European Biomass Industry Association

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EUBIA

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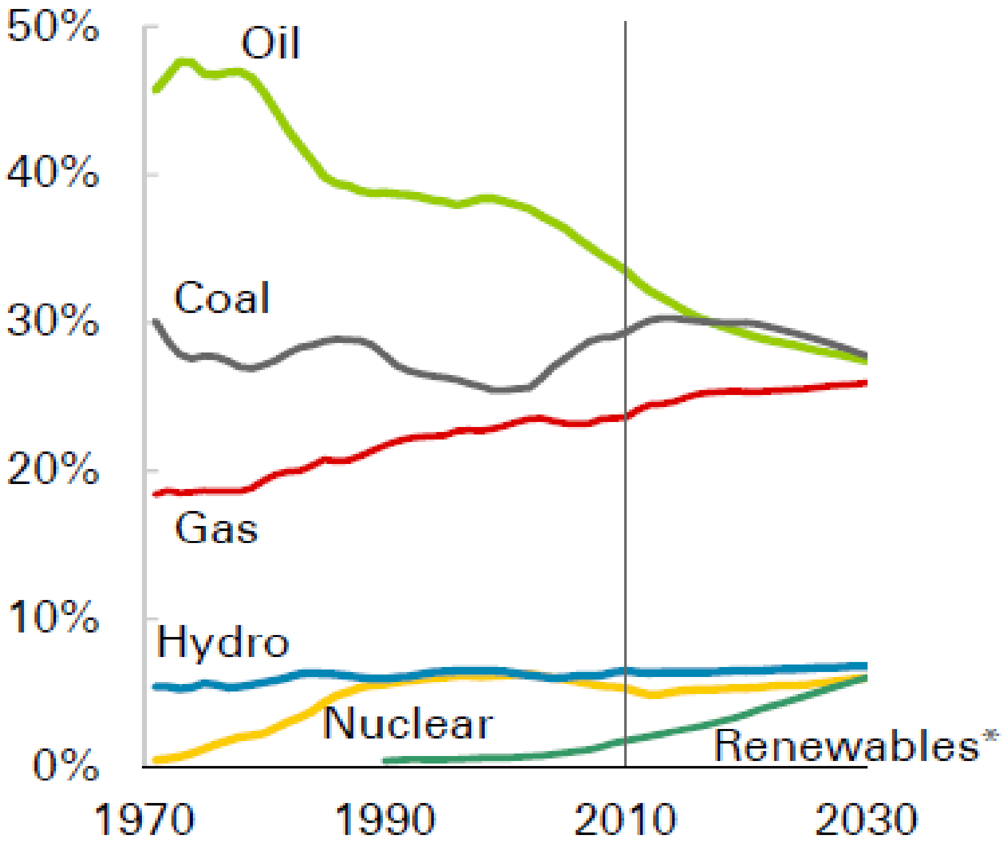
General World Context

ECONOMIC INDICATORS	2010	2020	2030	2040	2050
GDP (bil 2004 $)	45.233	60.050	79.627	103.434	133.242
Consumption (bil 2004 $)	27.706	36.942	48.494	62.846	81.028
GDP growth (% / yr)	1,9	2,7	2,9	2,5	2,6
Population (millions)	6.895,30	7.655,80	8.320,60	8.873,10	9.305,00
GDP per capita (2004 $)	6.560	7.844	9.570	11.657	14.319
GHG EMISSIONS					
CO2 Billion t	38,8	45,7	52	57,4	60,9
CH4 (Mt)	397,5	396,9	640,8	678,3	713
N2O (Mt)	11,41	11,21	14,48	16,35	18,36
PFCs (kt CF4)	14,61	3,66	6,03	6,53	6,59
No. OF VEHICLES (millions)	808	1003	1202	1384	1603
LAND USE (Mha)					
Cropland	1808,4	2003,9	2239,5	2463,6	2659,9
1 st generationBiofuels	43,2	75,1	78,8	69,7	61,5
Pasture	2800,3	2798,8	2730,3	2680,1	2631
Managed forest	563,1	509,5	484,4	460,7	441,8
Natural grassland	665,9	594,7	560,7	534,9	524,2
Natural forest	4243,6	4139,8	4024,9	3908,8	3799
Other	2997	2997	2997	2997	2997
TOTAL	**13121,6**	**13118,8**	**13115,7**	**13114,8**	**13114,3**

History of energy sources consumption (1970-2010). Estimation for next 20 years. Source BP.com



+ 5.4 %

Growth in coal consumption
Festest among fossil fuels

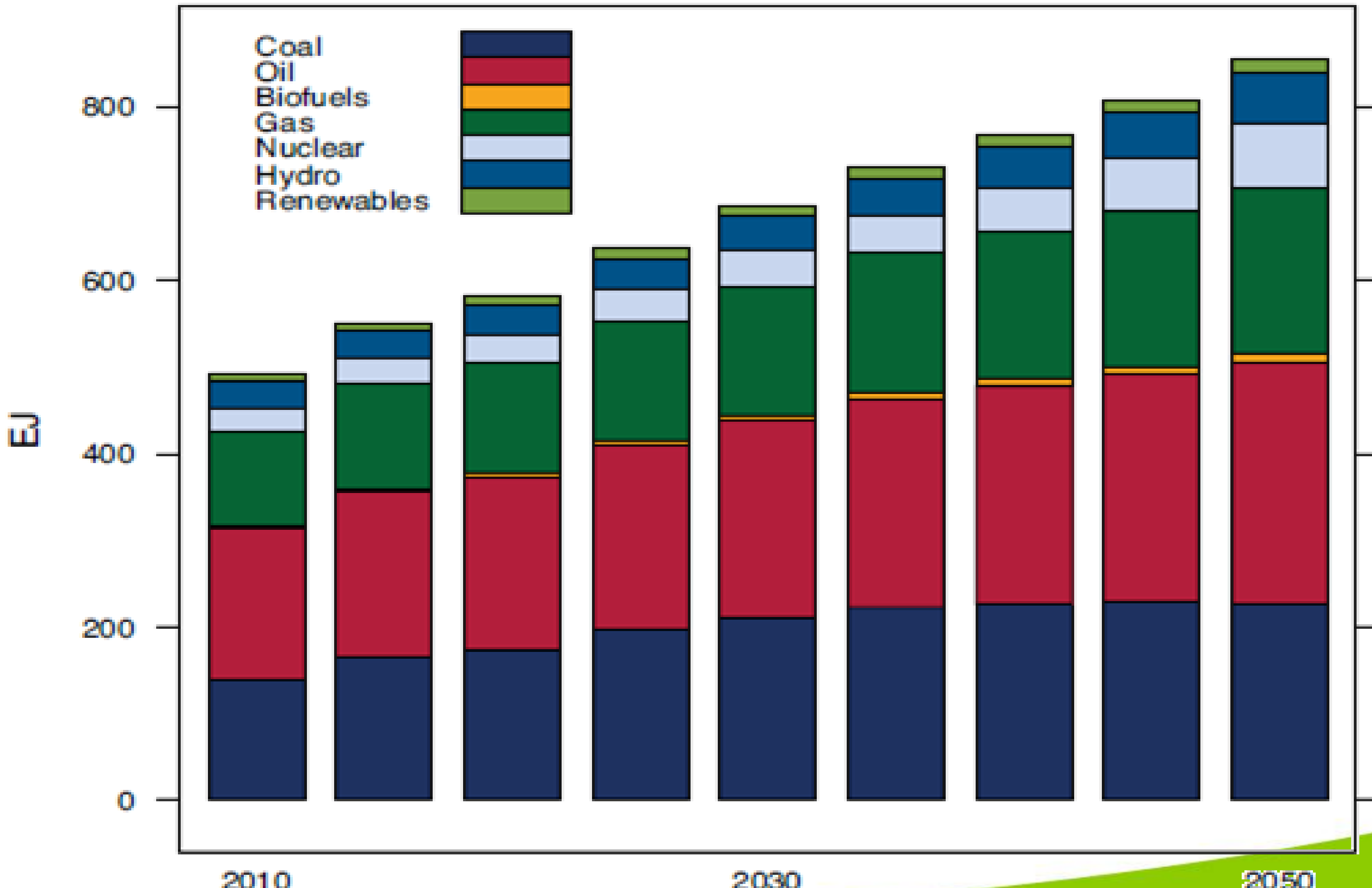
- 4.3 %

Decline in global nuclear output,
The largest on record

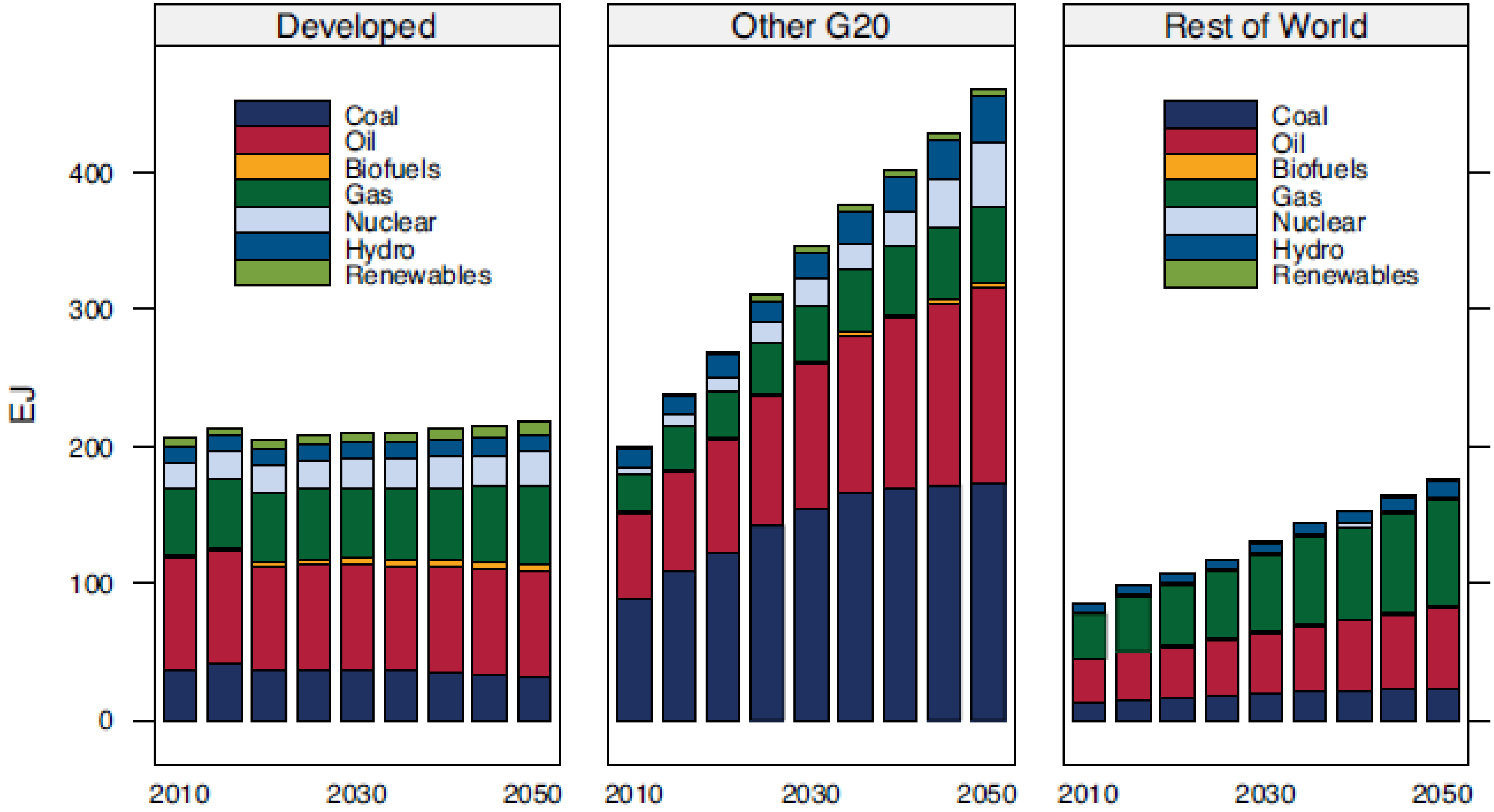
2.1%

Share of renewables in global
Energy consumptioin.

