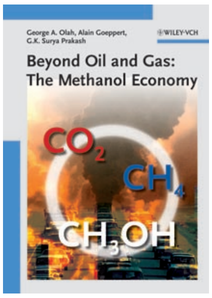
Beyond Oil and Gas: The Methanol Economy



By *George A. Olah*, *Alain Goeppert*, and *G. K. Surya Prakash*. Wiley-VCH, Weinheim 2006. 206 pp., hardcover, 24.90 €.—ISBN 3-527-31275-7

"Satisfying our society's needs while safeguarding the environment and allowing future generations to continue to enjoy planet earth as a hospitable home is one of the major challenges that we face today." (p. 1 f.) G. A. Olah and his coauthors have accepted this challenge of a sustainable development. They have written a most important book which is important with respect to their forward-looking suggestions and to their misconceptions as well. They address not only scientists and engineers, but also politicians and opinion leaders. This is the reason why it will be necessary to discuss this book intensely and broadly. The authors make suggestions for a future energy economy, when oil and gas will become increasingly scarce and expensive. "We have no choice but to develop new sources and technologies in order eventually to replace fossil fuels. The time to do this is now, when we still have extensive sources of fossil fuels available to make the inevitable changes gradually, without major disruptions or crises." (p. 26).

The following essential challenges are pointed out: 1) The fossil resources are really depleting. We need alternatives for the production of the necessary energy, fuels, and chemicals. (p. 51 ff.) 2) Humanity's responsibility for the observed climate change is real. The green house gas emissions have to be limited and reduced. (p. 72 ff.) 3) Once we produce energy, it still must be stored, transported, and provided in suitable form for subsequent use (p. 132). 4) Eventually, the efficient and economical production of fuels and organic chemicals from CO_2 and water will be necessary (p. 7, 256).

The solutions suggested by the authors are: 1) When all fossil energy reserves will be depleted, the necessary energy will be produced by nuclear reactors—including breeding and eventually fusion reactors. 2) The chemical recycling of CO_2 is necessary alternatively to CO_2 sequestration. While mitigating global warming it will eventually liberate mankind from reliance on fossil fuels. 3) Methanol is a more convenient energy storage medium than hydrogen.

All kinds of fossil energies, their finiteness and economically recoverable reserves and the associated global warming are discussed and documented with comprehensive data in seven chapters to corroborate these suggestions. Thus, the economically recoverable proven reserves of oil, natural gas, and coal contributing 35, 21, and 23 % of the total world primary energy supply represent about 40, 60, and 170 years, respectively, of supply at the current rate of consumption. Most estimates put our overall worldwide fossil fuel reserves as lasting not more than 200 to 300 years considering further fuel reserves such as low-grade coal, tar sands, and oil shale again based on the current rate and distribution of consumption (p. 27).

A simple calculation, unfortunately not presented by the authors, shows that these proven reserves will be completely exhausted in 82 years, at the current rate of consumption. Let's assume, that all human beings want to use as much energy as currently the inhabitants of the OECD countries—a desire that can not be refused—then all proven reserves will be depleted in only 27 years. Thus, there are proven reserves to meet the global energy demand for 27 to 82 years. The rapidly growing world population—growing by 50 % up to about 9×10^9 people in 2050—generating in addition a growing energy demand is not considered in these estimations. The consequences will be conflicts, both regional and global, which can already be seen in the daily news. Hence one has to agree explicitly with the authors that we should use the last reserves of fossil fuels which we are going to exhaust to create the conditions for a sustainable development of our civilization (p. 26).

