“Passion, purpose and partnerships”

Hydrogen Roadmaps for Developing Countries

Gabriel F. de Scheemaker
Royal Dutch Shell
General Manager, Hydrogen, Asia Pacific

UNU Conference on Hydrogen Fuel Cells & Alternatives in the Transport Sector
– Issues for Developing Countries
UNU-INTECH, 7-9 November 2005

Introduction
The European Union’s Hydrogen & Fuel Cell Technology Platform has concluded that early European markets could become established between 2007 and 2010 for fleet vehicles and portable fuel cell applications; while large-scale stationary applications could achieve commercialisation by 2015 and European mass-market transport applications before 2020. Indeed, given the right support, there could potentially be 5-10 million FCVs by 2020 globally, growing beyond 100 million between 2030 and 2040.

In short, a fully-fledged Hydrogen Economy could be just over two decades away. But if we do not start today, ten years from now it will still be two decades away. After all, the transition to mass production will require a massive overhaul of the energy infrastructure, whose success will depend entirely on significant public policy developments and funding.

Developing a Hydrogen Economy therefore requires visionary leaders – both in government and in business – who are passionate about making it happen; who can focus and keep their resolve. Hydrogen is a long-term solution to a long-term problem, requiring highly sophisticated levels of co-operation, co-ordination and commitment.

Shell Hydrogen - active in all the major hydrogen markets
Shell already has over 40 years’ experience using hydrogen in its refineries, where it handles more than 7,000 tons a day as part of its drive to produce ever-cleaner and better performing traditional fuels.

Shell Hydrogen was established six years ago as a global business in order to pursue business opportunities related to hydrogen and fuel cells, in transport and distributed power applications. Today, we operate hydrogen stations in all the major hydrogen markets and believe it can become an important element in the future energy mix, along with the cleaner, traditional fuels, and important advances such as modern bio-fuels and gas-to-liquids components.

Our aims are threefold: first, to produce hydrogen in the most cost-effective way possible, in whatever form the markets want it. Secondly, to support the development
of technical solutions required to convert primary energies to hydrogen; and thirdly, to stimulate the development of technologies that will advance a Hydrogen Economy.

In 2003, Shell opened the very first, publicly accessible, hydrogen refuelling station in the world in Reykjavik, Iceland. Since then, we have helped set up hydrogen stations for fuel cell buses in Amsterdam and Luxembourg, as part of the Clean Urban Transport for Europe (CUTE) initiative.

In North America, on the other hand, we have already begun building an ‘East Coast Corridor’. Starting with a station in Washington DC - which showcases the first hydrogen dispenser fully integrated at a regular retail gasoline station in the United States - it services a fleet of six FCVs from General Motors. A combined hydrogen/gasoline site, it demonstrates to people that hydrogen is nothing special: they can walk up to the pump, touch it and see hydrogen refilling taking place whilst they are refilling their own gasoline cars. In 2006, this will be extended with a station in New York and another connecting the two cities.

Shell is also a key member of the California Fuel Cell Partnership (CaFCP): some 20 partners from the automotive and energy industries, fuel cell developers and government. The CaFCP not only operates an extensive public programme of events, but has opened a state-of-the-art facility serving 55 FCVs. Up to three new projects are now planned for 2006.

In Asia, Shell is a key member of the Japan Hydrogen and Fuel Cell Demonstration Project (JHFC), which has 10 refuelling stations around the Tokyo metropolitan area, serving 59 FCVs. The Ariake station that Shell operates is the most highly used of these stations, which means that it is probably the most utilised hydrogen station in the world, having already serviced 1500 vehicles from eight different auto manufacturers.

More recently, Shell has undertaken a feasibility study with Tong Ji University and two local Chinese partners which confirms that Shanghai would be an ideal location to start building a cluster of hydrogen stations.

All our experience indicates that the industry will be able to bring hydrogen-powered FCVs to the point where both vehicle and fuel are attractive and affordable: a clear vision of the road ahead is emerging. It is therefore time to take the next step, which means implementing more realistic scenarios. Continuing to serve a handful of vehicles from single sites will not move us forwards.

