

The Production of Hydrogen based on Renewable Energy Sources – a Concept for the Sustainable Development of the Dobrogea Region

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Abstract

The concept of hydrogen economy is strictly connected to the sustainable development strategies. The key issue for the implementation of such a concept consists on the development of efficient technologies for the conversion of renewable energy sources to hydrogen. The paper includes the partial results of project HyRes, which aimed the evaluation of renewable energy sources from the Dobrogea region in order to conceive a distributed energy supply system based on hydrogen energy technologies.

Key words: *hydrogen economy, renewable energy sources*

Introduction

The Center for Advanced Engineering Sciences from „Ovidius” University of Constantza, coordinated a scientific research project dedicated to the evaluation of renewable energy resources available in Dobrogea region and of the conversion technologies of these energy resources for the production of hydrogen to be used as a future energy vector in an alternative energy concept system for the Dobrogea region. The research objectives have been structured as followings:

- The evaluation of biomass, wind and solar energy potential in the Dobrogea region;
- Defining the energy technologies for the production of hydrogen and evaluation of their efficiency, productivity and environmental impact;
- Development of an alternative energy concept system for the Dobrogea region correlated with European strategy in the field;
- Defining of implementation directions;
- Promotion of a awareness program for the local authorities and population regarding the exploitation of renewable energy sources through hydrogen energy technologies.

Romania is a country with significant potential of renewable energy sources (RES). Almost 40% of Romania's total land area (approx. 9 Mio ha) is considered arable.

In 2004 around 14 Mio t of Maize, 1,5 Mio t of Sunflower, 300.000 t of soybean, 100.000 t of rape seed and 670.000 t of sugar beet were cultivated.



Fig. 1. The Dobrogea region.

The Dobrogea region has over 1,557 kha, of which the farming land is of about 931.5 kha. The forests cover 128.3 kha and inland water surface 396.8 kha. The sea shore line is of 245 km.

Theoretical details

The production of hydrogen from renewable energy sources is one of the fundamental issues for the sustainable development [1]. The concept of sustainable development may be defined in simple words as: to meet the needs of the present without compromising the ability of the future generations to meet their own needs. The sustainable development strategy mix consists on the following components:

- efficiency – enhanced productivity / resource;
- consistency – enhanced economies embedded in the natural cycles;
- sufficiency – new concept of prosperity / satisfaction / material wealth.

The most important aspect in the new approach is that the three components can be considered only together but each of them should reach new levels of performance. Some of the management rules for the implementation of the strategy mix have might be defined as followings:

- the use of renewable natural resources must not exceed their regeneration rates;
- the use of non-renewable natural resources must not exceed the rate of substituting their respective functions;
- the emissions of pollutants must not exceed nature’s capability to adapt.

The development of a concept of sustainable energy supply based on hydrogen energy technologies might be developed as it is shown in figure 4. The system consists on the integration of several technologies for conversion of solar direct to hydrogen or by using the “derivatives” of solar energy namely wind and biomass and converting them to hydrogen.

The hydrogen is an energy carrier allowing the distribution through pipelines towards end-users and storage. At the end-user, the hydrogen is converted to electricity and heat at very high efficiency levels by using fuel cells.

The main advantages of such a system consist on covering the whole three aspects of sustainability:

- the highest efficiency rates of conversion using fuel cells;
- embedment of the conversion cycles into the natural cycles;
- production of electricity on demand.

At the same time, the hydrogen energy technologies have also two major contributions to the energy security namely:

- the fuel flexibility;
- distributed production of electricity.