The correlation of the usage of fossil feedstocks and climate change is discussed in chapter 7. A switch to fuels that emit less or no CO_2 per unit of energy produced will clearly be necessary. In this chapter beginning on p. 81, renewable energies including biomass as well as nuclear energy including nuclear fusion are addressed and the position of the authors is categorically assessed. "Wind, solar, and geothermal energy and energy from the combustion of biomass represent an increasing—but still small—fraction of our energy needs. One of the main obstacles to a wider application of these renewable energy sources is their cost, as well as technological limitations. All this makes the use and extension of nuclear fission power, which is a well established and reliable source of energy that does not emit CO_2, inevitable on a massive scale for the future. Of course, nuclear power should be made even safer, and problems of the storage and disposal of radioactive waste must be solved. There is also a need to develop new generations of nuclear reactors, including breeder reactors and eventually controlled fusion." This position is detailed in chapter 8, which deals, remarkably jointly, with renewable and nuclear energies. However, the most important aspects are developed in the above cited phrases. It is amazing how nuclear energy is presented as the greatest technological and in principle unproblematic achievement of the 20th century (p. 255), whereas in contrast the usage of biomass is stated as being impractical in the necessary order of magnitude. Thus, the authors believe that the disposal of nuclear waste has never been an unsolvable problem giving the remarkable substantiation: "If we were able to build the atomic bomb, we certainly should be able to solve the problems of radioactive byproducts and waste." (p. 126) Tschernobyl is addressed as "a consequence of human error, lack of safety measures, poor construction and design", and, significantly: "The explosion that occurred in Chernobyl however was not nuclear, but chemical." (p. 123) I want to refer the reader for a thorough discussion of the usage of nuclear energy after Chernobyl, including the problem of the disposal, to the articles which appeared in *Nature* (**2006**, *440*, 7087) on the occasion of the 20th anniversary of the disaster. In addition, the reader could expect that the principal problems of the usage of nuclear energy in politically unstable countries and regions, as currently in Iran, should be addressed. Unfortunately, this topic is not discussed. The authors are convinced that, eventually, nuclear fusion as energy source of the future "could provide our energy needs for centuries or millennia to come" and that the fusion reactor will be made practical during the 21st century (p. 130 f.). The late W. E. Parker drew a totally different conclusion in his recent study of the costs, visions, and problems of fusion reactors. "It's time to sell fusion for physics, not power." (Science **2006**, *311*, 1380). Parker may be correct. Billions of dollars, roubles, and euros have been wasted for more than 50 years on the utopian promise of the fusion reactor. Regrettably, the authors do not discuss deeply the extensive literature on the efficient use of our working fusion reactor, the sun, through biomass. After all, it is pointed out that biomass as an energy source has many advantages. It provides a convenient way of storing energy. It includes solid fuels such as wood, liquid biofuels such as ethanol and biodiesel, as well as gaseous fuels in the form of biogas or syngas. The use of biomass is carbon neutral. It is stated correctly that the "energy crops" should be grown on land not dedicated to food crops in order to avoid competition with food production. Furthermore, they should use minimal amounts of fertilizers, herbicides, and insecticides and have limited water needs. However, a large part of the world's agricultural land would have to be devoted to energy crops if they were to supply a substantial amount of our energy needs. Taken together it is stated: "Biomass can provide a significant but nevertheless limited amount of energy that is inadequate to sustain our modern society's needs."

Unfortunately, the authors do not discuss suggestions to reforest the billion hectares of formerly afforested areas which have been degraded and wasted in historical times by human activities in all continents and to harvest from these areas sufficient biomass for the future energy needs. This is indeed a great challenge for science and technology on the way to a sustainable future.

