BIOENERGY WORLDWIDE
Review of the world progress and future tasks.
Priorities in bioenergy technologies development.

Invited presentation by:
Dr. Spyros Kyritsis
President of the Greek Agricultural Academy

Renewable Energy Forum " REENFOR -2013"
Moscow, 2R2-24 October, 2013

I. Bioenergy expansion in the world and the future tasks.

Bioenergy is made available from materials derived from biological sources. Biomass is any organic material which has stored sunlight in the form of chemical energy.

Biomass as a fuel it may include, organic wastes, agricultural residues, and many other byproducts from a variety of agricultural processes.

By 2010, there was 35GW of globally installed bioenergy capacity.

From all the Renewable energies Bioenergy is the largest source of energy, providing more than 10% of global primary energy supply [15].

The big majority of bioenergy use is in developing countries, used for cooking and heating, as of the year 2010, the 41% of the world population relied on wood or other biomass sources to cook and heat their homes.

They are proposals [15] for the deployment of improved technologies, to meet 7.5% of world electricity demand in 2050, as today 17% of the global population did not had access to electricity.

In the developed countries, the biomass consumption for heat and power is expected to reach 3 times more in 2050.

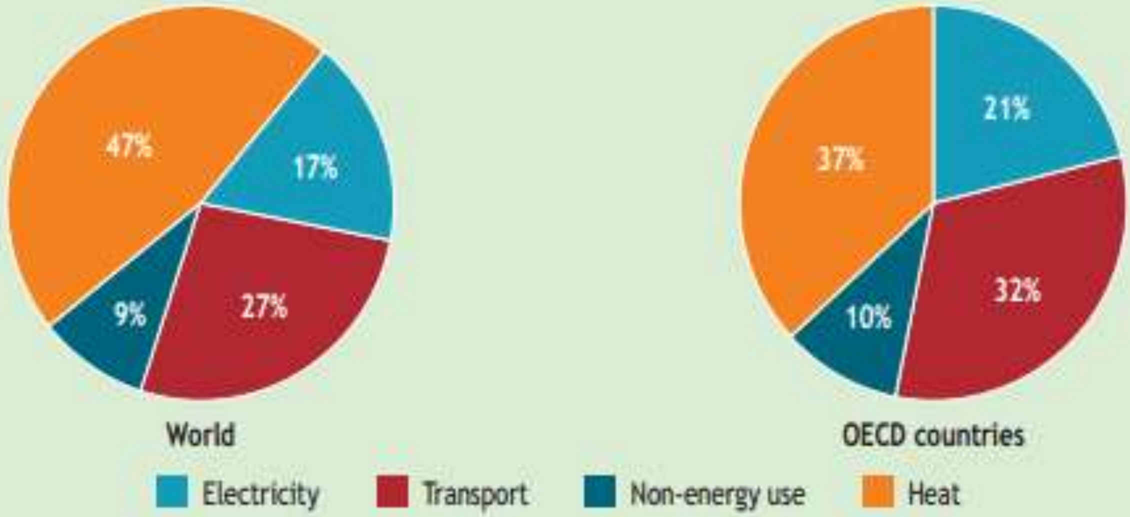
So, finally the world total primary energy supply is expected [15] to increase from 50 Ej today to 160 Ej in 2050, with more than 62% of this to be used for generation of heat and power.

The International Energy Agency estimations for bioenergy demand rise the today consumption three times more the year 2030.

Biomass as a renewable source, is also used to replace several industrial bio-products.

Even if today they are different cheaper uses of fossil *sources*, the reorientation of the world economy, **from fossil sources to biomass renewable products and energy**, presents many advantages, as they are:

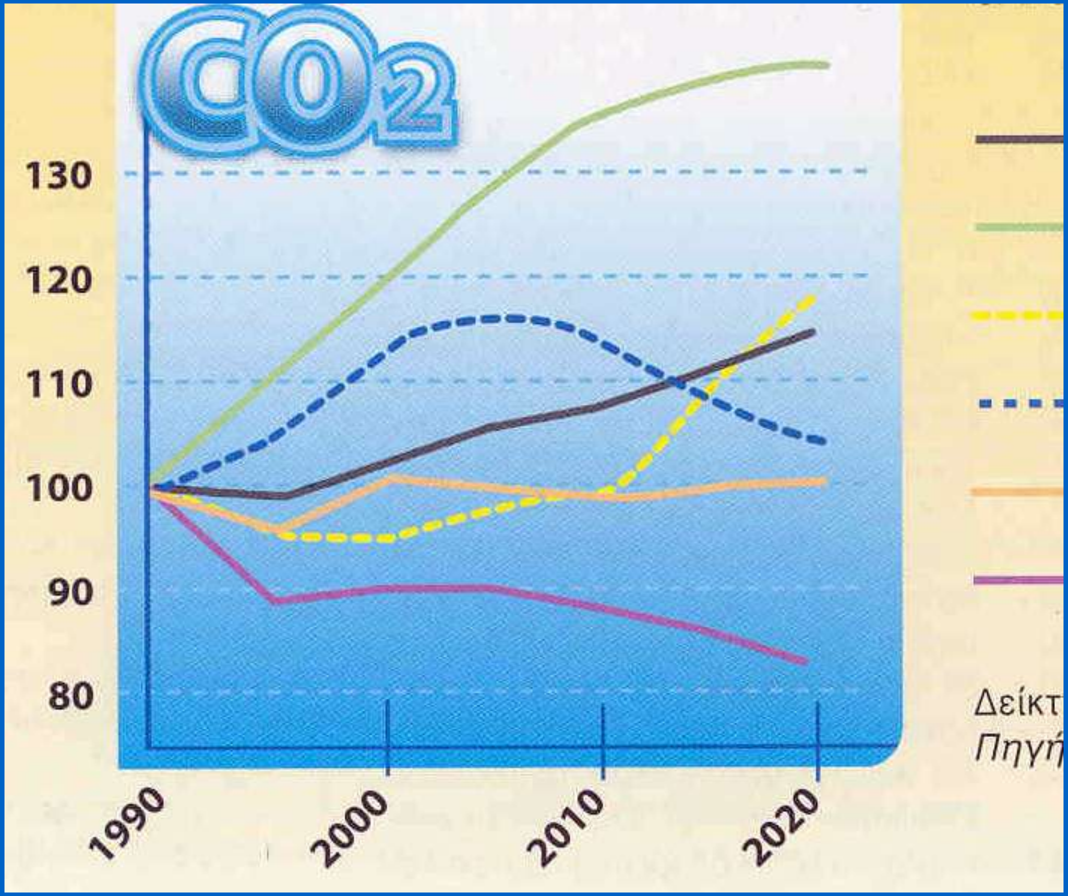
- Environmental considerations
- Energy security
- Socio-economic advantages (direct and indirect job creation etc.)



Notes: "Non-energy use" covers those fuels that are used as raw materials in the different sectors and are not consumed as a fuel or transformed into another fuel. For example, oil used to make plastics would be classified as non-energy use. Electricity use in transport is subtracted from final energy use in transport. Heat generated by auto producers for their own use will not be reported or registered, and therefore is not represented. Data on electricity use for heating in the industry sector and other sectors are unavailable, and therefore have not been taken into account.

Figure 1. Shares of the total final energy consumption in % for Electricity, Transport, Heat, and Non-Energy uses (figure: OECD study).

