

**Workshop on Materials Science and
Physics of Non-Conventional Energy Sources**

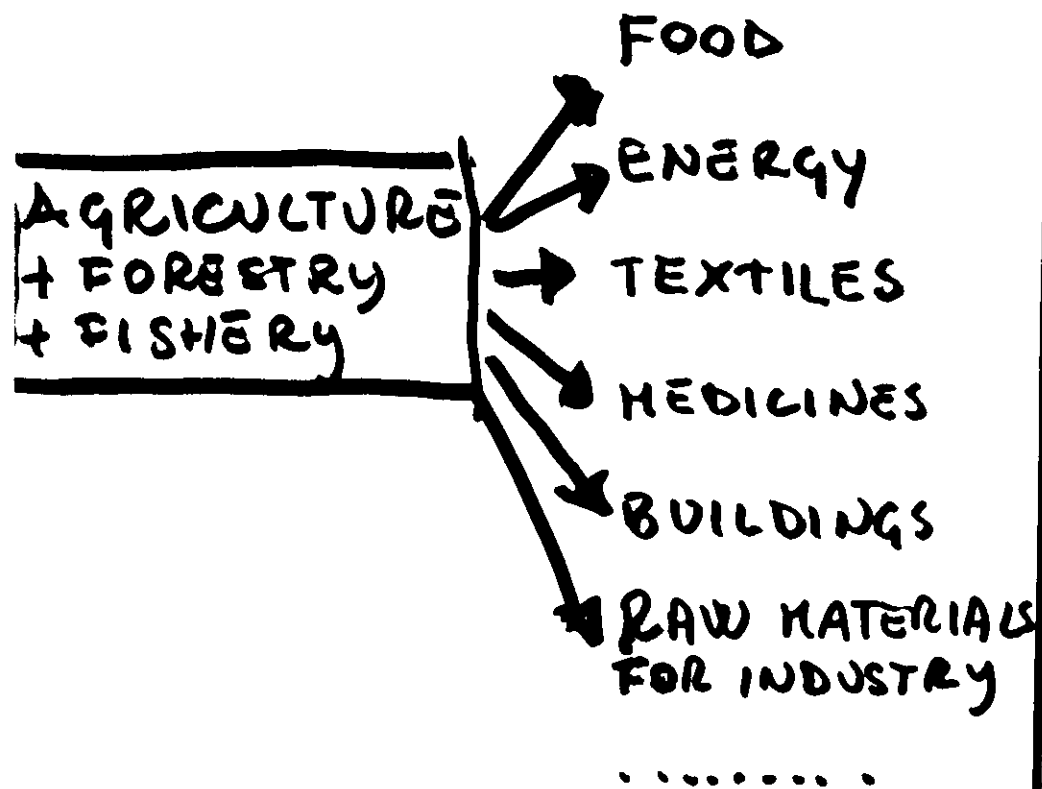
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"Perspectives on Agricultural Biomass Production"

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These are preliminary lecture notes, intended only for distribution to participants.

UNTIL 19TH CENTURY



AFTER 2nd HALF OF 19TH CENTURY

AGRICULTURE → FOOD
.....

COAL → ENERGY
OIL (AFTER 2nd WORLD WAR) → ENERGY
RAW MATERIALS FOR INDUSTRY

ENERGY DEPENDENCE ON IMPORTATION

	TOTAL ENERGY	CRUDE OIL
CE	$\approx 50\%$	$\approx 75\%$
ITALY	780%	790%

EARLY '70s
GULF WAR → PRECARIOUSNESS
OF OIL SUPPLYING

↓
STRATEGIC IMPORTANCE
OF DIVERSIFICATION
OF ENERGY SOURCES.

ENERGY

- PRESENT WORLD DEMAND PER YEAR $3.3 \times 10^{20} \text{ J}$
- WORLD DEMAND AT 2.000 E.C. $1.3 \times 10^{21} \text{ J}$
- SOLAR ENERGY REACHING THE EARTH PER YEAR $5.4 \times 10^{24} \text{ J}$
- USABLE WAVELENGTH 45-47 %
- SOLAR ENERGY CONVERTED IN CHEMICAL ENERGY $3.2 \times 10^{21} \text{ J}$
- DRY MATTER PRODUCED BY PHOTOSYNTHESIS BY GREEN PLANTS X YEAR $16 \times 10^{10} \text{ tons}$
- D.M. USED BY MAN AND DOMESTIC ANIMALS 5%

PHOTOSYNTHESIS

↓
10 TIMES PRESENT ENERGY DEMAND
3 TIMES ENERGY DEMAND
AT 2.000 E.C.

