The Potential of BIOENERGY in Portugal: Current status and future trends

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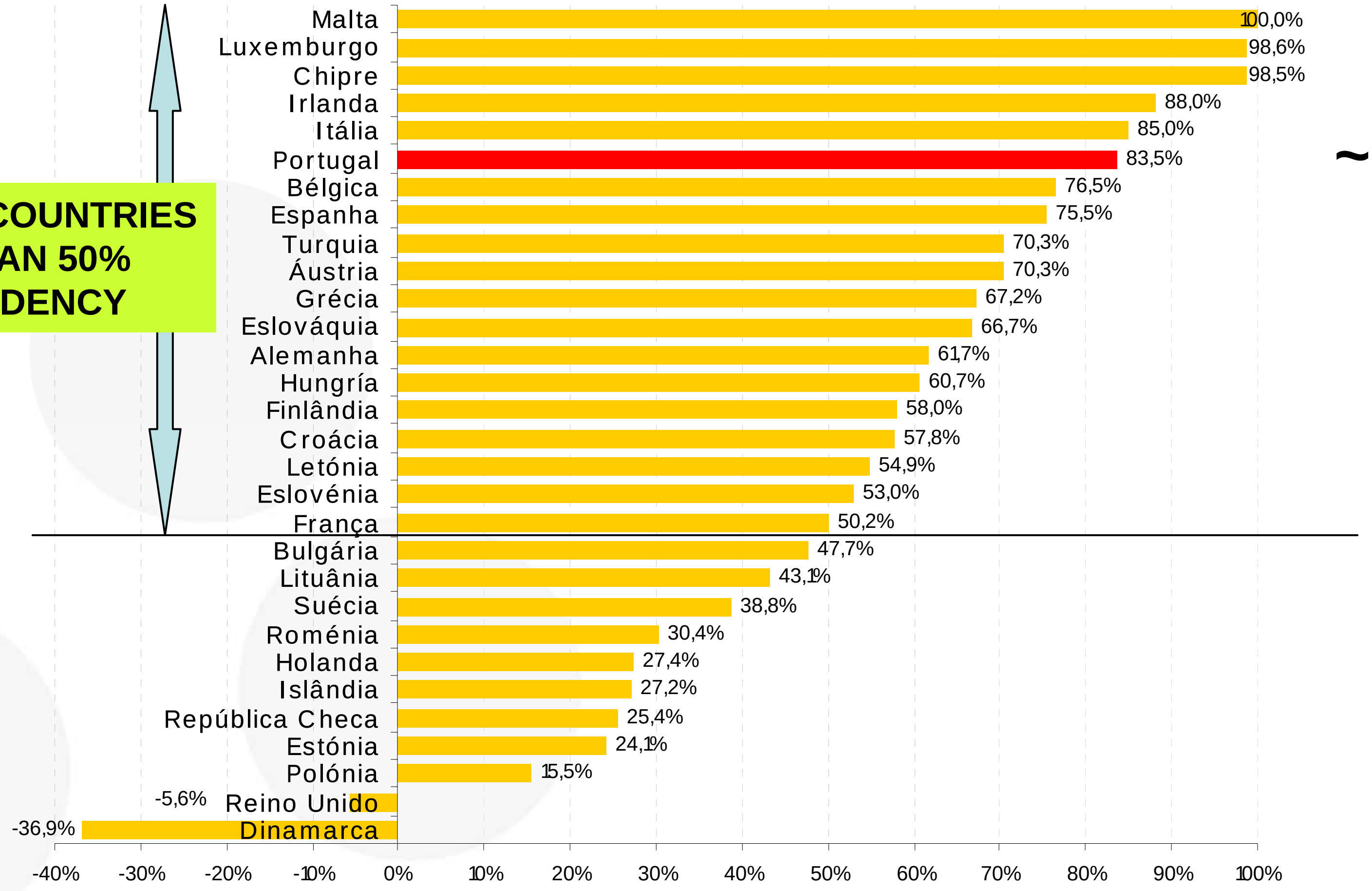
LNEG
Laboratório Nacional de Energia e Geologia, I. P.

MINISTÉRIO DA ECONOMIA E DA INOVAÇÃO

Portugal and other European countries: The Oil Dependency

17 EUROPEAN COUNTRIES HAVE MORE THAN 50% PETROL DEPENDENCY

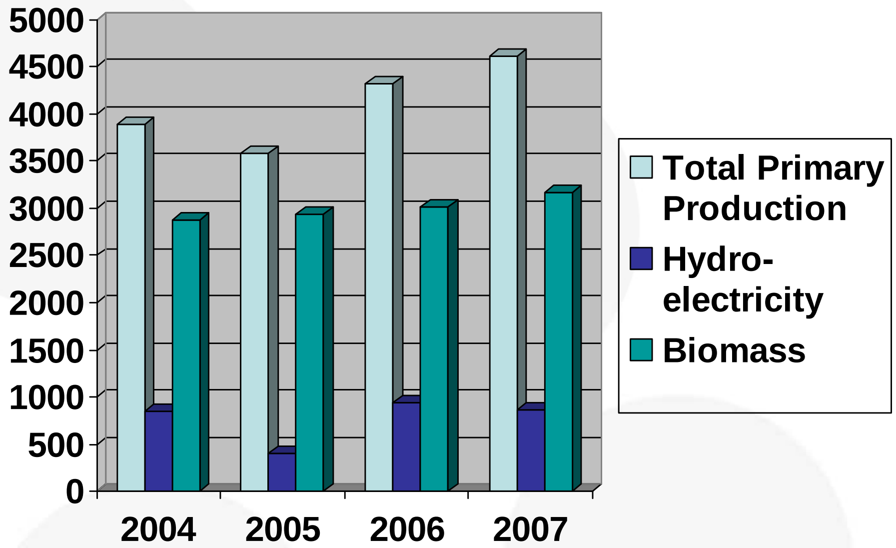


~84% !

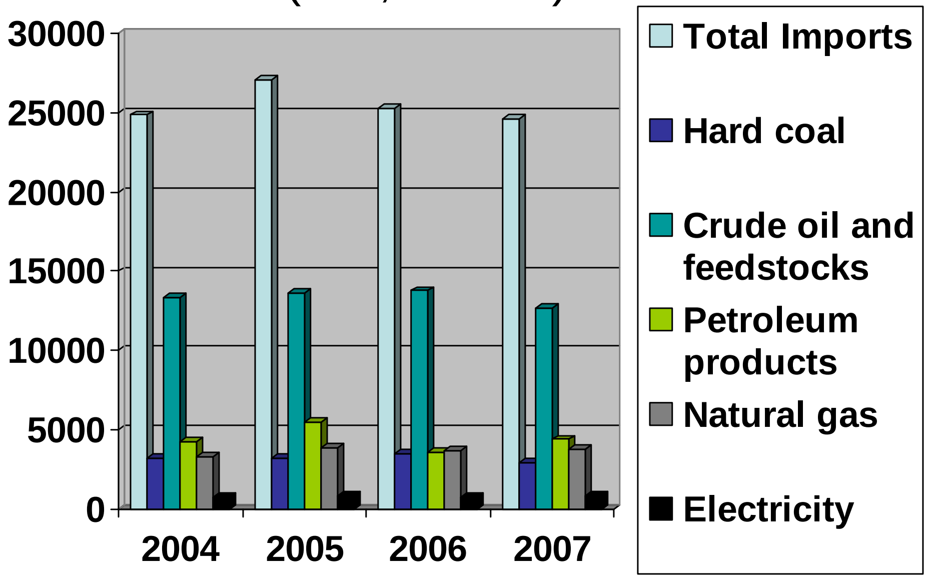
Source: DGEG, 2007

Portugal: The Energetic Bill

Primary Production
(in 1,000 toe)



Imports
(in 1,000 toe)



Source: Eurostat: EU statistics (2009)

Portugal: The Energetic Bill

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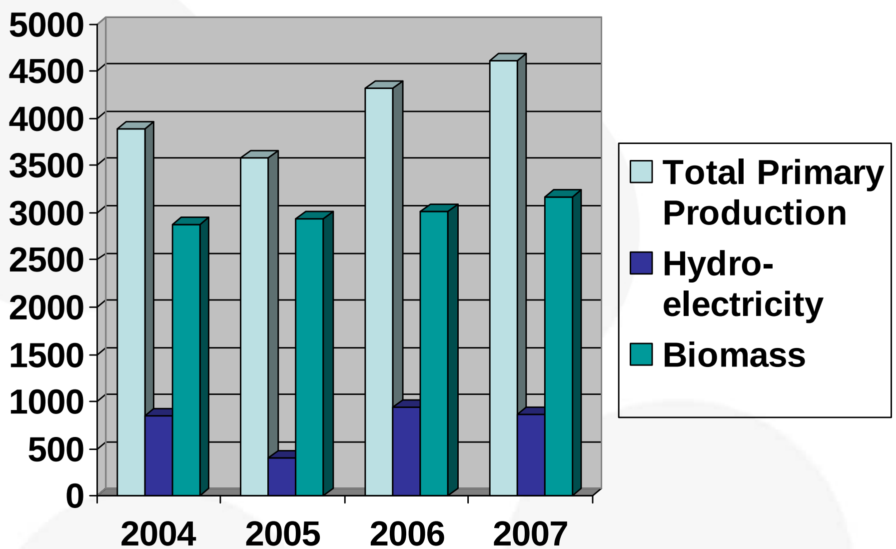

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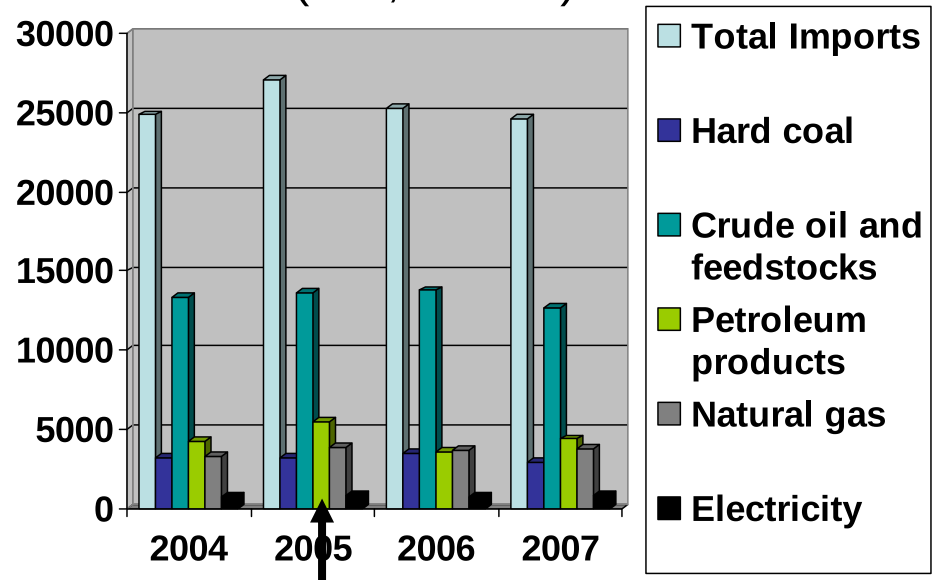
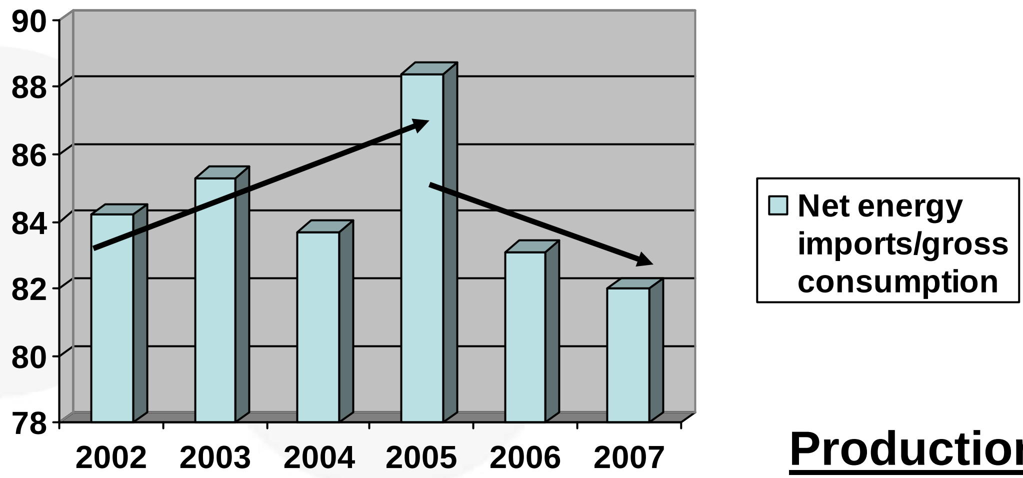


