European Biomass Industry Association

The development situation and outlook of world biomass energy & biochemicals Market

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General World Context. Source: MIT, 2012

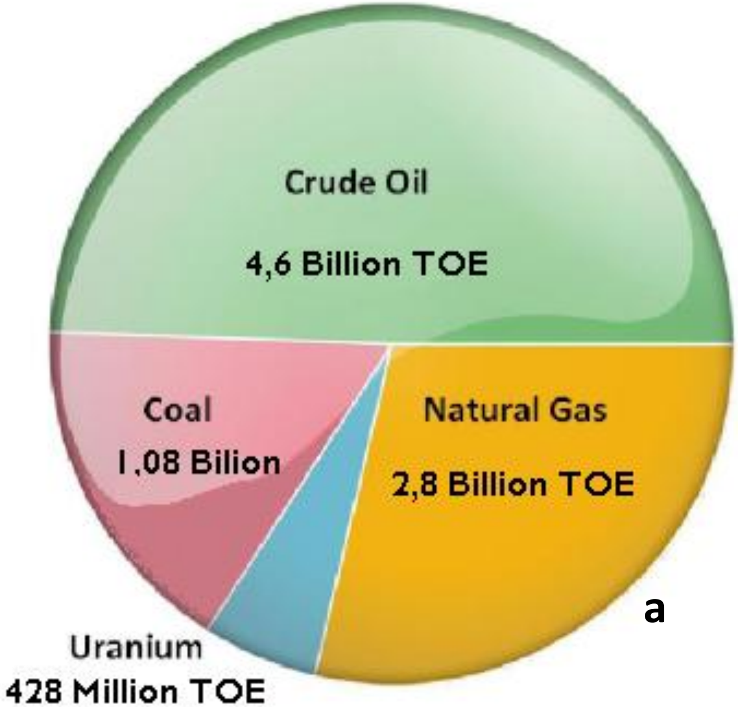
INDICATORS	2010	2020	2030	2040	2050
GDP Growth (% / yr)	1,9	2,7	2,9	2,5	2,6
Population (millions)	6.895	7.655	8.320	8.873	9.305

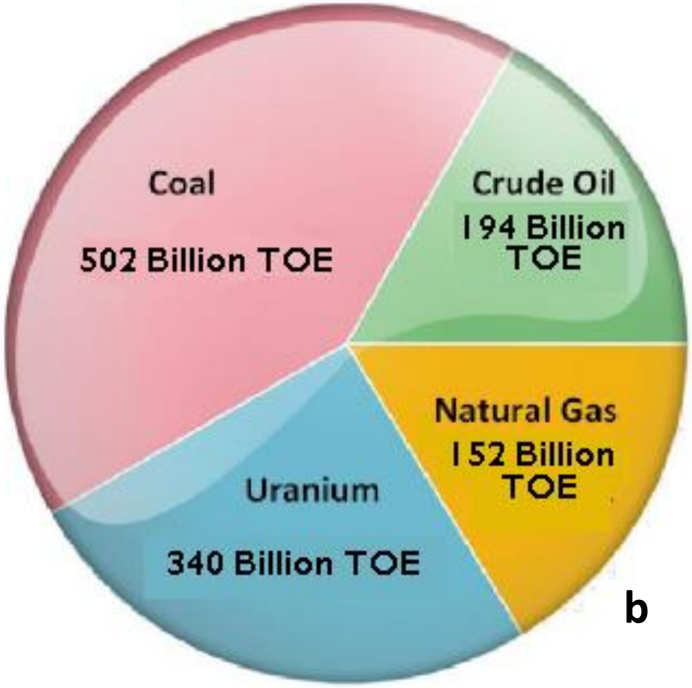
YEAR	2010	2020	2030	2040	2050
VEHICLES (millions)	808	1003	1202	1384	1603

GHG EMISSIONS	2010	2020	2030	2040	2050
CO_2 Billion t	38,8	45,7	52	57,4	60,9
CH_4 (Mt)	397,5	396,9	640,8	678,3	713
N_2O (Mt)	11,41	11,21	14,48	16,35	18,36

LAND USE (Mha)	2010	2020	2030	2040	2050
Cropland	1808,4	2003,9	2239,5	2463,6	2659,9
Pasture	2800,3	2798,8	2730,3	2680,1	2631
Natural grassland	665,9	594,7	560,7	534,9	524,2
Natural & managed forests	4806,6	4649,3	4505,3	4369,5	4240,8
Other	2997	2997	2997	2997	2997
TOTAL	**13.121**	**13.119**	**13.116**	**13.115**	**13.114**

Worlds total consumption (a) and estimated total reserves (b) of Oil, Natural Gas, Coal and Uranium



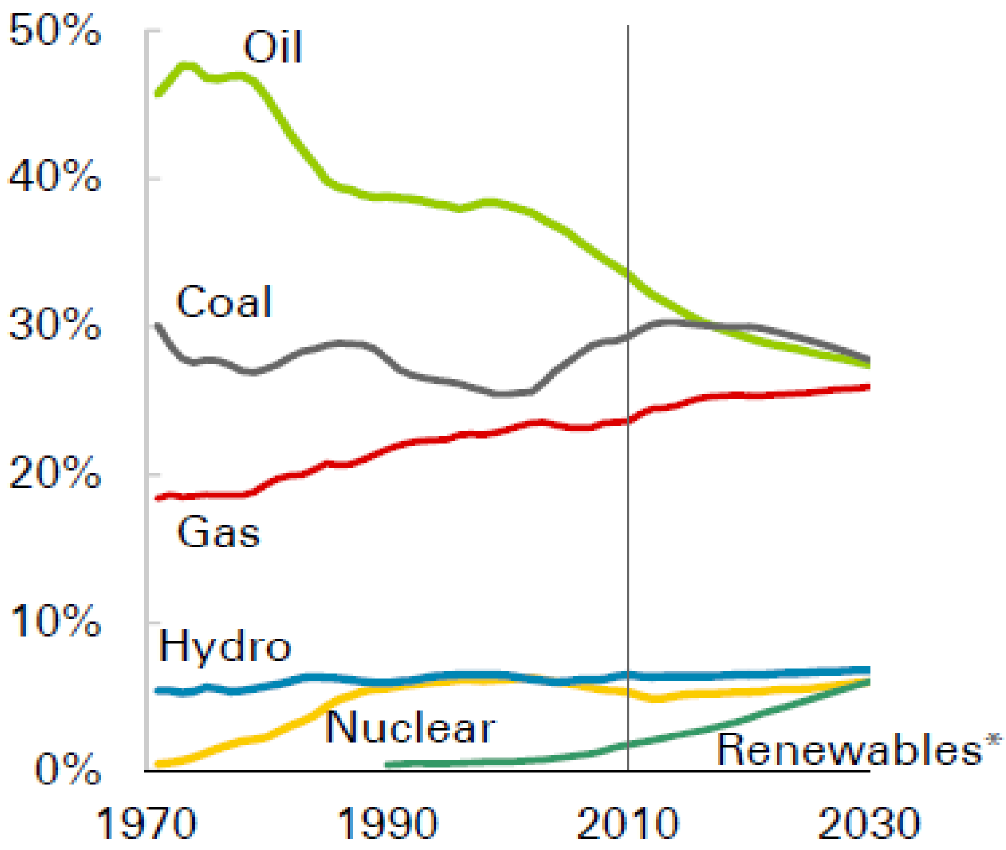


Source: BP Statistical Review of World Energy June 2012 Adapted by EUBIA

Non conventional oil and gas resources recently identified must be considered:

- Oil from sands: huge new resources (i.e. Texas)
- Nat. Gas from rocks: 470 x 10^{12} m^3
- Methane-hydrate: 100 - 500 x 10^{12} m^3

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



+5.4%

Growth in coal consumption, fastest among fossil fuels.

