# WINNER OF THE LINNEBORN PRIZE

# ENERGY FROM BIOMASS, SOME THOUGHTS ON THE PAST, THE PRESENT AND THE FUTURE

**A.A.C.M. Beenackers**

Thank you, Dr Overend, for your kind words. There is always a danger in over-emphasizing the achievements of prize winners because it may enhance the disappearance of the very last traces of their modesty by which they become rather unbearable.

Anyway, I express my gratitude to the Prize Committee for selecting me as the winner of the Johannes Linneborn Award.

I value this prize particularly also because I have had the pleasure of meeting Dr Linneborn personnally. That was in the early eighties at Dr Wolfgang Palz's office at the European Commission in Brussels.

These were the early days of the renewed interest in biomass as an energy source. As you all know, this interest was reaised by the sudden energy crisis of the seventies.

However, all leading technologies such as gasification and liquefication in those days came from Germany where the development during the Second World War had advanced much further than anywhere else in the world. After the war, interest died rapidly, also in Germany.

Dr Linneborn became a powerful promotor of bioenergy at the European Commission, based on his personal experience with world war biomass gasification technology. It catalysed the determination of the European Commission to start an Energy from Biomass Research and Development Programme and resulted in the first European Energy from Biomass Conference in Brighton in 1980, with its Proceedings edited by Wolfgang Palz of the European Commission, Philip Chartier and the late, unforgettable promotor for sustainable energy, Professor David Hall.

We started research in biomass gasification in Professor Wim van Swaaij's group at Twente University in Enschede, immediately after the energy crisis in the seventies. That was not because of a prophetic vision of Wim or me on the possibilities of bioenergy. In fact, it all started because an idealistic young student expressed his interest in developing small scale gasification to contribute to the rural energy scarcity in the third world. That student was Michiel Groeneveld. Wim at least must be given the credit that he had a good eye for the explosion risks of producer gas.

As a result, Michiel was banned, together with his first prototype of a down-draft gasifier, to the outskirts of the campus surrounded by a protective zone of no man's land. With hindsight the people of the city of Enschede could have wished a municipal government with Wim's keen judgement on explosion risks.

Michiel, however, managed to avoid a serious disaster and his PhD-thesis on down-draft gasification probably was the first thesis on biomass gasification, at least since the second world war. Michiel believed in the chances of his technology and started a gasifier manufacturing company. This way he learned the hard way that throughout the eighties consulting on bioenergy was a more profitable business than producing it.

Those of you who are curious to learn how Michiel's career has developed since those pioneering days may turn on CNN tonight, or any of the days ahead.

Good chances you see him in an expensive commercial of Shell, explaining what senior Shell executives keep busy these days, also with respect to renewables.

In the early eighties Wim van Swaaij and I worked on fluidized bed gasification (thesis of Frank van den Aarssen). It was driven by our belief that particularly gasification for liquid fuels production needed a large scale, too large to make moving bed technology attractive.

At the same time we developed with Herri Susanto a special down-draft gasifier in which the pyrolysis gases were sucked off and combusted in an separate combustor. In fact, this principle was firstly demonstrated in the Lacotte-gasifier, developed in France in the first part of the previous century. This Lacotte-principle is also known as down-draft gasification with external recycle of pyrolysis gas. A version for producing synthesis gas was developed by CEMAGREF, France, in the early eighties. Jean François Molle has died a thousand deaths in trying to operate it continuously. The problem was the ventilator which had to circulate hot pyrolysis gas loaded by dust and tars at temperatures above 500 degrees. Our improvement was that we used the air feed to suck the gases into the combustion chamber by applying the venturi principle. This way we could skip the troublesome ventilator.

We called this a down-draft gasifier with internal pyrolysis gas recycle, in contrast to the external recycle applied by Lacotte and CEMAGREF.

Recently, my friend Cees Day Ouwens in Eindhoven started developing an improved version of our gasifier by replacing our internal pyrolysis recycle by an external recycle, similar to Lacotte.

