Necessity of understanding the global energy system

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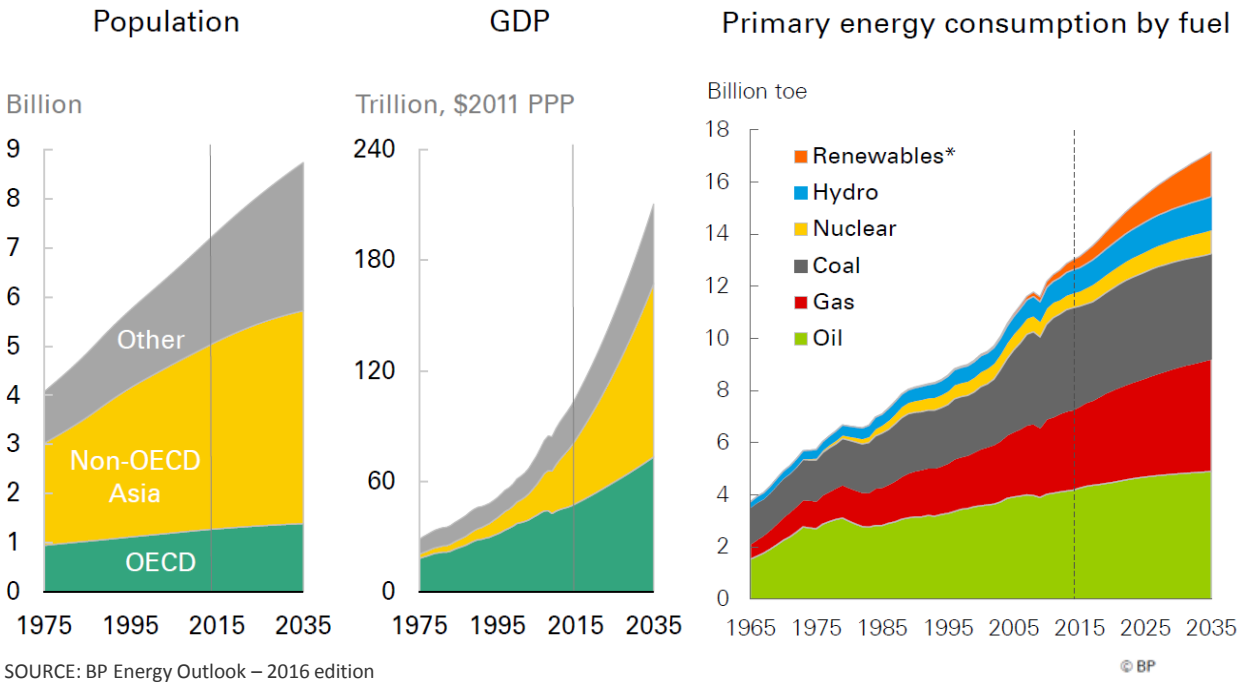
Gothenburg

The global energy challenge



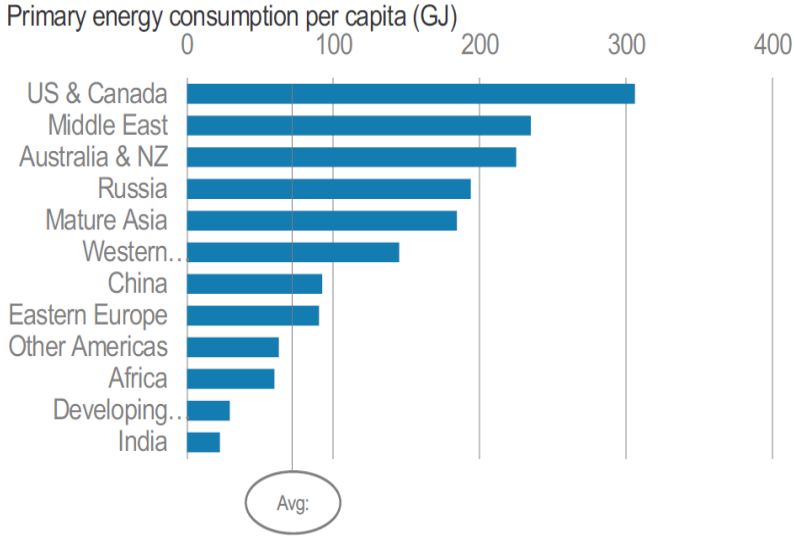
SOURCE: BP Energy Outlook – 2016 edition