**Lighthouse Projects: the bridge to commercialisation**

The fastest and most cost-effective way to do this is via Lighthouse Projects – clusters of consumer-friendly retail sites, where over 100 hydrogen vehicles from different car companies are served by more than four hydrogen stations.

Operated by two or more energy companies and involving fleet owners, they would be run on a semi-commercial basis, in international collaboration with government, as public-private-partnerships. As such, they will not only attract industrial commitment, but generate a critical mass of researchers and entrepreneurs, accelerate best practice and give confidence to the financial community.
Lighthouse Projects will therefore play a crucial role in bridging the gap between the current demonstration projects and commercialisation - a stepping stone to a full commercial infrastructure roll-out.

They will obviously be much more efficient to run than the current, stand-alone retail stations. They can also escalate in scale and sophistication, progressing from clustered integrated retail stations, to clusters connected through corridors, as the infrastructure is steadily filled in.

By focusing on a limited number of Lighthouse Projects in North America, Western Europe and North-East Asia initially, we can build and test the strategies, disciplines and incentive mechanisms we need to co-ordinate our activities for the next phase of development and enable the industry to grow. In fact, failure to do so could have serious consequences…

First, there is a real danger that if we do not focus our efforts, government funding and industry attention will become hopelessly fragmented, with valuable time being lost through duplication and re-inventing the wheel. This is entirely possible – we have already experienced the issue of infrastructure “earmarks” in the US; while in Europe, there will be a strong push from all 25 individual member states to site activities in their own country. But if our next move sees groups of five or six vehicles scattered in 100 places throughout the world, we will end up going nowhere fast. Together, we need to work out where the early markets will be.

The second danger is that even if we get over the technology and mass production hurdles for FCVs, we will run into a huge infrastructure ‘utilisation hurdle’ that significantly increases hydrogen supply costs.

A series of scenarios resulting from a Shell study of the rollout of vehicles and fuel infrastructure in a major metropolitan area demonstrates this point clearly. In one, retail stations are located in areas and sites which do not stimulate good, additional demand for FCVs and experience low facility utilisation.

In others, however, there is closer co-ordination with vehicle manufacturers on their anticipated customer needs, and with local authorities on effective site development; and this is further exploited, with effective utilisation of facilities, through realistic Lighthouse Projects. The result? A much clearer alignment of capacity with anticipated demand and more cost-effective matching of customer interests.

The model showed, not surprisingly, that a co-ordinated infrastructure rollout, which makes good use of existing manufacturing and retail assets, realises much lower full supply costs – by up to a factor of two! The alternative is higher hydrogen fuel prices, which will simply discourage vehicle purchase.

There is therefore a great need for mechanisms like larger scale Lighthouse Projects which encourage co-ordination between governments, vehicle and fuel suppliers so that the industry can grow from its pre-commercial beginnings, to the next phase of early commercial development.
Creating fuel cell valleys
We do not anticipate a shortage of interest. After all, who would not want to create a Silicon Valley in their economic area? It was very fortunate that universities such as Stanford and Caltech were already present there, but they alone did not make it happen. Nor was it the expertise and know-how of individual players or companies.

No, the real key to Silicon Valley’s success was the presence of sophisticated venture capitalists and what they achieved: attracting and providing capital and good management; nurturing start-up companies and linking them through the value-chain; lobbying informally on the industry’s behalf; handsomely rewarding investors and entrepreneurs when they exited, thereby attracting future capital. In short, keeping their eye firmly on the commercial ball.

That’s why it is important to attract a Lighthouse Project in an economic region; and Shell is willing to help create Venture Capital funds wherever Lighthouse Projects are being developed. We already have such funds in North America and Europe, where they play an active role in a wide range of projects and technology ventures. By demonstrating early profitability, they will play a key role in accelerating the hydrogen industry.

It’s not just about hydrogen stations
Of course, a Hydrogen Economy is not simply about transportation. Hydrogen stations will be hydrogen supply points, but not just to fuel cell vehicles. Micro-grids will also supply hydrogen to residential fuel cells, efficiently producing heat and power for domestic use. Metalhydride cartridges can be exchanged here to power clean two and three wheelers. Stations will exchange or recharge hydrogen based energy cartridges for portable and handheld devices.