AGRICULTURAL SURPLUSES

	CONSUMPTION/PRODUCTION RATIO
-	
- EVAPORATED MILK	1.87
- POWDERED MILK	1.28
- BUTTER	1.34
- CEREALS	1.19

WINE, SUGAR, HORTICULTURAL PRODUCTS....

↓
ECONOMIC BURDENS (80×10^9 ECU)
INTERNATIONAL TRADE CONFLICTS

↓
NEW PAC → REDUCTION OF PRICES
→ SET ASIDE
→ EXTENSIFICATION OF CULTURES

↓
SOCIAL AND ECONOMICAL PROBLEMS
ENVIRONMENTAL PROBLEMS

↓
NEED FOR CROP DIVERSIFICATION

CONSUMER AWARENESS



NEW MARKET NICHES:

- NATURAL FIBRES
- VEGETAL DYES
- DEGRADABLE PLASTICS
- ANALLERGIC SOAPS
- ALTERNATIVE SUGAR SUBSTITUTES
- NATURAL FOOD ADDITIVES
-

ENVIRONMENT AND GLOBAL CLIMATE

- GLOBAL ENERGY CONSUMPTION 7.400.000 TEP
- FROM FOSSIL FUELS 6.660.000 TEP
- TOTAL CO₂ PRODUCTION 20 BILLIONS OF TONS
- CO₂ ABSORPTION BY ORGANIC AND INORGANIC CYCLES 2×10^{11} TONS

CO₂ CONTENT IN THE
ATMOSPHERE

280ppm → 345ppm



+ 0.4 - 0.6 °C/decade

AIR OF METROPOLITAN AREAS

POLLUTION FROM - EXHAUST GAS
- HEATING

SULPHUR DIOXIDE

CARBON DIOXIDE

NITROGEN OXIDES

PARTICLES

"HE HAD BEEN EIGHT YEARS
UPON A PROJECT FOR EXTRACTING
SUN-BEAMS OUT OF CUCUMBERS,
WHICH WERE TO BE PUT INTO VIALS
HERMETICALLY SEALED, AND LET
OUT TO WARM THE AIR IN
INCLEMENT SUMMERS....."

JONATHAN SWIFT (1726) - GULLIVER'S
TRAVELS - PART III - A VOYAGE
TO LAPUTA - CHAPTER V. VISIT
TO ACADEMY OF LAGADO.