	Energy Demand (Mtoe) Current Policies Scenario		
Fuel	**2020**	**2030**	**2040**
Coal	4 051	4 710	5 327
Oil	4 548	4 960	5 402
Gas	3 194	3 898	4 718
Nuclear	793	936	1 032
Hydro	375	450	515
Bioenergy	1 540	1 695	1 834
Other Renewable	319	535	809
Total	**14 819**	**17 183**	**19 636**

IEA: World Energy Outlook 2016

Population and GDP growth drive global energy demand

- Population increase and GDP development are the key drivers behind growing demand for energy
- World's population is expected to reach 9,2 billion by 2040, an increase of 1,9 billion vs. 2014
- Over the same period GDP is expected to more than double
- China and India alone would account for almost half of the increase in global GDP growth
- Africa is expected to account for nearly half of the population growth. However, it would account less than 10% of the global GDP growth



MORGAN STANLEY RESEARCH: **Download the complete report**

Oil & Gas: From Molecules to Electrons - What Energy Transition Means for Oil & Gas Investors - January 5, 2017 GMT (22 pgs/ 911 kb)

SOURCEs: World Energy Outlook 2016, Morgan Stanley

Model the global energy system . . .

Many decarbonization measures are costly but have negligible impact on global warming. Fundamental problem is often of the missing analysis and understanding how the measure really impacts the climate.

Often, the measures do not decrease the use of fossil energy on global level.

Most urgently, we need to model the global energy system in a way that would give us robust outcomes on the real impact on climate and on cost to society of any decarbonization measure.

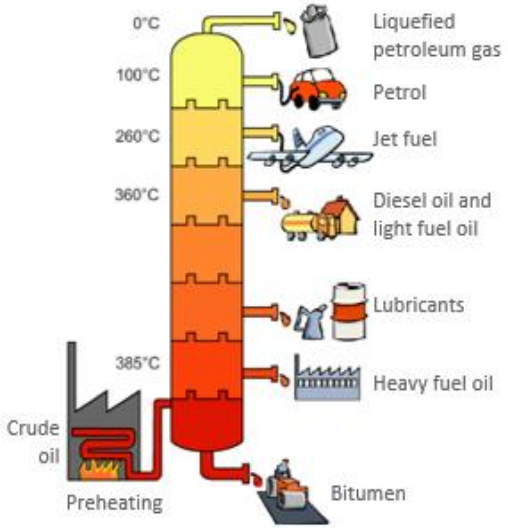
There are two major bottlenecks for decarbonizing the global energy system

1. Distillation curve challenge
2. Storing of the volatile renewable electricity to meet the peak loads is not economically feasible

Problem 1: The distillation curve challenge

Crude oil refining produces always the same product slate: light distillates, middle distillates, heavy distillates and residuum. E.g. if you produce Jet fuel, the process produces the other products as well

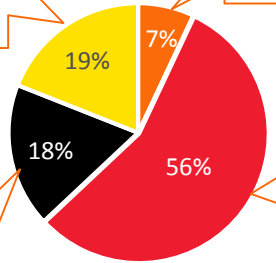
Crude oil product slate



How oil is used mb/d

Total other	19%
Power generation	6%
Buildings	8%
Agriculture and fishing	3%
Other	2%

Refinery losses and own use 7%



Total industry	18%
Petrochemical feedstock	12%
Steam and process heat	6%
Other industry	1%

Total transportation	56%
Road transport	43%
- personal light-duty vehicles	26%
- freight	18%
Aviation	6 %
Marine bunker	5%
Other	1%

Sources: Morgan Stanley Research, Petroleum & Biofuels Association Finland, Economic Information Office

