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POLITICS AND HYDROGEN ENERGY

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Abstract

Fossil fuels, which have been extensively utilized in industrial and domestic applications for a long time, have been causing problems as: energy deficit, environment pollution, global climate changes (global warming), world population migration, major environmental accidents and lower living standards.

European Union approved different research projects about development of hydrogen energy sources, where participated 39 European partners. The work package target was: safety, durability, transport and others.

The Black Sea contains dissolved hydrogen sulphide and its concentration is so high that except a top layer of 120-200 meters in the Black sea is almost no life. Accordingly, if hydrogen energy is produced from hydrogen sulphide in Black Sea deep waters, then the energy demand of regional countries can be partially compensated, and hydrogen energy can be transported to the European countries. This is possible with a power plant and its construction it might be performed by Romania and riparian countries with grants and technical skills appropriate local technologies.

There are claims that Romania and Russia have developed independent projects on exploiting this natural resource in the past, but the development of nuclear energy and the interest on exporting natural gas from Russia prevented their practical achievement. The question is if, the actual economic crisis combined with the energy crisis could make politics change the option in the region and in Europe.

Keywords: Black Sea, hydrogen suphide, co-operation

1. Introduction

Fossil fuels, which have been extensively utilized in industrial and domestic applications for a long time, have been causing problems as: energy deficit, environment pollution, global climate changes (global warming), world population migration, major environmental accidents and lower living standards.

Therefore, we propose another approach towards energetic needs. The first step is to underline the main advantages which the use of hydrogen may provide. Afterwards we refer to some other research projects in the area of energetic resources and what are the main research and development directions within the European Union.

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All these offer a background for our intention to propose a way to use the resources in hydrogen which are located in the Black Sea. Also, we shall refer to some political implications of using hydrogen from the Black Sea, given the geostrategic position of the sea and the political interests that may arise in the area.

The core reason for this topic to be developed is that hydrogen may stand on the verge of becoming the successor to oil. While the history of the oil economy shows that interest in alternative energy wanes with eventual oil price reductions, the current situation is different. Technological advances, huge increases in global energy demands, elevated environmental concerns, anxiety over potential peaks in global oil production, and a new appreciation of the need for energy security have formed a nexus of strong interest in promoting hydrogen as the fuel of the future.

The appeal of hydrogen is undeniable. It promises to resolve energy supply and demand problems in ways that neither non-renewable nor previous renewable sources like solar or wind ever could. It has the potential to render negligible to non-existent levels of damage to the environment. The possibility of producing hydrogen anywhere may mean all nations will have ready access. [1]

Hydrogen made from renewable energy resources is virtually inexhaustible, an environmentally benign energy source that could meet most of our future energy needs. It is more versatile and has more uses than electricity. These uses include energy for businesses, factories, electric utilities, homes, vehicles and airplanes. Hydrogen is also a domestically produced energy source that could reduce our reliance on foreign oil. This specific topic is the main idea which is going to be developed further, in reference to the Black Sea.

2. Advantages of using hydrogen

Besides the already mentioned benefits of the use of hydrogen, some other technical details support the advantages the use of hydrogen may provide.

Given the fact that hydrogen is non-toxic, a clean energy carrier which has a high specific energy on mass basis (e.g., the energy content of 9.5 kg of hydrogen is equivalent to that of 25 kg of gasoline); there are already many production processes for it. These include some processes where some of the hydrogen is contributed by fossil fuels (e.g., steam reforming of natural gas or other light hydrocarbons, gasification of coal and other heavy hydrocarbons), electrolysis of water, direct and indirect thermo chemical decomposition, and processes driven directly by sunlight.

Moreover, hydrogen can be safely transported in pipelines and also be used advantageously as a chemical feedstock in the petrochemical, food, microelectronics, ferrous and non-ferrous metal, chemical and polymer synthesis, and metallurgical process industries, and as an energy carrier in clean sustainable energy systems.

