Experience on Clean fuels in Europe

Michel Rouyer – Nairobi – 23 June 2011
Scope

- Evolutions of fuel quality
- Example of sulphur emissions
- Evolution of exhaust gas emission specifications
- Evolution of fuel specifications and their justifications
- Consequences of these evolutions on refining
- Conclusions
Environment and Sustainable Development: a worldwide evolution

**World**
- From Rio in 1992 to Johannesburg in 2002
- Kyoto Protocol in 1997

**North America**
- Clean Air Act
- Corporate Average Fuel Economy
- New fuels
  - LPG, bio-ethanol, NGV

**Europe**
- Auto Oil I & II
- Clean Air For Europe
- Alternative fuels
  - LPG, Biofuels, NGV, H2

**Africa & Asia**
- Africa: unleaded
- Asia: less sulphur

**South America**
- Many national environmental programs
- Use of alternative fuels (Argentina / Brasil)
Fuel Quality in Europe

Key driver: Air quality in Europe (CAFE program)

- Cost Benefit Analysis on the consequences of a reduction of emissions from the transport sector
  - Dataset of European emissions inventories
  - Use of a model to calculate the exposure of the European population to the pollutant concentrations
  - Estimation of the health impact in monetary terms and comparison of the different scenarios

Evolution of fuel quality

  - Key fuel parameters to reduce exhaust emissions: Auto-Oil 1
  - Key fuel properties to allow advanced exhaust gas after-treatments: AO 2
- 2005 → …..: “Low carbon fuels”
  - Lower consumption and non-fossil fuels
Example of $\text{SO}_2$
How to reach SO2 emission objectives

Emission limits
Stationary Sources
1700 mg / Nm3

- Use of Residual Fuel VLS < 1 % Sulphur
- Flue gas desulphuration
- Mix Combustion HFO LS / Gas

Vehicles

- Desulfuration of motor fuels
Evolution of Sulphur specifications in Motor fuels

Example of GO

Sulphur content in %

2008 : 10ppm
Consequences of these evolutions on SO2 emissions in France

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Evolution of the specifications of vehicles tail gas emissions
Reduction of the emissions from transport: a worldwide effort …

Emissions (HC, CO/10, Nox)

⇒ A strong impulse from USA (Clean Fuels Act) and Europe (Auto Oil)
⇒ Measures also taken in South America and Asia to switch to no-lead and less sulphur
A multiplication of technological innovations since 1970 have allowed this evolution

Gasoline engine:
- Multi-valves motors,
- Electronic & Direct injection,
- Post-treatment of exhaust gas using 3 ways catalysts,
- Recycle of exhaust gas (EGR) : NOx reduction

Example of 3 ways catalyst
The fantastic progress of diesel engine ....

- Common rail direct injection,
- Oxidation catalyst
- Diesel Particulate Filters (VL), Urea (PL)
- EGR

Example of Particulate filter (source PSA)
Diesel Particulate Filters (DPF) : drastic PM Emission Cuts

PM emissions – NEDC cycle

- Car A: without DPF
- Car B: with DPF
- For broad range of fuels
... with consequences on pollutants emissions during the last 30 years

These improvements could not have been made without the evolution of fuels:
⇒ Lowering sulphur in fuels for example opened the way to post-treatment...
Main evolutions of fuel specifications and justifications
Main evolution of fuel specifications in Europe to reduce vehicle emissions

- Introduction of unleaded gasoline during the 80’s
- Since 20 years, the improvement has mainly be the drastic reduction in sulphur levels

<table>
<thead>
<tr>
<th>Max Sulphur (in mass ppm)</th>
<th>Unleaded gasoline</th>
<th>Diesel</th>
<th>Heating oil</th>
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<tr>
<td>2009</td>
<td>10</td>
<td>10</td>
<td>1000</td>
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</tbody>
</table>

- The other changes are mainly for unleaded gasoline with levels for:
  - benzene lowered from 5 %vol to 1 %vol in 2000,
  - total aromatics, limited to 42 %vol in 2000, then to 35 %vol in 2005.
The European effort to improve fuels quality

- Need to adapt the refineries and the logistics to certify the quality of products
- Tax incentives speeded up the introduction of the new specifications
Why to reduce sulphur ....

- **In gasoline**
  - Sulphur reduces the efficiency of vehicle exhaust system oxidation catalysts. Reductions in sulphur will provide immediate reductions of emissions from all catalyst-equipped vehicles.
  - Sulphur also adversely affects heated exhaust gas oxygen sensors.

- **In gasoil**
  - SO$_2$ is the main sulphur compound emitted from the engine.
  - In catalyst-equipped vehicles, the conversion of SO$_2$ to sulphates (SO$_4$) increases. The sulphates and associated water coalesce around the carbon core of exhaust particulates and increase the mass of the emission of particulate matter (PM)
  - The fuel sulphur can reduce the performance and durability of the DPF system.
  - Sulphates can also gradually block the filter
and other pollutants

- **Benzene level in gasoline**
  - The objective is to minimise emissions of benzene at the exhaust and by evaporation

- **Total aromatics content of gasoline**
  - Lower aromatics reduce emissions of carbon monoxide and hydrocarbons

These changes in the specifications have been done in close concert with the car manufacturers in order to guaranty a proper operation of the motors
These evolutions have consequences …
A major reduction of emissions ....

- Significant improvement during the past decade for all the referenced pollutants ....
- .... but significant increase of CO2
- Strong contribution of the fuels due to the Auto-Oil programs
- Low sulphur fuels paved the way to new technologies that allowed emission reductions from vehicles
- Most of the work has been done on pollutants and room for improvement is now very limited

Since 2005 the objectives of the regulator have changed:
- Control of GHG emissions
- Security of supply
  ⇒ Time is now to alternative fuels and especially bio-components
and consequences for the refining industry

- Increase of CO2 emissions
- For the whole European refining, the total investment costs are high
  - About 20 Geuros for Auto-Oil 1
    (source Concawe)
  - For Auto-Oil 2:
    - 10 G USD to adapt to 50 ppm S
    - + 6 G USD to change from 50 to 10 ppm S
    - Together with a 20% increase of the operating costs
      (source Wood-Mackenzie)

The expected environmental benefits require the introduction of new vehicle technologies
Conclusions
The evolution of fuel specifications ....

- Evolutions of the specifications must
  - be both cost-effective and scientifically justifiable
  - target emission limits designed on the basis of local air quality needs, as it was in Europe
  - consider certain basic parameters (e.g. Lead and Sulphur) on which there is widespread agreement regarding their ability to compromise emission control devices
  - take into account the adequacy between fuel and motor

- A global numeric standard, based on Europe situation, is potentially misleading. It may not necessarily be cost-effective for the countries concerned to adopt it, depending on their local air quality issues.
must be managed carefully

Specification evolution is a must to both
  - address the health issues
  - stay in business: need to have fuels marketable

Specification evolution leads to huge investments with very limited/no hope to improve margins

So they have to be carefully planned on a long period to give time enough to the countries to adapt their refining tool and find a financing. It took 30 years in Europe.

Present evolutions must also consider other factors such as:
  - Climate change
  - Diversification of energy sources
  - Interest for bio-components
THANK YOU
FOR YOUR ATTENTION