Problem 2: Storing the electricity

Demand and supply always have to balance in the current electricity system

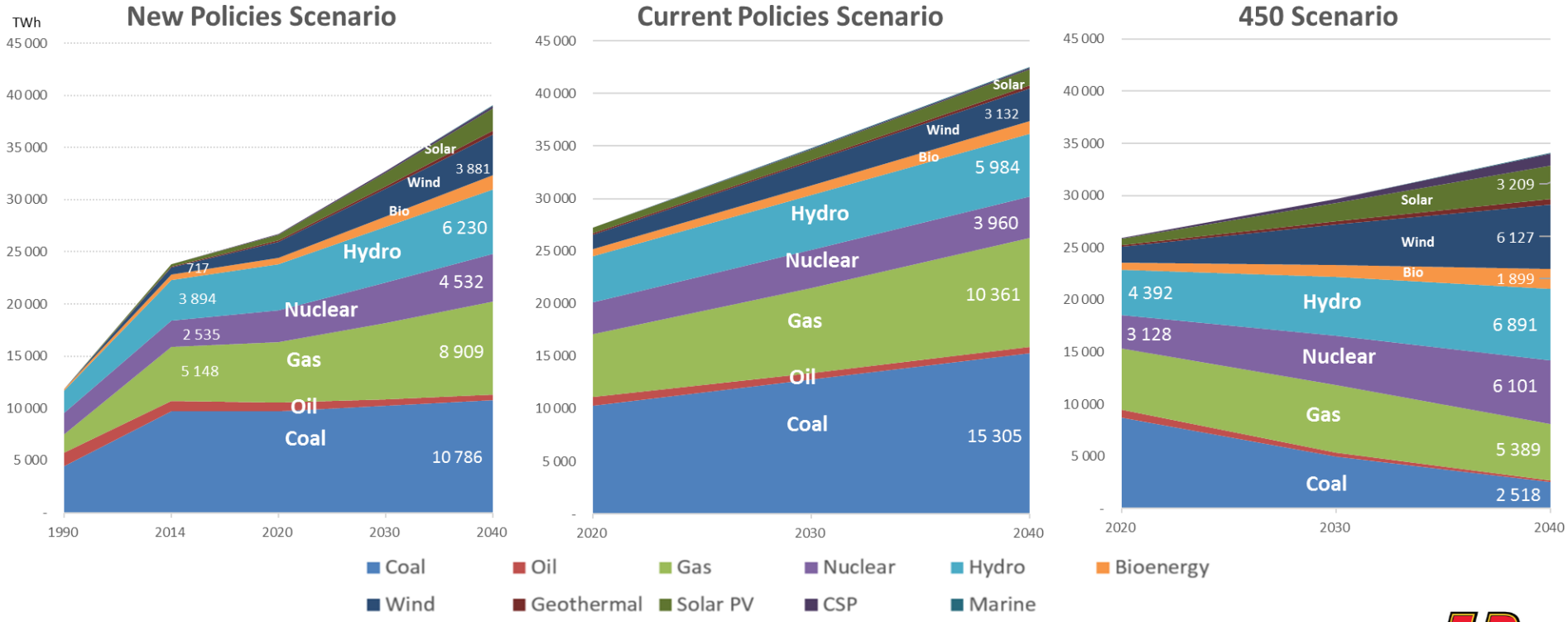
Volatility, unpredictability and the seasonality of the renewable electricity production creates a need for a feasible electricity storage solution. The problem is far from being solved

- Example: A battery capable of storing 1% of Sweden's annual electricity consumption (135 TWh) would cost € 1.350 billion.

It's not meaningful to structurally convert the global energy system towards increased electricity demand, because ca. 66% of the growth would be generated with fossil fuels *)

*) IEA World Energy Outlook 2016, Current Policies –scenario estimates that 34% (257TWh/a) of the annual global electricity demand growth (752TWh) could be generated with renewable energy by 2040

World Electricity generation outlook* . . .



* IEA, World Energy Outlook 2016

What should be done?