Global Energy Use. Different fuels consumption forecast (2010-2050). Source: MIT



Energy consumption in different world areas from year 2010 to 2050

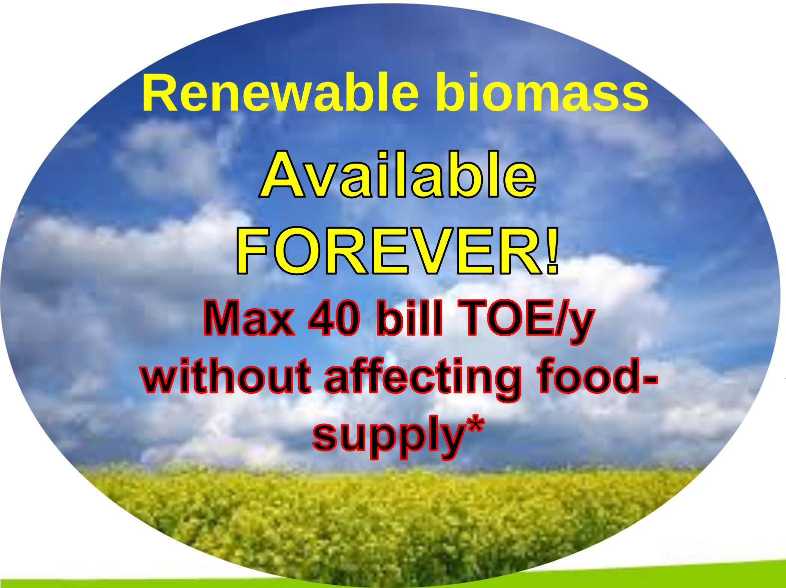


Limited availability of conventional resources

Coal: 167 years

Gas: 60 years

Petrol Oil: 47 years



* By espected long term effect from synthetic Biology

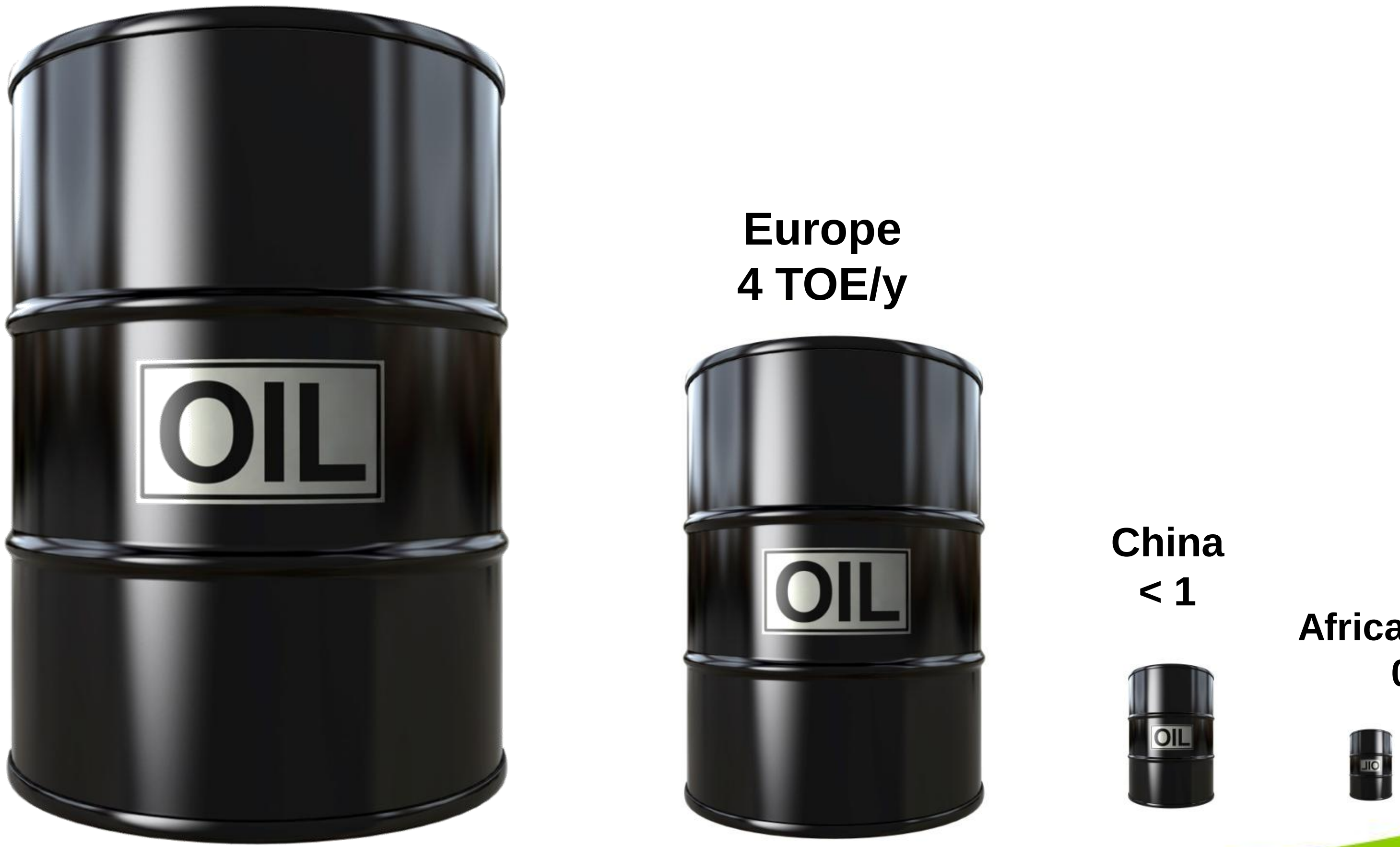
Large difference in Energy Consumption per person among Countries