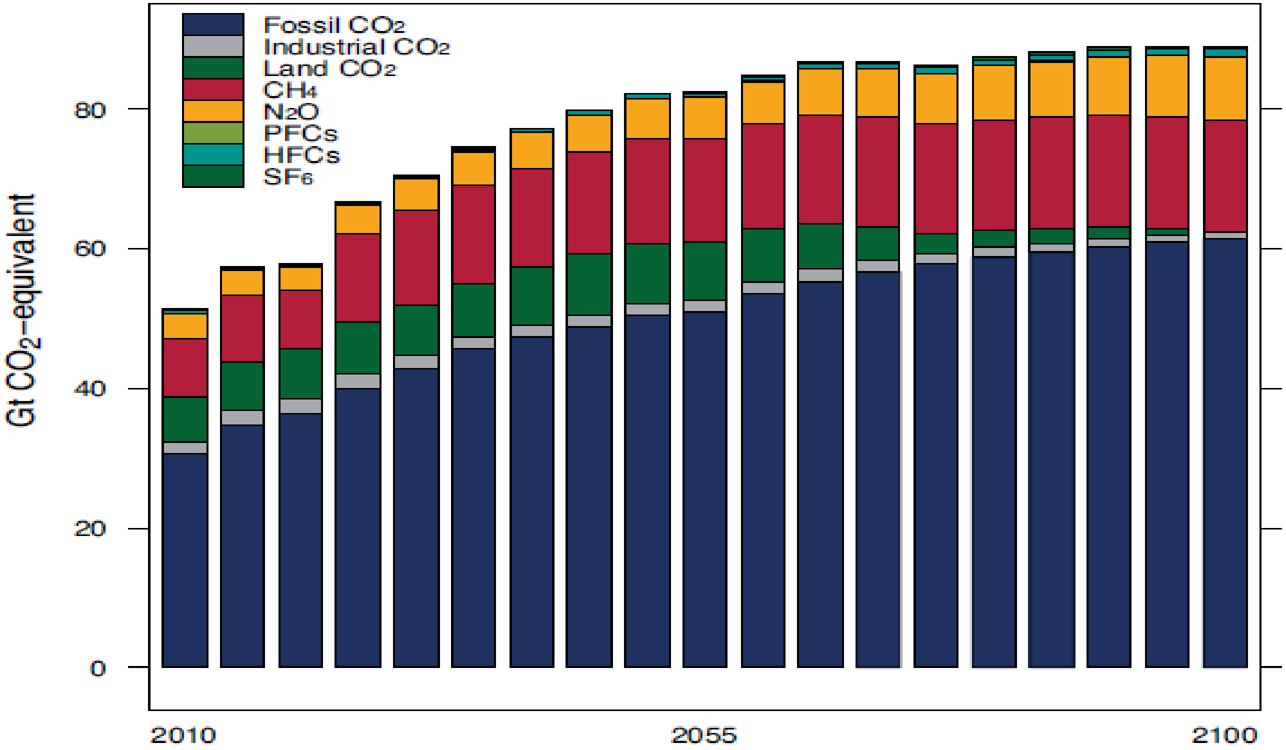
–4.3%

Decline in global nuclear output, the largest on record.

2.1%

Share of renewables in global energy consumption.

Global expected Greenhouse Gas Emissions. Source:MIT



CO2 Global emission expected increase:

- 2010: 38,8 Billion t
- 2020: 45,7 Billion t
- 2030: 52,0 Billion t
- 2040: 57,4 Billion t
- 2050: 60,9 Billion t

GHG EMISSIONS	2010	2020	2030	2040	2050
CH4 (Mt)	397,5	396,9	640,8	678,3	713
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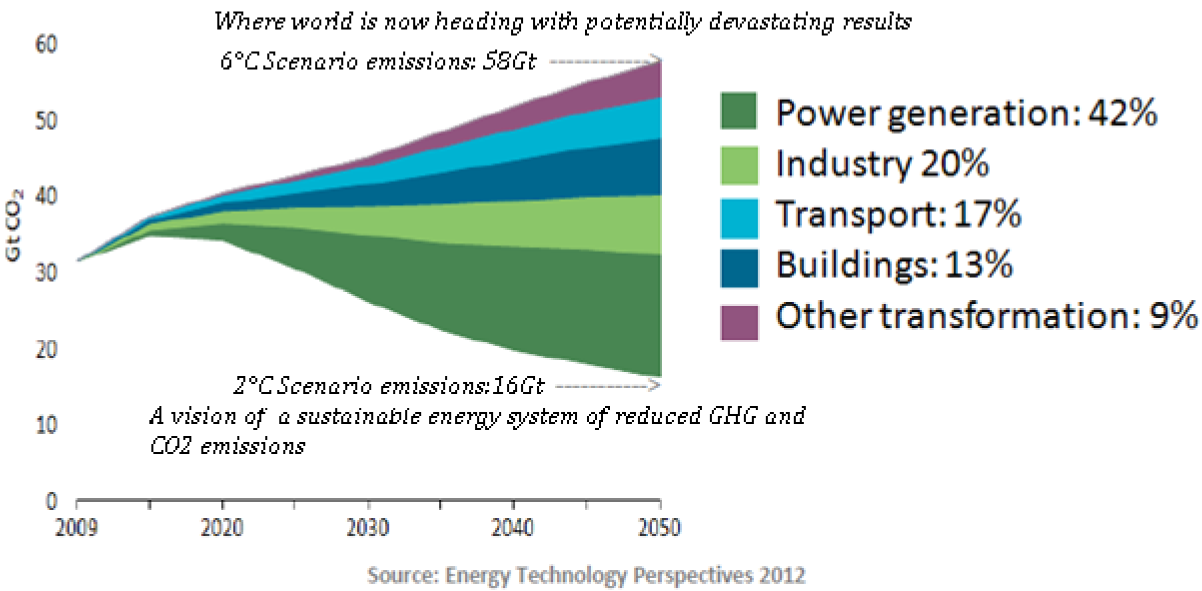
The Key role of Biomass in a low carbon future energy market

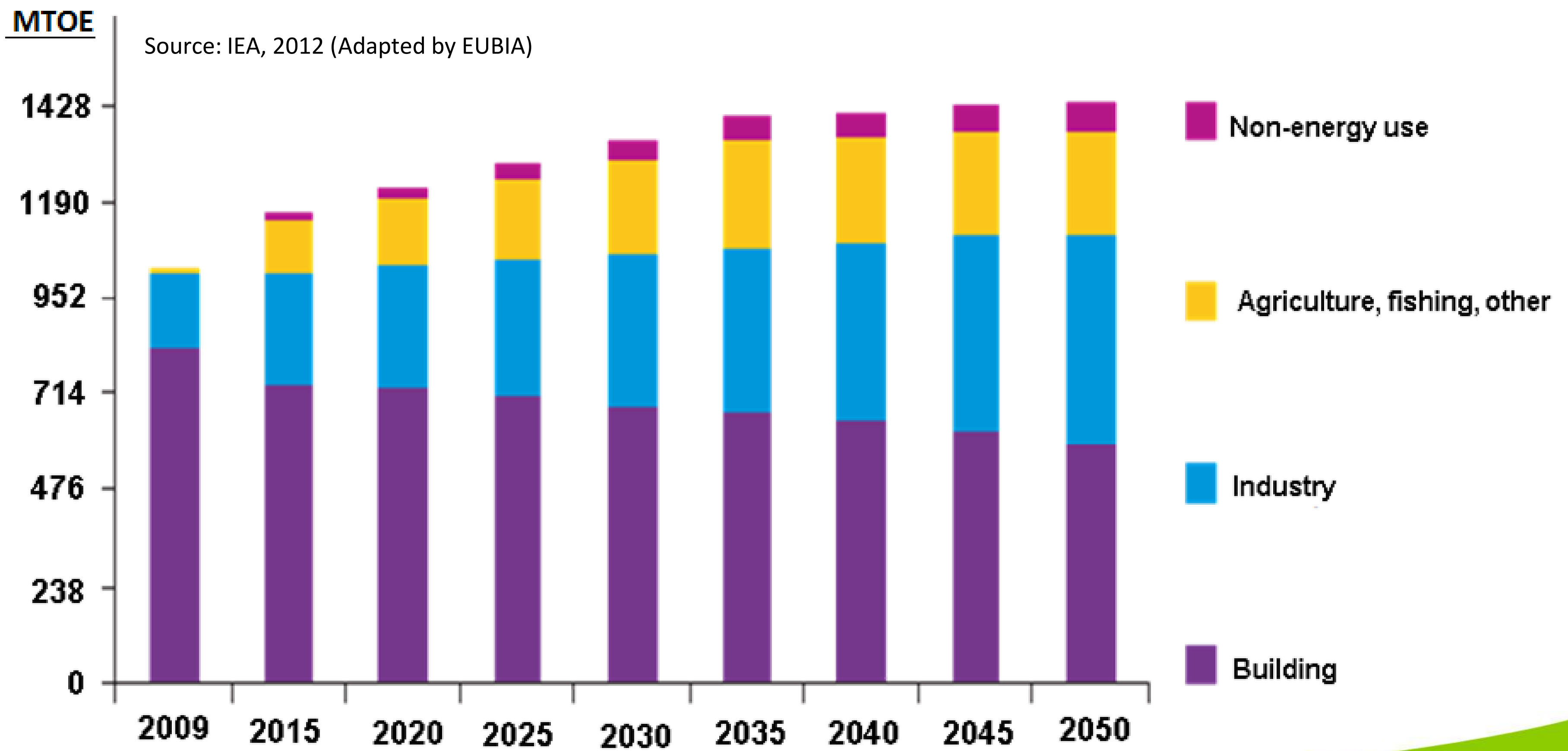


Bioenergy technologies	Emissions reduction in 2050
Bioenergy power	1.0 Gt $CO_{2\text{-eq}}$
Bio-power + CCS	0.3 Gt $CO_{2\text{-eq}}$
Bioenergy heat (industry)	0.5 Gt $CO_{2\text{-eq}}$
Bioenergy heat (buildings)	0.1 Gt $CO_{2\text{-eq}}$
Biofuels	2.1 Gt $CO_{2\text{-eq}}$
Total	**4.1 Gt $CO_{2\text{-eq}}$**

The target of 16 Gt CO2 emission established for 2050 will require a 42 Gt CO2 annual emissions reduction by 2050 through CO2-price and strong support policies

Total renewables contribution to the 2CS reduction is estimated to be 21%. Biomass is the only renewable energy source that can make a contribution in all sectors, providing around 10% of total CO2 emissions reduction!

Roadmap vision of world final bioenergy consumption in different sectors.



The key role of biomass as oil substitute in future energy market

Conventional fuel, in addition to a limited availability, have so an high impact on environment health. **In addition, now its price is higher than the past years.**

•The breakeven price of the major world oil producers (S.Arabia/Emirates/Oman-Russia-Venezuela) are respectively:

87 $/bbl - 115 $/bbl - 87$/bbl assumed to balance the country budget.

