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Sustainable Marine and Road Transport; H_2 in Iceland

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Abstract

Icelandic New Energy has conducted drive tests and running an electrolytic commercial hydrogen station for various types of vehicles since 2003. The integration into the traffic and social indicators have left numerous lessons. The vehicles have come from manufacturers in Germany, Japan and the USA. The hydrogen station is operated successfully and drivers have given various opinions and stories of success and failures to the researchers. Larger studies have been conducted on the needed energy to run the transport on locally made hydrogen in the future, but a well established national electricity grid gives rise to the future vision of methane from local sources, and battery and hydrogen vehicles for all transport means by 2050.

Hydrogen, marine FC, Iceland, cross-discipline research

1. Introduction

Icelandic New Energy (INE) was established in 1999 with the purpose to evaluate the potential of using hydrogen as a fuel for the local transport system. The company brings together partners that have unique position in the hydrogen business as they include the international actors: Daimler, Shell Hydrogen and StatoilHydro and Icelandic partners that have a strategic stronghold in renewable energy systems, research and innovation. The Icelandic partners are called VistOrka and comprise the Government of Iceland, Reykjavik's Energy, National Power Company, Sudurnes Heating Corporation, University of Iceland, Iceland ´s Innovation Centre, and the buisiness venture fonds Sterkir Stofnar & Aflvaki. INE started executing bound socio-technical projects at an early stage with the Icelandic energy team of know-how, Daimler as early developers of fuel cell vehicles, StatoilHydro as an experienced developer of electrolytic hydrogen stations (Norsk Hydro at the time) and Shell Hydrogen with their knowledge of fuel distribution systems. The local energy systems and settings are described in earlier papers. [8,7].

The company's goal is to function as an enabler and test hydrogen technologies where fossil fuels are currently in use. Already 80% of Iceland´s total power usage is based on renewable energy and if electricity can be used instead of imported fossil fuels, either directly in batteries or/and indirectly via hydrogen made from water, then Iceland could become 100% renewable and self reliant when it comes to energy. Only the transport system and marine application still use fossil fuels. It should be mentioned that methane has been collected for a decade from Reykjavik´s landfill and is used on service vehicles. The available amount of methane is estimated to be enough to fuel <5% of the fleet or 5-10.000 vehicles [9].

In Iceland 25% of CO_2 emissions come from the fishing fleet. It is important to understand that hydrogen and/or batteries can be used to reduce the fleet´s dependence on fossil fuel. As a part of the SMART-H_2 (see later details) project the potential of using hydrogen and hybrid systems will be evaluated. The company has organised demonstrations and supportive research as means to this ends but the national interest is widening towards an infrastructure that can facilitate the use of all local fuels that can avoid greenhouse gas emissions.

INE see´s battery and hydrogen vehicles co-exist in future scenarios but more experience has been established using hydrogen vehicles and most of the research is based on demonstration of these.

1.1 Activities

The first step in testing hydrogen was the ECTOS-project; demonstrating three hydrogen fuel cell Citaro-Daimler buses in the public transport of Reykjavik and operate a pre-commercial hydrogen electrolytic refuelling station. The test drive was prolonged from the original two year period (2003-2005) to almost four years because INE joined other partners in Europe in another EU supported project, the HyFLEET:CUTE. INE has also participated in other projects that were funded in the 5^{th} – 7^{th} research framework programmes. These are New-H-Ship, (barriers for using H_2 and FCs in marine environment), NEEDS, EURO-HYPORT (export of H_2 and education), Encouraged, CreateAcceptance, HyApproval, SUGRE to name a few. These projects are quoted in this paper in italics but introduced on INEs website [6]. Other national and Nordic projects are also listed there).

The successful demonstration of the buses and refueling station urged the team to continue to the next test called: Sustainable Marine and Road Transport, Hydrogen in Iceland (SMART-H_2). Here the goal is to test hydrogen and hybrid personal vehicles and a fuel cell on a sea-going vessel.

Local funding was secured for the equipment by VistOrka and the SMART-H_2 project was kicked off in March 2007. The goal is to test 20-40 H_2 vehicles of various brands by the year 2010 and offer companies to use them in their service fleets. While ordinary staff members are experiencing alternative vehicles, data is collected on technical, social and endurance aspects, maintenance and cost.

