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TRAFFIC BIOFUELS: GHG EMISSIONS, ENERGY EFFICIENCY AND SUSTAINABILITY

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- A. Sustainability: global potentials and Brazilian example
- B. LCA emissions and energy efficiency of traffic biofuels

More info:

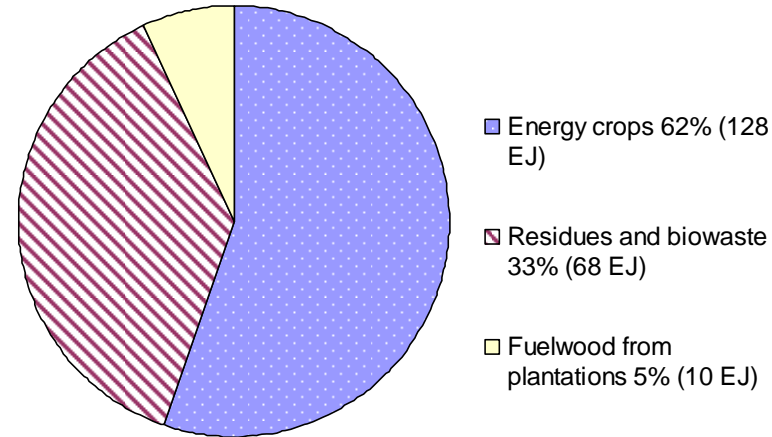
- in English: http://www.cc.jyu.fi/~ala/CR_bioenergy_survey.pdf
- In Finnish: <http://www.cc.jyu.fi/~ala/Maatalousenergia.pdf>

A. SUSTAINABILITY: GLOBAL POTENTIALS AND BRAZILIAN EXAMPLE

- Biodiversity concerns related to imported traffic biofuels should be taken seriously – but not let them block traffic biofuel use
- Traffic biofuel importing is a new phenomenon, started this decade by Brazil-USA ethanol trade
 - => opposed by the US crude oil industry after long traditions of lobbying against domestic biofuels, based on e.g. the famous Pimentel calculations started during the 1970's oil crises (and republished every few years) claiming that ethanol has negative energy balance, or that fossil fuel input for production is larger than biofuel output
 - => US campaigns against imported biofuels (but not against imported fossil fuels)
 - => biodiversity and other sustainability concerns raised (partly relevant, mostly disinformation)
 - => US campaign material flooding in EU via mass media and expert testimonies

Global ecological bioenergy potential in the UN RIGES scenario in 2050

(For the Rio Earth summit 1992, RIGES = Renewables Intensive Global Energy Scenario, Johansson et al. 1993)



Requirements:

- No deforestation of old-growth forests
=> neutral biodiversity impact, greenhouse gas (GHG) neutral
- Food production not compromised => negative biodiversity impact, GHG increase
- Uses only (with recycling of nutrients):
 1. Residues and biowaste from agriculture, forestry (not all residues), industry and human settlements (33%) => neutral biodiversity impact, GHG decrease
 2. Energy crops (62%, 400 Mha) from
 - Eroded agricultural soils => biodiversity positive or neutral, GHG increase
 - Excess agricultural lands => biodiversity neutral or positive, GHG negative or neutral
 3. Fuelwood from industrial tree plantations (5%) => biodiversity & GHG neutral

Substituting fossil fuels by biofuels => decreased global warming => positive biodiversity impact, GHG decrease

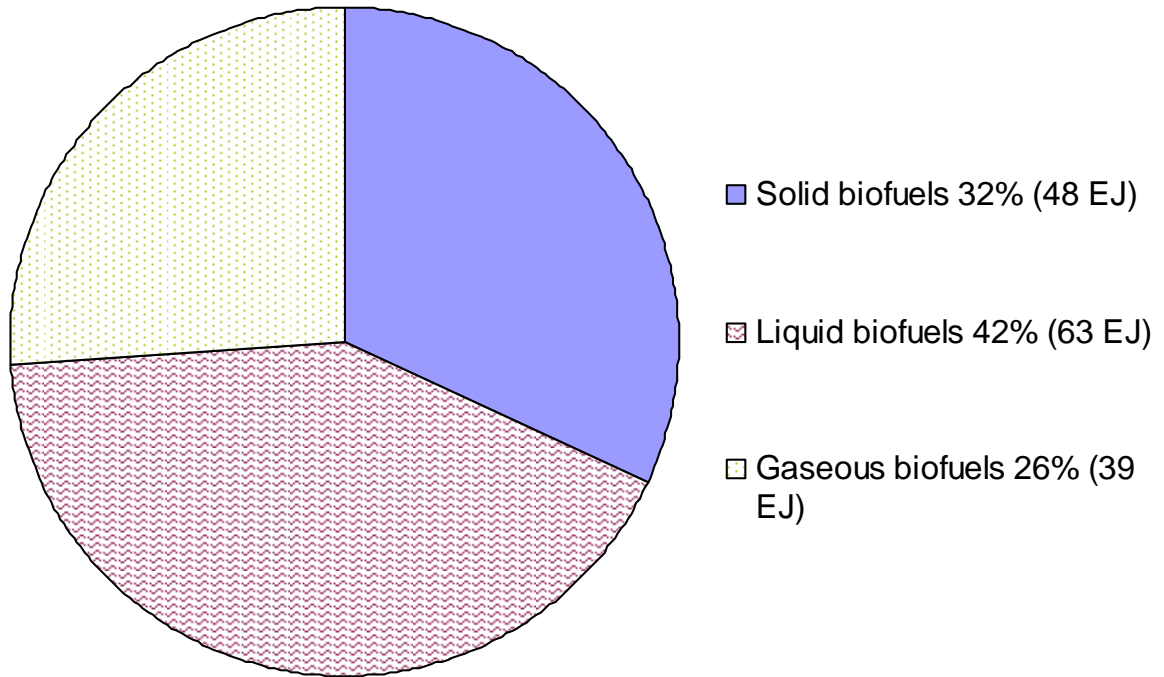
RIGES Bioenergy use:
only 32% used as solid
biomass

Current global primary
energy consumption:

- Transport 70 EJ
- Total 450 EJ

In 2050 (RIGES):

- Total 561 EJ
- Bioenergy 206 EJ



Additional renewable (transport) energy resources in 2050:

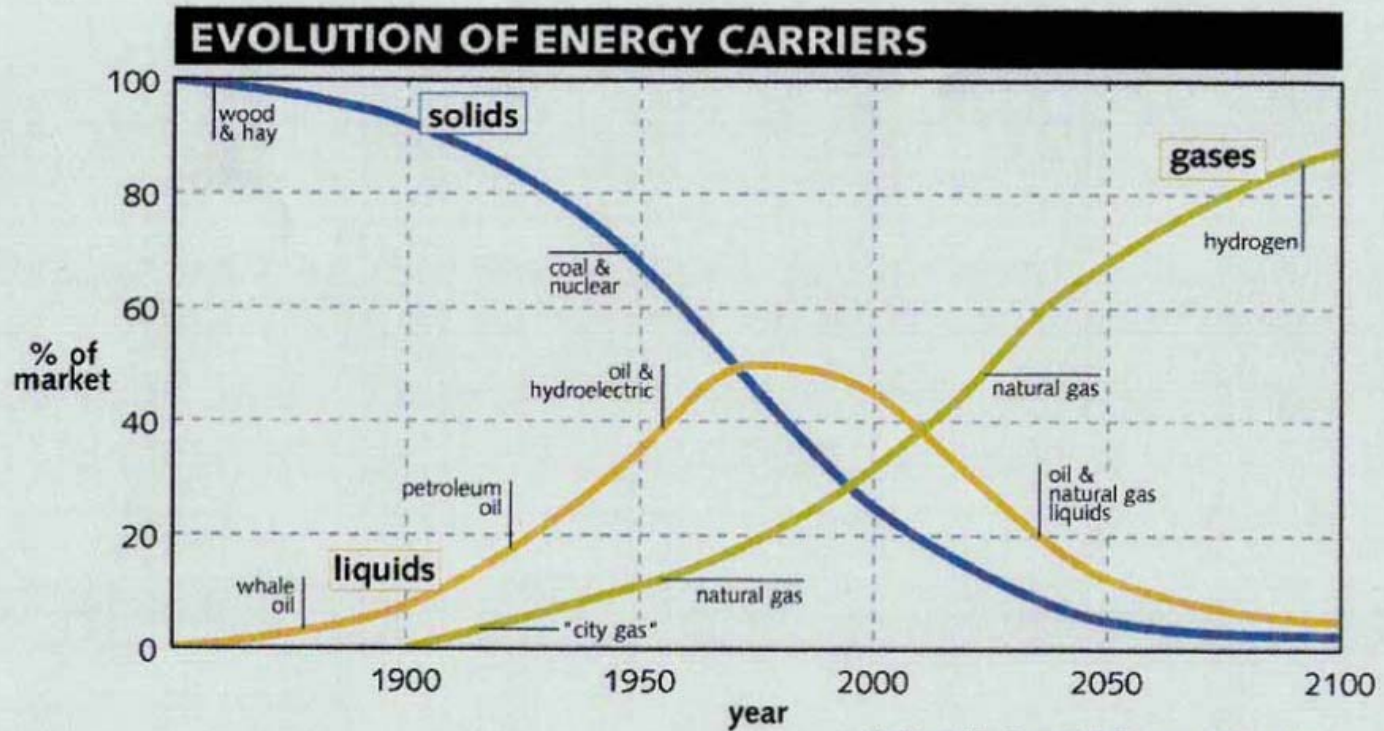
- Hydrogen (14 EJ) and electricity (34 EJ) production via intermittent renewables (wind, solar, wave, tidal?)
- Geothermal electricity (0,8 EJ)
- Hydroelectricity (17 EJ)
- Desert and ocean bioenergy resources (very large, but not included in RIGES)

Evolution of fuel use

Benefits of gaseous fuels:

- Highest efficiency of use
- Lowest emissions
- Most versatile: can be used in all kinds of heat engines and heat pumps

The Future: Gaseous Fuels



LCA emission comparison: Biogas vs. Diesel oil

<i>Emission [mg/MJ]</i>	CO₂	CO	NO_x	SO_x	CH₄	NMHC	Particles
Biogas, production and distribution¹	4 398	4.5	36	0.93	1.3	2.9	1.2
Biogas, End-use²	0	1.7	167	0	140	4.2	1.7
Biogas, total	4 398	6.2	203	0.93	141	7.1	2.9
Diesel, production and distribution²	3 500	2.0	31	19	2.0	33	1.0
Diesel, End-use²	73 000	11	720	1.6	6.0	11	11
Diesel, total	76 500	13.0	751	20.6	8.0	44	12.0

¹ C. Fredriksson and S. Bohlin (2004) ² S. Uppenberg et al. (2001)

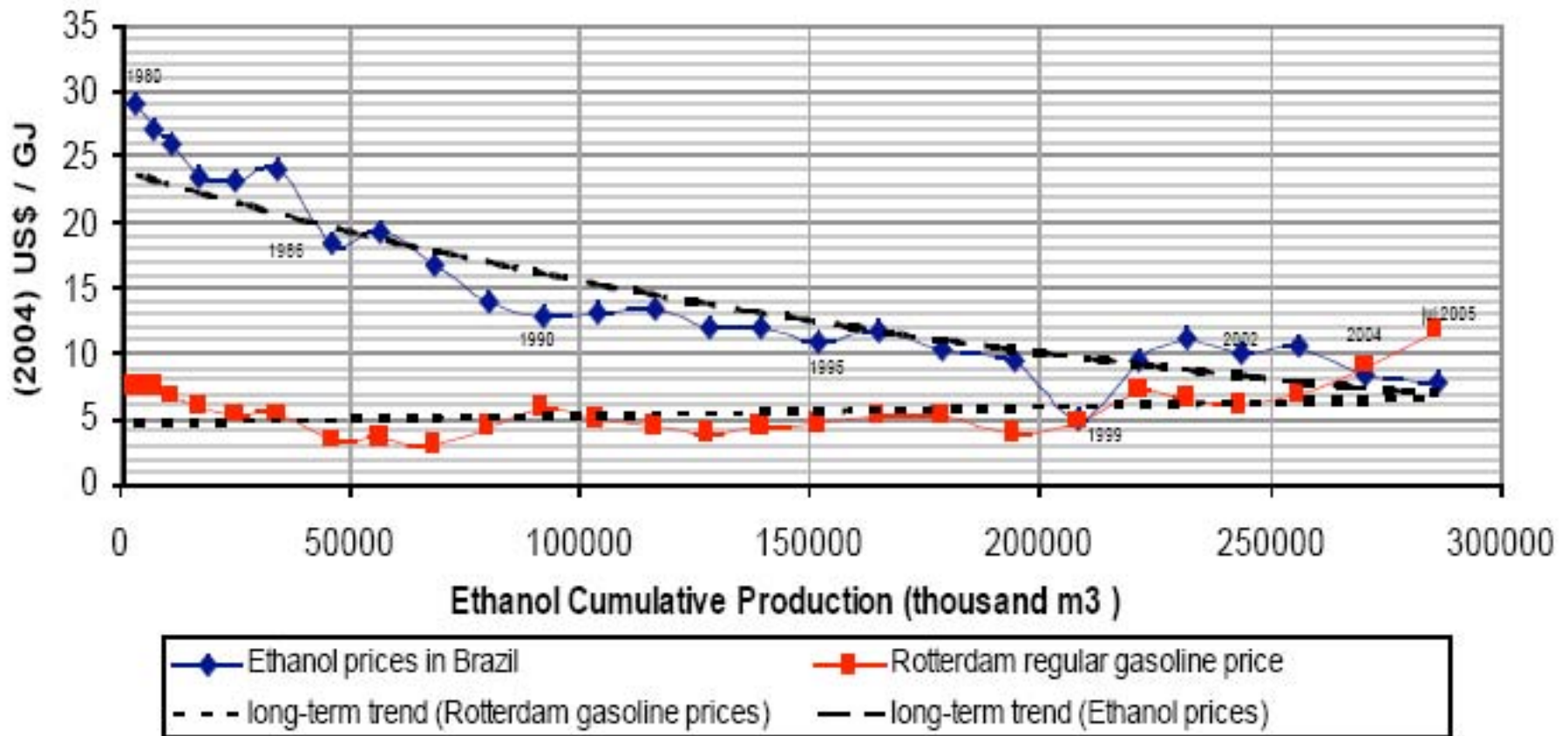
Brazilian example (e.g. for EU)