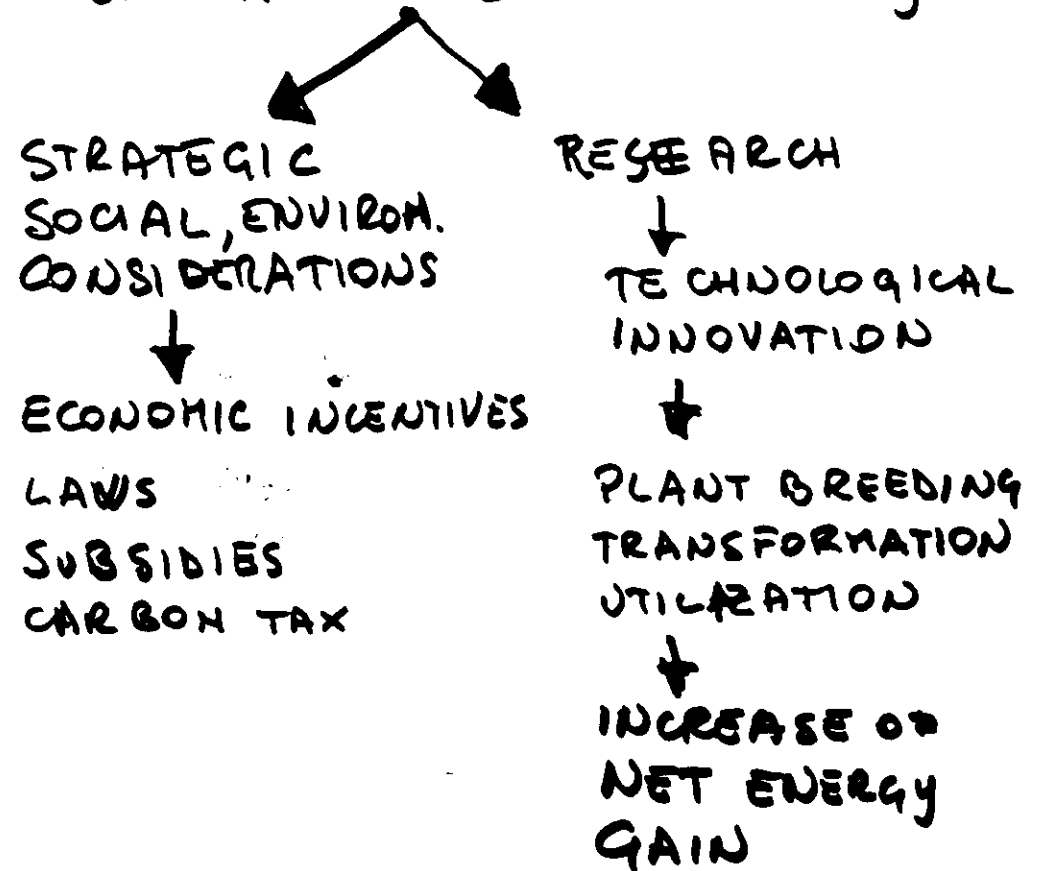
ADVANTAGES OF PRODUCTION AND UTILIZATION OF BIOMASS

- ① REDUCTION OF DEPENDENCE ON IMPORTATION OF ENERGY AND OF INDUSTRIAL RAW MATERIALS.
- ② SUBSTITUTION OF FOOD CROPS AND REDUCTION OF SURPLUSES
- ③ REDUCTION OF ENVIRONMENTAL IMPACT (GREENHOUSE EFFECT, AIR POLLUTION, GARBAGE BIODEGRADATION)
- ④ UTILIZATION OF MARGINAL LANDS AND OF SET ASIDE LANDS AND REDUCTION OF RELATED ENVIRONMENTAL PROBLEMS (EROSION, URBANIZATION, etc.)
- ⑤ DEVELOPMENT OF NEW KNOW-HOW AND PRODUCE INNOVATION

PROBLEM !!!

ECONOMIC COMPATIBILITY OF BIOMASS PRODUCTION AND UTILIZATION.

BIOMASS VS FOSSIL FUELS
BIOMASS VS CHEMICAL SYNTHESIS



RAW MATERIALS FOR INDUSTRY

COMPOUND	USE
STARCH (EC CONSUMPTION AT 2.000 = 2.6×10^6 TONS)	TEXTILE INDUSTRY PAPER INDUSTRY CHEMICAL INDUSTRY FOOD INDUSTRY FERMENTATION
CELLULOSE	TEXTILE INDUSTRY PAPER INDUSTRY CHEMICAL INDUSTRY
OILS (EC CONSUMPTION AT 1.000 = 3,500,000 TONS)	LIQUID FUELS LUBRICANTS CHEMICAL INDUSTRY
SUGARS (EC CONSUMPTION AT 1000 = 550,000 TONS)	FERMENTATION SUBSTITUTE SWEETENERS
GUMS, WAXES, RESINS	SEVERAL
OTHERS	BIOCIDES DYES FOOD ADDITIVES NICHE PRODUCTS

BIOMASS CONVERSION TO ENERGY

PLANT PRODUCT	CONVERSION PROCESS	ENERGY PRODUCTS
WOOD-CELLULOSIC BIOMASS	DIRECT COMBUSTION GASIFICATION PYROLYSIS	HEAT METHANE HYDROGEN OIL
VEGETABLE OILS	DIRECT COMBUSTION ESTERIFICATION	HEAT BIODIESEL
SUGARS/STARCH	FERMENTATION	ETHANOL