This is a nice example of how cyclic the developments in research sometimes are. There is no need to discuss here our later research work on rice husk gasification with Robert Manurung, on catalytic gas cleaning and pyrolysis modelling, both with Gerard Lammers. Our commitment to the development of novul slurry processes for the production of liquid fuels (methanol, gasoline and diesel) from synthesic gas now for more than 15 years. Nor on our first adventures in developing expert systems for the internet, together with BTG b.v., Enschede, again with Gerard Lammers. Most of it has been published, much of it was presented at these, now eleven, Energy from Biomass Conferences over the past 21 years, since Brighton.

I feel it is of more interest to evaluate where we are now and to look into the crystal ball to guess the future.

Moving bed gasification technologies from Linneborn's time have been further developped from unreliable, environmentally unfriendly early 20$^{th}$ century's technology into highly reliable, fully automatic, environmentally friendly technologies with the Bioneer-plants in Finland as a most convincing example.

Co-combustion of biomass wastes in conventional power stations is fully commercial under business as usual scenarios.

The same holds for anaerobic digestion of wet wastes.

Power generation via gasification will reach the 10 Mwe-scale this year by the start-up of the Arbre-plant.

Flash pyrolysis and bioethanol from biomass have reached the demonstration scale.

What will bring the future? That will depend on the driving force for implementing bioenergy. Also here we have seen remarkable changes. The initial interest in bioenergy at the end of the seventies was completely driven by concerns on exhaustion of fossile fuels. By then, any paper on economic feasibility of bioenergy predicted a sunny economic picture for bioenergy at crude oil prices of U.S. $ 30,= per barrel. In the nineties the focus changed dramatically. The argument to develop novel energy sources because of exhaustion of classical oil fields died more or less but at the same time the environmental reasons to promote the introduction of bioenergy (green house effect) gained rapidly momentum. This culminated in the Kyoto agreement which made a rapid introduction of bioenergy a necessity.

Today, the crude oil price is close to U.S. $ 30,= and indeed, we see a great number of applications of bioenergy generation to be commercially viable even without green subsidies.

In case the present day oil price remains stable, I see a great future in liquid biofuels on the short term. First, I see niche opportunities for methanol from biomass.

Also here we see a remarkable cyclic effect in the focus on attractive bioenergy options.

In the early eighties much attention went into the developments of liquid fuels from biomass. The European Commission had a special "Methanol from wood"-R & D-programme. With decreasing oil prices this interest vanished and in the nineties most attention turned into the development of (combined) heat and power applications. Now, since the Kyoto agreement and particularly since the recent high crude oil prices, liquid fuels from biomass are high on the agenda again.

Last year, the financial company Arthur D. Little, analysed a great number of technology chains to get at liquid fuels under responsibility of NOVEM, The Netherlands, and found various chains to be attractive already now, taking into account realistic $CO_2$-avoidance credits.

And there are technology chains which I feel are more attractive than the winners spotted by Arther D. Little.

The first, in my view, is, again methanol from wood. The niche is in combining the plant with existing methanol from natural gas plants. The synergetic effects come from benefits of scale and particularly benefits from an optimal syngas composition of a combined feedstock of natural gas and biomass. This can be seen as follows. The production of methanol requires $H_2/CO$ molar ratio of 2:

$CO + 2H_2 \rightarrow CH_3OH$.

However, natural gas delivers a syngas which is too rich in hydrogen:

$CH_4 + H_2O \rightarrow CO + 3H_2$.

On the other hand, biomass gives a syngas too low in hydrogen:

$0.2\ C_5H_{10}O_5 \rightarrow CO + H_2$

So, combining the two feedstocks may result in an ideal feedstock for methanol:

$0.1\ C_5H_{10}O_5 + 0.5\ CH_4 + 0.5\ H_2O \rightarrow CO + 2H_2$.

The second chain of probably highest potential in my view starts from large scale biomass production in the tropics where the yields are substantially higher and production costs much lower than in moderate climate zones. Locally this biomass can be converted in pyrolytic oil by recently developed efficient flash pyrolysis technology. In contrast to the original biomass, this oil can be cheaply transported over large distances, just as conventional crude oil. At the main ports of Europe and America this oil can be, relatively simply, converted into conventional gasoline and diesel.

Extra synergetic effects seem possible if this chain at the plantation level is combined with vegetable oil production, possibly for biodiesel.

It is these chains which fascinate me for the time being.

Technology providers, plantation owners and entrepreneurs who want to join with me are most welcome.