1. Model the global energy system, urgently.It would enable to analyse the impact and the societal cost of decarbonisation measures, at the global level.
2. Significantly step up the R&D efforts aiming to solve and remove the major bottlenecks of the global energy system, ie. distillation curve challenge and the problem of electricitys storing.
3. Mandate to energy companies to reduce the use of fossil energy. Listed companies would get a business motivation to increase efforts to find sustainable renewable energy solutions.
4. Reforest deserted areas into fertile arable land with the help solar power, i.e. globally deploy the agro-forest concpet at the large scale. And enable companies to fullfil their GHG reduction obligations by deploying agro-forest concept in a verified and audited way.
5. Influence consumer behavior through regulation aimed at supply. E.g. new personnel vehicles should be designed to a maximum speed of 120-130 km/h, that is the typical maximum speed limit in many countries. Forbid short flight (eg. <1h) if there a rail connection exists.
6. Improve the social standing of women in the developing countries. It would be the most significant measure in the long run to fight several global scale problems.

Addressing the problems with Agro-forest & Biocrude

Increasing and uncontrolled migration due to population growth and worsening living conditions

- Desertification, erosion, aridity and wars are causing immense human catastrophes and misery. Phenomena are accelerated or triggered by global warming.
- In Africa the population grows with 20 million per year and is expected to double during the next 25 year.
- Pressure for migration to EU and other developed countries is constantly increasing with no solution in sight.

Global warming

- To stay below the level of 2 degree Carbon Storage and Capture (CCS) is required, in addition to significant increase of renewable energy. Problems of the CCS have not been solved.
- Carbon sequestration into biomass is widely accepted as one key solution. But, it lacks a global economical model to put it practice.

Bottlenecks of the decarbonization through renewable energy

- Sustainably available biomass is limited to replace enough crude oil and other fossil fuels.
- At the global scale sufficient electricity storage solutions do not yet exist, today nor in the foreseeable future.

Agro-forest & Biocrude in nutshell

Energy

Energy is collected from the sun by concentrating solar radiation with a solar field

The variation of the solar irradiance is compensated with power generation of harvesting residue biomass from the plantation

Water

Seawater is desalinated by using solar energy for human consumption and irrigation

Food

Food crops is grown in the shade of tree canopy

Biomass

Eucalyptus is grown for liquid biofuel production. First harvest 10 years after planting the trees

