巻頭言

Creating a non-fossil energy economy in Iceland

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As Ambassador of Iceland in Japan I am grateful for the opportunity to present the Icelandic vision of creating a hydrogen society in the future.

I fully realise that we can not reach such a goal by ourselves, we do not have the fuel cell and hydrogen production technology required and are therefore dependent on co-operation with foreign scientists and companies such as the world automobile manufacturers, shipbuilders, oil companies *etc.* All the above mentioned parties visualise hydrogen as the fuel of the future. Iceland is in a unique position because it possesses abundant resources of geothermal and hydroelectric energy.

Iceland's energy economy benefits from its nature. Geologically it is situated at a hot spot on the border between the Eurasian and American continental plates where magma from the Earth's crust reaches the surface and forms active geothermal areas. Climatically abundant precipitation created by the dynamics of the Iceland low pressure, combined with the average land elevation of about 600 meters, provides plenty of potential hydroelectric energy. This combined energy potential provides the basis for the philosophy of the present new energy policy of Iceland.

Compared to population, Iceland possesses abundant amounts of un-harnessed renewable energy. The present estimate of the economically harnessable hydroelectric energy is about 30 TWh/year, of which only 22% have been harnessed. Geothermal energy estimated economically harnessable amounts to about 200 TWh/year (thermal), of which only 2 per cent has been harnessed.

Space heating and common domestic electricity needs are easily fulfilled by the above renewable energy sources. Also a considerable metals production industry is powered by hydroelectric energy (4.25 TWh/year) mainly producing aluminium and ferro-silicon. The total energy use in Iceland is about 34 TWh annually. Of the total 34 TWh/year, 50% is provided by geothermal, 20% by hydro or a total of about 70% and 30% by imported fossil fuels. The transport and fishing sectors are almost primarily powered by imported liquid fossil fuels, which amount to about 2/3 of the total import. Imported fossil fuels account for 10 Tons of CO_2 emission pr. capita pr. year.

Icelanders are contributing to the Geothermal knowledge of the world. The United Nations University with its headquarters in Tokyo has conducted an academic program in Iceland for two decades. The National Energy Authority, the University of Iceland and the Nordic Volcanological Institute in Reykjavík are among world authorities on geosciences and geothermal engineering.

Two energy infrastructure changes in a century

At the onset of the twentieth century Icelanders began harnessing hydroelectric energy of rivers and streams. This can be seen as a valuable contribution to a sustainable energy system

because of the savings of fossil import. At first the hydroelectric harnessing had purely practical reasons. The rivers and falls were simply there. Today, however, Icelanders have become aware of the fact that no human endeavour is free from a sustainability threat. For technical and ecological reasons research and development tied to hydroelectric and geothermal harnessing is probably one of the largest research and development targets in the country. Harnessing hydroelectric energy in a sustainable manner has become an important theme in the development of energy in Iceland.

The second energy infrastructure change happened in the period of 1940-1980 by the harnessing of geothermal energy. By now 95% of all buildings in the country are heated by geothermal energy.

The new challenge of synthetic fuels - the third energy change

Having saved fossil import because of hydroelectric and geothermal harnessing, Iceland is facing an important challenge. This is aggravated by the fact that metal industries produce large amounts of greenhouse gases. The remaining challenge is to reduce emissions from other sectors like the fishing and transport by using the abundant renewable energy sources. One of the possibilities is to produce synthetic fuels like hydrogen for use as an energy carrier. For the production hydroelectric power would be the main source in the beginning and in less amounts geothermal power. However, the future importance of geothermal power in primary energy production for hydrogen is very likely to increase.

The third energy infrastructure change in Iceland within a time span of a hundred years is being heralded by the government. In the future scenario, hydrogen can be produced by electrolytic splitting of water into hydrogen and oxygen. This is a well known technology and has been used in Iceland for over 50 years.

In order to provide the transport and fishing sector with hydrogen about 5 TWh/year of new electric energy to the present electric power would have to be added. The electric energy needed to replace the present oil import would therefore amount to 10% of the total electric potential in the country.

The new sustainable Icelandic energy cycle could become an example for the world to follow. It is clear that hydropower is a limited resource and can only serve in limited parts of the world. However, sources such as solar power have the potential to become the primary global energy source for hydrogen production and the subsequent infrastructure change. The demonstration projects in Iceland may serve as a guide to running such a new infrastructure.

A European movement is rising in the area of hydrogen based energy carriers in Iceland. An Icelandic-international corporation Icelandic New Energy Ltd. was formed in 1999. It is owned by an Icelandic holding company owned by Icelandic energy companies, the University of Iceland, as well as other research institutes (51%) on one hand, and on the other Daimler-Chrysler, Shell Hydrogen and Norsk Hydro (49%). The company is now working on a number of hydrogen related projects. It has created a work plan based on six main activities as follows:

The six step hydrogen scenario

Icelandic New Energy has envisaged a six step plan for the introduction of a hydrogen economy in Iceland.

Phase 1
A demonstration and evaluation project of operating hydrogen infrastructure and fuel cell buses in Reykjavík, the so-called ECTOS project (Ecological City Transport System).

Phase 2
Gradual replacement of the Reykjavík city bus fleet and possibly other bus fleets with fuel cell buses.

Phase 3
Introduction of "hydrogen based" fuel cell cars for private transportation.

Phase 4
Fuel cell vessel demonstration and evaluation project.

Phase 5
Gradual replacement of the present fishing fleet by fuel cell powered vessels.

Phase 6
Export of hydrogen from Iceland to the continent of Europe.

Phase 1, the ECTOS project, is the first key project, which formally began in March 2001. It is a European Commission, Fifth framework supported project involving 10 partners from 5 European countries. Three key elements will be investigated. The first concerns the integration of an on-site infrastructure in the city of Reykjavík. The second is to operate 3 fuel cell hydrogen buses in the Reykjavík public transport sector. The third, and probably the most important part, is to perform socio-economic research; life-cycle analysis, cost benefit analysis, urban transport analysis including comparison with other types of alternative fuels and social acceptance analysis (2001-2005).

In 2001 the project concerned creating and integrating hydrogen infrastructure into the existing urban setting; including production, storing and distribution of hydrogen. The project culminates in 2003-2004 when the actual demonstration of three fuel cell hydrogen buses will take place. It should be noted that the ECTOS project is interconnected with other fuel cell bus demonstration projects in Europe and therefore the basis for learning is extensive.

Presently the partners in Icelandic New Energy are discussing the possibility of making preparations for initiating phase 4 with the purpose of using hydrogen for powering a fishing vessel and phase 6 to investigate the possibility of demonstrating export of hydrogen to the European continent.

All the main car manufacturers in the world have stated that demonstration vehicles will be shown between 2003 and 2006. Series production will start between 2010 and 2015. It is estimated to have hydrogen ships becoming available between 2020 and 2030, which means that Iceland could become a full hydrogen economy in 2050.