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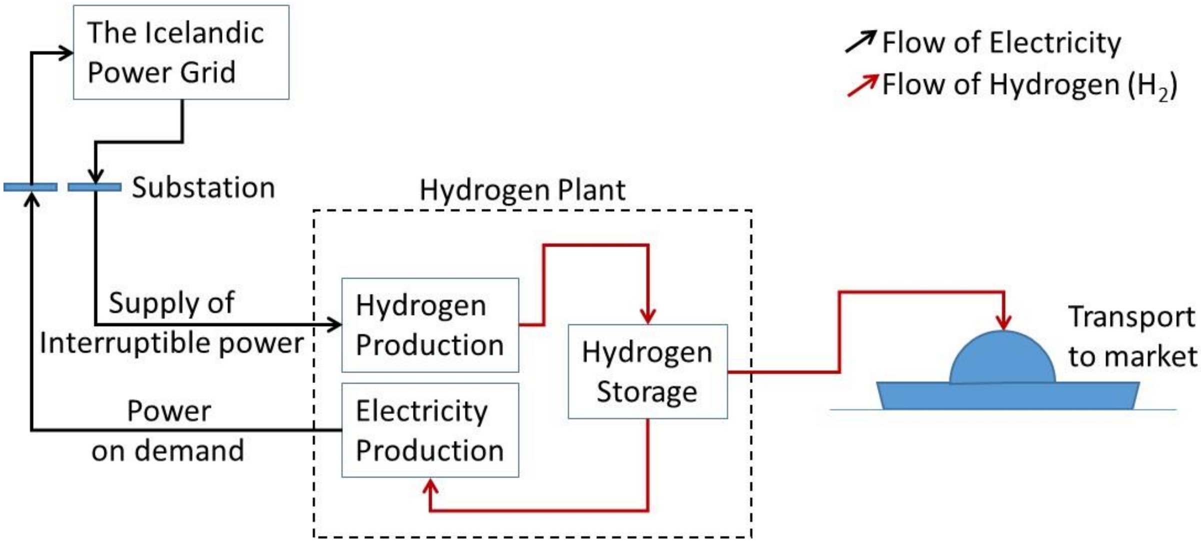
Hydrogen Plant in Iceland?

Introduction

Figure 1 shows a hypothetical Hydrogen Plant connected to the Icelandic electrical power Grid. The basic idea of the setup is to supply interruptible power from the Grid to the Hydrogen Plant at a low price and later produce at a higher price power from hydrogen on demand for the Grid.

Figure 1. Hydrogen production Plant in Iceland



In this study we assume that the production of hydrogen is based on electrolysis. The largest financial factor of the Hydrogen Plant is price and supply of electricity. The main purpose here is to clarify the exchanges of electricity with the Grid.

After providing hydrogen for electricity production on demand, rest of the produced hydrogen would be exported in liquid form by tanker ocean transportation.

The overall financial impact of hydrogen production and the additional financial impact on the Icelandic energy system is beyond the scope of this study.

The production of hydrogen from natural gas is currently the cheapest source of hydrogen. The downside to the process is that its major by-products are CO, CO_2 and other greenhouse gases.

Criteria

The study is based on several criteria:

1. Hydrogen production would be enabled by Grid electricity in the form of interruptible power.
2. The electricity would be bought from the Grid at a variable wholesale price of 0.25 to 4.00 ISK/kWh, to be explained later in the document. (ISK: Icelandic krona.)
3. Max supplied power from the Grid: 100 MW.
4. Max delivered power to the Grid: 100 MW.

5. The electricity produced from hydrogen would be sold to the Grid at a wholesale price of 6.00 ISK/kWh.
6. In current agreements for the power intensive industries in Iceland (Aluminium factories etc.) secondary power is sold at an assumed wholesale price of 2.00 ISK/kWh.
7. No consideration is taken of the internal structure of the Hydrogen Plant.
8. Supply of interruptible power from the Grid and power delivered to the Grid cannot take place simultaneously.