In addition, when combusted, hydrogen produces non-toxic exhaust emissions, except at some equivalence ratios (where its high flame temperature can result in significant NOx levels in the exhaust products). It is also worth mentioning the fact that hydrogen is generated from various energy sources, including the most renewable ones; compared to electricity, hydrogen can be stored over relatively long periods of time, and can be utilized in all parts of the economy (e.g., as an automobile fuel and to generate electricity via fuel cells).

Anyway, we should still not forget to remind of some shortcomings when using hydrogen as a resource for producing energy. When mixed with air, hydrogen burns in lower concentrations, causing safety concern and the storage of hydrogen in liquid form is difficult, as it requires very low temperatures [1].

However, the sustainability of the hydrogen use is proved if we see it as an abundant energy source which in the future could reduce or stop conflict among countries, and will facilitate or necessitate the development of new technologies. Also, it will contribute to the reducing of air, water and land pollution and the loss of forests, and least but not last will reduce energy – related illnesses and deaths.

In these conditions, hydrogen energy systems have the potential to provide the foundation for sustainable energy systems. Production of hydrogen is to be carried out sustainably since hydrogen can be produced from renewable and sustainable energy sources. Energy services are sustainable through hydrogen, since it provides potential uses in the industry, transportation, commercial, institutional, residential and other sectors of the economy with little or no emissions.

Accordingly, the transition to a hydrogen economy should be encouraged, and developed countries, in particular but not only, should increase investments in hydrogen energy.

Hydrogen's attributes as an energy carrier relate to energy demand, production techniques and application fields include the following: clean, not harmful to the environment or life, renewable, securely storable and transportable, broadly utilizable in various applications, producible by different techniques and from various sources, and economically usable.

The advantages underlined before entitle us to forecast that a hydrogen economy will be likely to be introduced in a relatively near term. On the other hand, because it is a complex process which implies a lot of changes and adaptations, the transition shall involve multiple phases.

Thus, in the near term, hydrogen is produced primarily by advanced steam reforming of natural gas, either at central or distributed facilities. This process is an opportunity to decrease the amount of carbon dioxide released to the atmosphere, since a by-product of steam reforming is a high-purity carbon dioxide that can be collected and used, or sequestered in many ways, such as in coal seams, depleted natural gas fields, or saline aquifers.

Afterwards, in the intermediate term, restructuring of the electric utility industry shall enhance opportunities for distributed generation, where hydrogen-powered fuel cells provide on-site generation of electricity. In addition to electricity, these fuel cells produce thermal energy for hot water, space heating, and industrial processes. During this phase, hydrogen could be increasingly produced from coal and from the pyrolysis or gasification of biomass. Biomass for hydrogen production comes from dedicated crops, agricultural residues, or municipal solid wastes.

Dedicated crops are particularly valuable for offsetting carbon dioxide emissions because biomass crops re-grown specifically for energy recycle carbon dioxide from the atmosphere, resulting in no net carbon dioxide emissions. In the intermediate term, an increasing number of hydrogen-fuelled zero-emission vehicles will also be on the road, due to improvements in onboard storage and other technologies. This occurrence, in turn, shall provide impetus for building a hydrogen infrastructure along dedicated transportation corridors or clusters of use.

Finally, in the long term, strong hydrogen markets and a growing hydrogen infrastructure offer the background for renewable hydrogen systems. Intermittent energy technologies such as wind turbines or photovoltaic, for example, could power electrolysis to produce hydrogen for fuel cells. The fuel cells use the hydrogen to provide electricity during higher demand periods or to supplement the intermittent energy sources. This era shall likely witness the emergence and growth of advanced technologies producing hydrogen from water and sunlight and storing it in high-energy-density systems. Market penetration of advanced technologies to produce, store and use hydrogen will be the landmarks of the establishment of the hydrogen energy economy.

In conclusion, for hydrogen technologies and systems, applications of exergy methods can have numerous broad and comprehensive benefits such as a better knowledge of the efficiencies and losses for the technologies and systems, and how they behave and perform; a clearer appreciation of the environmental impacts of hydrogen energy systems, as well as the mitigation of environmental that they can facilitate; and better identification of the ways hydrogen systems can contribute to sustainable development [1].

