PHYSICAL PROPERTIES OF BIOETHANOL

Specific gravity:	0.79 gr/cm^3
Vapour pressure (38°):	50 mm Hg
Boiling temperature:	78.5 °C
Dielectric constant:	24.3
Solubility in water:	∞

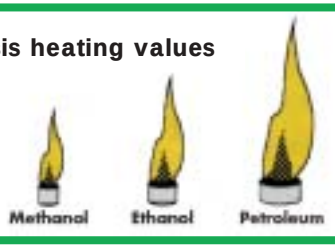
CHEMICAL PROPERTIES OF BIOETHANOL

Formula:	$C_2 H_5 OH$
Molecular weight:	46.1
Carbon (wt):	52.1%
Hydrogen (wt):	13.1%
Oxygen (wt):	34.7%
C/H ratio:	4
Stechiometric ratio (AIR/ETOH):	9.0

THERMAL PROPERTIES OF BIOETHANOL

Lower heating value:	6,400 Kcal/kg
Ignition temperature:	35°C
Specific heat (Kcal/Kg °C):	0.60
Melting point:	-115° C

Mass basis heating values



ECONOMICS
Plant: 10 t (ETOH) /day

COSTS	UNIT	COST/UNIT ($)
Sugar-juice	ton	2.500
Steam	ton	7.700
Electricity	kW	0.080
Cooling water	m^3	0.050
Process water	m^3	0.070
Sulphuric acid	kg	0.100
Salts	liter	0.600
Anti-foam	liter	0.160
Yeast	kg	1.300

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LATIN AMERICA THEMATIC NETWORK ON BIOENERGY

LAMNET

Microdistillery

For Decentralised Bioethanol Production

(Technological instrument for rural development)

Concept by Dr. Giuliano Grassi

This publication has been realised in the framework of LAMNET, thematic network funded by the European Commission, DG Research, Programme "Confirming theinternational role of Community Research" (Project no. ICA4-CT-2001-10106)

DECENTRALISED BIOETHANOL PRODUCTION

In a very long term the estimated Bioethanol world-wide potential production is very large (2 billion t/year or more). The present bioethanol world production is around 21 million m^3/year. Brazil is the leading country with an annual production of bioethanol from sugar cane around 13 billion li/year and a consumption of 12.4 billion li/year.

The average bioethanol production energy ration (energy output/energy input) is now 9.2 in Brazil. From the competitiveness point of view the anhydrous selling price (Dec 2002 before taxes) is on average 25$/barrel (160$/m^3) produced in large industrial plants, to compare with refinery-gate gasoline price (Brazil) of 35$/barrel.

Bioethanol is a good high-energy molecule and must be considered a good refined product to be compared to gasoline; its energy value is 70% of gasoline.
The USA is the 2nd largest bioethanol world producer from corn (5.5 billion li/year), produced in large capacity plants.

Considering the production by small plants in general, the economics of decentralised Bioethanol production in microdistilleries (capacity 5-10 ton/day) is penalised for the scale-effect expressed by "Capacity 0.6 exponential factor". But this negative effect can be compensated by:

- Large number repetition of standard optimised microdistilleries (production in series as indicated below).
- Adoption of small-scale bioenergy integrated complexes for the production of several coproducts from well-selected dedicated crops, to maintain the price of bioethanol at a preferential level

It is estimated that in this way production costs of about 250 $/li can be obtained also by small plants offering thus the opportunity to increase considerably the supply of bioethanol at world-scale and facilitating for developing countries the possibility of becoming large high value energy producers, with significant impact on their rural development and increase of the general Index of Human Development, this being so much related to the energy availability and use .

BIOETHANOL WORLD MARKET (year 2002)

Trading volume ~ 2 million m^3/y

Production Cost from Sugar Cane (Brazil) ~ 160 €/m^3

Price of anhydrous ETOH (Brazil) ~ 220 €/m^3

Dewatering Cost (depending on capacity) ~ 30/60 €/m^3

Production Cost of anhydrous ETOH (USA) ~ 250 €/m^3

Production Cost of anhydrous ETOH from CB real (EU) ~ 380/480 €/m^3

EU import duty: 190 €/m^3

POTENTIAL SMALL SCALE APPLICATION FUTURE MARKET

HEAT MARKET: Cooking Fuel (ETOH jelly)
Space heating – Cooling

COGENERATION
(microturbines-Engines-external combustion engines)
Power + water – space heating (hospital + hotel + shopping centres + building + schools)

TRIGENERATION
(microturbines + engines + absorption refrigeration systems)
Power + water/space heating + space cooling + food freezing(hospital + hotel + shopping centres + schools)

TRANSPORT MARKET
Addictivated low-grade (95°) bioethanol for Diesel
Low-grade bioethanol for external combustion power generators (hybrid – cars)