The impact of Energy to the Environment



Total CO_2 emissions

Transportation

Electricity production

Services

Households

Industry

Base, the year 1990 = 100

Source: European Commission

Figure 2. CO_2 emissions by sector, actual and predictions

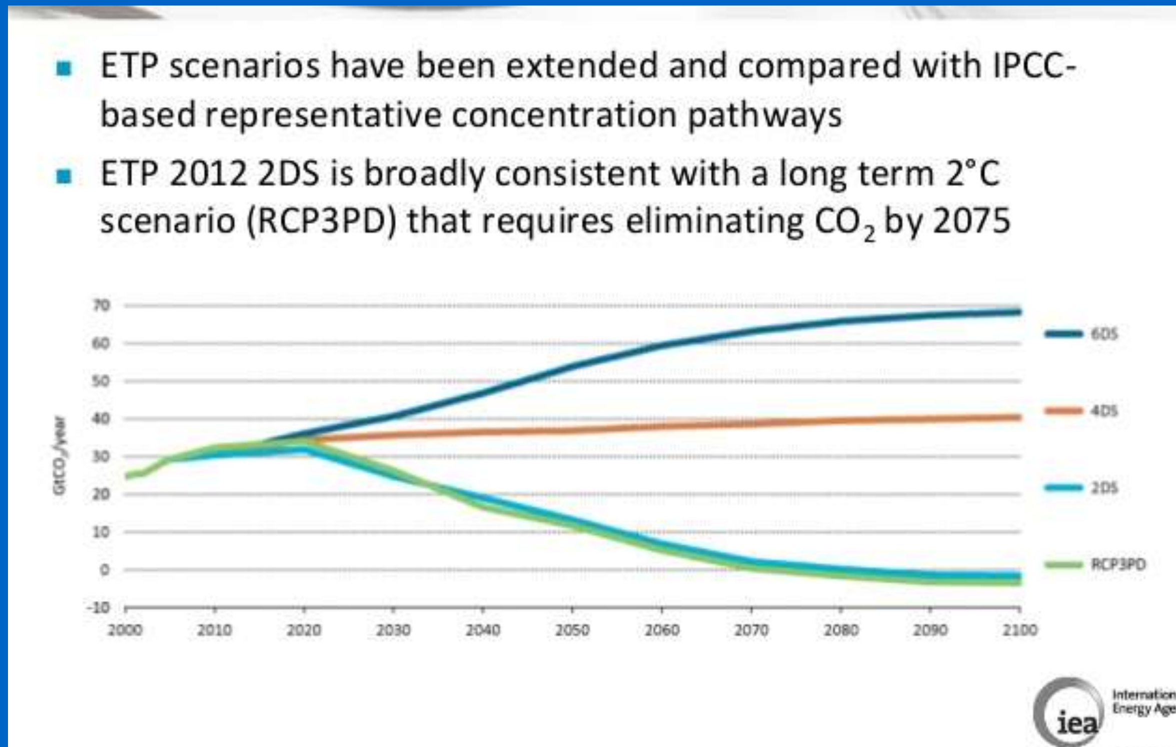


Figure 3. The 3 IEA scenarios for CO2 abetment up to 2050

(Picture from ETP 2012) [7]

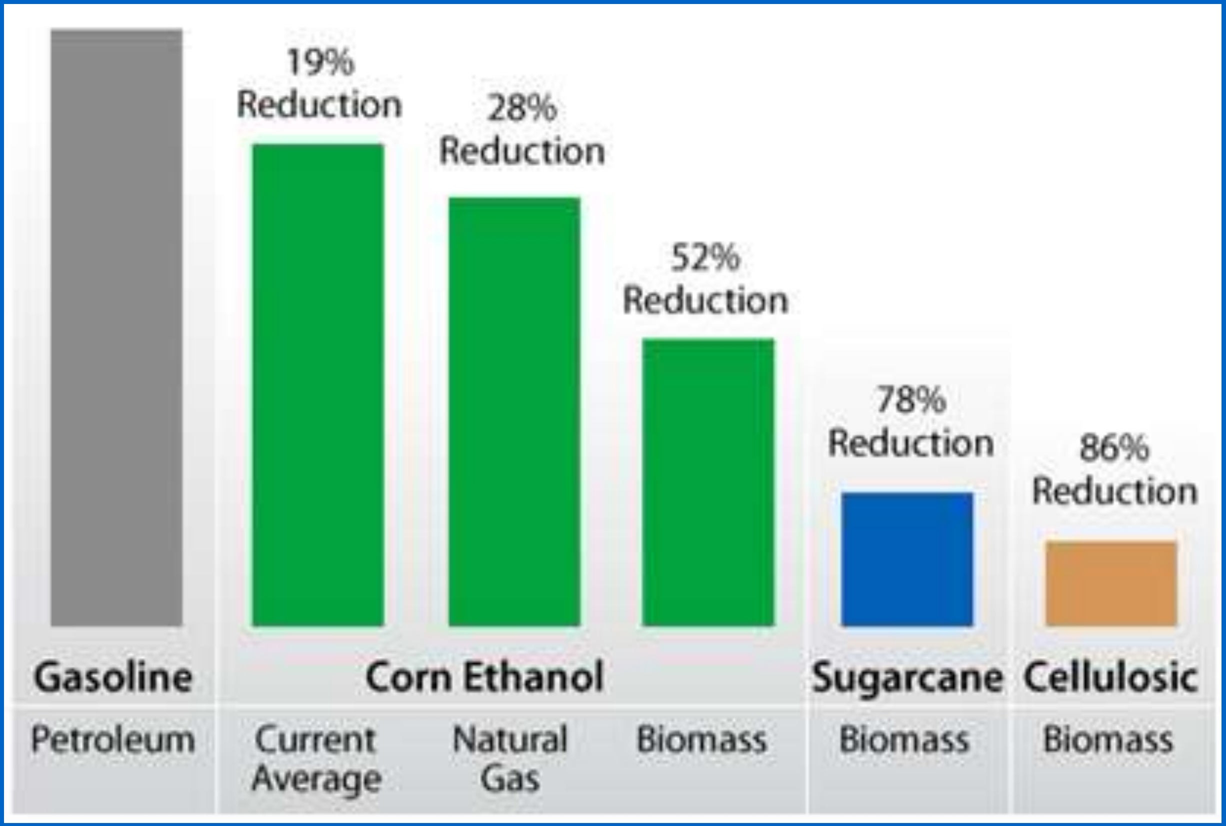


Figure 4. Greenhouse Gas Emissions of Trasportation Fuels. (By Type of Energy Used for Processing)

