Global Hydrogen Resource Analysis for the Transport Sector

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Overview

The International Energy Agency (IEA) established the Hydrogen Implementing Agreement (HIA) to pursue collaborative hydrogen research and development and information exchange among its member countries. The goal of Task 30 (Global Hydrogen Systems Analysis) is to "perform comprehensive technical and market analysis of hydrogen technologies and resources and supply and demand related to the projected use of hydrogen." The overall objectives of Subtask A (Global Hydrogen Resource Analysis) are to: 1) Analyze potential hydrogen production and distribution pathways for participating countries; 2) Develop a user-friendly pathways analysis tool that allows users to understand the resource options and constraints to meeting future hydrogen demand and that estimates potential petroleum savings and greenhouse gas emission reductions associated with various scenarios; and 3) Collaborate with IEA analysts as appropriate to support global hydrogen resource analysis. To assist in this analysis, we developed the Global Pathways Analysis Tool (GPAT), which calculates the least-cost pathways for hydrogen supply for participating countries. This paper introduces GPAT developed to answer questions about potential hydrogen pathways, such as: How might pathways differ between countries or regions? Under what conditions might countries import hydrogen from other countries rather produce it themselves? What pathways lead to significant reductions in projected greenhouse gas emissions from the transport sector? How would different levels of CO_2 pricing change the projected pathways and likely greenhouse gas emission reductions? GPAT is an extremely flexible tool that can be easily modified to explore a wide range of alternative scenarios.

Methods

The Global Pathways Analysis Tool (GPAT) calculates least-cost pathways for H_2 supply for eight participating countries: France, Germany, Norway, Spain, Sweden, Denmark, Japan, and the United States. The US was further divided into eight regions to allow for additional regional analysis. Additional countries could be added as data becomes available. The pathways include consideration of feedstock, conversion, distribution (regional and long-distance), and carbon costs. For each country, hydrogen demand is calculated based on assumptions about future hydrogen vehicle market shares. Hydrogen production costs are calculated based on country-supplied data on feedstock availability for hydrogen production by type, cost, and quantity from 2010 to 2050, and assumptions about hydrogen production technology assumptions (efficiencies, costs, etc.).

Results

GPAT was used to estimate the likely pathways for a range of scenarios and sensitivities for a wide-scale introduction of fuel cell electric vehicles (FCEV) by 2050. The results show that there are a large number of potential pathways for providing hydrogen to fuel significant FCEV fleet: resources are **not** the limiting factor to a hydrogen economy. Every country participating has identified multiple options for producing hydrogen domestically. In a low-natural-gas-price world, it is difficult for other feedstocks to compete for a share of the hydrogen production in the absence of CO2 prices or policies limiting its use. The results are also very sensitive to assumptions about distribution costs; transporting hydrogen can be expensive. Additional integration of the results from this Task with the distribution cost results of Task 28 (Infrastructure) would be a useful next step. It would also be useful to integrate additional countries into GPAT as all participating countries found the iterative data collection and modeling approach used for this Task to be a useful exercise that provided insight into the range of potential options for supplying hydrogen for the transport sector.

GPAT also quantifies the potential reduction in greenhouse gas emissions from the transport sector. For a wide range of scenarios, we estimate that emissions could be lowered 40% – 44% from current levels. While a portion of this is due to expected efficiency improvements in traditional powertrains, FCEVs can lead to significant further reductions, especially for pathways that do not include coal as a feedstock for the hydrogen production.

A key feature of the Global Pathways Resource Analysis Tool is the ability for users to vary key assumptions, including resource availability and cost, vehicle shares and efficiencies, carbon taxes, and renewable portfolio standards, and view real-time results, making the tool ideal for policy-level discussions.

Conclusions

This global resource analysis work is a subtask of the IEA Hydrogen Implementing Agreement Task 30 (Global Hydrogen Systems Analysis). The main objective is to analyze potential hydrogen production and distribution pathways for participating countries. To accomplish this objective, we developed a user-friendly pathways tool to help participants understand the resource options and constraints to meeting future hydrogen demand for various scenarios. The results show there are a large number of potential pathways for providing hydrogen to fuel significant fuel cell fleets and that resource availability is not the limiting factor for a hydrogen economy.

For a wide range of scenarios, we estimate that greenhouse gas emissions from the transport sector could be lowered 40% – 44% from current levels. While a portion of this is due to expected efficiency improvements in traditional powertrains, FCEVs lead to significant further reductions, especially for pathways that do not include fossil fuels as a feedstock for the hydrogen production. In a low-natural-gas-price world, it is difficult for other feedstocks to compete for a share of hydrogen production in the absence of CO_2 prices or policies limiting its use. For this reason, many countries expect their countries to require some percentage of their hydrogen production to come from low-carbon intensity fuels such as wind or biomass.

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