LATIN AMERICA THEMATIC NETWORK
ON BIOENERGY
LAMNET

BIOFUEL FOR TRANSPORT

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In the next 20 years the expected growth of the world economy will increase the demand of oil, in particular for transport (source Exxon) from ~85 million barrels/day to the huge value of ~ 330 million barrels/day (8 times the Saudi-Arabian capacity).

For the transport sector depending now for 100% on oil) a contribution to this immense energy supply volume will be provided by the **alternative liquid fuels** derived from natural gas (but with an energy loss for conversion of ~ 45% and thus significant decreasing CO_2 emissions) and at medium-long term from **biofuels** some of which (as can seen from the enclosed table) have the technical-economic potential to cover most of the medium term needs with a large impact on rural development (new jobs) and great benefits for the environment (zero CO_2 emissions, no SO_2 emissions for optimised closed bioenergy complexes).

TABLE I: World crude oil total gross consumption (year 2000) in MTOE/y

equal to 35 % of the total primary energy consumption = 9.978 billion TOE

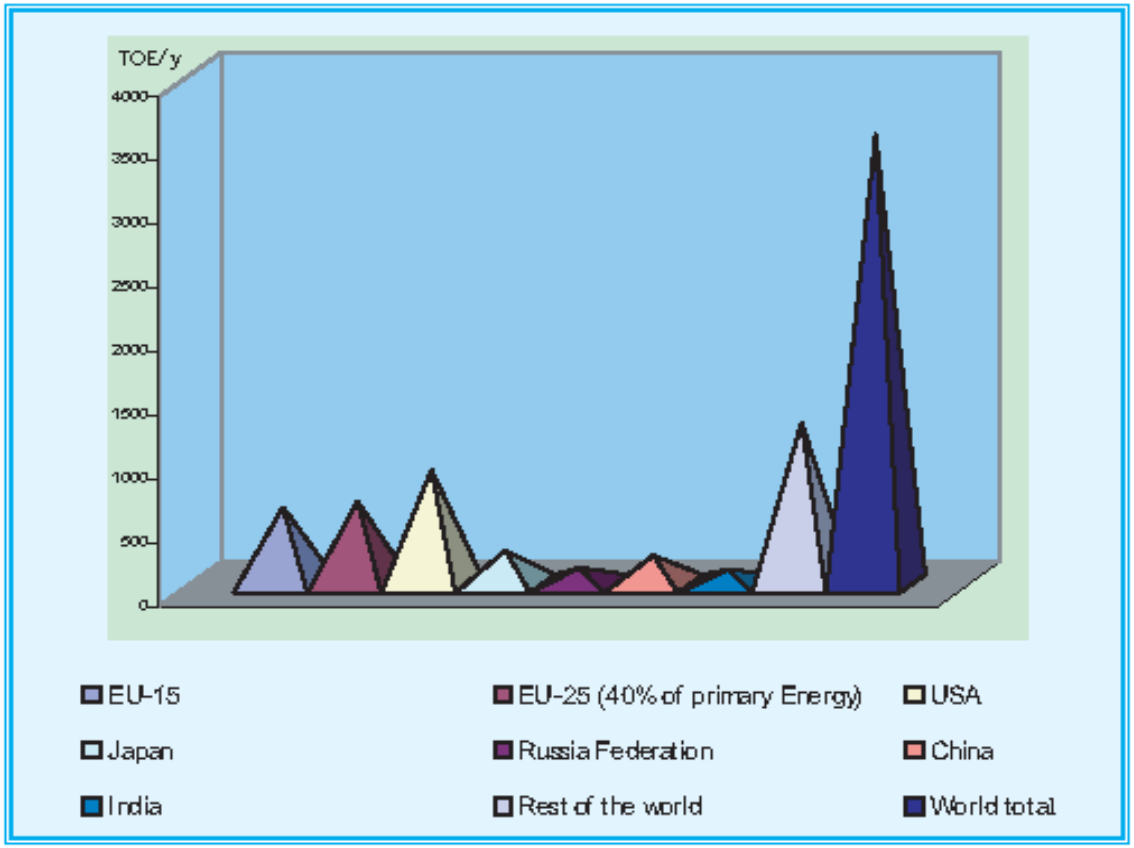
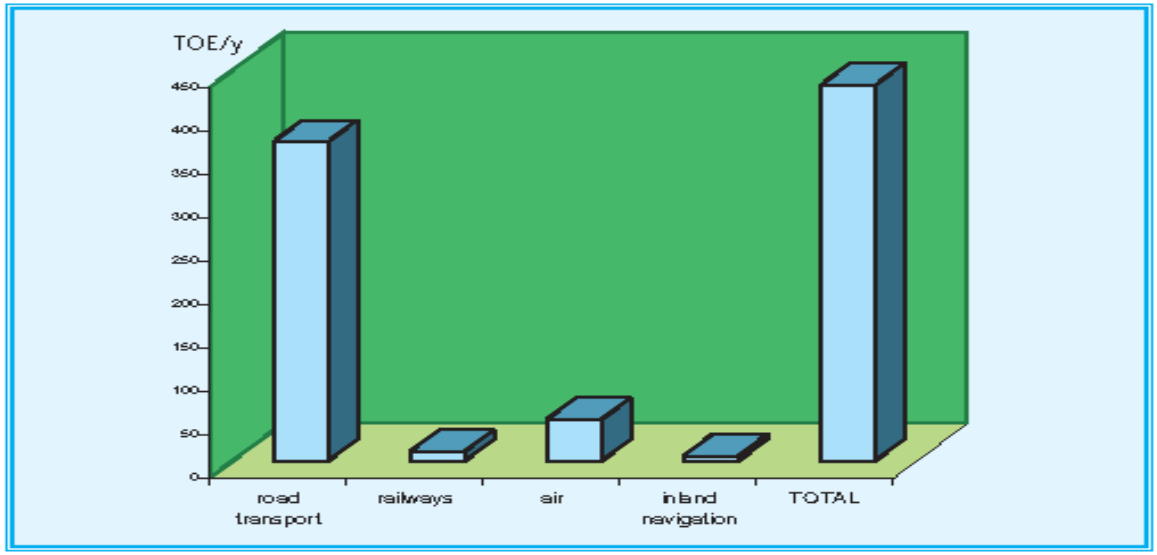