The Brazilian fuel ethanol programme (PROALCOOL 1975-) has been promoted by the UN (e.g. Rio 1992, Kyoto 1997, Johannesburg 2002 and Montreal 2005) as one of the world's best sustainable development practices

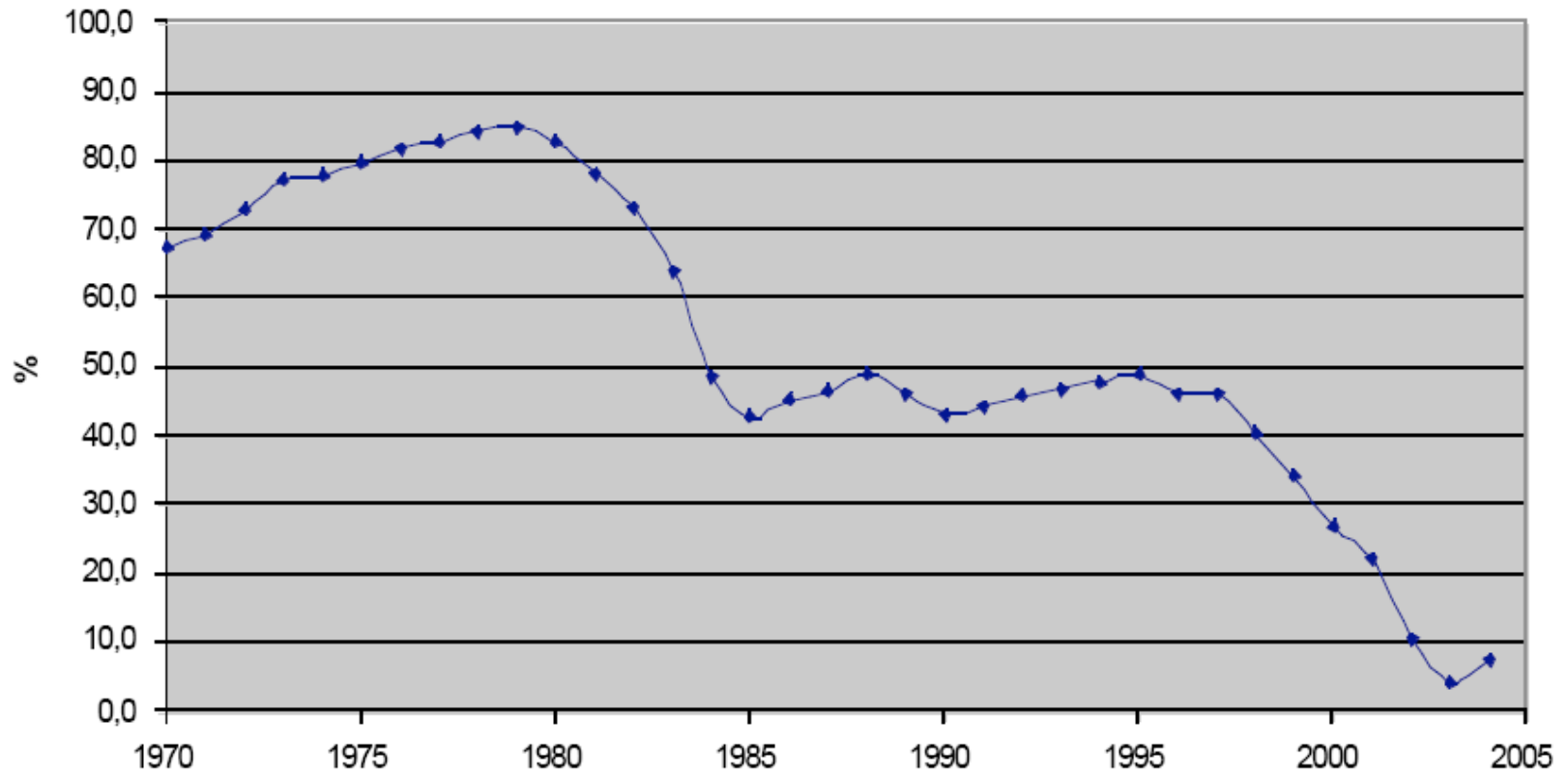
Why?