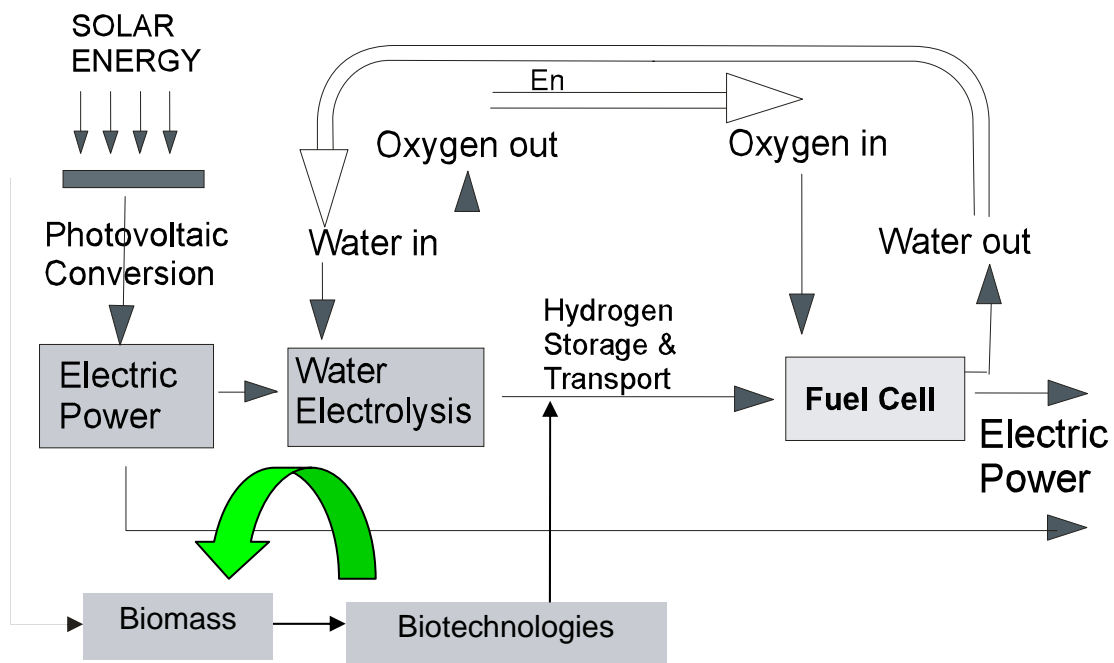


Fig. 2. The concept of sustainable energy supply system based on hydrogen energy technologies

The constrains for the development of such a concept for the Black Sea region are numerous starting from the existing conditions in the region up to the entry barrier of hydrogen energy technologies [2].

Results

Evaluation of Biomass Potential from Dobrogea Region

The research regarding the biomass potential in the Dobrogea region it has been divided into three large areas:

- biomass produced in Black Sea costal region;

- biomass produced in the Danube Delta and surrounding lakes;
- biomass produced on the inland.

The estimation of biomass on wetlands, the research has been correlated with data accumulated in the last three decades involving different plants especially for the lakes and wetlands from the coastal region. The figures obtained from these studies place the production between five and eight tones of biomass per day per hectare, for 150 days per year. So, the annual yield can reach between 770 and 1200 per hectare of wetland. These areas represent 350.9 thousand hectares in Tulcea County and 45.9 thousand hectares in Constanta County. Thus the total potential of the two counties is of 305 690 / 476 400 tones/year.

Regarding the potential of biomass yields from Danube Delta, it is estimated that the annual average of Danube flow is of 6400 cubic meters per second, maximum flow being registered in 1970 (15540 m³/sec), in 1958 (17799 m³/sec) and in 1897 (35000 m³/sec). The minimum flow was registered 1921 and it was of 1350m³/ sec. The salt concentration from Danube waters grew from 170mg/l in 1900 to 425 mg/l in 1990. In one year there are 86 million tones of salt that can assure the production of approximately 2 billion tones of biomass per year. These measurements show an important increase of pollution rate and Danube water eutrophication, which would impose the implementation of urgent strategies and measures. Among these, biomass production represents one of the most important active measures, even if in the beginning only a small portion of the estimated potential will be exploited.

Regarding the biomass production on the Dobrogea's dry land, the total farming surface is of 362.2 thousand hectares in Tulcea County and 568 thousand hectares in Constanta County. The forest regions represent 92.9 thousand hectares in Tulcea County and 35.4 thousand hectares in Constanta County. The total amount is of over 930 thousand hectares for farming and can produce 93 million tones of sorghum, thus almost 5 million tones of bioethanol and 4 million tones of solid fuel. The 1250 thousand of forest hectares can produce approximately 4 million tones of biomass per year.