Worldwide Biofuels demand today and in the near future

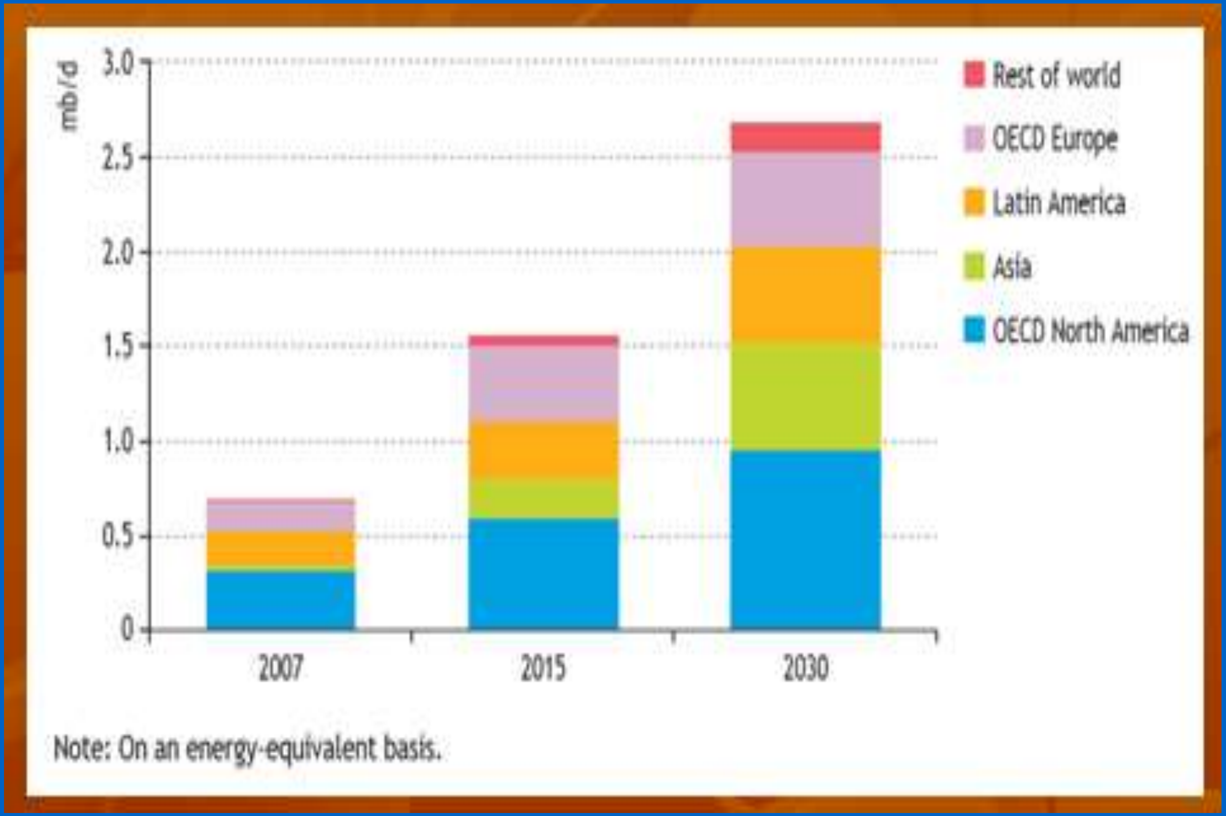


Figure 5. The predicted demand of bio-fuels globally [1]

Bioenergy for the Transport Sector in the different scenarios

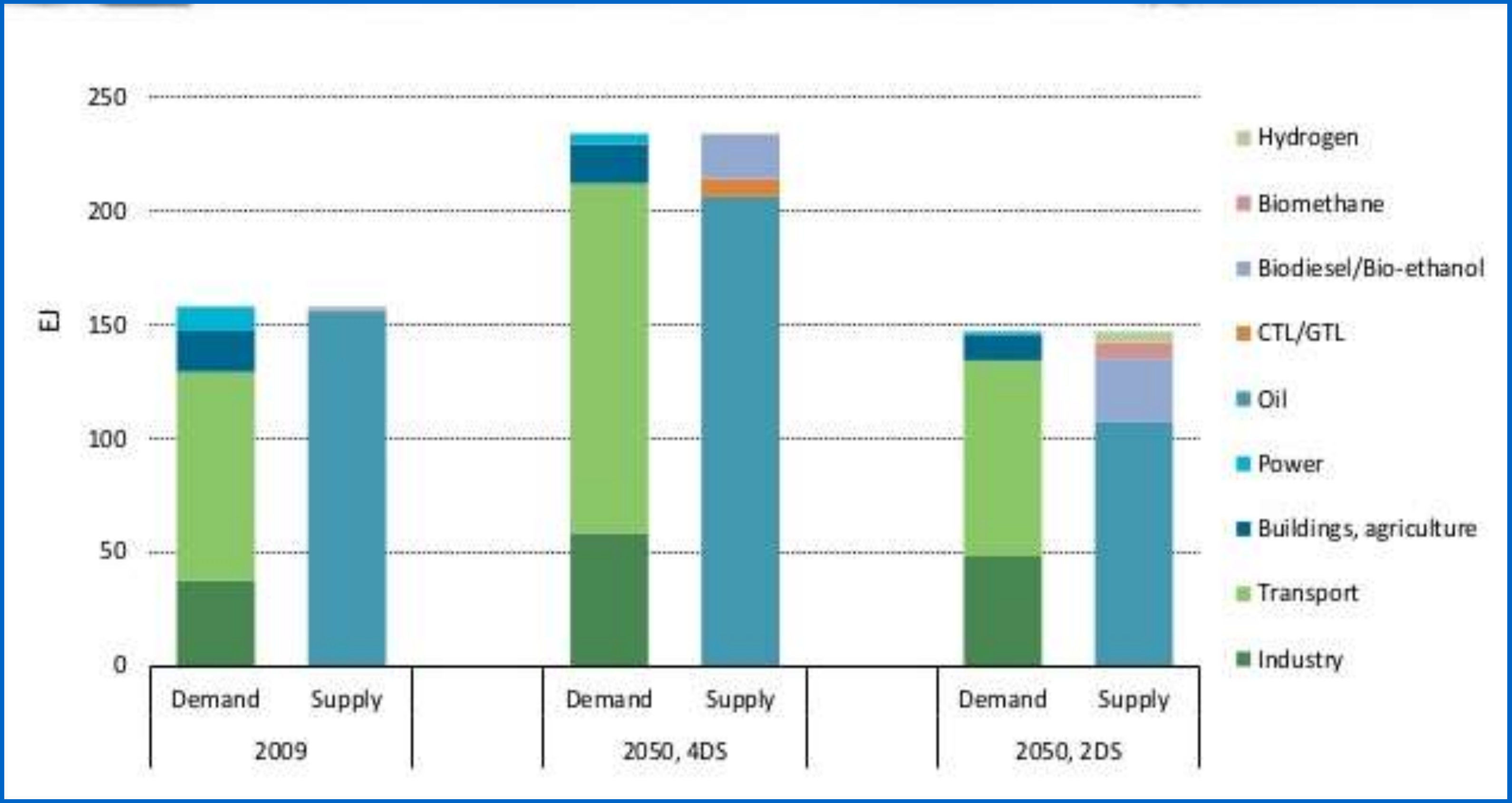


Figure 6. Liquid fuel demand, in the 2D Scenario of IEA, will be stabilized at today's level, largely due to efficiency improvements and electrification in the transport sector. (Fig. IEA) [7]