Already close to 20 hydrogen vehicles have been introduced within the SMART-H_2, either using internal combustion hydrogen fitted engines (ICE-H_2)) or fuel cells. INE prefers promoting the FC vehicles, due to their fast development and higher efficiency.

The homologation and design of the hydrogen distribution has already provided understanding of the codes and standards that need to be adopted and which safety requirements apply before the proper certification is issued.

Figure 1 Birds-eye view of the hydrogen station.

The first hydrogen station, (refer to fig 1) which was a turnkey solution from NorskHydro in 2003, was modified in 2007 to serve passenger vehicles, and is since then a certified commercial public fuel station. It is an unmanned station and the project relies entirely on this production, storage and dispenser unit.

The marine part of the SMART-H_2 project consists of demonstrating an integrated FC and battery system that is installed on board the commercial tourism whale watching boat "Elding" (see figure 2). It is only the auxiliary power system and can provide up to 15kW of electric power from the fuel cell and the hybrid battery, 10 kW Ballard fuel cell and additional batteries for support. It serves to furbish electricity for energy services on board; light, navigation, loudspeaker etc, leaving only the propelling to the main power engine which runs on oil. The on-board system is designed by Icelandic Hydrogen and H_2-Logic. In this part of the project the goal was to verify results from other marine studies such as the EU projects FC-SHIP and New-H-Ship.

Figure 2: The whale watching cruiser Elding.

A temporary refueling site was installed at the harbor and hydrogen is trucked from the production site in certified hydrogen cylinders.

Unfortunately, the operation of the boat did not reach the set milestones in 2008. The cause is not technical failure but problems due to organization difficulties and human interactions. The team has learned countless lessons on complex administrational issues and procedures linked to certification where international bodies and local authorities need to synchronize their efforts along with a company that runs a routine business. The team is looking forward to an extensive test period during 2009. This demonstration activity will provide the team with insight into the potential future use of hydrogen instead of fossil fuels in marine environment and tourism marketing.

2 The research agenda

Corresponding to the demonstrations described for SMART-H_2 a research agenda was outlined parallel to the project. The main idea is to base the research on a scenario where only local fuel sources are used and simultaneously decrease GHG emissions from transport. The goal of the research is to compare various types of local fuel and the corresponding drive and distribution technology for reliability, feasibility and customer acceptance. Data is acquired from methane-, battery-, hydrogen- and plug-in vehicles and the relevant fuel stations. Drivers and fleet operators that have experience from using these vehicles and the corresponding maintenance and service systems will be interviewed.

The outcomes should be an analysis of experience from these early generations of alternative vehicles and suggestions that can facilitate a strategy for shifting from oil products to local fuel options in transport and fisheries.

The research includes analysis of social criteria such as customer preferences, weighed importance of environmental issues and costs, and views on preferences for future transport policy. Secondly, the research includes studies on the foreseen efficiency and quantity of energy needed in a few scenarios in line with forecasts and types of fuel that can be derived locally and used to replace oil and gasoline in transport. Lastly the infrastructure, power generation and transmission as well as local distribution are outlined as well as the foreseen amendments and costs. Below a few of the suggestions are presented but further research is intended as to assess the total impact of using electricity in plug-in battery and hydrogen vehicles.

Examples from the list of research topics:

- Workshop: Future scenarios for using local fuel for transport
- Creation and loss of jobs
- Interviews with alternative car owners
- The current energy infrastructure and how it can cope with electricity distribution for transport options. The effect on tourism marketing from using alternative fuel
- Future development of electrolytic technology
- Prospects of biofuel production methods based on Icelandic feedstock:
- Electricity transmission and distribution for a strategic refueling plan in SW Iceland
- Well to tank analysis of a hydrogen pathway in Iceland: options and efficiency
- Data collection on maintenance and fuel performance of methane, electric and hydrogen cars. Synchronizing energy usage analysis
- Externalities of current and future hydrogen production technology

The company affiliated the University of Iceland, in particular the Department of Natural Resource Management, to assist in finding students with the appropriate background education to engage in research projects that have been outlined within the project. The company has assisted in applying for funding, in providing data and tutorial support. Already seven students have finalised their Master’s theses within the company’s framework and there are currently two students working on their tasks within SMART-H_2.

