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THE ENERGY CHALLENGE... THE HYDROGEN

F. Arvelo[1] and I. Padrón[2]

ABSTRACT

Energy is the very lifeblood of today's society and economy. Our work, leisure, and our economic, social and physical welfare all depend on the sufficient, uninterrupted supply of energy. Yet we take it for granted – and energy demand continues to grow, year after year. Traditional fossil energy sources such as oil are ultimately limited and the growing gap between increasing demand and shrinking supply will, in the not too distant future, have to be met increasingly from alternative primary energy sources. We must strive to make these more sustainable to avoid the negative impacts of global climate change, the growing risk of supply disruptions, price volatility and air pollution that are associated with today's energy systems. The energy policy of the European Commission(1) advocates securing energy supply while at the same time reducing emissions that are associated with climate change. This calls for immediate actions to promote greenhouse gas emissions-free energy sources such as renewable energy sources, alternative fuels for transport and to increase energy efficiency.

On the technology front, hydrogen, a clean energy carrier that can be produced from any primary energy source, and fuel cells which are very efficient energy conversion devices, are attracting the attention of public and private authorities. Hydrogen and fuel cells, by enabling the so-called hydrogen economy, hold great promise for meeting in a quite unique way, our concerns over security of supply and climate change.

The report highlights the need for strategic planning and increased effort on research, development and deployment of hydrogen and fuel cell technologies.

[1] Doctor en Marina Civil, Escuela Técnica Superior de Náutica, Máquinas y Radioelectrónica Naval, (parva@telefonica.net), Telf. 627609126, Calle Obispo Pérez Cáceres 19, 38205, La Laguna, Spain.

[2] Decano ETSNMRN, Universidad de La Laguna, (ipadron@ull.es), Telf. 922-319792, Avenida Francisco La Roche sn, 38071, Santa Cruz de Tenerife, Spain.

It also makes wideranging recommendations for a more structured approach to European Energy policy and research, for education and training, and for developing political and public awareness. Foremost amongst its recommendations is the establishment of a European Hydrogen and Fuel Cell Technology Partnership and Advisory Council to guide the process.

Key words: energy, hydrogen, the environment

FOREWORD

Worldwide demand for energy is growing at an alarming rate. The European "World Energy Technology and Climate Policy Outlook" (WETO) predicts an average growth rate of 1.8% per annum for the period 2000-2030 for primary energy worldwide. The increased demand is being met largely by reserves of fossil fuel that emit both greenhouse gasses and other pollutants. Those reserves are diminishing and they will become increasingly expensive. Currently, the level of CO_2 emissions per capita for developing nations is 20% of that for the major industrial nations. As developing nations industrialise, this will increase substantially. By 2030, CO_2 emissions from developing nations could account for more than half the world CO_2 emissions. Industrialised countries should lead the development of new energy systems to offset this.

Energy security is a major issue. Fossil fuel, particularly crude oil, is confined to a few areas of the world and continuity of supply is governed by political, economic and ecological factors.

These factors conspire to force volatile, often high fuel prices while, at the same time, environmental policy is demanding a reduction in greenhouse gases and toxic emissions.

A coherent energy strategy is required, addressing both energy supply and demand, taking account of the whole energy lifecycle including fuel production, transmission and distribution, and energy conversion, and the impact on energy equipment manufacturers and the end-users of energy systems. In the short term, the aim should be to achieve higher energy efficiency and increased supply from European energy sources, in particular renewables. In the long term, a hydrogen-based economy will have an impact on all these sectors. In view of technological developments, vehicle and component manufacturers, transport providers, the energy industry, and even householders are seriously looking at alternative energy sources and fuels and more efficient and cleaner technologies – especially hydrogen and hydrogen-powered fuel cells.

In this document, highlights the potential of hydrogen-based energy systems globally, and for Europe in particular, in the context of a broad energy and environment strategy. It then proposes research structures and actions necessary for their development and market deployment.

Why hydrogen ?