•The considerable 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

Bioenergy & bioproducts production can become competitive at a price of 100 $/bbl

Biomass has a capacity of penetration of numerous sectorial markets (Heat, power, transport, chemicals) with:

1. A potential substitution of many of the 73,000 products now derived from fossil fuels
2. New employments increase = 1 job for 400-500 ton of biomass).
3. Diversification and increase of incomes for farmers

Future perspectives. Biomass availability and ennvironmental challenges

Estimated global energy potential of biomass expected from 2020 and 2050:

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

Estimated available land for biomass production in 2050

Land management	Now (Billion ha)	2050 (Billion ha)
Total Crop Land	1.8	2.65 (9,3 Billion people)
Forest Natural + managed Land	4.8	4,24
Pasture & grass land	3,46	3,1
Others (desert, palude…)	3	3

WORLD BIOMASS SOURCES. General context

As defined above, there are several biomass sources depending on land use.

1. **Forests:**
    - **Natural (wood residues, etc..)**
    - **Managed (Short rotation plantations (Willow, Poplar, wood for paper)**
2. **Crop lands:**
    - **Food dedicated crops: Considerable amounts of residues (straw)**
    - **Biofuels dedicated crops: Sugarcane, S. Sorghum, Rapeseed, Sunflower,…**
3. **Pasture and grass land. Mixed with manure in anaerobic digesters**
4. **Food and agricultural organic wastes**: **Feedstock with great moisture content as manure, sludge, etc..**
5. **Peat Lands:** some countries consider these source of long scale renewable biomass
6. **Water ponds and sea**: **Microalgae, Seaweed, other water plants (water hyacinth, etc..)**

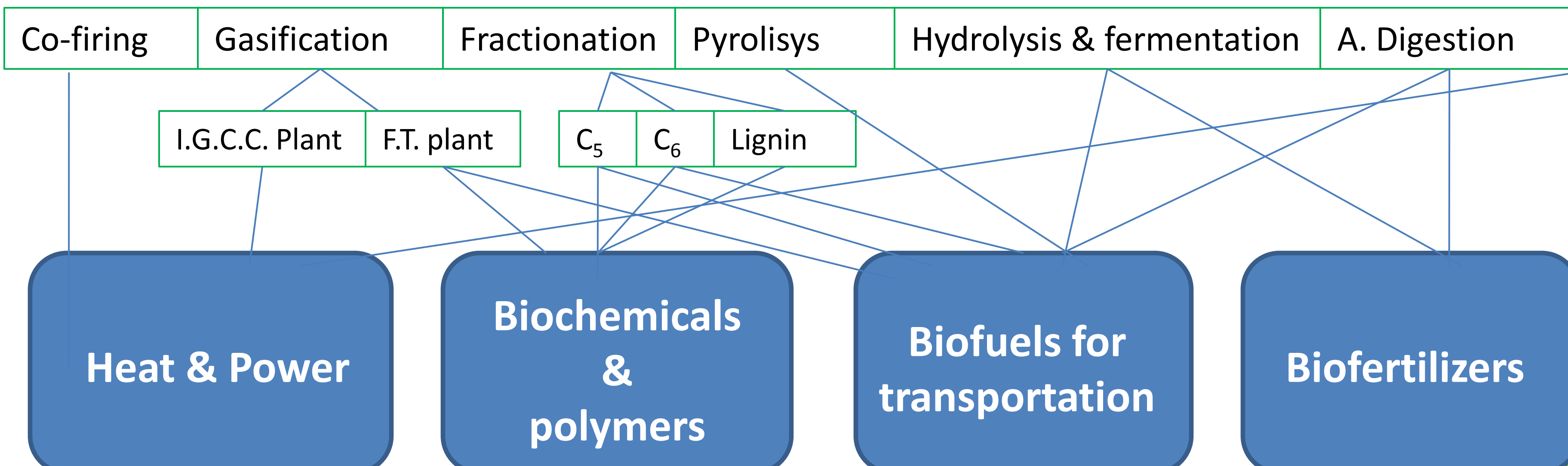
Biomass resources valorization Technologies

Solid biomass

Starch & Oil crops

Micro & Macro-Algae

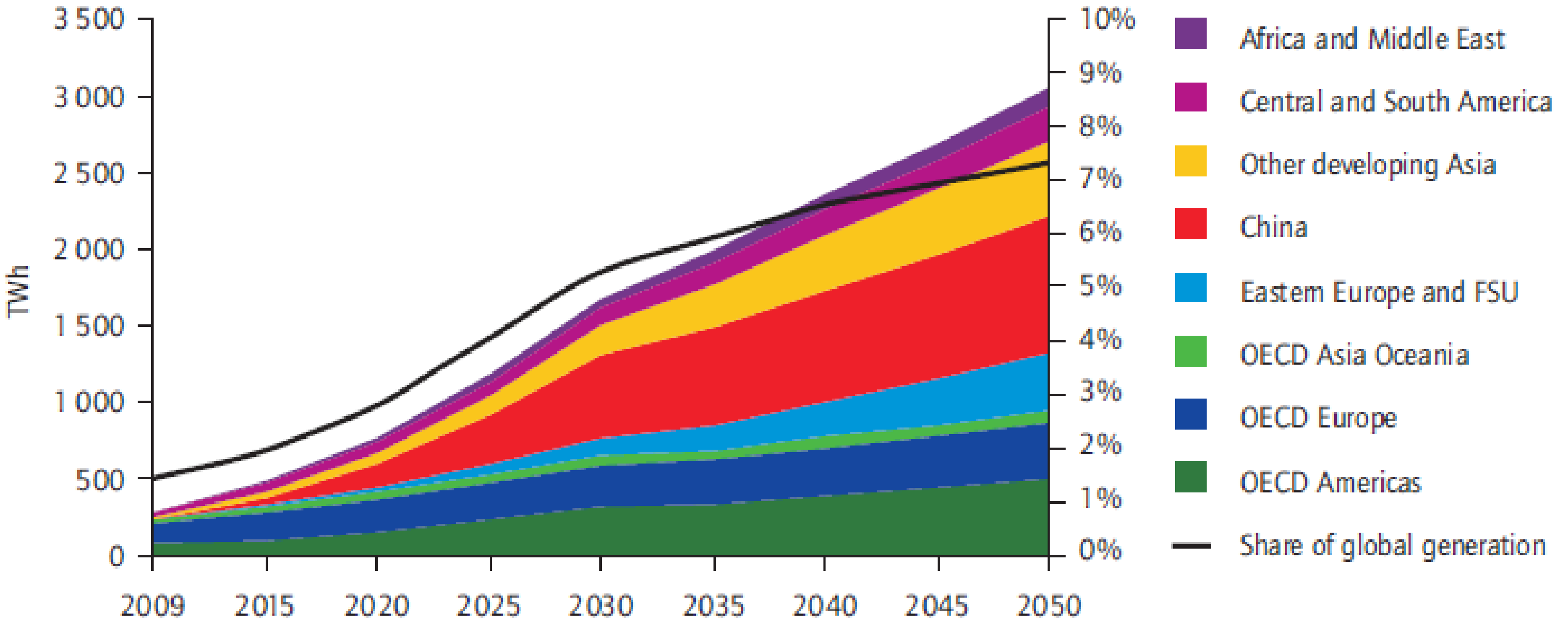
Organic wastes



BIOMASS FOR ELECTRICITY GENERATION

Commercial technologies, current development in World regions and future market perspectives

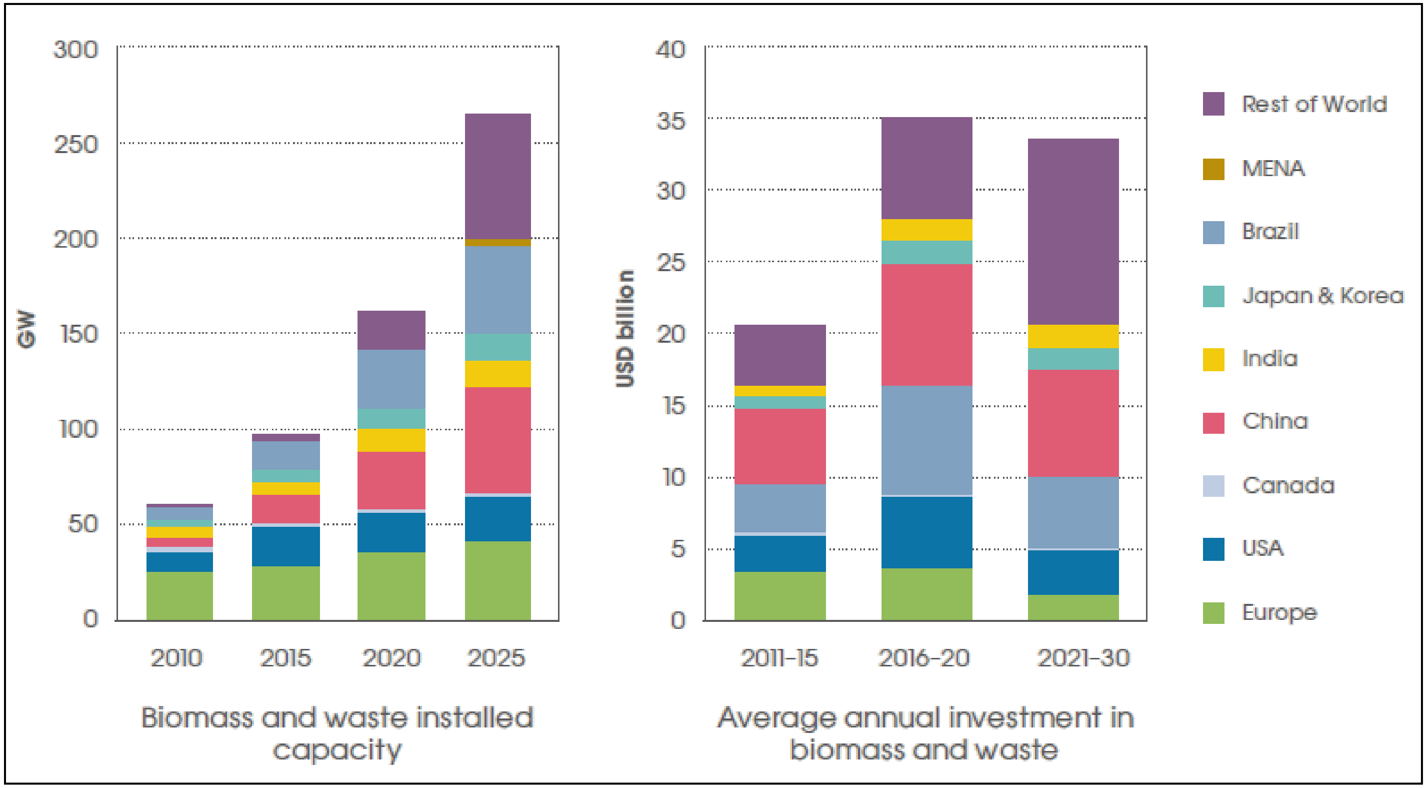
Biomass for Electricity. Commercial technologies and future market perspectives