Very dry year

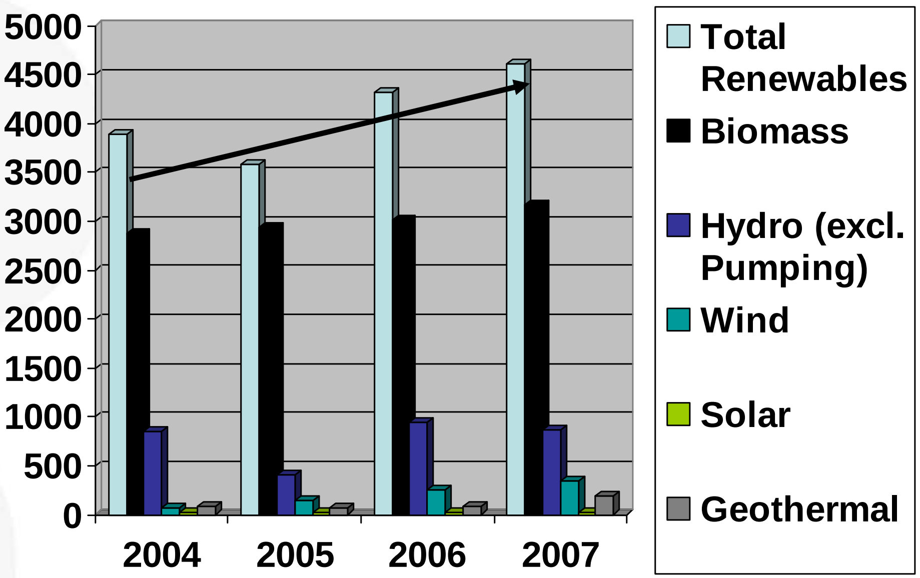
Due to the inputs to electricity and heating plants

Portugal: The Energetic Bill

The Portuguese Energy Dependency (in %)



Production from Renewables (in 1,000 toe)



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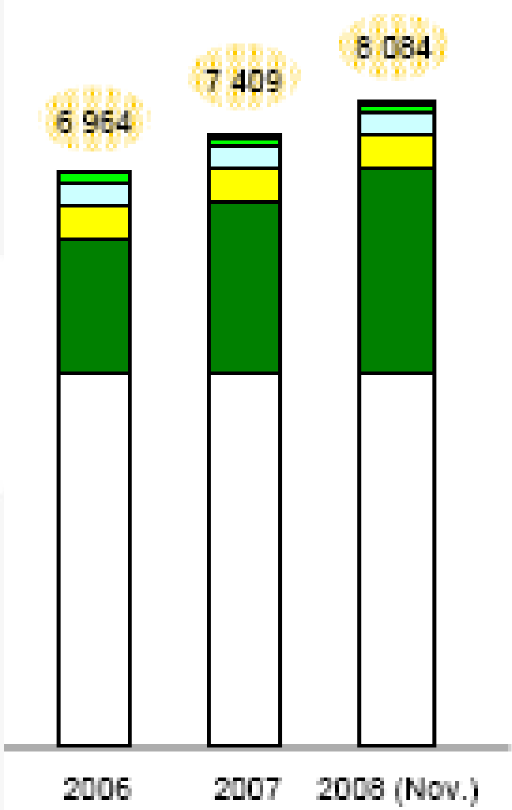
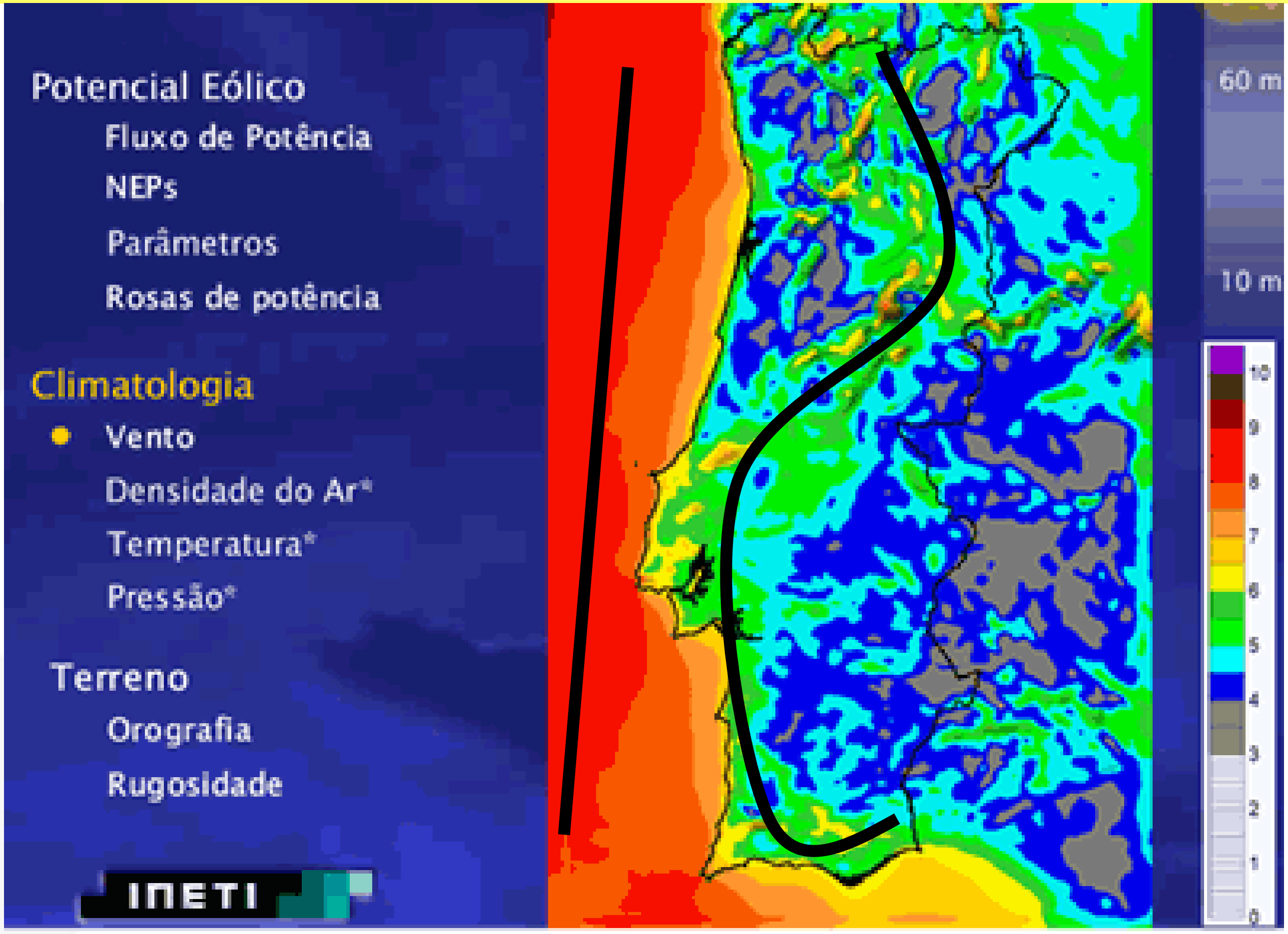
Portugal: The share of different renewables <u>for electricity</u>

<u>Relative increase between 2000-2008</u>



	$TCMA_{00\text{-}08\ (Nov.)}$	
Total potência instalada	6.9%	Total power
Fotovoltaica	43.9%	**<u>Photovoltaic</u>**
RSU[1]	0%	Urban Solid Sludge
Mini-hídrica	3.4%	Mini-hydropower
Biomassa e Biogás	1.4%	Biomass & Biogas
Eólica	57.5%	**<u>Wind</u>**
Hídrica	1.5%	Hydropower

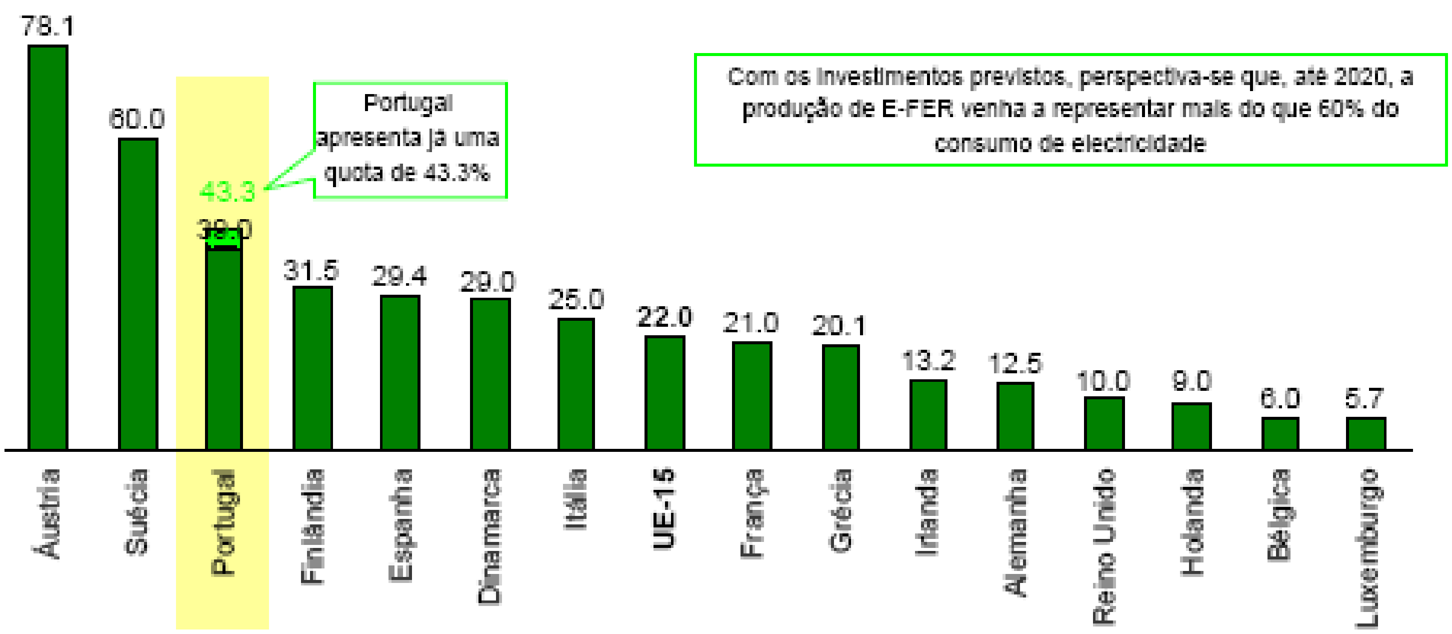
The **Wind Atlas** – Developed by LNEG it allows on-line data monitorization about wind at any part of the country



On-shore: currently under exploitation
Off-shore: next opportunity ?

Portugal '09 : Renewables for Electricity

The country share is now <u>43.3%</u> of total electricity consumption



SCENARIO 2020: According to the government plan (under due course), PORTUGAL will be **<u>over 60%</u>** of E-renewable

Portugal: Current status and prospectives for the transportation sector

2009 – current status

- Biofuels **(only biodiesel)**

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2020 - prospectives

1. Electricity for battery-powered cars **+/++**
2. Liquid Biofuels **(biodiesel and bioethanol) ++++**
3. Bio-Hydrogen (**wind power or wood-based biomass or microalgae + fuel cells**) **-/+**

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The New European Directive (2009) targets a **mandatory share of 10% renewables** for 2020 specifically for the transportation sector in each european country

The Portuguese Government targets to have a **mandatory share of 10% renewables** for 2010 in the transportation sector

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1. Electricity for battery-powered cars

- Portugal (and UK) will manufacture the innovative laminated **Li-ion Batteries** for Nissan electric vehicles

- A refuelling network for electric vehicles (Mobi-E) will be installed in the country:
    - 100 stations (2009)
    - 1300 stations (2012)

Nissan Leaf (autonomy: 160 km); available from the end of 2010 in Japan, Europe and USA.

Mobi-E refuelling network for electric plug-in vehicles (portuguese patent)

SCENARIO 2020: less than 1% share of for electric cars (doubt: from renewables ?)

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2. Fuels & Biofuels scenarios for 2010 in Portugal transportation sector

(for biofuels: ton of substitution corrected to the calorific value)

Type of fuel		2008	2010
Fossil Fuels	Gasoline (ton)	1 678 058	1 500 000
	Diesel (ton)	4 761 420	5 000 000
	% of addition	2.9	10
Biofuels	BIOETHANOL (ton)	0	236 550
	BIODIESEL (FAME) (ton)	149 000	581 000

Scenarios for 2010 in Portugal transportation sector

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- Current installed capacity of 1G-biodiesel plants: **600 000 ton** FAME

- Current installed capacity of 1G-bioethanol plants: **0** ton

- Gasoline/Diesel share forecast (2010): **23/77**

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Vegetables Oils for 1G-Biodiesel: Portugal (2007)

	Raw Material			Total (ton)
	Domestic	Imported		
	Domestic Oil extraction (ton)	Domestic oil extraction (ton)	Oil imported (ton)	
soybean	-	117.888	-	117.888
rapeseed	66	32.563	6.859	39.488
Palm oil	-	-	19.795	19.795
Sunflower oil	5.833	-	-	5.833
total	5.899	150.451	26.654	183.004

Only 3% domestic vegetable oils were used for biodiesel in 2007 !