Annual biomass growth captures and stores CO_2 from air

Bioproducts

Biocrude to replace crude oil

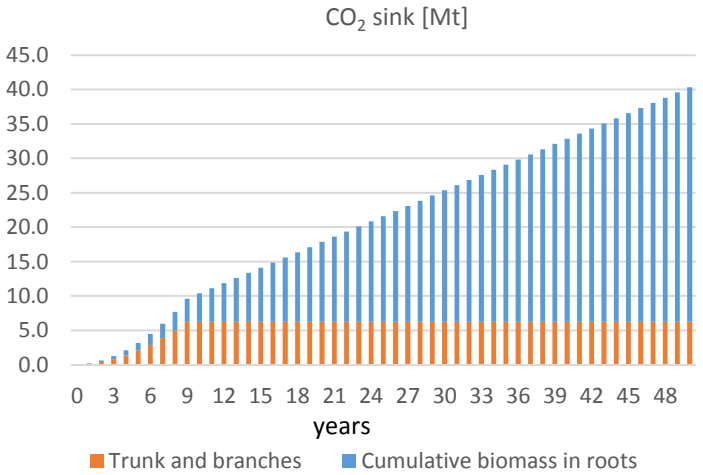
Biocarbon

Carbon sinks

Branches 15%

Trunk 50%

Roots 35%



The power of sun

Just 1 km^2 of desert

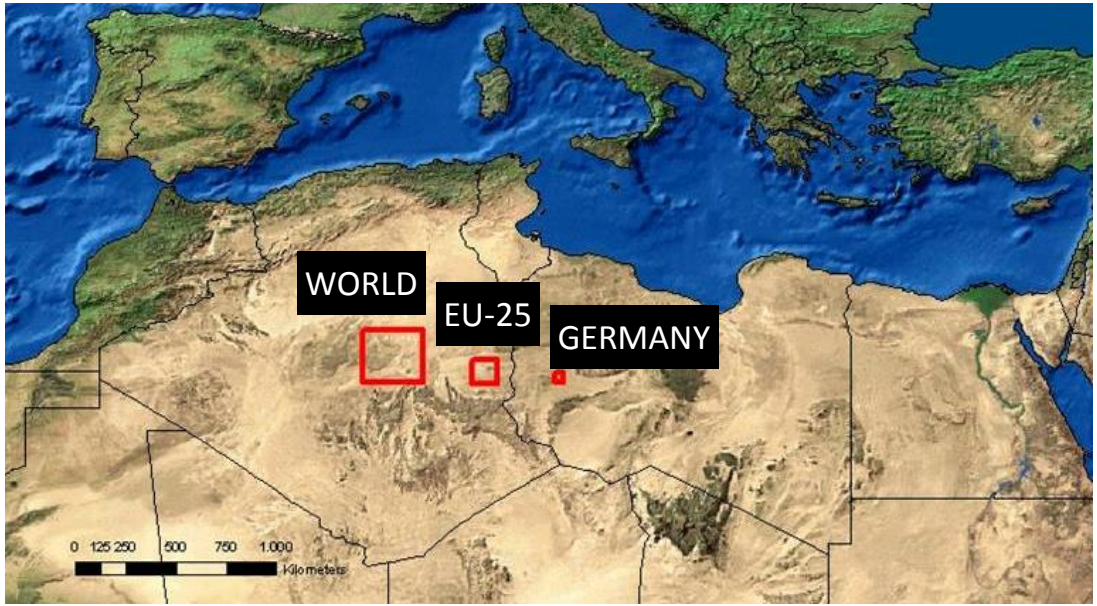
PRODUCES
200 - 300
GWh/a
Electricity

EQUALS
50 MW
coal or gas
plant

ABATES
200.000
tons of
CO_2/a

REPLACES
79.500.000
liters of oil
annually

PRODUCES
165.000
m^3/d
fresh water



Area required by Concetrated Solar Power to supply power to mentioned region

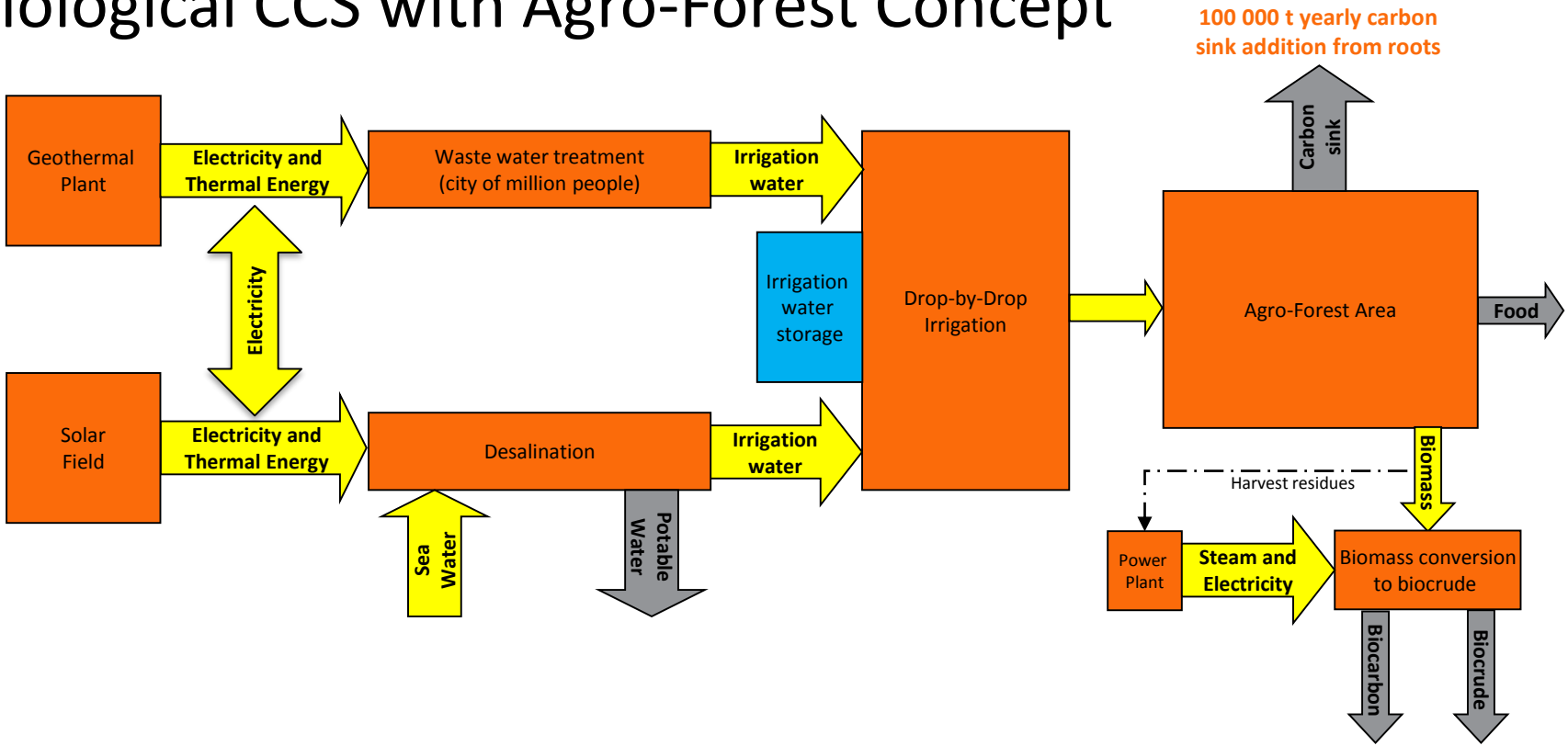
Food Production is the Key Element of Success

