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Production of biomass for food and energy

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ABSTRACT: There exists already a considerable market for many biomass based products (food, coffee, cotton, wood, paper, energy (pellets), etc). This paper analyses the possibilities of partly solving several global problems like poverty in mainly rural areas and problems linked to the world energy supply by an increased use of biomass; this without jeopardizing the world food supply. Energy crops will influence the prices of the present market of crops. Prices of, for instance, coffee or cotton will increase. Higher prices create room for investment (e.g. fertilizer) and this way yields will go up and less land is needed. So the future market will be determined by two main products: energy crops and crops for other purposes. A choice has to be made: producing crops for energy or for other purposes. In this paper this is called a *"two products philosophy"*. All farmers and agro-business companies will benefit from this development. However, this promise holds especially for Developing Countries; Brazil is a convincing example. Of course in practise the two products are often combined; both products will for instance be produced during the processing of biomass. These possibilities are elaborated in bio refinery concepts. The environment will also benefit from this development. There is a central role for governments and international organisations to guide this development in a sustainable way; a stimulating policy is needed. Otherwise, it will not lead to a socially sustainable development with poverty elevation. As examples of new energy products entering the market, two developments are described: the production of Fischer-Tropsch oil and bio oil from Jatropha. It is concluded that the evolving energy market creates a complete new, stimulating situation for the production of crops, both in Industrialized and Developing Countries.
Keywords: biomass production, developing countries, market implementation

1 INTRODUCTION

Biomass is traded on a global and local scale for food (e.g. wheat, maize, rice, vegetables, fruit and meat), other applications (e.g. wood for paper and building materials, cotton and flowers) and energy (e.g. charcoal, waste materials, wood, ethanol, and bio diesel). However, a new way of thinking about the production of biomass for food and energy is emerging because of several serious global problems. Concerning the food supply, there is an over-production of crops. In general, due to this over-production, in all countries the market prices for many crops like coffee and cotton, for instance, are low. Farmers in developing countries only survive by accepting the very low prices, but live in poverty. In rich countries farmers survive by subsidies. The expectations are that this over-production might even be aggravated by the tendency to produce more per ha. The potential of the increase of production is enormous because the present production in many -mostly Developing- countries is still low. Concerning energy, there are strong driving forces to change our present energy supply into a sustainable one, based on renewable energy sources and efficient use of energy [1, 2]. Most important forces are:

1. Interdependence and vulnerability of the oil and gas supply; need for security of supply.

2. Climate change (CO_2); need for considerable reduction of emissions.
3. Regional or rural development; need for new economic activities.

These forces form the basis for policies to increase the use of biomass.
Now the main question in this article is: to what extent can an increase in the use of biomass be part of the solution of these problems without jeopardising the food supply. To give an answer to this question, the following aspects are considered.

- What does a higher production of biomass mean for market prices and can the land, which becomes vacant by increased agricultural yields, be used for the production of energy crops?
- What is the potential for energy crops?
- What does it mean for poverty reduction?
- What does it mean for local and global markets?
- Can the increase be implemented in a sustainable way?
- What are the policy implications to realize such a change?

As an illustration two examples are presented at the end of the article.

2 TWO PRODUCTS PHILOSOPHY

A conscious choice for two main areas of important market products of biomass, food and energy, with all its implications is called the “Two products philosophy”. Several aspects concerning this philosophy will be dealt with.

2.1 Higher biomass production and the energy market

In several countries production of crops increased in an impressive way after the Second World War. Temporary market protection was always part of this development. This way, farmers were ensured of an income for some time and had an incentive to gather capital for necessary investments. Consequence was an intensive agriculture system which led to over-production and lower prices. However, in many countries the production is still low; this holds especially for Developing Countries.
Suppose there is capital available and this capital is used for investments in the agricultural sector (e.g. for fertilizer). The production can go up to levels similar to these of Western Europe or North America. So with higher yields and without over-production a lot of land becomes available. This land can be used for the production of biomass for energy purposes [3, 4].
Because of competition between the two markets, the prices will go up. Higher prices create capital needed for the investments and create extra welfare at the same time. Brazil is a well known example of this development: a choice has to be made between the production of sugar or ethanol depending on world market prices of these two products. Mozambique is given as an example of the possibilities for a developing country [5]. The yield of crops in Mozambique is very low and is about 0.7 ton (dm)/ha.y. An increase to 13 ton must be possible [5]. However, for the calculations an increase to 7 ton has been taken. In this last mentioned number all aspects concerning sustainability are taken into account. If the land, which becomes vacant, is used for energy crops, than the total energy content of the biomass produced is about 6.5 EJ. If this biomass is converted in the country into, for instance, Fischer-Tropsch liquids, than the market value is about € 80 billion. This means an increase in the GNP of a factor 2 to 3. The increase creates many new economic activities, so the real influence on the GNP will be even more.
An important issue is the way the extra income is spread. In the first place farmers in rural areas in mainly Developing Countries will make the most of it. They come in a stronger