WORLD HIGHER
PLANT SPECIES ≈ 300.000

PLANT SPECIES
UTILIZED BY MAN ≈ 3.000

CULTIVATED PLANT
SPECIES ≈ 150

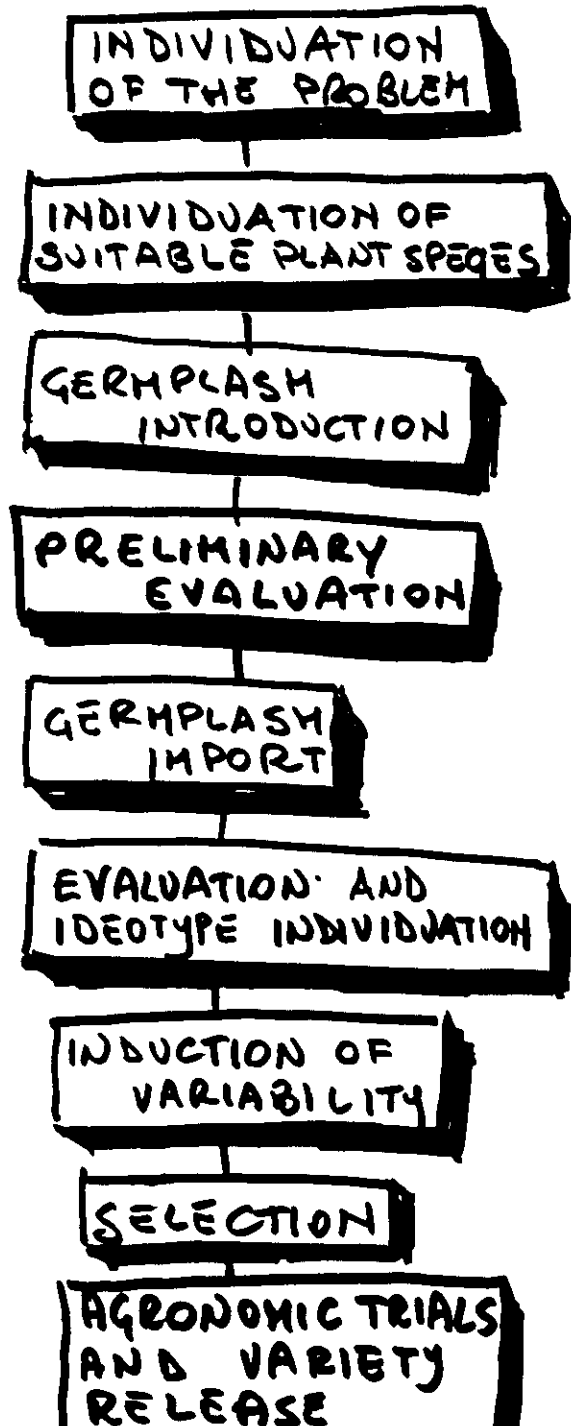
ALMOST TOTALITY
OF AGRICULTURAL
PRODUCTION ≈ 15

PLANT SPECIES
POTENTIALLY
EXPLOITABLE
FOR BIOMASS
PRODUCTION ≈ 150

CHOICE OF PLANT SPECIES

- ① CONVERSION TO NEW USES OF
PLANTS CULTIVATED FOR FOOD
PRODUCTION (SUGAR BEET, SORGHUM,...)
- ② REINTRODUCTION OF PLANTS CULTIVATED
IN THE PAST (HEMP, COTTON,....)
- ③ INTRODUCTION OF EXOTIC CULTIGENS
(KENAF, SWEET POTATO,....)
- ④ DOMESTICATION OF WILD SPECIES,
BOTH INDIGENE AND EXOTIC
(CRABBE, CUCURBITA, EUPHORBIA,.....)

FLOW CHART OF PLANT BREEDING



INDIVIDUATION OF PLANT IDEOTYPE

- ① PLANT MORPHOLOGY AND ARCHITECTURE
- ② CYCLE
- ③ ENVIRONMENTAL ADAPTATION (SOIL, WATER AVAILABILITY, PHOTOPERIOD, TEMPERATURE)
- ④ ABILITY TO COMPETE WITH WEEDS
- ⑤ RESISTANCE TO BIOTIC STRESSES (VIRAL, BACTERIAL AND FUNGAL DISEASE, NEMATODES, PEST INSECTS, HIGHER ANIMALS)
- ⑥ ADAPTATION TO AGRONOMIC PRACTICES AND TO MECHANICAL HARVEST.
- ⑦ YIELDING ABILITY
- ⑧ TECHNOLOGICAL AND CHEMICAL QUALITY OF THE PRODUCT
- ⑨ PROPAGATION SYSTEM
- ⑩ OUTPUT/INPUT RATIO OF ENERGY (FOR ENERGY CROPS)