Evaluation of Wind Energy Potential

Wind energy potential was evaluated based on the corroboration of data published in the literature and of monitoring wind characteristics on specific locations. The potential of wind energy is very high in Dobrogea region compared with the other regions of Romania. It is estimated (ICEMENERG 2006) that at national level there is a potential to use wind energy, technically achievable, of 8 TWh/year from which it can be exploited economically 5.3 TWh/year. With an average wind speed between 5 – 11.5 m/s, Dobrogea is the region that can assure half of the national potential.

The main problems that limit the development of wind energy in Dobrogea region regards the sensitivity of wind energy projects on a series of environmental factors, the possible impact on RADAR equipment located in the region and the limits of the national energy system which is not able to operate and to transfer electrical energy fluxes that would be produced by wind farms. The project emphasized also the existence of wind energy potential in the off shore region from the Black Sea.

In order to validate the data regarding wind energy potential, it was developed a mobile station to measure wind parameters that consists of a metallic structure, easy to disassemble, with a height of 10 meters, on which are placed measurement equipment and an automatic acquisition system, connected to the wind energy evaluation laboratory within the Center for Advanced Engineering Sciences.

Evaluation of Solar Energy Potential

In order to evaluate the solar energy potential, there were comparative analyses between data published in the literature. In the National Strategy for Renewable Energy Resources it was considered that the solar energy potential in Romania has an average value of 1100kWh/m² per year.

The level of solar radiation can be determined based on the location with some radiation charts. In Dobrogea region, radiation intensity is higher than 1150kWh/m² per year and the annual radiation is more than 1600 hours. Compared with the European situation, the solar energy potential from Dobrogea is between average and high, being exceeded only by southern regions from Spain, France, Italy, Malta, Cyprus, Albania and Greece.

Alternative Distributed Energy System Concept for the Dobrogea Region

The concept of a system with distributed energy resources assures the production of electrical energy with a minimum environmental impact and maximum efficiency on locations close to the end user. Based on the evaluation of renewable energy resources, a concept was proposed to assure the distributed production of energy, using an intermediate stage to convert energy into hydrogen.

The hydrogen is considered to be a potential candidate to become the vector or the energy carrier for the next century. The concept of distributed system of energy for Dobrogea region is a hybrid concept which integrates many conversion technologies, transport and storage. Thus, to use wind energy, it is recommended connecting wind farms directly into the national energetic system (SEN). Presently there is an estimated capacity of 600 MW of the SEN to transfer the energy produced by wind farms. For a complete use of wind energy potential from Dobrogea area a series of investments are necessary to upgrade SEN, by installing intelligent network equipment but also the expansion of the capacity of the network to take over the electric energy for the national and regional end users.

In order to use solar energy, it is considered that the best alternative is the conversion into thermal energy, in order to be used in hotel industry and residential system.

Regarding the use of biomass, it can be achieved by processing biomass in order to obtain biogas and singas, to be used as a fuel for local applications and also for the conversion of biomass into hydrogen for mobile applications.

In order to test the conversion procedure of biomass into hydrogen, it was developed a multifunctional stand for scientific research activities on biomass processing for hydrogen production. The stand consists of two main modules, namely a biomass processing module by oxygen free fermentation and biogas production and a second one that consists of a biogas reforming installation and hydrogen production.

Conclusions

The Dobrogea Region is a very special region of Romania with a large potential of RES but, also a region which is sensitive to environmental constrains.

The use of the RES should take into consideration the complexity of the regional conditions without harming the very special protected ecological areas.

The results obtained from HyRES project have demonstrated the possibilities of the development of a distributed energy resources strategy for the region based on a mix of technologies that might include the hydrogen energy technologies.

References

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Producerea hidrogenului din surse energetice regenerabile - concept de dezvoltare durabilă pentru zona Dobrogei

Rezumat

Conceptul de economie bazată pe hidrogen este în mod strict legată de strategiile de dezvoltare durabilă. Problema esențială pentru implementarea unui astfel de concept constă în dezvoltarea de tehnologii eficiente pentru conversia resurselor energetice regenerabile în hidrogen. Lucrarea propusă include o parte a rezultatelor obținute în proiectul HyRES care a avut ca scop evaluarea resurselor energetice regenerabile din zona Dobrogei în vederea conceperii unui sistem energetic alternativ care să integreze tehnologiile energetice pe bază de hidrogen.