Alternative fuels context in the world

IFP Sessions - Which Technologies to Diversify Transportation Fuels?

9th December, 2009

Daphné Lorne
Economics Department

Three main topics

- **Why Alternative Fuels?**
- **Current pathways and market**
- **Upcoming Potential and development issues**

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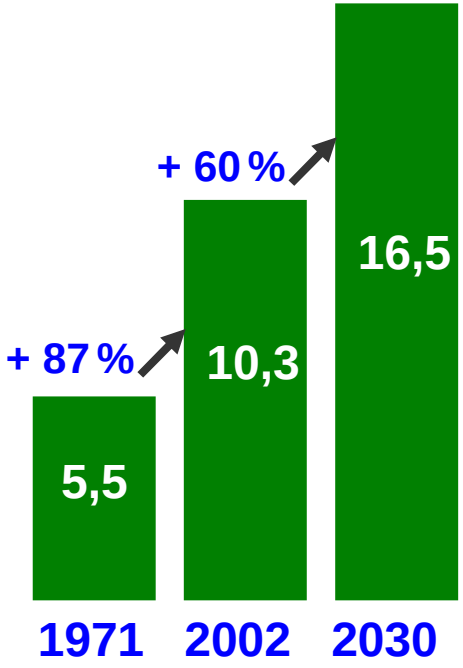
Why alternative fuels
Three worldwide challenges

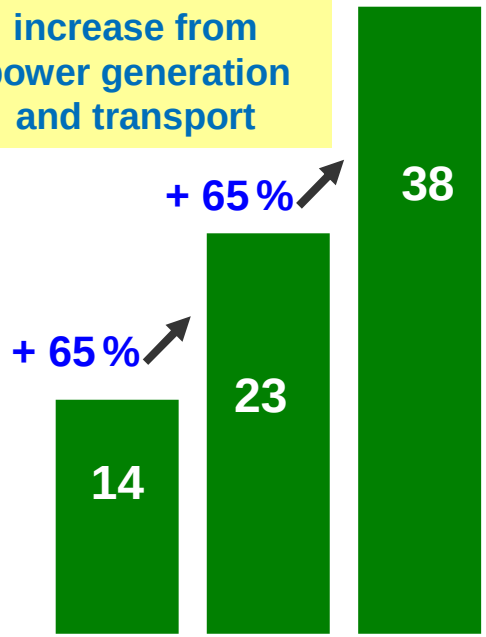
Energy demand
2002/30 : + 60 %



Billion Toe

CO_2 emissions
2002/30 : + 65 %

Most of the increase from power generation and transport

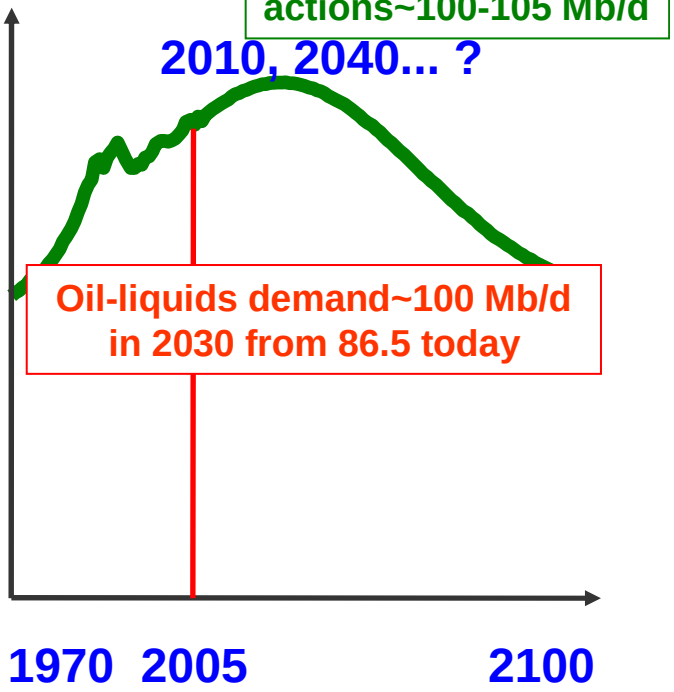


Billion Tonnes

Oil peak or plane

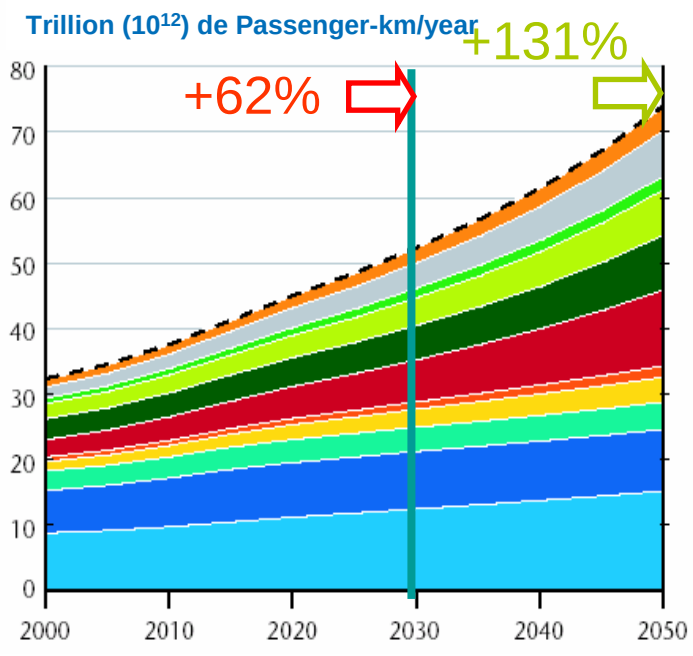
Peak oil zone with no actions~90-95 Mb/d