Bio-electricity generation expected growth in different world regions. The share of renewable electricity will increase from 19% in 2009 to 50-60% in 2050.

Bioenergy Share in total electricity generation increases from 1.5% today, to 7.5% in 2050

Biomass for Electricity. Commercial technologies and future market perspectives



Global Biomass and waste installed capacity and annual investment per country. Source: IRENA 2012

The total capacity of proposed biomass power generation projects that are either under construction or have secured financing and will be completed by 2013 is 10 GW. 87% are for combustion technologies, (BNEF, 2011).

Biomass for Electricity. Commercial technologies and future market perspectives

Bioelectricity is expected to have a constat growth in the next years and represents one of the most promising market for biomass sector.

Among the different technologies, co-firing is the most developed at commercial scale. Followed by stoker boiler combustion and Anaerobic digestion CHP plants.

Power Technology	Investment cost USD/kWe
Stoker Boiler	1880-4260
Bubbling and circulating fluidised boilers	2170-4500
Fixed and fluidised bed gasifiers	2140-5700
Stokers CHP	3550-6820
Gasifiers CHP	5570-6545
Landfill gas	1917-2436
Anaerobic digetsion	2574-6104
Co-firing	140-850

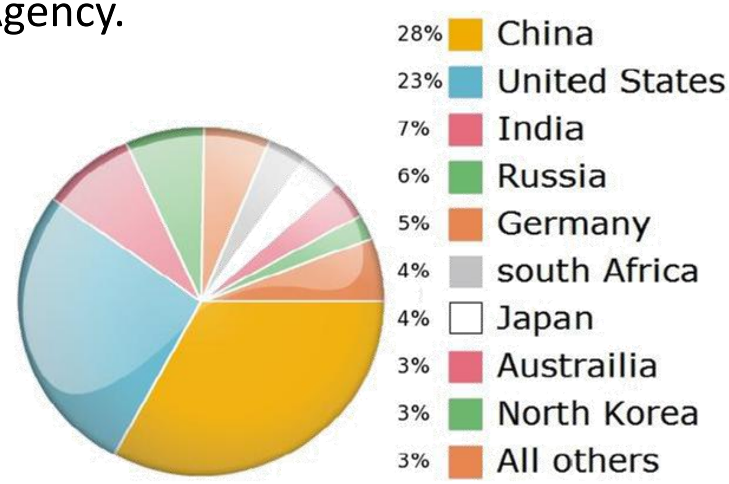
Biomass Co-firing & combustion competitivness is limited by the feedstock cost, as wood pellets cost is still to high compared to coal or Nat. Gas.

Bioelectricity Market. Co-Firing future market perspectives

Investments in different forms will be needed to achieve a total bioenergy electricity capacity of 575 GW in 2050 as defined by International Energy Agency.

Global investment volumes sum up to USD 290 billion during 2010-30.

The highest absolute investments during this period will be required to refit coal-fired plants for higher co-firing rates in China, OECD Americas, as these countries are consuming alone the 61% of the global coal consumption.



Coal global consumption →

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.

T. of biomass for co-firing →

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

Biopower generation target for next decades. Investment estimation (Billion USD).

Region	2010-20	2021-30	2031-50
OECD Europe	21	8	22
OECD Americas	13	11	20
OECD Asia Oceania	4	6	6
Africa and Middle East	7	3	7
China	39	99	54
India	14	8	10
Central and South America	16	5	17
Other developing Asia	12	15	52
Eastern Europe and FSU	3	6	15
World	130	160	202

Note: Numbers might not add up due to rounding.

Investment needs in Billion USD in bioelectricity generation capacity, including co-firing, in different world regions

Agropellets in Large Co-Firing power plants

With this huge amount of solid biomass demand and the expected increase within the next 20 years, utilization of agropellets must be considered for fuelling both co-firing and full biomass power plants. Many trials have confirmed the possibility of pelletizing a very wide range of biomass mixtures even with peat and mineral coal powder.

In the present absence of international agreed standards for pellets Utilities adopt specific criteria as i.e. The Italian Utility ENEL uses the following formula for acceptance of a given quality (type) of Biomass for Co-firing to avoid also corrosion problems:

IR (Index of risk)= $Na_2O + K_2O/LHV < 0,35$ kg/kj

Na_2O : 20kg/t ashes
K_2O : 150kg/t ashes

Here below typical values of the I.R

Type of residue	LHV	Index of risk
Forestry residues	2,500 Kcal/kg	0,12
Straw	1,8-3,500 Kcal/kg	0,7

Typical fuel characteristics for Co-Firing operation:

	LVH	Density(Bulk)	Volumetric Energy
Chips	10-10.5 MJ/Kg	250-350 kg/m3	2.6-3.6 GJ/m3
Coal	25-29 MJ/Kg	800-900 kg/m3	20-26 GJ/m3
Agro-pellet	15,7MJ /Kg	~700 kg/m3	~11 GJ/m3
Torrif. AP.	20,9 MJ/Kg	~800 Kg 1m3	~16, GJ/m3

Bio-power Generation growing technology: Biomass Gasification

Gasification:
endothermic reaction with
carbon and steam/CO_2

$$C + H_2O \longrightarrow CO + H_2$$

$$C + CO_2 \longrightarrow 2CO$$

CO : H_2

	Methanol	Fischer-Tropsch	Methane	Oxo synthesis	Ethylene
CO : H_2	2:1	2:1	3:1	1:1	1:1
Products	• 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 nature of biomass and type of reactor.

Tar gas-cleaning cannot yet be considered a solved problem !

GASIFICATION AND SYN-GAS PRODUCTION

Gasification of conventional fuels (mainly coal) has reached a considerable volume world-wide, 70,800 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%**

MAJOR WORLD SYNGAS PRODUCING COUNTRIES:

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

North America: Capacity of 34,450 MWth (10% of world total). Largest planned capacity increase (27 plants in 2016) utilising coal, natural gas, for the production of chemicals, power, fertilizers(ammonia), 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

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 Syngas capacity (36%)

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

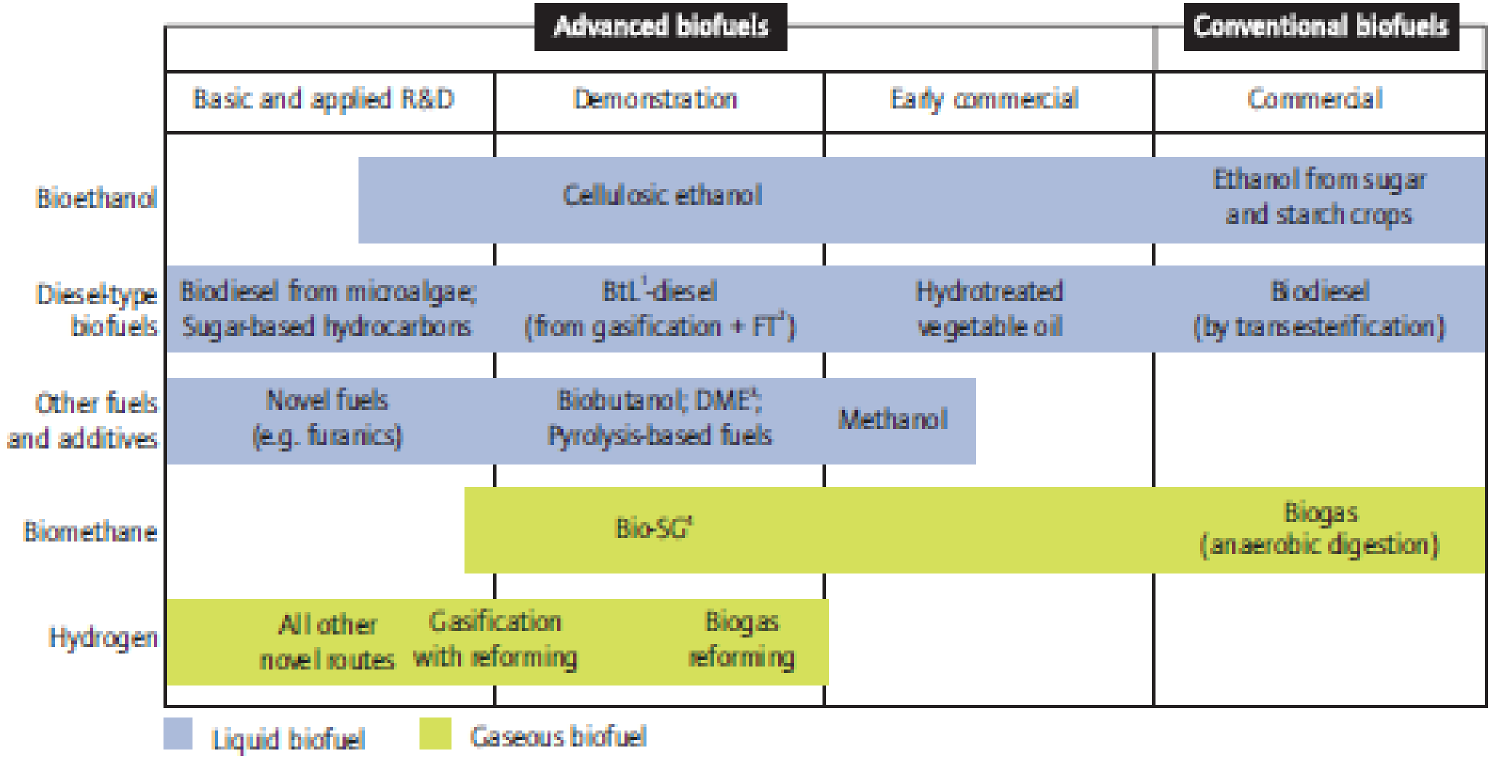
BIOFUELS PRODUCTION TECHNOLOGIES.

