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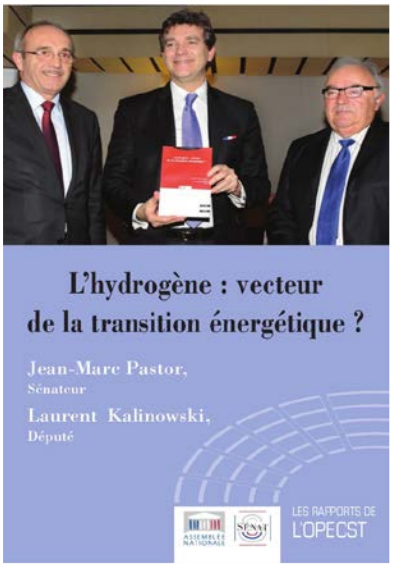
Hydrogen: an energy carrier for energy transition?

Summary of the report submitted on behalf of OPECST
by Laurent Kalinowski, MP, and Jean-Marc Pastor, Senator

OPECST received a request from the Senate Economic Affairs Committee for a study on "the numerous questions arising from the development of a hydrogen sector, ranging from production of the gas, its storage and transport, to its final use". Following an enquiry which led them to meet with close to two hundred experts directly involved in the energy uses of hydrogen, as well as in wider energy matters, Laurent Kalinowski and Jean-Marc Pastor sought to answer these questions in their report, while situating their work in the wider context of current thinking on energy transition. The report was unanimously approved on December 18 2013.

Improving the integration of renewable energy

As shown in previous reports of the OPECST, large-scale variable energies such as wind and solar require, in addition to other solutions, such as "smart grids" and erasing, devices for massive energy storage. Indeed, only the latter are able to compensate in the long term for the significant fluctuations in the production of renewable energy.



Combining renewable energy devices with energy storage makes it possible to reduce very significantly the peaks in demand on the power grid, and thus the need to update its infrastructure. While these storage devices have a cost, it has the advantage of being quantifiable in advance. On the other hand, it is clear that the deployment of variable energies without associated storage leads to the discovery, after the fact, of the effects on the network and of the extent of the upgrading required. In this matter, hydrogen could play a complementary role to that of existing solutions, such as electrochemical batteries and Pumped Storage Power Stations (PSPS).

Replacing fossil fuels

Compared to other technologies for energy storage, the value of hydrogen is twofold. First, it imposes no restrictions in terms of geographic location or dimensioning. Moreover, hydrogen is not merely a means of storing electricity for later return. It allows direct use of the energy stored for diverse applications: as fuel for vehicles or for micro CHP in buildings, for direct injection into the gas grid, in proportions of about 5% (or up to 20% by modifying existing infrastructure), for the enrichment of biofuels to create synthetic fuels, and as a component for chemistry. These direct uses of hydrogen correspond to energy needs which go beyond those met by electricity generation.

For these reasons, the rapporteurs consider that hydrogen produced without CO_2 emissions could play an important role in the coming energy transition, helping to circumvent the twin obstacles of the variability of new energy sources, and the need to find substitutes for hydrocarbons.

Transforming hydrogen into a carrier for sustainable energy

Hydrogen is the lightest and smallest element in nature, and also contains the most energy per unit weight. On our planet, it is almost

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always found in combination with other atoms.

From these compounds, obtaining hydrogen in the form most useful to energy applications, dihydrogen (H_2, itself commonly called hydrogen) requires an energy input. Unlike fossil fuels present naturally in the subsoil, hydrogen is not an energy source but an energy carrier which can store or transport energy from other processes.

As with electricity, all sources of energy known to date — fossil, nuclear and renewable — make it possible to produce hydrogen. An economy based solely on these two vectors could therefore dispense with any exclusive dependence on a single source of energy.

Research into the exploitation of natural hydrogen

IFP Energies Nouvelles has begun researching the possibility of using land-based sources of natural hydrogen, which are spread over all the continents. These investigations have determined the location of possible sources in Europe: northern Italy, Cyprus, Greece, Russia, and in small quantities in southeastern France. If the research carried out leads to the conclusion that these sources can be exploited under acceptable economic and environmental conditions, hydrogen would then become not only a carrier, but also a source of sustainable energy.

Despite the variety of possible sources, most of the hydrogen produced today — about one million tons in France, primarily for use in chemistry and petrochemicals — is from natural gas or other hydrocarbons. Related technologies, such as steam reforming, steam cracking, etc., are well in hand and are continually being optimised. At the point of production, the average price of hydrogen obtained is about two euros per kilo, which is quite competitive. However, there would be little advantage in using this hydrogen as a substitute for oil, as its production emits CO_2. It would of course be quite different if natural gas were replaced with biogas or coal with wood materials.