Peak oil zone with actions~100-105 Mb/d

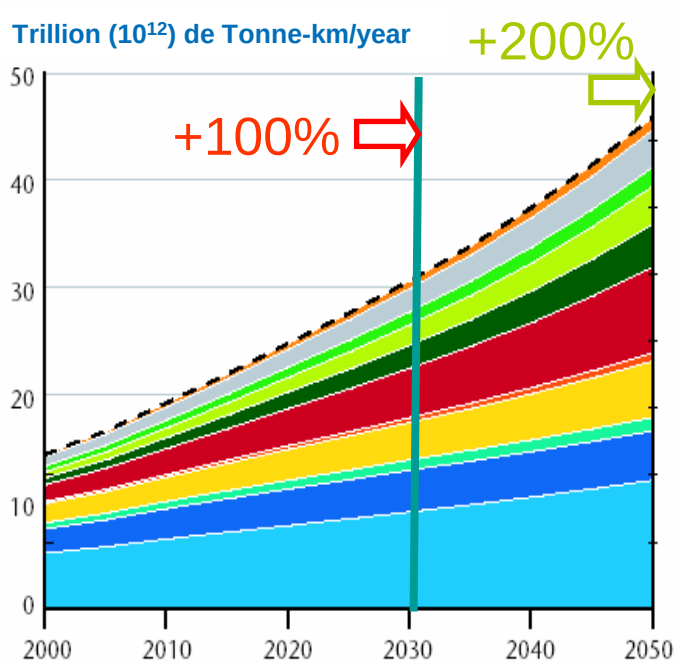


Why alternative fuels?
Growing mobility demand

Passenger



Freight



Étude « The Sustainable Mobility Project », WBCSD , 2004

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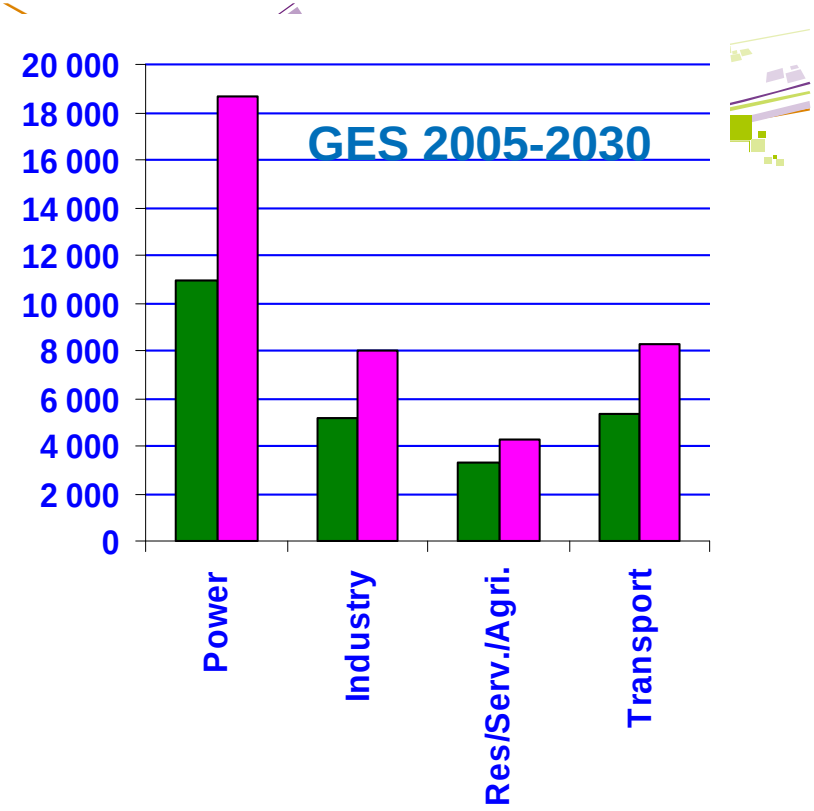
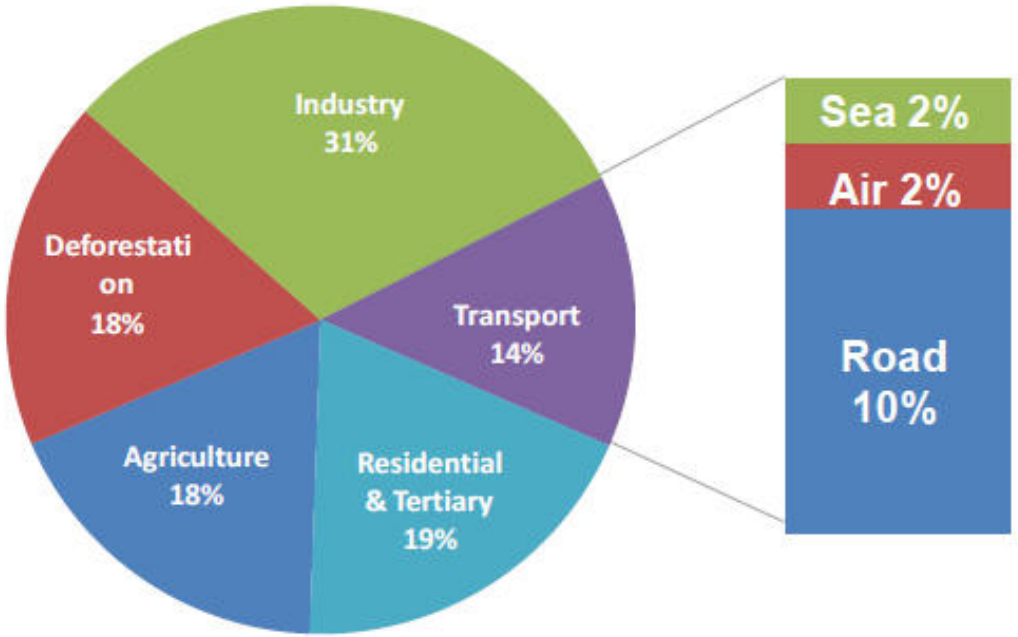
Why alternative fuels?
Greenhouse gases by sector



42 billions of tonnes in 2000



More than 98% of energy of transport comes from fossils

Source : WRI - World Resources Institute

Why alternative fuels?
Ways to reduce transport emissions

- **More sustainable behavior, optimized urban and rural planning models**
- **Vehicle fuel efficiency**
  - **Variable Valve Timing**
  - **GDI stratified combust**
  - **CAI combustion**
  - **Downsizing**
  - **Hybridization**
- **New engine technologies (electric cars, PHEV, Fuel cell...)**
- **Fuel technologies from less limited or renewable resources**

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Three main topics

- Why Alternative Fuels?
- **Current pathways and market**
- Upcoming Potential and development issues