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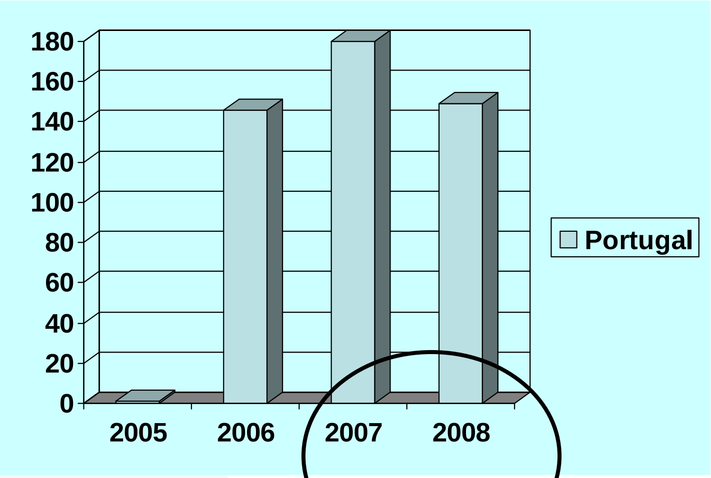
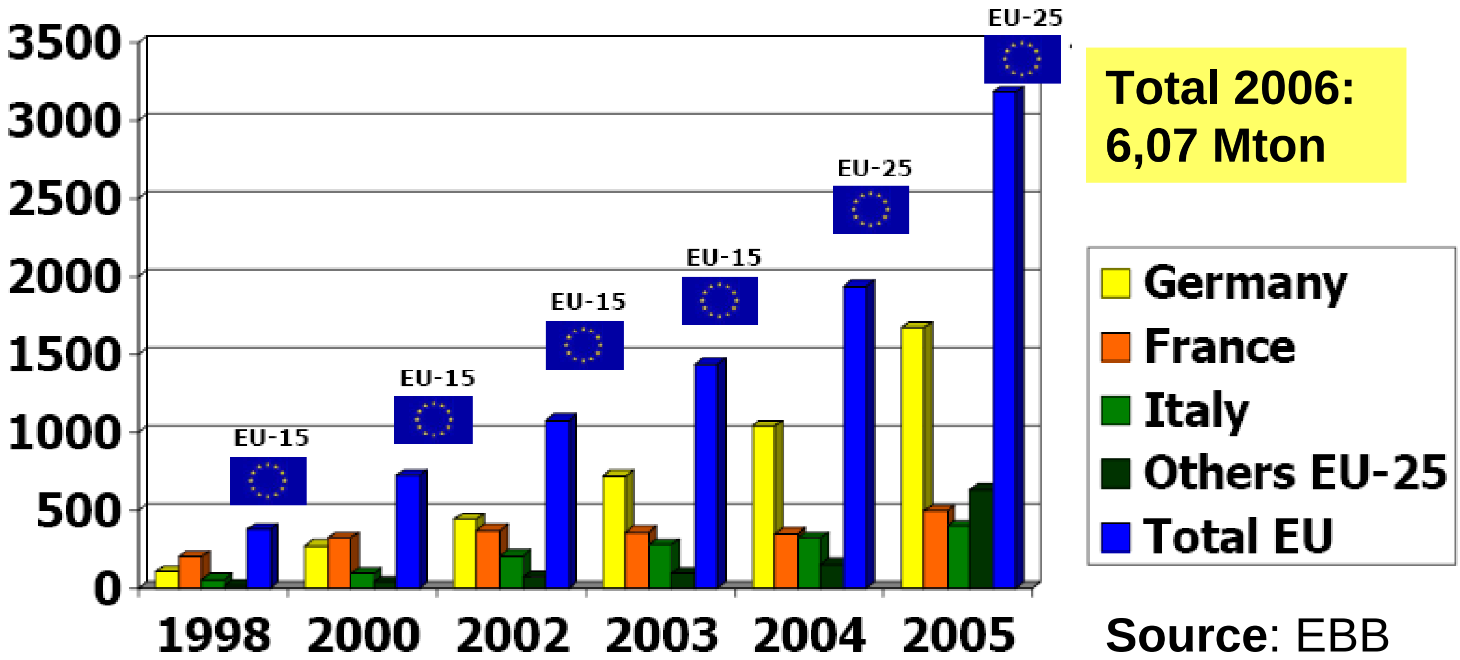
1G Biodiesel (FAME)

In 1,000 tonnes)



0.1 → 1.4 → 3.2 → 2.9%
(biofuels share)

In 1,000 tonnes)



Total 2006:
6,07 Mton

Source: EBB

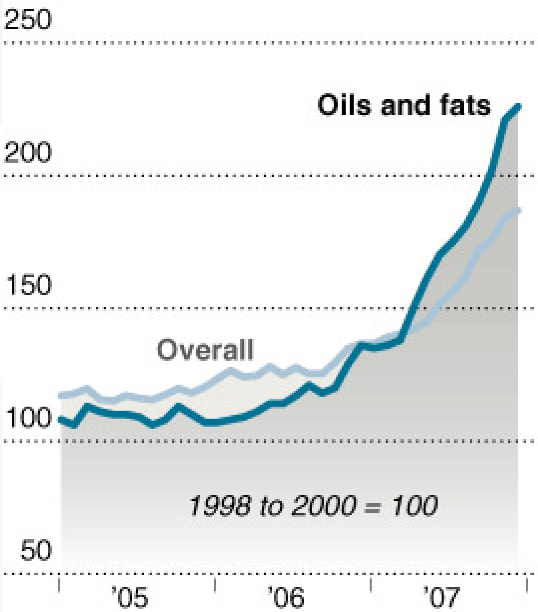
Main threat: Raw materials cost due to Food Competition

Rising Costs Felt at the World's Dinner Tables

FOOD PRICES

Export prices for 60 internationally traded food commodities have soared. No category has risen faster than oils and fats.

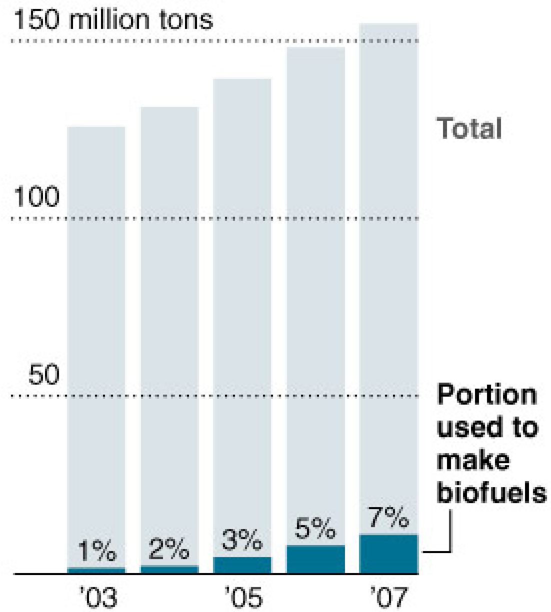
United Nations Food and Agriculture Organization food price index



OIL CONSUMPTION

Most vegetable oil is used for food purposes. But turning it into biofuels represents the fastest-growing demand for oils.

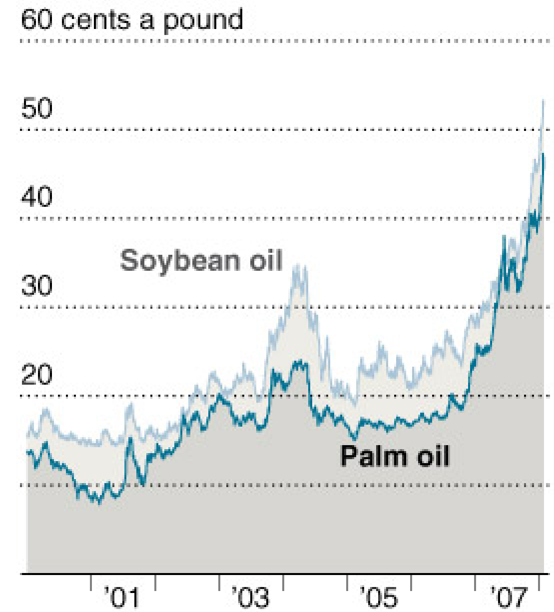
World consumption of oils and fats



OIL PRICES

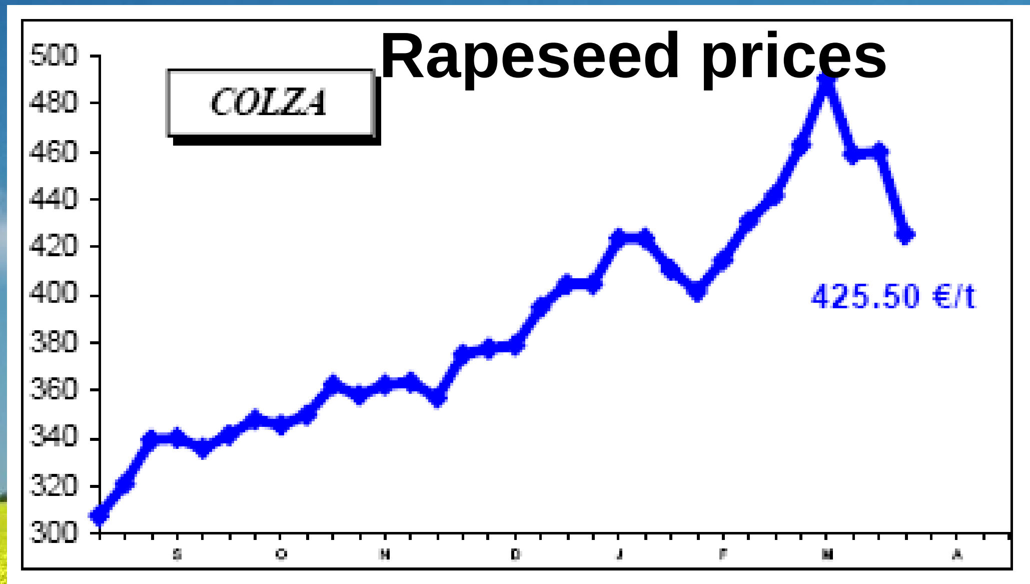
Farmers in the United States and China have been planting less soy, causing a shortage that has helped raise prices for palm oil, the main alternative to soybean oil.

Near-month futures contracts



Sources: Bursa Malaysia, Chicago Board of Trade, via CEIC Data; United Nations Food and Agriculture Organization; Oil World

1G Biodiesel (FAME) in Europe



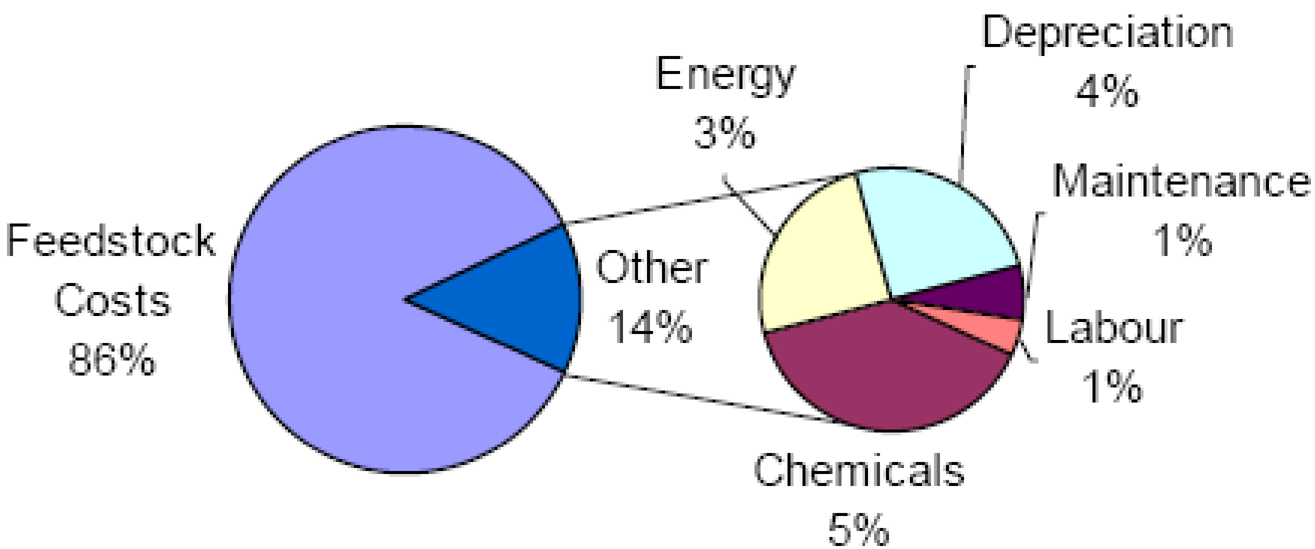
Prices: FOB Moselle

set07

apr08

6 MONTHS PERIOD: about 50% increase !

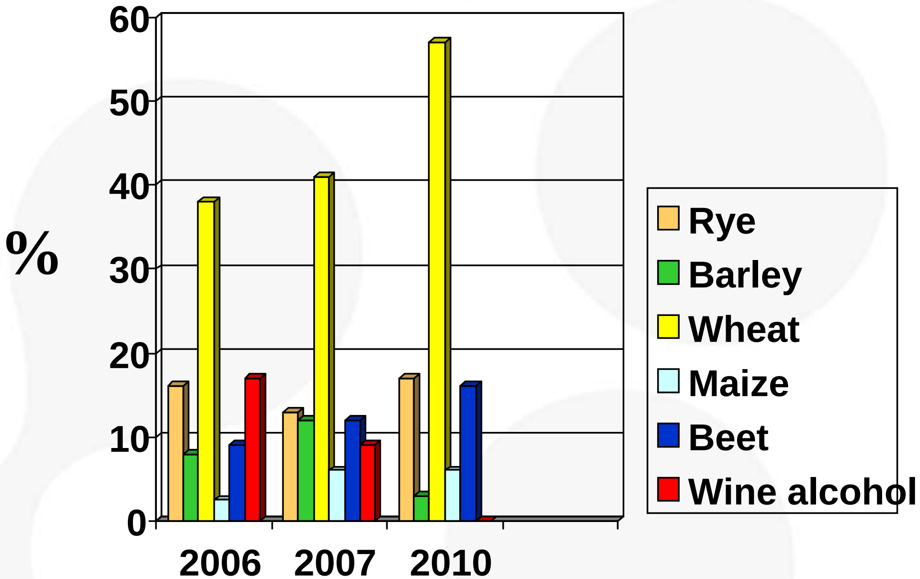
Influence of the raw material price on biodiesel production cost

