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AGRICULTURE AND FUELS OF THE FUTURE

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Summary. The increasing demand for energy and transport fuels with reference to PKB (gross national product). Energy demand with regard to conventional fuels (crude oil, natural gas). Abilities and limitations of agriculture as a producer of energy or energy raw materials. Hydrogen as a fuel of future.

Key words: energy raw materials, agro-energy, biomass, cost of production, natural gas, air pollution, hydrogen, gasification, electrolysis, fuel cell, distribution

ENERGY AND FUELS

All the analyses that have been made up till now show the substantial interdependence between the increase of PKB and increase of energy demand including demand for transport fuels as a very important factor of total energy consumption. The IMF (International Monetary Fund) estimates that an increase of oil crude barrel price by 5$ causes a decrease of economy development rate by 0.3%. At the same time about 2/3 of the global oil crude reserve is concentrated in a very politically restless region of the world, i.e. in the Near East countries and that is very unfavourable from the point of view of safety of energy stability. However, crude oil may be obtained form the big resources accumulated in bituminous slates or sand but the technology of exploitation of these „raw materials" is very expensive. On the basis of a global prognosis we can expect the crude oil demand will increase by ca 50% till 2025, which is due to the important fuel consumption by China (average annual growth of transport fuels consumption amounts to 20%).

It should be mentioned that the increase of transport fuels and electric energy demand is caused, first of all, by „demographic and quantitative" reasons, because with respect to the „quantity" understood as an individual consumption of energy or fuel by one man (or vehicle) – we observe a clear downward tendency. This is well illustrated by the energy consumption trends in USA. For the last thirty years energy consumption has grown up by about 25%, but in terms of consumption by one inhabitant it has fallen down by about 40% in spite of considerable increase of NGP (National Gross Product).

Non-agricultural sectors of national economies dealing with energy production treat agriculture like an „intruder", but in many developed countries (especially in EU and USA) hard works are being carried out aiming at a diversification of agricultural production. Farms, besides the production of industrial raw-materials, will gain energy from agricultural products (especially from biomass) and transform it into fuels for transport and for electric energy production. The predicted increase of transport fuels consumption and, on the other hand, obligatory reduction of emission of toxic components and greenhouse gases (Euro III, IV, Clean Air Act in USA) impose a necessity of enhanced production of „ecologically clean" fuels during the next 20 – 30 years.

A univocal definition of „agricultural energetic raw materials" or „agro-energetic" has not been elaborated yet. Production of such „energy raw-materials" as biomass from energy crops or forest as well as production of methanol from agricultural by-products, as for example manure or some kind of crops, may be treated as „agricultural" in the full sense of this word.

Due to the limitation of agricultural production space, solar energy (collectors or photovoltaic cells) and wind energy may be also treated as „agro-energy", but there is some doubt as regards water course and flows energy and geothermal energy.

According to the majority of research papers on transport fuels, during the nearest 10-15 years the sulphur-poor diesel oil (<15 ppm) and petrol (<30 ppm) will predominate. But compressed natural gas (CNG) and liquid natural gas (LGN) will become more and more important for local transport, but mixtures of diesel oils and plant oil esters (for example B 20) – for long distance and sea transport. At the same time, the production of diesel oil on the basis of synthesis gas (syngas), using Fischer-Tropsch method (natural gas and biomass), will develop, and the method of replacing methanol in light fuels (petrol) by ethanol will be improved. Hydrogen should become the predominant fuel thereafter.

Gas fuels – methanol and natural gas

It is estimated that the natural gas resources amounting to about 200 billion m^3 should be sufficient for several dozen years only and within this time new economic technologies of methanol production from biomass should be developed. Methanol contents in natural gas depending on origin source ranges from 40 to 54 GJ/Nm^3 (94-101 GJ/t). As the relative accessibility to natural gas resources is temporarily limited (just as to crude oil) and assessment of perspectives of economical gas transmission in the form of CNG (pipelines) or LNG (liquid gas carriers) is difficult, there is a quite important divergence of evaluation of gas demand for production of electric energy needed for hydrogen production (now the energetic efficiency is negative).

Hydrogen

Though hydrogen is not a direct energy source, its is considered as a future energy carrier that could be used for many purposes and this is due to:
- practically non-limited resources,
- clean burning process, without emission of environment treating factors (water and a minimal quantity of NO_x),

– elimination or essential limitation of green house gases emission (CO_2) depending on the technology of producing and processing,
– verified possibilities of utilisation in fuel cells – hydrogen may be used for production of electric energy and inversely, and that is why it is especially very useful for dissipated energy which in future will take about 30% share of the total power,
– different potential resources – hydrogen may be obtained from hydrocarbons, water and biomass.

