ANAEROBIC DIGESTION AND SUSTAINABILITY

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Two paradigms have recently altered worldwide the perception of environmental issues by the general public. First of all, the concept that the climate has changed is now broadly accepted. Secondly, the fact that the oil reserves are not endless but in the near future have to be supplemented by bio-fuels has also become evident.

In the context of global warming, the processes relating to anaerobic digestion are bound to become of critical importance. Indeed, anaerobic digestion produces methane which is often dissipated in the environment. The release of methane by marshes, rice paddies, landfills, the gastro-intestinal tracts of men and animals but also digesters contributes for a considerable extent to the problem of the greenhouse gas effect. Hence, all scientists and technologists dealing with anaerobic digestion must be heavily concerned about this aspect and dare to face their responsibility to control the methane production processes and minimize emissions to the atmosphere.

In the context of renewable fuels, the attention at present is mainly focussed on bio-ethanol and bio-diesel. Indeed, a whole set of research programmes are launched worldwide to produce these two commodities. The key feature is that these fuels directly tune in to our needs to further assure our mobility with motor vehicles. Yet, at the same time, these bio-fuels raise tremendous controversy in terms of their overall sustainability. Life cycle analysis allows to take into account all aspects of the production of these commodities, from the ecosystems which grows them, the factories which produce them to the consumers and their environments which consume them. Values for the number of net tonnes of oil equivalent (TOE) per ha that can be generated by crops are now commonly available. Bio-fuel in the form of wood does not require labouring of the soil nor upgrading. This gives a high net yield of the order of 3-4 TOE per ha per year. Biogas can be generated by fermenting all parts of the plant; the biogas distils all by itself and can be used as such. This yields a very nice net energy equivalent of 4-5 TOE per ha per year. Yet, in the case of bio-ethanol, only the high value carbohydrate part of the crop can be fermented to ethanol. This product needs moreover to be distilled from the fermentation broth and rectified before it can be used. This explains the low net output for ethanol which is in the order of 0.4 -1.0 TOE per ha per year. Finally, the productivity of crops such as soy bean, palm oil and canola to generate the vegetable oil is limited and the upgrading to a high calorific content is demanding so that the overall net yield for this bio-fuel is also low; i.e. in the order of 0.5-1.0 TOE per ha per year. These data are corroborated by the values of the energy efficiency of these lines of production of bio-fuels. Indeed, the ratio of net energy harvested over energy invested for wood, biogas, bio-ethanol and bio-diesel are in the ranges of 5-7, 2-3, 1.0-1.3 and 2-3, respectively. Hence, from these figures it is quite apparent that in the future of the concept of “ biomass to energy “ clearly has to be sought in the so-called dry biomass line in which the wood is produced and straightforwardly burned or gasified and the so-called wet line in which fermentable biomass is subjected to the very straightforward process of anaerobic digestion.

An often heard remark to this point of view is that these two processes do not directly yield a fuel which can be used for transport of our cars. However, there are sound and sustainable technological solutions already present to attend this. Indeed, one can produce BTL (biomass to liquid) fuel for transport from wood or other dry plant biomass by gasification coupled to Fisher Tropsch (FT) conversion. One can also, as evidenced by the city of Stockholm, efficiently compress the biogas and use it for transport of motor vehicles. It is quite interesting to cite the number of km of transport one can obtain from one hectare of land per year. The values for biodiesel, bioethanol, and BTL by FT-conversion respectively BTL by biogas digestion are of the order 20 000 km, 30 000 km, 60 000 km and 65 000 km, respectively. Clearly, anaerobic digestion ranks top.