USA
8TOE/y

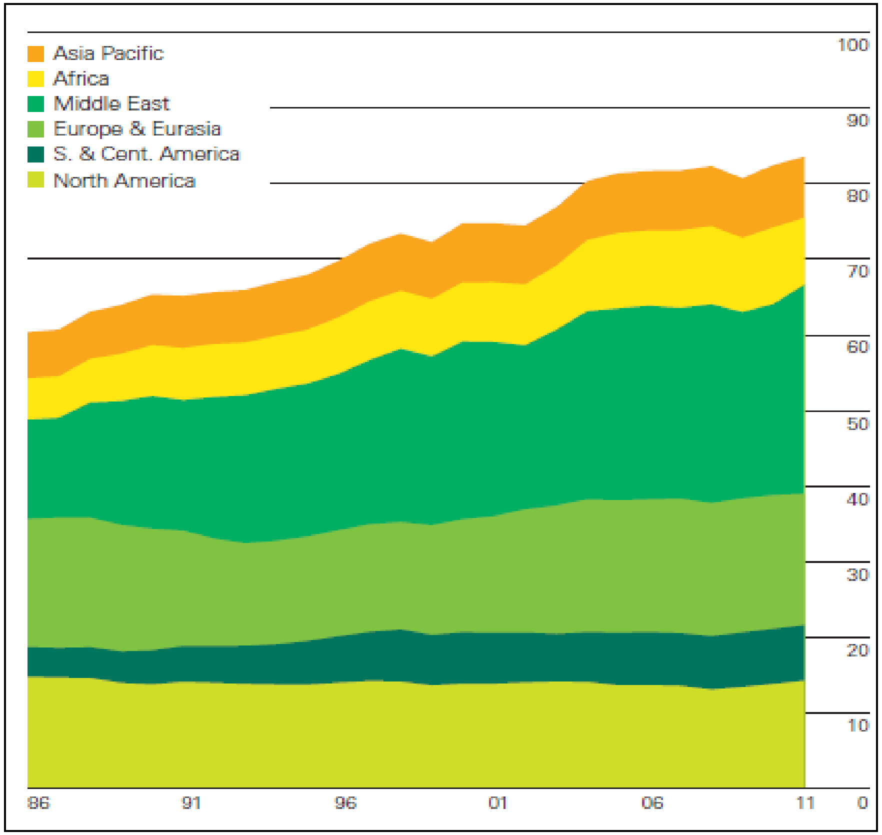
Europe
4 TOE/y

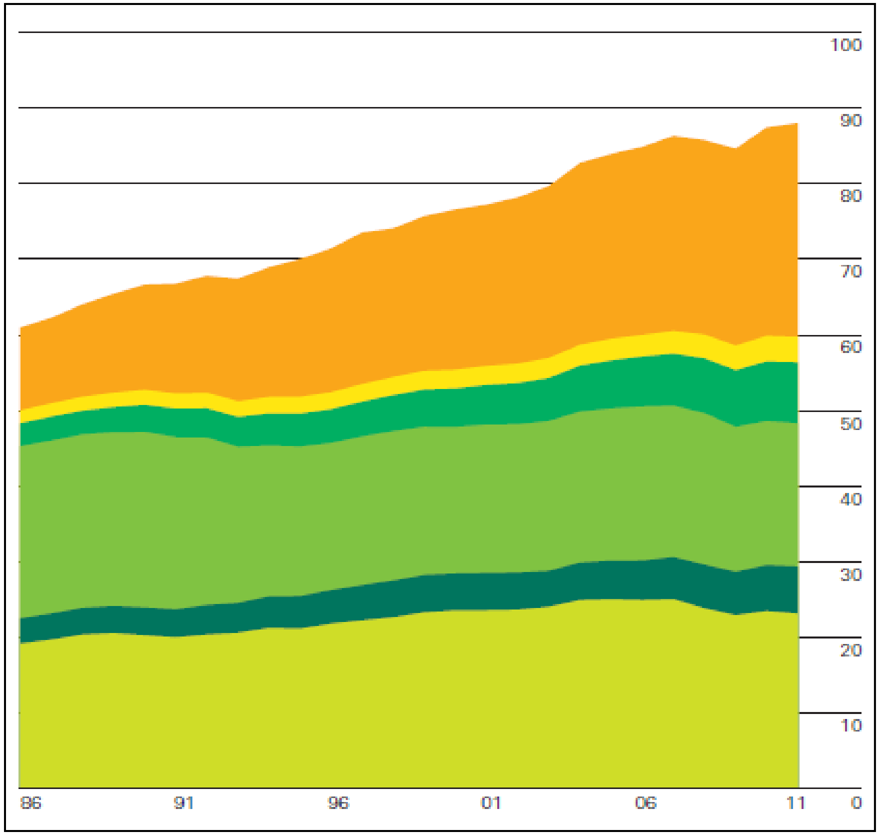
China
< 1

Africa sub-saharian
0,5 TOE/y



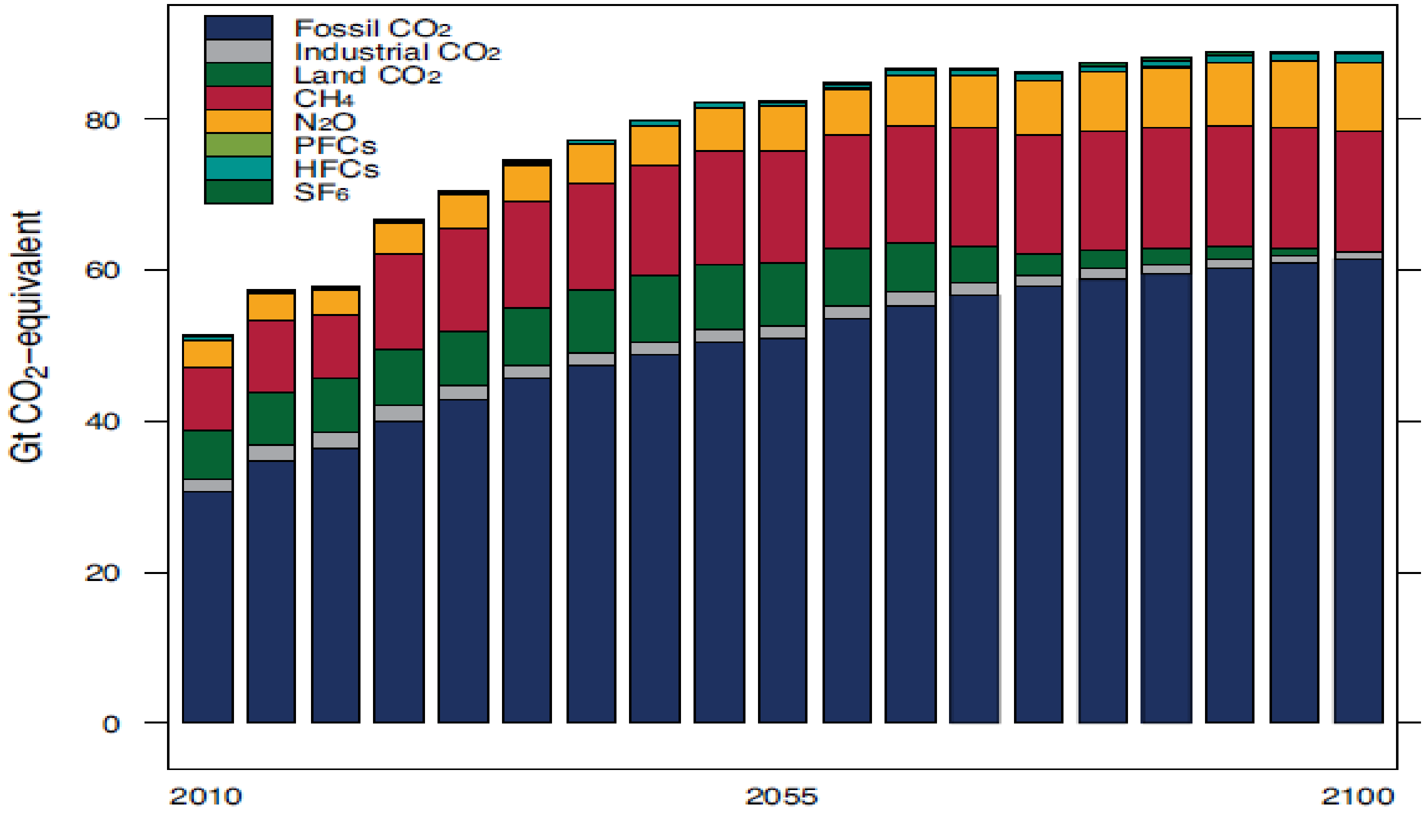
Oil production and consumption among different world regions (Mio. bbl/daily). Source: BP.com





W.R.F.S. World Refining Fuel Service: Estimated Oil demand for 2030: 113 mio bbl /d. but with estimated current supply is of only 93.5 mio bbl /day

Global Greenhouse Gas Emissions



GHG EMISSIONS	2010	2020	2030	2040	2050
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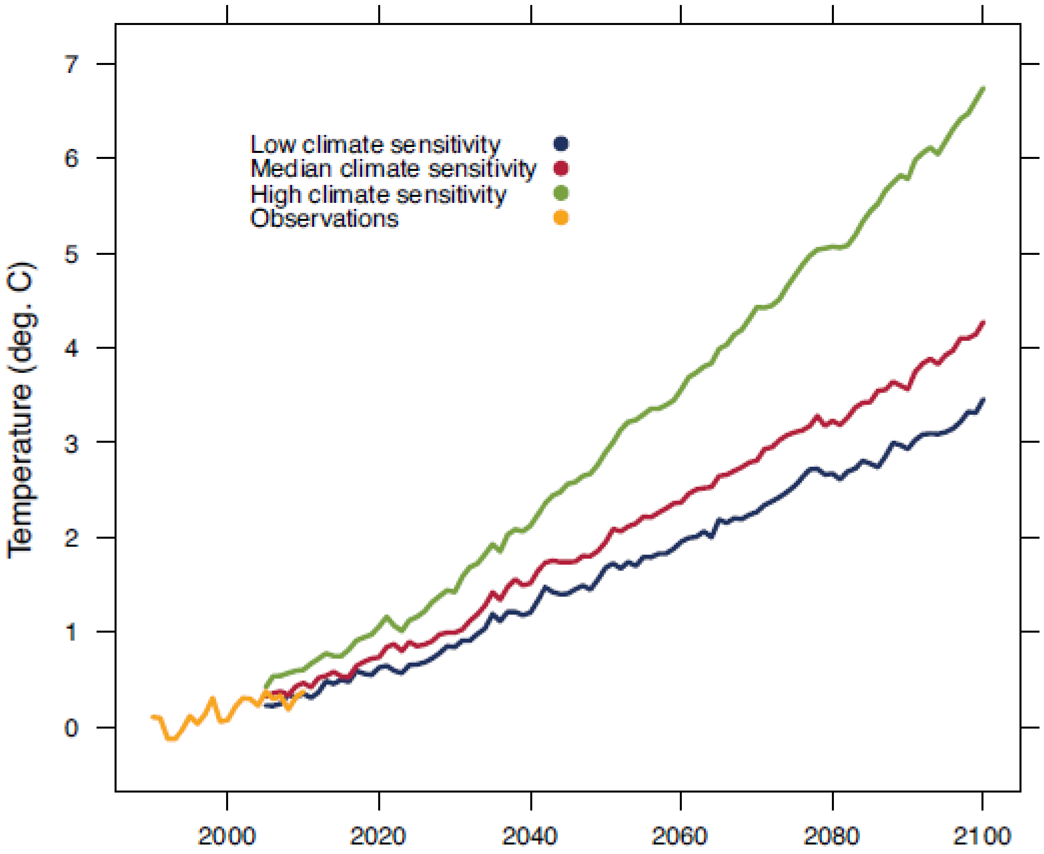
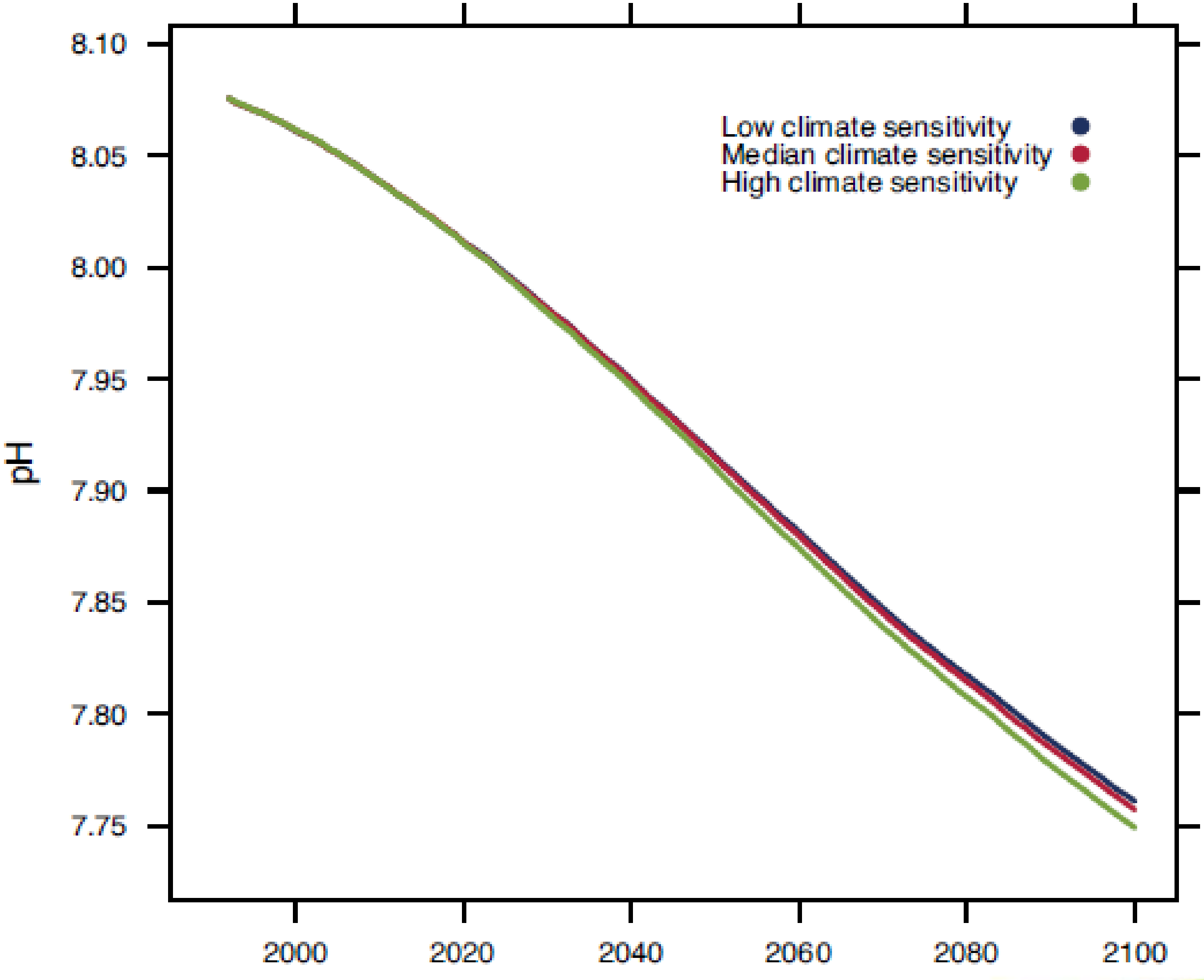
Negative impact of Emissions: Projection of surface temperature increase in 100 year



Even with drastic CO_2 emissions decrease in industrial countries, the mean surface temperature will increase as 2.8 °C around year 2010.
In USA the monitored increase of surface temp (over last 10 years): ~ 0,5 °C

Negative impact of emissions: CO_2 emissions causing ocean acidification



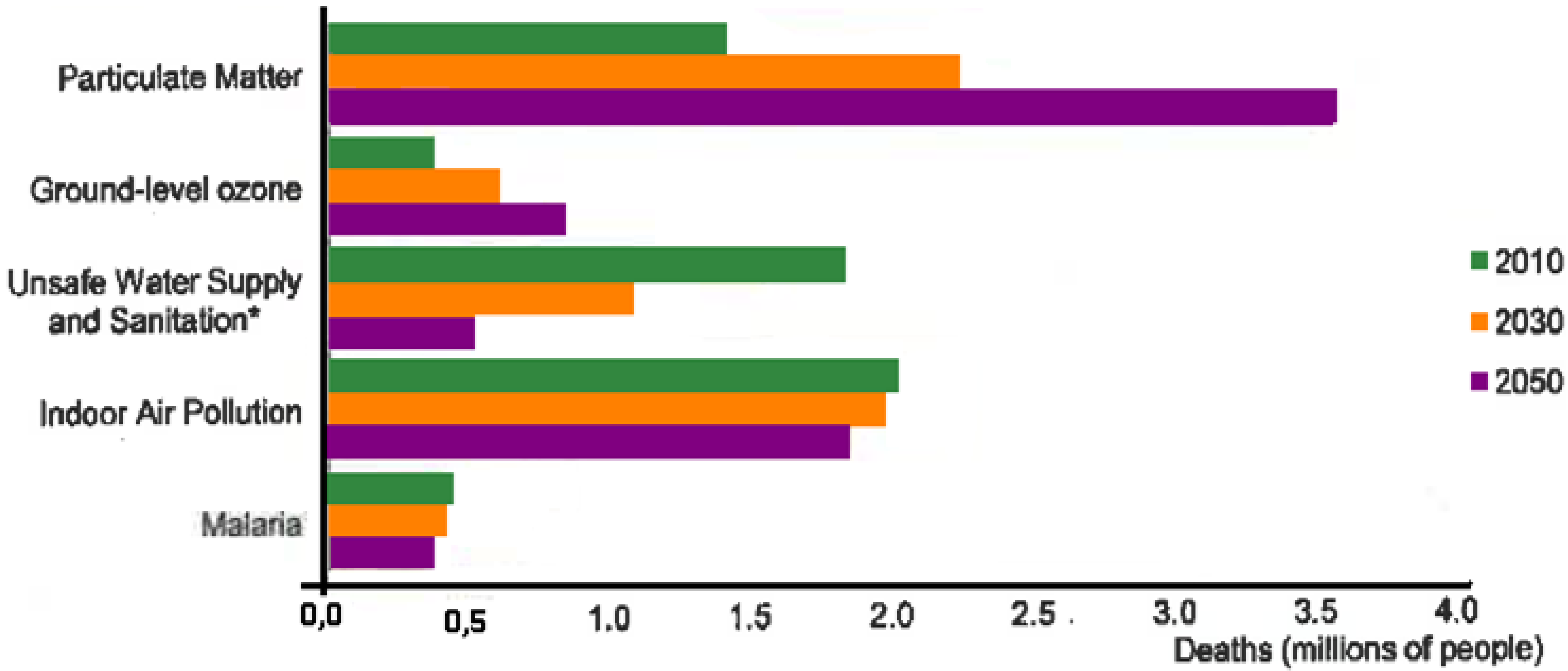
The ongoing **decrease** in the **pH** of the Earth's oceans (acidification) is caused by:

•the uptake of anthropogenic CO_2 from the atmosphere

• its concentration increase in the ocean water.