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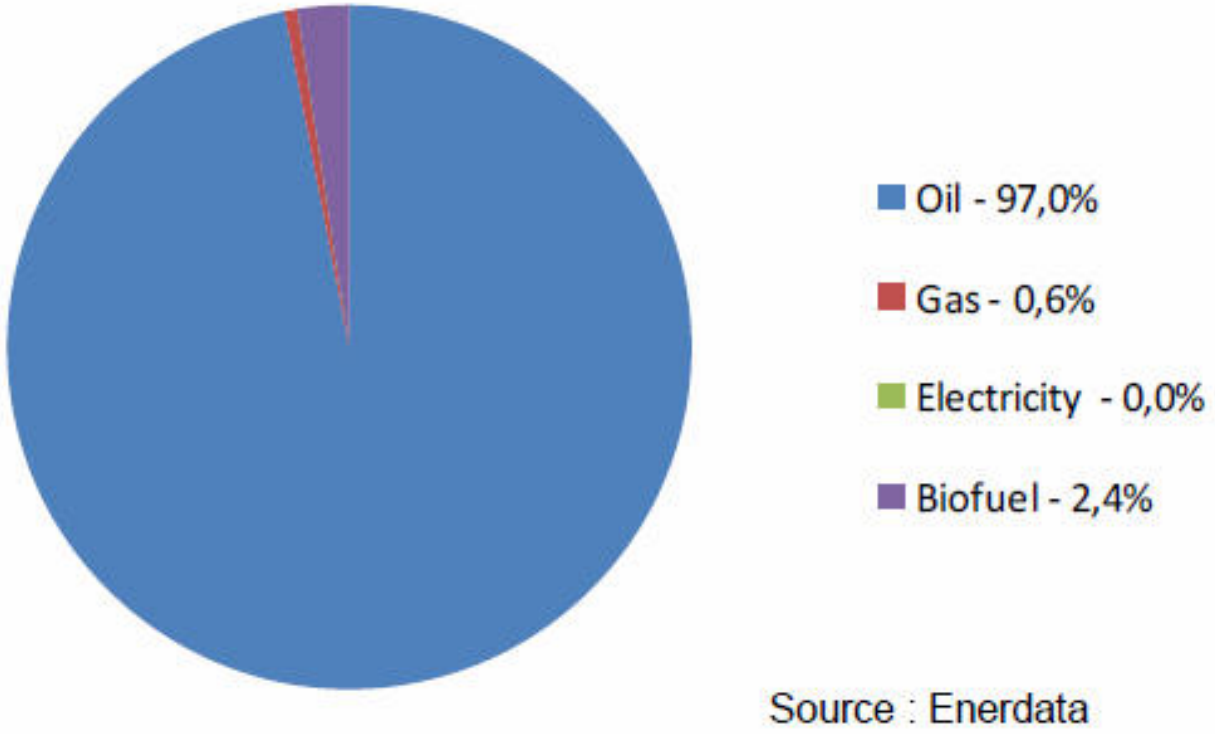
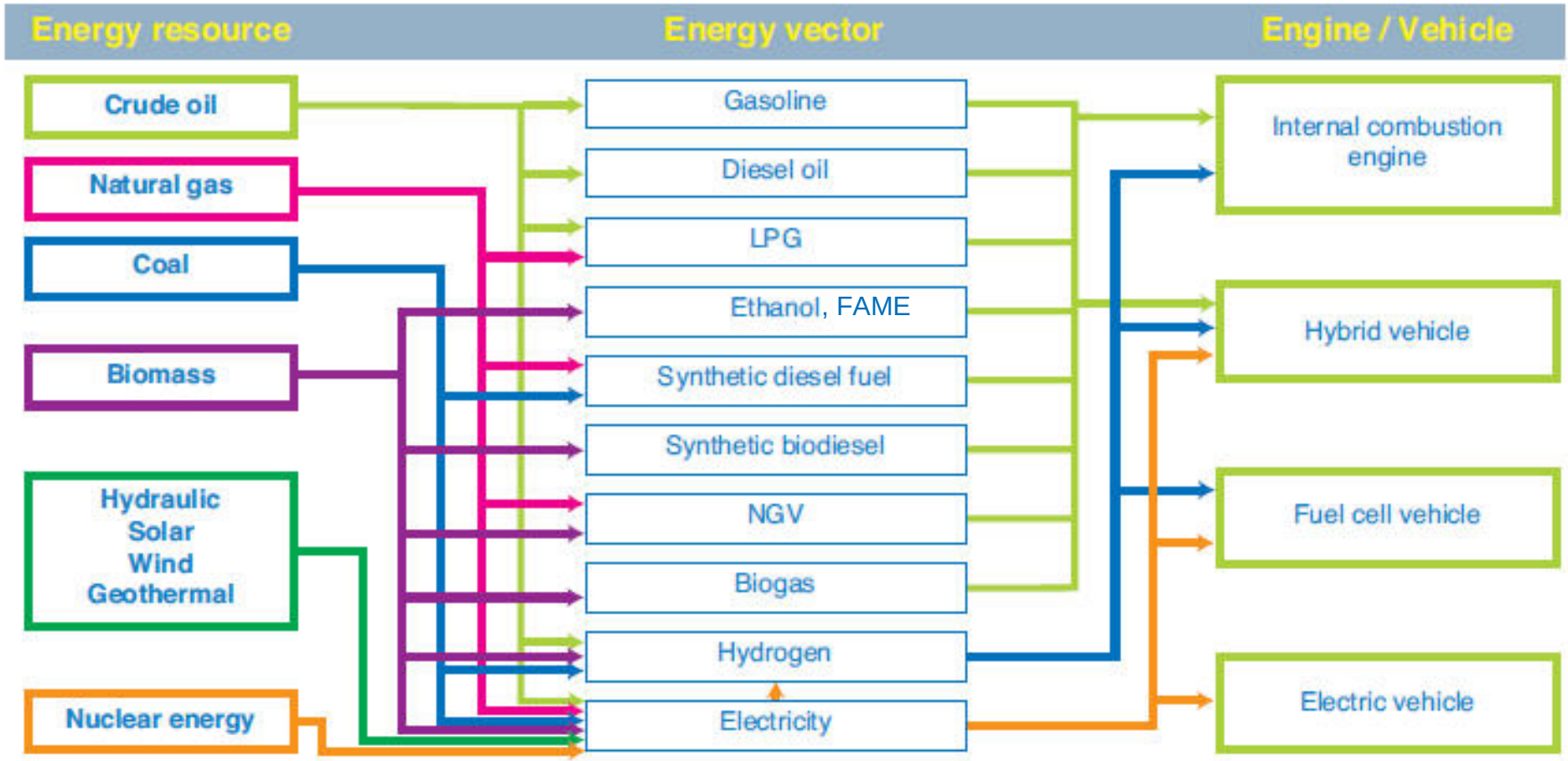
Current pathways and market

Energy used in road transport in the world

- **In the world, 97% of the energy used in road transport is based on oil.**
- **Transport consumes over 50% of global oil consumption**
- **Biofuels are the most mature alternative technologies today**



Why alternative fuels?
Alternative pathways



What are their respective performances regarding economic, environmental impacts and resource availability ?