TABLE II: EU-25 crude oil total gross consumption (year 2000) in MTOE/y

- The EU–25 oil import dependency is 76,5%;
- 83% of total oil consumption (535 MTOE/y) is used for energy;
- The non-energy consumption is 110 MTOE/y
- The oil consumption for transport in MTOE/y is as follows:



The present EU oil refining capacity is:

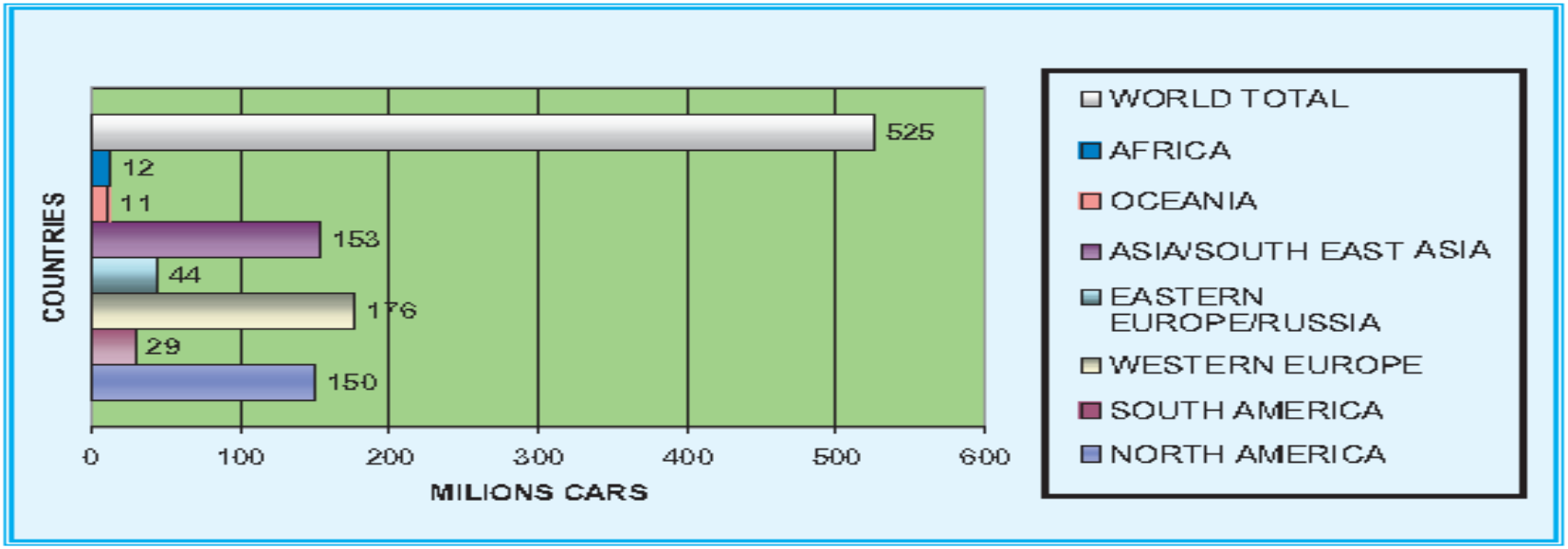
ATM distillation:	**668 MTOE/y**
Vacuum distillation:	**256 MTOE/y**
Reforming:	**90 MTOE/y**
Hydrocracking:	**40 MTOE/y**
Catalytic craking:	**108 MTOE/y**
Vis breaking & thermal crak:	**81 MTOE/y**
TOTAL:	**1,243 MTOE/y**

Energy losses for transport products refining is: ~ 10% for gasoline and ~ 20% for diesel.

Evolution of world car park and transport fuel consumption

Road transport represents a challenging future task due to its high share of total transport volume fuel consumption and to the large expected increase in number of vehicles world-wide as shown in table III:

TABLE III: World car market (year 2000)



- 390 million cars in industrial Countries: urban population, 727 million
- 135 million cars in developing Countries:rural population, 2,166 billion
- Present world car market: ~ 55 million cars/year
- **World total number of cars** (estimate for year 2020): **1.2 billion**

This huge increase (world-wide) of the number of cars will require a large increase of transport fuel consumption, from 2.1 to 3.4 billion TOE/y, as indicated in the following table.

TABLE IV: Evolution of world transport fuels consumption (MTOE/y) (source IEA / ISBN 92-64-01512-4)

	Year 2000		Year 2020	
	Gasoline	Diesel	Gasoline	Diesel
North-Central America	561	242	778	293
South-America	30	34	56	56
Brazil	24	3	50	61
Europe + Russia	242	333	386	439
Asia	186	253	397	469
Asian Countries	30	60	63	111
India	8	43	22	100
Africa	30	34	65	65
TOTAL world	1,111	1,002	1,817	1,594

Biofuels could provide a significant contribution

EU taxation on transport fuels (**year 2004**):

- gasoline: 0,350 €/l (minimum)
- diesel: 0,302 €/l (minimum)
- V.A.T.: 15% - 25%

Biofuels for transportation

TABLE V: Production targets of biofuels in the EU (EU Directive 2003/30/CE)

YEAR	Targets (not mandatory) in MTOE/y
2000	~ 0.9
2005	~ 5 (2% of total)
2010	~ 17 (5.75% of total)
2020	~ 37 (new target under evaluation)

The long-term world-wide technical estimated potential of biofuels for the transportation sector are indeed very large i.e. **7-10 billion TOE/y** (Table VI), but their penetration on the transportation fuel market will depend mostly of their competitiveness (in energy terms) in

comparison with conventional fuels (gasoline-diesel); their industrial cost in the EU is (in July 2004 for oil at 40 $/bbl):