2.1 Social studies

During the ECTOS project in 2001 – 2007 public surveys showed repeatedly very high social acceptance of the Icelandic public towards the idea of testing and using hydrogen and fuel cell buses in the city's public transport [1]. In these surveys and interviews no reluctance or fear was shown to towards the idea of using hydrogen as the main fuel for transport in Iceland.

Whereas new alternative drive trains had emerged in the local discourse since 2005, the research team organised a discussion workshop in February 2008 to outline views on future fuel options for Icelandic conditions and kicked off further studies that could be based on the experience of demonstration hydrogen vehicles. People that deal with social, financial and environmental administration was invited as well as experts from the energy sector and vocational and technical schools. The goal was to set a frame for expanded studies and list relevant topics that should be answered by research and thus establish essential insight into the options and set basis for decision makers [1]. From the workshops 21 cross-disciplinary study-topics were recognised, as shown in the list earlier. These issues were the subjects of students' and experts' research during the first two years of the SMART-H_2 project but linked to several earlier studies within the company.

To continue the inquiries of social acceptance two steps were taken for in-depth analysis of public views. Firstly focus group discussions were conducted with young people with background in economics, environmental science and energy consultancy plus young politically involved persons from all cadres of politics [5]. This target group was selected as a representative for those who may become influential in future governance. In-depth interviews were carried out on one hand with decision makers in the local energy sector and on the other hand owners of conventional Toyota Prius cars as a target group that would be interested in low emission vehicles [12]

Some controversial views were raised. Energy experts stressed energy efficiency while customers listed aesthetics and image as their most important criteria while selecting vehicles. Some claimed that the international development should set the frames for development in Iceland while others pointed out that ethanol would not be an option. A majority stated that local energy sources should be used to fuel the transportation and energy independence reached because energy security is important. Other interviewees insisted that transport system based on local solutions on such as small market would be too expensive and methane and ethanol should be imported as in other countries. No consensus was formed regarding the option of charging for GHG emissions.

From analysing the focus group discussions four indications were observed. 1) The participants had not reflected on the possibility of surviving an end to the oil era or stopping the importation of fuel. 2) The participants were more concerned about internalizing the cost of pristine land as externalities from extending the national energy systems that would provide for electric transport rather than emissions from the current system. 3) Their basic knowledge of energy and fuel types was poor, and only the politically involved were willing to make a choice for the future energy systems. 4) The media was quoted as influential to the participants' views rather than their education, and they did not find the focus group topics of high urgency. The latest media message was taken as

THE truth and quoted rather than verified information [5]. These outcomes reflect mostly the discussion in local media, and it should be kept in mind that at this point little discussion had been in Iceland regarding Global Climate Change, potentially since Iceland has very high utilisation of renewable energy already. Over the last few years the discussion of potential climate change has increased so views might have changed. In the in-dept interviews and workshop people outlined their future view of fuel and transport mechanism in Iceland, refer to the ranking in Table 1.

Table 1: Overview of criteria listed by energy experts when outlining infrastructure for future fuel systems [5].

	Options for new fuel types	Future fuel systems	How will transition evolve?
1st	Secuity of supply Price Efficiency Locally made	Price will rule the development	Government must set policy and support energy companies in tests Clean fuel and vehicles should be less taxed Best option NOT a political choice
2nd	Depending on international technical trends Test what scientists recommend	Environmental factors will influence but not drive change Hybrids for efficiency	The value of environment/nature should be included in charge Companies should cooperate in testing new technology
3rd	Electricty ideal Hydrogen too low efficiency Methane too scarce, Ethanol questionable	Begin with fuel mix on market	Public movements should inform about all Warn of dubious decisicions
4th	Keep all open during transition Clean image good for Iceland Power production will cost environm. impacts	Link to the independent locally developed energy system	Drawback that selected persons get most funding rather than all ideas.

