Justification
The public discussion in the media on the effect of substituting fossil fuel by woody biomass on the CO2 concentration in the atmosphere often leaves the interested layman in confusion behind. With this observation I hope to clarify the effect.

I S A F O R
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The biomassa discours: Back to the basics

This observation regards the effect of substituting fossil fuels by woody biomass on the CO2 concentration in the atmosphere. It takes as starting point the two separate stocks of CO2. They are: Compartment 1, under ground with fossil fuels like oil, coal and gas and compartment 2 above ground, including soil and oceans, with solid biomass and CO2 gas. Compartment 2 is split in 2a where all solid biomass is being stored and 2b the atmosphere with CO2 in the form of gas.

With the generation of energy from fossil fuel CO2 from compartment 1 is being added on to the already present CO2 in compartment 2. Thus increasing the total CO2 stock in compartment 2.

Compartment 2 hosts a dynamic system. CO2 is being released with generating energy but at the same time CO2 is sequestrated by, mainly but not exclusively, forests, trees and oceans. In order to assess the effect of substituting fossil fuel by woody biomass, it is important to distinguish between *CO2 absorption/capture*, and *CO2 storage.* Forests and trees capture annually CO2. That is the *annual absorption*. Focal point is the absorption of CO2 which will be stored for several years, notably in stem and branches. Absorption of CO2 in leaves and soil which after a short while will be turned into CO2 gas is not considered to be part of the annual absorption. However the share of the annual absorption of CO2 that stays in the soil is considered to be part of the *annual absorption* of CO2 by the forests.

As long as trees are growing they store cumulative the *annual absorption* in their stem, branches and roots. This is considered as *temporary storage*. Direct after the tree has been cut, the *temporary storage* of CO2 in the stem finishes and turns either into emissions of CO2 through burning the wood for energy, or into *long term storage* through the application of the wood in the building industry, furniture and the like. Branches may be left to rot or may be burned to generate heat and energy. (Of course there are situations of mid-term storage in cases where wood or paper is been used for a while and then will be burned.)

The CO2, which is being added to compartment 2 through burning of fossil fuel finds its way to the atmosphere and from there partly to the conversion into solid biomass via absorption by forests, trees and oceans. In what degree the conversion takes place depends on the absorption capacity of compartment 2a.

Sustainable reduction of the CO2 concentration in the atmosphere requires in the first place sufficient *annual absorption capacity* and secondly *long term storage capacity*. Bearing in mind that trees and forests above a certain age show little or no increment, prerequisites for maintaining or even increasing the CO2 *absorption capacity* of forests (i.e. the annual m3 increment) are timely thinning and harvest and regeneration (See box 1). The more fossil fuel is being burned, the more CO2 is being added to compartment 2 and the more *long term storage capacity* is required.

Is it thus more effective to burn biomass instead of fossil fuels? Doing so the stock of CO2 in compartment 2 will not increase and there is no need to expand long term storage capacity to offset additional CO2 in compartment 2.

Box 1 Absorption capacity of forests

Forests absorb CO2 as long as they are vital and growing. Old trees start to decay and rot resulting in CO2 emission. The annual absorption capacity of CO2 is proportional to the annual wood increment of the forests. Apart from the climate, soil, species and genetics, three factors determine the annual wood increment:

- *Size of the forest area*. The greater the size the more wood increment.
- *Age of the trees in the forests*. Growth of trees follows a S shaped curve. The highest mean annual increment is reached long before the trees start to decay. Ideally, the area should be covered by trees of different ages in order to realise a continuous wood flow and a stable annual absorption. Timely regeneration is key. Aiming at the highest reachable standing wood volume means lower annual increment and annual absorption and is there for not helpful in countering climate change.
- *Number of trees per ha*. The more canopy cover the more annual absorption. Forest management achieves the highest absorption by maintaining closed canopies while at the same time competition between trees leading to decay should be avoided. There for timely thinning is key.

But, where does the CO2 stay which is emitted by burning woody biomass? Basically it follows the same route as the CO2 that is emitted by burning fossil fuel. So it finds its way to the atmosphere and then turns partly into solid biomass. In what degree the conversion into solid biomass takes place depends on the absorption capacity of compartment 2a. The amount CO2 that will be absorbed is the same as the amount CO2 from fossil fuel. The rest stays in the atmosphere. But burning woody biomass brings more CO2 in the air per Kwh than coal or gas. Compared with coal 15% and with gas 100% more. Only energy generation from woody biomass that otherwise would have been rotten or would have been burned without an useful purpose might have a more favourable net CO2 emission (see box2). The volume of these categories are however far from sufficient to meet the vast growing demand for woody biomass.