However, electrolysis of water is now the mode of hydrogen production which is most promising for energy applications. This is the chemical separation of the water molecule in oxygen and hydrogen under the influence of a direct electric current between two electrodes. There are currently three main technologies: alkaline electrolysers, proton exchange membranes (PEMs) and solid ceramic electrolytes. Unfortunately, each of these technologies has drawbacks. Given these limitations, the area of electrolysis remains wide open to scientific investigation and industrial development, and should be supported, for example by taking the duty off electricity used in the electrolysis of water. Because of its very low density, the storage, transportation and distribution of hydrogen are more difficult than for liquid fuels. Progress in the field of storage under pressure — at 350 or 700 bars — or in solid form, including hydrides, means that even in the case of demanding applications such as motor transport, the range of solutions available should meet needs, at an acceptable cost, after industrialisation. It is quite different in the case of the transportation of hydrogen, which will remain expensive. For this reason, decentralised solutions making it possible to produce hydrogen closer to the places of consumption should be preferred.

Measuring the range of applications of hydrogen energy

Almost all energy uses of hydrogen pass through a device for producing electricity directly: the fuel cell. This uses an inverse principle to that of electrolysis. As with electrolysers, there are several types of fuel cells, including two major ones: low temperature batteries with a proton exchange membrane — well suited to mobile applications — and solid oxide fuel cells operating at very high temperatures, which are more suitable for stationary applications.

Progress in these two categories of fuel cells, in terms of price, reliability and service life, explains why energy applications of hydrogen are increasing, although they are still limited to niche markets. In 2012, 46,000 fuel cells were sold worldwide, an increase of 86% in one year. As shown by the public hearing on October 30, 2013, these niche markets relate to uses for which the advantages of the fuel cell and hydrogen allow them to win out against existing technologies, e.g. for energy autonomy in remote locations, or for forklifts. These uses should precede applications for the general public in areas such as aids to mobility, recharging phones and computers, cars, and micro-CHP: the production of electricity and heat in buildings.

Where cars are concerned, the exclusive choice by the two major domestic manufacturers of the 100% electric vehicle led to the identification of mobility applications where the hydrogen vehicle could become competitive with other solutions on the market. One of these is service vehicles, which amount to 15% of light vehicles. This is why the development of such solutions should be encouraged, by extending the benefit of the environmental bonus to commercial vehicles whose CO_2 emission threshold is below 20 g/km. In order not to increase corporate taxation, this bonus would be funded solely by an insurance premium on passenger cars. The opening to the public of hydrogen stations serving these fleets should also encouraged.

Connecting the electricity and gas networks through "Power to Gas"

In addition to these applications, which use the fuel cell, another is developing, which concerns the direct reuse of hydrogen in the gas system, known as "Power to Gas". The advantage of this technology is that it enables exchanges in both directions between electric and gas networks. So far, only the production of electricity from gas has been possible. However, electrolysis combined with the injection of hydrogen enables the discharge into the natural gas grid of surplus electricity production, particularly from intermittent renewables. According to a study presented by GRT-Gaz, by 2030 there will be twenty-five terawatt hours of annual surplus production, which could be converted to reduce gas imports, with a final cost equivalent to that of the latter.

Creating the conditions for the emergence of an innovative new industry sector

At the end of their study, the rapporteurs find that simultaneous efforts undertaken in recent years by several countries, in research and development of hydrogen technologies and energy, have helped to unlock the last barriers which restricted usage, even though these initially concern specific markets.

France has significant scientific and industrial potential in this area, as the rapporteurs have had the opportunity to verify, with interviews and visits, throughout their study. This is true in France, both nationally and locally, but also abroad, the sector being already largely export oriented.

In the context of energy transition, the rapporteurs consider that, alongside other technologies, the development of these new hydrogen applications allows better integration of variable renewable energies, by facilitating the storage of electricity, and would contribute the substitution of fossil fuels, particularly in transportation.

They stress the importance of a strong Government commitment to integrating and coordinating the efforts of all those involved in this new industry. They feel it is imperative to address regulatory barriers to innovation, alongside other measures to ensure the emergence of new markets for hydrogen. Finally, they emphasize both the essential role of the territories in the development of this energy vehicle, and the need to take its European dimension into account.

To this end, the rapporteurs propose five major guidelines to create conditions for the development of a national hydrogen energy sector.

Five guidelines for structuring a national hydrogen energy sector

Guideline n° 1 - Establish the three-fold organisation necessary for the development of a national hydrogen sector and a steering committee

1. The Government must state, at the highest level and at the earliest opportunity, the strategic importance for a successful energy transition of hydrogen as an energy carrier, and of the development of a corresponding national industrial sector .