CHEMICALS MARKET
ETOH for Hydrogen production

LARGE PLANTS BIOETHANOL CROPS & YIELD & COST

TYPE	m^3 ETOH/ha	COST $/$m^3$
Sugar-beet (15€/t)	2,500-3,000	300-400
Sugar-cane	3,500-5,000	~160 (best)
Corn	2,500	250-420
Wheat	0.5 - 2.0	380-480
Potatoes	1.2 - 2.7	800-900
Sweet-Sorghum	3.0 - 5.0	200-300
Cassawa	1.5 - 6.0	700
SYNTHESIS ETOH	-	540 (min)

WATER & CHEMICALS INPUTS

TYPE	WATER m^3/ton	FERTILISERS Kg/t crop	Energy OUTPUT/ Energy INPUTS
Sugar-beet	750	N=5 P=1-2 K=5-6	1.76
Sugar-cane	500	N=1 P=1 K=5	2.5 – 9.0
Sweet-sorghum	250	N=0.9 P=0.9 K=1.3	2.5 – 5.0
Corn	500	N=10 P=4 K=5	1.30

Why Bioethanol

by Dr. Giuliano Grassi

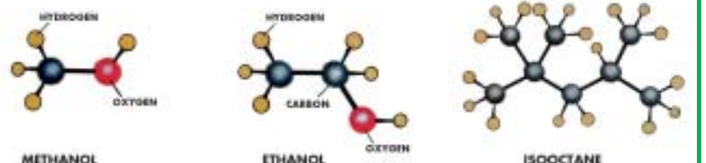
Transport is a vital strategic sector for modern society. The car industry is a pillar of most countries economy accounting up to 10% of GNP and large percent of all consumer expenditures.Yet vehicles also endanger the quality of life contaminating both urban areas and global atmosphere (greenhouse emissions). The fuel and car industries must overcome unprecedented technical – political – social – financial challenges to mitigate these serious environmental consequences and health risk. There is now a large consensus that a transition to new clean alternative fuels and in particular BIOFUELS (together innovative efficient propulsion systems) is urgently required!

Among the most interesting transport biofuels there are:

- Bioethanol
- Biomethanol
- BIO-DME (Biodimethylether)
- BIO-Hydrogen

Bioethanol has the largest potential (billion of t/year), as it can be produced from all type of biomass resources (sugar – starch – lignocellulosic)) and can be produced at reasonable cost by large and small plants (decentralised production).

EMISSIONS



Simple hydrocarbon fuels (i.e. ethanol, methanol) burn cleanly, forming mostly CO_2 and water. Gasoline molecules (i.e. isooctane) are considerably more complex and their combustion generates more polluting emissions.

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The activities of LAMNET include the analysis of available bioenergy technologies and systems as well as the development and implementation of policy options for the promotion and deployment of bioenergy.

Should you wish to receive more information on this Thematic Network, please contact the project coordinator:

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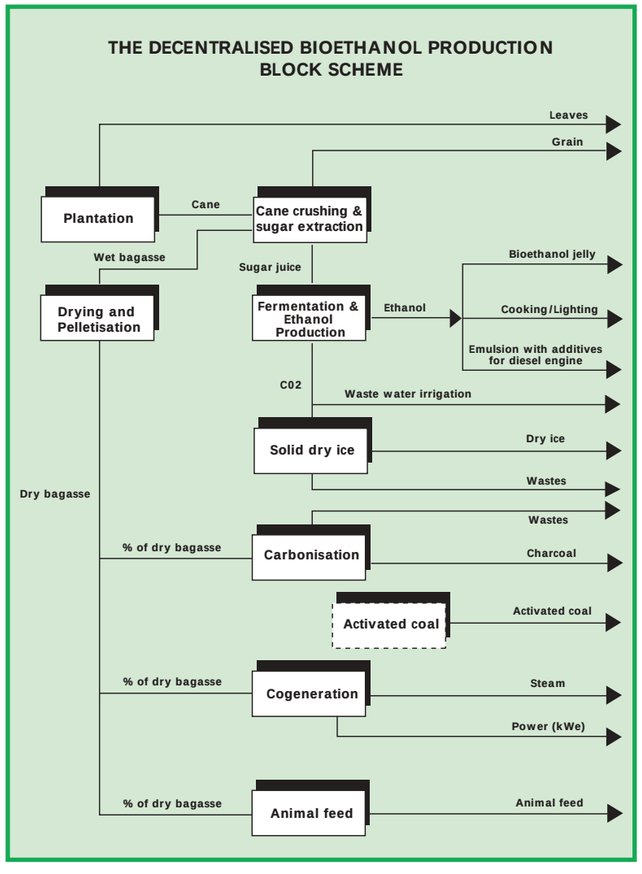
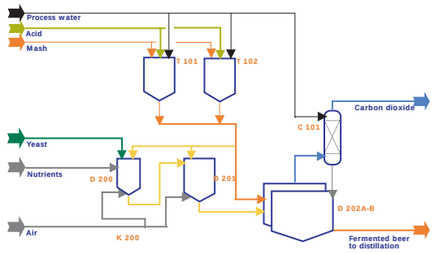
THE DECENTRALISED BIOETHANOL PRODUCTION BLOCK SCHEME