A sustainable high quality of life is the basic driver for providing a clean, safe, reliable and secure energy supply in Europe. To ensure a competitive economic environment, energy systems must meet the following societal needs at affordable prices:

— *Mitigate the effects of climate change;*
— *Reduce toxic pollutants; and*
— *Plan for diminishing reserves of oil.*

Failure to meet these needs will have significant negative impacts on:

— *the economy;*
— *the environment; and*
— *public health.*

Measures should therefore be introduced which promote:

— *more efficient use of energy; and*
— *energy supply from a growing proportion of carbon-free sources.*

The potential effects of climate change are very serious and most important of all, irreversible. Europe cannot afford to wait before taking remedial action, and it must aim for the ideal – an emissions-free future based on sustainable energy. Electricity and hydrogen together represent one of the most promising ways to achieve this, complemented by fuel cells which provide very efficient energy conversion.

Hydrogen is not a primary energy source like coal and gas. It is an energy carrier. Initially, it will be produced using existing energy systems based on different conventional primary energy carriers and sources. In the longer term, renewable energy sources will become the most important source for the production of hydrogen. Regenerative hydrogen, and hydrogen produced from nuclear sources and fossil-based energy conversion systems with capture, and safe storage (sequestration) of CO_2 emissions, are almost completely carbon-free energy pathways.

Producing hydrogen in the large quantities necessary for the transport and stationary power markets could become a barrier to progress beyond the initial demonstration phase. If cost and security of supply are dominant considerations, then coal gasification with CO_2 sequestration may be of interest for large parts of Europe. If the political will is to move to renewable energies, then biomass, solar, wind and ocean energy will be more or less viable according to regional geographic and climatic conditions.

For example, concentrated solar thermal energy is a potentially affordable and secure option for large-scale hydrogen production, especially for Southern Europe. The wide range of options for sources, converters and applications, shown in Figures 1 and 2, although not exhaustive, illustrates the flexibility of hydrogen and fuel cell energy systems.

Fuel cells will be used in a wide range of products, ranging from very small fuel cells in portable devices such as mobile phones and laptops, through mobile applications like cars, delivery vehicles, buses and ships, to heat and power generators in stationary applications in the domestic and industrial sector. Future energy systems will also include improved conventional energy converters running on hydrogen (e.g. internal combustion engines, Stirling engines, and turbines) as well as other energy carriers (e.g. direct heat and electricity from renewable energy, and biofuels for transport).

The benefits of hydrogen and fuel cells are wide ranging, but will not be fully apparent until they are in widespread use. With the use of hydrogen in fuel-cell systems there are very low to zero carbon emissions and no emissions of harmful ambient air substances like nitrogen dioxide, sulphur dioxide or carbon monoxide. Because of their low noise and high power quality, fuel cell systems are ideal for use in hospitals or IT centres, or for mobile applications. They offer high efficiencies which are independent of size. Fuel-cell electric-drive trains can provide a significant reduction in energy consumption and regulated emissions. Fuel cells can also be used as Auxiliary Power Units (APU) in combination with internal combustion engines, or in stationary back-up systems when operated with reformers for on-board conversion of other fuels – saving energy and reducing air pollution, especially in congested urban traffic.

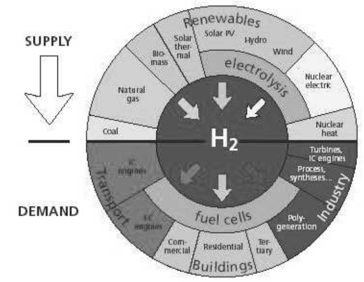

Figure 1: Hydrogen: primary energy sources, energy converters and applications

In brief, hydrogen and electricity together represent one of the most promising ways to realise sustainable energy, whilst fuel cells provide the most efficient conversion device for converting hydrogen, and possibly other fuels, into electricity. Hydrogen and fuel cells open the way to integrated "open energy systems" that simultaneously address all of the major energy and environmental challenges, and have the flexibility to adapt to the diverse and intermittent renewable energy sources that will be available in the Europe of 2030.