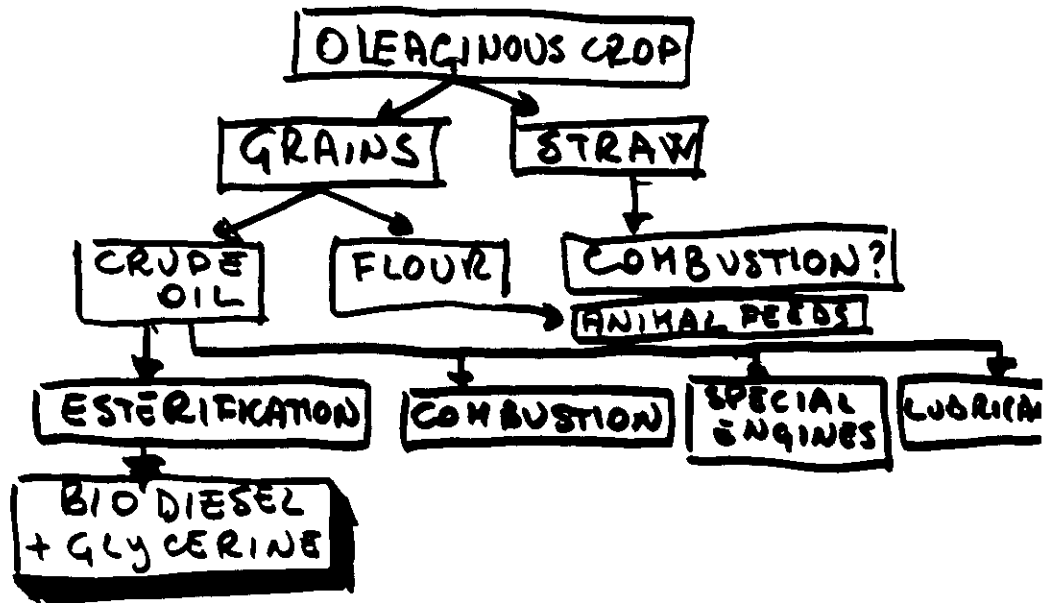
CHARACTERS CRITICAL FOR PLANT DOMESTICATION DERIVED FROM ONE OR FEW GENIC MUTATIONS

- ① ADAPTATION TO ARTIFICIAL ENVIRONMENTS
- ② REDUCTION OR INCREASE OF PLANT SIZE
- ③ CHANGE OF BRANCHING PATTERN
- ④ CONTEMPORARY TILLERING
- ⑤ PHOTOPERIOD REQUIREMENT CHANGE
- ⑥ REDUCTION OF SEED DORMANCY
- ⑦ REDUCTION OF CYCLE LENGTH
- ⑧ THORNLESS TYPES
- ⑨ INCREASE OF SIZE OF ORGANS UTILIZED (ROOTS, STEMS, TUBERS, LEAVES, FRUITS, SEEDS).
- ⑩ CONTEMPORARY RIPENING AMONG PLANTS
- ⑪ CONTEMPORARY RIPENING IN PLANTS
- ⑫ SEED INDURSCENCE
- ⑬ NAKED SEEDS OR EASE TO REMOVE GLUTES
- ⑭ RACHIS HARDINESS
- ⑮ MODIFICATION OF REPRODUCTION SYSTEM
- ⑯ INCREASE OF PARTHENO-CARPY
- ⑰ SUBSTITUTION OF SEXUAL REPRODUCTION WITH AGAMIC PROPAGATION
- ⑱ MODIFICATION OF CONTROL OF CHROMOSOMIC PAIRING
- ⑲ INCREASE OF CONTENT OF A COMPOUND (OIL, STARCH, PROTEINS, SUGARS) IN A ORGAN
- ⑳ CHANGE OF COMPOSITION IN FAT ACIDS
- ㉑ CHANGE OF AMINOACIDIC COMPOSITION OF PROTEINS
- ㉒ INCREASE OF UNDESIRABLE COMPOUNDS (TOXINS)

GROUPS OF PLANTS	NUMBER OF SPECIES
NEW FORMS OF CULTIVATED PLANTS	9
PLANTS CULTIVATED ABROAD	46
PLANTS OF POTENTIAL INTEREST	46
PLANTS OF POSSIBLE INTEREST	47
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UTILIZATION	NUMBER OF SPECIES
BIOMASS FOR ENERGY	8
SUGARS AND POLYSACCHARIDES	38
CELLULOSE FOR TEXTILE FIBERS AND PAPER	17
HYDROCARBONS (LATEX)	3
POLYMERIC HYDROCARBONS	5
GUMS AND RESINS	12
TANNINS AND PHENOLIC COMPOUNDS	3
WAXES	7
VEGETABLE OILS	38
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VEGETABLE OILS