Agro-forestry:

- Food, living and hope for the better future could be created in areas where it does not exist today. Fights the root causes of the poverty, famine and global migration.
- Carbon would be sequestrated from the atmosphere.
- Captures and stores solar energy in high potential areas, but with marginal demand. And allows it to be used in other format (liquid fuels) in a market where it's needed (transport).
- Rehabilitates the soil that are being considered as "lost forever".
- Can be freely disseminated globally w/o any IP rights.
- **Lacks the business motivation to attract the investments.**

Background

Biological CCS with Agro-Forest Concept



Opportunities of Agro-Silviculture

Irrigation of deserted land could provide opportunities for inter-cropping agricultural crops and plantation forest in the same areas.

There are significant social benefits when adopting agro-silvicultural land use regimes.

Typical production yields can reach 4 t/ha/a of agricultural crops such as barley or corn, depending on management regime

Examples of inter-cropping practises

Production of Eucalyptus Wood and Barley

Production of Eucalyptus Wood and Corn

*The report (**China's fight to halt tree cover loss**) also looks at global trends: the researchers found that roughly half of the world's forest cover has been lost over the past 10,000 years, and that tree cover is being lost in low-income countries at the rate of around 25 000km² per year.*

http://rspb.royalsocietypublishing.org/content/284/1854/20162559

Money can convert a desert into paradise . . .

HIGH SEASON FROM
£179.00

GOLF DAYS FROM
£POA

AVAILABLE
MEMBERSHIP

Emirates Golf Club Majlis Course
Dubai, UAE

Lähde: http://www.ispygolf.com/golf-courses?region=Dubai&gclid=EAIaIQobChMIxauw-vi11QIVDSjTCh3IdgCBEAAYAiAAEgJSsPD_BwE

Full Credit of Carbon Sequestred from year 1 onwards is imperative

Energy crops – woody, oil seeds or grassy – grown on deserted or degraded land needs to eligble feedstock for advanced biofuels