Although hydrogen offers numerous advantages to society, it has not been perceived by the individual consumer yet. It is clear that hydrogen energy presents neither financial nor technological problems. The barriers to the hydrogen energy are not technical but the mindset, regulatory and political interferences are the source of the problems.

3. EU and the hydrogen energy: research, initiatives and policies

Presently, the use of hydrogen as a resource is not widely applicable. This is why thorough research is required. In this respect, the European Union is a key player, especially because in the field of world energy it has already developed an integrated and well-organized energy market. However, in terms of energy policies, there are some adjustments and improvements to be considered in the future.

The EU is the world's largest importer of fossil fuels and is leading the global action in accelerating the transition to renewable energy and low-carbon economy at present. Renewables make the second-largest contribution to domestic energy production after coal.

Renewable energy flows in Europe are large in comparison with commercial energy demand. Technologies exist to tap these flows, at costs that often are competitive if the evaluation includes external costs and benefits, and subsidies to conventional energy are eliminated. If renewable energy is to grow to a much larger fraction of energy supply, there must be a combination of efficient and effective policy instruments to reach the guiding objectives, an appropriate technical and regulatory infrastructure, clear and efficient administrative procedures, public acceptance, R&D leading to innovation, new technologies entering the marketplace, and a cadre of professionals to design, build and operate renewable energy systems.

The European Union is also one of the largest economic entities in the world. Although there is a signification and fast integration of many relevant policies of the EU members' states, the development of a common EU energy policy in its different dimensions is a complicate process. Furthermore, the enlargement of the UE created new challenges for energy policy and the energy policy arena in Europe [2]

Although some member states have the capacity to develop individual energy programs, as is the case of Germany, the most important regional policy initiative comes from the European Union (EU) and European Commission (EC).

In this respect, we refer at a major report issued by the EU/EC in 2003 that outline the hydrogen vision [3]. The report is a significant indication of the EC's commitment to a long-term conversion to a hydrogen economy — the first major political body to do so beyond Iceland and Japan. A High-Level Group (HLG) was put together to examine the potential contribution that hydrogen and fuel cells can play in the long run to achieving viable, sustainable energy systems for Western Europe. It consisted of representatives from some of Europe's leading energy, automobile, and research institutions, i.e., 'stakeholders'. The report suggested that traditional fossil fuels and nuclear power can be used to produce hydrogen energy, along with renewable energy sources, though with carbon sequestration in the case of the former feedstocks.

The report recommended at the moment the creation of a European Hydrogen and Fuel Cell Technology Partnership. It also suggested drafting of a Strategic Research Agenda and a Roadmap to define research priorities, for planning, to set technical targets, and to outline pathways for the development of European hydrogen and fuel-cell technologies. The driving forces behind these recommendations were both to secure a sustainable energy future (and to not contribute to global climate change), to secure diverse energy sources and avoid over-reliance on Middle Eastern oil imports.

The same document noted that renewable energy would play an increasingly important role in hydrogen energy production, along with nuclear power but, in the short term, de-carbonized fossil fuel extraction would continue to be the primary hydrogen source. There are of course dissenting views to this philosophy, e.g. in the UK and especially in Germany, where wind and solar energy are thriving [3].

In the last years, EU has intensely and constantly invested in The Fuel Cells and Hydrogen Joint Technology Initiative. Therefore, in the area of fuel cells and hydrogen research, and in order to address the energy challenges facing Europe, within the EU Framework Programmes (FPs) the funding increased from 8M€ in FP2 to 315M€ in FP6. Thus, the financial effort is not sufficient, as there are still barriers, technical and non-technical as well, and strong global players such as US, Japan, China and emerging countries imply a strong international competition [*The Fuel Cells and Hydrogen Joint Technology Initiative*, MEMO/08/617, Brussels, 14 October 2008, online at http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/08/617&format=HTML&aged=0&language=EN&guiLanguage=en].