They opted for higher use of local energy to run the transport and fisheries sector, even though import of methane from neighbouring regions was also mentioned. The vision of using electric battery vehicles was supported highly. Participants leant towards the idea of reducing imports and establish a local system of transport energy as an extension of the national grid. The economists wanted to engage in economic cost benefit analysis but agreed that environmental impacts had to be included. When asked specifically about selected fuel options such as hydrogen the reply was clear: the view of respondents depended highly on who had been the advocates of each type of fuel rather than the virtues of the fuel itself. Thus the views of people rested on their trust in the messenger rather than the message itself.

Furthermore there was detected a gap between the public expectations and the technical performance of the alternative vehicles that are available or arriving. Illusions were stated such as that battery cars would take 5 minutes to recharge, that fast recharging can occur via home sockets and the new electric vehicles have the same range as a modern gasoline car. Hydrogen cars were stated to have little power, vehicles were stated to have low efficiency not recognising the efficiency of conventional vehicles does not compare well. It was very evident that pure battery vehicles cannot provide the same performance as conventional modern gasoline cars and therefore not stand up to the expectations. Misleading or missing information may need to be modified; otherwise the consumer will be disappointed.

When asked about criteria that people follow when buying a new car, aesthetics and image of the vehicle ranked higher in the priority list that would rather than the efficiency. Cost of fuel was set higher as an influential criterion than the cost of vehicle itself and some controversial issues were raised (see Table 1).

2.2 Environmental aspects

The environmental impacts from using hydrogen are mostly related to the scheme of the use natural resources and expected pollution from the systems' perspective. 1) Emissions connected to the material and energy that is inherent to the manufacture and maintenance of technological modules (studied with LCA). 2) All emissions and primary energy demand according to the total efficiency in a hydrogen fuel chain (studied as WTW).

An LCA was made on the hydrogen station modules and the FC buses during the *ECTOS & CUTE* projects. These show that the environmental impacts of using hydrogen depend to the highest extent on the source of hydrogen [2]. If the hydrogen is made with electrolysis from renewable energy it is the manufacturing phase of the modules that gives the most environmental impacts. In Iceland, the energy sources for the electrolytic process come from hydro- and geothermal power.

A WTW study has recently been released on the fuel chain for the Icelandic conditions allowing for uncertainties [4]. The distribution grid in the service area of Reykjavik's Energy that provides the of South-West of Iceland with power, heat and water, has a transmission efficiency of approximately 95% from the source of the electricity to the step down transformer that would be linked to an electrolytic hydrogen production station through substations (WTT part).

A study evaluated the eventual need for primary energy and emissions from hydrogen transport. The study presents carefully supported assumptions for a fleet composition that is according to official transport forecast [11] and effciency as presented by the EC project Roads2HyCom [1]. Only the geothermal part of the power generation gives rise to GHG emissions and for the WTT pathway (assuming that electricity composition is 30% geothermal energy and 70% hydro energy) in 2030. It is estimated to be in the range of 7.2 to 9.9 g CO2 eq./MJ of produced hydrogen. The emissions from the transport sector in 2030, only including hydrogen vehicles is then estimated to be 87,752 tons of CO_2 equivalence; about 90% less than the year 2006.

In the study the latter part of the fuel economy, or TTW, the composition of the fleet is set in three simplified scenarios where methane vehicles and pure battery vehicles are ignored for simplification. In the scenarios outlined in the paper the total primary energy demand required for the entire transition to hydrogen FCV in 2030 is estimated to range from 17.8 PJ to 32.5 PJ, which is a rather large range, but other scenarios include hydrogen internal combustion vehicles in some categories.

To put this in context it means that mean estimations of total primary energy demand for the transport sector in 2030 is equivalent to 14% of the total domestic primary energy use in Iceland in

2007. The estimated amount of electricity needed to produce the required amount of hydrogen for the transport sector based on the evaluated total primary energy demand and the estimated mean efficiency of electricity production is ranging from 3.32 - 6.05 TWh (for more details see [4]).

A still more simplified view is to use the composition of the fleet as it was 2007 and compare the difference in energy requirements in the future if all vehicles are 1) Hydrogen hybrid internal combustion vehicles, 2) FC hydrogen vehicles 3) Plug-in hybrid FC vehicles and use it to forecast the energy need according to only one type of drive technology at a time (refer to figure 3).