Bioenergy for electricity production

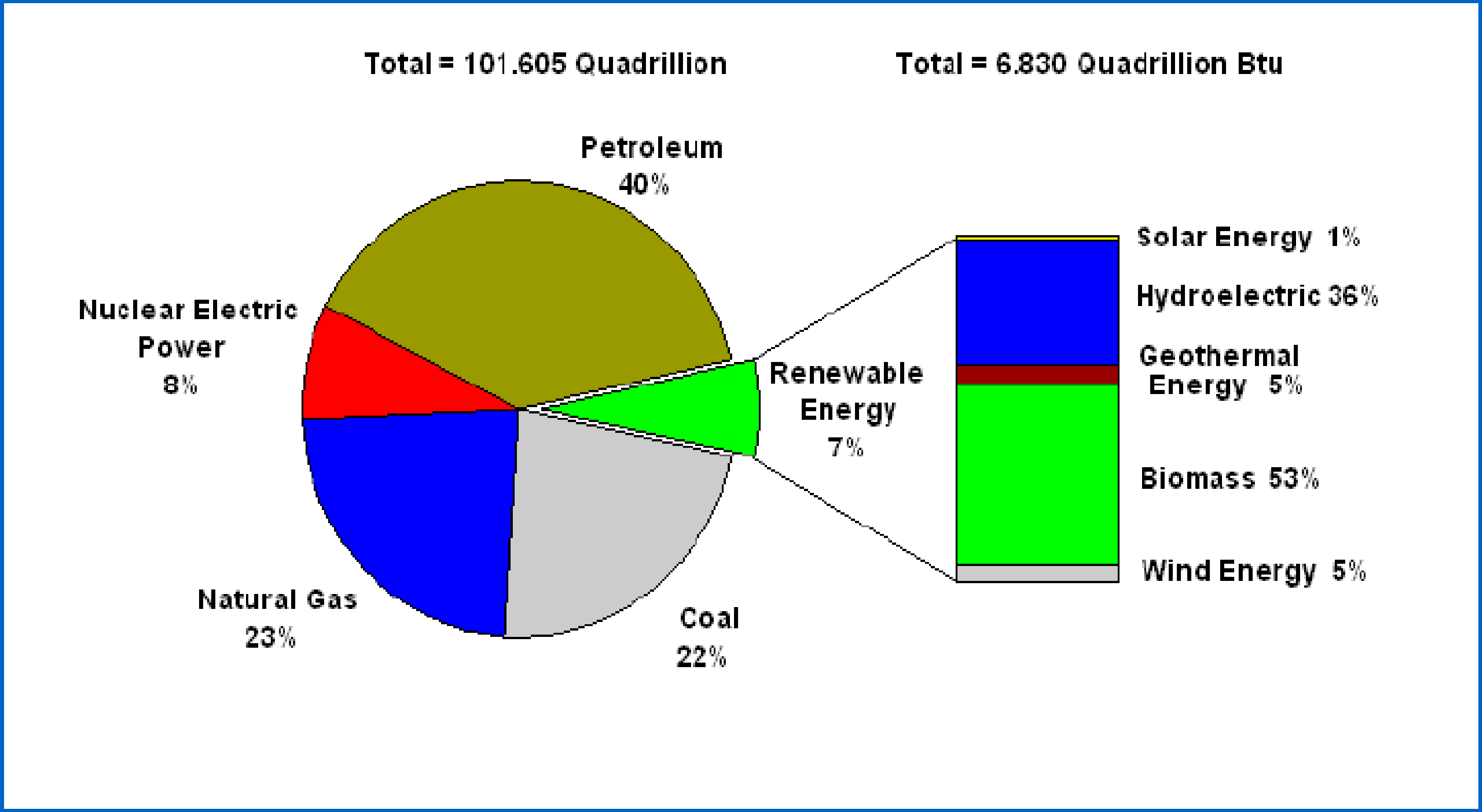


Figure 7 . Worldwide primer energy used for power production, and the Renewables sources contribution[5]

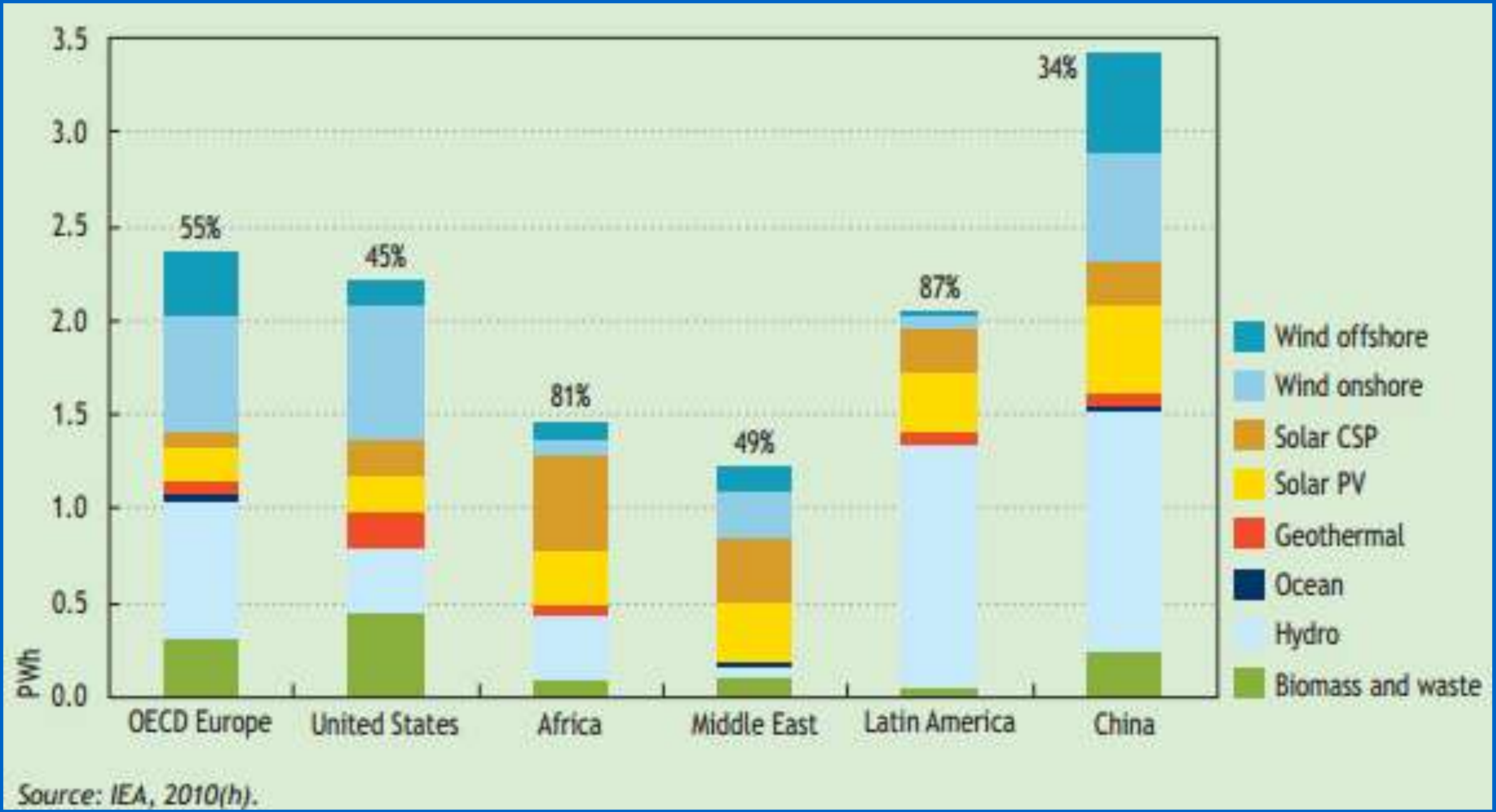


Figure 8. Renewable electricity generation in the BLUE MAP scenario of IEA for key countries and regions in 2050 [8]

Bienergy for HEAT production (or Direct biomass combustion)

The Heat production by Bioenergy is the largest primer biomass energy in the world.

In our days, Bioenergy is used for Combined Heat and Power production or for co-firing in existing coal- fired power, or heat plants (the % of biomass in mixture with coal are given in the Bioenergy Technologies).

This sector includes, beside the power generation in industry, the Local Heating systems, as they are :

- the multi-dwelling residential buildings,
- the single-family homes,
- the cooking and space heating, in developing countries (the largest part worldwide).

The annual biomass for heat and power consumption in EU is predicted to grow by 850 TWh by 2020 to a total of 1.650 TWh (doubling of today's level).

The EU Commission's recent report on the sustainability of biomass concluded:

"the most common types of bioenergy for heat and power applications reduce emissions by 55 to 98%, compared to today's fossil fuel mix in EU power generation, even in situations where the biomass is transported internationally (??) [6]".

II. Biomass uses worldwide

From one side the growth of biomass use for energy and bio-products , as well as the continuous growth of the demand for food/feed, and from the other side the priority given (first priority in EU) to the sustainability of biomass products, raised the world concern for the future use of the world biomass sources.

So, these two reasons dictated **«two new rules”** for the future biomass production:

1) Not to use food/feed and the land cultivated for their production for alternative uses (as they are bioenergy and bio-products).

2) The biomass sources have to fulfill the sustainability criteria.

So, bioenergy and other bioproducts have to come from feedstocks produced:

on marginal land, on land covered with water, from the wastes and from the agricultural /forest residues.

At the same time biomass production and processing have to be sustainable.