position and there is more room for negotiations to obtain better prices for their crops. In the second place the agro-business companies will take advantage. However, an important question still rests: will all people, especially the poor, benefit from this development?

2.2 The potential

Mozambique has been taken as an example, but what does it mean for the potential on a global scale? In Table 1 a survey is given, based on [3, 4]; the numbers are rounded off. In these numbers the increase of agricultural yield, the use of wastes and the production of biomass on degraded land are incorporated. The range in the numbers is caused by the policy executed. The most stimulating policy gives the highest numbers and without any policy the lowest numbers will hold. So the governmental support for the market development determines the final result

Table 1. Biomass potential in EJ for several regions. The range is determined by the degree of applied, stimulating policy measures [14].

	potential (EJ) in case of minimum measures	potential (EJ) in case of few measures	potential (EJ) in case of more measures	potential (EJ) in case of maximum measures
Europe	1	20	50	60
Russia	2	70	110	140
E. Asia	10	20	180	220
S.E. Asia	30	80	120	150
Africa	40	150	360	450
N. America	4	30	110	140
S. America	50	180	250	310
Total	140	550	1180	1470

The numbers can even go up if forests, originating from reforestation programs, are partly used for the energy supply. In [6] a range of 200-400 EJ is given. All these numbers are still without the potential of using the cultivation of algae in desserts or in the ocean. So, a final global potential lies in the range of 1000 to 2000 EJ. With a world market price of € 4/GJ this means a value of € 4000 to € 8000 billion.

2.3 Poverty reduction

During the U.N. conference in Johannesburg (September 2002), about Sustainable Development, agreements have been made and tied up in the so called World Summit on Sustainable Development (WSSD) “Plan of Implementation”. For energy the agreement means that in 2015 the number of people that has no access to reliable, clean and affordable energy must be halved. The total amount of people that lack access to such a supply today lies between 2 and 3 billion. One way to generate energy for the poor people is by use of biomass. In this case the energy supply can be directly combined with income generation to reduce poverty. There are several concepts for the local production of energy, based on biomass, by which income for the poor people can be generated. In this article the use of Jatropha is given as an example for the production of bio fuels [7, 8]. However, one can also combine reforestation with the production of charcoal [9] or by using pigs for the production of meat and bio diesel from their fat [10]. Other possibilities are the local production of bamboo or miscanthus (elephant grass). Poverty reduction can of course also be realised by the overall

increase of GNP in a country. However, as we questioned before, will the poor directly benefit this way?
Another important aspect is the saved foreign currency because the energy is now produced within the country. This money can be used for other purposes.

2.4 Local and global markets

For hundreds of years food and energy (wood) were mainly produced and used on a local scale. The use of fossil fuels changed of course this pattern; only in several Developing Countries biomass is still the most important energy source on a local scale. If biomass is getting again a central role in the world energy supply then on the one hand there will be a new emphasis on the local use of biomass, but on the other hand the global trade will expand. In the present situation it is difficult to predict which tendency will be decisive.