2. Bring together before 30 June 2014, industry players in the hydrogen sector around a coherent project and program of medium-term development, which will allow our country, within five to ten years, to have competitive solutions at the main points of the value chain, from production and storage to the use of hydrogen energy.

- Mobilise resources from the private sector through the use of public-private partnerships at national, regional and local levels.

- Given the transverse nature of hydrogen energy, complete the implementation of this three-fold organisation by adding a 35th Recovery Plan aimed at developing applications.

3. Create, before June 30, 2014, a National Steering Committee of the hydrogen sector, under the auspices of the Ministry of Productive Recovery, which will be a forum for consultation, referral and follow-up, including in particular representatives of the state, ANCRE (the French National Alliance for Energy Research Coordination), the Parliamentary Office, and the territories, along with the major industry players and SMEs concerned, to monitor the development plan set for the sector.

Guideline n° 2 - Overcome regulatory barriers to innovation

- Before March 31, 2014, re-specify the conditions for the application to hydrogen energy uses of existing legislation on industrial production of hydrogen, particularly with regard to individual applications in limited volumes or for internal use.

- Reassess before March 31, 2014, the thresholds for hydrogen storage, particularly in respect of individual uses in limited volumes or for internal use.

- Mission INERIS (the National Competence Centre for Industrial

Safety and Environmental Protection) before March 31, 2014, in conjunction with the Hydrogen Technology standardisation commission of AFNOR (the French Standardisation Organisation) with the development of a technical reference for new hydrogen uses, in order to accelerate the development of appropriate regulations for these uses, aiming at common regulations for all energy gases.

- Establish before March 31, 2014, a pluralistic working group comprising experts from the General Directorate for Risk Prevention and the General Directorate of Civil Security and Crisis Management, INERIS, AFNOR, the industry, and at least one environmental protection group. This working group will be charged with examining license applications submitted by the DREALs (Regional Directorates of Environment, Planning and Housing) and will meet at least once a month .

- Take before June 30, 2014, all measures necessary to limit to three months the waiting period for an initial response on the feasibility of any new application in the field of hydrogen energy, and to twelve months the period of thorough investigation of this type of case.

- Simplify all these regulations, drawing on the German model of provisions common to all energy gases.

Guideline n° 3 – Create the conditions for development of new markets for hydrogen energy

- Exempt hydrogen from taxation, for a transitional period, except for hydrogen produced from hydrocarbons. This would be collateralized by the introduction of a tax on oil when used as a raw material to produce hydrogen, particularly for the refining of petroleum products.

- Provide the facilities for producing hydrogen by electrolysis with access to tax free electricity, modeled on the tax regime accorded by Article 265a of the Customs Code to installations for electricity production for their supply of petroleum products. This may be collateralized by withdrawing the exemption on the latter.

- Given the absence of a project by French industry for hydrogen vehicles, facilitate the development of solutions for the extension of autonomy based on hydrogen, suitable for electric vehicles, expanding by 30 June 2014, the benefit of environmental bonus to commercial vehicles — including electric and hydrogen — whose CO_2 emission level is below 20 g / km. In order not to increase taxation of companies, this bonus would be financed by an insurance premium on passenger vehicles.

- Foster, as has been done for electric utility vehicles, the deployment of fleets of electric utility vehicles with hydrogen extension, more suitable for intensive use, in government and public enterprises, ensuring whenever possible to take into account when installing the charging stations, the possibility of eventually opening them to the public (ergonomics, positioning on the premises, provision of payment facilities).

Guideline n° 4 – A new place for the Territories: making sufficient room for local initiatives, the better to unite them, and work towards a new regional energy governance, complementary to the national approach

- Along the lines of the creation of a hydrogen center in the framework of the Pacte Lorraine project, ensure the emergence of coherent local hydrogen pathways by the implementation of "special State-Region contracts" in other territories which have potential in this field.

- Encourage local authorities to promote, in government and public enterprises, the deployment of innovative solutions based on hydrogen and / or fuel cells for applications such as cogeneration in buildings with high energy efficiency, power on remote sites, etc.

- Foster the deployment of intermittent renewable energy such as wind and solar, in conjunction with the storage of electricity in the form of hydrogen (production, storage and use).

Guideline n° 5 – Take into account the European dimension of the development of hydrogen energy

- Develop international cooperation in research, particularly with our German neighbors, in areas such as materials, electrolysis, methanisation and the safety of hydrogen.

- Encourage the establishment of a European framework adapted to new energy uses of hydrogen and their associated infrastructure, using the example of what has already been done in regulating the registration of hydrogen vehicles.

The report can be read on the OPECST website:
http://www.assemblee-nationale.fr/commissions/opecst-index.asp
http://www.senat.fr/opecst/index.html

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