100kW fuel cell vehicles will give new meaning to distributed power generation, with their mobile power generator and energy storage device, flexibly deployed to power both residences and workplaces - wherever humans develop activity.

This will reduce the size of the energy infrastructure’s required overhead and put to good use the energy generating capacity, of which half is now dormant at any moment in time. Indeed, a new energy infrastructure based on hydrogen will not only introduce significant savings in the use of energy and capital investments, it will reduce a nation’s medical bill by providing a cleaner environment, thereby freeing up even more capital.

But let’s come back from the future and concentrate on finding pathways to get there. Current activities and investment in creating a Hydrogen Economy focus on the developed areas of the world: mainly North America, Western Europe and Japan. Does this mean that developing countries will take a back seat?

Issues for developing countries
Shell has recently issued its Global Scenarios to 2025, which includes trends for demography and energy demand growth.

The United Nations Population Division estimates that the world’s population is likely to increase by 50% in the first 50 years of the 21st century - from about 6 billion to
about 9 billion. Some regions, however, will become more populous faster than others. The UN’s analysis shows that, despite net migration of about 2 million people each year into the developed countries, their share of the global population will steadily fall.

In Asia, population growth of 1.3 billion will not prevent a slight decline (about 2%) in its share of the world population. Meanwhile, Africans – despite HIV/AIDS – will increase their share by nearly a third, from nearly 14% to about 20% of the world’s population.

On a country-by-country basis, the shift in population share is noteworthy. For example, consider China growing from 1.28 billion in 2000 to 1.4 billion in 2050; and compare that with India, growing from 1.02 billion (i.e. 20% fewer people than China) to 1.53 billion (i.e. nearly 10% more people than China).

The Russian Federation’s population, on the other hand, is expected to decline by one-third within the same time period. In general terms, the developing world population is projected to increase from 81% of the world total in 2005, to 84% in 2025, and 86% in 2050.

Previous Shell scenarios observed a clear trend of urbanisation, most notably in the developing world. This trend shows no signs of abating. According to the UN, in developed regions, 75% of the population already lives in urban areas and this is expected to rise to 80% by 2025. In developing countries, the shift is much greater: from 43% of people in 2005, to 54% by 2025.

What makes this shift so significant is not the percentage rise, but the rise in total population in developing countries. That rise means that while the rural population will stay approximately the same, cities will have to absorb all the growth in the world’s population. This will put increasing pressure on local capacity to provide clean water, housing and food – as well as education, healthcare and other services or public goods. This will, in turn, put increasing pressure on energy provision.

Growth depends on energy and if the energy industry does not rise to the challenge, it may stand in the way of world economic growth...

**Developing countries and hydrogen**

A fit between this ‘highest tech’ of mobility and energy technologies and the often ‘low-tech’ reality of developing countries may be closer than is first apparent. Some differences are actually quite trivial. The relevant time horizon for the Hydrogen Economy is long - it is at least 20 years away for developed countries. Developing countries can implement after developed countries have taken out the initial flaws - and after having spent billions of dollars doing so.

New energy infrastructures will develop from clusters and hydrogen is particularly efficient in urban areas. Relatively low infrastructure investments will bring clean mobility, as well as energy. In 20 years time, the same amount of primary energy may transport someone over twice the distance - or, more pertinently, twice the mass - with a significantly reduced environmental footprint.
Legacy assets often obstruct the deployment of new technology. Countries with little legacy technology embedded in their current energy infrastructure can actually leapfrog those with much more, skipping one or more generations of technology.

Could developing a new energy infrastructure based on hydrogen and fuel cells over, say, a 30-year period, be the tool to modernise and diversify emerging economies, and promote inclusive growth?

A new industry, supported by a healthy small and medium-sized enterprise sector depends on the presence of an enabling environment, characterized by political stability, property rights, rule of law, right investment climate, financial services and products, and a transparent and stable legal infrastructure.