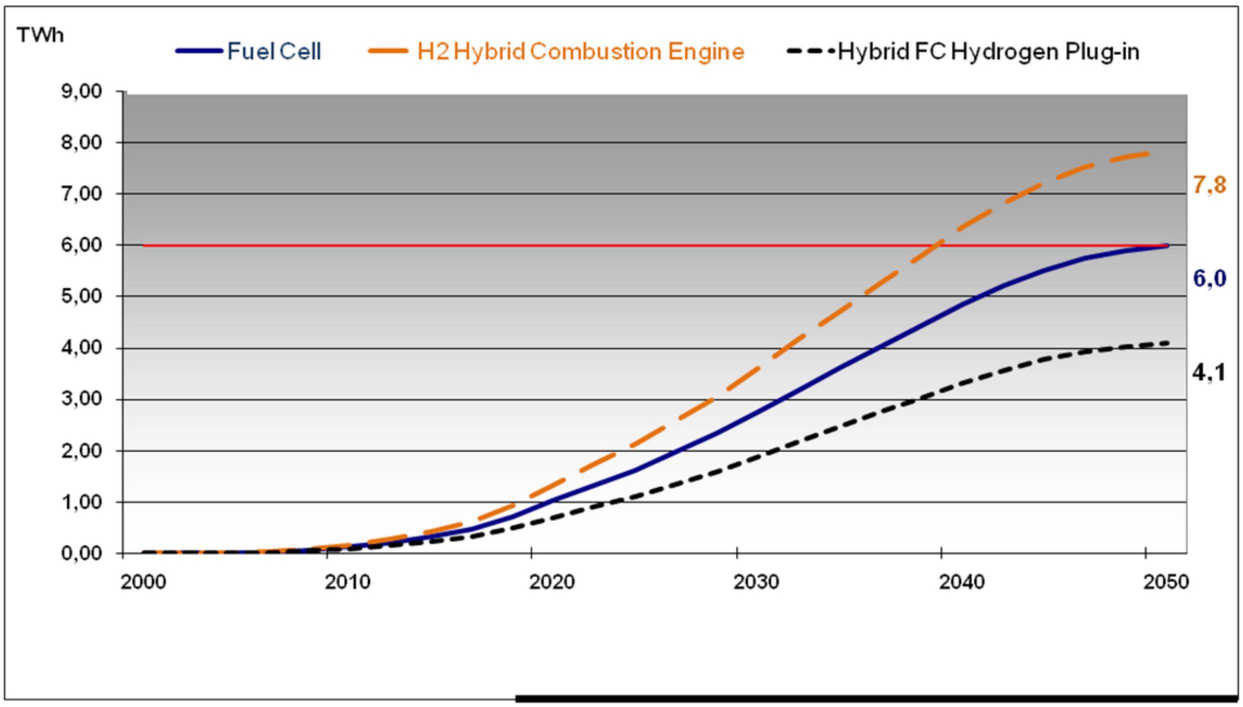

Figure 3 : Overview of primary energy demand for the entire conversion to hybrid H2, FC and plug in H2- electric vehicles. The figure is based on simplified assumptions forecasting all transport to use only Hydrogen internal combustion engines, only fuel cells or only fuel cells and plug in batteries used in short ranges.

This is done only to visualise the difference while looking at vehicles that use the electric grid for transmitting transportation energy vectors

2.3 Technological aspects

2.3.1 The hydrogen station

An electrolytic hydrogen production storage and refuelling station was inaugurated in 2003 in the east skirts of Reykjavik (see figure 1). It has been operated safely and showing good reliability even though the production is kept low due to lack of vehicles. The station is kept unmanned but monitored carefully by trained hydrogen technicians. All drivers have trained the filling procedures and fill the vehicles themselves. There are instructions on the dispenser that explain step by step how to operate the dispenser. In case of mistakes the station shuts down for safety reasons. Since the modification of the station in November 2007 it has been operated safely and downtime has been less than 2%. In February 2009 the accumulated hydrogen that had been used on tanks of vehicles and buses amounted to more than 28.000 kg. And this station has the longest commercial operation in the world. This indicates that the hydrogen infrastructure is getting closer to commercialization and ready for a larger market introduction of hydrogen vehicles.