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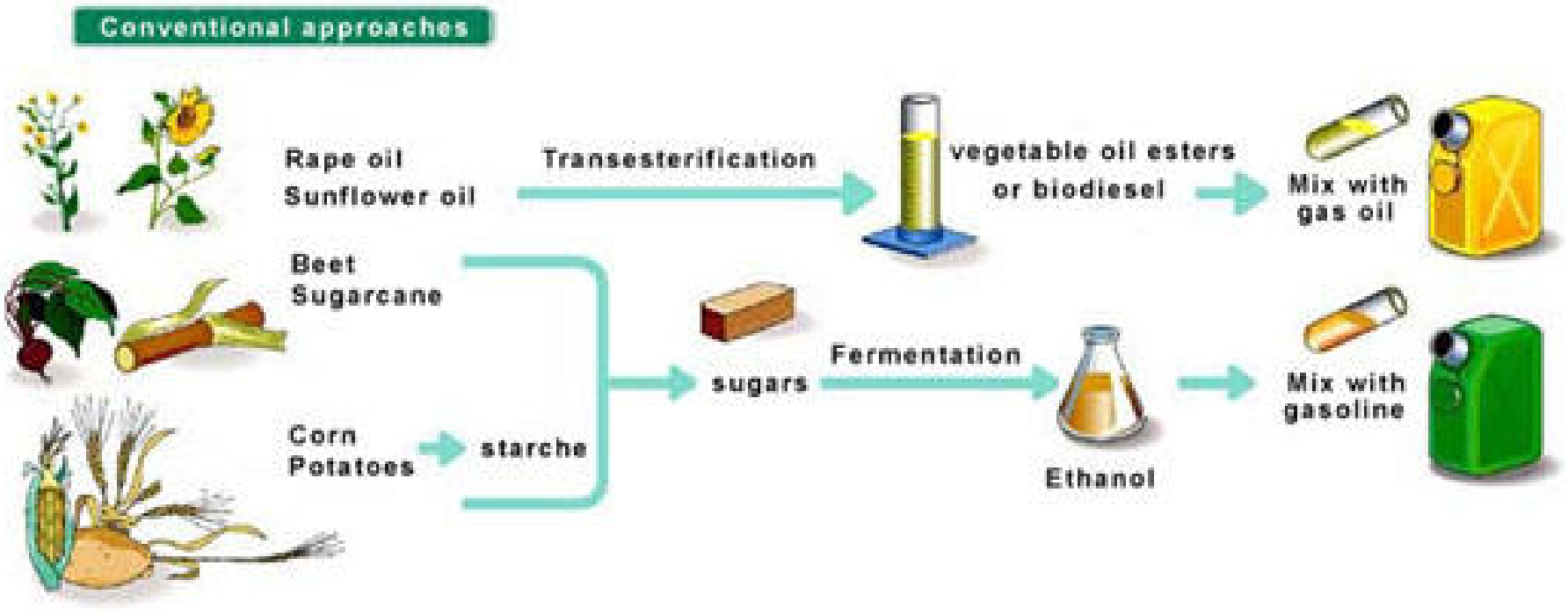
Current pathways and market
Two main current biofuels pathways

- **First generation biofuels**



Biomass from conventional agriculture

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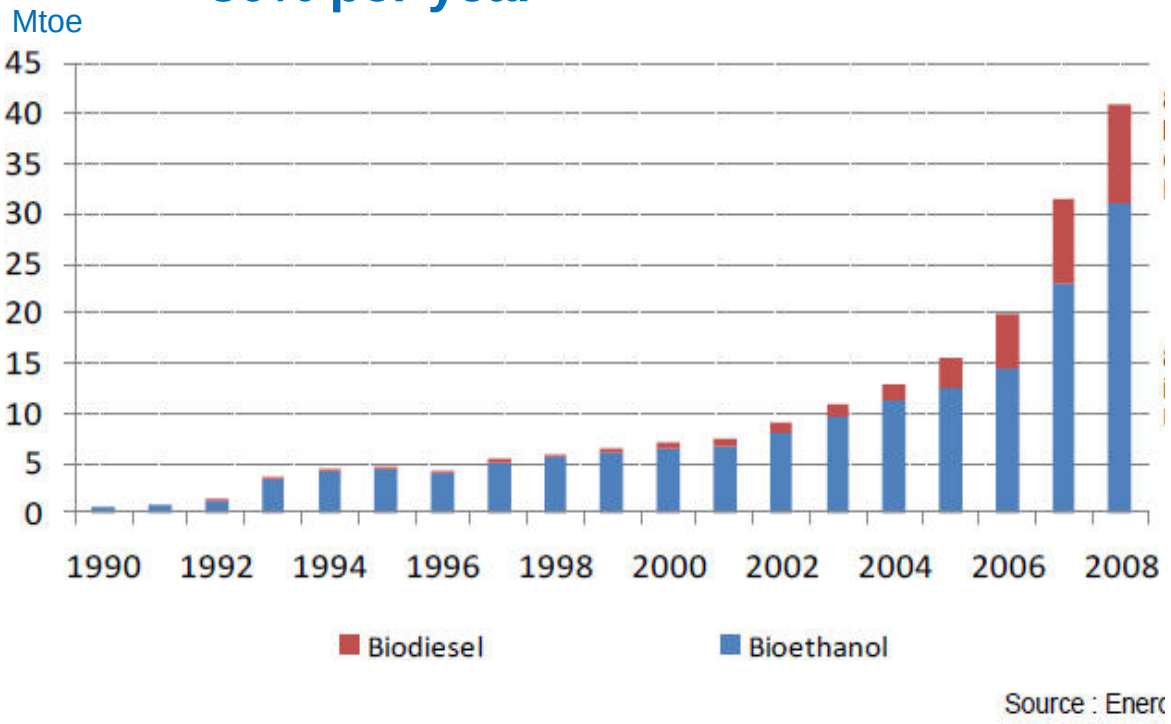
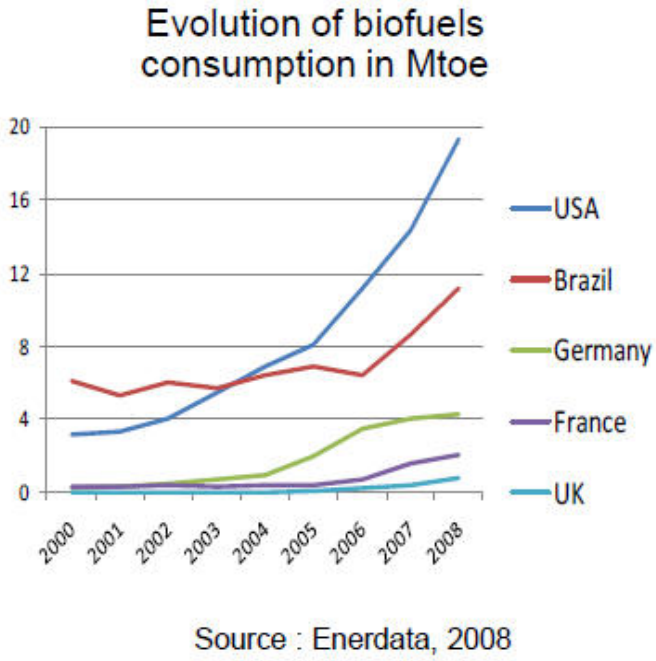
Current pathways and market
A very strong increase of biofuel consumption

