Amela Ajanovic, Reinhard Haasand Nebojsa Nakicenovic

ASSESSMENT OF HYDROGEN CHAINS BASED ON RENEWABLE ENERGY

Energy Economics Group, Technische Universität Wien
Gußhausstraße 27-29/373-2, A-1040 Wien, Austria
Phone: +431/58801-37364, Fax: +431/58801-37397, E-mail: ajanovic@eeg.tuwien.ac.at

Objective

Hydrogen is widely considered as an energy carrier with the potential to reduce local and global emissions and to increase supply security. This paper examines the economics of innovative technologies for hydrogen production from renewable energy. They include hydrogen production by the electrolysis of water with electricity generated from wind and photovoltaic power plants as well as the gasification of biomass followed by steam reforming to produce hydrogen. The analysis covers both, stationary applications (households) and mobile uses of hydrogen.

The costs of renewable hydrogen and the costs of the provided energy services are analysed in a dynamic context till the year 2050.

Methodical approach

In this study hydrogen energy chains based on various production methods from renewable energy sources are investigated. The hydrogen chains are divided into five parts: hydrogen production, hydrogen preparation (compression or liquification), transport and distribution, storage and end-use applications.

Figure 1 shows the costs of hydrogen supply for some renewable hydrogen chains in comparison to H2 from natural gas. Renewable hydrogen is produced onsite, so no transport is required. In the case of the natural gas hydrogen is produced central and needs to be transported to the point of consumption.

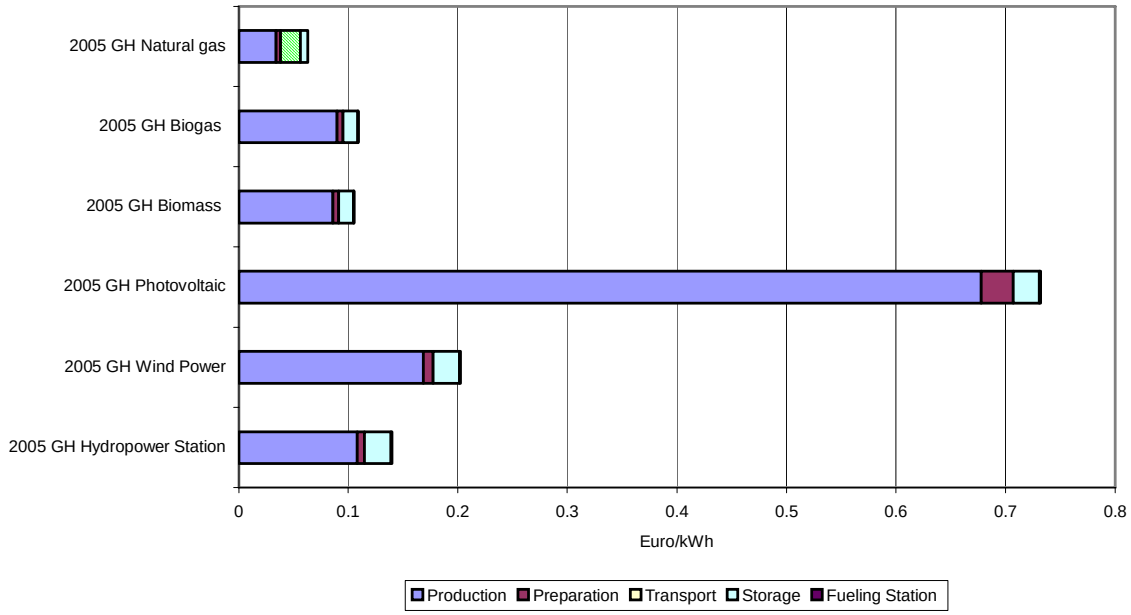

Figure 1: Costs of hydrogen supply for final consumers

The future prospects for a wider use of renewable hydrogen were analyzed by varying the assumptions about the technology learning rates and market growth rates.

Hydrogen used as a fuel for transport could be interesting only if the price of the hydrogen vehicles becomes close to the price of conventional vehicles. Of course, the cheaper hydrogen vehicles become, the faster they will penetrate the market. Figure 2 shows the total costs for the mobility in Euro (€) per kilometer as a function of different market penetration rates of hydrogen vehicles.