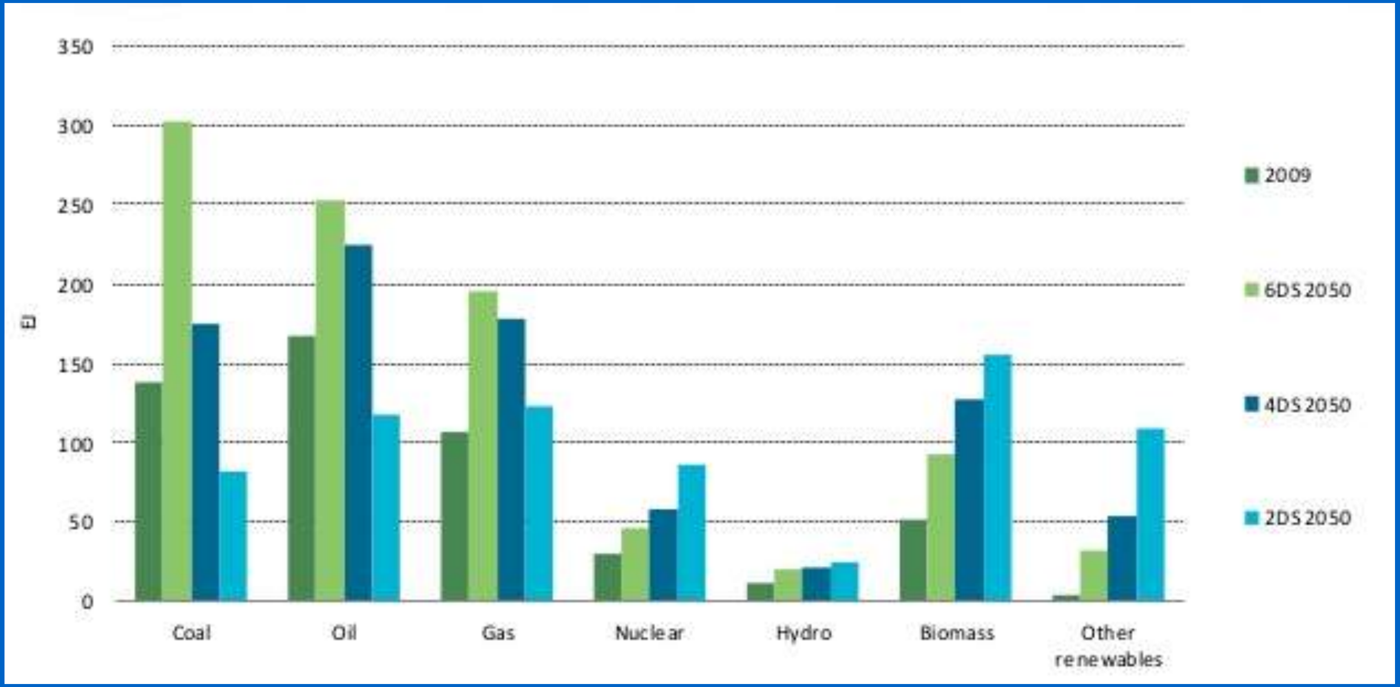
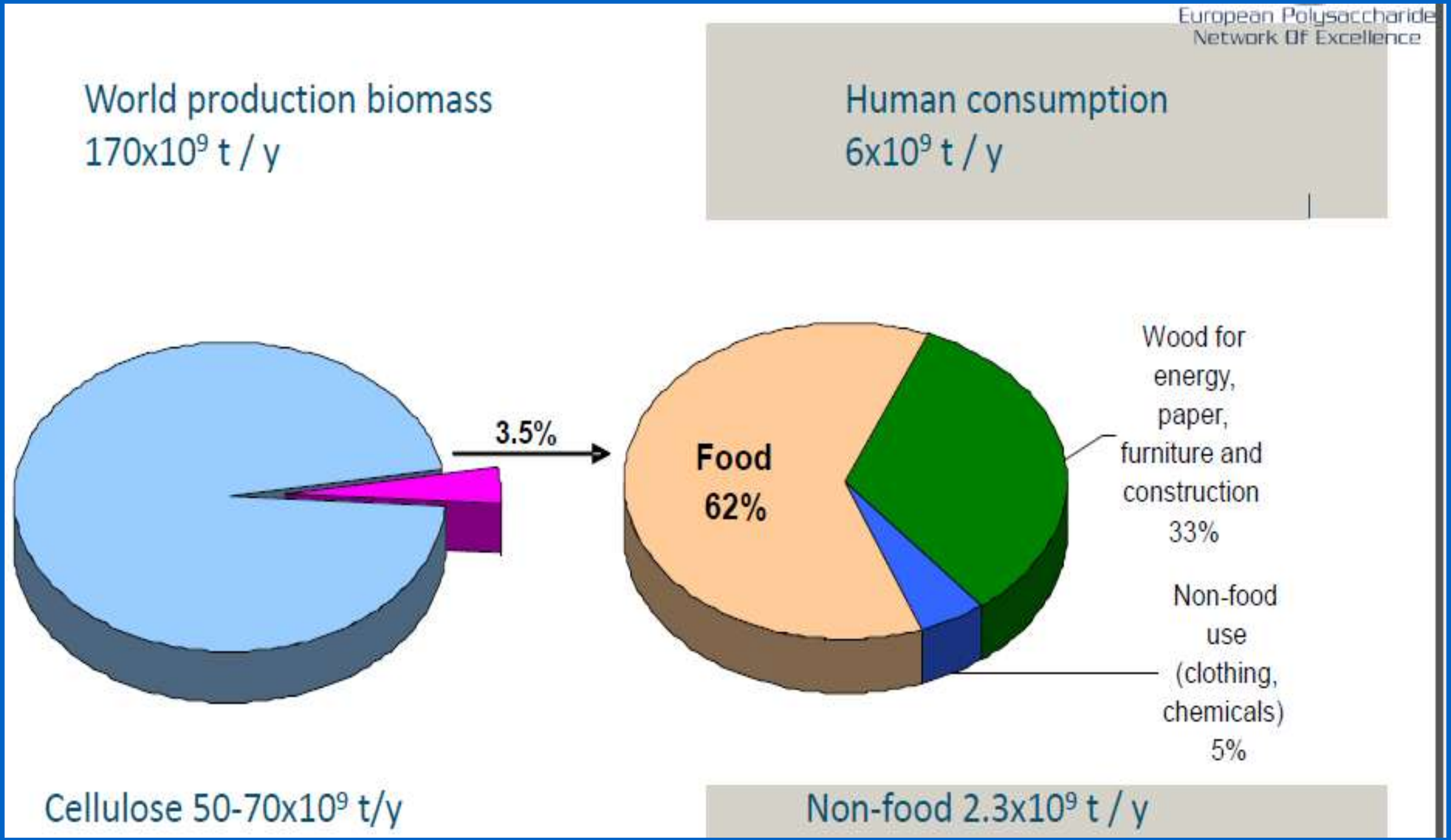


Figure 9. Biomass will becomes the largest primary energy carrier by 2050 in the 2DS IEA's scenario [7]

The World Food and Feed concern



Source: Food& Biobased Research, Wageningen, NL

Figure 10. Total biomass production globally and % designated for food.