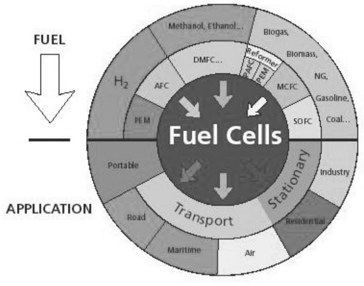

Figure 2: Fuel cell technologies, possible fuels and applications

PEM *= Proton Exchange Membrane Fuel Cell;*

AFC *= Alkaline Fuel Cells;*

DMFC *= Direct Methanol Fuel Cell;*

PAFC *= Phosphoric Acid Fuel Cell;*

MCFC *= Molten Carbonate Fuel Cell;*

SOFC *= Solid Oxide Fuel Cell*

Europe should lead in undertaking rational analysis of alternative energy options and in demonstrating the benefits of a transition to a widespread use of hydrogen and fuel cells. They will have to provide cost-effective solutions to the following key challenges – the main drivers for Europe's future energy systems.

Energy security and supply

Today's society depends crucially on the uninterrupted availability of affordable fossil fuels which, in future, will be increasingly concentrated in a smaller number of countries – creating the potential for geopolitical and price instability. Hydrogen opens access to a broad range of primary energy sources, including fossil fuels, nuclear energy and, increasingly, renewable energy sources (e.g. wind, solar, ocean, and biomass), as they become more widely available. Thus, the availability and price of hydrogen as a carrier should be more stable than any single energy source. The introduction of hydrogen as an energy carrier, alongside electricity, would enable Europe to exploit resources that are best adapted to regional circumstances.

Hydrogen and electricity also allow flexibility in balancing centralised and decentralised power, based on managed, intelligent grids, and power for remote locations (e.g. island, and mountain sites). Decentralised power is attractive both to ensure power quality to meet specific customer needs, as well as reducing exposure to terrorist attack. The ability to store hydrogen more easily than electricity can help with load levelling and in balancing the intermittent nature of renewable energy sources. Hydrogen is also one of the few energy carriers that enables renewable energy sources to be introduced into transport systems.

Economic competitiveness

Since the first oil crisis in the 1970s, economic growth has not been directly linked with growth in energy demand in the industrial sector, whereas in the transport sector increased mobility still leads to a proportionate increase in energy consumption. The amount of energy needed per unit growth must be reduced, while the development of energy carriers and technologies to ensure low-cost energy supply is of great importance. Development and sales of energy systems are also major components of wealth creation, from automobiles to complete power stations, creating substantial employment and export opportunities, especially to the industrialising nations. European leadership in hydrogen and fuel cells will play a key role in creating high-quality employment opportunities, from strategic R&D to production and craftsmen.

In the US and Japan, hydrogen and fuel cells are considered to be core technologies for the 21st century, important for economic prosperity. There is strong investment and industrial activity in the hydrogen and fuel cell arena in these countries, driving the transition to hydrogen – independently of Europe. If Europe wants to compete and become a leading world player, it must intensify its efforts and create a favourable business development environment.

Air quality and health improvements

Improved technology and post-combustion treatments for conventional technologies are continuously reducing pollutant emissions. Nevertheless, oxides of nitrogen and particulates remain a problem in certain areas, while the global trend towards urbanisation emphasises the need for clean energy solutions and improved public transport. Vehicles and stationary power generation fuelled by hydrogen are zero emission devices at the point of use, with consequential local air quality benefits.

Greenhouse gas reduction

Hydrogen can be produced from carbon-free or carbon-neutral energy sources or from fossil fuels with CO_2 capture and storage (sequestration). Thus, the use of hydrogen could eventually eliminate greenhouse gas emissions from the energy sector. Fuel cells provide efficient and clean electricity generation from a range of fuels. They can also be sited close to the point of end-use, allowing exploitation of the heat generated in the process.

The table I illustrates how, in a mature hydrogen oriented economy, the introduction of zero carbon hydrogen fuelled vehicles could reduce the average greenhouse gas emissions from the European passenger car fleet, compared to the average level of 140g/km CO_2[(1)] projected for 2008.