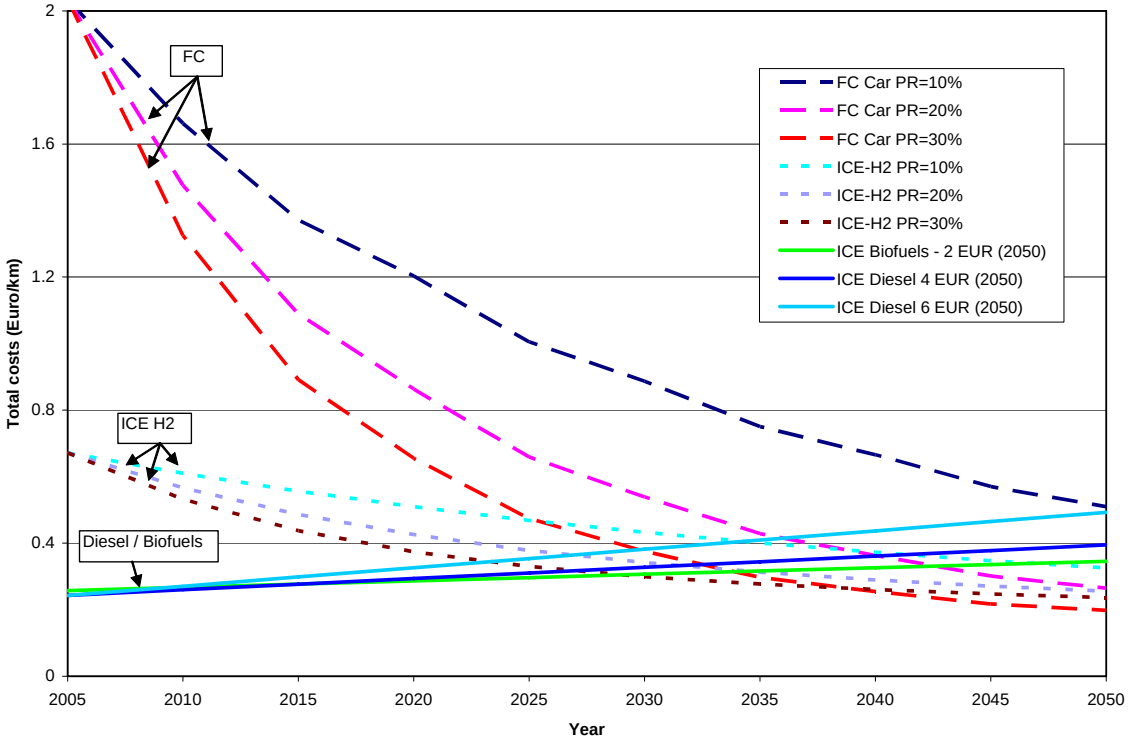

Figure 2: Total costs per kilometre (km) for hydrogen cars with fuel cell (FC) and internal combustion engines (ICE); different scenarios are considered with diesel reference prices increase to between 2 and 6 EUR/liter till the year 2050 with annual market penetration rates PR of 10%, 20% and 30% (Hydrogen from wind power)

Results and conclusions

This analysis shows that the entire renewable hydrogen chain requires higher capital costs than when renewable energy sources are used directly (e.g. using electricity as the carrier) to provide the same quantities of energy services.

Currently, from an economic point-of-view there is no argument for using renewable energy via the detour over hydrogen compared to the direct use of renewable energy. As long as the capacity of electricity transmission and distribution is sufficient it is cheaper to use electricity from hydro power, wind power, or photovoltaics directly. For transport the direct use of biofuels is in every reasonable scenario cheaper than using hydrogen produced from biomass.

A rapid increase of the market shares of fuel cell vehicles with hydrogen is not expected in the near future, because the hydrogen infrastructure is still not available and the costs of the fuel cells are still very high. In the meantime, the internal combustion vehicles powered by hydrogen could become an alternative to fuel cell vehicles because they are considerably cheaper and are thus more competitive compared to the conventional vehicles. Yet, it has to be stated that the competitiveness of hydrogen vehicles would be significantly enhanced through “downsizing” of vehicles, e.g. by reducing weight and thus reducing energy required per passenger kilometer.