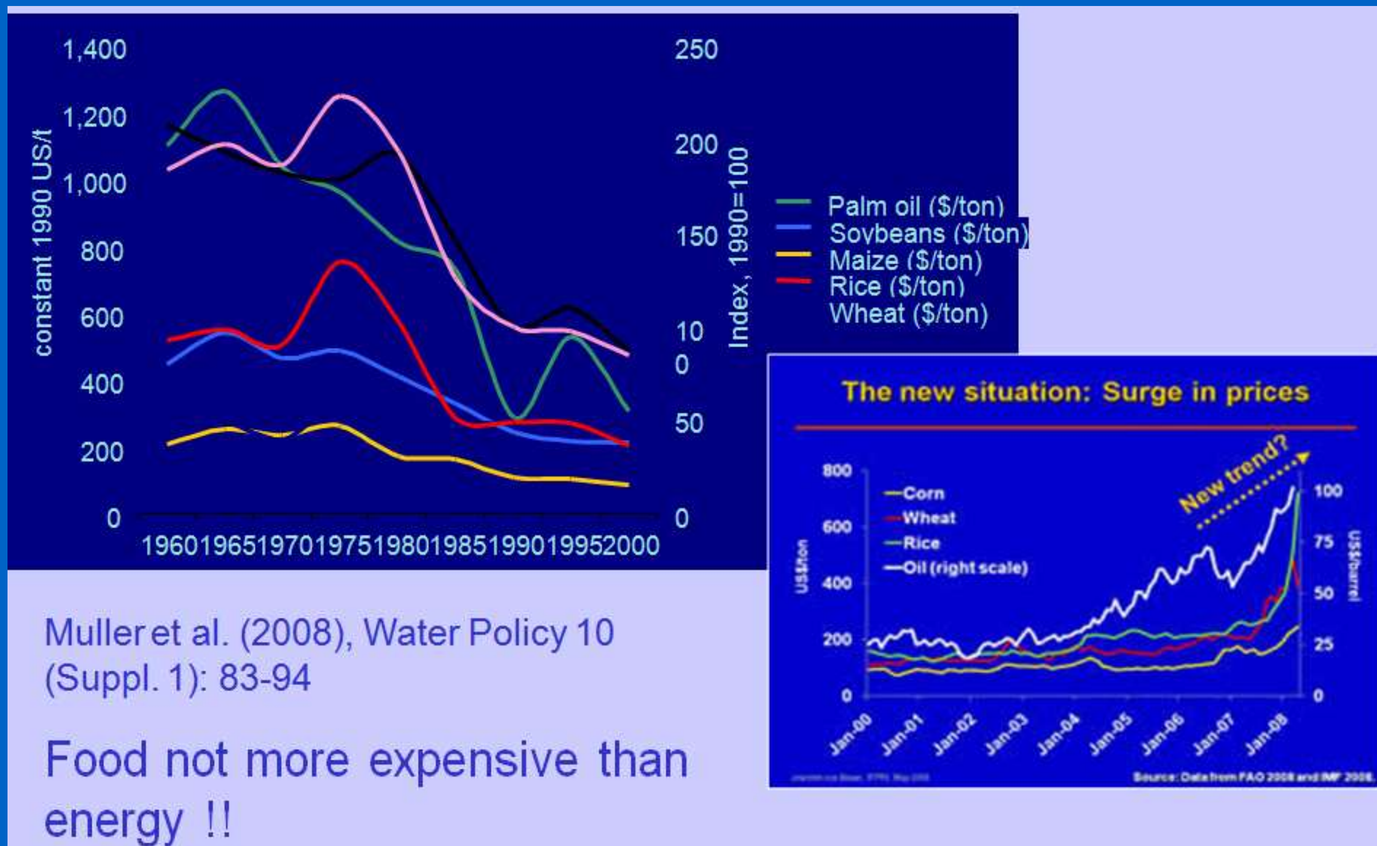


Figure 11. The past and recent evolutions of prices for food/feed, and energy (source: FAO)[9]

The new researchers' obligation.

The world's hopes to solve the problem of biomass sustainability avoiding the use of agricultural land, based on the next generation bio-fuels produced by lignocelluloses, face some practical problems, as they are:

1.**The limited productivity of marginal lands to cover the growing demand of biomass feedstock.**

Here we should have in mind that to replace corn ethanol coming from 1ha , the corn produces 4.7 m^3 ethanol and 3.26 t feed, but 1ha of marginal land can produce to day only 1.12 m^3 of bio-fuel and restricted feed production**.**

2. **The high cost of investment and finally the high cost of the next generation bio-fuels, like bio-ethanol and BtL** (wood-diesel)**.**

To face the above two problems, research has to solve the difficult and complex problem of the future biomass production:

To produce large quantities, low cost biomass, with sustainability and out of fertile agricultural land.

In parallel research has to succeed to a better bioenergy and biorefinery efficiency.

III. Priorities in bio-energy technologies development

Besides the new rules to be followed by the biomass feedstock, today bio-energy technology has also to be sustainable and efficient. To that direction there is a continuous progress worldwide, summarized as follows:

1. Bio-refinery technology development. This relatively new technology for bio-products and bio-energy production uses all the chemicals of biomass, and it has succeeded (LUCINTEL, a US-based market research company)[12] **“ the global market for synthetic bio-products to reach the value of $ 2.1 billion in 2010, and is expected to reach $ 3.8 billion by 2016”.**This progress of the technology is expected to continue, especially in the synthesis of bio-products.

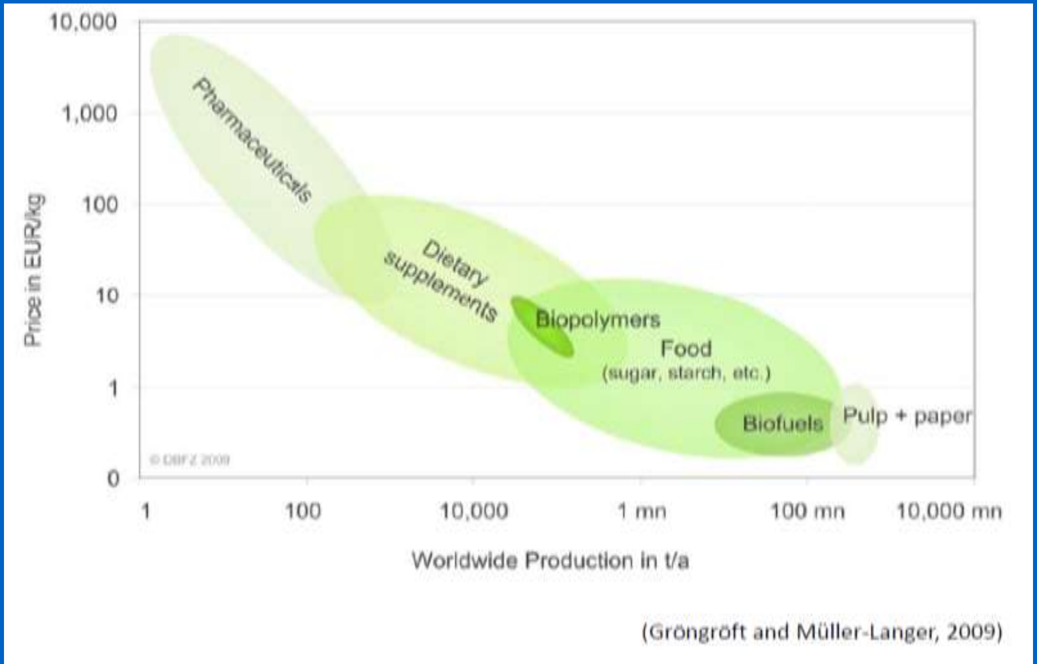


Figure 12. The world market of bio-products

Bio-refineries present an opportunity for the forest industry (especially in several countries like Russia and Canada) to produce higher value products from low cost ,renewable raw materials.