Oceans are now absorbing 1/3 of the CO_2 emitted into the atmosphere, with strong consequences for plancton, fishes, mollusks, corals (these cease to exist at PH=7,7).

Negative impact of emissions: Global premature deaths from selected environmental risks.



* *Note: Child mortality only*

Source: OECD Environmental Outlook Baseline; output from IMAGE suite of models.

INSTABILITY OF THE OIL PRICE

Conventional fuels have an high impact on environment and human health. Additionaly they have a limited availability. Oil has now reached a high value and it is espected to maintain the present level of 100 $/bbl (670$/TOE) because:

•The breakeven prices of the major world oil producers (S.Arabia/Emirates/Oman-Russia-Venezuela) assumed in the balance of these country are respectively 87 $/bbl, 115 $/bbl, 87$/bbl although the production cost is respectivelly: 22,1 $/bbl- 52$/bbl- 86,7$/bbl.

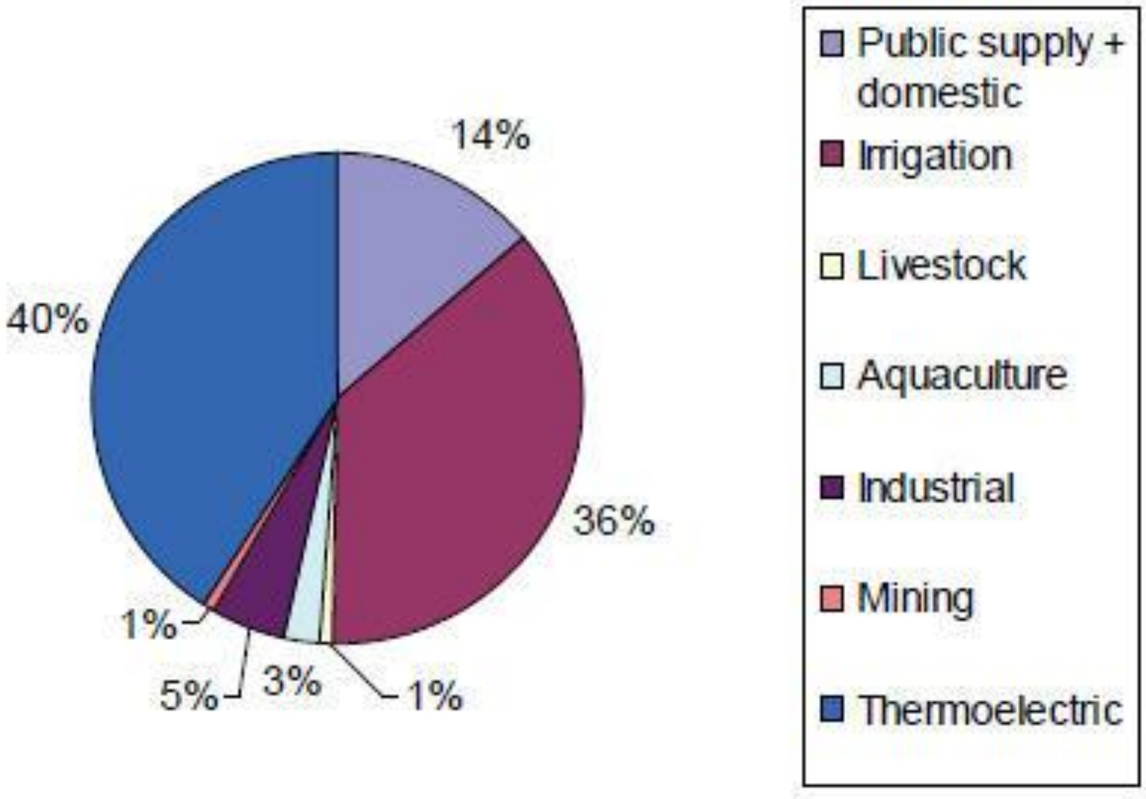
•The production of Oil from sands (Canada), which is now 3,2 million bbl/d and is espected to increase untill 4,7 million bbl/d by 2020, has an actual production cost of about 90 $/bbl.

•The large estimated increase of oil-demand over the next 20 years: 20 mio. bbl/day

•**At an Oil price of 100$/bbl:**

1. **Bioenergy production can be competitive**
2. **Chemicals production with biomass source can become competitive**

Water-scarcity and its Impact on Bioenergy

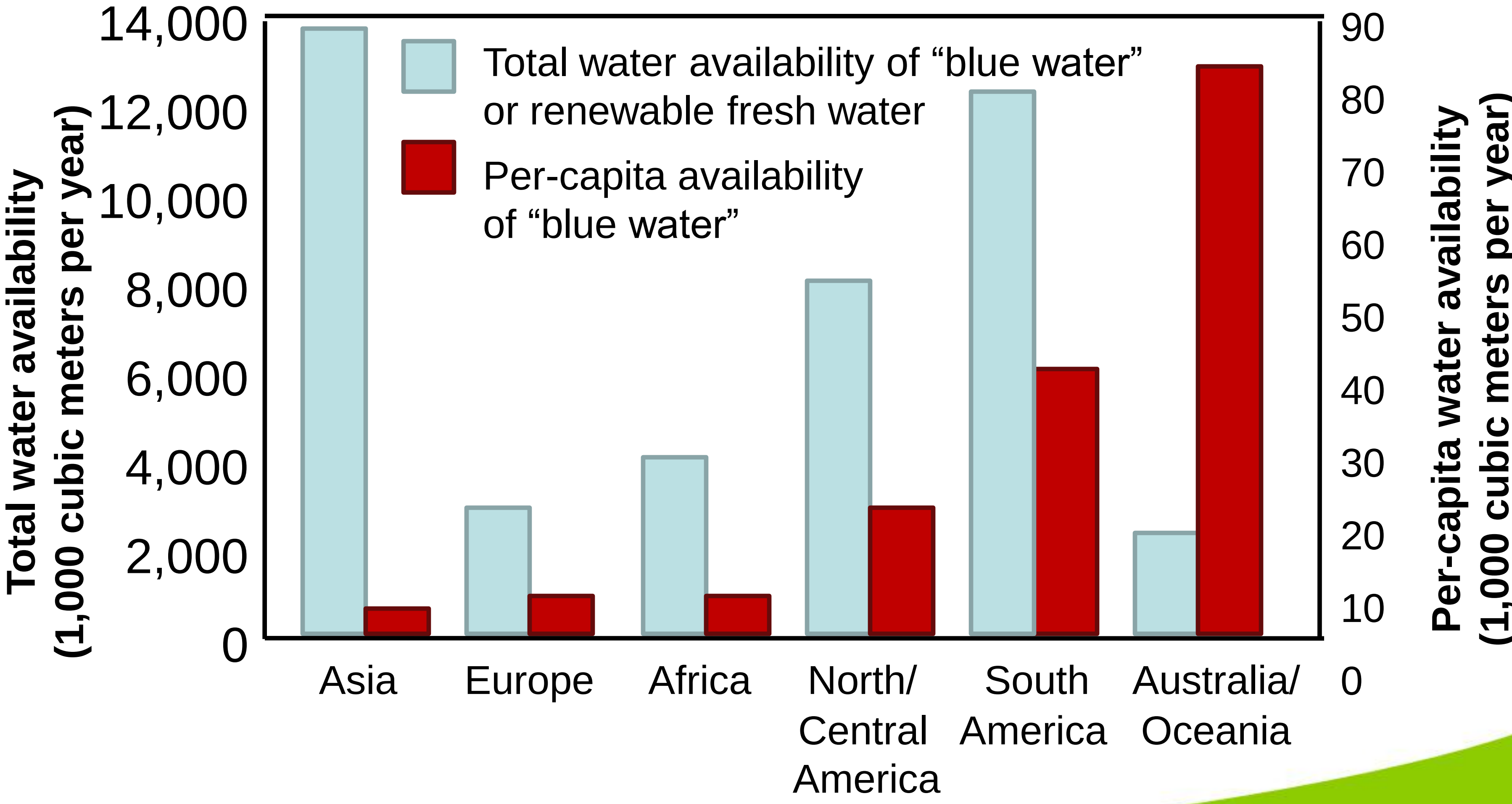


Water use by sectors in 2005 (Source: Kenny et al., 2009). Courtesy of NRDC

Water scarcity could limit the economic growth of a country and in particular, its production of biomass.

The estimated average need of water for biomass production is: 200-1000 lit/kg of dry biomass produced. Moreover, recovery-treatment-recycling is becoming a critical need because water supply is under extreme pressure. Beyond irrigation, industrial uses is large (i.e.1000MWe power plant needs 110,000 m^3/day).

Global and per-capita availability of "fresh water" by country



BENEFITS AND LIMITS OF BIOENERGY ACTIVITIES

Capacity of penetration of numeros sectoral markets. (Heat, power, transport) With a potential progressive substitution of many of the 73,000 products now derived from oil, Nat. Gas and Coal) using the large biomas potential.

