Solutions for reducing energy consumption and pollutant emissions from the road transportation sector.

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University of Michigan– September 23, 2008

Summary

1. Introduction
   - What do we need / How to deliver?
   - Impacts and challenges

2. Solutions for reduction of energy consumption and emissions
   - Alternative energy sources
   - Alternative vehicle technologies
   - Better mobility management
   - New culture concerning mobility

3. Contribution of Research & Development
   - Evaluation of alternative solutions
     - Numerical Simulation
   - Experimental testing and validation
   - Evaluation of the Impact of road transportation
   - Environmental impacts of road transportation

1. Introduction

What do we need?
Accessibility... not mobility

- To people
- To places
- To information
- To goods
- To services (job, school, ...)
- To entertainment
- ....
Main providers of urban mobility

**Motorized Modes**
- Car
- Bus
- Motorbike
- Train
- Metro

**Soft Modes**
- Walking
- Biking

Mode Distribution (Europe)

![Mode Distribution Graph](image)

Mobility and Energy

![Energy per pass.km Graph](image)

Energy per capita

![Energy per capita Graph](image)

MJ, kWh, kCal, liters, MPG, m3

Lack of sensitivity
Kyoto Protocol

World: 5% reduction by 2008-2012 (1990 as a baseline)
Europe: 8% reduction
Portugal: 27% increase
Portugal CO2 emission will increase by more than 35%
(Transports: CO2 emissions doubled in 2003 vs 1990)

Approved: 1997
Ratified: 2004
Official start: 16/2/2005

Main challenges

- Security of supply
- Competitiveness
- Environmental sustainability

2. Solutions for reduction of energy consumption and emissions

How to reduce the impact of Mobility

Lower emission and better efficiency

Energy Source / Energy “Chain”
- Biofuel
- Ethanol
- Hydrogen
- Electricity, hydrogen...

Vehicle Technology & Efficiency
- Lighter vehicles
- Hybrid
- Electric and Plug in...

Mobility Management
- Public Transport
- Soft modes
- Parking management
- Tolls
- Urban Planning...

Change of behavior
- Training
- Education
- New Culture Concerning Mobility
TF1  Sofia: como separar o supply do demand?!  
Tiago Farias; 25-08-2008
2. Solutions for reduction of energy consumption and emissions

Fuels and Vehicles

- New Propulsion systems
  - Hybrid, electric, plug ins, fuel cells...

AFV – Alternative Fuelled vehicles

New energy sources / energy “chains”
- Ethanol
- Biodiesel
- Natural Gas
- Biogas
- Electricity...
- Hydrogen

More than 100 years of technology development

Same fuels...same propulsion system and they look good...

Vehicle evolution: mass and fuel consumption

The key questions… not always addressed

1. Why? Does it make any sense?
2. Is there fuel available … at a competitive price?
3. Are there filling stations?
4. Are there vehicles ready to adopt the fuel?
5. Is legislation ready?
6. Who wins?
7. Who pays?

… Is it sustainable?

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**Biofuels**

- Energy Source
- Life Cycle analysis
- Cost
- Fuel versus food
  - production method
    - 1st generation
    - 2nd generation
  - Sustainability
  - taxation and incentives
- ...  

**Directive 2003/30/CE**

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Portuguese commitment by 2010: 10%

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**Electric Vehicles**

- Autonomy
- Battery charging
- Vehicles technology
- Cost
- Life Cycle

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**Full Electric vehicles**

Niche Market applications

Gulliver Mini Bus and the Blue Line Concept
Hybrids: already on the road…
but energy source is still gasoline

GM Volt
• Series hybrid
• ICE gasoline 1 liter, 3 cylinder, 53 kW
• Generator 53 kW
• Motor 120 kW
• Battery Li-ion 16kWh

Mercedes-Sprinter
• Parallel hybrid
• ICE gasoline 2 liter, 4 cylinder, 81 kW
• Motor 70 kW
• Battery NiMH 14kWh

Plug-in: promising …
but still to come

Hydrogen
• Production
• Transportation
• Storage
• Filling station
• Vehicles technology
• Safety
• Cost
• Life Cycle

Hydrogen vehicles from different vehicle manufactures
3. Contribution of Research and Development for Reducing Energy and Emissions from Road Transport

The role of research and development

- Energy Source
  - Fuel production
  - Fuel performance
  - Life Cycle Analysis

- Vehicle Technology & Efficiency
  - Lighter vehicles
  - Propulsion system
  - Exhaust gas treat.
  - V2V analysis

- Impact of Mobility
  - Traffic Emissions
  - Pollutant dispersion
  - Human Exposure
  - Env. Accessib. Indicators

Scenario and Projections
Hydrogen Cycle

- Renewable Source
  - electrolysis
- Oil
  - refinery
  - "steam reforming" natural gas

H2 filling station in Berlin

- LPG Tank
- Compressor
- LPG-Reformer
- Public H2 Dispenser (LH2 + GH2)
- L1 Tank
- L1H2 Technology

CO2 emissions W2T

- Well-to-Tank CO2 emissions for the different fuels analyzed:
  - Diesel
  - CNG
  - H2 fuel station
  - H2 central production
  - H2 electrolysis (grid power)
  - H2 electrolysis (renewable power)

Emissions:
- Diesel: 0.00E+00
- CNG: 5.00E-02
- H2 fuel station: 1.00E-01
- H2 central production: 1.50E-01
- H2 electrolysis (grid power): 2.00E-01
- H2 electrolysis (renewable power): 2.50E-01
- Diesel: 3.00E-01
- CNG: 3.50E-01
- H2 fuel station: 4.00E-01
- H2 central production: 4.50E-01
CO2 emissions W2W

Well-to-Wheel CO₂eq Emissions for the different fuels analyzed

Diesel  CNG  H₂ fuel station  H₂ central production  H₂ electrolysis (grid power)  H₂ electrolysis (renewable power)

Fuels

Tank-To-Wheel  Well-To-Tank  kg/km

Experimental laboratory

Experimental evaluation of alternative fuels

- Ethanol
- CNG
- Hydrogen
CUTE - Clean Urban Transports for Europe

Impact of new vehicle technologies
- Weight reduction
- Regenerative breaking
- Stop/start systems
- Hybrids technologies
- Plug ins concept
- Fuel cells
  
Complete Life Cycle Analysis

Emission and energy consumption in:
- Producing / dismantling the vehicle
- "Producing" the fuel
- Using the vehicle

Ecogest Model

Energy required for the propulsion system
Driving simulation

Fuel consumption

\[ E = \text{CO}_2 + \text{HC} - \text{CO} - \text{NO}_x - \text{PM} \]
3. Contribution of Research and Development

Impact of Mobility

Results/ Full life cycle results

- Comparison based on: P/W = 55 W/kg 0-100 km/h = 10s
- Vehicle total life: 150,000 km (10-15 Years)

Cascas - Lisbon

Traffic behavior characterization:
Videotaping ⇒ Queue length; stop&go cycles; ...

Vehicle dynamic measurements

Emissions from pay tolls

Daily emissions for conventional tolls, Electronic tolls (ETC) and no tolls

- Vasco da Gama bridge
- 25 of April Bridge
- A5 Carcavelos Toll Plaza
Speed Control traffic Signals

Obrigado!

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