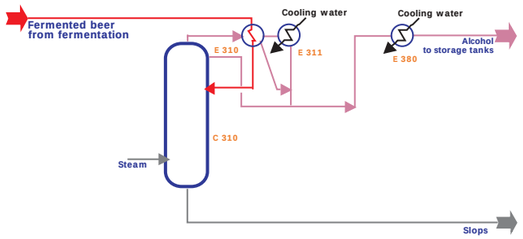


MASH PREPARATION AND AND FERMENTATION PLANT



CONTINUOUS DISTILLATION PLANT

Process flow scheme

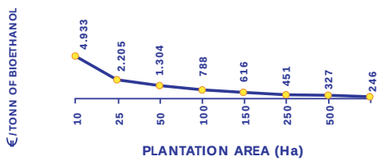


DISTILLATION DATA KINDLY PROVIDED BY ING. ALDO NARDI

CONTINUOUS DISTILLATION PLANT

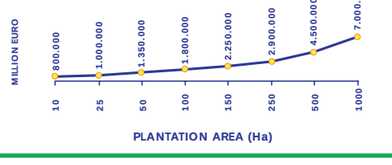
BIOETHANOL DISTILLATION COSTS

(The effect of co-products is not considered.
Only the processing of sugar-juice has been taken into account)



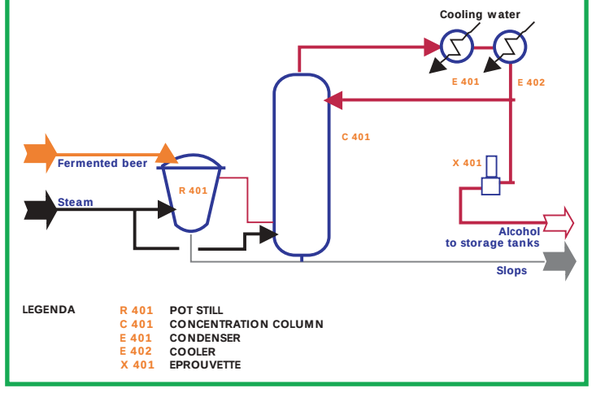
INVESTMENT (BUDGET FIGURES) FOR SMALL BIOETHANOL PLANTS

(Only sweet-sorghum juice is considered)



DISTILLATION PLANT (BATCH SYSTEM)

Process flow scheme and picture



MOTIVATION FOR SMALL BIOETHANOL PLANTS

- It is now possible to supply modern bioenergy complexes for remote rural villages based on the utilisation of different crops able beyond the satisfaction on the essential needs of the population (food, animal feed, energy), to produce an extra-income from the surpluses sale for an economic sustainable activity
- The comprehensive utilisation and processing of the biomass resource in integrated complexes with the simultaneous production of several high value commodities is essential for the improvement of the economic activity and for a large scale sustainable deployment of these bioenergy complexes
- These Integrated Complexes could provide a vital contribution for a general rural socio-economic development and for considerably increasing the Index of Human Development of the population (60-70%). It seems that a specific investment of 500$ - 1500$ are sufficient in very poor situations to change the life of one person forever
- Significant effort to expand the availability and local manufacture of commercial small size technologies, for technical assistance and for education & training (especially for a sustainable biomass production) must be envisaged as vital measure to ensure a viable and durable operation

MAIN CHARACTERISTICS

The project can include other possible processing integration to improve the economical performance of the complex and the feasibility of the activity. The focus is here on the treatment, besides sweet sorghum, of other sugar-starch crops such as fruit (pears, apples, etc.), cane, beet molasses and cereal (wheat, corn, barley, etc.) as most can use the same fermentation and distillation equipment installed for the treatment of sorghum. So that the working period of the unit can be extended as these last raw materials can be stored, without any problem, for a long period of time.

The process can benefit of the most advanced, proven and reliable technologies and the basic design will:

- Adopt a complex design which could function as an integrated unit rather than a set of individual parts
- Utilise the best available commercial technologies for maximum energy efficiency and minimum environmental impact
- Dedicate a large effort to engineer the plant for long life and reliable operation but without "gold plating" which would unnecessarily increase plant costs

PROCESSING UNITS

The main components of the bioethanol plant enclose:

Raw material receiving and mash preparation

Fermentation

Distillation

The proposed technologies are well proved and commercial.

EFFECTS OF THE MANUFACTURING VOLUME OF PLANTS ON THE INVESTMENTS

1 plant (i.e. 10 t (ETOH) / day): 2.90 mio €

10 plants (i.e. 10 t (ETOH) / day): 1.50 mio €

100 plants (i.e. 10 t (ETOH) / day): 1.15 mio €

1000 plants (i.e. 10 t (ETOH) / day): 0.80 mio €