The world energy consumption up to the year 2050 will double. The demand for energy cannot be met by petroleum and natural gas alone, but the so-called renewable resources have to be exploited as well. By 2050 only around 50 percent of the energy will still originate from petroleum and natural gas, the balance will proceed from coal and, increasingly, from biomass.

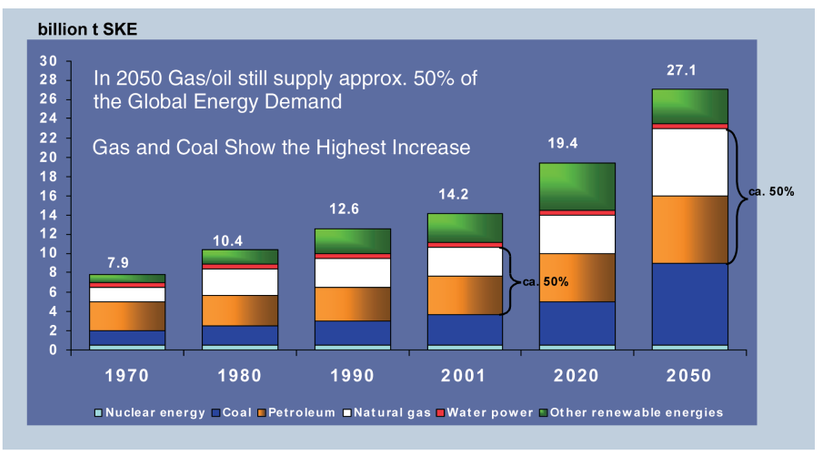
The *future energy* proceeds from plants

LUDOLF PLASS

In 2005, biomass only covered 10 to 15 percent corresponding to 45 ± 10 Exajoule (EJ) of the global energy requirement of 420 EJ. At the same time, 3.8 billion tons of crude oil were processed. Although emission levels of noxious substances are being curbed continuously, the CO_2 release to the atmosphere will increase steadily unless more effective technologies or renewable resources are applied. The Kyoto Protocol and the associated requirement to cut CO_2 emissions drastically, mainly take effect in Europe. This European trend will also prompt other countries like the USA, Brazil and China to issue the respective laws and to invest in technologies for the production of biofuels.

Biofuels of the first generation

Biodiesel and bioethanol, the so-called first-generation biofuels, are produced from oil fruit and plants supplying starch. In 2005, 125 million tons of fats and oils were produced of which around 90 percent was consumed in the food industry.



Picture: Lurgi; Source: BP (until 2001), World Energy Council

Global energy consumption split by resources

These figures illustrate that the use of biodiesel and bioethanol only constitutes a first step in solving the world energy problem. Experts estimate that until the year 2010, 14 to 15 million tons of the mentioned two fuels will be added to fossil fuels in Europe. The situation is much different in Brazil. There, meanwhile more than 50 percent of the transport fuels is produced from sugar cane. The US, too, are increasingly concentrating on ethanol. Meanwhile more than 10 million tons per year are produced there. For comparison: in 2005, the world output of bioethanol amounted to about 40 million tons.

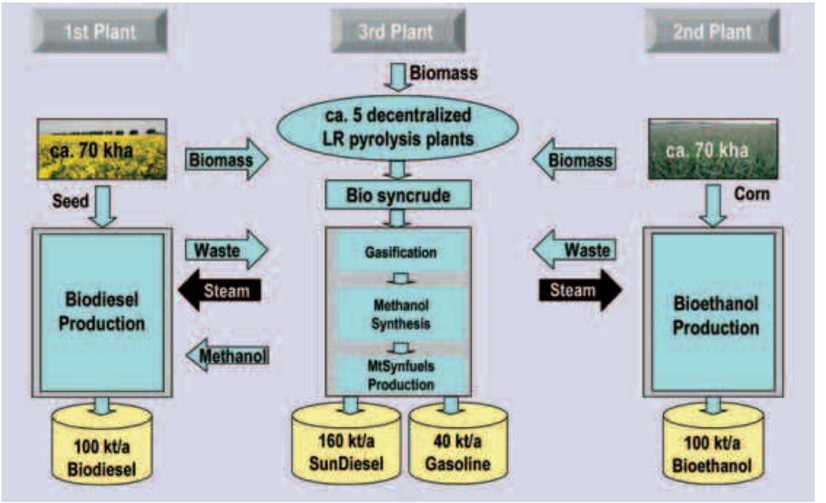
Many countries are in the process of considering existent and future technologies for producing fuels on the basis of renewable resources. The Frankfurt-based plant engineering contractor Lurgi has raised its biodiesel process to a world standard, based on its fats and oils technologies. In 2005, about 50 percent of the biodiesel produced worldwide originated from plants using the process of that company. This trend is bound to intensify up to the year 2010. The plant sizes will increase from, initially, between 10,000 and 40,000 up to between 200,000 and 500,000 tons per annum. Such plant sizes will become viable as a result of the ongoing development and optimization of the plant concepts, modularization of plant components and the processing of the most diverse vegetable oils. Experts anticipate that by the year 2010 bioethanol plants will be built in Europe which will attain the same size as those for biodiesel. In this sector, Lurgi is benefiting from its experience with the most varied raw materials like sugar, cereals, corn and cassava in the USA and in Europe. In the field of bioethanol, the trend is in the direction of distinctly higher plant capacities. Initially, 50,000 tons were produced, but meanwhile the world standard plant sizes yield outputs of 100,000 to 300,000 tons of bioethanol per year.