- **The increase was about 8-10% par year in 90's, it is now 20-30% per year**



Source : Enerc



Source : Enerdata, 2008

2008 90% of ethanol is produced by USA and Brazil = 52,5 Mt
80% is consumed by USA and Brazil

60% of biodiesel is produced in Europe = 13,7 Mt
80% is consumed in Europe

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Current pathways and market
1st generation biofuels limits

- **Conflicts of use**
  - **The 1st generation biofuels cannot be produced wider without threatening of food supplies and biodiversity.**
  - **Land availability, and possible conflicts of use (food)**
  - **Water availability, and possible conflicts of use**
- **Due to difficult economics, public support is required in most of the cases**
- **Lower environmental benefits**
  - **Some of the 1st generation produce only limited Greenhouse gas emissions saving, some of them are below EC threshold**
  - **Some crops require more fertilizers, pesticides**
  - **Deforestation and biodiversity impacts, soil erosion could sometimes damage the balance**

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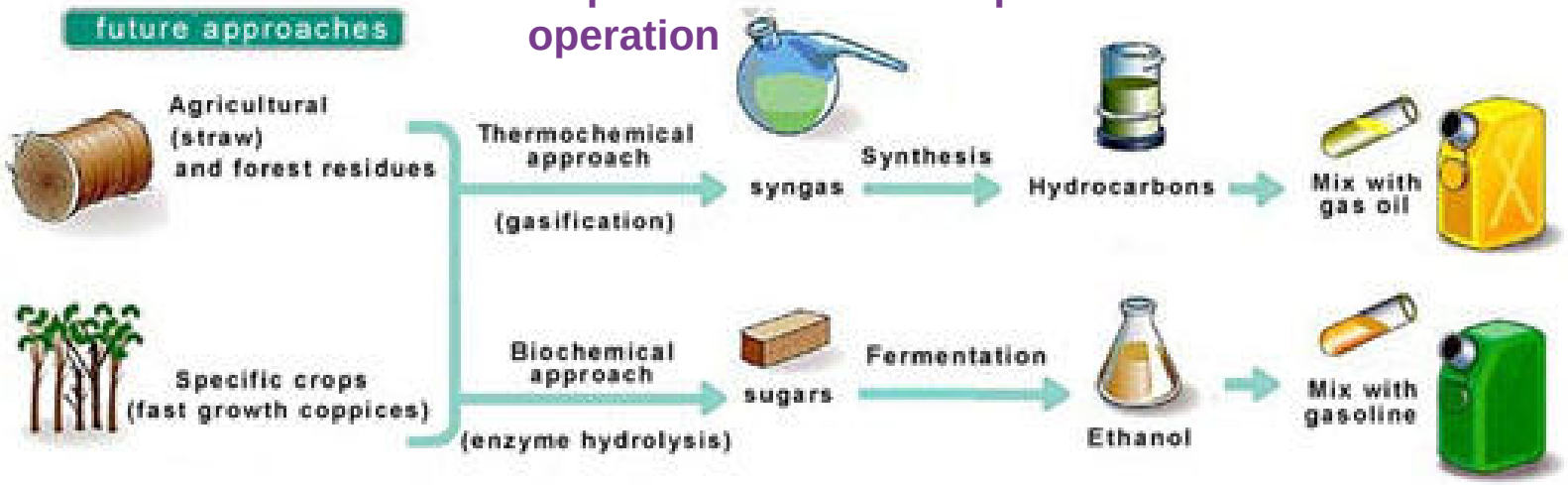
2nd generation biofuels – Two main pathways at R&D stage

- **Second generation biofuels**

14 pilot/demonstration plants in the world / 6 in operation



34 pilot/demonstration plants in the world / 13 in operation

- **Goal of the second generation is to extend the amount of biofuel that can be produced sustainably by using non food biomass**
- **A real potential to go up 10% in worldwide transport fuel demand: large amounts of biomass residues and a lot of crops to be evaluated**
- **A CO_2 net reduction around 85%**

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Current pathways and market

2nd generation biofuels – Two main pathways at R&D stage

- **Technical and especially economic problems remain**
  - **High biomass supply costs specially for BTL**
  - **high technology costs (enzymes, syngas production)**
  - **Competition between biomass uses : wood material, pulp and paper, electricity and heat... Local heat and Electricity easier markets than biofuels**
- **Blending of renewable and fossil fuels: co-processing of biomass and refinery residues**
  - **Vacuum residue, Petcoke**
  - **Biorefinery concepts**
  - **Environmental acceptability depends on the biomass/residue ratio**
- **Attention will also have to be paid to …**
  - **Land availability, and possible conflicts of use (food)**
  - **Water availability, and possible conflicts of use**
  - **Deforestation and biodiversity impacts, soil erosion**