1. 700,000 new direct rural jobs created (350 private industrial units and 50,000 private growers) + 3.5 million indirect jobs (ethanol production employs 150 times more than gasoline production per produced energy unit)
2. \$50B savings in imported crude oil (10 times more than investments into ethanol production)

3. 80% decrease of the production cost since 1980 (very strong learning curve): now competitive with gasoline without subsidies (all subsidies removed by 1999), present production cost \$0.20/l = €0.24/gasoline equivalent liter



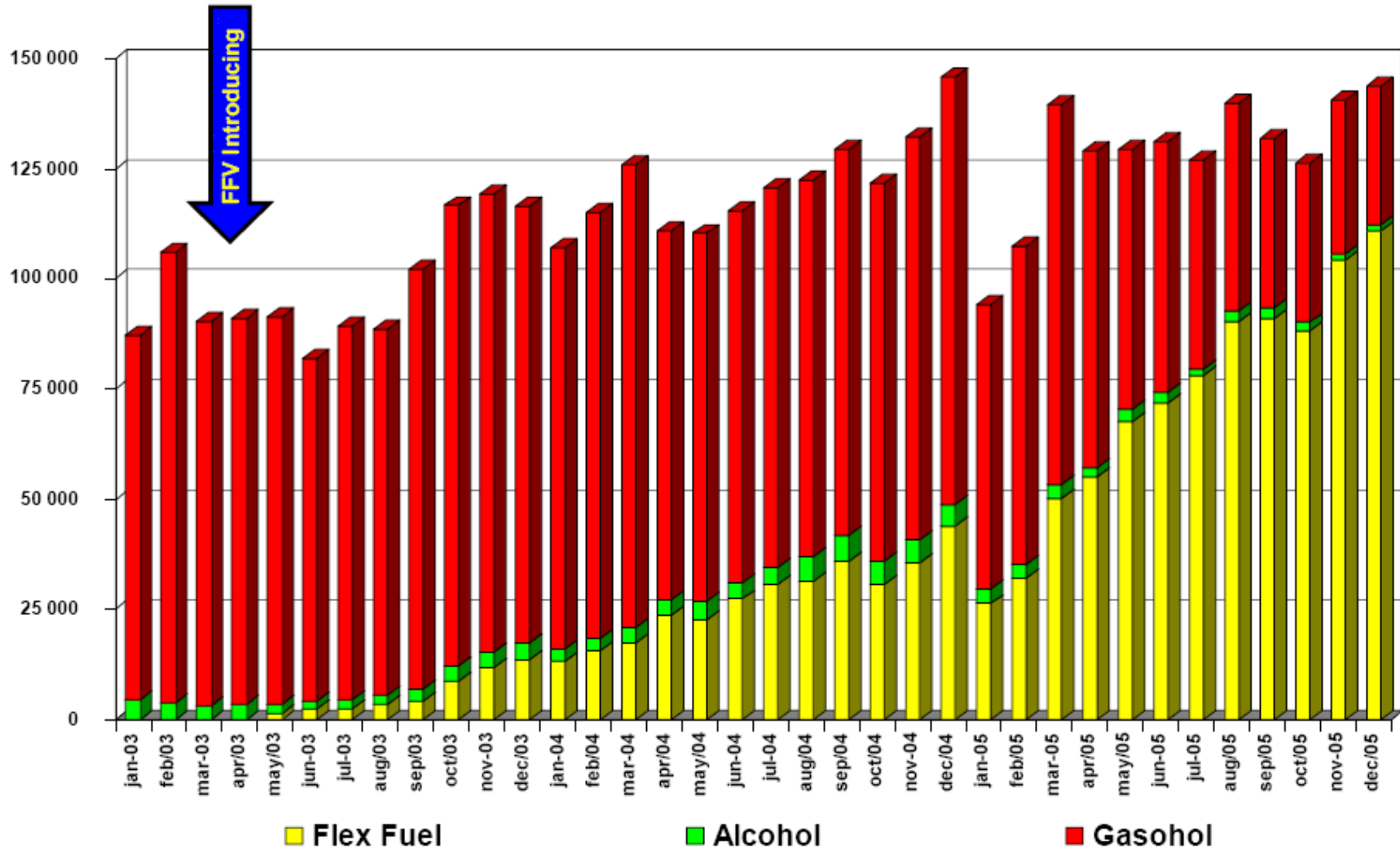
4. Oil self-sufficiency: Brazilian external oil dependence 1970-2004 (Coelho 2005)



5. Extremely fast diffusion of FFV technology (E100)

Monthly new car sales in Brazil

January 2003 to December 2005



Source: Henry Joseph Jr, VW Brasil



NOVO MOTOR
1.4
Flex

Chegou o novo Peugeot 206 1.4L Flex.
Finalmente um motor forte por um preço acessível.

CONHEÇA O CARRO



Msituarmos tduo e fziemos o bic mobutsível mias rápdio dsa rsua.



Novo Ford Fiesta 1.6 Flex. Um motor especialmente desenvolvido para ser o mais eficiente e potente da categoria. O ganho é comprovado chegando a até 11% de consumo. É o único que possui uma válvula de injeção eletrônica que proporciona menor consumo de combustível. E é o menos poluente do mercado. Novo Ford Fiesta 1.8 Flex. Outras vantagens que só o seu Ford Fiesta tem.

Novo Ford **fiesta**
FLEX



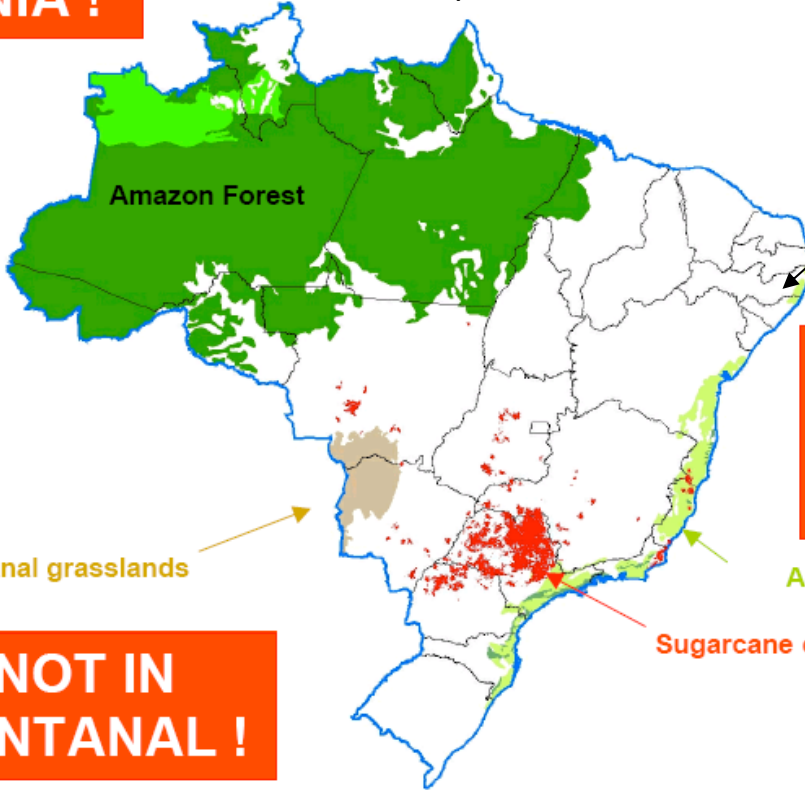
Fazer um Ford é responsável com

6. Sugar cane plantations for fuel ethanol production has replaced excess production areas (new deforestation forbidden by law):

- Sugar cane plantations for export sugar production
- Export coffee plantations and other export crop plantations, e.g. soya
- Grazing land for export meat production
- Degraded agricultural land

Sugar cane plantations for fuel ethanol production, 60% in state of Sao Paulo (Coelho 2005)

NOT IN AMAZONIA !



