4th International Seminar
ADVANCES IN HYDROGEN ENERGY TECHNOLOGIES_AHET
November 2011, Viana do Castelo, Portugal

A STRATEGY FOR INTRODUCING HYDROGEN STATIONS IN PORTUGAL

E. AMORIM[1,*], R. S. BENTO[2]

[1]ECT-UTAD, Quinta de Prados, 5001-801 Vila Real, Portugal
[2]INESC Porto, ECT-UTAD, Quinta de Prados, 5001-801 Vila Real, Portugal
*eamorim@utad.pt

ABSTRACT: In recent years, the use of hydrogen as a clean energy has been paid attention to in terms of global warming prevention, by reducing carbon dioxide emissions to atmosphere mainly in transport sector. Hydrogen is used as an energy carrier and as a fuel. This paper presents an infrastructure evolution analysis between LPG and BEV stations in Portugal. Based on the results of geographical location and time evolution, a cluster strategy simulation of building early hydrogen refuelling infrastructure is presented. A Geographical Information System Model was created as a decision support tool for introducing hydrogen vehicles and refuelling infrastructure, considering: station location; convenience of fuel type; hydrogen supply and motorization rate. Assuming a zero emission policy in transport sector for 2050, the initial infrastructure design could have a major impact on the financial success of the hydrogen initiative in Portugal.

Keywords: Hydrogen infrastructure, stations, alternative fuels, network creation.

1. INTRODUTION

The increasing global demand for fuel is one of the main reasons for the rise in greenhouse gas emissions. Emissions of CO2, the main greenhouse gas from human activities, are the subject of a worldwide debate about energy sustainability and the stability of the global climate. Evidence that human activities are causing the planet to warm up is now unequivocal according to the Intergovernmental Panel on Climate Change (IPCC) [1]. In September 2009, both the European Union (EU) and G8 leaders agreed that CO2 emissions must be cut by 80% by 2050 if atmospheric CO2 is to stabilise at 450 ppm and global warming stay below 2ºC, a 80% decarbonisation overall by 2050 may require 95% decarbonisation of the road transport sector, which is a difficult challenge.

At a global level, greenhouse gas emissions from the transport sector and from fuel production represent a major problem and are increasingly subject to regulation around the world.

A hydrogen-based energy system will increase the opportunity to use renewable energy in the transport sector. This will increase the diversity of energy sources and reduce overall greenhouse gas emissions.

The robustness and flexibility of the energy system will be increased by the introduction of hydrogen as a strong new energy carrier that can interconnect different parts of the energy system.

2. DECARBONISATION OF THE ROAD TRANSPORT SECTOR

The Fuel Cells and Hydrogen Joint Undertaking produced a study entitled: “A portfolio of Power Trains for Europe: a fact based analysis” that shows four ways to reduce carbon dioxide emissions to atmosphere in transport sector: development of more efficient Internal Combustion Engines (ICEs) with hybridisation; introducing Battery Electric Vehicles (BEVs); Plug-in hybrids (PHEVs) and Fuel Cell electric Vehicles (FCEVs).

This study shows that over the next 40 years, no single power-train satisfies all key criteria for economics, performance and the environment. Table 1 shows autonomy range for different power-trains.

Table 1. Autonomy range for power-train comparison

	BEVs	FCEVs	ICEs
Min. range	150 km	400 km	800 km
Max. range	250 km	600 km	1200 km

The world is therefore likely to move from a single power-train (ICE) to a portfolio of power-trains in which BEVs and FCEVs play a complementary role: BEVs are ideally suited to smaller cars and shorter trips; FCEVs to medium/larger cars and longer trips. PHEVs could be an attractive solution for short trips or where sustainably produced biofuels are available.

Car manufacturers have signalled by the Letter of Understanding in 2009 that they are ready to mass-produce FCEVs as they are technologically ready and can be produced at much lower cost for an early commercial market over the next five years. The next logical step is therefore to develop a comprehensive and co-ordinated EU market launch plan study for the deployment of FCEVs and hydrogen infrastructure in Europe.