There are additional arguments to promote anaerobic digestion as a first rank process for sustainability. All processes cited above bring about a very advanced removal of the biomass from the farm and hence from the overall ecosystem. The processes of total harvesting followed by burning/gasification of wood provide little return to the soil. The practice of harvesting cane, wheat, sugar beet, ….and obtaining a fermentation liquor suited for ethanol production also tends to decline the soil organic matter level. The cultivation of vegetable oil crops associated with the practice of collecting the oily seeds and harvesting the vegetable oil and rest products for consumption in the feed industry is poorly compatible with a significant input of plant material into the pool of soil organic matter. Agricultural data indicate that a viable crop production system needs at least several tons of dry organic matter per year to assure a healthy soil which maintains its structure, its fertility and the variety of other services it normally provides. The formidable exception in this respect is again the chain of “biomass to biogas”. Indeed when the crop after harvesting is digested, the anaerobic process leaves all woody, lignin containing parts untouched; they remain as a form of humus. The process removes no mineral nutrients neither. Hence, by returning the digested matter back to the farm land, a perfect cycle is construed in which the sun is harvested as biogas but in which also a part of the organics as well as the minerals return to the soil so that the organic matter and nutrient status can be maintained. There is good evidence that indeed this system of cropping, resembling actual plant production systems with ample return of unused organic matter to the soil, is sustainable over decades. This way , the soil life in all its biodiversity is respected.

The closed cycle comprising the biomass to biogas as depicted is of course only valid for decentralised biogas installations. Yet, this is exactly the scale at which bio-energy cropping by means of the biogas route is most effective. In this scenario, the farmer can have normal crop rotation (all normal annual crops can be fermented; no special adaptation of the system is needed provided they are chopped up to 1-2 cm pieces). Moreover, the decentralised configuration assures that only the concentrated product (electricity respectively compressed biogas) has to be transported and not the bulky plant biomass as such. This way, small to medium sized installations ranging from 20 to 2000 ha of farm land become the driving forces of renewed energy supply at rural scale. At present, in Germany some 3 500 biomass to biogas installations, representing a total 1100 MW are already in operation. Currently, biogas installations at capacities in the order of 1-10 MW are being built all over the world. The size of these installations should not become larger, because they need to be compatible with the farmland supplying them with biomass. The fact that they are not restricted to the industrial world but are, both in terms of capex and opex feasible all over the world, is most encouraging. Indeed, it indicates that this technology can avoid the pitfalls of the other bio-fuel supply routes in terms of accentuating the polarisation along the Nord-South axis. As a matter of fact, the reports about the destruction of the rain forest to grow palm oil or soy beans and the putative problems of the local handling of the waste products of palm oil industries in these countries have already been voiced in the world press and have rightfully risen concern about such large scale approaches mainly to the benefit of the industrialized world.

At present, we are all aware of the fact that we must decrease our contribution to the emission on greenhouse gases. As indicated before, we must increase our efforts to contain unwanted dissipation of biologically produced methane. There is good progress possible in terms of improved microbial control and removal of methane. Also, reactor technology allowing to minimize methane emissions from digester installations is progressing considerably. There is also the need to use less fuel for heating. Most of all, we particularly need to combust less fuel for individual motor vehicle transport. The EU has calculated the amount of fossil fuel CO_2 for mobility that has to be decreased. At the 2007 international congress on anaerobic digestion in Brisbane, data based on studies for the EU commission indicated that, by applying the route "biomass to biogas to BTL for vehicle transport", one could by this specific policy achieve 50% of the EU 2020 bio-fuel for mobility demands. Most interestingly, because biogas can be produced from all kinds of crops, also those grown on marginal land and even land one wants to clean up, hardly any change in land use is considered necessary to achieve the latter 50% goal.

Overall, there can be no doubt that anaerobic digestion is a key technology for the future of our planet. Although at present, attention is mainly focussed on other routes, the fact that the process converts millions of different molecules to basically CO_2 and CH_4, which nicely distil spontaneously out of the biomass, constitutes a major opportunity for branching the conventional energy and chemical supply lines onto this wonderful process.

Anaerobic digestion is versatile, democratic and holistic. It is sustainability at its very best.