Tabla I

Year	% of new car (1) fuelled by Zero-Carbon hidrogen	% of fleet fuelled by cero-carbon hidrogen	Average CO_2 reduction (all cars)[(2)]	CO_2 avoided per year (Mt CO_2)
2020	5	2	2,8g/km	15
2030	25	15	21,0 g/km	112
2040	35	32	44,8g/km	240

1) Figures based on an assumed Europen fleet of 175 Millions vehicles the fleet size will increase significantly by 2040, with correspondingly larger benefits.

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(1) The European Automobile Manufacturers' Association (ACEA) has made a voluntary commitment to reduce the average level of CO2 emissions to 140 g/km for new vehicles sold on the European market in 2008. The average level today is around 165-170 g/km.

2) Calculation is independent of total number of cars. The last column shows the corresponding amounts of CO_2 emissions that could be avoided. This may be compared to a projected total level of 750-800 $MtCO_2$ emissions for road transport in 2010. The numbers for H_2-fuelled cars are an assumption based on a survey of experts for conventional and alternative automotive drive trains, but not a prediction of future production or sales.

Greenhouse gas savings of about 140 $MtCO_2$ per year (14% of today's levels of CO_2 emissions from electricity generation) could be achieved if about 17% of the total electricity demand, currently being supplied from centralised power stations, is

replaced by more efficient decentralised power stations, incorporating stationary high-temperature fuel-cell systems fuelled by natural gas. Fuel-cell systems will be used as base load in the future decentralised energy systems.

These examples *are not proposed as targets,* but merely to serve as illustrations of the CO_2 savings that could be achieved with quite modest penetrations of hydrogen vehicles and fuel cell-based stationary power generation. Together, 15% regenerative hydrogen vehicles and the above distributed fuel cell/gas turbine hybrid systems could deliver about 250 $MtCO_2$ savings per year. This is approximately 6% of the energy-related CO_2 emissions forecast in 2030.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

To maintain economic prosperity and quality of life, Europe requires a sustainable energy system that meets the conflicting demands for increased supply and increased energy security, whilst maintaining cost–competitiveness, reducing climate change, and improving air quality.

Hydrogen and fuel cells are firmly established as strategic technologies to meet these objectives. They can create win-win situations for public and private stakeholders alike. The benefits will only start to really flow after public incentives and private effort is applied to stimulate and develop the main markets – stationary power and transport. This should be done in a balanced way that reflects the most cost-effective use of the various alternative primary energy sources and energy carriers.

Competition from North America and Pacific Rim countries is especially strong, and Europe must substantially increase its efforts and budgets to build and deploy a competitive hydrogen technology and fuel cell industry. This should not be left to develop in an uncoordinated fashion, at the level of individual Member States. Gaining global leadership will require a coherent European-level strategy, encompassing research and development, demonstration, and market entry similar to the development of the European aircraft industry.

The establishment of specific 'initiative' groups to take forward the development of a broad and far-reaching hydrogen and fuel cell programme, comprising:

Hydrogen production

Hydrogen can be produced in many different ways, using a wide range of technologies. Some of these involve established industrial processes while others are still at the laboratory stage.

Some can be introduced immediately to help develop a hydrogen energy supply system; while others need considerable research and development.

Current hydrogen production is mostly at a large scale. Before a hydrogen energy system is fully proven and fully introduced, many regional demonstration and pilot projects will be required.

Aside from large-scale industrial equipment, small-scale production technologies, including electrolysers and stationary and onboard reformers, which extract hydrogen from gaseous and liquid fuels like natural gas, gasoline and methanol, will be needed.

Many organisations are developing technologies specifically for this scale of operation. Safety will be a paramount issue. The table 1 below compares the principal hydrogen production routes.