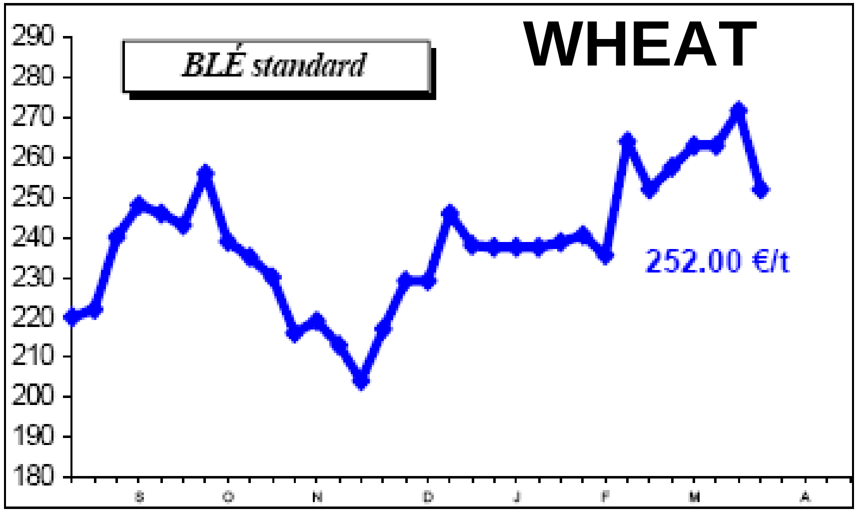


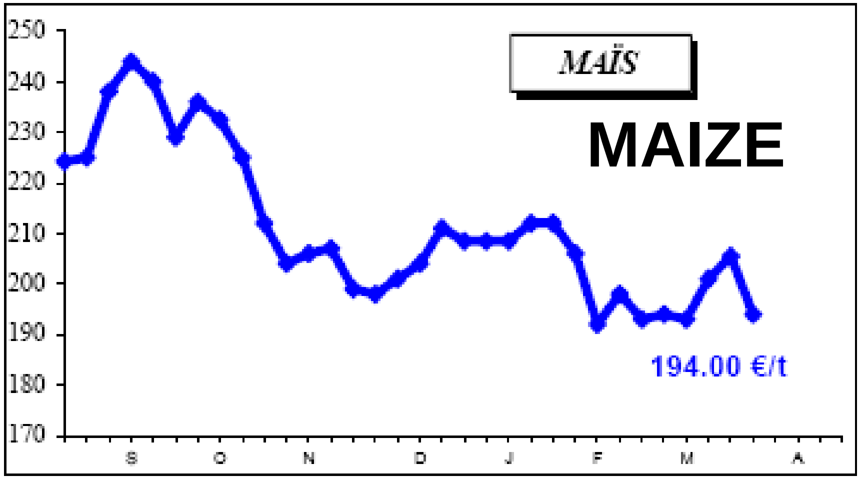
Source: Lurgi biodiesel technology from rapeseed

1G Bioethanol in Europe

Abengoa, Babilafuente, Salamanca







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Prices: FOB Creil

The problem is European-scale: To reach 10% share on biofuels…Europe needs:

Total Biofuels <u>2006</u>

= 7,661 Mton

+ 522%

Total Biofuels necessary in <u>2020</u> (10% target)

= 40 Mton (replacing 31 Mtoe of fossil fuels)

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Total EU Agricultural land used in <u>2005 for biofuels</u>

= 2,8 Million ha (**~3 % of total arable land in EU**)

10 X

Total EU Agricultural land necessary to be used to reach the target of 10% biofuels in <u>2020</u>

= 27 – 30 Million ha (**~30 % of total arable land in EU**)

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Short summary about first generation biofuels

- Europe´s capacity to produce rapeseed and cereals for energy is limited;

- The 1st generation biofuels technologies hardly…reduce, in a significant way, the GHG emissions.

First generation biofuels is not a long-term solution for Europe (and for the World) !

So...what it is the next step (short-term) for Europe ?

- To start importing massively biofuels/feedstocks instead crude oil ?

Or

- To start producing sustainable biofuels using 2nd generation technologies/raw materials ?

Signs of massive importing of plant oil (for biodiesel): the portuguese status

Portuguese investors/biodiesel producers are verticalizing its business by acquiring oleaginous transforming industries (oil producers units) in Africa, Asia and Latin America to....prevent european vegetable oil shortage and to be better prepared for the mandatory 10% EU target.

Signs of massive importing of plant oil (for biodiesel): the portuguese status

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Which domestic raw materials for sustainable biofuels production ?

Biodiesel

- Forest residues (gasification route) ?
- **<u>Microalgae (cultivation route) ?</u>**

Bioethanol

- Forest residues (biochemical route) ?
- Cereal straws (biochemical route) ?
- Dedicated energetic crops ?
- **<u>Microalgae (cultivation route) ?</u>**

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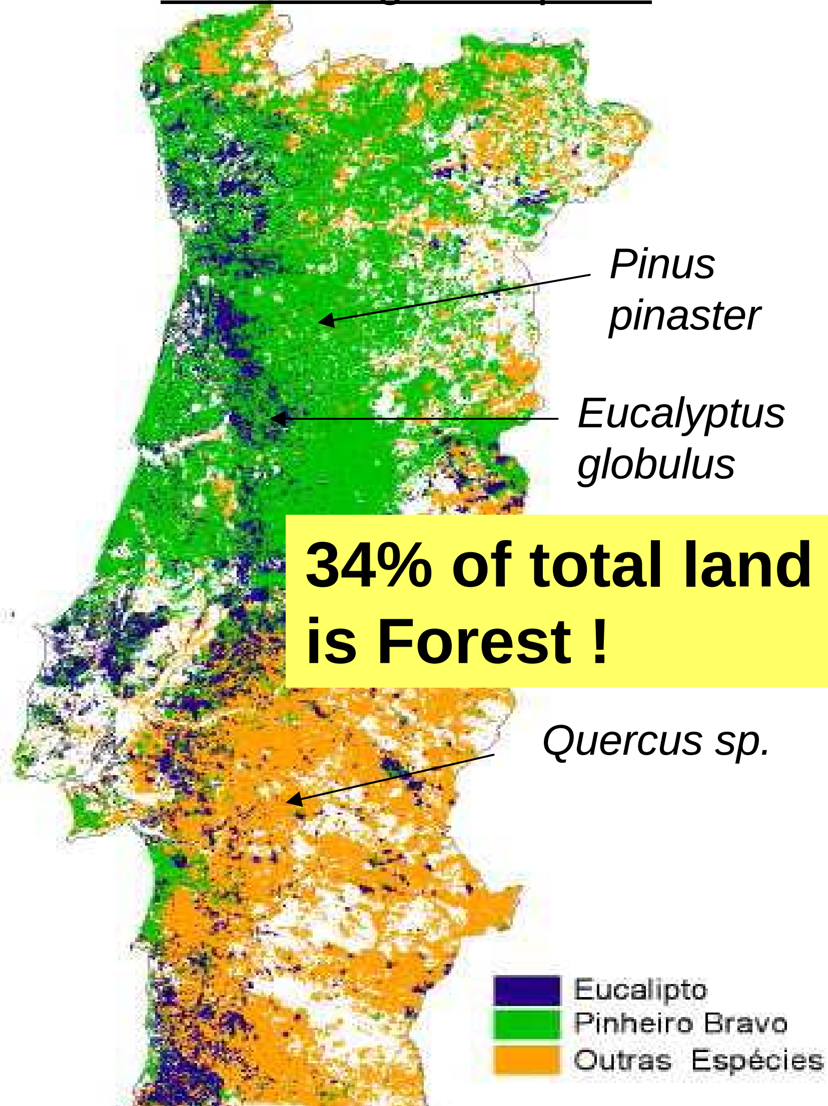
LNEG – Bioenergy Programme: The Forest Biomass Resources

2010: 150 MWe from forest residues

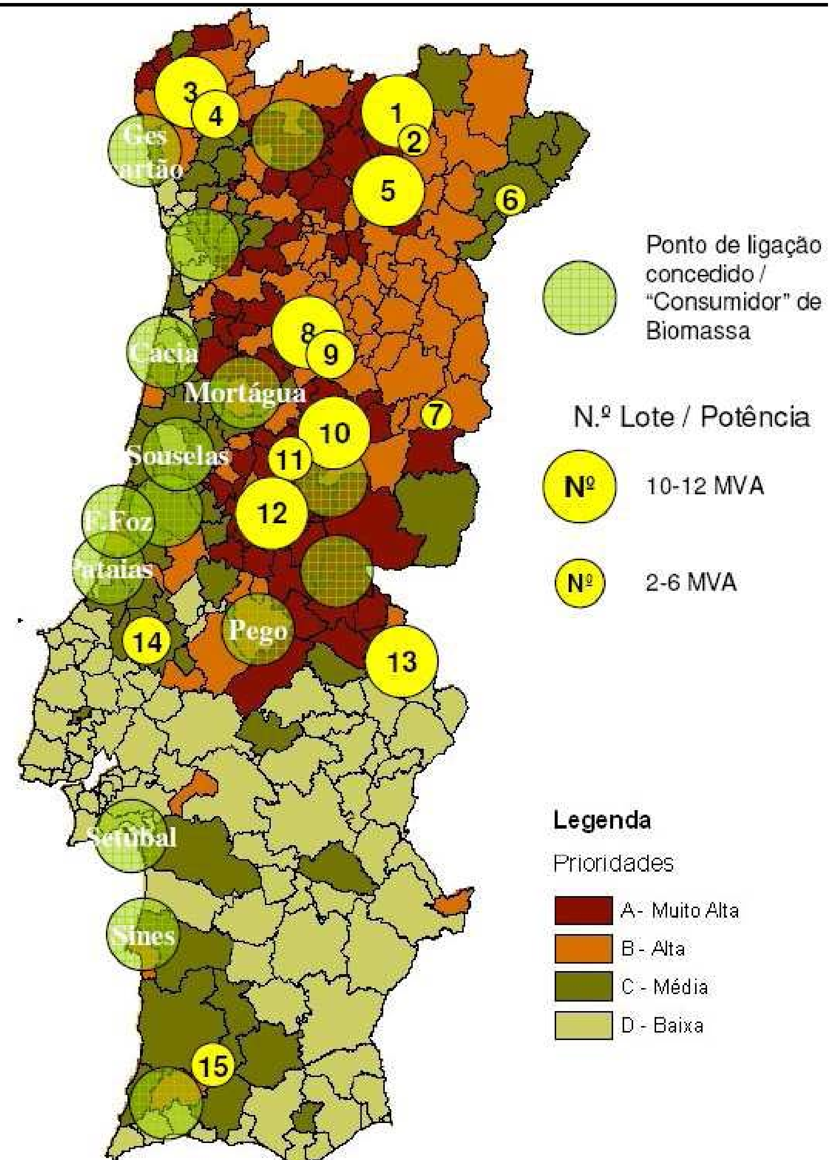
Dominating tree specie



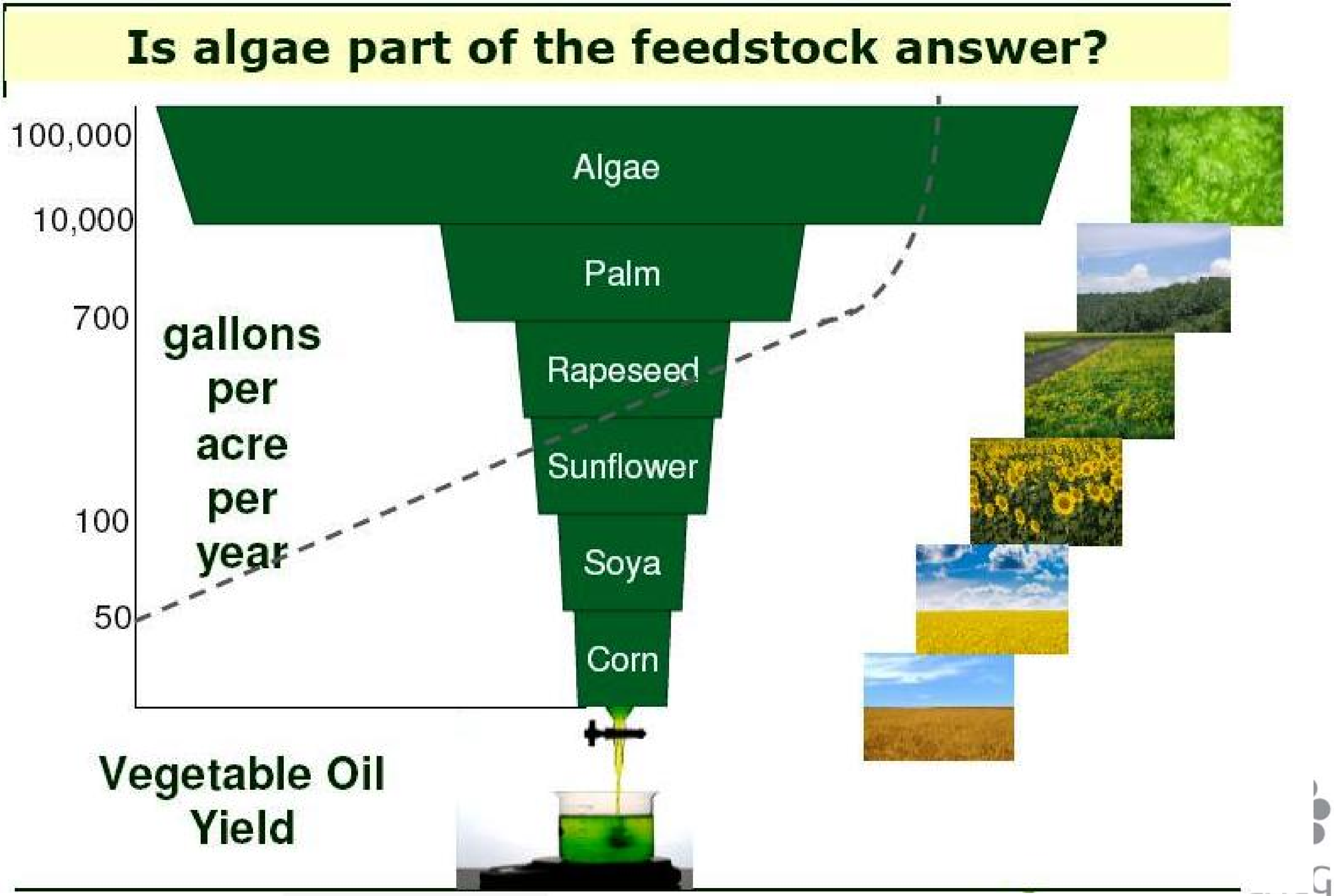
34% of total land is Forest !