Site of the Finnish MOT "ethanol slaves" TV program, area where the Portuguese first introduced sugar cane for sugar production in the 16th century (no fuel ethanol production!)

NOT IN ATLANTIC RAINFOREST !

NOT IN PANTANAL !

Pantanal grasslands

Atlantic Rainforest

Sugarcane cultures

7. Sugar cane plantations (monocultures) cover 5 Mha, 1.5% of agricultural land of Brazil (0.57% of Brazil's total area), half of it is for fuel ethanol production

- In 2004 domestic use 13.5 B liters (360 PJ), export (mostly to US) 2.5 B liters (70 PJ)
- Covers 40% of all Otto engine fuel use in Brazil: 3 million pure ethanol cars (decreasing), 1.5 million FFVs (growing rapidly), all other gasoline cars and boats use gasohol (E20-26), also in aeroplanes
- Average energy output/input ratio = 9.2
- Annual CO₂ emission decrease by 50 Mt

8. Production process:

- No irrigation
- Effluent recycling
- No sulfur and toxic emissions

9. City air quality improvement

10. Legislative and technological improvements in some areas still posing environmental or social problems, e.g. pre-harvest burning => air pollution, loss of energy

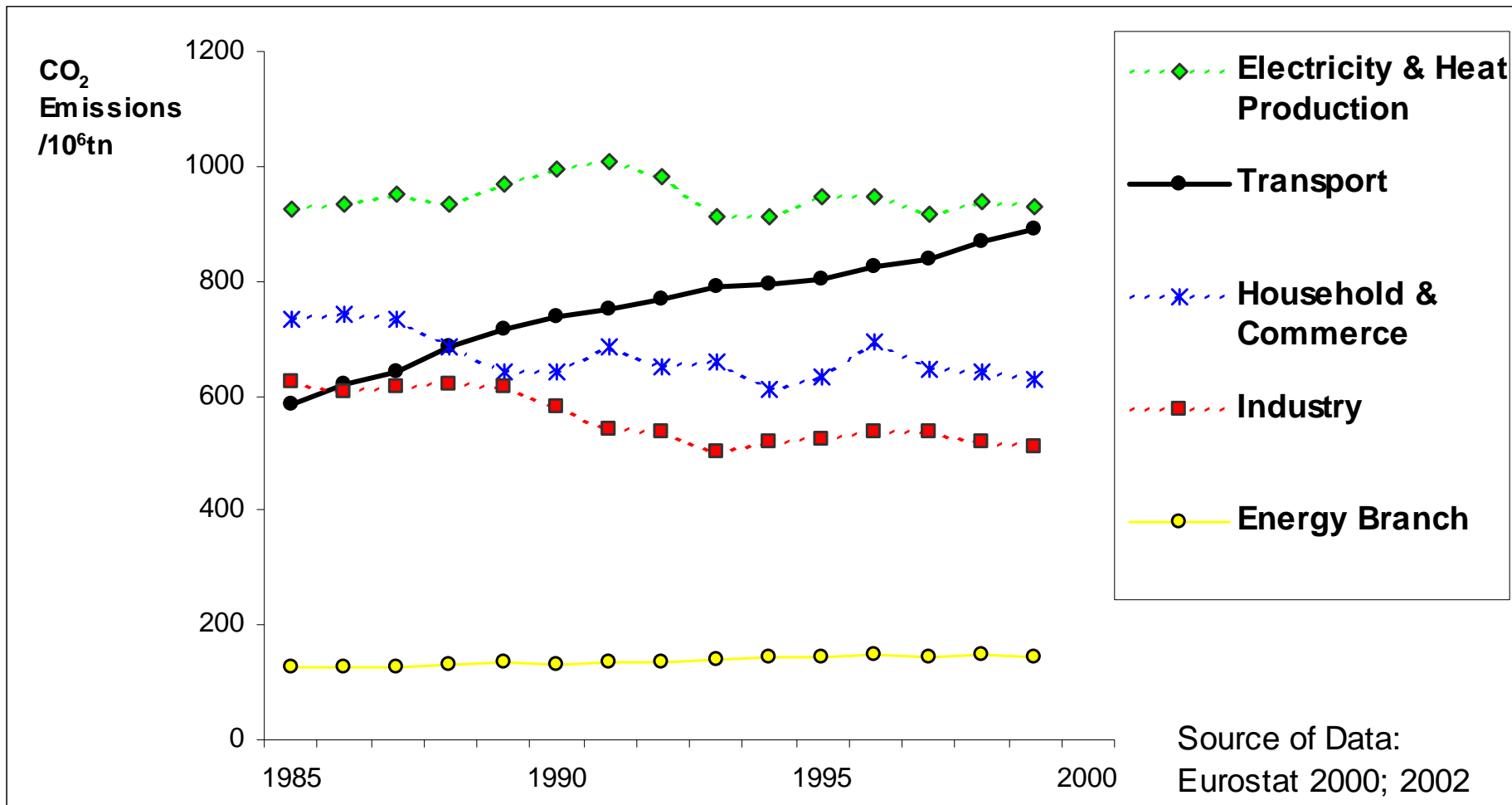
How? (actions in the 1970's):

- State oil company Petrobras required to:
 - buy specified minimum amounts of fuel ethanol at guaranteed price for growers
 - distribute it in its gas stations as pure ethanol
 - blend it in all gasoline produced and sold (first 5%, currently 20-26%, i.e. gasohol), diesel blending next step
- State budget neutral cross-subsidy from gasoline to ethanol buyers (gasoline taxes used for subsidizing ethanol)
- Subsidies for production units and ethanol vehicle manufacturers