Year forecast	Biomass World potential
2020	2 Billion TOE/y
2030	4,2 Billion TOE/y
2050	10,4 Billion TOE/y

Increased employment opportunities especially in rural areas (1 job for 400-500 ton of biomass) with supplementing incomes for farmers (impact on rural developement);

Absorption of 1,5 t CO_2 every ton of dry biomass produced

Improvment of microclymatic condition with extensive biomass production schemes

BENEFITS AND LIMITS OF BIOENERGY ACTIVITIES

Bioenergy is a very complex mosaic of activities involving a wide range of technologies. However, economic, technical and envronmental sustainability will always be the driving elements for final choices and implementation. Here below, the main issues to overcome:

I. **Insufficient economic-environmental sustainability for many production-conversion-utilisation systems.**

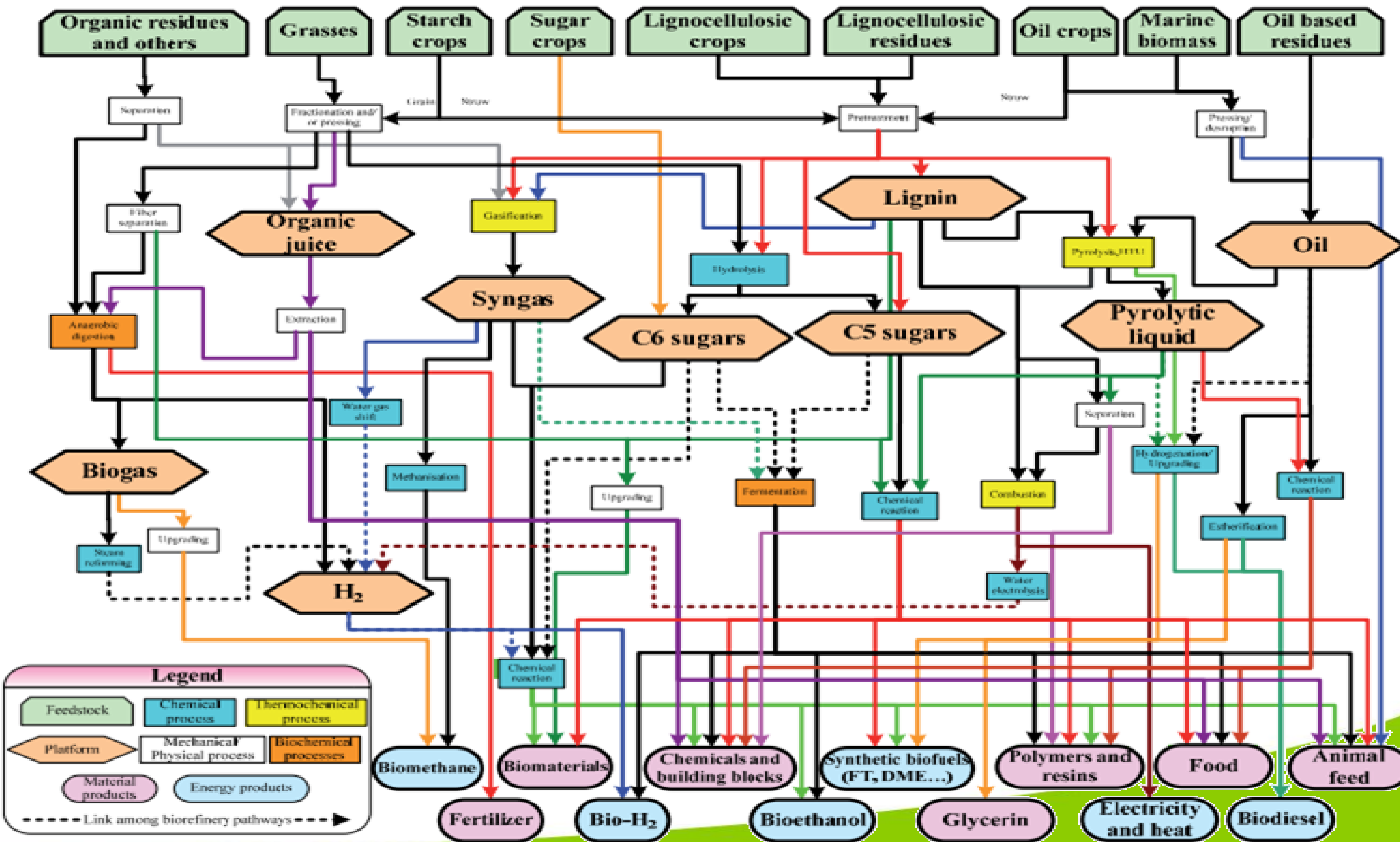
II. **Competition for the use of land. (Food/Energy/Chemicals).**

III. **Large amount of water needed for the production (300-1000 kg/kg biomass) and for conversion / utilisation.**

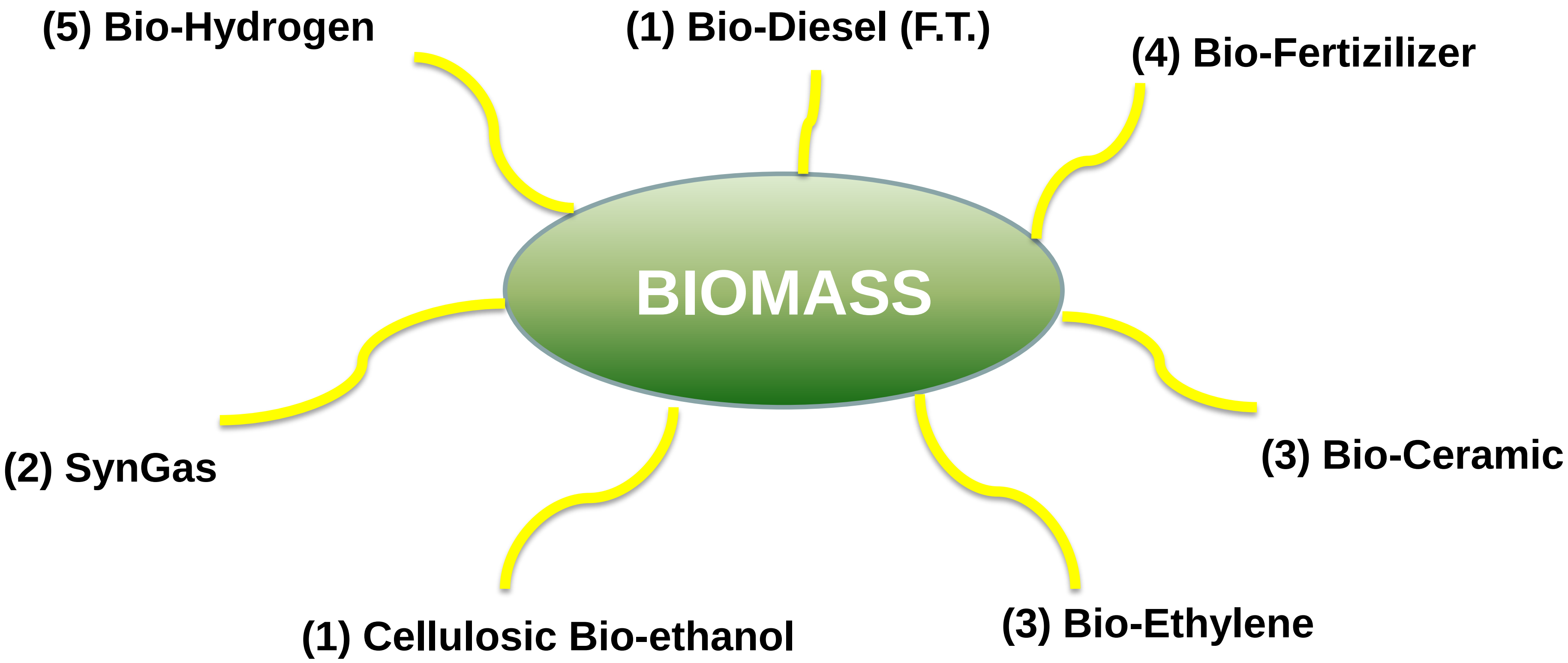
IV. **Limited photosinthetic efficiency (1-4%)**

V. **Respect of biodiversity**

Mosaic of Bioenergy activities



BIOENERGY ACTIVITIES BASED ON ADVANCED TECHNOLOGIES. (medium term)



SIGNIFICATIVE COMMERCIAL BIOENERGY ACTIVITIES AT WORLD LEVEL

Bioethanol:	**90 million/year**
Biodiesel:	**35 million m^3/y vegetable oil**
Bioelectricity:	**400 TWhe /year (Total: 20,000 TWhe/y)**
Heating with pellets:	**15 million ton/y**
Biogas production:	**8,3 million TOE/y**
Charcoal (p.i.g. iron production):	**30 million m^3/y**

The total of this energy utilization represents only the 1.5% of the total present world final energy consumption

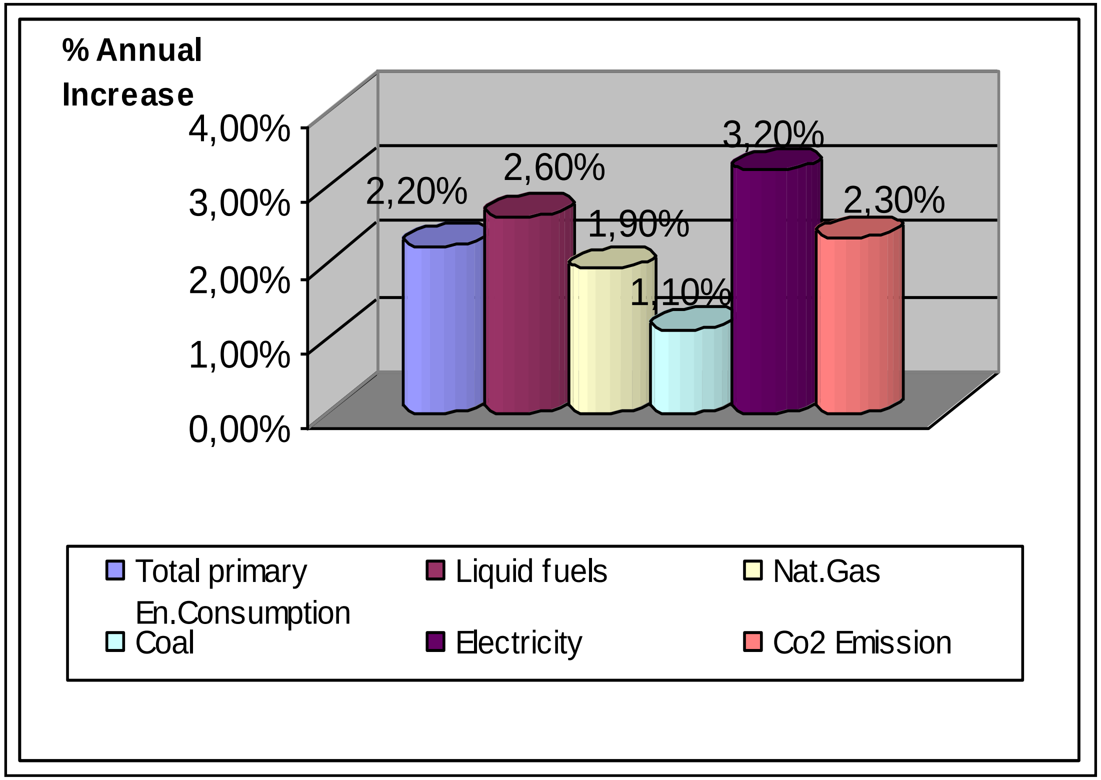
(1) Biodiesel and bioethanol market opportunities.

(Forecast next 20 years)

"Among the different energy sources, a major world demand increase is expected for liquid fuel and electricity". In short-medium term Bioethanol is the preferred biofuel, that can be produced by:

•Milling of sugar cane or sweet sorghum and fermenting the sugar juice.

• Hydrolysis – saccarification (Enzymathic catalysis) of woody biomass.



A combined co-production of bioethanol / biodiesel and bio-electricity from some specific crops can improve both the environmental and economic benefits.

