



Fuelling the future

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Hydrogen – A sustainable energy solution

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The rise in oil prices, together with the increasing energy demands from China and India, shows that alternate energy sources will have to be considered. To introduce hydrogen successfully into the energy mix for use in transportation and in stationary and portable power, a number of challenges have to be overcome.

Most of the technologies that are required to implement a sustainable hydrogen-based energy system are in either a development or demonstration phase, and are not yet ready to be used on a wider commercial scale. Further work needs to be done to overcome the technological and economic barriers, but this work has already begun in earnest.



Hydrogen-powered micro fuel cell devices.

Hydrogen production challenges

Hydrogen can be produced from a wide range of primary energy sources such as natural gas, coal, nuclear and renewable energies. This makes hydrogen a versatile energy carrier that can be produced from the natural resources of each country, reducing dependence on imported fuels.



Hydrogen passenger vehicle.

The technologies for producing hydrogen are well established. Currently, over 50 millions tonnes of hydrogen are produced on a yearly basis for refinery and industrial uses, mainly via natural gas reforming. Smaller quantities are also produced from coal gasification and water electrolysis.

Before hydrogen becomes a major energy carrier, the cost-effectiveness of hydrogen production techniques will have to be improved. Indeed, it is foreseen that hydrogen production costs will have to be reduced by a factor of between three and 10 depending on the technology used.

Cheap CO₂ sequestration techniques will also need to be available, since it is unlikely that the demand for hydrogen in the short and medium term will be met by renewable energies alone.

In the early market introduction phase, small-scale decentralized natural gas reforming and water electrolysis systems can play a very important role in establishing an infrastructure of distributed refuellers for cars and buses. These on-site hydrogen production systems have the advantage of not requiring large investments for the introduction of pipeline distribution systems. This is also an important factor that attracts developing countries like India and China to hydrogen.

In the long run, centralized hydrogen production plants hold the promise of increased efficiency and lower costs. Hydrogen demand will, however, have to increase substantially before the investment can be justified. Indeed, the cost to put in place a hydrogen distribution pipeline will not be negligible. Also, further research and development will still have to be carried out in order to determine to what extent existing natural gas pipelines can be used for transporting hydrogen.



Hydrogen cylinders.

Hydrogen infrastructure challenges

The synchronization between automotive commercialization plans and infrastructure build-up is an important challenge that still has to be overcome. One of the key research, development and demonstration (RD&D) issues resides in defining the optimal on-board storage system.

The use of hydrogen in the energy sector will require the development of a distribution and storage infrastructure. Storage technologies for stationary and mobile applications, pipeline infrastructure, as well as refuelling stations and associated equipment, will be required if hydrogen becomes a major energy carrier and fuel.

“Hydrogen can be produced from a wide range of primary energy sources such as natural gas, coal, nuclear and renewable energies...”

Since hydrogen is currently used in the petrochemical and chemical industries, the technologies for the physical transport and storage of gaseous and liquid hydrogen are commercially available and in use for local transport and distribution.

Technologies for intercontinental transport of hydrogen are, however, in their development phase. In the long term, solid-state transport and storage technologies have the potential to be widely used. The most promising of these solid-state technologies are the nanotubes and the metal hydrides.

None of the technologies under consideration seems to fully meet the needs of the automotive industry. Further work is required to come up with an economically viable storage system that will provide comparable autonomy and storage space as today's passenger cars.

Since the on-board storage tank technology will have an impact on the refuelling infrastructure, it would be premature to deploy a full refuelling station network before this decision is made. Currently, onboard gaseous



Hydrogen fueling station.

hydrogen storage at 35 MPa and 70 MPa and liquid hydrogen storage are available. Solid-state storage at lower pressures is being investigated.

Fuel cell challenges in the transportation sector

Due to their higher efficiency compared to internal combustion engines (ICE), proton exchange membrane (PEM) fuel cells are seen as the most promising technologies for vehicle applications at the present time. However, they have to overcome a number of challenges before they can penetrate the market.

One of the challenges consists of improving the durability and reliability of fuel cells. Achieving the desired target of 3 000 to 5 000 hours in terms of service life will be necessary to gain consumer acceptance in these new products.

To be competitive with conventional ICE technology, PEM fuel cells will need to meet the targeted cost of USD 50 per kilowatt. Also, their sensitivity to hydrogen fuel contaminants is a

About the author



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ment, compliance and harmonization with a special focus on hydrogen, fuel cells and alternate fuel sectors. Mr. Dey is chair of ISO/TC 197, *Hydrogen technologies*, and holds leadership positions in other codes and standards forums related to hydrogen and fuel cell technologies. He is coordinating the ISO Round Table on Global Harmonization of Regulations, Codes and Standards for Gaseous Fuels and Vehicles which will be held in Geneva on 10 January 2007.

challenge. Higher temperature fuel cell membrane types are also being developed which may not require the level of fuel purity. Indeed, the fuel purity requirements have a direct impact on the associated price of hydrogen.

Fuel cell challenges in the stationary sector

Fuel cells are also seen as a promising avenue for back-up power and distributed power generation. As hydrogen fuel cell technology emerges, back-up power applications are viewed as the first commercial stationary power market. PEM fuel cells are currently being installed to meet the growing demand for reliable and space-efficient back-up power.

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Molten carbonate fuel cells and solid oxide fuel cells are considered as a likely candidate for decentralized combined heat and power units. Their cost still has to be reduced by a factor of between 5 and 10 to become competitive.

Fuel cell challenges in the portable sector

The convergence of voice, data and multi-media is driving the demand for more power/energy availability in cell phones, laptops, cameras and other portable and micro devices. Micro and portable fuel cell systems provide an interesting alternative to batteries by providing high energy density, extended runtime and fast “recharging” capability. Few challenges have to be overcome before these fuel cell technologies reach commercialization. The advantages they present over the conventional battery technologies will make them attractive to consumers in the not too distant future.



Environmental and energy security policy challenges

According to the IEA spell-out report, *Prospects for Hydrogen and Fuel Cells*, the business-as-usual trends in energy policy will not necessarily result in switching to hydrogen and fuel cells.

“In an ideal case, governments should first establish credible and long-term energy security and environmental policies and targets, without which no reason exists to switch to hydrogen. They should then foster the establishment of International Standards for hydrogen and fuel cells in close consultation with industry, promote infrastructure investment, and provide incentives for consumers to adopt new technologies,” the report states.

It is through the combination of effective climate and energy-security policies that hydrogen can become a significant player in the market as a transport fuel. In this respect, the *Stern Review: The Economics of Climate Change* has highlighted the urgency to reduce greenhouse gas emissions and has shown that the benefits of strong, early action considerably outweigh the costs.

The *Stern Review* forecasts that 1 % of global gross domestic product (GDP) per year should be spent on tackling climate change immediately. The cost of inaction could cost the world at least 5 % of GDP each year.

Conclusion

Uncertainty remains as to how the world will meet the challenges of global warming, energy security and economic efficiency. Hydrogen is an important energy carrier, especially in the transport sector, when compared to the other technologies being considered as sustainable energy solutions.

ISO/TC 197, *Hydrogen technologies*, is actively developing consensus-based International Standards that will facilitate the market entry of these new technologies. Working together, we can help to make hydrogen a sustainable energy solution. ■