Source: CELPA

15 Biomass Power Plants under construction



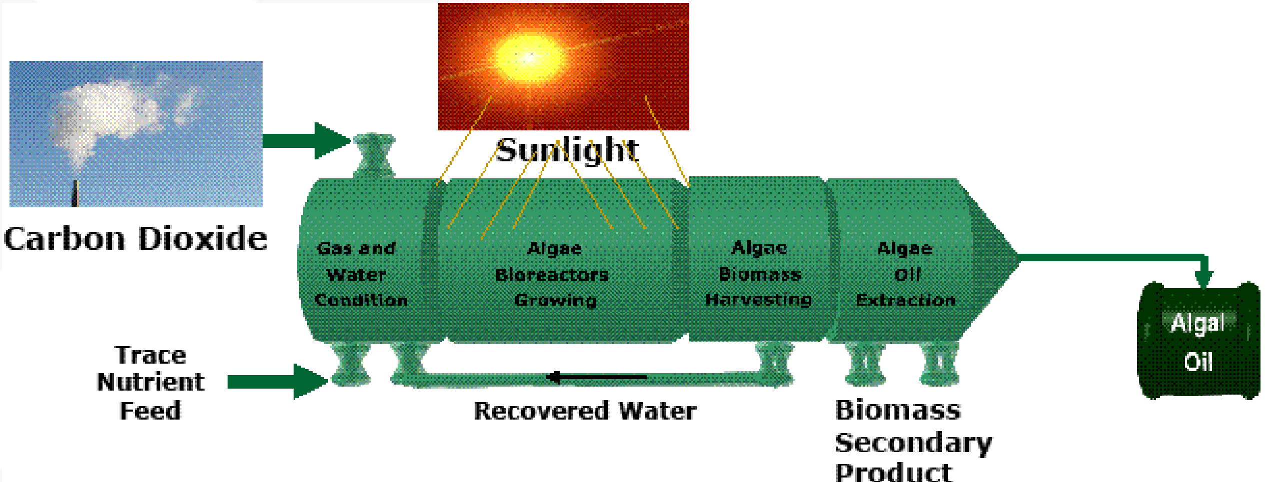
What about microalgae (cultivation route) ?



In: Valcent Inc.

SOME ADVANTAGES FOR MICROALGAE AS AN ENERGETIC CROP

1. **Higher photosynthetic efficiency**
2. **Higher biomass productivities than terrestrial crops**
3. **Faster growth rate**
4. **Highest CO_2 fixation (1-3 ton CO_2/** ton biomass) **and O_2 production**
5. **Use of fresh, marine and brackish water**
6. **Facility to manipulate liquids and culture medium can be recycle**
7. **Possible utilization of degraded soils**
8. **Cropping area necessary to produce biomass less than for traditional crops**
9. **Possibilities of carbon credits revenues**
10. **Continuous production – doesn't follow any harvest regime and biomass harvest can be daily**



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more than 300 X less land area beeded as compared with corn (for av. 30% oil content, by wt.)

Crop	Oil yield (L/ha)	Land area needed (M ha)[a]	Percent of existing US cropping area[a]
Corn	172	1540	846
Soybean	446	594	326
Canola	1190	223	122
Jatropha	1892	140	77
Coconut	2689	99	54
Oil palm	5950	45	24
Microalgae[b]	136,900	2	1.1
Microalgae[c]	58,700	4.5	2.5

[a] For meeting 50% of all transport fuel needs of the United States.
[b] 70% oil (by wt) in biomass.
[c] 30% oil (by wt) in biomass.

In: Chisti, 2007

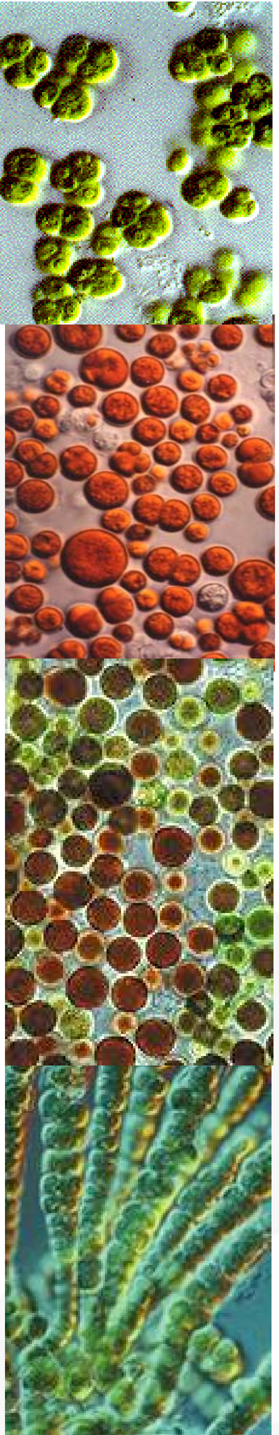
Algae provides standard oil which can meet <u>biodiesel specifications</u>

Comparison of properties of biodiesel from microalgal oil and diesel fuel and ASTM biodiesel standard

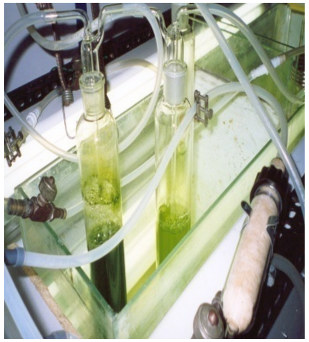
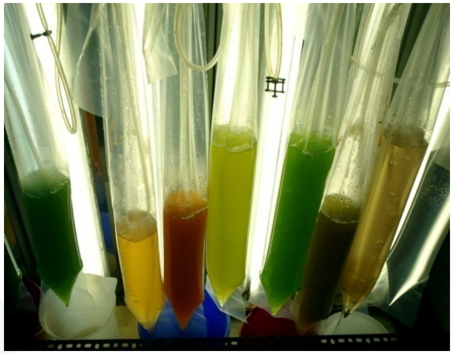
Properties	Biodiesel from microalgal oil	Diesel fuel[a]	ASTM biodiesel standard
Density (kg/l)	0.864	0.838	0.86–0.9
Viscosity (mm^2/s, cSt at 40 °C)	5.2	1.9–4.1	3.5–5.0
Flash point (°C)	115	75	Min 100
Solidifying point (°C)	−12	−50 to 10	–
Cold filter plugging point (°C)	−11	−3.0 (Max −6.7)	Summer max 0; winter max < −15
Acid value (mg KOH/g)	0.374	Max 0.5	Max 0.5
Heating value (MJ/kg)	41	40–45	–
H/C ratio	1.81	1.81	–

[a] The data about diesel fuel were taken from published literature as indicated in the text.

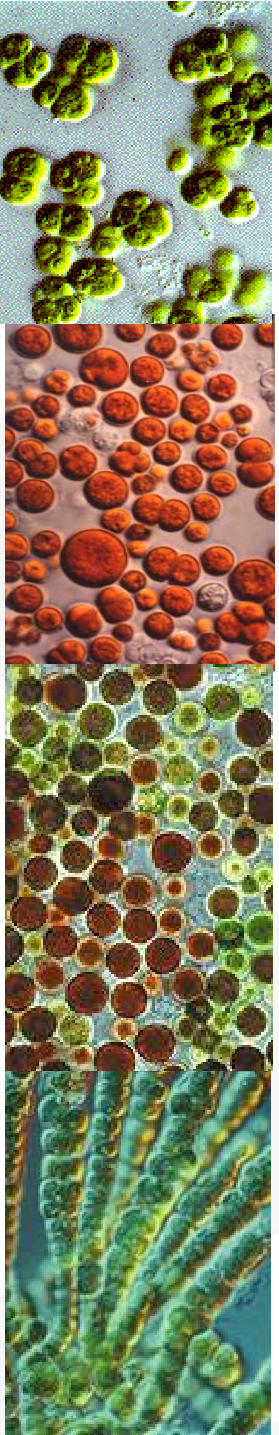
In: X. Miao, Q. Wu, (2006) Bioresource Technology 97: 841–846



LNEG – Bioenergy Programme:
The Microalgae studies at LNEG

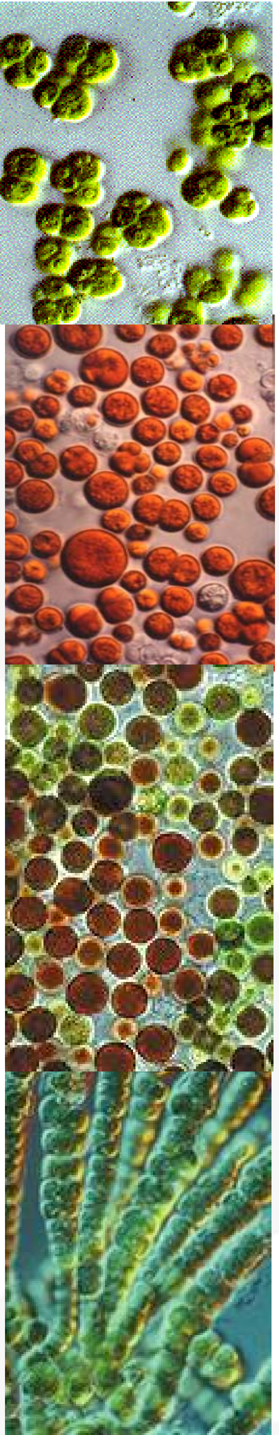




LNEG – Bioenergy Programme: The Microalgae studies at LNEG for biodiesel

<u>Current R&D targets for biodiesel</u>:

1. Increase photosynthetic efficiency to enable increased biomass yield on light
2. Enhance biomass growth rate and increase oil content in biomass
3. Improve temperature tolerance to reduce the expense of cooling
4. Reduce susceptibility to photooxidation that damages cells
5. Integration with other renewables energies and exploitation of other valuable compounds using the biorefinery approach