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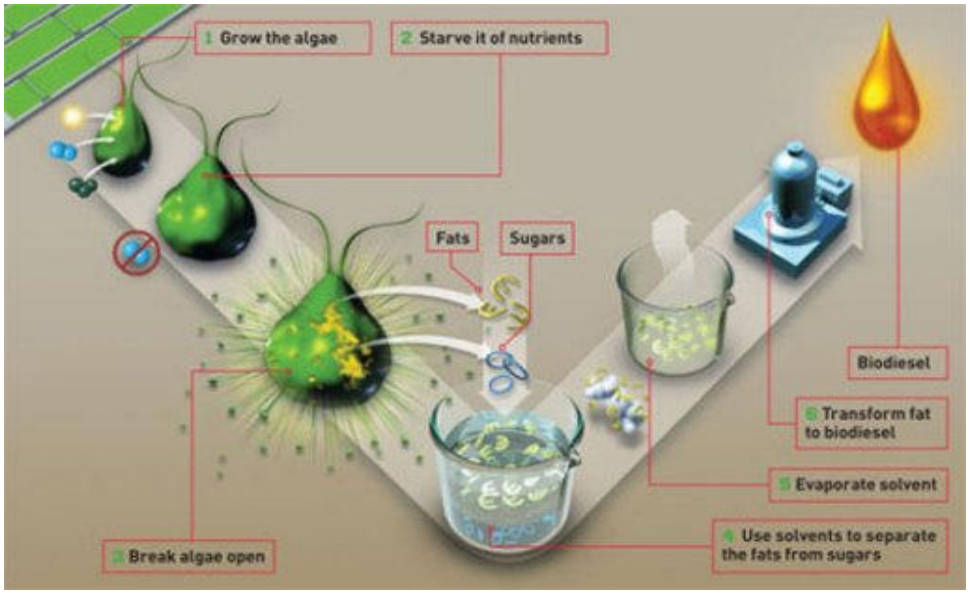
Current pathways and market

3rd generation biofuels - State of the art

- **Main goal : obtain oil from new biomass resource without food/land competition, to produce biofuels like biodiesel and biojet**

- **Several advantages**
  - **High yield potential per ha (x15 vs. rapeseed today and theorically x30)**
  - **Lower competition with the food/feed sector, no agricultural land required**
  - **Easier and faster growing**
    - No phytosanitary inputs
    - No constraint on rotation
    - Growing in open or closed environment
  - **Possible coupling with an industrial source of CO2**
  - **Numerous valuable coproducts**



- **But today: more than 100 stakeholders, just few labs able to supply few liters of algae oil**

  - Uncertainty on cost issues

  - Uncertainty on energy balance

  - Technology under R&D status

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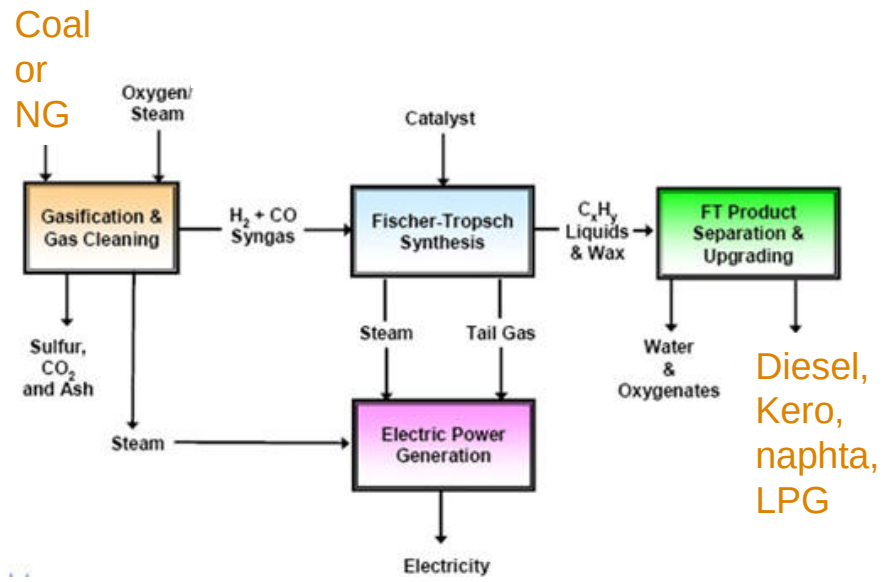
Current pathways and market
FT synthetic fuels : GtL and CtL

- **Commercial plants for GtL**
  - In Asia (Malaysia - Shell), in Qatar (2007 – Sasol & Qatar Petroleum)
- **Announced projects GtL**
  - 2010: 100 000 b/d
  - 2020: 1 million b/d capacity (Malaysia, Qatar, Uzbekistan, Nigeria)
- **Announced projects CtL**
  - 2030: 750 000 b/d capacity (China, Philippines)
- **Plants located in regions where NG or coal resource is abundant and inexpensive (**Middle East or North



- **Synthetic fuel's combustion is much cleaner than conventional fuel combustion, near-absence of sulfur and aromatics**
- **But Well-to-Wheels GHG emissions result : GTL~ 15% higher than conventional diesel fuel and CTL~ 130% higher than conventional diesel fuel (JEC 07).**
- **The cost of CtL could be competitive, even if it will be impacted by CCS and transport cost**

Current pathways and market
LPG - State of the art

- **Production/distribution**
  - In 2008, world LPG consumption reached 238 million tonnes (South Korea, Japan, Poland, Turkey, Mexico, ...)
  - Production and distribution mature
  - Limited resources to increase the actual consumption
  - In the European Union, LPG is mainly consumed in Poland

- **Vehicle technology**
  - The main advantage of LPG vehicles is a reduced environmental impact compared to gasoline and diesel (devoted vehicles)
  - LPG engines are quite similar to gasoline engines
  - LPG vehicles suffer from a bad public opinion, due to safety issues
  - No particular improvements expected

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Current pathways and market

CNG and biogas internal combustion engine development

- **Production/distribution**
  - **Consumption in the world : market has jumped from 1.7 million to 8 million vehicles around the world since 2000 (Pakistan, Argentina, Brazil, India, Italia, ...)**
  - **to develop a natural gas market as a fuel in transportation, distribution has to be improved**
  - **dedicated biogas pipelines: expensive**
  - **injection into the natural gas pipeline grid:**
    - the biogas must be cleaned: H_2O and H_2S have to be removed
    - and then it must be upgraded to natural gas quality : CO_2 is removed

- **Vehicle technology**
  - CNG has a lower cost of production and storage compared to LNG (no expensive cooling process and cryogenic tanks).
  - But CNG requires a much larger volume to store the same mass of gasoline or petrol and uses of very high pressures.
  - Main advantage of CNG vehicles : a reduced environmental impact compared to gasoline and diesel fuel, mostly if gas comes from biomass digestion (CBG)
  - Natural gas engines : the major challenge is to tailor the combustion system to a natural gas dedicated alimentation.