The results expected within the Fuel Cells and Hydrogen Joint Technology Initiative should be reinforced. Thus, the initiative is expected to develop in its area of research technologies to the point of commercial take off and also enable industry to take the large-scale commercialization decisions necessary to achieve mass market growth in the time-frame 2015-2020. Moreover, for stationary fuel cells (domestic and commercial) and portable applications, the JTI will provide the technology base to initiate market growth from 2010-2015.

For example, within the Sixth Framework Programme it was developed NATURALHY, an integrated project co-financed by the European Commission. Its main objectives were to contribute to the establishment of the hydrogen economy in two steps: identifying and removing potential obstacles of the hydrogen as an energy carrier, and start the practical transition towards the hydrogen economy [online at http://www.naturalhy.net/index.php?option=com_content&view=article&id=45:joomla-community-portal&catid=25:the-project&Itemid=28]. The project reunited several companies, having as core business the transmission and distribution of gas.

For urgent progress towards developing hydrogen as a realistic energy option, a practical strategy must be adopted within the context of the existing, extensive natural gas system. In the view of the NATURALHY partners, this is the only realistic solution to large-scale distribution of hydrogen in Europe in the next 30 to 50 years [O. Florisson and R. Huizing, *A practical step towards "hydrogen": The conditions under which existing natural gas system can be used for mixtures of hydrogen and natural gas (the NATURALHY- project)*, International Gas Research Congress, Vancouver, 2004, online at http://www.naturalhy.net/docs/presentations/A%20practical%20step%20towards%20hydrogen.pdf].

The results showed that the hydrogen economy will enhance innovations as well as economic prosperities with the support of appropriate policies. Formulating such policies requires a timely and detailed understanding of the latest R&D trends and developments in science and technology policy in all developed countries, and the comprehensive analysis of these developments to enable accurate predictions of future science and technology trends [4].

Several factors have led to growing interest in a hydrogen energy economy, especially for transportation. A successful transition to a major role for hydrogen will require much greater cost-effectiveness, fuelling infrastructure, consumer acceptance, and a strategy for its basis in renewable energy feedstock. Despite modest attention to the need for sustainable hydrogen energy system in several countries, in most cases in the short to midterm hydrogen will be produced from fossil fuels.

The idea of being above all a European initiative is supported by the officials' declarations. The EU Commissioner for Science and Research, Janez Potočnik, said: "*(...) the development of new technologies is crucial if we are to meet EU objectives to address climate change and energy challenges (...)This JTI brings together the most significant players to put Europe ahead of the game in new energy technologies. I hope we will see a snowball effect in other strategic research areas.*" The Chairman of the Governing Board of the Joint Undertaking, Gijs van Breda Vriesman, adds: *"The Fuel Cells and Hydrogen Joint Technology Initiative is the best possible vehicle to accelerate the development of technologies and bring the commercialization of hydrogen and fuel cells forward. The JTI provides us with the unique opportunity to implement our plans on a large European scale.*" [*Developing New Energy for the future: Europe launches a 1 billion Euro project to get into pole position for the Fuel cells and Hydrogen race*, IP/08/1498, Brussels, 14 October 2008, online at http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/1498&format=HTML&aged=0&language=EN&guiLanguage=en] The former speaker put forward again the need to ensure cooperation of all stakeholders involved: Research, Industry and Government, at regional, national and European level.

In terms of commercial take off of the hydrogen technologies it becomes worth mentioning the EU initiative in road transport. An official press release from 2008 referred to EU funding a scientific research project – The HyWays - which has found that introducing hydrogen into the energy system would reduce the total oil consumption by the road transport by 40% between now and 2050. Thus, the transition is not expected to be easily made, as some economic, technological and institutional shortcomings have been noticed. Supporting the idea of common effort towards a hydrogen economy, the HyWays project brings together industry, research institutes and government agencies from ten European countries. So far, following a series of more than 50 workshops, the project has produced a Roadmap (based on country specific analysis from Finland, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Spain and the United Kingdom) to analyze the potential impacts on the EU economy, in particular and on society and environment in general. Also, it established an action plan detailing what are the necessary steps to be followed in order to introduce on a large – scale the use of hydrogen [*European research shows that hydrogen energy could reduce oil consumption in road transport by 40% by 2050*, IP/08/299, 25 February 2008, online at http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/299&format=HTML&aged=0&language=EN&guiLanguage=en].