350 – 450 €/TOE
(variation according to the EU Countries)

with a structure of average supply final cost at refuelling station (before taxes) as follows:

0.20 €/l	(cost of oil)
0.05 €/l	(transport by ship)
0.09 €/l	(refining cost & loss of fuel)
0.07 €/l	(delivery by truck to refuelling St.)
0.41 €/l	(~ 540 €/TOE) **(1 bbl = 159 l)**

BIOFUEL YIELDS (TOE/ha):

Bioethanol (average productivity):

- Sugar cane-sweet sorghum: 3.0/4.2
- Sugar-beets: 3.5/4.5
- Corn : 1.5/2
- Wheat: 1.2
- Potatoes: 1.8
- Lignocellulosic crops: 3/5

Biodiesel:

- Rape/sunflower: 1.2
- Palm oil: 2 - 5

Biomethanol from energy crops:

- S.R.F.: 2.4
- Herbaceous crops: 4.5

Dimethyleter: 1.8 - 3.7

Bio – Hydrogen: 2.4 ÷ 4

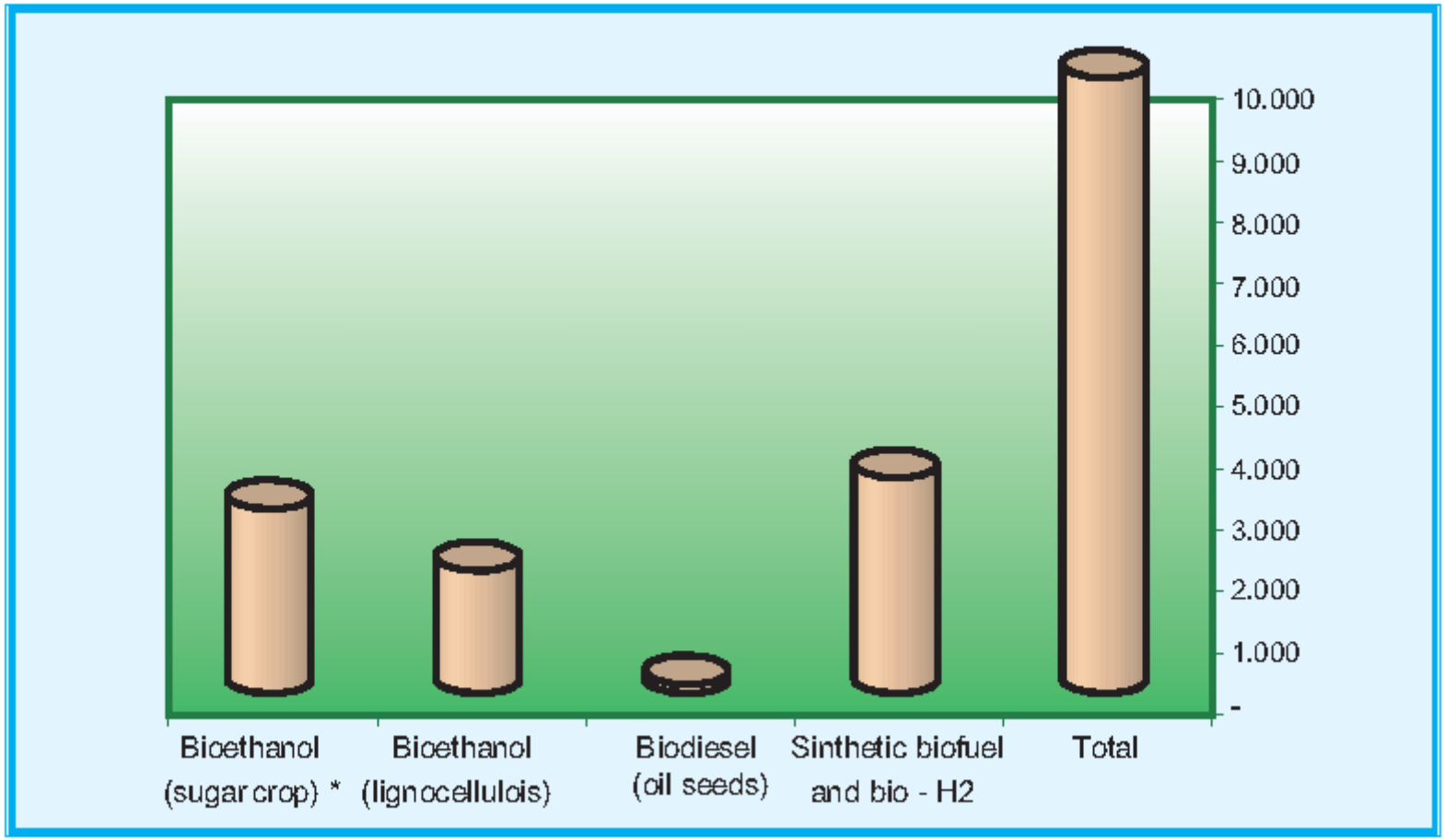
Among the different existing biofuels, **bioethanol appears to be the most promising** in short, medium and long term for the following reasons:

1. It is a refined high quality energy carrier with specific energy content ~ 70% of gasoline.
2. It can be utilized as blending component of gasoline (or diesel fuel in small amounts: 3%) or for gasoline reformulation (ETBE) acceptable in conventional vehicles as well as in the new **Flexible-Fuel-Vehicles** (FFV) able to run on any mixture of gasoline and ethanol. These FFV constitute a breakthrough in the transition towards dedicated ethanol-fuelled vehicles (under development but not yet commercial) that once optimised should present an efficiency increase of 7% in comparison with gasoline vehicles (6% if biomethanol is used).

CHARACTERISTICS OF BIOFUELS:

	Diesel engines				Otto engines				
	Diesel	Bio-diesel	DME	F-T diesel	Gasoline	Ethanol	ETBE	Methanol	MTBE
Chemical formula	$C_{12}H_6$	Methyl ester	CH_3O-CH_3	Paraf-fins	C_8H_{15}	C_2H_5-OH	$C_4H_9-OC_2H_5$	CH_3OH	$C_4H_9-OCH_3$
Cetane number	50	54	55-60	> 74	8	11	-	5	-
Octane number (MON)	-	-	-	-	86	92	105	92	100
Density (kg/l)	0.84	0.88	0.67	0.78	0.75	0.80	0.74	0.79	0.74
LHV (MJ/kg @ 15∞C)	42.7	37.3	28.4	44.0	41.3	26.4	36.0	19.8	35.2
Stoich. air / fuel ratio (kg/kg)	14.5	12.3	9.0	-	14.7	9.0	-	6.5	-
Oxygen content (wt-%)	0-0.6	9.2-11.0	-	~ 0	-	-	-	-	-
Kinematic viscosity (mm^2/s)	4	7-4	-	3.6	-	-	-	-	-
Flash point (∞C)	77	91-135	-	72	-	-	-	-	-
Boiling temperature	-	-	-	-	30-190	78	72	65	55

TABLE VI: Biofuels long-term (2050-2100) world potential estimations (MTOE/y)



The FAO estimations of worldwide surplus land suitable for sugar-cane is ~ 1 billion ha.

ECONOMICS (estimation) €/TOE:

Bioethanol from:	NOW	LONG TERM
♦Sugar-cane	220 (Brazil)	200
♦Sugar-beets	750 (EU)	
♦Wheat	700 (EU)	
♦Corn	570 (USA)	500
♦Sweet-sorghum	350 (EU)	200-250
Biodiesel:	800 (rape seeds)	600-300
Biomethanol:	480	300
Dimethylether:	~ 600	400
F-T Diesel:	~ 700	400
Bio-H_2:	550-1,000	500

(For comparison the average industrial cost of gasoline-diesel fuel in the EU is ~ 400 €/TOE with oil at 40 $/bbl)

Among several biofuels, **bioethanol appears to be the most promising.**

Flexible Fuel Car