLEAN FUELS

#### Lower Heat Values of various useful fuels





### REDUCING CO<sub>2</sub> EMISSIONS







Assumption of 20% improvement on each parameter





### IMPROVING THE VEHICLE ENERGY EFFICIENCY

- Internal Combustion Engines:
  - Downsizing
  - Biofuels
  - Hydrogen (H<sub>2</sub>), Natural Gas (CH<sub>4</sub>)
- Electric Vehicles:
  - New generation of electric energy storage systems: batteries, supercapacitor, fly wheels...
  - New generation of electric machines
- Hybrid vehicles:
  - Hybrid Electric Vehicles
  - Hybrid Hydraulic Vehicles...
- Fuel Cell vehicles





### IMPROVING THE VEHICLE ENERGY EFFICIENCY

- The NEW PROPULSION SYSTEMS are based on the same basic ideas:
  - Stop the engine if at standstill: 8% CO<sub>2</sub> gain
  - Recovery of energy during braking: 13% of CO<sub>2</sub>
  - Engine downsizing: 30% CO<sub>2</sub> gain
  - Full hybridization: 45% CO<sub>2</sub> gain
- BUT you also have to play on OTHER LEVERAGE:
  - Lightweight structure: aluminum, composite materials, optimized shapes and profiles of the structure
  - Low rolling resistance tires
  - Improved aerodynamic performance (C<sub>x</sub>, frontal surface)
- FUELS with less carbon

■ H<sub>2</sub>, CH<sub>4</sub>.



### REDUCING EMISSIONS: THE TOYOTA ROAD MAP



#### Toyota road map to reduce CO<sub>2</sub> emissions







# CONCLUSION



#### SOLUTIONS DEPEND ON USAGE PROFILE!







## SHIFT IN POWERTRAIN TECHNOLGIES



#### 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



### CHALLENGES IN AUTOMOTIVE INDUSTRY







### CHANGING INDIVIDUAL MOBILITY



Car Manufacturers

Mobility Providers

- Mobility and ownership models will diversify
- New players are emerging



### AUTONOMOUS VEHICLES: IN THE TRACK OF ADAS

EGE



### AUTONOMOUS VEHICLES: THE CROSSROAD













### 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...





# QUESTIONS









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