The literature on the hydrogen infrastructure has made substantial progresses in the last few years [3]. Most contributions in the literature can be interpreted as long-term cost estimates. More studies on relatively small infrastructure projects using short-term cost estimates are needed.

3. LPG DISTRIBUTION AND ELECTRICAL GRID IN PORTUGAL

In recent years two retail networks have been built in Portugal: The Liquefied Petroleum Gas (LPG) filling station network and the electrical grid to provide slow and fast charge to BEVs.

Since 1970, LPG cars have been slowly increased and today exists more than 45 thousands users in about 290 refuelling stations in mainland Portugal (Fig. 1).

Fig. 1. LPG refuelling stations map (Autogas.pt).

The MOBI.E network is currently underway and in the first phase includes the installation of a Pilot Network of 1,300 normal charging stations and 50 fast charging stations in places of public access throughout Portugal. Presently are built 159 charging stations and 371 charging connections points (Fig. 2).

The MOBI.E network is an intelligent charging network available throughout Portugal, which will allow to an optimal exploitation of the electric grid. In a near future it will allow grid managers to control the electric vehicles charging process, transferring consumption from peak to low demand periods; later on, it will have the possibility to re-enter into the grid the electricity stored in the EVs in a simple and user-friendly way, avoiding in this way the peaks of electricity production.

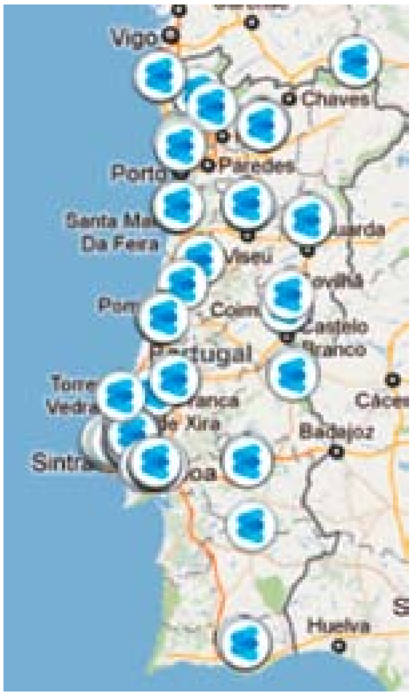

Fig. 2. MOBI.e electrical charging grid map (mobie.pt).

4. HYDROGEN PRODUCTION, TRANSPORT AND DISTRIBUTION

Hydrogen is used as an energy carrier and as a fuel. It can be produced from several sources using various methods and delivered to the fuel station or it can be produced at the filling station. Electrolysis of water or reforming of hydrocarbons such as natural gas can produce hydrogen in a big plant or even at the filling station.

Hydrogen can also be produced using renewable energy such as wind, hydroelectric, solar, or geothermal, and by that way it has zero emissions from well to wheel. Hydrogen can be transported by road via cylinders, tube trailers, cryogenic tankers, and in pipelines or can be produced onsite. Each of these delivery and production modes requires a significantly different filling station design.

In the literature assume that hydrogen will be exempt from taxation. Although alternative fuels benefit from special tax treatment, any tax credit should be expected to last only as long as hydrogen has a small share of the market [4].

The introduction of a hydrogen fuel system is best accomplished initially through the distributed production of hydrogen, mainly on-site at the fuelling stations. This is the most economic approach, as it avoids constructing an extensive and costly transport and distribution infrastructure, which accompanies centralized production [5]. This could be deferred until the demand for hydrogen is large enough.

A distributed production system during the transition phase can be installed rapidly as the demand for hydrogen expands, thus allowing hydrogen production to grow at a pace, which is reasonably matched to hydrogen demand. This approach gives the market time to develop and diminishes the risks for investors, as it avoids fixing large amounts of capital in underused large-scale production and distribution facilities, while it is still unclear how hydrogen demand will develop.