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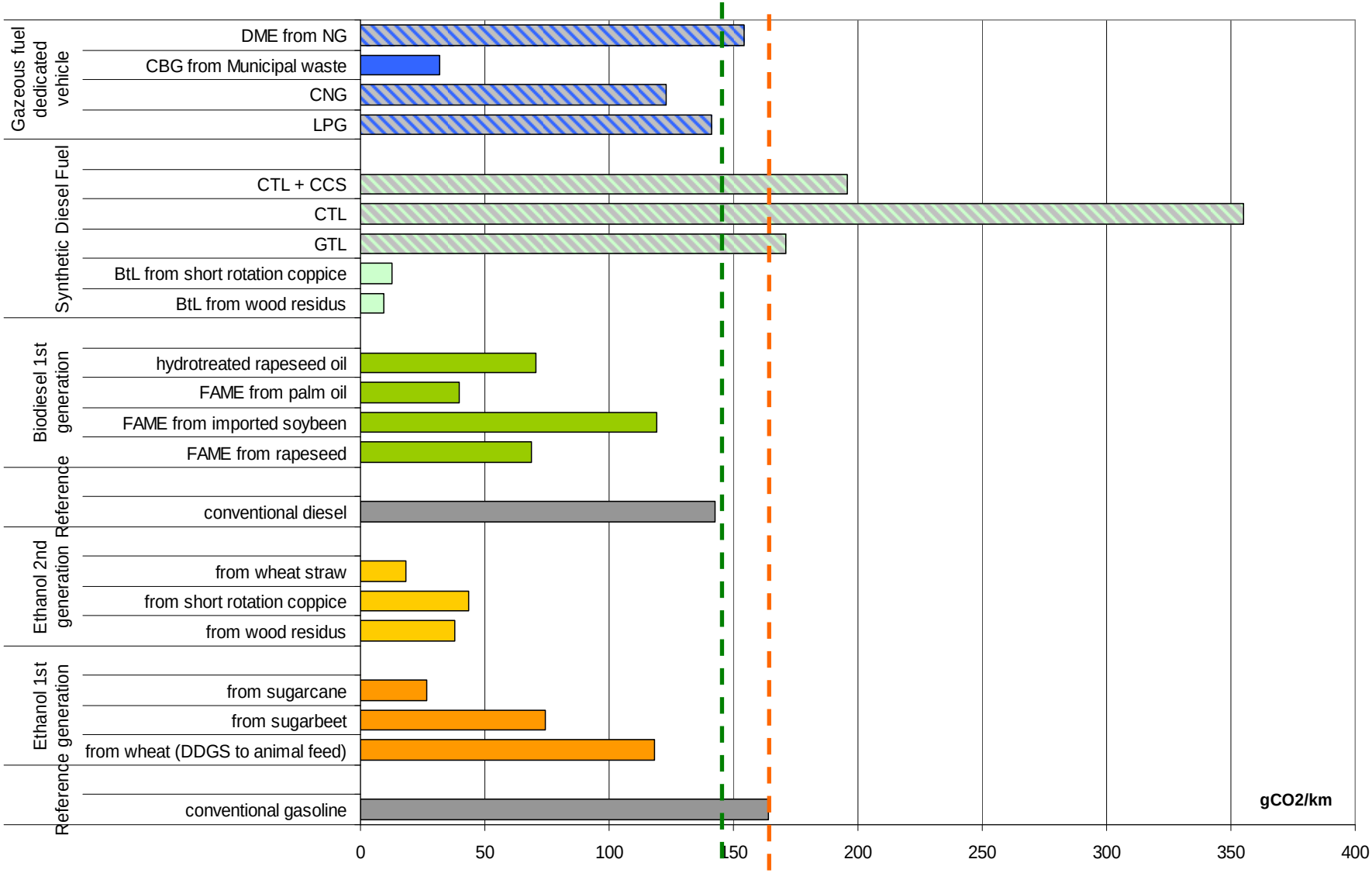
Current pathways and market
GHG Balance of alternative fuels

JRC-EUCAR-Concawe, 2007



Current pathways and market

Hydrogen production and use in vehicles (fuel cells and ICE)

- **Production/distribution**
  - **Main issue : which production route for hydrogen ?**
  - **In Europe, focus on two main pathways :**
    - Hydrogen from electrolysis using nuclear electricity
    - Hydrogen from electrolysis using renewable energy (wind, in particular offshore)
  - **Other pathways :**
    - Need CCS for fossil resources pathways
    - Are less likely to be developed, such as H_2 from thermo-chemical cycles
  - **creation of a distribution network**
- **Vehicle technology**
  - **Hydrogen internal combustion engines**
    - ICE with H_2 alimentation exist (BMW)...
    - ...but they still can be optimized in regard to environmental impact and efficiency.
  - **Fuel cell vehicle**
    - fuel cell reformer technology
    - improved hydrogen storage (compressed/liquid/other?)