The hydrogen economy and especially the associated problems are discussed in detail in chapter 9. It is self-evident for chemists—but unfortunately not for most politicians—that hydrogen is not a primary energy source but only an energy carrier and that some of its physical characteristics are not well suited for this purpose, especially as a transportation fuel. A totally new and expensive infrastructure would have to be built to supply consumers with hydrogen. This gives the authors the opportunity to introduce the concept of the "Methanol Economy", dealing with the challenges of how to store and to best use energy. They detail in chapters 10–14, that methanol is best suited to do this job. "It is suggested that methanol be used as (i) a convenient energy storage medium; (ii) a readily transported and dispensed fuel, including uses in methanol fuel cells; and (iii) as a feedstock for synthetic hydrocarbons and their products …" (p. 170). A carbon and a hydrogen source are needed for the production of methanol. Currently natural gas is used predominantly as the source for both. For the time beyond natural gas producing methanol by the hydrogenation of CO_2 in suggested. "The required hydrogen will be obtained from water (an inexhaustible resource), using any energy source—atomic or renewable energy." CO_2 could be obtained from the exhausts of fossil-fuel burning power-plants as long as fossil fuels are available. "The carbon source will eventually be the air, which is available to all on earth, while the required energy will be obtained from alternative energy sources, including atomic energy. … At the same time, the 'Methanol Economy' by recycling excess atmospheric CO_2, will mitigate one of the major adverse effects on the earth's climate caused by mankind, namely global warming." (p. 170 f.) "As the CO_2 content of the atmosphere is low (0.037 %), new and efficient ways for the separation of CO_2 are needed." (p. 258). As a matter of course it is mentioned that nature itself recycles CO_2 in the photosynthetic process (p. 258), having an efficiency of about 1 % (p. 108). However: "The subsequent formation of fossil fuels from plant life is … a very slow process requiring hundred of millions of years." It seems to be most remarkable that the authors have lost their confidence in science and in the ability of chemists with regard to this challenge for chemists and engineers to make available the energy and the carbon trapped in biomass and especially in lignocellulose, in wood, for our modern civilization. There is available a comprehensive literature on this topic. The technical realization of the conversion of lignocellulose to hydrogen and carbon monoxide can certainly be realized technically and economically (p. 229 ff.). The conversion of synthesis gas to methanol and hydrocarbons in a Fischer–Tropsch process is clearly state of the art. Thus, a biomass-based methanol economy could be realized technically. The key questions will be if, how, and where the huge amounts of lignocellulose which are needed, will be available. This point was already addressed above.

It is eye-catching that many quantitative data are used in this book. Unfortunately, no quantitative data are given with respect to the suggested methanol production from CO_2 and water which are important. Hence it may be amended. 12×10^9 t of CO_2 had to be separated from air, and 15×10^9 t of water had to be electrolyzed using the energy of 5000 1-GW reactors to generate the hydrogen necessary for the production of about 8.5×10^9 t of methanol equivalent to the world oil consumption of 4×10^9 t of the year 2004. In other words: a methanol plant having a capacity of 1×10^6 t/a would require a CO_2 plant of 1.4×10^6 t/a and a water electrolysis of 1.7×10^6 t/a, and in addition a 1-GW nuclear reactor to produce the necessary energy to electrolyze the water.

On the other hand, the same quantity of methanol can be produced by reforestation of approximately 300–500 Million ha degraded areas and conversion of the harvested wood, approximately 10×10^9 t/a to methanol. An area of about 100000 ha would be necessary for a methanol plant having a capacity of 1×10^6 t/a. In contrast to nuclear reactors reforestation has additional highly important consequences which, unfortunately, are not discussed in this book. 1) The global desertification will be stopped. 2) The global water and especially drinking water resources are regenerated and stabilized. 3) It is the base of a sustainable supply with food and other necessary goods for the global population. 4) High-value jobs will be created in rural areas of developing countries. 5) Reforestation is cheap compared to all other strategies, can be started immediately, has an impact in some few years and can be realized in some decades.

Beyond Oil and Gas: The Methanol Economy is a topical book, which challenges the important questions of this century. This book will contribute to the intense discussion to find the right answers. Some questions have been answered forward-looking. Methanol is a convenient energy storage medium. The carbon which is necessary for the production of liquid fuels and of chemicals will be recycled from the atmosphere, thus mitigating global warming, however, in contrast to the suggestion of the authors this will be by using photosynthesis carried out by trees as has been done for millions of years and not at all by industrial CO_2 separation devices. The necessary energy will be generated by nuclear fusion, however not on earth as suggested by the authors, but by the sun, and plants use this energy "allowing future generations to continue to enjoy planet earth as a hospitable home".

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DOI: 10.1002/anie.200685410