The preferred technology is small-scale natural gas reforming (using the existing natural gas pipeline network), followed to a lesser extent by gasification of biomass and on-site electrolysis (from grid electricity or wind or solar energy)[4,6,7].

5. HYDROGEN REFUELLING STATION NETWORK IN PORTUGAL

As we saw with MOBI.e, a coordinated effort must be made to create a balanced hydrogen infrastructure to cover throughout Portugal, and provide confidence to consumers and reduce risk investment. Government incentive mechanisms will be necessary to go hand by hand with retail investors.

Fig. 3. Proposed hydrogen refuelling station network

The network topology was created considering a mean access to a hydrogen filling station of 40 km. The stations were located on major cities and along principal road itineraries (IPs) of national road map. This basic network allows any owner to circulate though all country with no fear of lack of fuel. As was observed in Table 1 a minimum autonomy to FCEVs of 400 km it's about 10 times de mean access to a filling station.

As consumers start to increase FCEVs the next phase would be a reinforcement of network according to number of vehicles by station point. The histogram of distances to nearest hydrogen filling station is presented in Fig. 4.

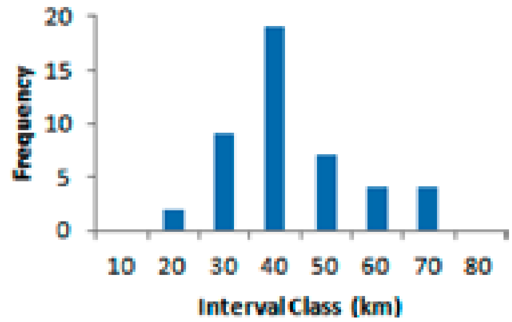

Fig. 4. Histogram of distances to nearest hydrogen filling station

LPG refuelling stations, MOBI.e Electrical grid and Hydrogen refuelling stations don't differ too much because of basic criteria of national access and location near main roads and cities but considering FCEVs autonomy the proposed 45 stations are less than grid density needed for BEVs.

6. CONCLUSIONS

A combination of FCEVs and a hydrogen infrastructure is a way forward to combat the long-term challenges of climate change for Portugal. The new hydrogen economy potentially offers the possibility to deliver a range of benefits for the country including environmental sustainability.

A private global consortium of stakeholders and a co-ordinated EU roll-out plan study for hydrogen infrastructure is needed. As Portugal and other countries have showed in recent years new fuelling station networks have been successfully created or initiated. The proposed hydrogen 45 stations seed network could create an early market to a new economy in a decarbonised transport sector.

REFERENCES

[1] M. Balla, M. Wietschelb. The future of hydrogen – opportunities and challenges. *Int. J. Hydrogen Energy* 34 (2009) 615 – 627.

[2] HyNet. On the way towards a European hydrogen energy roadmap. Ottobrunn: HyNet; 2005.

[3] R. Moore, V. Raman. Hydrogen infrastructure for fuel cell transportation. *Int J Hydrogen Energy* 23 (1998) 617-620.

[4] D. Myers, G. Ariff, B. James, R. Kuhn. Hydrogen from renewable energy sources: pathway to 10 Quads For transportation uses in 2030 to 2050. Washington, DC: The Hydrogen Program. Office of Power Technologies. U.S Department of Energy, 2003.

[5] C. Yang, J. Ogden. Determining the lowest-cost hydrogen delivery mode. *Int J Hydrogen Energy* 32 (2007) 268-286.

[6] S Prince-Richard, M. Whale, N. Djilali. A techno-economic analysis of decentralized electrolytic hydrogen production for fuel cell vehicles. *Int J Hydrogen Energy* 30 (2005) 1159-1179.

[7] R. Wurster. Pathways to a hydrogen refueling infrastructure between today and 2020. Ottobrunn: L-B-Systemtechnik GmbH., 2002