In order to reinforce the advantages of using hydrogen as a resource, we restate that it is one of the most realistic options for environmental and economic sustainability in the transport sector, in particular passenger transport, light duty vehicles and city buses. The HyWays Roadmap estimates that in 2030 there will be 16 million hydrogen cars and the total cumulative investment for infrastructure build-up will amount to €60 billion.

4. Iceland and Norway

So far, we mentioned merely hypothetical development towards hydrogen economy, but they are examples which show us actual measures in this area. Iceland and Norway, two countries which are not members of EU, seem to be the most serious players about transitioning to a hydrogen-energy economy

Iceland captured world attention in February 1999 when it declared a national goal to convert its economy to hydrogen energy by 2030. With only 294,000 inhabitants and no fossil fuel resources, Iceland has tapped its ample hydroelectric and geothermal energy resources to supply over half of its energy requirements and almost 100% of its electricity needs. The oil-import dependence of Iceland's significant automobile and fishing boat fleets is high, however, which are the primary targets for the planned conversion to hydrogen. ***With inexpensive electricity at 2 cents/kWh***, Iceland already makes 2000 tons of electrolytic hydrogen a year and thus hopes to provide sufficient renewable hydrogen for its entire transport sector [2].

While Norway also has nearly 100% renewable electricity generation from its abundant hydroelectric resources, unlike Iceland it has extensive natural gas resources, production, and expensive cars, gasoline and diesel fuels due to high taxes. This context makes Norway highly suited for a transition to hydrogen energy. A National Hydrogen Commission was established in 2003, which released its report in 2004. An initial 10-year development program and US $125–145 in funding was recommended. A 580-km hydrogen highway already has been launched between Stavanger and Oslo, with several new fuelling stations to be built along this corridor [2].

5. International cooperation

Given the high importance of this area of research and development, the international cooperation becomes crucial for its success. For example, the International Energy Agency (IEA) has recognized the potential benefits of a hydrogen economy since it launched its Hydrogen Agreement 35 years ago (!).

Moreover, the IEA recognizes the technological potential of hydrogen to contribute to a stable, sustainable supply of energy and to reduce carbon dioxide emissions. Consequently, recent projects focus on collaborative research support among member nations on cost-effective hydrogen production, transportation, distribution, end use and storage based on renewable energy sources. The current hydrogen research priorities of the IEA are electrolysis from photovoltaic cells, wind and biomass energy sources, storage in metal hydrides and carbon nanostructures, and integrative modelling tools [5].

The next steps toward commercial deployment of cost-effective hydrogen energy technologies may be facilitated by the International Partnership for the Hydrogen Economy (IPHE). The IPHE was established during a meeting in Washington, DC, hosted by the DOE, from November 18–21, 2003 and reunited countries from all over the world. The IPHE coordinate its activities with the IEA and it hopes to achieve a practical option for participating countries' consumers to be able to purchase a competitively priced, safe, hydrogen-powered vehicle that can be conveniently refuelled, by 2020. A Shell Hydrogen representative estimated that $20 billion would need to be invested to supply just 2% of Europe's cars with hydrogen by this date [5].

The work of the IPHE shall reflect the policies of its member states in their focus on energy feedstocks. Thus, the initial assumption is that the hydrogen sources will be a mix of fossil fuels, nuclear power, and renewable energy sources, reflective of national energy mixed and policies as discussed earlier.

6. The Black Sea

These specific initiatives proves us *it is possible* and in the future we shall seek every chance to valorise the resources held by Romania in this respect.