Box 2 Woody biomass with (partly) compensated CO2 emissions.

Some sources of biomass would have emitted CO2 also in case they were not burned for energy regeneration.

- *Post-consumer wood and industrial wood residues* that would have been burned without a useful application. In this case energy generation does not lead to additional CO2 emissions. However CO2 emissions of processing and transport of this type of biomass must be calculated as additional emissions.
- *Forest residues, top and branches* left in the forests will decay and rot over time. Burning this type of biomass releases immediately their entire CO2 volume. Thus that emission is initially only partly compensated by avoiding the CO2 released from the rotting process. The annual decrease of CO2 emissions by avoiding the rotting process can easily be counted for by increasing the annual absorption of the forest with the same value, e.g. 0.6 ton CO2 (15 m3/ha of forest residues, i.e. 12 ton CO2 per ha emitted in 20 years). However in that case the CO2 emission of burning forest residues has to be fully counted.

Under the present global circumstances and indeed those during the lasts decades, the global annual CO2 absorption capacity has been fully utilized and exceeded by the annual emissions. Witness thereof is the continuous increase of the CO2 concentration in the atmosphere. As long as there is no evidence that the harvesting of wood for energy leads to an increase of the annual wood increment or to a decrease of the decomposition of tops and branches of a magnitude enough to compensate for the relative high emissions per Kwh of woody biomass, substitution of fossil fuel by biomass only increases the climate problem.

Conclusion

1. **Burning woody biomass brings more CO_2 in the air per Kwh than coal or gas. Compared with coal 15% and with gas 100% more.** Only energy generation from woody biomass that otherwise would have been rotten or would have been burned without an useful purpose might have a more favourable net CO_2 emission. The volume of these categories are however far from sufficient to meet the vast growing demand for woody biomass.

2. **As long as the annual global CO_2 emissions exceed the global annual absorption fossil fuel should not be substituted by woody biomass.**
   During the last decades the global annual CO_2 absorption capacity of forests trees and oceans has been fully utilized and exceeded by the combined annual CO_2 emissions from fossil fuel, biomass and other sources. In that situation, substitution of fossil fuel by woody biomass increases the net CO_2 emission and thus the CO_2 concentration in the atmosphere.

3. **As long as burning woody biomass does not lead to an increase of the annual absorption capacity of a magnitude enough to compensate for the relative high emissions per Kwh of woody biomass**, **substitution of fossil fuel by biomass only increases the climate problem.**

4. **Climate neutral energy generation with fossil fuels requires <u>continuous additional</u> *long term storage* of wood after the harvest of trees.** Conversion of wood into CO_2 should be avoided. Additional *long term storage* is not needed anymore for energy generation with woody biomass once a climate neutral level of CO_2 emissions has been achieved.

Final remarks

It is important that the annual wood increment of the forests in the world is maintained or rather grows. Management systems that include clear cuts of sizes appropriate to the natural ecosystems must not be rejected. Contrarily, **where clear cuts lead to regenerations that otherwise would not have been realised, CO_2 absorption capacity may be maintained or even increased.**

The scale to substitute fossil fuels biomass by is limited, because insufficient land and forests are available to produce enough biomass. An unrealistic vast extension of the forest area is necessary to substitute fossil fuels by woody biomass. Extension of the forest area is however very useful to increase the earth absorption capacity in order to capture (part of) the excess CO_2 in the atmosphere. Also a shift of management towards higher annual wood increments would be very effective.

Unfortunately the last decades show global trends of decreasing forest areas, mainly due to conversion into oil palm plantations, soy, other agricultural crops, cattle grazing and to some extent mining. Also the annual wood increment in the remaining forests is decreasing as a result of mismanagement. Where annual absorption capacity should rise, it is in fact declining. **The answer is: stop deforestation, expand the forest area and intensify forest management.**

Sustainable production applies to wood for all purposes not only to biomass for energy production. However, **sustainable forest management is not a guarantee for climate neutral burning of biomass**, it rather guarantees that the source of the biomass is sustainably managed.

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