LNEG – Bioenergy Programme: The Microalgae studies at LNEG for bio-hydrogen

Non-biological systems

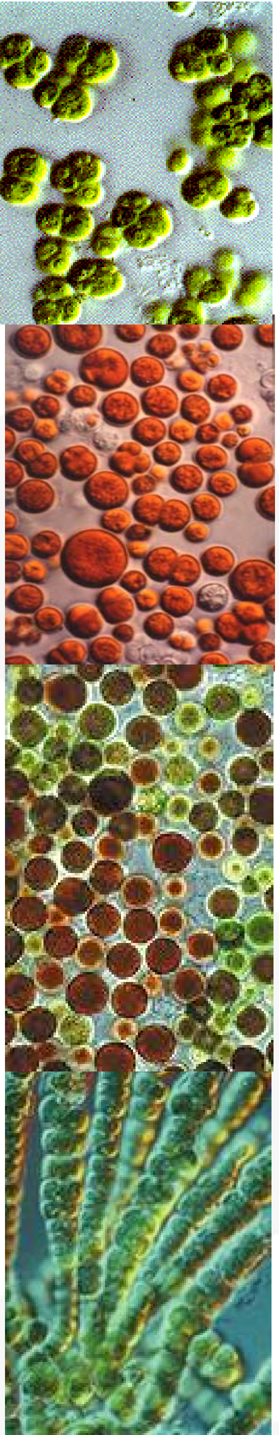
Biological system

Electrolysis plant

H2

Cleaning, pressurization, liquefaction or absorption

- Local small-scale units
- Centralised plants



LNEG – Bioenergy Programme:
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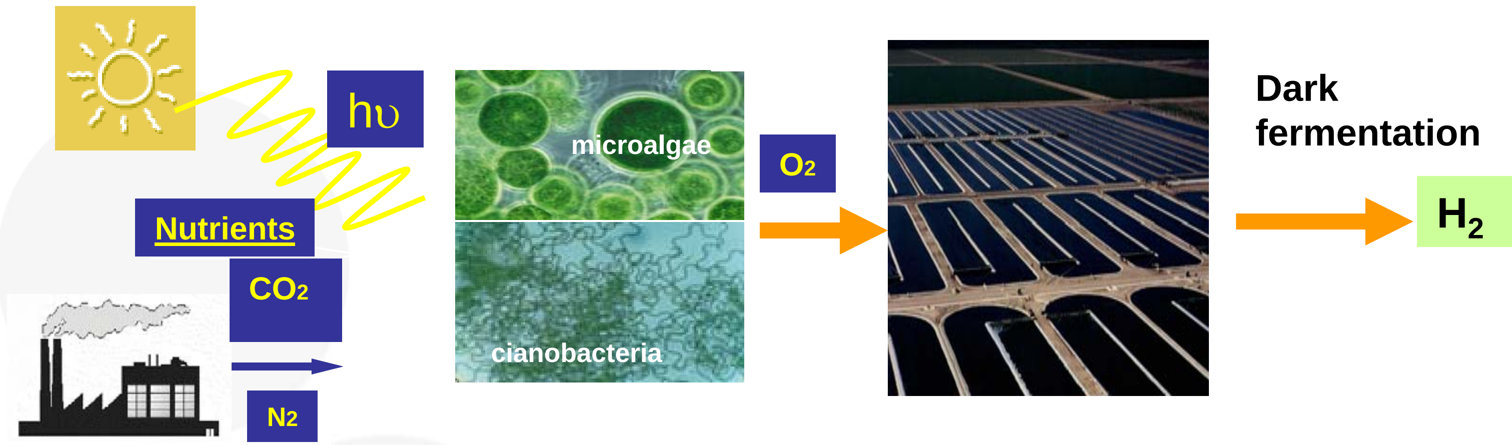
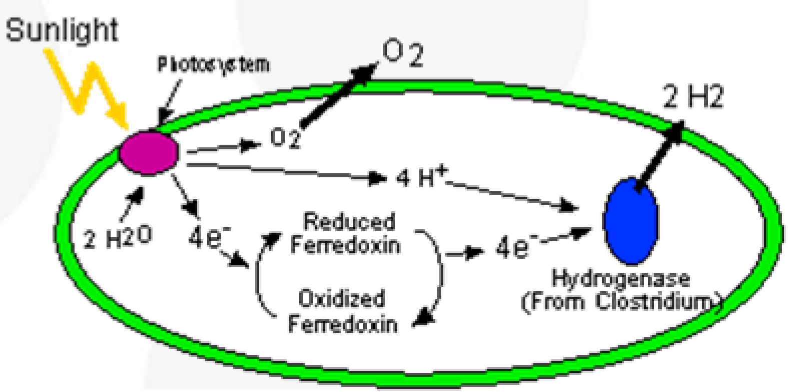
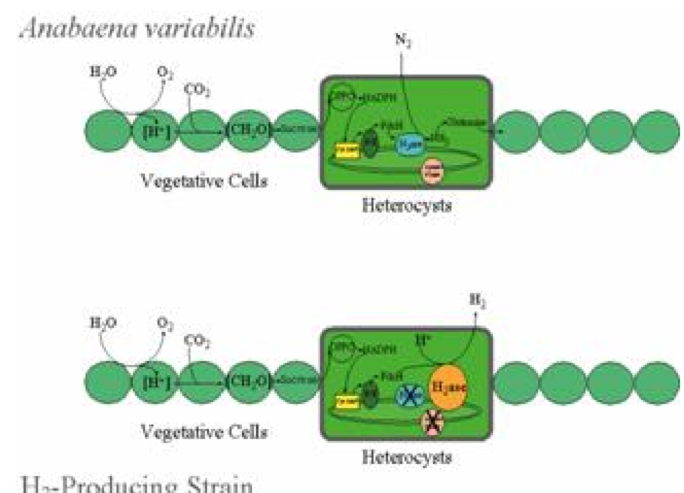
1. Microalgae photosyntetic production

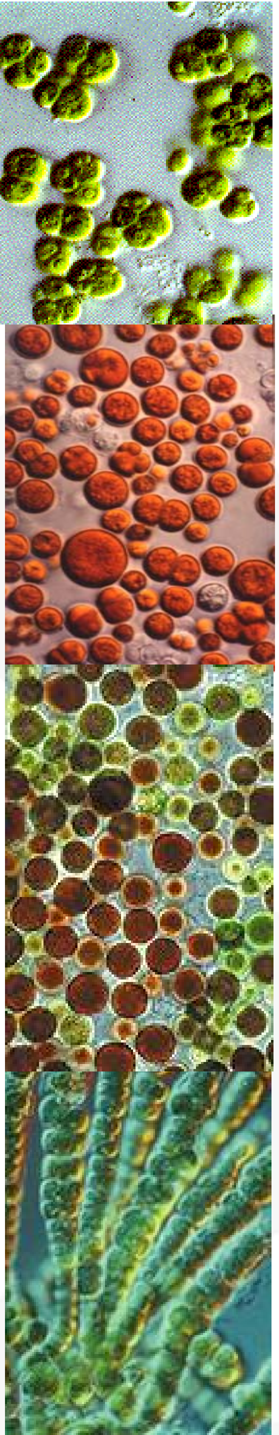


Phosynthetic microalgae



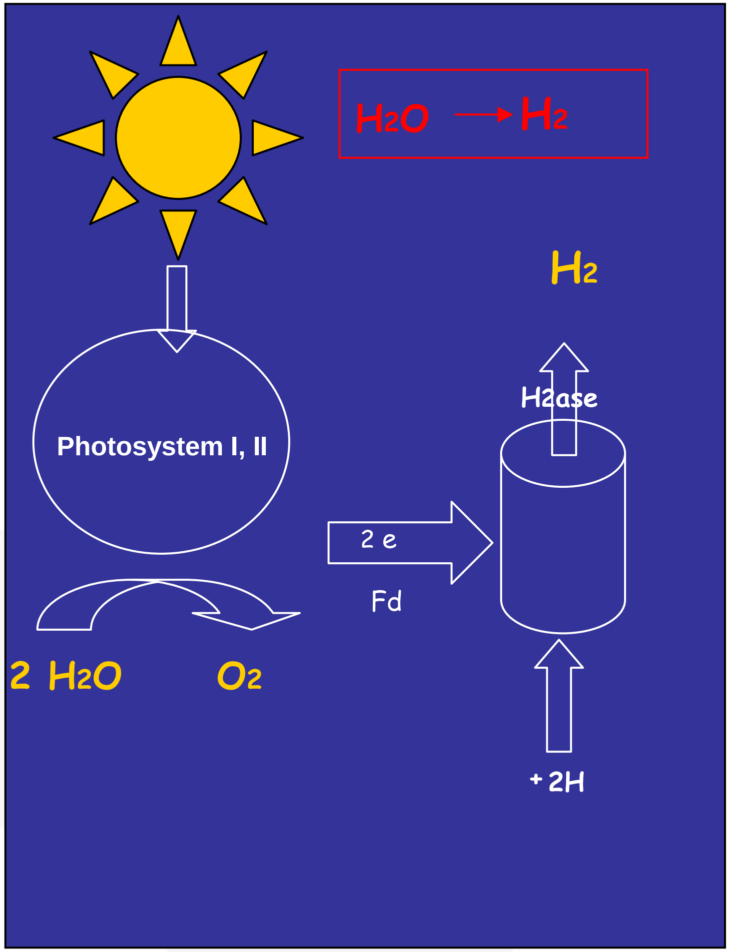
Cyanobacteria



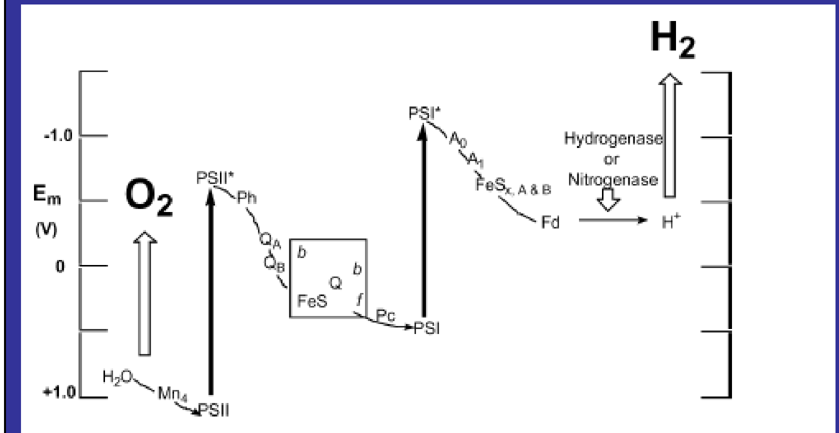


LNEG – Bioenergy Programme:
The Microalgae studies at LNEG for bio-hydrogen

1. Direct photoproduction of H2 w/ cyanobacteria and microalgae

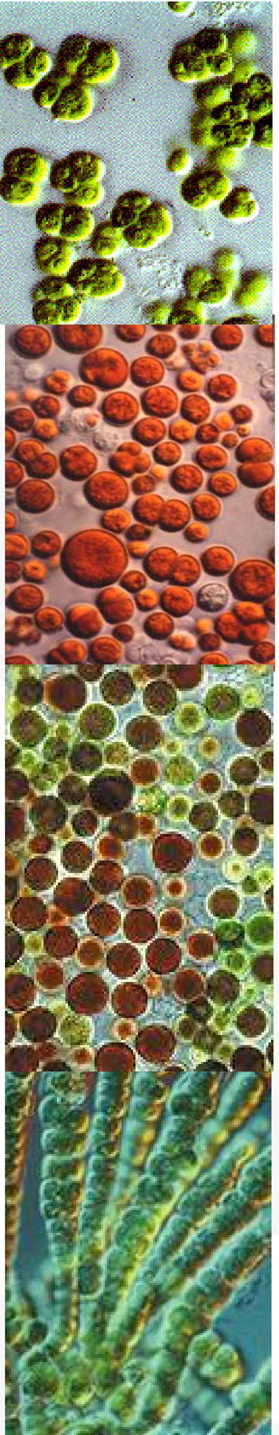


Direct H2 photo-production



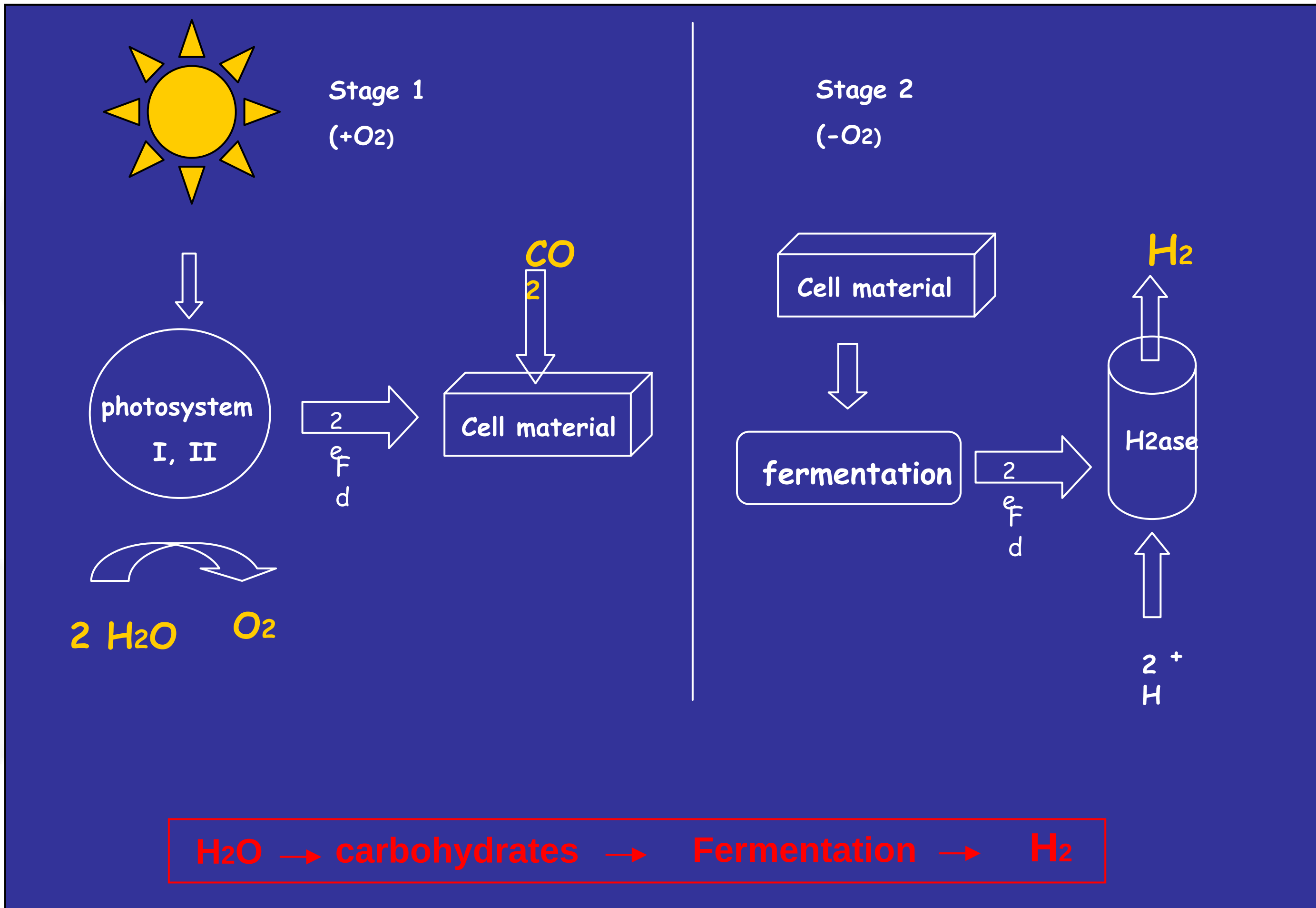
Direct photoproduction of hydrogen. Hydrogen and oxygen are evolved simultaneously in this design.