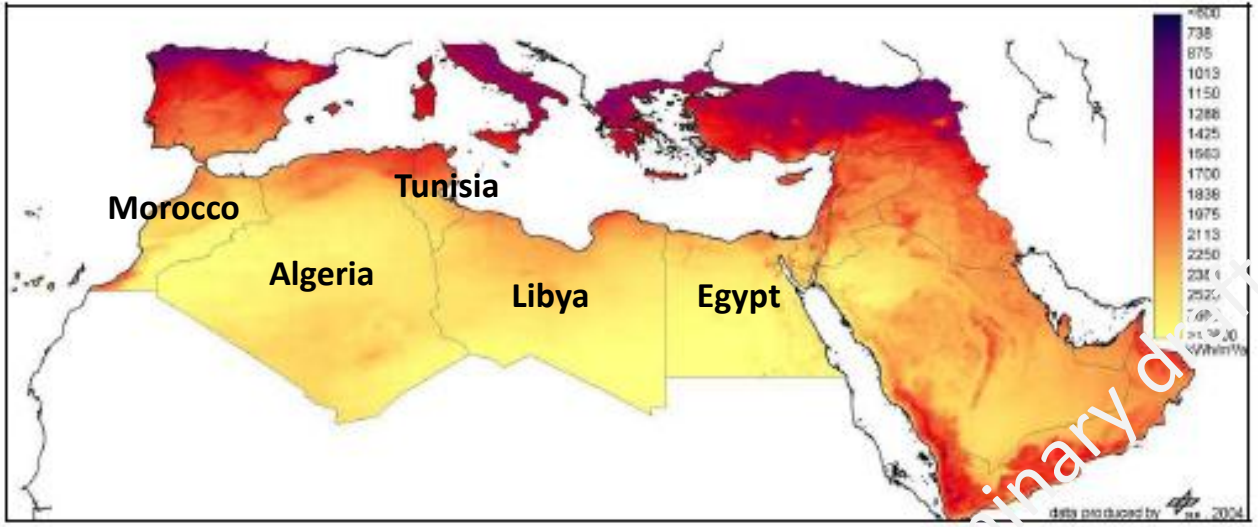
Positive cash flow from year 1 is needed to create the investment case

- An obligated party (oil company) should be allowed to fulfill it's annual obligation (GHG reduction or energy based mandate) through the carbon sequestration corresponding to the required amount of carbon abatement of physical biofuels blending during the target period (most often calendar year).
- Flexibility should be allowed to use the stored carbon during target period or to accumulate it over the years to be used when appropriate.
- Sequestered carbon (above ground and underground) needs to fully credited for in the GHG calculation of advanced biofuels.
- Eg. If the rotation period of the wood is 10 years, the carbon sequestration during the period of 1-10 years could be used to fulfill the obligation. From year 11 onwards the advanced biofuels would be used physically in transport to fulfill obligation. And it should be possible also to use a combination of carbon sequestered and advanced biofuels physically used in transport.

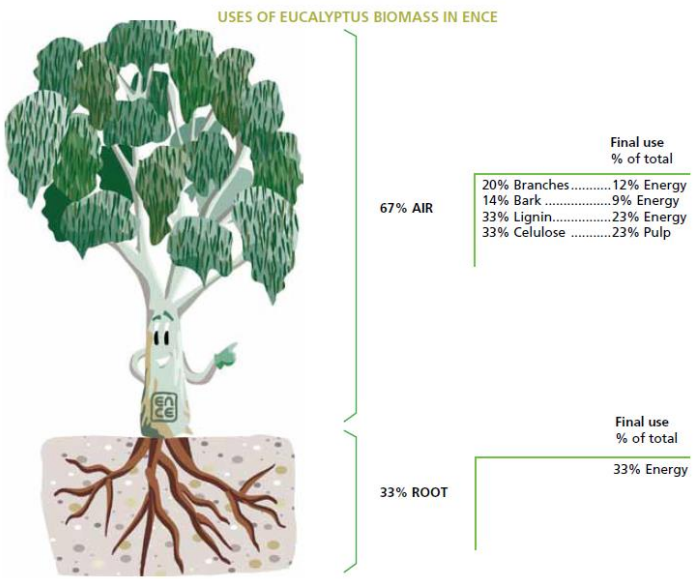
The amount of carbon sequestered should be verified and audited on annual basis through real-time satellite survellaince which give extremely precise and reliable data.

When such advanced biofuels is used (tank to wheel), the physical carbon released to atmosphere is considered to constitute 0 g CO_2/MJ

Potential Target Area



Eucalyptus Trees



Fast growing Eucalyptus trees are planted in tree plantations in Asia, Australia, Europe and the United States for fuel wood, poles, timber, lumber, biomass, essential oil and are an excellent source of nectar for honeybees.