Environmental Sustainability, market competitiveness and new advanced technologies

World Biofuels production. General Context

- The two dominant liquid biofuels are bioethanol and biodiesel. 80% and 20% of the market, respectively).
- Together they meet about 3% of the global transport fuel demand and are produced using 2-3% of the global arable land.
- IEA estimates that the use of liquid biofuels could grow reaching a level of 9% (11.7 EJ) of the total transport fuel (126 EJ) by 2030 and about 27% by 2050.
- Biodiesel is mainly produced and consumed in Europe (78%).
- Ethanol is largely produced in tropical regions and in USA from Sugarcane, Sweet Sorghum, Maize, etc..
- Natural Gas Vehicles started developing at fast rate in the last two decades in both developed and under development world regions. These vehicles can be fed easily with Bio-Syngas and biomethane upgraded biogas.
- This new market seems to have promising perspectives due to the lower cost of biomethane compared to BTL , F.T. diesel, and advanced lignocellulosic biofuels.

Commercialization status of liquid and gaseous biofuels



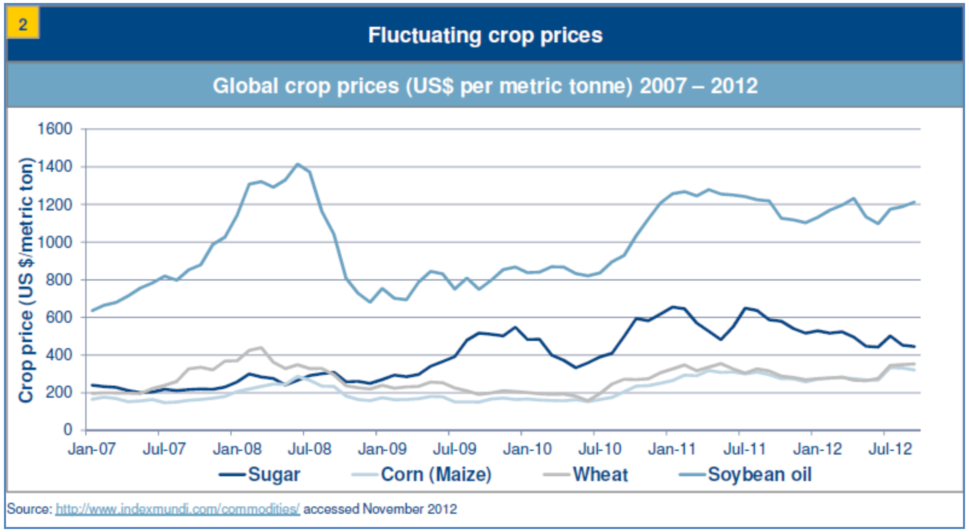
❑Adanced biofuels are still under research and not competitive due to the lignocellulosic biomass pretreatment high costs both when thermochemical and in biochemical cases.

❑Biochemical fractionation of woody biomass is a promising technique but enzimes costs make it still not competitive with fossil fuel in transportation sector.

Decreasing market perspectives of conventional biofuels

Due to the Indirect Land Use Change challenge and to the flexibility of crops price, first generation biofuels will decrease their contribution to the biofuels market.

Lignocellulosic biofuels represent the valuable future substitute:

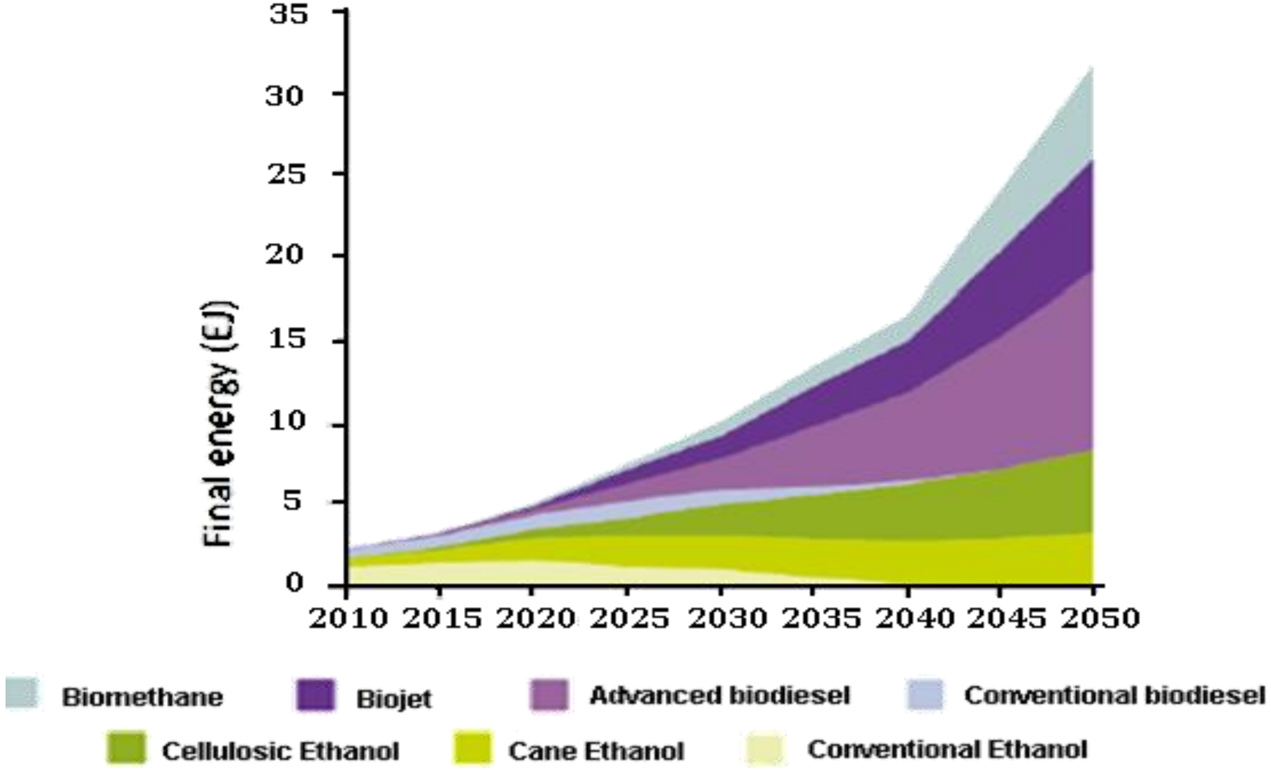


1. Much more biomass available due to the utilization of all biomass wastes and residues
2. Higher GHG emissions mitigation (on a par of sugarcane ethanol)
3. Higher yields of bioethanol per given land area

However, problems related to high costs and to the research stage of technologies make lignocellulosic ethanol still not a commercial competitive biofuel:

The US Government has reduced its mandate for second generation biofuels from 500 million gallons to 8.65 million gallons[1]

Expected growth of biofuels global market: 2010 to 2050.