The main problem of hydrogen fuels implementation on a larger scale as the clean energy carriers is the cost of hydrogen production, storage and distribution. At present hydrogen is produced from natural gas, crude oil or cheaper sorts of coal but it hasn't got features of renewable fuel and emission of CO_2 is on the same level as if conventional fuel was combusted instead. The cheapest method of hydrogen production consists on natural gas and water vapour processing (cost amounts to 4–7 $/GJ for the system of capacity of 18.000 GJ per day). The cost of hydrogen production from water gas (carbon and water steam) amounts to about 9 $ when carbon price is 1.5 $/GJ). The cost of hydrogen produced in the experimental system of biomass gasification amounts to 7--10 $/GJ when biomass price is 2-4 $/GJ. To compare – the cost of hydrogen obtained as a result of electrolysis process in a hydro-electric pumped-storage power plant amounts to 10-20 $/GJ, in wind-power plant – to 20–45 $/GJ, showing a downward tendency to 17 –25 $/GJ.

At present there are three methods of hydrogen production from biomass:
– biomass gasification → electric energy → electrolysis→ **hydrogen**
– treatment of biomass with overheated water vapour → gas cleaning → **hydrogen**
– biomass pyrolysis → liquid hydrocarbons → gas transformation → **hydrogen**

A majority of scientific research results that have been carried out till now have proved that by the thermo-chemical transformation method we can obtain from 1 t of biomass dry matter about 6–7 % H_2 (occasionally maximum 12–15% is possible) in the form of the gas containing 10-25 % of H_2 by volume. However it should be underlined that due to the thermodynamic conditions of the biomass gasification processes the increase of the above indicator cannot be expected. This gas, generated in the conditions of high temperature and pressure, contains, besides hydrogen, the following gases: CH_4, CO_2 and CO. These „components" makes it impossible to directly utilise the gas in the fuel cells that are available nowadays. Preliminary gas cleaning is effected by treatment with water vapour of 600 ^{o}C temperature and as a result CO and H_2 are produced, during the second stage, at temperature of 200–300^{o}C, water steam reacts with CO „transforming" it into H_2 and CO_2. During further cleaning measurements CO_2 or sulphur compounds are removed. In the experimental systems for gas cleaning there are used porous ceramic and polymer pipes, operating at system working pressure amounting to about $100 \bullet 10^5$Pa.

The alternative method of hydrogen production involves biomass pyrolisis, during which at the first stage biomass is subjected to the process of gassing by means of steam, in the second stage, steam saturated with hydrogen is condensed to oils within heat destruction process (bio-oils), from which, after reforming it with steam, the hydrogen is obtained in the quantity of 12-17% of the biomass dry matter. In the further perspective we should expect a utilization of enzymatic methods (biotechnology, phytobio logy) in which the solar radiation is utilised by water organisms (algae, bacteria) containing the enzyme of hydrogenase to the production, in certain circumstances, of hydrogen with an efficiency exceeding 24%. Hydrogen produced with methods of the electrolysis is characterised by very high cleanness which enables an immediate utilization of it to the power supply of fuel cells. However, a necessity of double transformation of energy lowers the efficiency of the process, but the potential lack of necessaries of the construction of distribution network makes up for this indigence. The important production cost is the essential fault of the electrolysis method. According to the American data, hydrogen production with electrolysis method is profitable if the energy price does not exceed 1.5 –2 ∉/kWh (actually it amounts to about 4∉/kWh.

Independently of hydrogen production method (energy from renewable sources as wind, geothermal, photovoltaic or others) or biomass production (fermentation, gasification), the hydrogen as transport fuel (engine fuel) may be utilised in the form of compressed gas or liquid. It is necessary to consider whether further transportation of hydrogen in the form of mixture with natural gas is possible using existing gas pipelines. Currently exploited solutions are more expensive than the traditional technologies, but we can expect that their costs will become lower as methods of hydrogen production are improved and urbanization is advanced. Utilization of methanol as additional hydrogen carrier is the simplest method. In certain types of fuel cells methanol is used as fuel. However, negative methanol impact on health together with high costs of its production from biomass (energy woods) question reality of utilization of such a solution in future.

RECAPITULATION OF THE ARTICLE

1. Energy demand including transport fuels shows a growing tendency due to the essential dependence upon National Gross Product increase.
2. Capabilities of agriculture as „energy producer" are limited by the agricultural production area dimension (biomass crops) as well as by the economical effectiveness and energy efficiency of „transformation" into transport fuels.
3. The most important advantage of transport fuels of agricultural origin is that they are environmentally friendly, which in future may balance the present economical and effectiveness handicap.
4. Hydrogen becomes the fuel of future and production of agricultural raw materials from which it is generated, especially of biomass, should be the subject of different research works. Establishment of the UE High Level Commission on Hydrogen Fuels at the end of 2002 clearly proves the importance of the problem.

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