2.3.2 Infrastructure study

Whereas there is not a huge difference between the efficiency of small and large electrolytic production plants, and transport of hydrogen is ineffective due to low energy density the established electricity grid becomes the most attractive distribution system that can both serve hydrogen and battery driven transport, but up to now the configurations for hydrogen refuelling are better established. A study has been conducted to foretell the needed adaptations of for the current electricity distribution system in the service area of Reykjavik's Energy [3]. The study also investigated the customer preferences as a means to support the selection of sites for H_2-refuelling stations.

Electricity is transmitted within the service systems to a network of primary substations that are operated on a daily basis only to distribute 50% of the maximum current they can carry. In the case of failure, this amount can be doubled and one substation can take over and provide current into an additional subsystem and cover further parts of the service area. Therefore the system can carry much more than the basic load.

When preparing to establish hydrogen production stations it is most efficient to place these near primary substations to prevent losses in transmission and make use of the inbuilt unused carrying capacity. In short, there is no need to add to the capacity of the existing electric infrastructure during the installation of the first 22 hydrogen fuel stations, which should be enough to fulfil the demand for hydrogen in the capital area, drastically reducing future investment costs for hydrogen or plug in infrastructure (refer to fig4).

Each production station would conventionally be run on a constant basis but the production volume can be regulated between 20 and 100% according to availability of power and varying demand.

The distribution system must be designed as a problem of flow regulation to selected sinks if substations are to provide current to several options as well as established hydrogen stations.

An important feature in future development of electrolysers is to avoid flushing with Nitrogen each time the production is shut down. This eliminates a lot of cost in the early start up phase as supply will be higher than demand due to few vehicles at introductory phase. Also in times of high load on the electric grid it would be possible to temporarily halt production.

The study was also extended as to include a survey that asked about preferences and customer behaviour concerning refuelling their vehicles, i.e. near their home or working site. An integration pattern was drawn up for the establishment of 22 hydrogen stations of three various sizes with the aim of minimizing both overall investment cost and customer travel cost when using the fuelling system.