•Land Use conflict with food crops will eliminate first generation biodiesel from the market

•Expected growth from 2.5 EJ today to 32 EJ in 2050

•Biofuels share in total transport fuel increases from 2% today, to 27% in 2050

•Trade will be needed to balance supply and demand for feedstocks and biofuels

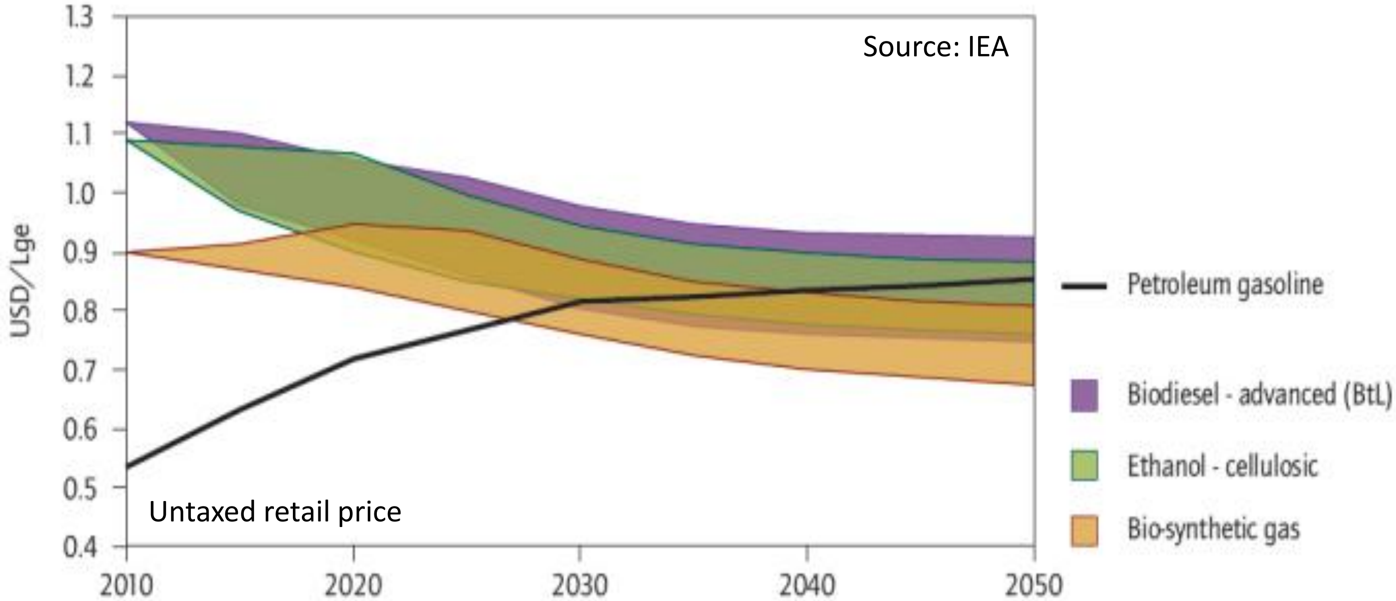
Gasification technology: Competitivness of Bio-Syn-Gas

1. The Bio-Syn-Gas production became of large interest for global market.
2. The processing technology is now approaching the “Commercial” quality level.
3. The Syngas production represents already the 14% of gasification market

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 SYNGAS (Steam reforming of carbonized pellets)	100
NATURAL GAS	75		
SYN GAS	107	HIGH QUALITY SYNGAS(future) (advanced gasification-DOE target)	90

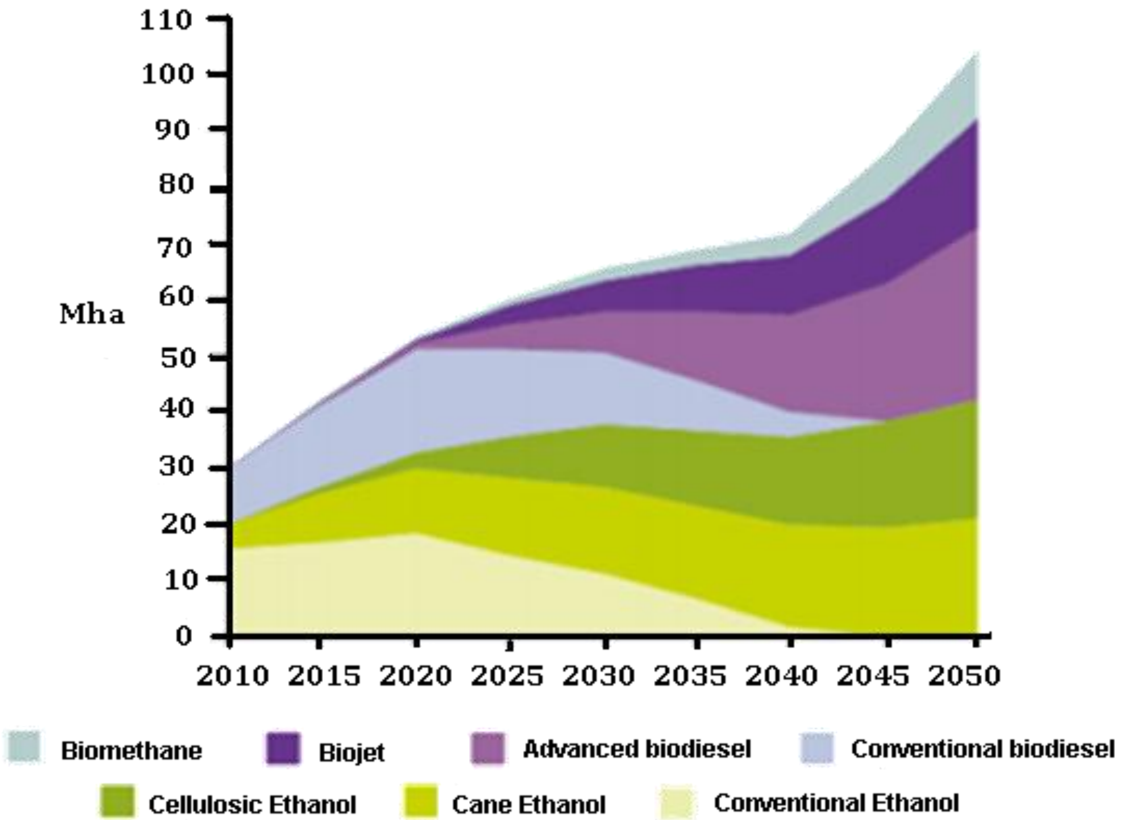
General Estimation of Biofuels cost perspectives compared with petroleum gasoline within the next 40 years



"A valuable Solid Biomass supply chain, with efficient collecting, harvesting and storage systems, could make solid biomass thermochemical processes more competitive and efficient"

- The syngas production, as well as biogas upgrading to biomethane are cheaper than the BTL, 2° generation Cellulosic Ethanol, DME, etc..
- Gasification is already a well known technology largely used in many developed countries for coal gas production and it is going to reduce its installation and operating costs.
- BIO-SYN-GAS can become the cheapest transportation biofuel in the next decades

Sustainability of liquid and gaseous biofuels. Indirect Land Use Change

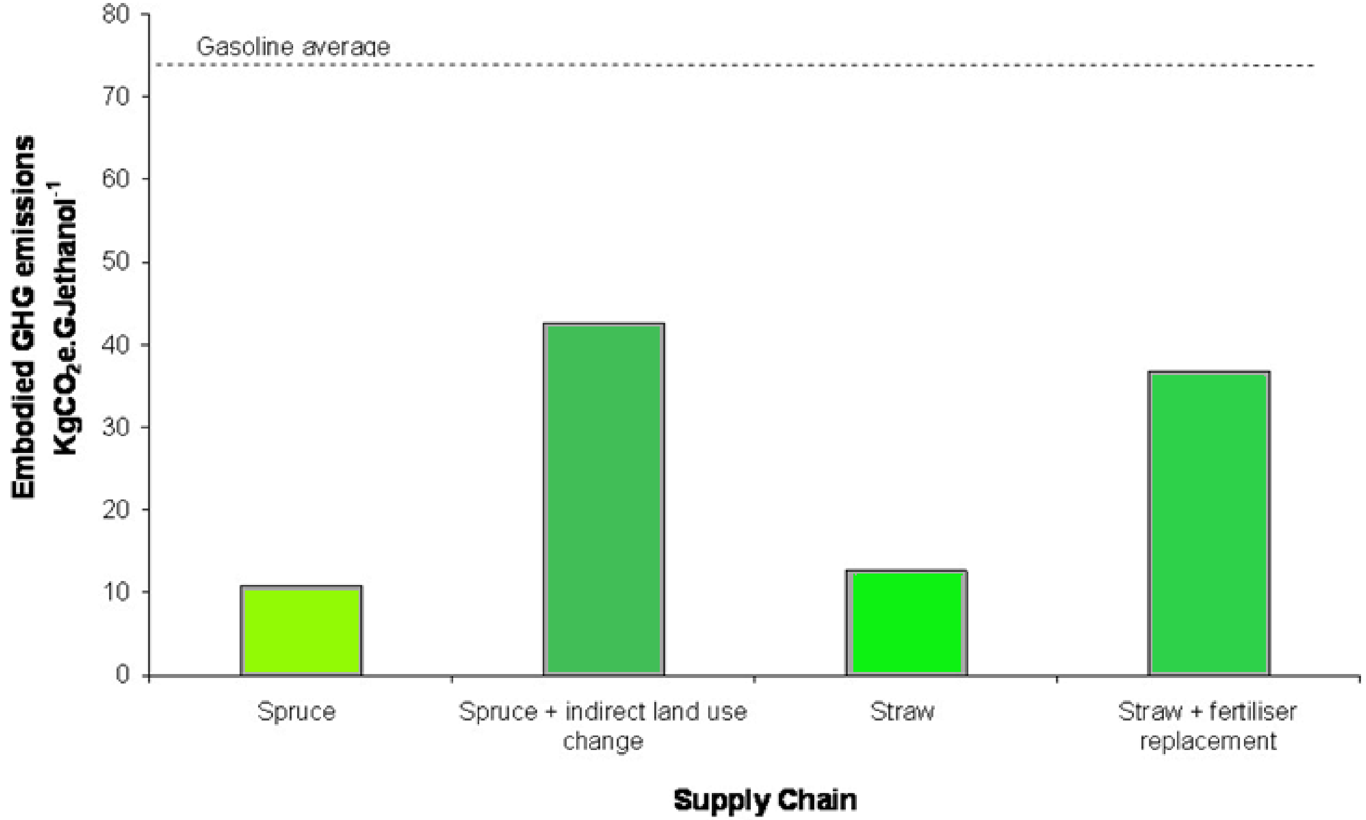


Note: Gross land demand, excluding land-use reduction potential of co-products

- Land requirements to produces biofuels increases from 30Mha to 100 Mha in 2050, in addition to 1 billion tons of residues.
- The world produces residue biomass that could be sustainably harvested and converted into nearly 1,2 Billion TOE/yr.