(1) High yield of bioethanol & bioelectricity from dedicated crops

	m^3 BIOETHANOL/ha KWhe/ha + KWhth/ha	R: OUTPUT EN./ INPUT ENE.
Sugar-cane	ETOH : 6,0 m3/ha 17 000 Kwhe/ha - 34 000 KWhth/ha	**~ 4**
Corn	ETOH : 3,5 m3/ha 8 200 Kwhe/ha - 16 400 KWhth/ha	**~ 1,4**
Sugar beet	ETOH : 5,5 m3/ha 1 700 Kwhe/ha - 23 400 KWhth/ha	**~ 1,7**
Sweet sorghum	ETOH : 5,0 m3/ha 20 000 Kwhe/ha - 40 000 KWhth/ha	**~ 4**
Jerusalem artichoke	ETOH : 5,5 m3/ha 16 000 Kwhe/ha - 32 000 KWhth/ha	**~ 4**
Sweet potatoes	ETOH : 4,3 m3/ha 24 000 Kwhe/ha - 48 000 KWhth/ha	**~ 2**
Wheat	ETOH : 2 m3/ha. 8 200 Kwhe/ha - 16 400 KWhth/ha	**~ 1,2**
Rape	ETOH : 1,50 m3/ha. 10 000 Kwhe/ha - 20 000 KWhth/ha	**~ 1,3**

Combined Productivity of Bioethanol and Power & Bio-Heat from different crops (average) [m^3 of ETOH + KWhe + KWhth/ha.year]

Promising Decentralized Bioenergy Activities

Refining for more efficient use	Pelletization of Biomass and homogenization of products by blending
Small-scale bio-heat production	heating/cooling of wellings, commercial building, schools, hospitals..
Small-scale cogeneration plants. (Under development)	Advanced electric generator for small activities fed wiith biofuel(10-500kWe)
Biogas plants (50-1000 kWe)	Anaerobic digestion is well known,but expensive (4500 $/kWe)
O.R.C-plants (Organic Rankine Cycles) power generators:	Commercial but very expensive (6,500$/kWe) can exploit low temperature heating
Solid Biomass/Steam Condensing:	Efficient small scale system, not yet commercially available (3,200-4,000 $/kWe)
Vegetal Oil plants:	Supply of feedstock to biodiesel plants (15,000 t/y capacity)
Small-scale S.Sorghum Biorefinery (1000 ha):	Production of Bioethanol, Bioelectricity, animal feed, fertilizer. Investment 50 mio. $ (R.o.i = 10-20%)
Production of Biofertilizers & Biogas	New technology under investigation)

PROMISING CENTRALIZED BIOENERGY ACTIVITIES

1. Large-Scale Refined (pelletization and torrefaction) biomass production plants (0,5-1 mio.ton/y)

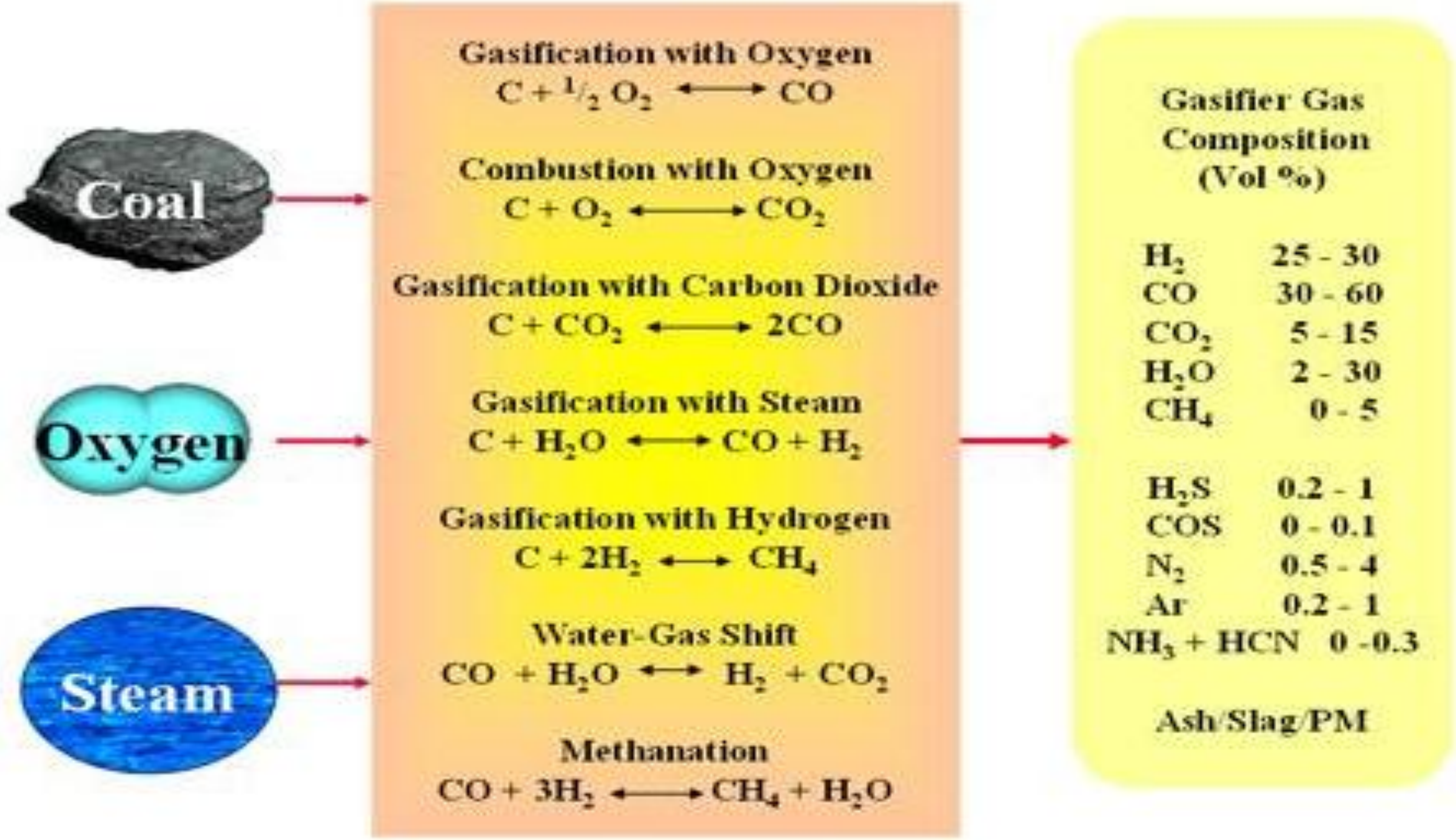
2. District Heating Systems (50 – 400 MWth)

3. Production of Steam-Biomass for industry uses (substitution of steam-coal) i.e.: in Cement-factories, Metallurgical activities, Petrochemicals, etc.. To reduce their high CO2 emissions (typical):

Cement Factories	~ 1 tCO2 /t Cement	1 bill t cement/y
Steel Factories	~ 3tCO2 /t steel	1.2 bill steel/y
Power Plants (coal):	~ 1kg CO2 / KWhe	18000 bill Kwhe/y
Oil Refineries	~ 0.5 tCO2/t oil	3.5 bill t/y

4. Bio-Electricity Production. (see next slide)

(2) Overview on typical Syngas composition from coal gasification process:



(2) GASIFICATION AND SYN-GAS PRODUCTION

Gasification of conventional fuels (mainly coal) has reached a considerable volume world-wide, 92,000 MWth / year, and is now expected to grow up to 131,000 MWth by 2016 (58 new plants).

Shell is the dominating Organization followed by G.E., Sasol, Lurgi, etc..

The present gasification markets are:

- Production of Chemicals dominate the total gasification outputs: **35%**
- Fisher-Tropsch Liquid fuels: **13%**
- Electric Power generation by I.G.C.C. plants: **38%**
- Synthetic Natural Gas production: **14%**

(2) MAJOR WORLD SYNGAS PRODUCING COUNTRIES:

China: Dominates market**.** 29% of world capacity and 56 operating plants (coal)

North America: Capacity of 34,450 MWth (38% of world total). Largest planned capacity increase (27 plants in 2016) utilising coal, natural gas, for the production of chemicals, power, fertilizers(ammonia), synthetic Nat.Gas

Central-south America: 648 MWth syngas capacity (1%) in S. Domingo for chemicals and gaseous fuel production

Asia-Australia: Syngas capacity of 20,810 MWth (23%)

Europe: 11,422 MWth of capacity (6%). **42** operating plants:

5 petroleum
3 coal IGCC plants
25 chemicals (Nat. Gas)
9 Biomass/waste

Africa/Middle East: 25,138 MWth Syngas capacity (36%)

- Shell has 18 gasification plants for 10,938 MWth
- Sasol produces Fisher Tropsch fuels & chemicals

(2) BIOMASS' MOST PROMISING PRODUCTS: Competitivness of Bio-Syn-Gas

The Bio-Syn-Gas production becomes of large interest for global market.

The advanced biomass processing technology is now approaching the "demonstration" high quality level.

Bio-Syn-Gas competitivness in comparison with Nat. Gas and conventional Syn-Gas:

CONVENTIONAL FUEL	$/bbl	BIOMASS (60 $/dT)	$bbl
PETROL OIL	100	LOW QUALITY BIO-SYNGAS (Steam reforming of carbonized pellets)	100
NATURAL GAS	75		
SYN GAS (high quality)	107	HIGH QUALITY SYNGAS(future) (advanced gasification-DOE target)	90

(2) BIOMASS GASIFICATION AND BIO-SYN-GAS PRODUCTION

Gasification of biomass is of great future interest for the production of:

1. **Green-power (combustion for steam and gas turbines combined cycles))**
2. **Bio-chemicals (cathalytic craking, producing Ethane, Ethylene, etc..)**
3. **Biofuels (transportation)**
4. **Sythetic Gas (Reforming, other energetic processes)**
5. **H_2 (Petrochemical process, energy markets..)**

- **Gasification of solid biomass is more difficult than gasification of conventional fuels (coal).**
- **The progress of technology has still not reached the commercial level, but thanks to its numerous potential markets, bio-synthetic-gas could become one of the most promising 1° conversion bio-product bio-economy activities for the future**

(2) BIOMASS GASSIFICATION PROCESS:

Gasification:
endothermic reaction with
carbon and steam/CO_2

$C + H_2O \rightarrow CO + H_2$

$C + CO_2 \rightarrow 2CO$

CO : H_2

Methanol	Fischer-Tropsch	Methane	Oxo synthesis	Ethylene
2:1	2:1	3:1	1:1	1:1

- Formaldehyde
- Gasoline
- Aromatics
- Olefin

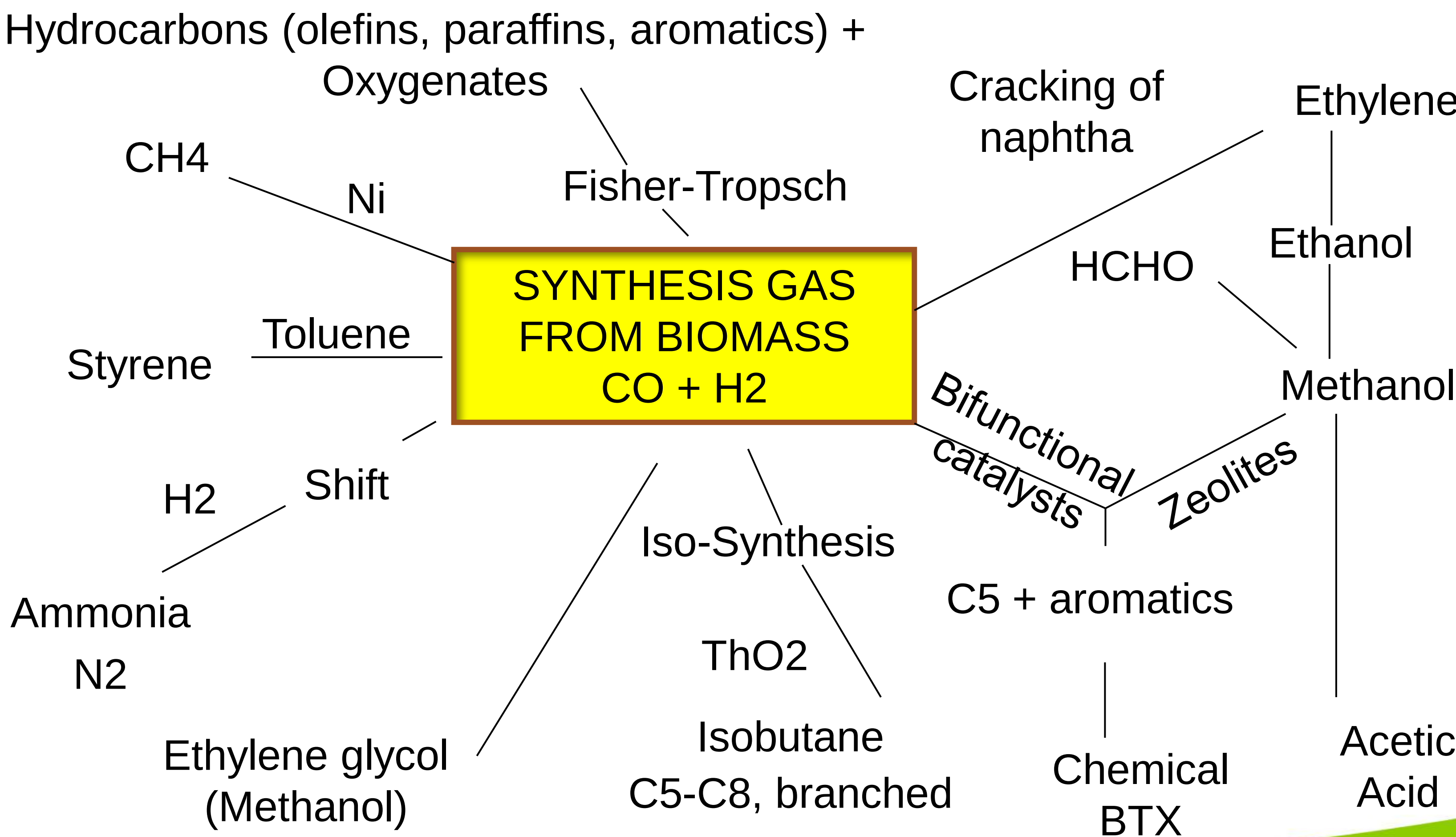
- Gasoline
- Middle distillates
- Waxes

- Aldehyde
- Alcohols
- Hydrocarbons

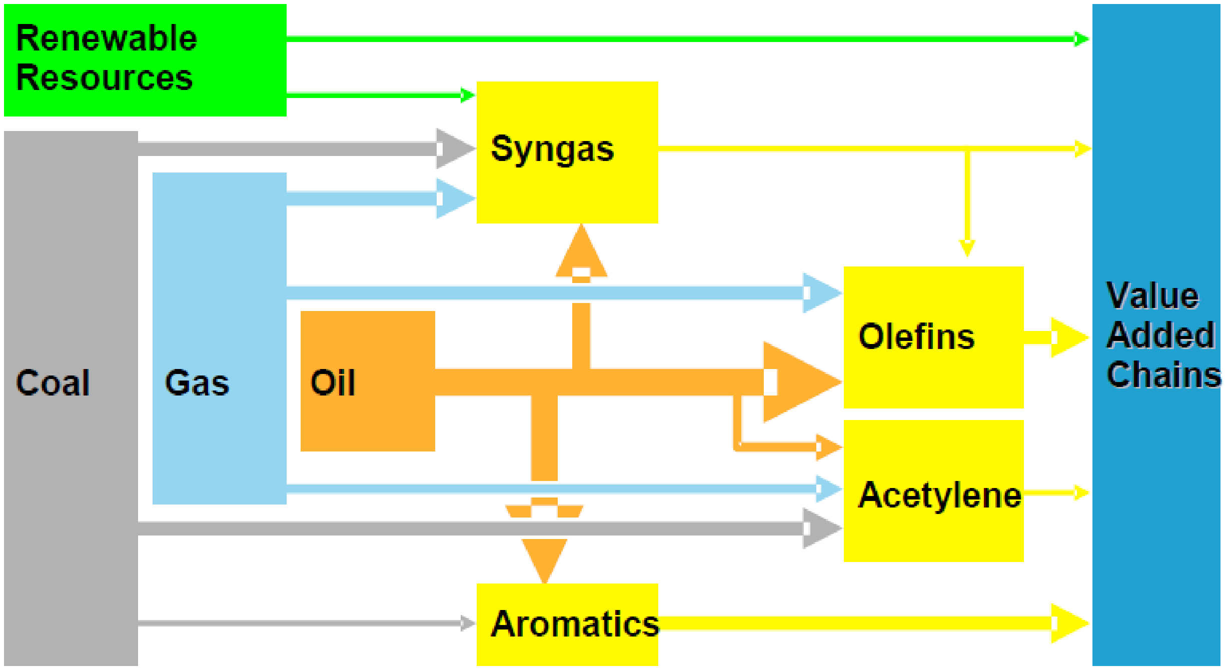
- Ethanol
- Acetic Acid
- Glycol Ether

Unfortunately synthesis-gas from wood contains **tars** (mixture of hydrocarbon compounds) and traces of HCl,HF,NH3 and alkaline metals; their concentration depends on the nature of the biomass and the type of reactor. There's also risk of low-melting of ashes.**Tar gas-cleaning can not be considered yet a solved problem !**

(3) MAIN BIO-CHEMICALS FROM SYNTHESIS GAS (Source : wender, i.)



(3) MAIN RAW MATERIALS USED FOR CHEMICALS PRODUCTION



"Biomass is the only renewable carbon based feedstock to produce chemicals".

Currently the most used feedstock in North America, south america and Russia is Natural Gas, while coal and Oil are used mainly in Middle East countries and China

Biomass can partially replace the conventional raw materials (Coal, Oil, Nat.Gas) without increasing production costs. Biobased products market is $ 46 billions and it is expected to more than treble by 2020.

(3) CHEMICAL PRODUCTION WITH BIOMASS. MARKET OPPORTUNITIES.

1. In 2010, biobased products accounted for 10% of sales within the global chemical industry, accounting for $125 billion in value (1,7$ billion bio-plastics).

2. Chemical industry currently uses 8-10% renewable raw materials to produce various plastics. (bags, hygiene products, packaging for biological waste)

3. The market is expected to grow by 32.4% a year within 2015, reaching an estimated value of €8.2 billion in 2015.

4. The worldwide capacity of biobased plastics is expected to increase from 0.36Mt to 2.3Mt in 2013 and to 3.5Mt in 2020. This is equivalent to average annual growth rates of 36% between 2007 and 2013 and 6% between 2013 and 2020

(4) BIOMASS FOR SUSTAINABLE BIO-FERTILIZER PRODUCTION

Currently the most used artificial fertilizers are UREA and AMMONIA. These fertilizers are now mainly produced with Natural Gas refining system:

- High energy consumption
- High emissions

The present fertilizer price is nearly 500$/ton. But this price is going to grow hard in the next 20 years, reaching probably the 1,500 -2000 $/ton

Thanks to the advanced present technologies, (Anaerobic Digestion, Thermophilic digestion) biomass can be now treated to produce gas and biofertilizers.

The next years development is aimed at producing high value and environmental sustainable bio-fertilizers with competitive market price

(5) OIL REFINING SYSTEM AND HYDROGEN CONTENT

Basic refining process of heavy oil into light oil and the conversion of distillation residues, consists of cracking the molecules to increase the hydrogen content and to decrease the carbon content of the derived products with expenses of energy (endotermic process)

OIL REFINING	**H_2 CONTENT** (wt)
Heavy – oil	11%
Medium – oil	12%
Gasoline	14%
(Methane)	(25%)

Main ingredients for refining processes:

Temperature	Pressure	Hydrogen	Catalyst

(5) TYPICAL FINAL REFINED PRODUCTS

Products	**(Classical Refining)** Vis-breaking plus Cathalytic Craking	**(Deep Refining)** Cathalytic Craking plus Fluid Coking
Gas/GPL	~ 6%	~ 8,4%
Gasoline	~ 23%	~ 28%
Distillate	~ 42%	~ 52%
Heavy Fuel	~ 22%	~ 5%
Fuel burn in the refinery	~ 7%	~ 7%

Large Amount of hydrogen must be added in the process to obtain valuable products

(5) BIOENERGY FOR CRUDE-OIL REFINING

Potential bioenergy Contribution to supply the energy inputs for refining

- Heat (steam)
- Electricity
- Hydrogen

Large amount of energy input is needed (Process η =80%)

- 0.4 MTOE/y
  (Refinery capacity = 2 MTOE/y)
- 2 MTOE/y
  (Refinery capacity = 10 MTOE/y)

Most promising <u>Biomass Resource</u>:

- cost similar to Natural Gas
- easily handled, transported, stored

→ **BIO-PELLETS**

Amount of Biopellets needed per year

- 0.85 mio t/y
  (Refinery capacity = 2 MTOE/y)
- 4.2 mio t/y
  (Refinery capacity = 10 MTOE/y)

Amount of fuel to produce 1 ton of Hydrogen

(Steam-Reforming)

Resources	Fuel	Amount
From Biomass resources	Pellets	18.2 t
	Charcoal	7 t
	Bioethanol	4.1 t
	Electricity	45 MWhe
From Fossil resources	Coal	10.1 t
	Oil (220$/t)	5.1 t
	Nat. gas	6,400 m^3
	Nafta	4.8 t

→ 1 ton H_2

BIO-ELECTRICITY PRODUCTION:

Co-firing with coal (typical capacity 100-400 MWe). Coal is the most polluting fuel and it provides the largest contribution to the total world energy needs.

Coal global consumption for power generation →

2010: 2.6 billion TOE/y (3,710 power plants)
2020: 2.9 billion TOE/y (4,215 power plants)

Co-combustion of biomass with coal is the most efficient way for bioelectricity production. A world-wide pellets co-firing activity will require.

Total biomass for co-firing →

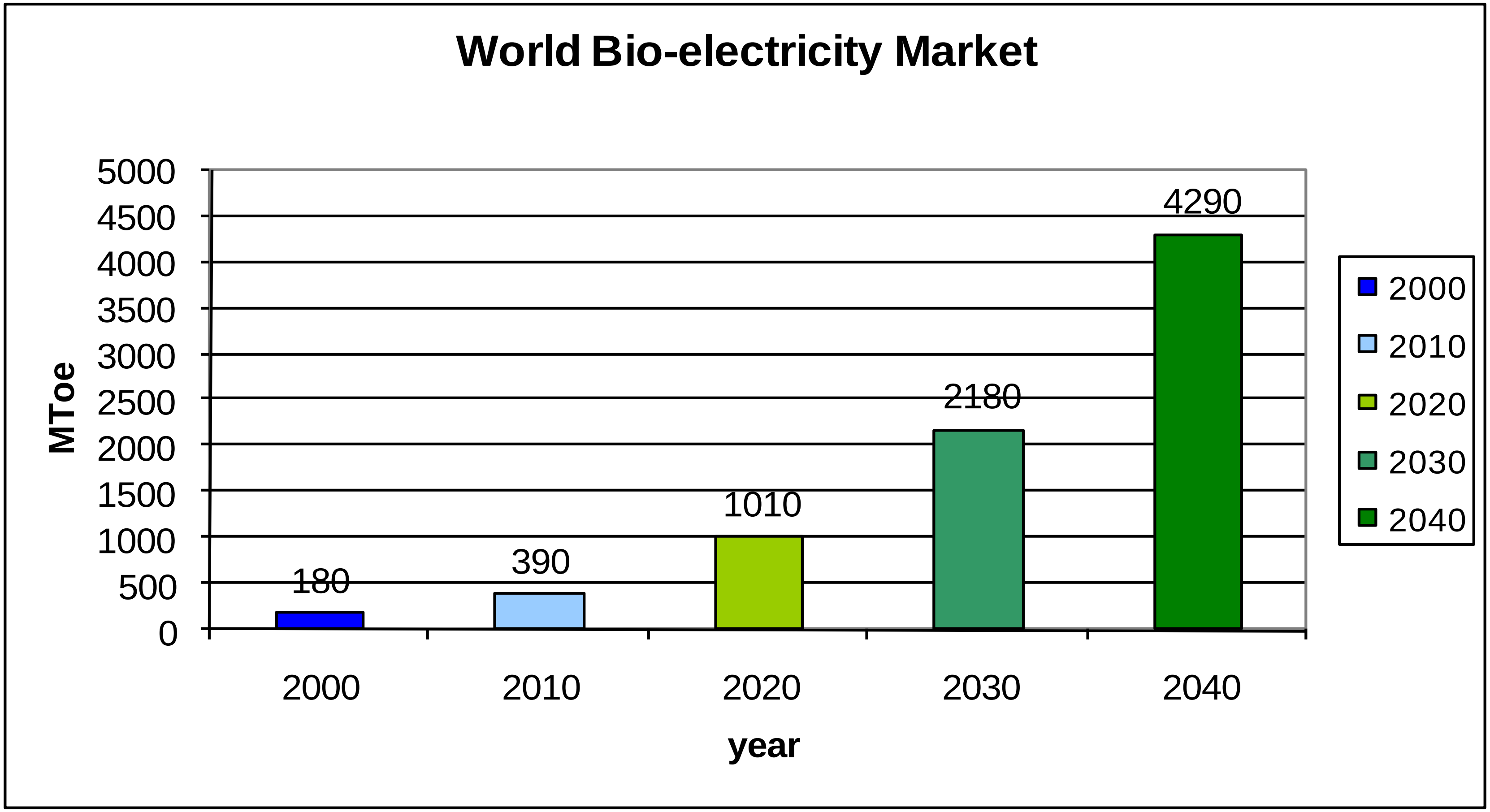
20% of biomass en. input = 1,5 billion tons pellets/y
40% of biomass en. input = 3,0 billion tons pellets/y