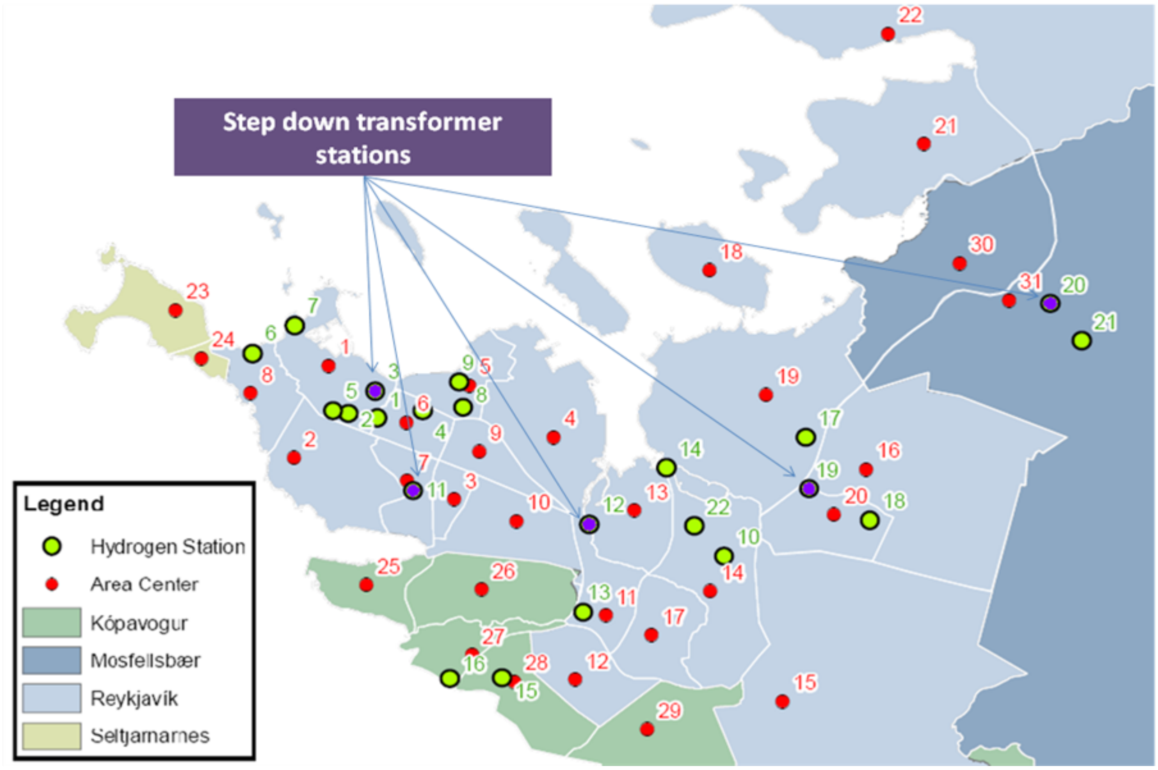

Figure 4: A map of Reykjavik and the neighbouring communities showing eventual locations for hydrogen stations. Locations have been optimised according to a) estimated demand in each of 31 postal code areas; b) invested customer travel time and c) locations of step down transformers or distribution grid substations. The numbers indicate in which row each station would be introduced. [4].

The most effective investment to meet growing demand is by selecting the largest production modules each time and placing them strategically close to sites that are central to the harbours, large residential areas and main traffic lines.

2.3.3 The vehicles

Several types of hydrogen vehicles from Daimler, Ford and Toyota have been tested so far see figs 5, 6 & 7). The accumulated distance driven by Feb 2009 was close to 100.000 km. The FC buses drove over 140.000 km during their demonstration in Reykjavik. Two A-Class Fuel Cell vehicles were in use for over a year, without any major repairs or failures. The fuel use was slightly higher during the winter moths than during the summer. On average the fuel consumption per 100km was 1.4 kg H_2. One Ford Focus FC car has been in regular use since 2008. The range is over 300 km and fuel economy is slightly higher than for the A-class. The same fuel cell system is in both vehicles but the Focus is a larger vehicle with a larger hydrogen storage system.

The maintenance of the FC vehicles has been minimal and the customer experience is positive towards the FC cars.

Figure 5 The Daimler FC A-Class.

In 2007 Vistorka imported ten Prius cars that were retrofitted for H_2 and certified in California by Quantum. These cars have internal combustion engines that work similarly as in a normal hybrid Prius but burn hydrogen instead of gasoline. During the winter when the temperatures are below freezing the performance of these vehicles is not satisfactory. When the vehicle is used for short distances during cold spells water tends to condense and accumulate in the engine and contaminate the engine oil. The low temperature also affects the battery performance, the ignition coils and spark plugs. This has called upon more maintenance and garage time than for the FC test cars. During the summertime the car works well and the drivers are satisfied.

A test was made by installing engine heaters (block heaters) that warm up the engine of the Prius cars and its interior during the winter. These are monitored with a clock to coincide with startup times. Most of the water contamination in the oil disappeared if the block heater is used correctly and the fuel consumption decreased 15%. Without block heaters the fuel consumption of the Prius is close to 1,8 kg/100 km but with the block heaters the fuel consumption per 100 km drops close to 1,5 kg.

Figure 6: Connecting a block heater on Prius hydrogen car with ICE engine.

This effect will be further studied in 2009 and the energy for heating measured. Also the energy download for plug-in hybrid cars using other type of fuel will be monitored. Surprisingly it has not been the custom to use block heaters extensively in Iceland as in other northerly climates.

In some instances the hydrogen vehicles are used in comparison with methane cars and diesel driven cars and the plan is to introduce a few electric battery vehicles alongside these test vehicles that are kept as service fleets. An earlier generation of battery cars was tested in the 1990s, and could be used as benchmarking in comparison with newer battery models expected to arrive for testing in 2009. For this purpose the government has signed a MoU with Mitsubishi to introduce iMIEV vehicles.

During the year 2009 a driving monitor will be installed in each type of the alternative vehicles for two weeks each and the fuel economy monitored carefully and compared with the driving behavior as well as other parameters. This equipment is called Saga-monitor and is provided by the company New Development [10].

Figure 7: The Ford Edge, plug-in hydrogen hybrid.

3 Conclusions and Discussion

The test drives and research has the goal to support future decision makers regarding which steps to take in a sensible integration of locally derived fuels types with lower emissions and support good transition management for the needed infrastructure and distribution systems.