Hydrogen storage

Hydrogen storage is common practice in industry, where it works safely and provides the service required. Also, hydrogen can easily be stored at large scale in vessels or in underground caverns. However, for mobile applications, to achieve a driving range comparable to modern diesel or gasoline vehicles, a breakthrough in on-board vehicle hydrogen storage technology is still required. Innovative vehicle designs could help overcome current drawbacks. Significant research and development is under way, with new systems in demonstration.

Conventional storage, such as compressed gas cylinders and liquid tanks, can be made stronger, lighter and cheaper. Novel methods, including hydrogen absorption using metal hydrides, chemical hydrides and carbon systems, require further development and evaluation.

Hydrogen end-use

Hydrogen can be burned either to provide heat, or to drive turbines, or in internal combustion engines for motive and electrical power. Many of these technologies are quite mature, although improvements in materials and processes will help them work better and last longer. Fuel cells are in the early stages of commercialisation and offer a more efficient hydrogen use. Hydrogen internal combustion engines in vehicles may provide an important route to enable hydrogen introduction while other technologies, such as fuel cell electric drive trains develop.

Hydrogen infrastructure

Infrastructure is required for hydrogen production, storage, and distribution and, in the case of transport, special facilities will be required for vehicle refuelling. This has implications for landuse planning as well as for the safe operation and maintenance of hydrogen equipment.

Other issues must also be addressed. Trained maintenance personnel, specifically trained researchers; accepted codes and standards all form part of a successful support infrastructure for any product or service, and will be vital for the successful introduction of hydrogen and fuel cells.

The use of hydrogen-fuelled transport will depend on the successful development of an affordable and widespread refuelling infrastructure. Currently, only a few expensive hydrogen refuelling stations exist worldwide, and refuelling station costs need to be reduced to make them commercially viable. The greatest challenge will be to support millions of private cars but, before that, fleet vehicle fuelling stations will be introduced. Providing hydrogen fuel for ferries and other local water-based vehicles could also come early in the development of an infrastructure, particularly in environmentally sensitive areas.

Relative greenhouse gas emissions and costs of hydrogen fuelling pathways

The total electricity generating capacity in the 15 European Union member states (EU15) is currently around 573GWel. Forecasts for 2020 to 2030 predict electricity generating capacities from fuel cells will be in the range 30 to 60 GWel.

Assuming fuel cell generating capacity of 60 GWel by 2020- 2030 (at the upper end of the forecast range), would result in CO_2 savings of around 140Mt per annum. This would correspond to around 10% of forecast CO_2 emissions in 2030 from electricity generation in the EU15. These figures assume base load operation of future natural gas fuelled fuel cell power stations having an efficiency of 60% and operating 7500hours per year, with no CO_2 capture.

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EL RETO DE LA ENERGÍA ....EL HIDROGENO

RERSUMEN

La energía constituye la savia de la sociedad y de la economías actuales. Nuestro trabajo, nuestro ocio y nuestro bienestar económico, social y físico dependen de que el abastecimiento de energía sea suficiente y no se interrumpa. Sin embargo, actuamos como si estuviera garantizado, y la demanda de energía continúa creciendo año tras año. Las fuentes de energía tradicionales basadas en combustibles fósiles tales como el petróleo son limitadas, y el creciente desfase entre una demanda en aumento y una oferta en retroceso tendrá que ser compensado, en un futuro no muy lejano, utilizando fuentes de energía primaria alternativas. Tenemos que esforzarnos por que éstas resulten más sostenibles y así conjurar los efectos negativos del cambio climático planetario, el riesgo creciente de perturbaciones del abastecimiento, la volatilidad de los precios y la contaminación de la atmósfera asociados a los sistemas energéticos actuales.

La política energética de la UE (1) aboga por garantizar la seguridad del abastecimiento de energía y reducir al mismo tiempo las emisiones asociadas con el cambio climático. Esto exige actuaciones inmediatas de fomento de las fuentes de energía que no generan emisiones de gases de efecto invernadero, tales como las renovables, de los combustibles alternativos para el transporte y del aumento de la eficiencia energética.