- The global potential from residue biomass is estimated to be approximately 1,9-2,3 Billion TOE/yr by mid- to late- century

Sustainability of liquid and gaseous biofuels. CO2 Emissions and Indirect Land Use Change

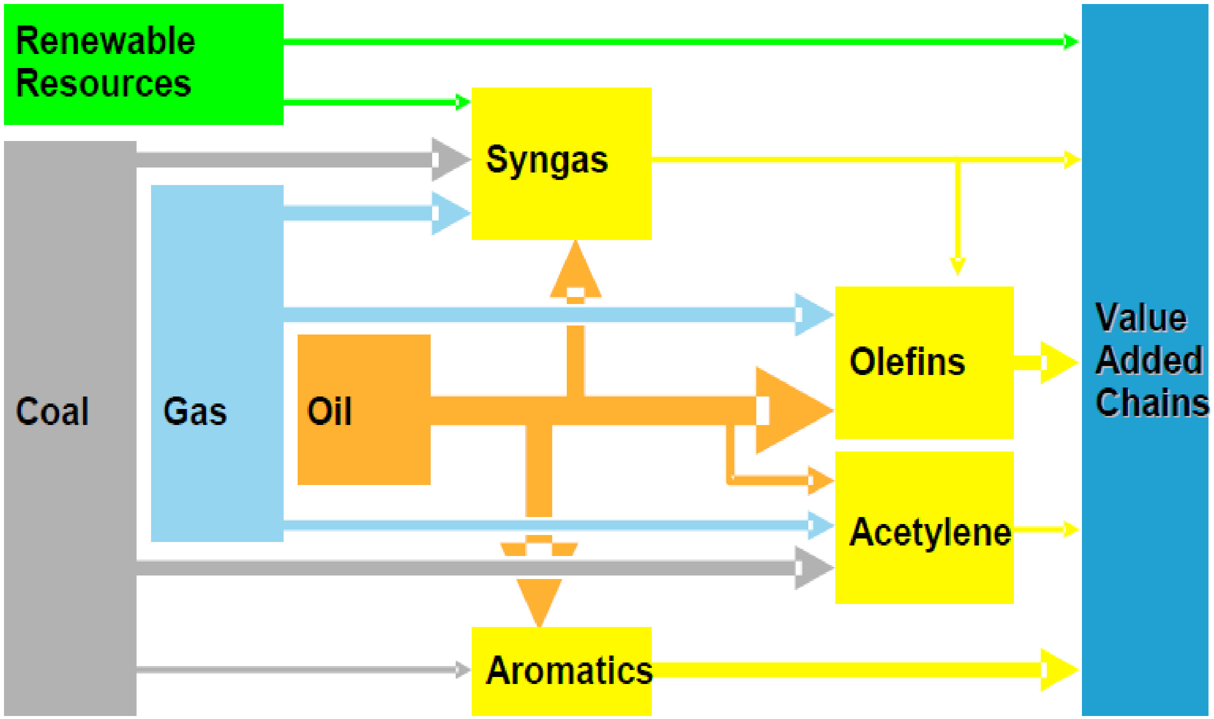


Greenhouse gas emissions for supply chains including consequential impacts (indirect land use change and fertilizer replacement). Source: Imperial College

BIOCHEMICALS AND BIOPLASTICS INDUSTRY.

An Emerging competitive Market for future biomass valorization

MAIN RAW MATERIALS USED FOR CHEMICALS PRODUCTION

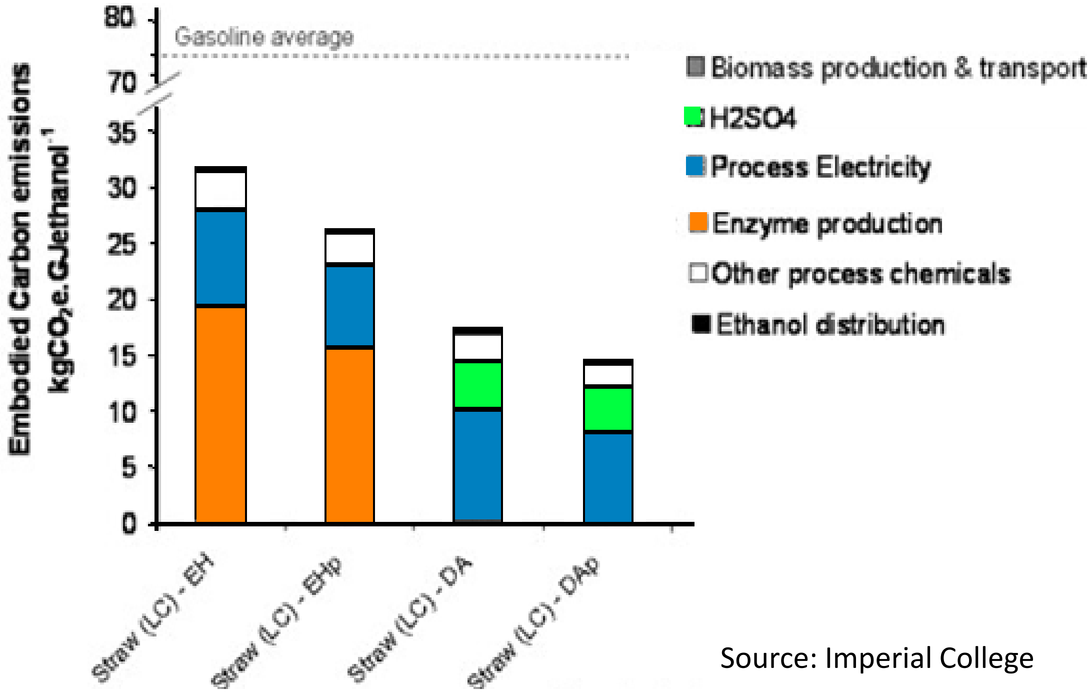


"Biomass is the only renewable carbon based feedstock to produce chemicals".

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 is expected to more than treble by 2020.

The concept of Biorefineries: Biofuels from lignocellulose and bio-based chemicals



Source: Imperial College

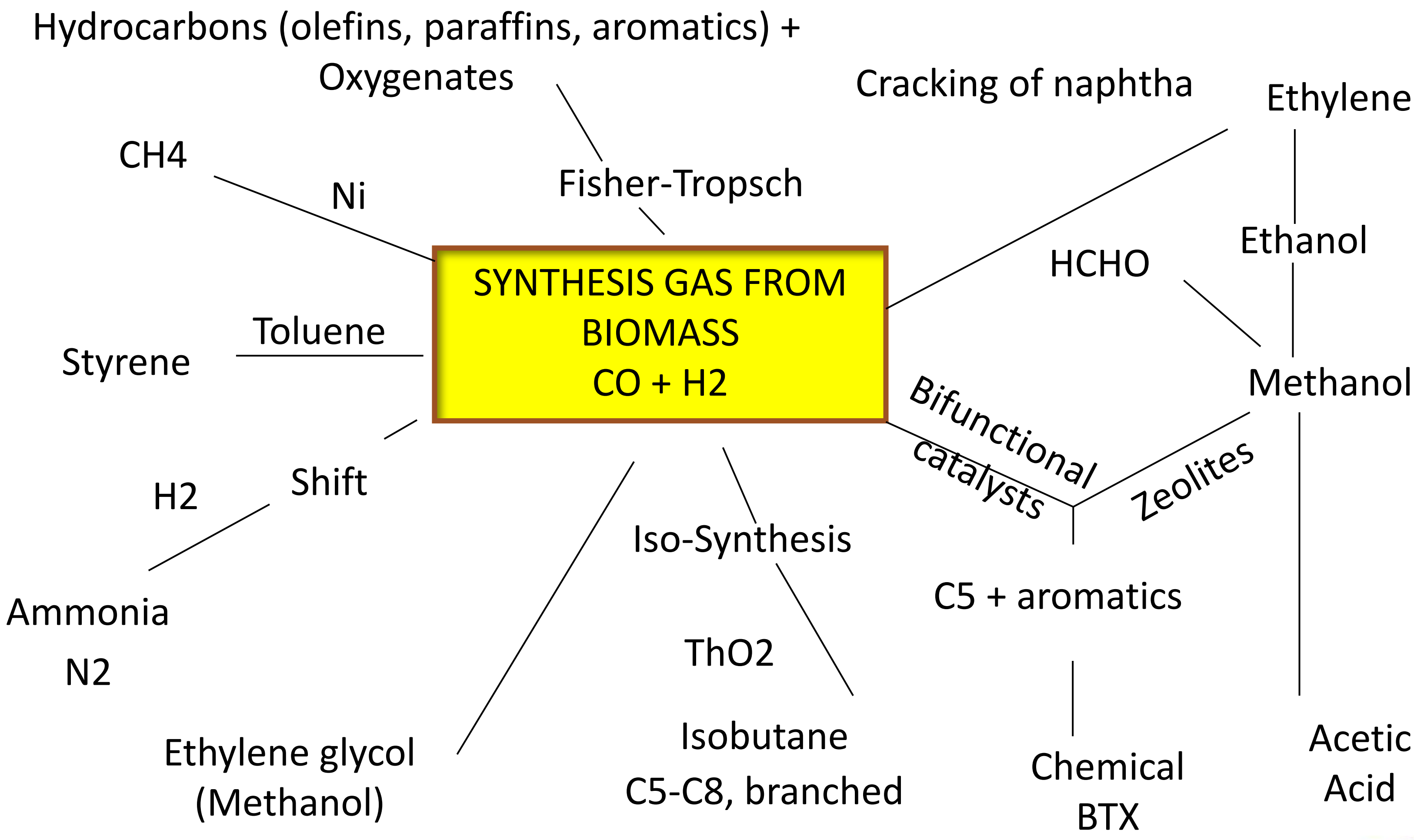
Large integrated Biorefineries represents the future of chemicals and energy production from Biomass, in order to avoid wastes, and to diversify the marketable products.