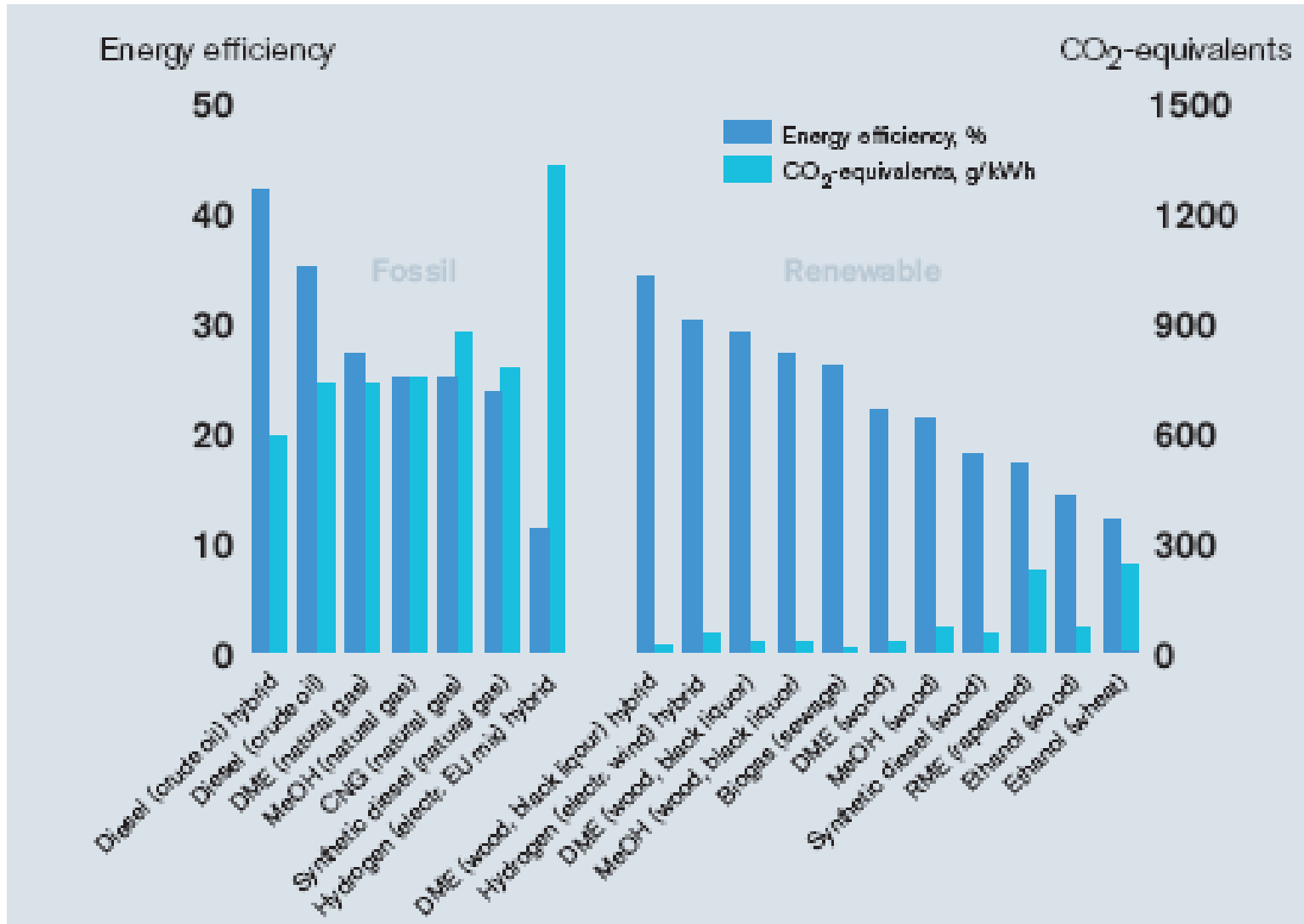
B. LCA EMISSIONS AND ENERGY EFFICIENCY OF TRAFFIC BIOFUELS

- Well-to-wheel analysis is an LCA including the impacts of the whole fuel chain from production to use of the fuel, but not including
 - production impacts of machinery for production, transport and use of the fuel
 - exploration, production and transport impacts
 - impacts of military protection of resources
- WtW GHG emissions include the impact of energy efficiency

CO₂ emissions by sector in EU15 1985-1999



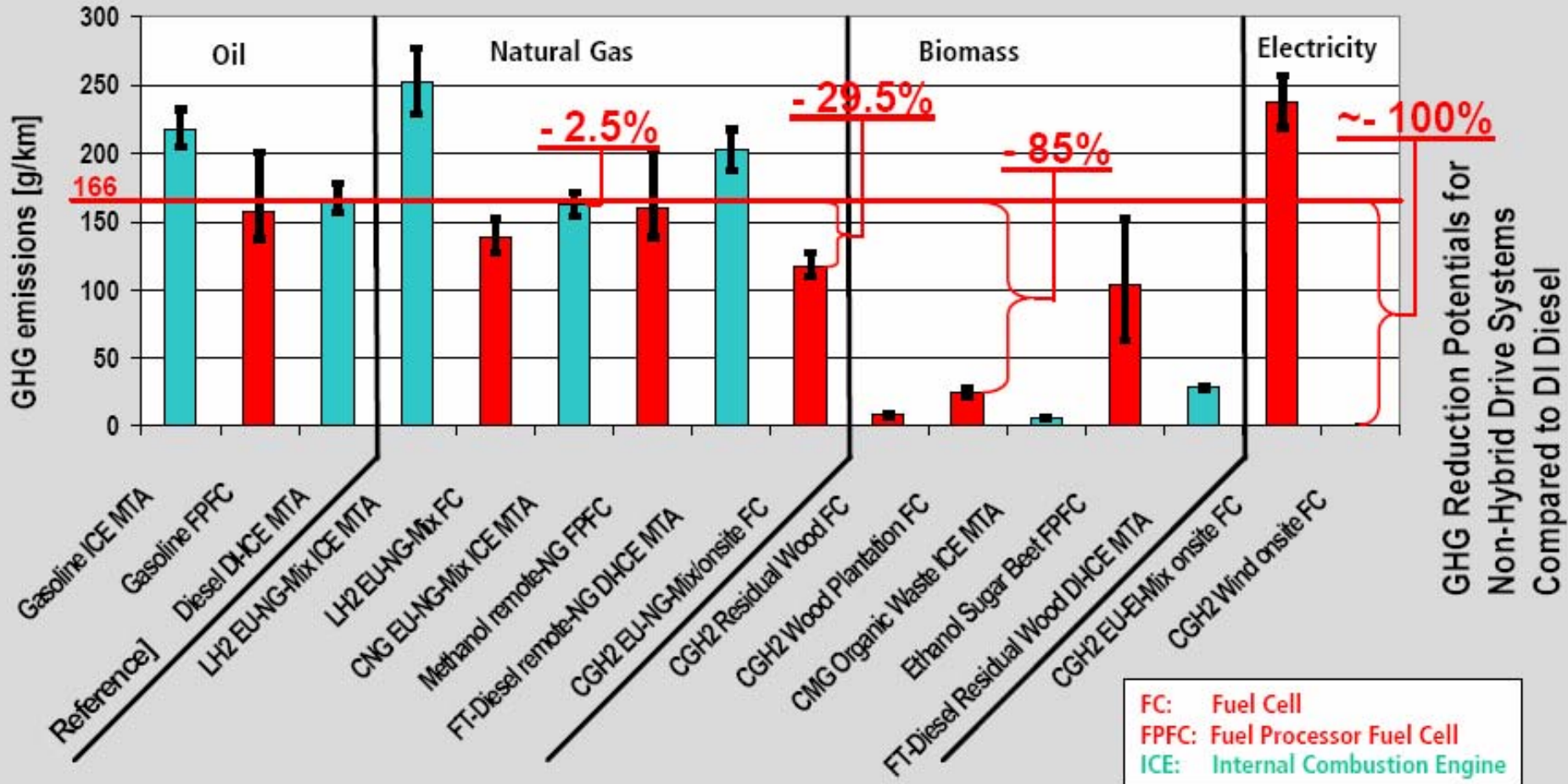
WtW GHG emissions and energy efficiency for trucks (Volvo 2004)