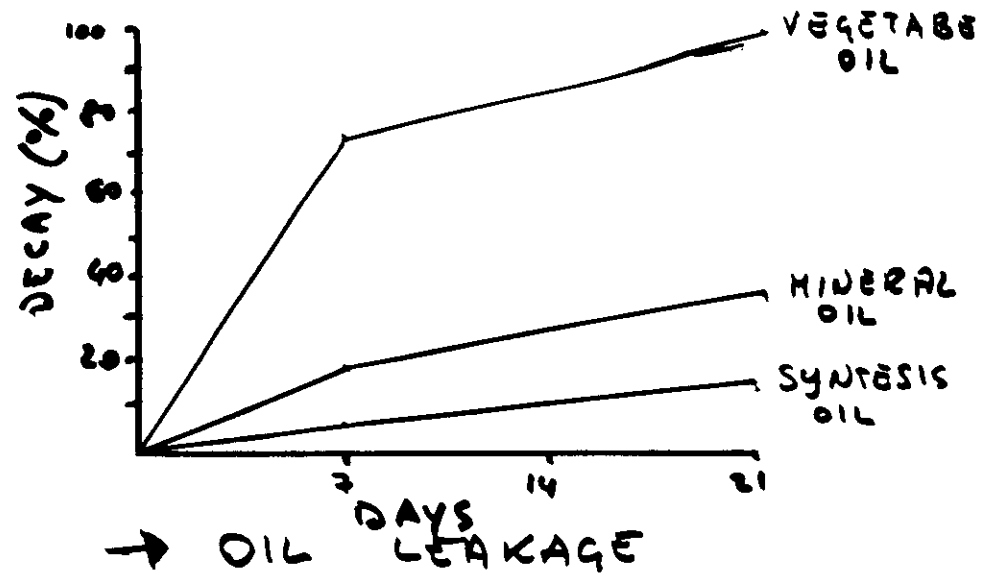
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AGRICULTURAL PHASE

YIELD (t/Ha)	2.5	3.5
DRY MATTER (t/Ha)	2.0	2.8
TOTAL INPUTS (GJ/Ha)	24.73	24.73
TOTAL OUTPUTS (GJ/Ha)	56.20	78.70
OUT/IN RATIO	2.27	3.18

INDUSTRIAL PHASE

OIL (t/Ha)	0.86	1.20
FLOUR (t/Ha)	1.15	1.60
ESTER (t/Ha)	0.97	1.35 (+glycerine)
ENERGETIC COST (GJ/Ha)	2.15	3.00
FINAL OUT/IN RATIO	1.82	2.32



→ OIL LEAKAGE
EXHAUSTED GASES → AIR POLLUTION
BIO DIESEL vs. DIESEL

SO _x	-100%	O ₂ CO ₂ BALANCE → 1.5 Kg/l SAVED
CO _x	-60%	
NO _x	~	
AROMATIC POLYCYCLICS	-75%	
SMOKE INDEX	-50%	
PARTICLES	-50%	

→ POWER REDUCTION 78%
LUBRICANT OIL DILUTION
PAINTINGS COMPATIBLE

PRICE: 900 Lit/l + VAT BIO DIESEL
400 Lit/l + VAT + MANUFACTURE TAX
= 1400 Lit/l
ONLY IF DIFFERENT FROM ...

BIODIESEL PRODUCTION PLANTS

AUSTRIA 14.000 t/year
+ LUBRICANTS (BIOSTAR)
ITALY 60.000 t/year
FRANCE 25.000 t/year (IN CONSTRUCTION)
SWEDEN LUBRICANTS (BINOL)

DEMONSTRATIONS OF USE

1991 BUSES OF MUNICIPALITIES OF
ZÜRICH AND VICENZA
7200.000 KM COVERED
TAXIS OF FREIBURG
1992 BUSES OF MUNICIPALITIES OF
FLORENCE, GENOVA, TURIN,
PISTOIA, NOVARA, LEIGHURM,
COMO
CIVIL HEATING IN MILAN