Two different approach can be identified:

- Energy based biorefinery (often thermochemical treatment)
- Biochemicals based biorefinery (often biochemical pretreatment).

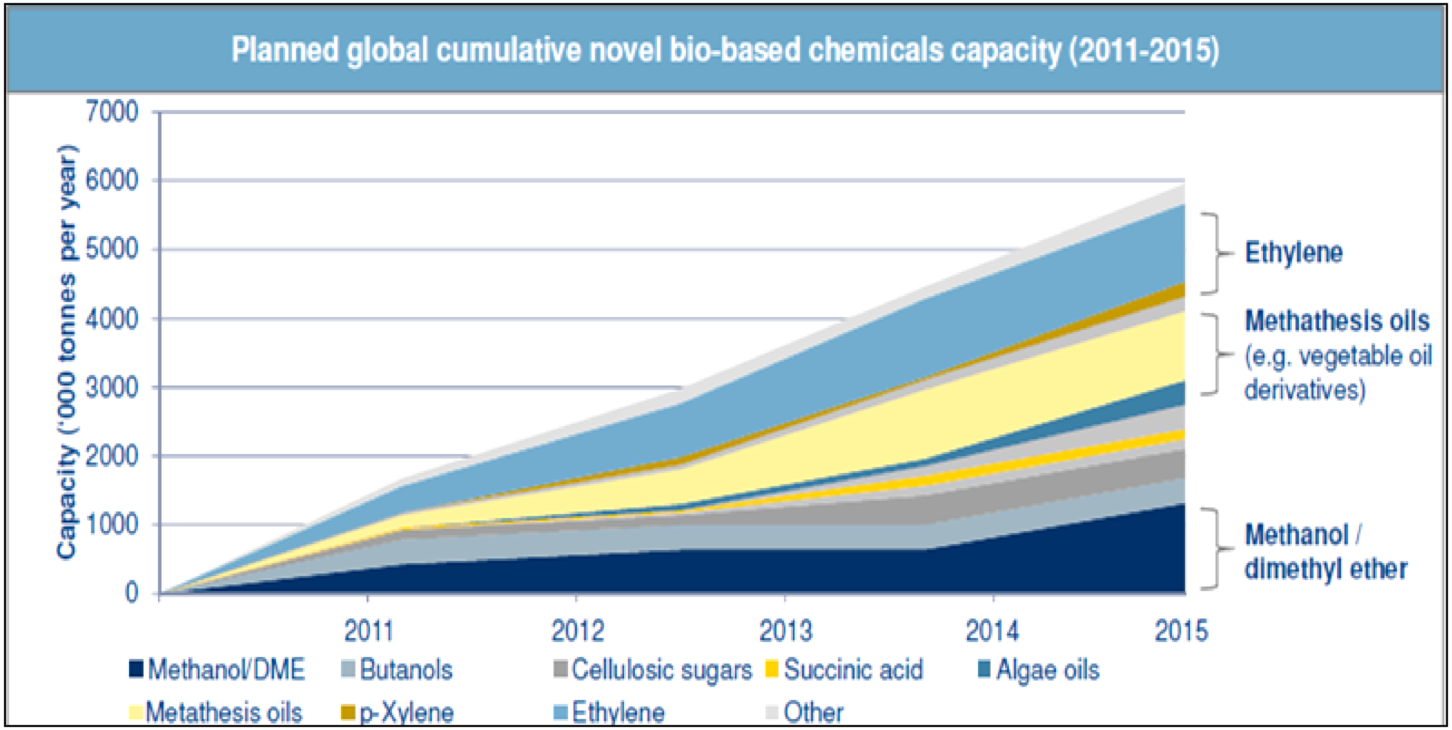
Biochemical biorefineries success is dependent by the advanced technologies for solid biomass fractionation (enzymatic, organosolv, steam explosion, Ammonia explosion, alkaline acid hydrolysis etc..). In addition, GHG emission contribution of Enzimes is a big part of advanced biofuels treatment

MAIN BIO-CHEMICALS FROM SYNTHESIS GAS



Biobased chemicals market perspective

From 2006 to 2011 bioplastic production grew by 1,500 percent to an aggregate capacity of 470,000 tons and a 10.9 percent share of all biobased materials.



Source: Phil Webster et al. A market overview on bio-based fuels and chemicals, 2012

Biobased chemicals and materials industry capacity is expected to double in market potential to $19.7 billion in 2016 as global manufacturing capacity increases by 140 percent. Lux Research, 2012.

Chemical production from biomass. Market opportunities.

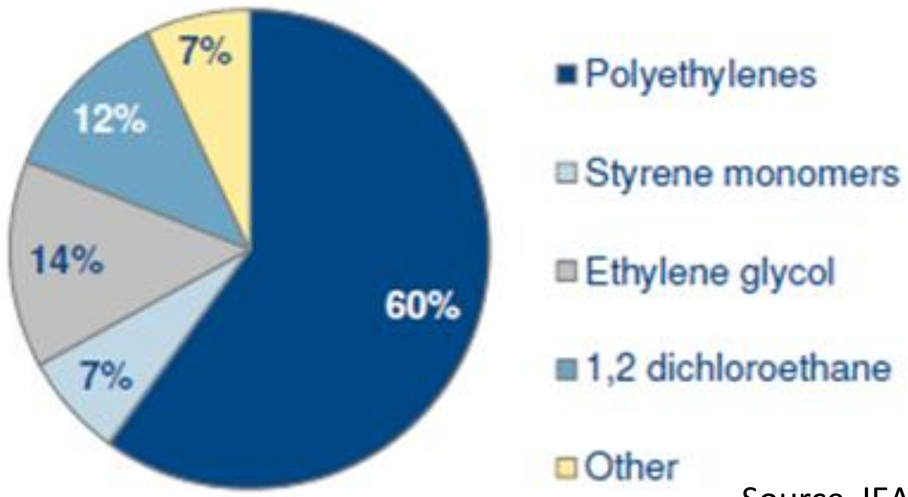
- According to the report, titled "Global Bio-based Chemical Capacity Springs to Scale," the global capacity for 17 major biobased materials doubled to 3.8 million tons this year. Over the next five years, capacity is expected to climb to 9.2 million tons.
- Glycerin and lactic acid accounted over two-thirds of the bio-based chemical market by value in 2011.
- By 2021 this market share will shrink to 53% as the emerging markets for bio-based polyethylene (PE) and epichlorohydrin (ECH) achieve 10-fold growth through the decade.

Bio-Based Chemical	Reference petrolchemicals
Ehyl lactate	Ethyl acetate
Ethylene	Ethylene
Adipic Acid	Adipic Acid
Acetic Acid	Acetic Acid
n-Butanol	n-Butanol
PTT	PTT & Nylon 6
PHA	HDPE
PLA	PET and PS
FDCA	Terephtalic acid
Succinc Acid	Maleic Anhydride

Biobased chemicals assessed for market penetration and reference materials

- SBI Energy expects the bio-based chemicals market to grow to $12.2 billion by 2021, accounting for 25.4 billion pounds of bio-based chemical production at the end of the decade.

The Bio-ethylene promising Market



Source, IEA

Bio-ethylene: Current derivates

Bioethylene processing system:

- Dehydratation of bioethanol using alumina catalyst
- Cracking of bionaptha from Fischer Tropsch process

Utilization as building block for bio-based polymers:

- Polyvinyl chloride from 1,2 dichloroethane
- Poly-ethylenes
- Polythylene terephthalate

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

A new intelligent and efficient biomass supply chain and sustainable valuable technologies will be the key solution for a future global sustainable biomass based market

Biomass environmental sustainability must represent a strenght of this renewable energy source and not a challenge

The Integration with other renewable energies and fossils is a core aspect for the next future development of bioenergy sector

Current bioenergy commercial technologies are more developed due to the easier approach and integration with old energy market (co-firing, waste anaerobic digestion, etc..)

Different bioenergy production technologies can become profitable and competitive depending on the world areas needs and available resources, both in OECD and non-OECD countries

Bioenergy and biochemicals market have grown at fast rate in last decades and, thanks to the needs of GHG mitigation and of new renewable energies, this sector is going to grow even more in the next years. Biomass market has still to show its potentials

THANK YOU FOR YOUR ATTENTION

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