WtW GHG emissions for Opel Zafira (LBS 2002)

GHG Emissions (CO₂ Equivalent): Well-to-Wheel

Vehicle: Opel Zafira



Lowest LCA CO₂ emitting cars in Swedish market 2003 (www.gronabilister.se)

Plats	Märke	Modellbeteckning	Drivmedel	Bränsleförbrukning blandad körning (l/100 km)	energimått	CO ₂ beräknat, blandat körning (g/km)	storleksklass
1	Opel	Astra Kombi 1,6 CNG	BIOGAS	6,3		9	Lilla mellan
2	Audi	A2 1,2 TDI 3L	RME	3,5		10	Småbil
3	Volkswagen	Lupo 3L TDI	RME	3,5		10	Minibil
4	Opel	Zafira CNG (Bifuel)	BIOGAS	7,4	Nm3 gas, o	10	Familjebuss
5	Volkswagen	Golf Variant 2,0 BiFuel	BIOGAS	7,4	Nm3 gas	10	Stora mellan
6	Volvo	S80 Bi-Fuel CNG	BIOGAS	8,2	Nm3 gas	11	Stora mellan
7	Volvo	S80 Bi-Fuel CNG	BIOGAS	8,2	Nm3 gas	11	Storbil
8	Volvo	V70 Bi-Fuel CNG	BIOGAS	8,7	Nm3 gas	12	Storbil
9	Ford	Focus Kombi Flexifuel	E85	8,7		51	Stora mellan
10	Ford	Focus Kombi-Sedan Flexifuel	E85	8,7		51	Lilla mellan
11	Audi	A2 1,2 TDI 3L	DIESEL	3,0		82	Småbil
12	Volkswagen	Lupo 3L TDI	DIESEL	3,0		82	Minibil
13	Smart	City Coupé 37kW & 45 kW	BENSIN	4,7		117	Minibil
14	Opel	Corso ECO Easytronic	BENSIN	4,9		122	Småbil
15	Volkswagen	Lupo FSI	BENSIN	4,9		122	Minibil
16	Toyota	Prius	BENSIN	5,1		126	Lilla mellan
17	Opel	Astra Kombi 1,6 CNG	NATURGAS	6,3		137	Lilla mellan
18	Opel	Corso 1,0 3d & 5d	BENSIN	5,8		139	Småbil
19	Honda	Jazz 1,4 LS	BENSIN	5,7		141	Småbil
20	Hyundai	Getz 1,1 GL	BENSIN	5,8		144	Småbil
21	Volkswagen	Polo 1,4 FSI 3d & 5d	BENSIN	5,8		144	Småbil

Fuel performance

Most biofuels and other alternative traffic fuels are better fuels for conventional vehicle engines

Otto engine fuel	Octane number	Diesel engine fuel	Cetane number
Gasoline	90-100	Diesel oil	40-55
Methanol	107	Rape oil	> 38
Ethanol	108	DME	> 55
Propane	112	Biodiesel	48-72
Methane	130	Ecopar FT-diesel	73-81
Hydrogen	> 130	NExBTL syndiesel	84-99

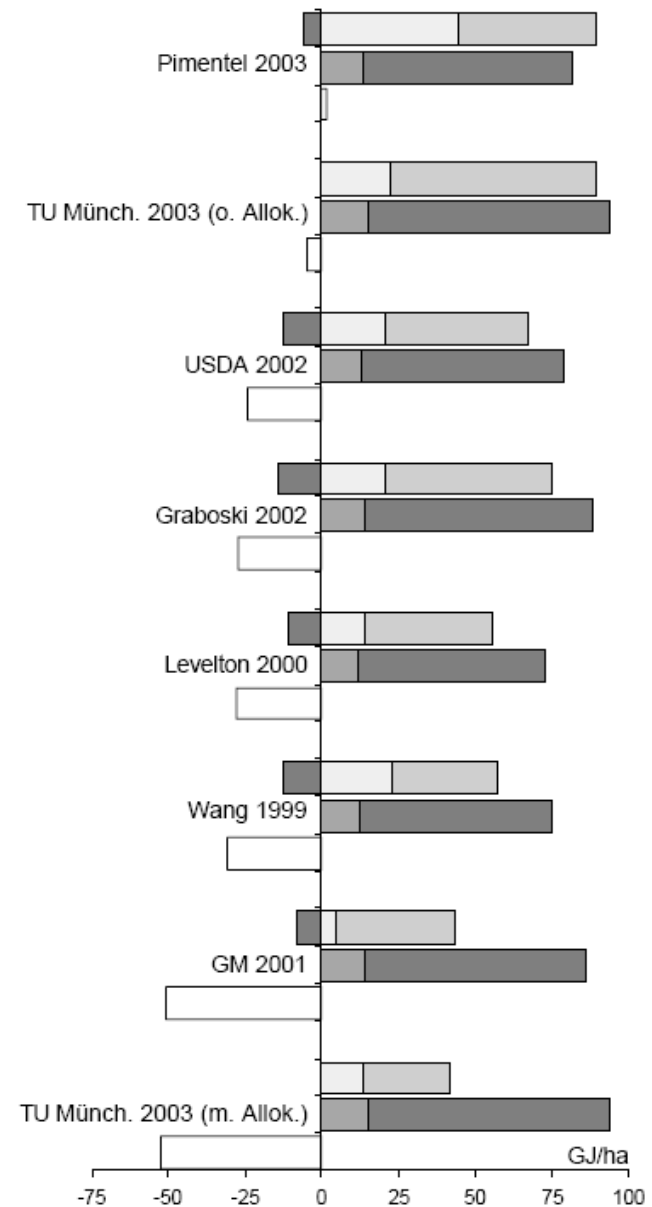
The Pimentel studies on negative energy balance of corn ethanol 1973-2005