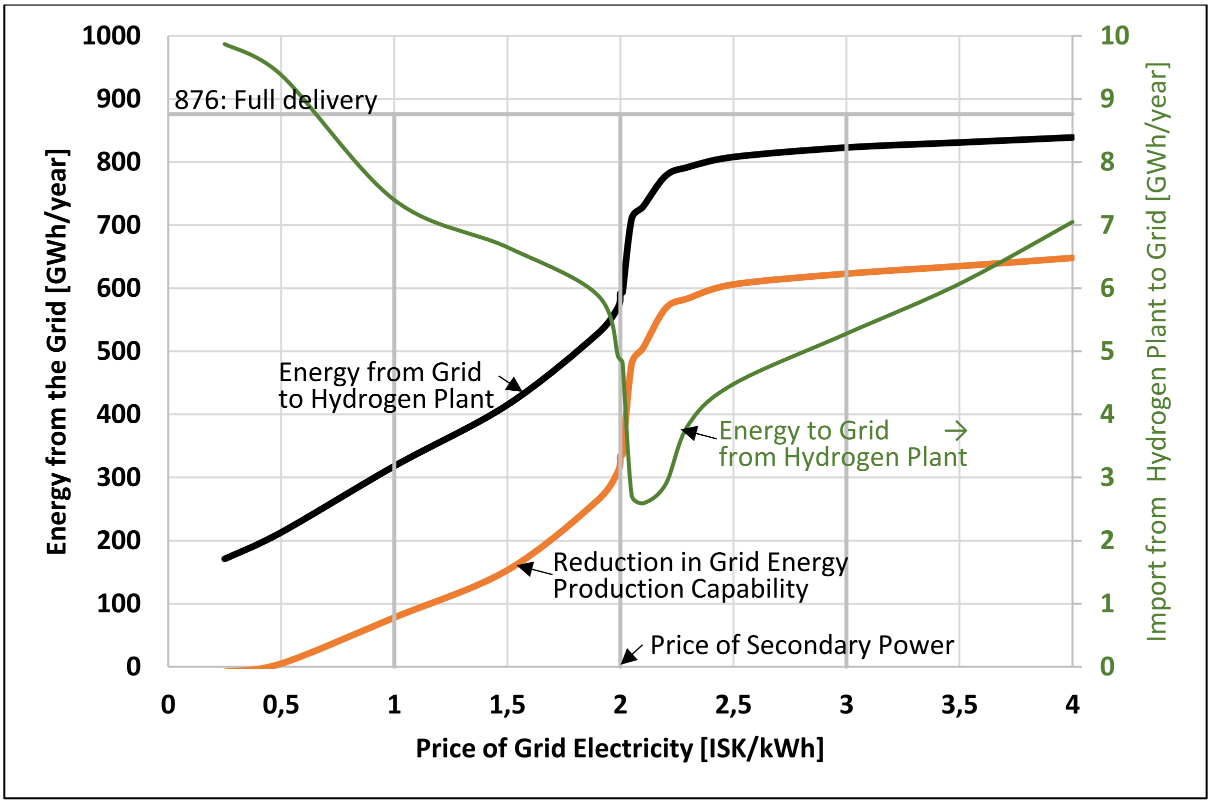
A simulation/optimization model of the Icelandic power system was used to generate results. Some of the data are approximate but the general purpose was to study the methodology.

Results

Figure 2 shows average energy from the Grid to the Hydrogen Plant and average energy from the Hydrogen Plant to the Grid. The delivered energy varies with price of interruptible power. The higher the price the more delivery takes place. The Energy produced in the Hydrogen Plant and delivered to the Grid is showed on a different scale in green to the right.

The figure also shows the reduction of Grid power production capability as a function of price of interruptible power.

Figure 2. Energy exchanges at the Hydrogen Plant



Large variances are around the price of existing Secondary Power but in the model prices determine which category (secondary power or interruptible power) has priority for the Grid.

As an example, price of Grid electricity to the Hydrogen Plant of 1.00 ISK/kWh would lead to an average delivery of interruptible power from the Grid to the Hydrogen Plant of 318 GWh/year and an average delivery of energy on demand from the Hydrogen Plant to the Grid of 7.4 GWh/year. Reduction of Grid power capability would be 78 GWh/year and could for example be compensated by a new geothermal power plant equivalent to 10 MW. Extra hydrogen storage capacity needed all the time should enable electricity production to the Grid for at least 4 months of full production.

Price of Grid electricity to the Hydrogen Plant of 3.00 ISK/kWh would lead to an average delivery of interruptible power from the Grid to the Hydrogen Plant of 823 GWh/year and an average delivery energy on demand from the Hydrogen Plant to the Grid of 5.3 GWh/year. Reduction of Grid power capability would be 623 GWh/year and could be compensated by a new power plant equivalent to 78 MW geothermal. Extra hydrogen storage capacity needed all the time should enable electricity production to the Grid for at least 2 months full production.

Other interesting areas

It might be interesting to look at other methods of using additional renewable energy sources to produce electricity for the hydrogen plant, for example nearby wind power stations that would not make use of the transmission system, thus eliminating significant power transportation costs.

The same methodology and a model similar to figure 1 could also be used for other interesting conditions of energy exchanges with the Grid:

1. Icelink submarine cable from Iceland to Britain. It has been estimated that the transmission capacity should be 1000 MW, which is of an order of magnitude larger than the Hydrogen Plant. It would then be necessary to treat the problem accordingly.
2. Large separate battery backup for the Grid similar to the 100 MW Tesla Lithium-Ion Battery Backup that is currently being installed in Australia. The battery will be able to deliver 100 MW, but only for 1-3 hours, so again here is another order of magnitude as compared to the Hydrogen Plant.
3. Use of the vehicle fleet as a battery backup for the Grid. Only a short-time backup capabilities with same restrictions as in 2.

For the model of the Icelandic power system none of these cases reveal the same advantages as the Hydrogen Plant.