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Three main topics

- Why Alternative Fuels?
- Current pathways and market
- **Upcoming Potential and development issues**

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Potential and development issues
Jet fuel under CO_2 constraints

- **June 2009: IATA took a landmark decision to adopt a set of ambitious targets to mitigate GHG emissions from aviation:**
  - **an average improvement in fuel efficiency of 1.5% per year from 2009 to 2020;**
  - **a reduction in CO2 emissions of 50% by 2050, relative to 2005 levels**
    - **IATA has set a target to be using 10% alternative fuels by 2017 : ~30 Mtoe or 0.63 Mbdoe**

- **Alternative fuels to substitute conventional jet kerosene consumption**
  - **stringent specifications for jet fuels**
  - **short term solutions:**
    - **Synthetic jet fuels (GtL, CtL)**
    - **HVO from non edible vegetable oils (jatropha, camelina...)**
  - **middle to long terme solutions:**
    - **Bio synthetic jet fuel (BtL)**
    - **HVO from algae oil**

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Potential and development issues
Ambitious Biofuel policy

- **European Union**
  - **Indicative target in 2010: 5,75%**
  - **Mandatory target in 2020: 10% of renewable fuels**

- **USA**
  - **7,5 billion gallons by 2012 (5-6%)**
  - **36 billion gallons by 2022**

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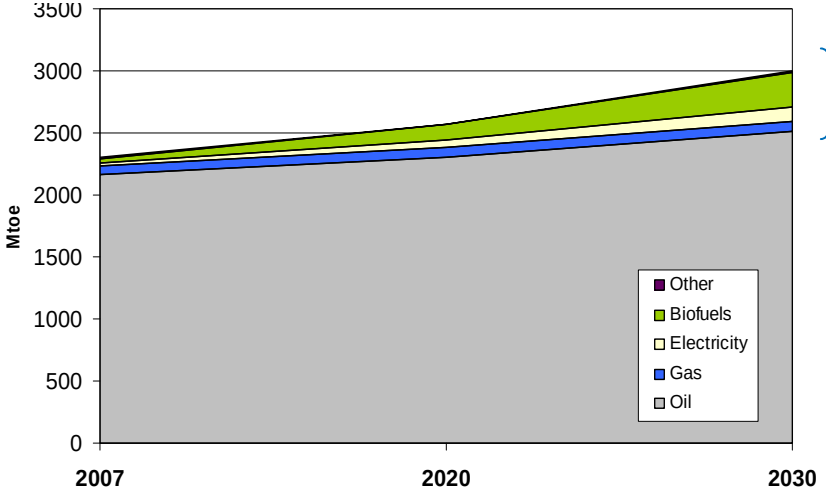
Potential and development issues
Prospect development scenarios

World transport energy consumption by fuel
(WEO 2009 – CO2 constraint scenario)

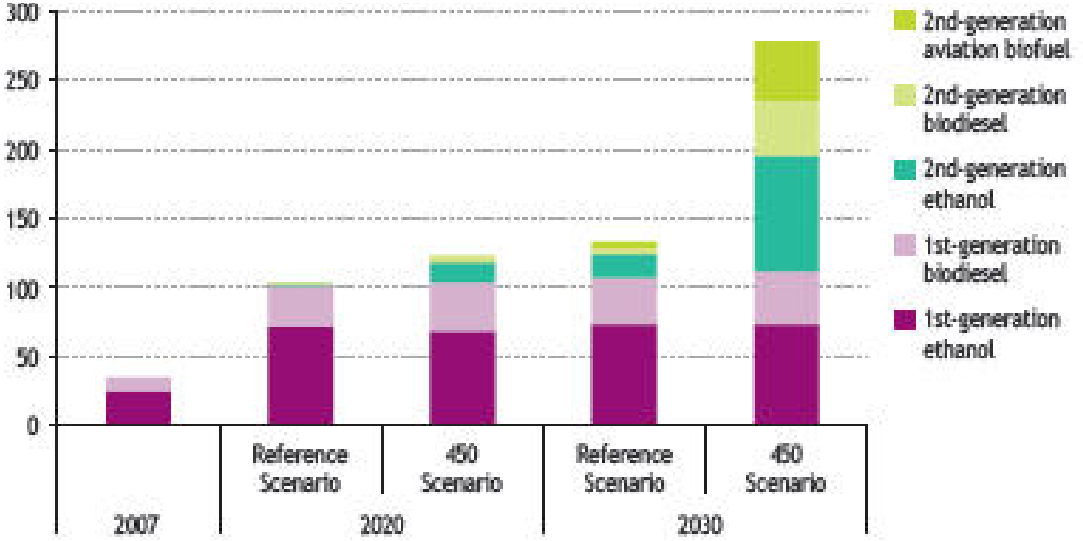


485 Mtoe alternative fuels
=
16% of energy demand for transport in 2030

Biofuel development level between 139 and 278 Mtoe by 2030 (11% of road transport fuel). They make up almost 15% of aviation fuel in 2030.

166 Mtoe of second generation biofuels in the most optimistic scenario

Biofuels demand by type and scenario (WEO 2009)



Potential and development issues
Prospect development scenarios

- **But attention will have to be paid to …**
  - **Land availability, and possible conflicts of use (food)**
  - **Water availability, and possible conflicts of use**
  - **Deforestation and biodiversity impacts, soil erosion**
  - **Socio-economics (agriculture and agrobusiness issues)**

  ...to avoid reducing GHG balances

- **But biomass and land availability are not unlimited**
  - **13 Gt ~ 5,6 Gtoe primary energy potential of biomass (1% of coal reserves)**
  - **Availability and economic constraints to remove**
  - **R&D programmes necessary**

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Potential and development issues
Electric and plug-in hybrid vehicles

- **Production/distribution**
  - **production and distribution are in place (Mature pathway)**
  - **but some questions about "raw material" for battery (eg Li) including recycling potential**
  - **electric grid available but WtT power generation: key for global CO2 impact**

- **Vehicle technology**
  - **electric motors have a potential for improvement both in performances and packaging**
  - **advanced batteries and supercapacitors will improve the performances and autonomy of the vehicles (higher power output and more energy storage, quicker recharge)**
  - **Extra cost to review the business model of vehicle**

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Conclusion

- **Fuels from Coal have high potential in term of availability and economic advantage, but environmental benefits are limited**
- **Gaseous fuels could have a significant contribution with a limited development in short terms for specific fleets (except in NG production countries)**
- **Biomass potential could be significant but important issues on competition for lands and products; means to produce biomass have to be regulated.**
- **Necessary establishment of sustainability criteria for bioenergy and certification system to ensure GHG balances announced**
- **No fuel miracle but a mix of complementary products in terms of economic, environmental and social issues, ensuring sustainable mobilization of resources**
- **And a mix, which will be directly dependent on evolution of customer behavior, vehicle models and mobility models**

Thank you for your attention

daphne.lorne@ifp.fr

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