The discussion on electric battery cars is not addressed here because these have still not been displayed in regular use in Iceland but are expected to arrive in 2009. There is no doubt that electric battery vehicles will take a considerable market share and will be used for short range and can be reloaded during the night when the demand for electricity on the grid is low. Intelligent synchronisation of supply and demand regulation of the grid awaits the arrival of such fleets. But for longer range and convenient filling time hydrogen powered vehicles are seen as a natural option. Electricity generation can be from various sources and additional hydro and geothermal power stations. Generating hydrogen by a mix of electricity and high (geothermal) heat is seen as an interesting future option for Icelandic conditions. Literature tends to point to gas reforming as the cheapest way of producing hydrogen in large centralised production stations but purity criteria and inefficient transport in cylinders make the electrolytic option very interesting especially where an electric grid is already established or renewable power stations need buffering.

After testing of several types of hydrogen vehicles it is stated that the FC vehicles perform excellently, need for maintenance is very low, the driving experience is pleasant and the performance is good in temperatures that fluctuate between zero and 15 degrees. Citaro buses, Ford Explorer, Daimler AClass and Ford Focus all of these have performed as well as ordinary cars though some have shorter range than would be ideal. Yet another type, the Ford Edge has been demonstrated in Iceland and evoked high impression (Refer to fig 7). It is a plug-in hybrid H_2 fuel cell vehicle with an optional range of roughly 40 km on batteries and 320 km on hydrogen. During testing in Iceland in 2008 it became evident that it fulfilled all expectations of users, i.e. fast refuelling, adequate range and excellent efficiency when using the batteries alone as most vehicles are mostly used for short trips.

The Icelandic team intends to continue on the similar path not overlooking the possibilities of using all locally derived methane with or without mixing with hydrogen (hythane). The support of multinationals like Daimler, StatoilHydro and Shell Hydrogen has been vital for the activities and combining that with the domestic and EU support the Icelandic case can be a model for others to follow.

It is time for active and measurable implementation steps not only in Iceland but at an international level. Implementing a "sustainable mobility and fuel” policy can be a very effective tool and currently INE and its partners are encouraging the government, communities and companies to take on such policy steps and show social responsibility in action.

References

♡1♣ EU projects: CreateAcceptance, ECTOS, HyFLEET:CUTE, Roads2Hycom, HyApproval, SMART-H2 are introduced at www.newenergy.is

[2] Fischer,M. M. Faltenbacher, O.Schuller Life cycle impact assessment of hydrogen equipment, ECTOS/ CUTE report no 16. www.newenergy.is

[3] Guðmundsdóttir Lilja (2008) H2 infrastructure in Reykjavik. Hydrogen infrastructure build-up in the Orkuveita Reykjavikur service area. MSc, theses. Dept. of Industr.Eng. Faculty of Engineering. and Natural Science, University of Iceland, Oct 2008.

[4] Guðmundsdóttir Rósa (2009) Well to Wheel Analysis of Future Hydrogen Pathway in Iceland, MSc, theses. Dept. of Industr.Eng. Faculty of Engineering. and Natural Science, University of Iceland, Feb 2009.

[5] HyFLEET:CUTE University of Iceland ed. M. Maack Deliverable No. 5.4, Hydrogen moves from a societal niche to a systemic integration. Social implications of introducing hydrogen as fuel in Reykjavik; EC supported project TREN/05/FP6EN/ S07.52298/019991

[6] Icelandic New Energy, www.newenergy.is

♡7♣ Maack María, Jón Björn Skúlason (2004) Implementing the hydrogen economy, International Journal of cleaner production. Vol 14 issue 1.

♡8♣ Maack Maria, Thomas H. Schucan, case study: Ecological City Transport System 2006, IEA Hydrogen Implementing Agreement www.ieahia.org/pdfs/ECTOS.pdf<http://www.ieahia.org/pdfs/ECTOS.pdf>

♡9♣ Metan, www.metan.is

♡10♣ New Development, www.nd.is

♡11♣ Orkuspá, Energy forecast for Iceland2009 – 2030. www.or.is

♡12♣ Ögmundardóttir Helga. 2007- 08. In-depth interviews on alternative vehicles and local fuel. Study for Icelandic New Energy

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