Hydrogen is a long-term solution to a long-term problem, but if we do not start today, it will remain a long-term solution. While developed countries are implementing Lighthouse Projects, how can developing countries move towards a Hydrogen Economy?

**Designing a Hydrogen Roadmap**

This is a difficult question and I do not know the answer. However, I do know where to start and this is by designing a Hydrogen Roadmap, integrating all the expensive lessons that the developed countries have learnt.

What are these? Well, one thing is clear - the vehicle is on the critical path and the volume must go up. An effective component supply chain is essential for vehicles and other applications to move down the cost curve towards mass production. This means giving component suppliers a realistic outlook on activity and investment levels over future years, while applications achieve the necessary performance and attractiveness criteria.

From a fuel provider’s perspective, when dealing with high volumes, hydrogen distribution from central production must be developed as early as possible in order to address the issues of supply and distribution logistics. Developing countries will probably roll out later, and therefore with less uncertainty, dealing rapidly with relatively high volumes.

Then there is the public response. This can vary enormously - from enthusiastic to fearful - depending on how effectively public engagement has been conducted locally, or how politicised the subject has become. For example, in communities like Iceland, where support and desire have been built up over several years, implementation was swift. In Washington DC, however, where the hydrogen project was originally greeted with both community *and* regulatory suspicion, significant delays and budget overruns resulted.

A Hydrogen Roadmap should therefore address public awareness and education as early as possible, so that there is a fertile ground of public support and regulatory experience when take-off does, eventually, become possible. Otherwise, progress will suffer long and unnecessary delays.
It means informing key decision makers and future customers about the long-term benefits and near-term realities of hydrogen, fuel cell systems and related infrastructure. We also need to work out a clear customer value proposition and address all the barriers to social acceptance – town planning, health and safety issues, risk assessments etc.

This will not only facilitate market acceptance and manage expectations, but help create the necessary human capital - researchers, technicians and engineers. We need to establish qualification guidelines for trade and industry, and engage industry associations to co-ordinate and step up this activity.

But it’s not just the public who need to have confidence in hydrogen, it’s also investors. They need to see both a transparent legal infrastructure and a stable environment: what taxes will this industry face and in what form? What incentives will be put in place and for how long? What will regulations, codes and standards look like and what permits will be required?

In short, there must be a clear line of sight to normal – competitive – commercial operation in order to build confidence in its long-term viability. It means having a coherent framework of incentives and regulations that cross different countries - reducing risk and “friction”, and providing a focus for industry development.

Clarity on fiscal and other long-term economic incentives is therefore essential for establishing credibility - stimulating infrastructure investment, building up vehicle demand and establishing supply chains - whilst the economies of large-scale production build up. Naturally, they will be structured to reduce as volume increases, but it must be clear how this will happen.

We should also not lose the opportunity to develop and apply incentives to reduce CO2 emissions in the broader policy arena. For now, hydrogen and CO2 are two sides of the same coin, so we need to set targets for the latter and create investments for its capture and storage. We also need to be clear that when we talk about “clean coal”, we are in fact talking about hydrogen.

Intellectual property rights, too, are crucial for encouraging new technology and protecting investment in R&D, whilst not being so open as to encourage broad claims and delay development. IP rights should be considered in the context of internal - particularly American and Japanese - patent practices.

Above all, Hydrogen Roadmaps must underline the importance of a clear, co-ordinated focus on commercialisation by all relevant parties. In fact, it is essential if we are to attract investors and convince them that a Hydrogen Economy can not only be cost-effective, but highly profitable – the carrot for all entrepreneurs.

I believe that 80% of individual roadmaps have common content and I believe that an institution such as the UN University can play a vital role in building a template for a Hydrogen Roadmap. The main players in this fledgling industry are certainly keen to support this effort by communicating the latest lessons learnt. They are equally keen to develop relationships with their industrial partners of the future, augmented by
visionary investors and funds managed by firms that are expert in the hydrogen and fuel cell industry.

As with many of the issues that are facing developing countries, the creation of a new energy infrastructure will not be easy. But with passion, purpose and partnerships, we will surely find a way.

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