Integrated Design for Demonstration of Efficient Liquefaction of Hydrogen (IDEALHY)

Fuel Cells and Hydrogen Joint Undertaking (FCH JU)

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Publishable Summary

This report documents work on the development of MS Excel workbooks for the production and utilisation of hydrogen in Task 3.3 on life cycle and economic assessment in the IDEALHY Project which is supported by the Fuel Cell and Hydrogen Joint Undertaking (FCH JU) under Grant Agreement No. 278177 with funding from the European Commission.

The aims of the IDEALHY Project and the rôle of Task 3.3 within Work Package 3 on whole chain assessment are re-iterated. The list of final versions of the workbooks for evaluating total primary energy inputs (as an indicator of energy resource depletion), total greenhouse gas emissions (as an indicator of global climate change) and total internal costs (excluding taxes and financial incentives) for specific means of hydrogen production, hydrogen liquefaction, liquefied and compressed hydrogen transportation and hydrogen utilisation in fuel cell road vehicles, as well as baseline oil-based road transport, is summarised. A sample of complete hydrogen pathways, from source to use, is specified and the use of simplified workbooks for generating results from these assembled pathways is noted.

The finalised workbooks contain considerable functionality and this means that a wide variety of results can be generated depending in the values used for accessible parameters. Instead of presenting all possible results, a series of comparative results are illustrated. In most instances, these results are based on default values incorporated in the workbooks.

Total primary energy inputs, estimated using consequential life cycle assessment methodology which includes the manufacture of all plant, equipment, machinery and vehicles, are presented. Estimated total primary energy inputs for hydrogen pathways based on wind and solar power are, unlike some that use hydrogen from natural gas and brown coal, are higher than those for conventional oil-based road transport. Contributions to total primary energy inputs are provided which demonstrate the importance of hydrogen production and utilisation, consisting mainly of fuel cell vehicle manufacture, maintenance and decommissioning.

Total greenhouse gas emissions are derived using both the Renewable Energy Directive methodology, which excludes plant and equipment manufacture, and the consequential life cycle assessment methodology. Results for hydrogen fuel obtained with the Renewable Energy Directive methodology are compared with minimum net greenhouse gas emissions savings required for biofuels. It is shown that certain pathways for providing hydrogen fuel are unable to achieve these minimum savings. However, it is noted that, as currently formulated, the Renewable Energy Directive does not apply specifically to renewable sources for transport other than biofuels and bioliquids. Additionally, the expected higher energy efficiency of fuel cells relative to internal combustion engines is not taken into account.

Total greenhouse gas emissions, derived using the consequential life cycle assessment methodology, are also presented for the chosen hydrogen pathways. Comparison with total greenhouse gas emissions associated with conventional oil-based road transport indicates that these results can be lower or higher depending on specific details of particular hydrogen pathways. Illustrations of the contributions to total greenhouse gas emissions again show that these are dominated by hydrogen production and utilisation.

The workbooks adopt less sophisticated approaches to the calculation of total internal costs. This means that such results should only be regarded as indicative rather than definitive. The results obtained demonstrate that the total internal costs of all hydrogen pathways are higher than those for conventional oil-based road transport. Assessment of contributions to total internal costs shows that these are dominated by hydrogen utilisation, consisting of fuel cell vehicle manufacture and operation.

Given the main focus of the IDEALHY Project on hydrogen liquefaction, the workbooks were used to compare hydrogen pathways that incorporate liquefied and compressed hydrogen fuel delivery. In particular, variations of results with hydrogen fuel delivery distance are investigated. As might be expected, pathways with compressed hydrogen fuel delivery are more strongly influenced by increasing delivery distance than those based on liquefied hydrogen fuel delivery. It is shown that, based on a selection of hydrogen pathways, delivery of liquefied hydrogen fuel above given distances has lower total primary energy inputs (between 100 and 150 km round trip distance), lower total greenhouse gas emissions (between 120 and 150 km round trip distance) and lower total internal costs (between 240 and 260 km round trip distance).

Key Words

Life cycle assessment of hydrogen pathways

Economic assessment of hydrogen pathways

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