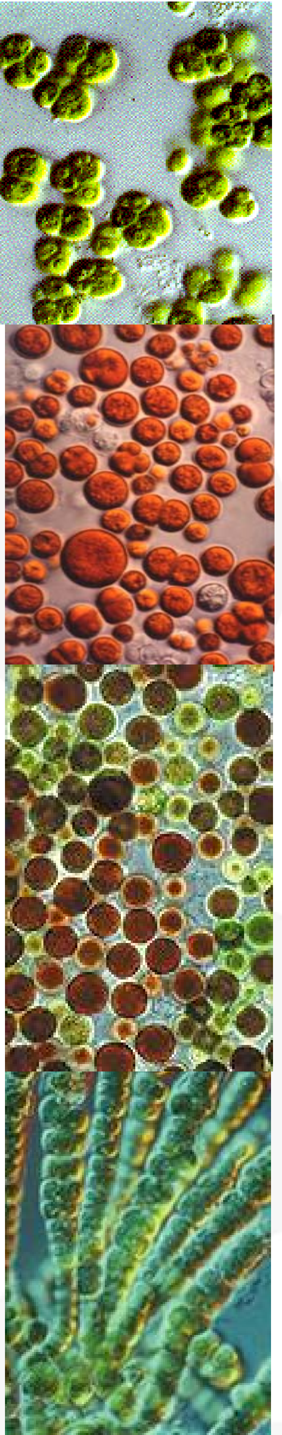
Prince & Kheshgi (2005)
Critical Reviiews in Microbiology, 31: 19-31



LNEG – Bioenergy Programme: The Microalgae studies at LNEG for bio-hydrogen

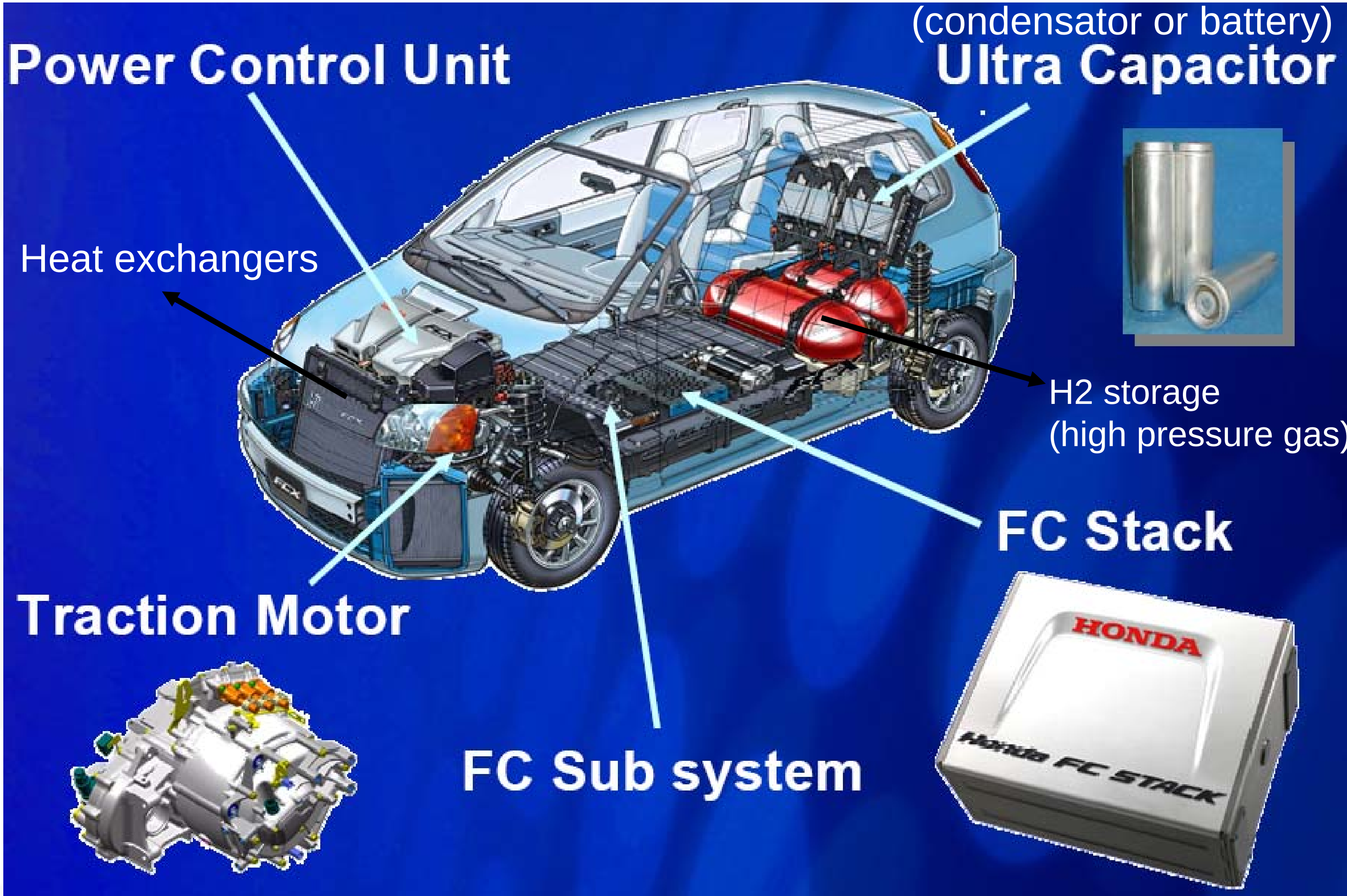
2. Indirect photoproduction of H2 w/ cyanobacteria and microalgae



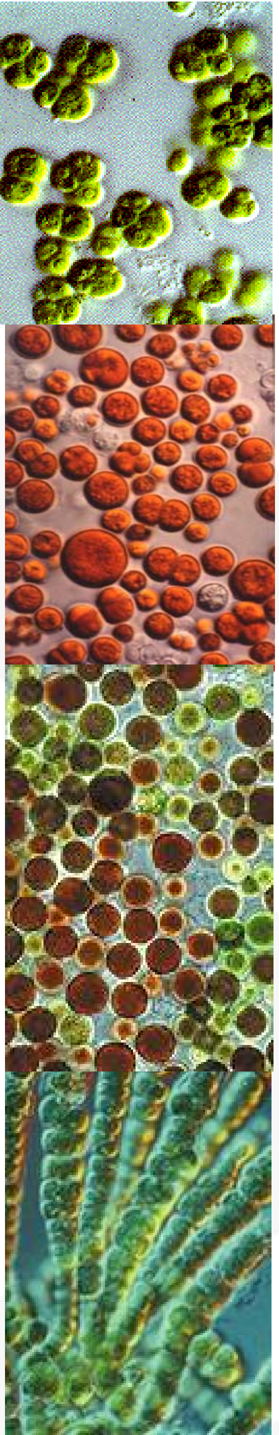


LNEG – Bioenergy Programme: The Bio-Hydrogen for the transportation sector

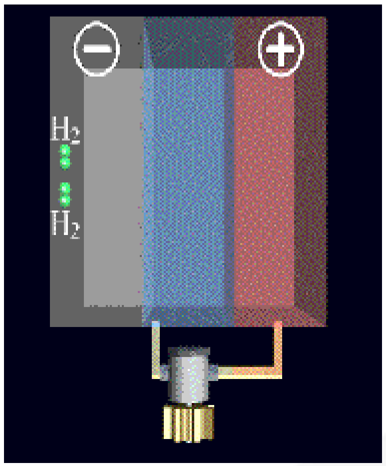
e.g. HONDA Fuel Cell Vehicle (source: Honda)

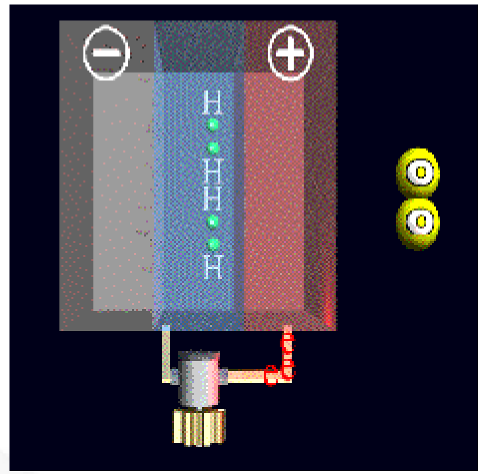


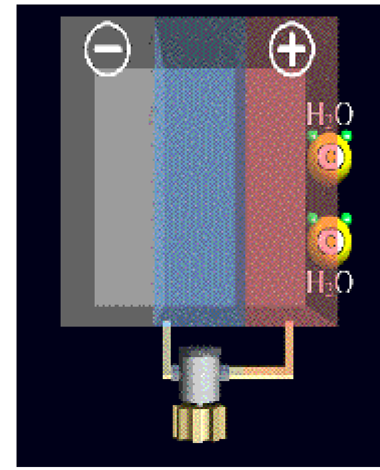
LNEG – Bioenergy Programme: The Bio-Hydrogen for the transportation sector

