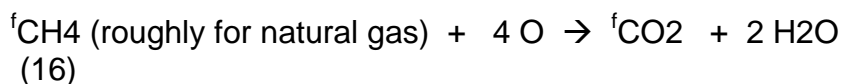
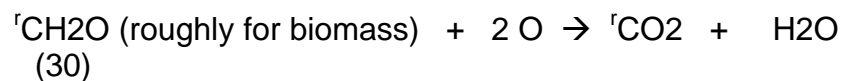


Dear colleagues,

Thank you, Dr. Bonnenberg and Mr. Ting Shiang Lee, for your comments giving me the opportunity to extend my argumentations in favour of the biogas solution.

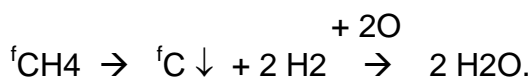
First of all, the reason for the proposal to use biomass for energy generation is the ever-increasing flow of fossil-originated CO₂ into the atmosphere. I guess, nobody would engage himself to change the present system of our energy provision without the threat of fossil CO₂-initiated climate change. Dr. Bonnenberg has pointed out that he did not believe in the relation of climate change and atmospheric CO₂ increase. The facts speak against you, but I agree with you insofar that we need obviously a greater effort from science to spread these facts.

I confess that I don't see biomass as an ideal raw material for energy generation in terms of yield and energy flow density because:



(r stands for recent, f for fossil. These two types of carbon can be differentiated by isotopic analysis, indeed).

The double weight (30:16) of biomass will yield in the best case half of the energy (40 : 20), of natural gas. This is a mass related energy yield of 1/4. Furthermore, energy flow density is limited by the application of living catalysts, thus, reaction temperature has to be low which affects over-all reaction velocity not positively. But as already stated in the article the unique, overwhelming advantage of biomass is that it consists of recent carbon, written here as ^rC. Biomass, and all products derived from it, produce, when burned, only climate-neutral ^rCO₂. Fossil materials produce, when burned, climate-damaging ^fCO₂. If we take the climate change and its reasons for serious we had to regard that fossil-originated ^fCO₂ must not escape to the atmosphere but has to be stored apart from it or has to be avoided totally in energy generation (The latter could be realized according to a proposal of Kreysa



This seems to be a solution in competition to the biological variant, simultaneously appropriate to reduce the threatening deposits of fossil methane hydrates in the sea).

Moreover, the biomass variant offers a perfect cycling of carbon, infinitely functioning as long as man does not destroy the natural conditions. It corresponds to Dr. Bonnenberg's desire, to see closed cycles in energy generation. It sounds funny, but without the modern industry, mobilizing large amounts of fossil carbon and increasing by this the atmospheric concentration of CO₂, there would be no climatic trouble in the world at all. But mankind needs industry, not at last, as Dr. Bonnenberg pointed out, to offer the rising number of inhabitants a safe life on earth. Thus, industry must have its free development. But its limits are unambiguously there where the damage of the basis of life on earth begins.

Solutions for energy generation will be manifold. And not all of them are already known. But as long as we live in the carbon-determined era of energy provision we have to regard the existing danger emerging from wrong uses of carbon. There is so much carbon immobilized in soil and sea that its conversion into CO₂ can end human life. Already further increase of the atmospheric concentration of CO₂ is a danger for the existence of man. Non-dangerous solutions are easily thinkable. They should be physically performable and economically as favourable as possible. The biological solution has been proven physically performable because it is in function since long. Its economic behaviour has to be measured in terms of efforts to holding constant the atmospheric concentration of CO₂.

Today's economy is definitely wrong if it asks for comparison of the production costs of fossil and recent raw materials for energy generation, only. Such a comparison necessarily turns out in favour of the use of fossil raw materials. Asking for comparison of the costs, including those for the strict avoidance of increase of atmospheric CO₂ concentration through the considered raw materials, will result in another picture. The cost structures will change dramatically. While recent carbon materials will stay unchanged, fossil materials will suffer e.g. from the addition of the costs of CCS measures.

Mr. Ting Shiang Lee has given the friendly advice to show a picture of a 1000 MW biogas plant . I regret to disappoint you but I don't see the future in such big plants. The size of a biogas plant has to be harmonized with the surrounding agricultural raw material production and that includes the length of transport ways of harvested materials to the biogas plant as well as of liquid residues from the biogas plant back to the acres. So many relatively small biogas-producing units might be the optimal solution. At least a gas grid is needed connecting the single plants with centralized points of gas storage and gas conversion. Gas conversion at the place of gas production seems to be advantageous only, if the evolved heat can be used there. Open seems to be where separation of methane and the accompanying CO₂ should take place. This CO₂ contains only ¹³C. It can be recycled into plant growth or simply released to the atmosphere.