Bio-Electricity production in dedicated large Power generators (10-50MW):

•Steam condensing power plants fuelled by solid biomass (inv. 3,000 $/kWe)

•C.C.-steam/gas turbine generators fuelled by low-quality bioethanol, bio-syngas..inv: 1,000 $/kWe)

SECTORAL MARKETS FORECAST



ADVANTAGES OF AGRO-PELLETS

(LOW MOISTURE, HIGH DENSITY)

Volume equivalent to 1 ton of oil (m^3)

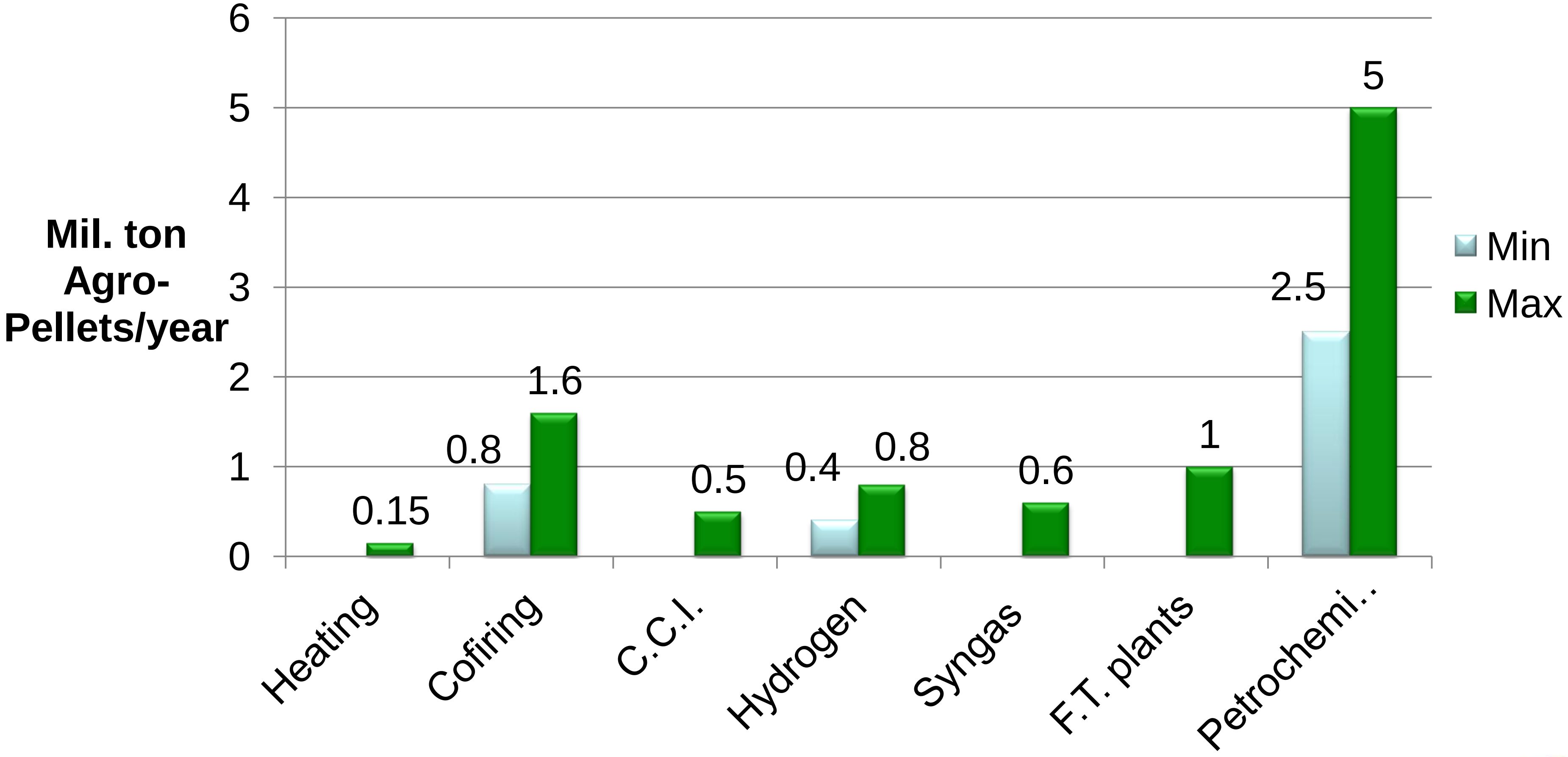
1 m^3 oil
S=1 TOE/t

17,5 m^3 dry chips (10% moisture):
S = 0,122 TOE /m^3

3,8 m^3 Agro-pellets:
S = 0,285 TOE/m^3

18 m^3 straw bales: S = 0,062 TOE/m^3

AVERAGE BIOMASS SUPPLY VOLUME FOR TYPICAL LARGE SCALE ACTIVITIES



TORREFIED AGRO-PELLETS

Even if Agro-pellets is already a valuable refined biomass commodity, in the next future, Torrefied Biomass could represent the **refined biomass commodity** for all sectoral bioenergy and biochemical markets.

Torrefaction process
(T= 280-300 C)

The torrefied agro-pellets is a 2° stage refined product with valuable properties:

✓Omogenization of processed biomass resource.
✓Higher energy density per m^3 (+20%)
✓Higher energy content (+15%)
✓Less pollution (low tars, Cl).

“Why torrefied Agro-pellets are such a promising commodity?”

- This commodity can penetrate all sectoral energy and chemichal markets

- Resonable investment and processing costs

- Reduction of transport and handling costs due to:

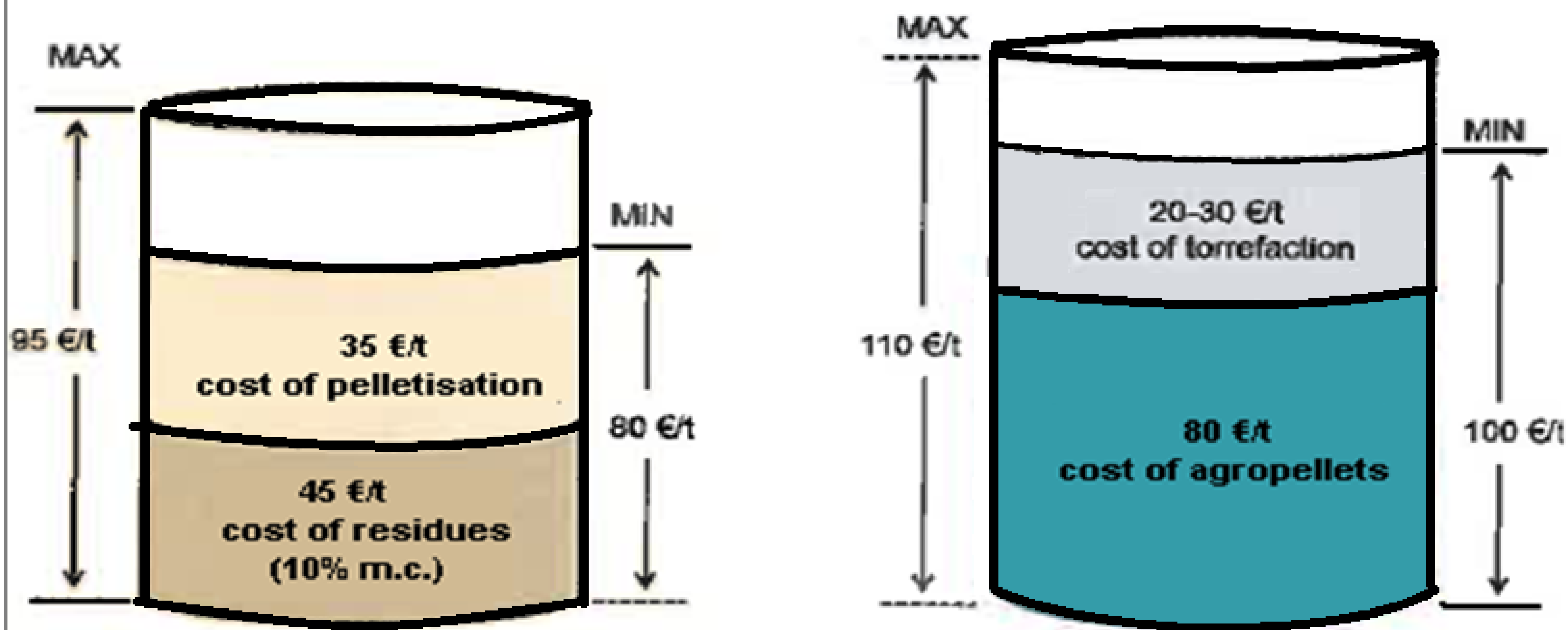
  - High energy density facilitates transport logistic and storage.
  - Hygroscopicity allows outside long-term storage, without losing its characteristics.

- More efficient utilisation/conversion.

- Promoting large scale biomass trading among continents.

- Impact on the infrastructures for the biomass supply

PRODUCTION COST OF REFINED BIOMASS



PRODUCTION COST
OF AGROPELLETS
0.41 TOE/t
0.30 TOE/m³

PRODUCTION COST
OF TORREFIED AGROPELLETS
0.52 TOE/t
0.34 TOE/m³

BIOMASS NEW TECHNOLOGIES:
Solutions to Overcome the Present difficulties

I) A wide range of more efficient and environmental friendly technologies & integrated systems (i.e. biorefinery) will be available.

II) Biology research progress, by OMG and MAS (market assisted selection) methods to improve the yield and quality of biomass as a result of development and selection of new seeds. (as the new Monsanto ‘s corn seeds requiring 30% less of water!)

III) The progress expected in the sector of genetic engineering and in particular in the “synthetic biology” (based on the assembling of genes from different organisms – rather than simple genes transfer - and being able to generate complete new organisms to modify the methabolism of plants) could amon others be able to increase the photosynthetic efficiency up to 30%. The potential of biomass resources could therefore become huge.

BIOMASS NEW TECHNOLOGIES:
Solutions to Overcome the Present difficulties

IV) Respect of biodiversity will be facilitated by the progress of genetic engineering.

V) The drastic reduction of biological processes i.e. the genoma sequencing cost:

- Human genome sequencing reduced of 10 000 times during the last 20 years from 100 Mio. $ to 12,000 $ with an anticipated supplementary reduction of 1000 times over the next 20 years.

- The high speed computing systems will accelerate the progress on biomass resources availability: the cost will be reduced more than 1000 times over the next 20 years

Thank you for your attention!

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