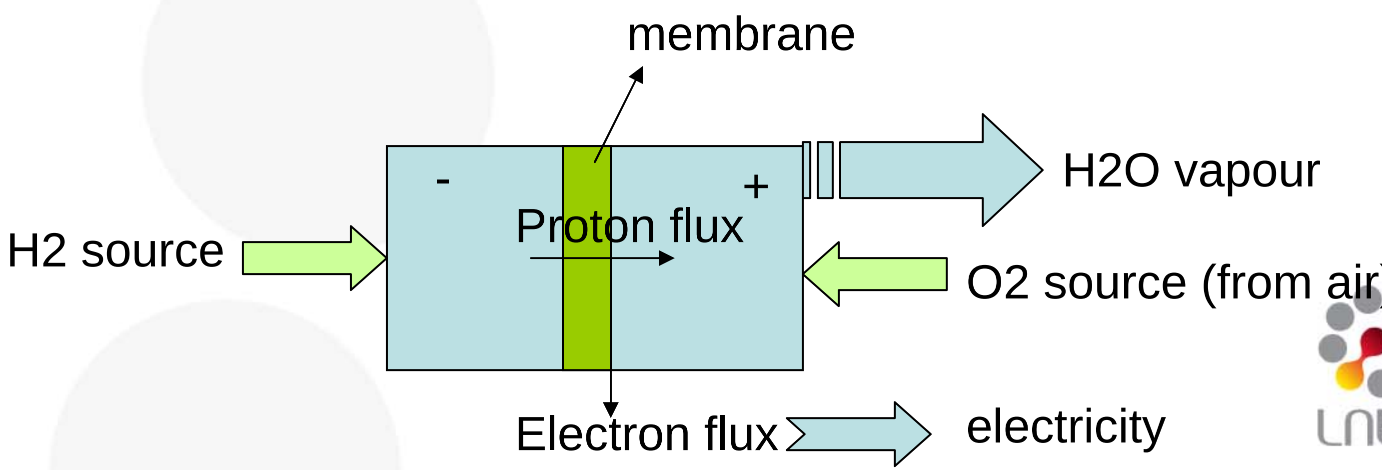


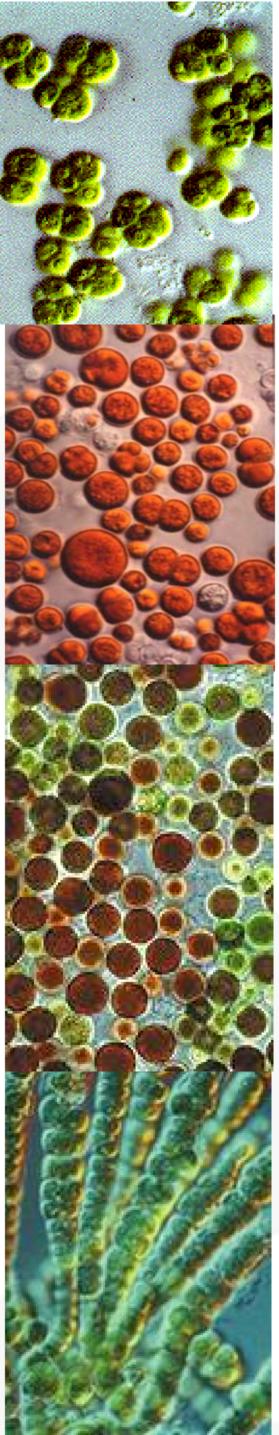
Principle of a Fuel Cell











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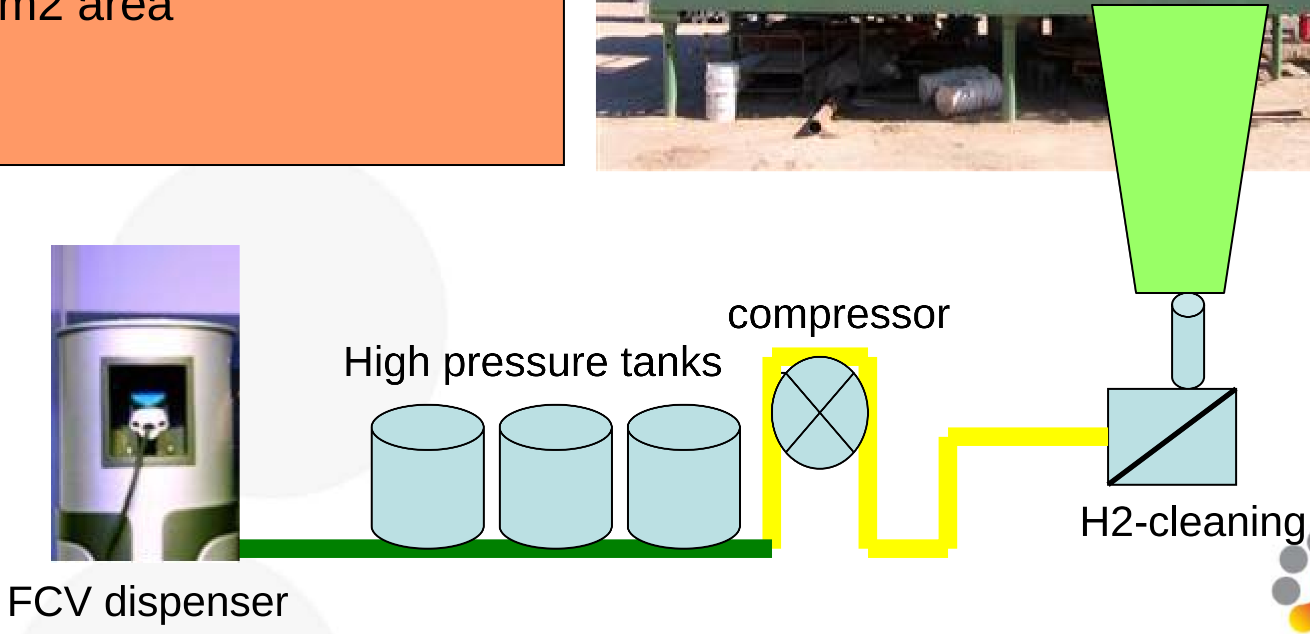
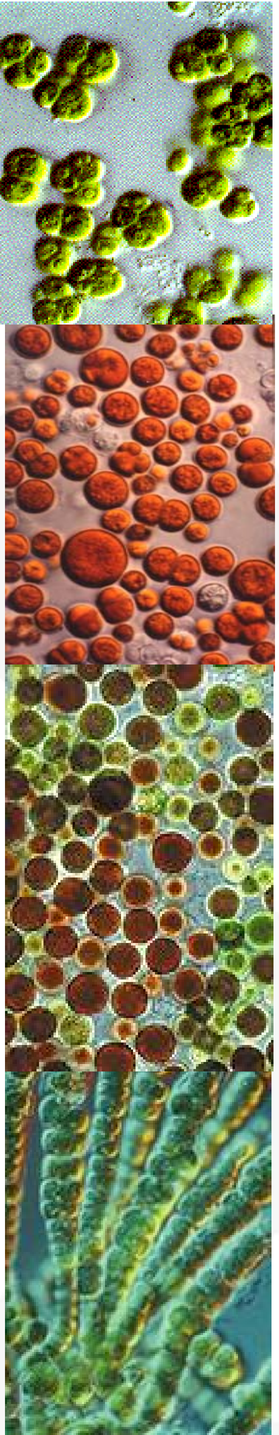
<u>Hydrogen Refueling Station</u>

Average Dispensing:
200 000 Litres Petrol/yr

= 138 000 m3 photobioreactors
= 360 m2 area





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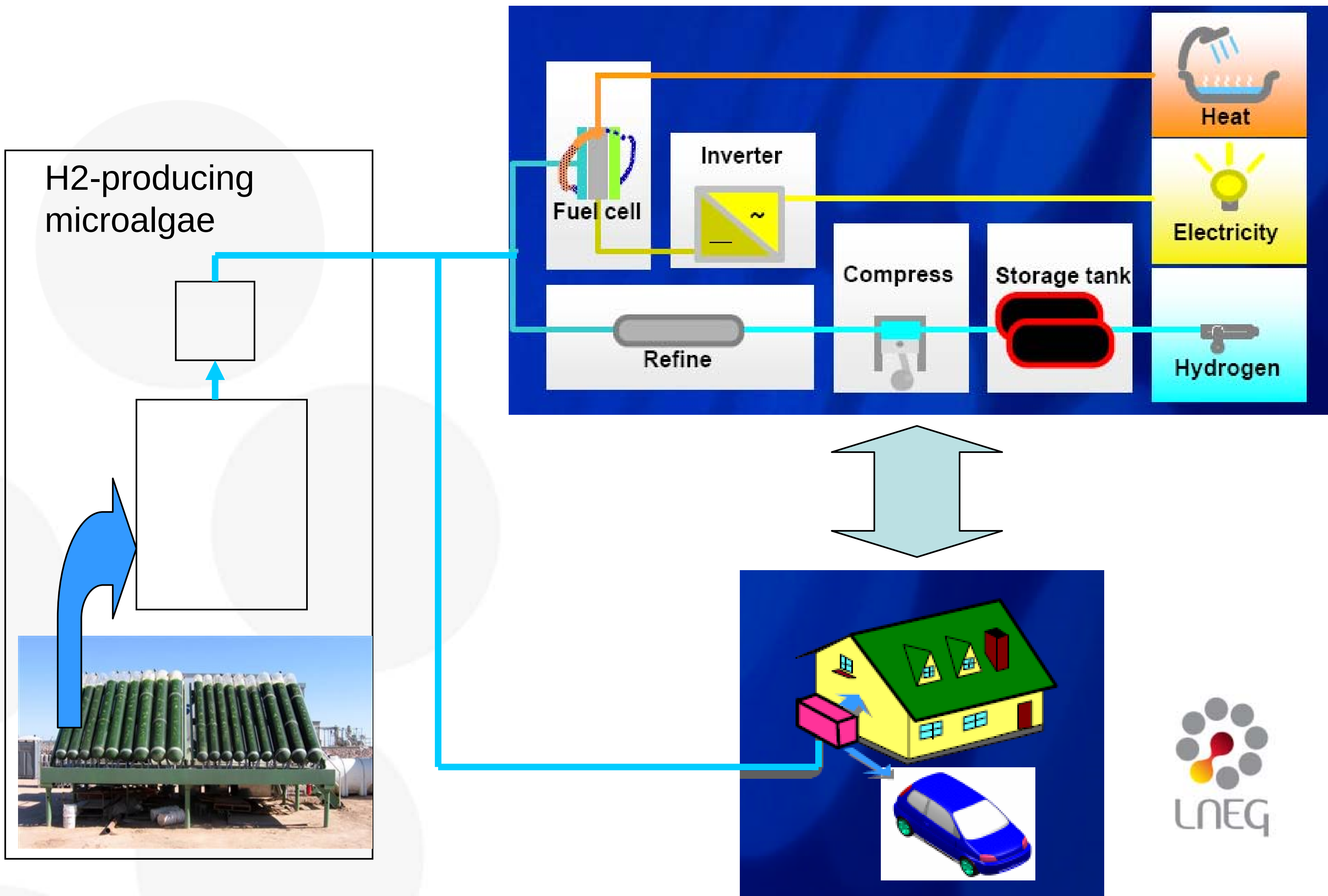
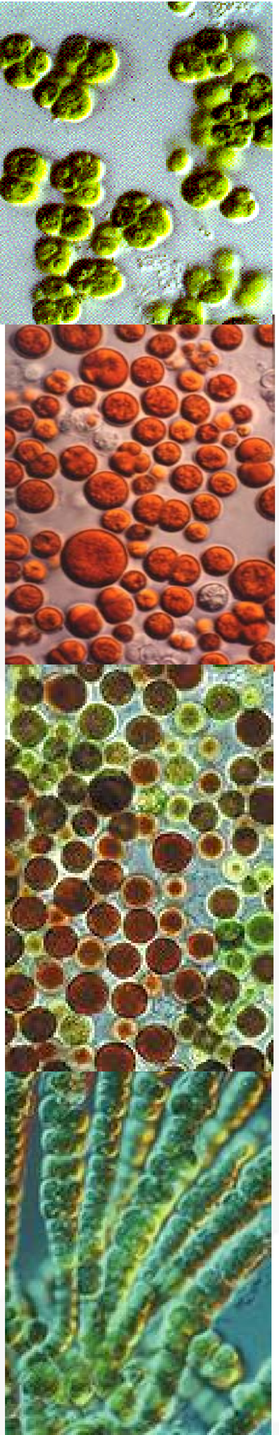
HOME ENERGY STATION: The Concept

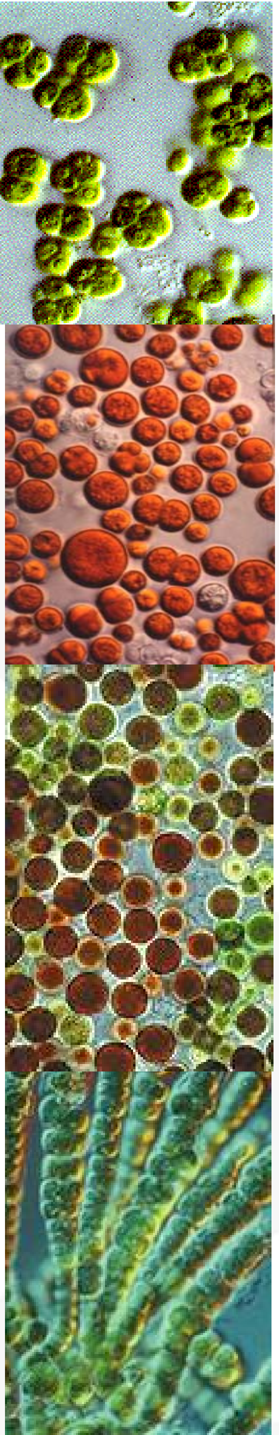




LNEG – Bioenergy Programme: The Microalgae studies at LNEG

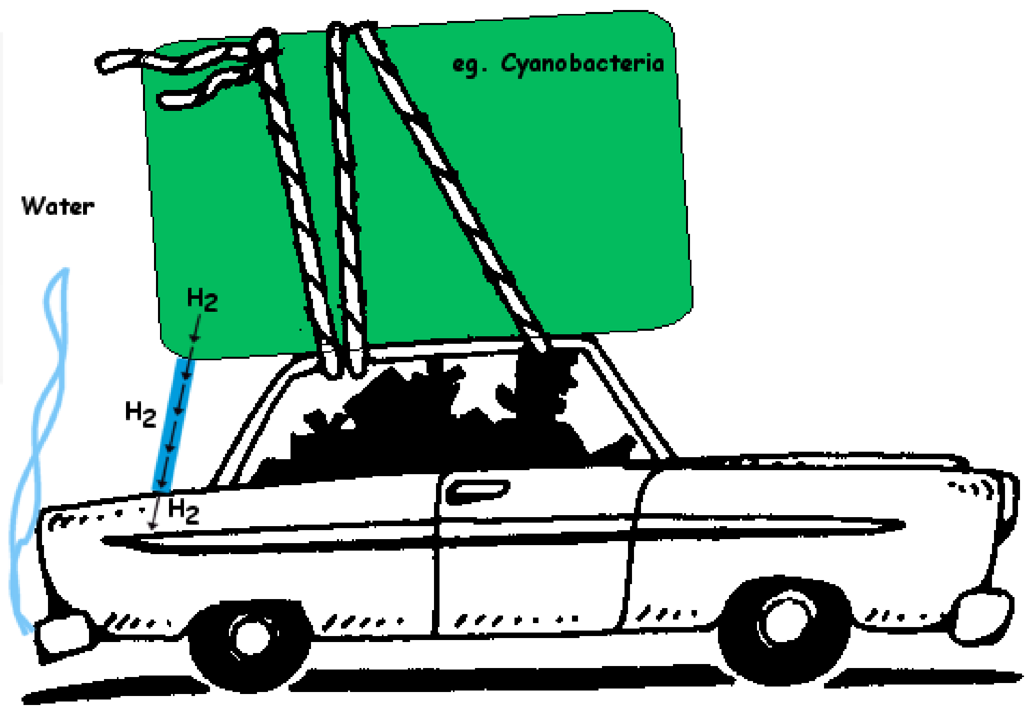
Current R&D targets for bio-hydrogen:

1. **Metabolic engineering** towards more O_2- tolerant enzymes and lesser energetic requirements
2. **Bioprocess integration:** dark fermentation – photofermentation
3. **Photosyntetic production of hydrogen through cyanobacteria or microalgae**: increasing the efficiency of hydrogen recovery
4. **Developing electrochemical systems** for bio-hydrogen purification from hydrogen enriched biological mixtures
5. **Enhancing hydrogenases resistance towards oxygen** through biochemical engineering tools
6. **Nanostructured high performance materials** for hydrogen storage
7. **Optimization of fuel cell systems**: experimental and numerical studies
8. **Transport phenomena on DMFC cells**



LNEG – Bioenergy Programme: The Bio-Hydrogen for the transportation sector

Towards Zero CO_2 emmissions !...with the help of microalgae !



Thank you

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Laboratório Nacional de Energia e Geologia, I. P.

MINISTÉRIO DA ECONOMIA E DA INOVAÇÃO