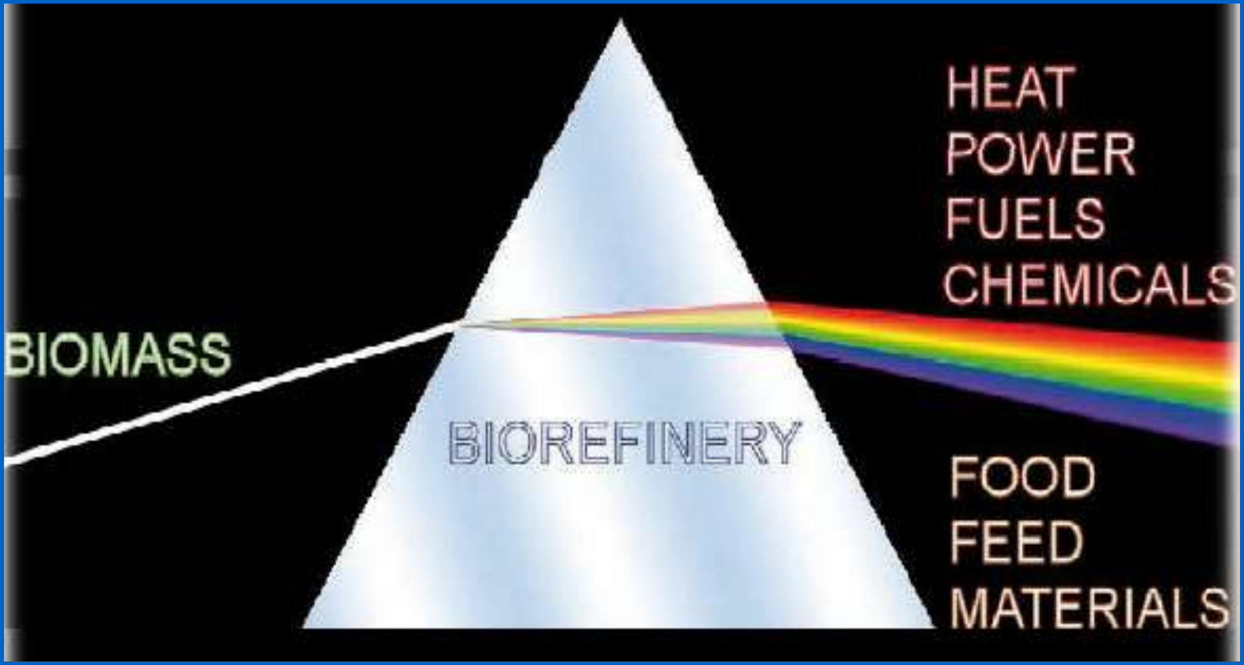


Figure 13. The International Energy Agency (IEA) gave the following definition for biorefinery: **"Biorefinery is the sustainable processing of biomass into a spectrum of *marketable products (food, feed, materials,* chemicals) and energy (fuels, power, heat)".**

Biomass feedstock

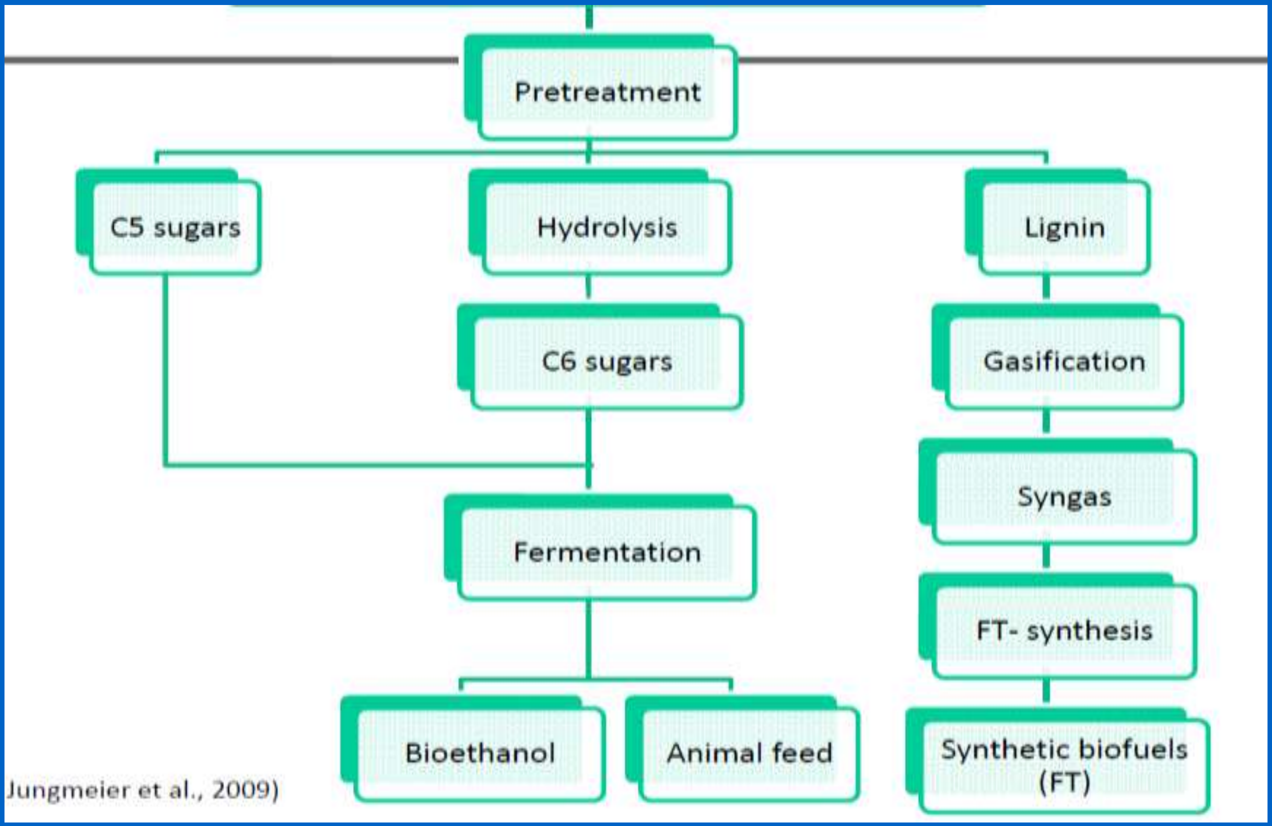


Figure 14. An example of a typical flow of chemicals and their processing in a simple biorefinery for bio-ethanol and food/feed production [10] .

2. Co-firing bioenergy technology is a major application area for biomass in existing coal-fired power and/or heat plants. The possible % of biomass in co-firing depends on what alterations companies are willing to undertake, and what efficiency losses they are willing to accept, and it also varies from plant to plant.
Commonly biomass % used in European industry co-firing applications, are given bellow [11]:

■ Up to 5 % biomass (on an energy basis) is possible in close to all plants without any major investments or losses of efficiency.

■ 5-15 % co-firing is possible in most plants younger than 30 years, but may require upgrading plant equipment such as storage, grinders, feed systems, burners, air blowers, and flue gas cleaning equipment.

■ 30-50 % co-firing has been done in a number of European plants, with the same type of alterations as mentioned above, but with higher requirements on the quality and consistency of the biomass feedstock.

■ Fully converting an existing coal plant to dedicated biomass combustion often requires changing parts of the boiler, or the entire boiler.

■ The co-firing potential is broadly similar for hard coal and lignite plants, but co-firing in hard coal plants generally requires high-quality biomass (e.g., wood pellets),while lignite plants can, in certain cases, also burn wet fuels (wood chips), or fuels with longer fibers (straw).

Finally biomass co-firing with coal, in large power production units, **is in progress** , but **more progress** is expected in this technology with more % of biomass feedstock in the mixture and better than the today (average 30%) conversion efficiency.

3. Gasification technology for power, CHP, polygeneration and Syngas production ,is in a continuous research effort, especially in the Center and North of the EU.
The liquid fuel expected by Syngas remains expensive, but progress is expected in near future.

4. **The technology for the next generation bio-fuels** is in the hands of large private companies, and marks a continuous advance. But the market demand for ethanol produced from lignocelluloses and for wood diesel, produced via synthesis gas (respecting sustainability, ex. better ILUC), from feedstock produced in marginal lands, still hurts upon the reality of high production cost(because of the low productivity of biomass feedstock, and the high investment for the factory). The high investments from private companies, and the economic incentives mainly from USA government, is expected to give better results in the future.

5. **Pellets production technology**, storage and long distance transportation is always expanding (besides the questions on its sustainability) [6], but the humidity poses problems to economic production, safer storage and transportation.

6. **Torrefaction** technology shows progress, especially in Sweden, and can solve the above mentioned problems of pellets.