Biofuels of the second generation

In spite of the enormous investment efforts made in the meantime, fuels like biodiesel and bioethanol based on seeds and fruits of plants alone are not capable of solving the CO_2 problem and meeting the growing energy demand. For this purpose, biofuels of the second generation are needed which are made from feedstock based on the whole plants and biomass and which, in the opinion of experts, could cover one third of the world energy demand. This is the reason why worldwide more and more research projects are being launched for the purpose of developing biomass-based processes to commercial maturity.

In order to utilize biomass, this material must first be compressed to achieve high energy density and to convert it to synthesis gas, a mixture of CO, H_2, CO_2 and N_2. Independently of the raw material processed, the various synthesis gas production technologies are playing a key role in this context. The most varied biomass processing technologies are being developed worldwide. Two processes have turned out to be especially successful: in the first of these, previously pelletized biomass is directly gasified at low pressure, the resulting syngas being purified and submitted to a Fischer Tropsch synthesis reaction. The

The article is based on a keynote lecture held at the GVC/DECHEMA Annual Meeting 2006 by Dr.-Ing. Ludolf Plass, Senior Vice President Sales Technology, Lurgi AG, Frankfurt am Main/Germany.



Picture: Lurgi

2nd generation biofuels: combi biofuels plant for the future

second process is being developed to commercial maturity in cooperation with the Large-scale Research Center Karlsruhe. In decentralized units, biomass is converted to so-called Bio Crude Oil which can be transported and stored. The LR (Lurgi Refinery) technology, which has been tried and tested on a commercial scale for many years, is applied to this end. This is a flash pyrolysis process based on which the biomass is converted within seconds to pyrolysis oil, gas and coke in a double-screw reactor. The stabilized Bio Crude Oil can subsequently be transformed to syngas in an entrained flow gasifier, for example. The gas is purified by means of proven commercial-scale processes like Rectisol, a method of converting carbon monoxide to hydrogen in order to adjust the right syngas ratio, followed by a synthesis reaction to obtain petrochemicals or fuels.

For the production of petrochemicals, methanol synthesis is applied as key reaction. This can most suitably be implemented according to the company's MegaMethanol technology which allows producing up to 6,500 tons of methanol per day. The methanol thus obtained can be processed further to propylene by applying the Methanol-to-Propylene (MTP) technology. This technology is already being used in two commercial-scale plants in China where polypropylene is to be made from coal. However, methanol can also be used as such or employed in the Methanol-to-Synfuels process. When applying the method, an intermediate stage will yield olefins which can be processed downstream to produce diesel, gasoline or lube oils.

Alternatively, syngas may be converted to olefins or fuels by applying the Fischer Tropsch process. Today, Lurgi offers this method in a technology joint venture with Statoil and Petro SA on the basis of natural gas.

As a further development of the existing biodiesel and bioethanol processes, the concern has devised the concept of combi-biofuel plants in order to allow the optimal utilization of the plant fruits and whole plants. According to this concept, in the first two steps a biodiesel and a bioethanol plant are built and subsequently the residual biomass plus additional biomass are processed to Bio Crude Oil. Options on this basis are the energetic exploitation or the downstream processing to syngas and synthetic fuels. From the synthesis gas, methanol may also be produced in an intermediate stage. This product can in turn be fed to the biodiesel process for obtaining 100-% green biodiesel.

Conclusion

Summing up, it should be highlighted that the first-generation biofuels like biodiesel and bioethanol have to be placed on a broader raw materials base in order to render them economically feasible. And, what is more, the byproducts have to be utilized as well.

However, this first generation is not capable of meeting the world fuel requirements or satisfying the demand for energy. For this purpose, it is essential to exploit the plant as a whole as raw material source. Worldwide studies on biomass availability confirm the future development of biomass conversion to energy sources. Conservative assumptions predict that in the year 2030 one third of the world energy demand will be covered from biomass. For this to materialize, it is imperative to intensify research efforts in this field and build demonstration plants in the various regions. Furthermore, those development projects should be integrated with long-term programs and backed by reliable legislation. ■