2.5 Sustainability

Sustainability has been taken as a prerequisite for the increased use of biomass. In the context of this article sustainable means: economy, environment and social development are in balance or integrated. Sometimes this is referred to as: profit, planet, people. Concerning the social development only poverty elevation is mentioned as part of a development in which welfare and wellbeing are optimised.
It is very difficult to give a detailed picture of the economical consequences of the increased use of biomass. Local circumstances may influence the market price of biomass drastically because of, for instance, different currencies, subsidies, monopoly position of companies, and logistics. However, it is expected that the biomass will be traded on a global scale for a full grown market, for € 4 to € 5/GJ [11]. This number has to be compared with about € 8 to 9/GJ for oil and about € 2/GJ for coal (2007); in these numbers no environmental cost is included.
For the environmental aspects, the reduction of greenhouse gas emissions (mainly CO_2) and the relation with bio diversity are taken as important issues connected to an increased use of biomass. The reduction of greenhouse gas emissions is determined by the use of the amount of fossil fuels in the whole production chain; a low amount of the use of these fuels means a higher reduction. A recent study shows a reduction for the production of ethanol and bio diesel from respectively corn and soybean of 40 %, for reed canary grass 85 % and for switchgrass and hybrid poplar of 115 % [12]. A reduction of more than 100% is possible because part of the carbon is fixed in the soil. This example shows that there are great differences and energy balances help choosing the most optimal crop.
Biodiversity can be preserved or restored. Often new crops have to be selected and a mixture of (native) plants may be needed. An example is the replacement of the monoculture corn by a mixture of prairie plant species in the United States [13]. The yield may go up with more than 200 %. This possibility is strongly supported by the National Wildlife Federation [14]. Other examples are connected to reforestation in, for instance, Kenya [9] or the recovery of degraded land in India [15]. These positive examples don't mean that all activities are sustainable. The destruction of many tropical forests for the production of palm oil is of course a very negative example.

2.6 Policy

Most of the aspects mentioned in this article are strongly influenced by policy and the choice of policy instruments. This holds for the policy of local as well as for governmental and international institutions. The severe problems mentioned have already led to many initiatives. For instance, the EU has made regulations for the introduction of "green" liquids: 2 % in 2005, 5.75 % in 2010 and 10% in 2020 of total use of transportation liquids. Several countries have set even higher targets. Sweden is a forerunner: its aim is to have zero consumption of

fossil oil in 2020. So a market is created for the introduction of bio fuels. Another example is Brazil. It developed its ethanol program quite isolated from the rest of the world. There was a strong incentive to become independent of the foreign oil supply and Brazil created a fuel supply of its own. Afterwards ethanol became an export product. Recently 14 West African countries stated that they will become the Bio-OPEC of the world.
Though many initiatives are taken, a lot more is needed to realize a real large biomass based energy market. In this respect is the often pushed development to a “free market” a very negative development. Especially the poor, mainly African countries need a protected situation to develop their agricultural systems for food and energy. As mentioned, other countries have also passed through such a development.
Special policy is needed for support for the poor people. They are very vulnerable. In many countries there is a tendency for large scale plantations without really considering the position of the poor. Only on a governmental level guarantees for poor people can be incorporated in a well balanced policy.
Another important area is the need for an intensive R&D program. Though biomass conversion systems are already well developed, in many areas spectacular improvements are possible. This research has to be directed to the agricultural system as well as the many conversion systems. Also the concept of a bio refinery needs special attention [16].

3 NEW DEVELOPMENTS

Apart from the above mentioned tradable forms of biomass, new ones are coming onto the market. Two examples are given in the field of bio fuels [17]. The first one concerns the production of liquids using the Fischer-Tropsch process. This is an example of a large scale system for which transport of biomass over long distances is necessary. The second one is the production of bio diesel from the plant Jatropha. It is an option which is especially suited for the local production of diesel in rural areas in Developing Countries.

3.1 Fischer-Tropsch oil (diesel) [11, 18, 19]

The Fischer-Tropsch (F-T) process is well known and already applied on a large scale by, for instance, Shell in Malaysia (based on natural gas) and by SASOL in South Africa (based on coal and natural gas) [1, 2]. Both companies start new plants in Qatar using natural gas.
For biomass, the process is demonstrated only on a laboratory scale. The feeding material (coal, natural gas or biomass) is first gasified. Synthesis gas is formed (a mixture of CO and H_2). This gas is converted to C_nH_{2n+2} by using a catalyst. The F-T process is operating at temperatures between 200 and 300 ºC and pressures between 10 and 50 bar. It is an exothermic process and about 20% of the energy content of the converted gas is released in the form of heat.
There are two main concepts for the production of the F-T liquids. In the first concept, the F-T reactor is placed between the compressor and a STAG (STeam And Gasturbine). The syn-gas passes the F-T reactor once. As the gases pass the reactor only once, it is a "once through process". Because F-T liquids as well as electricity and heat are produced, the whole is called tri or poly generation. Between 40 to 60 % of the gas will be converted into a liquid fuel and the rest is fed into the gas turbine for the production of electricity. In the second concept only (or mainly) liquids are produced. In this case the gases must be recycled after the F-T unit. This concept is more complicated and is, for this reason, more expensive.
The chemical equations for the F-T production of liquids and gases are:

$(2n+1)\ H_2 + nCO \rightarrow C_nH_{2n+2} + nH_2O$ (Co as a catalyst)
$(n+1)\ H_2 + 2nCO \rightarrow C_nH_{2n+2} + nCO_2$ (Fe as a catalyst)
(C_nH_{2n+2} are paraffins or alkenes)

The main characteristics of the F-T fuel are highly attractive. It is:

- A very clean fuel: no sulphur and no aromatics; it is even used for medical applications;
- Non-toxic and biodegradable;
- Directly applicable as F-T diesel in the existing infrastructure (distribution and cars). This aspect is of extreme importance;
- Producing emissions less than 30 to 50 % when used in cars if compared with fossil fuels,
- Suited for long distance transport and long term storage;
- Allowing for the minerals to be used locally again, when the F-T diesel is produced in the area where the "woody" or "grassy" materials are harvested;
- A liquid with a high energy density (between 30 and 40 MJ per litre).

These characteristics make the fuel attractive for large-scale use. Many car producers are eager to use the fuel in their (new) motors.

3.2 Jatropha oil [20, 21]

A new development is the production of bio oil in developing countries. In these countries large areas are available in the form of wasted, degraded or salty land, not suitable for agriculture. On these kinds of land oil-producing crops like Jatropha and Pongamia will grow. Depending on the problem of that land, such crops can help restoring it, as these scrubs are deeply rooted. They can also be grown together with food crops where they do not compete so much with such annual crops as their rooting system is deeper. A closed nutrient cycle is possible when extracting the oil. Around the world there are about 2 billion ha of this kind of degraded land. The plants grow in almost all the countries around the equator. Jatropha grows around fields (hedges) and in the "wild"; seeds are inedible. Reasonable to high yields are obtained depending on local conditions. If we suppose an average of 2.5 ton /ha.year in the form of seeds then the total energy production of the whole area of available degraded land can be even more than 100 EJ and more than 35 EJ in the form of oil. These numbers only illustrate that the potential is enormous. If a market price of 40 Euroct/litre is assumed, the plant oil business turn over would be more than 200 billion Euros. If only a part of this potential would be used for helping poor people, the effect can be impressive.
Projects are started to help especially poor people and women [20]. A part of the oil produced will be used locally and stimulate the economy by direct income generation. In a later phase a part can be used for export. This way the EU can fulfil its obligations concerning the introduction of green liquids and at the same time capital can be raised in Developing Countries. In the figure a plantation in Mali is shown.

4 CONCLUSIONS

A conscious choice for growing biomass to produce food and energy, is called the "Two products philosophy". Based on this philosophy the following conclusions can be drawn.

1. Biomass is an important source for the production of food and energy. However, it can become even more important if the yield levels of agricultural crops in many countries are increased and land area becoming vacant is used for energy crops. Biomass, originating from reforestation programs, can also contribute. Main global problems, caused by over-production of crops and the world energy supply, can partly be solved.
2. Because of the competition between the two main products, food and energy, prices will go up. However, present prices are too low for an economically healthy agriculture. Higher prices create capital needed for new investments (e.g. fertilizer) to increase the yield of crops. A temporary pricing policy may do the job.
3. The potential of the extra biomass production is enormous and lies between 1000 and 2000 EJ. The market value of this biomass lies between € 4000 and € 8000 billion.
4. A main aspect is the possibility of poverty reduction. This holds especially for farmers in rural areas. Whether everybody benefits from the increase of GNP is mainly determined by a sound poverty reduction policy.
5. The development described may stimulate local as well as global markets.
6. Sustainability is possible if the right policy is performed. Concerning the sustainability aspects: environment, economy and social, it is stated that:
   - The CO_2 emissions can be substantially reduced and the biodiversity can de preserved or restored;
   - The cost of biomass for the energy supply will be, for a full grown market, between € 4 and 5 €/GJ. Local situations may lead to different prices;
   - For the social aspects only the positive effect on poverty reduction is considered. The present emphasis on a free market will not lead to a sustainable situation.
7. Policy is a central element for the "Two Products Philosophy". Local, national and global institutions have all to play their role. Several countries implement already a policy in which markets are created. A strong R&D program is needed to optimise the whole chain of biomass production for the energy supply.
8. New developments like the production of Fischer-Tropsch liquids and oil from the plant Jatropha will stimulate the use of biomass for energy applications.

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