7. **Small Pellettizing units,** for small producers or farmers, need the attention of researchers. There is a need for equipment, able to pelletize a variety of biomass feedstock. Successful results to this direction will lead to a wider use of agricultural and forest residues and offer more socio-economic advantages to the rural population.

8. **Small and large combustion units** for pellets or other biomass feedstock need researchers' attention in order to achieve more efficient combustion with less CO_2 emissions.

The introduction of CHP will ameliorate considerably the overall efficiency.

9. Conversion and cost of existing industrial and residential heating.

Bioenergy technology in this sector needs amelioration, either by replacing current coal, gas, and oil heating systems, with a biomass boiler, or through establishing / expanding district heating networks connected to biomass heat plants. Local conditions, such as: the scale of the installation, type of use, climate, and the type of heat (low or high temperatures), determine which of these alternatives is better.

Physically, biomass boilers can be installed in most buildings where there is a water-based heating system, and where there is enough space to store the pellets, but:

1). At present, the cost of converting residential and industrial heating from oil or gas to pellets varies widely, depending on the scale of the installation. For example, systems for residential, multiple dwellings with a heating capacity of around 100 kW can cost from 30,000 to 65,000 Euros.

2). Comparable investments for oil, or gas are much lower, approximately 20,000 to 25,000 Euros and 18,000 to 30,000 Euros respectively, depending on local conditions.

3). For single-family houses, investments range from 10,000 to 16,000 Euros for pellets, compared with 5,000 to 13,000 Euros for oil and 5,000 to 12,000 for gas.

10. Anaerobic fermentation tecnology (for bio-methane production) is expending rapidly, especially in some European countries (Germany, Austria, Denmark and others). The new technological achievements offer more efficiency and stability.
The problem of the economic competition with fossil energy is minimized, if the co-produced heat will be used closer to complete.

The fact that this technology manages wastes, protects ground water, produces fuel and recycles nutrients, makes it attractive for further applications.

More research is needed in this technology for lower investment cost, and for more sustainable and low cost cultivated feedstock, not in competition with food/feed production, as it happens with the majority of actual cases.

Recent research to this direction in Chile and Mexico with the plant Opuntia ficus indica, used for bio-methane production gave interesting results, as they are:

The bio-methane produced is characterized by the absence of sulfuric acid and the rapid generation of bio-gas with short retention times (5-10 times faster than animal manure).

According to Dr. R. Morales (head of ELqui Global Energy centre in Chile), one ha of Opuntia produces 17,500 m^3 of bio-gas, or the equivalent in energy 10. 00m^3 of diesel.

11. The technologies "on the farm biomass feedstock proccesing to energy", have to be examined carefully for further development . These technologies present the advantages of low cost and more sustainable energy products, and better social results[2].

The example of the Sweet Sorghum Ethanol Association (SSEA) in the US for **"ethanol production on the Farm",** has to be considered for adoption, not only for ethanol production, but to be adopted in a variety of other bio-energy technologies.

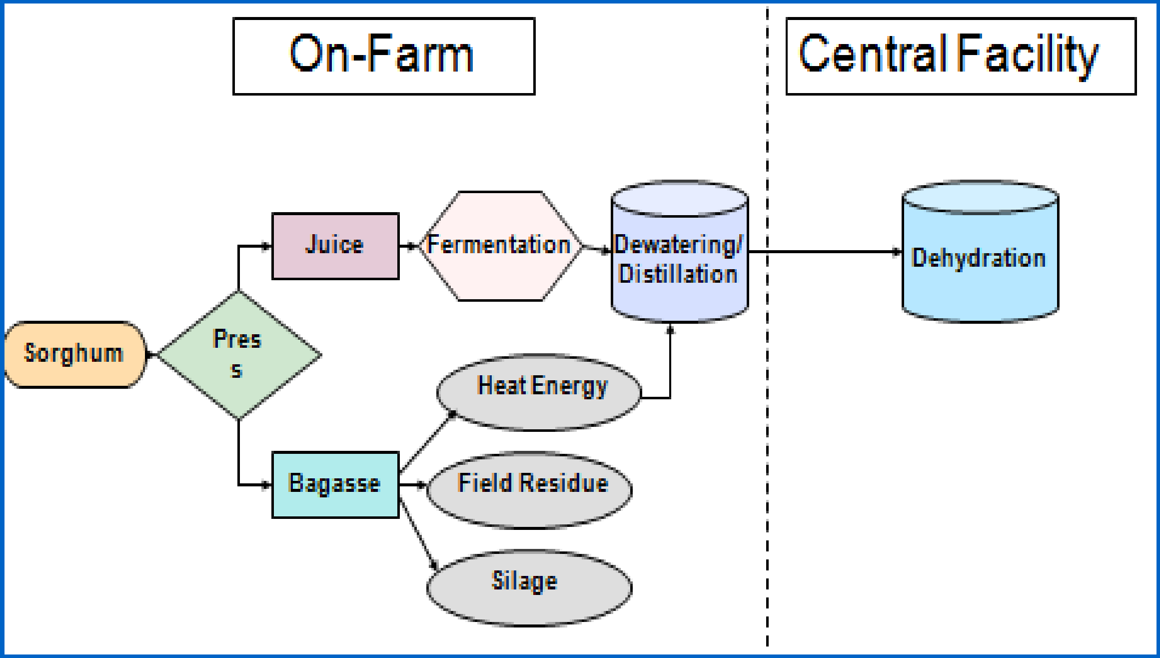


Figure 15. Sweet sorghum processing on- Farm for ethanol production, practiced in the South States of USA. (Fig. by Oklahoma State University) [3,4]

Main characteristics of Sweet sorghum processing on-Farm for ethanol production[2]:

- Investment cost for ethanol processing: \$ 0.264/lit, instead of \$ 2.64/lit for a central industry ,

-the production cost of ethanol is \$ 0.132/lit, instead of > \$ 0.35/lit from a central industry,

-on-Farm ethanol has around 8 times less CO2 emissions in comparison to the today corn ethanol

- gains in income/ha (> 7 fold) compared with the gains from the today corn ethanol production.

12. The technology for agricultural residues cost reduction is a need, as the main cost reduction levers are gathering, transportation, and loading of the residues, which together account for around 50% of feedstock costs. In each of the processing steps, costs can be reduced by 20% through improved baling practices (i.e., larger and denser bales), achieved by using specialized field pressing equipment that increases bale density by 30%. Larger and denser bales increase the amount of energy in each loading or transport operation, reducing the operational cost per energy unit. In addition, storage costs (some 25% of total costs) can be reduced by up to 90% if bales are stored outside rather than inside, and appropriately protected (by plastic tunnels, for example). The capital cost of storage barns is a large part of current storage costs in the today practice.

13. The new hybrids and plant species for biomass production advances world wide.Hybridism is a new sector of research for better biomass productivity. The sector gave already spectacular results[13,14], especially in hybrids coming from private companies, but more should be expected in near future, by the research expansion to that direction.

Conclusion

Bioenergy is in expansion worldwide having the target**: "the transition from an economy based on fossil raw materials (coal, oil, natural gas) to a sustainable world economy, which will be based on the use of renewable biomass feedstock for the production of fuels/energy and other chemical products".**

The prediction in the different scenarios for the future use of biomass feedstock for energy creates food/feed security in the world.

To secure environmental and social sustainability from the always growing use of biomass sources, the world scientific community and the policy makers are taken several measures, as they are: not to use agricultural products and the land used for their production for "alternatives uses", the progressive use of all the organic materials of biomass (residues, wastes, etc.) and to raise the technology efficiency in bio-products production (energy and other), in order to make biomass use more sustainable today and in the future.

The scientific research is in progress in the different bioenergy technologies and biomass feedstock production, where gave already spectacular results.

But more progress is needed in the near future to assure the expected sustainability from biomass and its expansion use avoiding to influence the security of food/feed.

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Thank you for your attention

Spyros KYRITSIS
E-mail: skir@aua.grskir@aua.gr