(Here should be noted that ¹³CO₂ should not be used for growth of plants including algae. The produced biomass contains ¹³C as well as all products derived from it. Thus, when burned, this biomass will contribute to the rise of atmospheric CO₂ concentration.)

I have understand both colleagues with their main question: Is the biological variant realistic in terms of agricultural production area, change of landscape, continuous flow of raw materials? Clearly, one main trend of modern technology development cannot be maintained with the biological solution. This concerns high concentration of production, high energy flow density of processes, and high stability of systems. Biological solutions using sun energy need area, need dilution by water and cannot exceed stability criteria beyond those of life. Hopeless? Yes, in terms of our present picture of technology. No, definitely not, in terms of a future picture of consequently environment-regarding technology. To come into a new technological era needs a break to the existent one. It is not easy and takes time. Fortunately, it is not necessary to be radical and to install the new system at once. The chancellor of Germany has named the aims at the Heiligendamm Summit in 2007, more or less maintained since that time and more or less accepted by the leaders of the greatest

industrial and threshold nations: Reduce fossil CO₂ output to the atmosphere worldwide till 2020 by 20 % and till 2050 by 50 %.

In 2007 under the impression of the Heiligendamm Summit and the announcement of the Baltic sea gas pipeline (North Stream) construction I made the following calculations:

The planned import of natural gas in the year 2010 should be $27,5 \cdot 10^9 \text{ m}^3$. If, correspondingly to bio-ethanol and gasoline, bio-methane should replace 5 % of the natural gas, it would be necessary to use $2,75 \cdot 10^9 \text{ m}^3$ biogas in order to separate $1,375 \cdot 10^9 \text{ m}^3$ bio-methane. The relative contents of methane and inert gas would correspond to H_(GUS) natural gas.

In the surrounding of the pipeline arrival place (assumed diameter of 50 km) we could find that time 6 biogas plants with a total capacity of $2,3 \cdot 10^3 \text{ m}^3/\text{h}$. The pipeline delivers $(27,5 : 8760) \cdot 10^9 \text{ m}^3/\text{h}$, this are around $3 \cdot 10^6 \text{ m}^3/\text{h}$. Replacing 5 % means to be able to feed $1,5 \cdot 10^5 \text{ m}^3/\text{h}$ bio-methane into the system. This is about 65 times higher than the available gas amount from these 6 plants. To realize that replacement out of the surrounding area would need a combination of process intensification and plant amplification. Intensification of about one magnitude is realistic by optimising yield and velocity of the biogas process adding continuously to the fermentation broth hydrolytic enzymes for accelerated breakdown of the polymeric compounds of the raw material as well as mixtures of trace metals for acceleration of the microbial methane formation and continuously controlling the fermentation process. Thus, $2,3 \cdot 10^4 \text{ m}^3/\text{h}$ bio-methane would be available after successful optimisation of the available plants. That optimisation reduces decisively the necessary amplification of equipment, from 65 to 6,5.

To replace 20 % of the natural gas in 2020 would need $5,5 \cdot 10^9 \text{ m}^3$ bio-methane/a. This would correspond to something more than twice of the amount of the German biogas production of 2007 (theoretically $2,4 \cdot 10^9 \text{ m}^3$ bio-methane/a from practically $4,6 \cdot 10^9 \text{ m}^3$ biogas/a). Replacement until 2050 would be $13,75 \cdot 10^9 \text{ m}^3$ bio-methane/a, corresponding to 6 times of the German biogas production of 2007.

To follow the aims of the German chancellor is by no means a promenade walk but a realistic effort. It will change to a certain extent agricultural and industrial production but it will neither be impossible nor destroy neither the agricultural production nor the industrial production system. The exact amount of necessary changes including those of landscape, should be subject of further investigations, local decisions and practical experience. It seems to be clear that working places are created by this development and export chances for process knowledge and equipment are opened. Production of food and production of raw materials for energy production must find together in a new quality satisfying both. With the product bio-methane we have no decrease in the usual properties, customers are accustomed to when using natural gas.

The final remarks of Dr. Bonnenberg about a new identity of Europe appear to me as very helpful to encourage the promotion of such a new technological solution combining available area with environmentally sound production.