Native to Australia, Eucalyptus trees are grown both by small farmers for profit and subsistence and by large conglomerates for industrial wood supply. Certain species of eucalyptus yield valuable essential oils, whilst some also provide an excellent source of nectar for honeybees. An estimated 50 million hectares of eucalyptus have been planted worldwide.

Eucalyptus trees have many favorable characteristics including high growth rates, wide adaptability to soils and climate, seed availability and ease of managing due to the coppicing ability of many species.

Eucalyptus can often produce utilizable wood products generally faster than any other species averaging 6 to 10 feet of vertical growth per year.

https://www.ence.es/pdf/Eucalyptus.pdf, page 59

https://www.treeplantation.com/eucalyptus.html

Starting A Eucalyptus Tree Plantation

A Eucalyptus timber plantation requires high-density planting (about 1,000 trees per acre → about 2,500 trees per hectare).

High density planting forces rapid terminal top growth and natural branch pruning in the field. Assuming the plantation was started with 12-inch eucalyptus seedlings, a first thinning of every second tree should commence in year 5 or 6 when Eucalyptus saplings are 10 feet or more in height. A second and final thinning should be preformed in year 15.

A Eucalyptus biomass plantation requires the same high-density planting pattern as the Eucalyptus timber plantation. To maximize biomass volume, no thing is required during the life of the plantation. Harvesting should occur year 10. Because Eucalyptus regenerates from cut stumps, harvesting and re-harvesting occurs in 8 year cycles.

A cut Eucalyptus tree will grow new Eucalyptus trees from the stump. Good Eucalyptus stump regeneration depends on the tree having a good supply of buds beneath the bark.

https://www.treeplantation.com/eucalyptus.html

Eucalyptus Tree Facts and Cost Estimations

- Eucalyptus trees are the world's most widely planted hardwood species
- The Eucalyptus tree is prized globally for excellence in paper and energy production
- Eucalyptus trees grow faster than most hardwood species
- Eucalyptus trees will grow on upland landscapes, reducing pressure on environmentally sensitive areas
- Eucalyptus trees grows commercially with similar inputs to Pine
- Eucalyptus trees produce feedstock for fiber and energy in short rotations

Seedlings costs range between $25 and $100 per thousand and should preferably be cloned hybrids.

Total capital expenditure including fertilization, land costs, irrigation, seedlings, site preparation, weed mitigation and labor average between $1,000 and $3,000 per acre.

Total revenue before expenses may average between $5,000 and $10,000 per acre depending on market conditions, wood quality, wood use and location.

https://www.treeplantation.com/eucalyptus.html

Water Consumption of Eucalyptus Compared with Other Wood Species

Species	Water consumed (litres/ yr)	Biomass Produced				Total Biomass produced per litre of Water (g / litre)	Water Consumed per g of biomass (litres /g)
		Shoots	Roots	Leaves	Total		
		(g / yr)					
Acacia auriculiformis	1231.50	1023.5	361.6	327.9	1713.0	1.39	0.72
Albizzia lebbek	1283.90	1132.4	1085.6	136.8	2354.8	1.83	0.55
Dalbergia sissoo	1534.05	1129.3	775.5	99.77	2004.5	1.31	0.77
Eucalyptus hybrid	2526.35	2519.0	2094.3	594.9	5209.0	2.06	0.48

http://www.kenyaforestservice.org/documents/Eucalyptus%20guidelines%20%20Final%202.pdf
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Case: CO_2 Reduction in Uruguay

Estimation of eucalyptus forest plantations carbon sequestration potential in Uruguay with the CO2fix model

The results of this study show that currently the 707,674 hectares of eucalyptus plantations in Uruguay have the potential to sequester 65 million tonnes of carbon and reduce 238 million tonnes of CO2.

The implications of the results are that eucalyptus plantations in Uruguay actually enhance carbon sequestration, are carbon sinks and store more carbon than grassland and abandoned pasture land. Plantations have a vast sequestration potential and are important in mitigating of CO2 emission and effects of the climate change. The findings endorse the significance of plantations to increase carbon sinks and this role will broaden in the future.

https://helda.helsinki.fi/handle/10138/135575