Smil et al. (1983): “Clearly it is dangerous to make policy recommendations based on Pimentel’s and Terhune’s value for the energy requirement for the (farming) process, which may be overestimated by 80 %.” Pimentel et al. (1973, 1977) achieved this by:

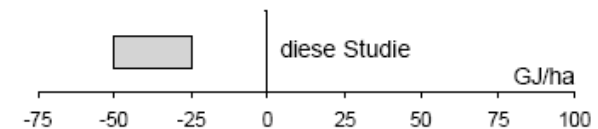
- using old data and neglecting technological improvements, especially fertilizer synthesis but also machinery production and cultivation
- over-estimating fuel energy content, fertilizer use and corn energy content
- counting some nonagricultural energy use, e.g. fuels for farm families’ automobiles included
- double-counting some energy use, e.g. all electricity consumption (incl. home use) + electricity in irrigation and drying
- neglecting manure use

IFEU (2004): Only Pimentel (2003) achieves negative energy balance for corn ethanol, by

- Using outdated data
- Using third higher energy consumption for N fertilizers than current technology
- Including human labor (not included in normal LCA practise)



IFEU (2003)/Annex 2



Pimental & Patzek (2005): Energy outputs from both bioethanol and biodiesel are less than fossil fuel input for production:

Abstract "Energy outputs from ethanol produced using corn, switchgrass, and wood biomass were each less than the respective fossil energy inputs. The same was true for producing biodiesel using soybeans and sunflower, however, the energy cost for producing soybean biodiesel was only slightly negative compared with ethanol production. Findings in terms of energy outputs compared with the energy inputs were:

- Ethanol production using corn grain required 29% more fossil energy than the ethanol fuel produced.
- Ethanol production using switchgrass required 50% more fossil energy than the ethanol fuel produced.
- Ethanol production using wood biomass required 57% more fossil energy than the ethanol fuel produced.
- Biodiesel production using soybean required 27% more fossil energy than the biodiesel fuel produced (Note, the energy yield from soy oil per hectare is far lower than the ethanol yield from corn).
- Biodiesel production using sunflower required 118% more fossil energy than the biodiesel fuel produced."

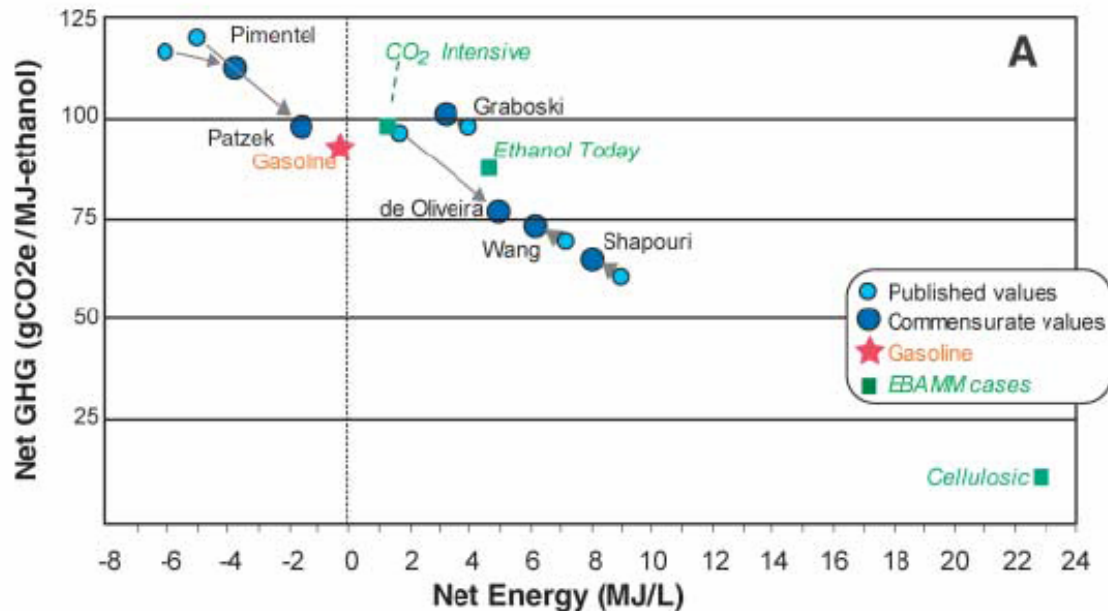
Science 27.1.2006 (Hurtley & Szumori): “**Farrell *et al.* rigorously analyzed a variety of relevant investigations, and found that the studies reporting negative net energy values are flawed.”**

Pimentel & Patzek (2005) achieved this by:

- ignoring energy content of co-products (they are always included in fossil fuels)
- overestimating N fertilizer energy use and misreporting data from cited source
- using obsolete (up to 107 years old), unverifiable, misreported, incorrectly cited and inconsistent data for supporting high energy use

Farrell et al. 2006/Fig. 1A:

The current coal intensive US corn ethanol reduces LCA GHG emissions by -7% to -15% (USDA/Shapouri -35%). In all cases intensive agricultural practices are assumed, alternative land use is wasteland and produced biofuels are not used in production => a lot of room for improvements. Cellulosic ethanol offers -88% decrease.



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Future can already be experienced in Sweden