En este contexto, dos tecnologías están atrayendo la atención de las autoridades públicas y del sector privado:

el hidrógeno, vector energético limpio que puede producirse a partir de cualquier fuente de energía primaria, y las pilas de combustible, dispositivos muy eficientes de conversión de energía. El hidrógeno y las pilas de combustible, al hacer posible la denominada energía del hidrógeno, prometen como ninguna otra tecnología disipar nuestras inquietudes en materia de seguridad del abastecimiento y cambio climático.

El informe subraya la necesidad de efectuar una planificación estratégica y de redoblar los esfuerzos en materia de investigación, desarrollo y despliegue de las tecnologías del hidrógeno y de las pilas de combustible.

INTRODUCCIÓN

La demanda mundial de energía está creciendo a un ritmo alarmante. La «Perspectiva mundial sobre política climática y tecnología energética» WETO (This World Energy, Tecnology and Climate policy Outlook) europea predice para la energía primaria en el mundo un crecimiento medio del 1,8 % anual durante el período 2000-2030. Esta mayor demanda se satisface fundamentalmente utilizando las reservas de combustibles fósiles, que emiten gases de invernadero y otros contaminantes. Reservas que, por otra parte, irán encareciéndose a medida que vayan disminuyendo. Actualmente, el nivel de emisiones de CO_2 per cápita en las naciones en desarrollo asciende al 20 % del correspondiente a las grandes naciones industriales. Esta proporción se incrementará sustancialmente al industrializarse los países en desarrollo. Para 2030, las emisiones de CO_2 de los países en desarrollo podrían representar más de la mitad de las emisiones mundiales de CO_2. Los países industrializados deberían liderar el desarrollo de nuevos sistemas energéticos que puedan contrarrestar esta tendencia.

El abastecimiento seguro de energía constituye un problema importante. Los combustibles fósiles, en particular el petróleo, se produce solo en determinadas zonas del mundo, por lo que la continuidad del abastecimiento se ve gobernada por factores políticos, económicos y ecológicos. Estos factores conspiran para que los precios del combustible resulten volátiles, y a menudo elevados, al tiempo que la política de medio ambiente exige una reducción de los gases de invernadero y de las emisiones tóxicas.

Resulta necesaria una estrategia energética coherente, referida tanto a la oferta como a la demanda, que tenga en cuenta el ciclo de vida completo de la energía, incluyendo la producción, transmisión y distribución del combustible y la conversión energética, así como el impacto sobre los fabricantes de equipos energéticos y los usuarios finales de los sistemas de energía. A corto plazo, el objetivo debería ser aumentar la eficiencia energética e incrementar el abastecimiento basado en fuentes europeas, en particular renovables. A largo plazo, una economía basada en el hidrógeno tendrá consecuencias para todos estos sectores. A la vista de los avances de la tecnología, los fabricantes de vehículos y componentes, los transportistas, la industria de la energía e incluso los particulares están pensando seriamente en adoptar combustibles y fuentes de energía alternativas y en tecnologías más eficientes y limpias, en particular el hidrógeno y las pilas de combustible alimentadas por hidrógeno.

En el presente trabajo, se subraya el potencial de los sistemas energéticos basados en el hidrógeno a nivel mundial, y en particular en Europa, en el contexto de una estrategia general en materia de energía y medio ambiente. A continuación, señala las estructuras y actividades de investigación necesarias para su desarrollo y su despliegue en el mercado.

METODOLOGÍA

La metodología utilizada en el presente trabajo ha consistido en la consulta de diversas bibliografías, para poder entender correctamente la evolución del tema tratado.

Se ha utilizado además de la bibliografía ordinaria la información disponible en la red en portales de organismo internacionales solventes. La bibliografía ha sido tanto nacional como internacional.

Finalmente complementamos el artículo con la información más reciente en cuanto a la legislación correspondiente a dicho tema por parte del organismo correspondiente de la UE. Asociación Europea del Hidrogeno. HyWeb – the Hydrogen and Fuel Cell Information.

