Green hydrogen support with overlapping climate policies

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Overview

A large body of literature examines the interactions between overlapping climate policies. So far, this literature has focused on emissions pricing and subsidies for renewable electricity generation. More recently, extensive support policies for electrolytic hydrogen have been introduced, but interactions with existing climate policies remain poorly understood. Here, we use an analytical and a numerical model to examine the combination of an emissions trading scheme and subsidies for renewable electricity and electrolytic hydrogen. In particular, we investigate the implications of requiring electrolytic hydrogen to be matched with additional renewable electricity on an annual or more granular temporal basis to be considered "green hydrogen" and qualify for the subsidy.

With our analysis, we contribute to two strands of literature. First, we add to the longer-standing economic analysis of overlapping climate policy instruments. In particular, specific support for renewable electricity generation has been frequently found to undermine the cost-effectiveness of an emissions trading scheme in mitigating climate change (e.g., De Jonghe et al., 2009; Böhringer & Rosendahl, 2010; Fankhauser et al., 2010). Second, we complement previous studies on temporal matching requirements for green hydrogen (e.g., Ricks et al., 2023; Ruhnau & Schiele, 2023; Giovanniello et al., 2024; Zeyen et al., 2024).

Methods

We first use an analytical partial equilibrium model of the electricity sector to draw general, qualitative conclusions on the main mechanisms of interactions between hydrogen, emissions, and renewable energy policy. Our analytical model represents the partial equilibrium of the electricity and hydrogen market by a social planner aiming to minimize total system costs, i.e., the sum of annual production costs of electricity and electrolytic hydrogen. Thereby, we assume perfect markets and exogenously defined demand quantities and policy targets.

We complement our analysis with a detailed numerical model to derive more specific, quantitative insights. As for the analytical model, the numerical model represents the electricity market in a partial equilibrium by a central planner minimizing total system costs. The model decides on capacity expansion and dispatch of power plants for the year 2030 in an hourly resolution. This high temporal resolution allows us to adequately capture the effect of hourly matching and the expansion of renewable energy sources with hourly varying availability. The model is applied to a subset of the European electricity market, including Germany and 13 connected bidding zones, covering two-thirds of the European electricity demand. For simplicity, the impact of the investigated policy mixes on emission prices is approximated through a price-inelastic cap on modeled power sector emissions.

Preliminary Results

We find that subsidizing hydrogen without matching leads to a shift from coal- to gas-fired electricity generation, an increase in electricity and emission prices, and a decrease in renewable subsidies. By contrast, subsidizing hydrogen with annual matching increases renewable subsidies while the electricity generation mix, electricity prices, and emission prices remain unaffected. With intra-annual matching, introducing a hydrogen policy leads to a more-than-proportionate increase in renewables and, as a result of the exogenous emission cap, a shift from gas- to coal-fired electricity generation; electricity and carbon prices decrease, but the hydrogen subsidy increases.

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