Romania's coast to the Black Sea measures 240 km and this background advantage entitles us to review the possibility to use its water column as a resource for hydrogen.

Therefore, the water column of the Black Sea consists of heterogeneous layers, which do not mix. The top layer - a 'living': ordinary water, which is inhabited by marine organisms. The lower layer - the 'dead': it contains dissolved hydrogen sulphide being the world's largest water body containing H_2S, and its concentration is so high that except the upper layer of 120-200 meters in the Black sea is almost no life.

Being an acid gas, H_2S is generally considered to be an environmental pollutant. Hydrogen sulphide occurs naturally, and its concentration is nearly constant, around 9.5 mg/L at 1500 m depth. Its high solubility, and the existing chemical environment facilitate its accumulation and containment in the seawater, and its extraction poses a challenge.

We must to mention that the total hydrogen potential in Black Sea deep waters is almost equal to 808 million tons of gasoline or 766 million tons of NG (natural gas) or 841 million tons of fuel oil or 851 million tons of natural

petroleum. These values show that the hydrogen potential from hydrogen sulphide in Black Sea deep water could play an important role to supply energy demands of the regional countries. Thus, it can be said that hydrogen energy reserve in Black Sea is an important candidate for the future hydrogen energy systems.
Furthermore, if hydrogen energy is produced from hydrogen sulphide in Black Sea deep waters hydrogen energy could be also transported to the European countries. This would be possible with a power plant and its construction it might be performed by Romania and riparian countries with grants and technical skills appropriate local technologies.

Possibility of hydrogen and sulphur production from H_2S contained in the waters of Black Sea was investigated conceptually. A multistage process is considered which involves extraction of seawater, adsorption of H_2S, electrochemical production of hydrogen and polysulphides; fresh water production by desalination of seawater and further hydrogen production from the resulting salty solution through chlorine–alkaline electrolysis [6].

Considering H_2S as a pollutant and a source of hydrogen and sulphur, development of a technology for its decomposition will contribute to the global objectives regarding reduction of environmental pollution, decrease of waste and more effective use of resources. The reduction of H_2S is not only a solution to the anoxicity problem in the Black Sea, as its contribution to sustainability of life in the oxygenated top layer may be significant [7]. Anyway, a new technology aiming at pollution reduction may have to compete with already established technologies in the field.

As we already mentioned before, apparently the most solid obstacles towards an efficient use of the H_2S from the Black Sea remain for the moment the political issues. Although there are not official statements regarding the energetic intentions of Russia in the area of Black Sea, we mention forward some key aspects in this regards.

7. Political issues in the area

As the likelihood increases that Russia will dominate the European Union's (EU) energy supply, questions have emerged as to whether Russia would use the energy weapon to influence EU member policies and extract political concessions. Looking to the future, the plausibility of Russia using the energy weapon to exploit Europe's dependence, particularly on gas, is also examined [8].

There are claims that Romania and Russia have developed independent projects on exploiting the hydrogen sulphide from the Black Sea in the past, but the development of nuclear energy and the interest on exporting natural gas from Russia prevented their practical achievement. The question is if, the actual economic crisis combined with the energy crisis could make politics change the option in the region and in Europe.

On the other hand, Turkey has become in the last years an important player interested in exploiting this natural resource in order to solve some of its energetic problems. Furthermore, a co-operation with Romania and Bulgaria having as result the export toward Europe of this source of energy, could increase its adhering chances to EU, jeopardized by the bad relation with Armenia, another regional actor, which has a strong support on this subject from France – one of the most important pillars of EU.

Anyway, we support the idea that for the greater benefits which may be brought by an efficient use of the hydrogen resource from the Black Sea, there must be found a resolution in the political area.

Reviewing the examples which led to the development of the alternative sources of energy, respectively the hydrogen (technological development, ideas regarding the infrastructure, the design and adaptation of policies, experience), an important step forward would be a strategic political view which will enable the use of hydrogen from the Black Sea. In this regard, the same approach of joint partnership should be enabled in order to design common policies towards the use of this resource.

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