Posteriormente el análisis del material recopilado, el examen y comprensión de los contenidos tanto en el tiempo como en el espacio, configurarían el estudio del contexto. Como en toda revisión, la documentación consultada es el sostén de nuestras opiniones sobre el tema propuesto, llegando finalmente a las conclusiones que culminan este trabajo.

CONCLUSIONES

Para preservar la prosperidad económica y la calidad de vida se necesita un sistema de energía sostenible capaz de hacer frente a las demandas contradictorias de aumento del suministro, mayor seguridad, mantenimiento de la competitividad de costes, lucha contra el cambio climático y mejora de la calidad del aire.

El hidrógeno y las pilas de combustible están sólidamente asentados como tecnologías estratégicas para alcanzar estos objetivos, y pueden crear situaciones en las que tanto las partes interesadas públicas como privadas salgan ganando. Los beneficios sólo empezarán a hacerse patentes si se aplican incentivos públicos y esfuerzos privados al fomento y al desarrollo de los mercados principales: producción energía estacionaria y transporte. Y esto debe hacerse de forma equilibrada, reflejando el uso más eficaz en función de los costes de las diferentes fuentes de energía primaria y vectores energéticos alternativos.

La competencia de los países de América del Norte y del arco del Pacífico es especialmente vigorosa, y es imprescindible que Europa incremente sustancialmente sus esfuerzos y sus presupuestos para construir y desplegar una industria de pilas de combustible y una tecnología del hidrógeno competitiva. Y no debe permitirse que esto suceda de forma descoordinada, a nivel de cada Estado miembro.

Para ser líderes en el mundo será necesaria una estrategia coherente a nivel europeo que incluya la investigación y el desarrollo, la demostración y la entrada en el mercado, en la línea seguida para el desarrollo de la industria aeronáutica europea.

Por consiguiente, es necesario crear unos «grupos de iniciativa» específicos capaces de impulsar el desarrollo de un programa amplio y ambicioso en materia de:

Producción de hidrógeno

El hidrógeno puede producirse por vías muy distintas, utilizando una amplia gama de tecnologías. En algunas de ellas intervienen procesos industriales consolidados, mientras que otras están aún en fase de laboratorio. Algunas se podrían introducir inmediatamente para contribuir al desarrollo de un sistema de abastecimiento de energía a partir del hidrógeno, mientras que otras precisan todavía de una investigación y desarrollo considerables.

Actualmente el hidrógeno se produce principalmente a gran escala. Para tener un sistema energético basado en el hidrógeno plenamente comprobado y totalmente introducido serán necesarios numerosos proyectos piloto y de demostración regionales. Aparte de los equipos industriales a gran escala, resultarán necesarias tecnologías de producción a pequeña escala, incluidos electrolizadores y reformadores o estacionarios y de a bordo, que extraen hidrógeno de combustibles líquidos y gaseosos tales como el gas natural, la gasolina y el metanol. Muchas organizaciones están desarrollando tecnologías específicamente para esta escala de funcionamiento. Siendo la seguridad una cuestión vital..

Uso final del hidrógeno

El hidrógeno puede utilizarse para generar calor por combustión, para impulsar turbinas o, en motores de combustión interna, para generar energía eléctrica y de movimiento. Muchas de estas tecnologías están ya maduras, aunque la mejora de los materiales y los procesos contribuirá a que funcionen mejor y duren más. Las pilas de combustible se encuentran en sus primeras fases de comercialización y ofrecen mayor eficiencia en el uso del hidrógeno. Los motores de combustión interna de hidrógeno instalados en vehículos pueden constituir un buen medio de introducción del hidrógeno, en tanto se desarrollan otras tecnologías, tales como grupos motopropulsores eléctricos de pilas de combustible.

Infraestructura del hidrógeno

Es necesaria cierta infraestructura para la producción, el almacenamiento y la distribución del hidrógeno, y en el caso del transporte harán falta unas instalaciones especiales para que los vehículos reposten. Esto tiene consecuencias para la planificación del uso del suelo, así como para la explotación y el mantenimiento seguros de los equipos relacionados con el hidrógeno.