Carbon Potential of Green Hydrogen

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Definition

As a potential storage material, hydrogen (H2) is considered to be promising and considerable research has been invested into this matter. Scientists and industry discriminate between different colors of hydrogen depending on the method of production: Green hydrogen, for example, implies that production is (almost) CO2-neutral using e.g., bio gas or renewable energies such as wind power; whereas gray hydrogen is produced using fossil fuels such as oil or gas. Turquoise hydrogen implies using methane pyrolysis fueled by renewable energy sources, i.e., it is also considered to be CO2-neutral.

1.Introduction

The recent public debate about green energy technology is fairly binary and often with a predermined result: fossil technologies such as gas or coal fired power plants or fossil fuels themselves (oil, gas, coal) are considered to be dinosaurs that have to disappear very quickly. Further explorations are supposed to be canceled, as Denmark recently decided to do. In the future, energy generation should be renewable. As a potential storage material, hydrogen (H2) is considered to be promising and considerable research has been invested into this matter. Scientists and industry discriminate between different colors of hydrogen depending on the method of production: Green hydrogen, for example, implies that production is (almost) CO2-neutral using e.g., bio gas or renewable energies such as wind power; whereas gray hydrogen is produced using fossil fuels such as oil or gas. Turquoise hydrogen implies using methane pyrolysis fueled by renewable energy sources, i.e., it is also considered to be CO2-neutral. Eventually, blue hydrogen denotes the combination of steam reforming with a carbon capture and storage (CCS) procedure. This version is often regarded as bridge technology on the way towards a carbon-neutral economy, whereby it is often assumed in public and demanded by some non-governmental organizations that the switch from fossil to renewable energy production can be done within a very short period of time of, say, a couple of years. This article intends to test this hypothesis using Germany as an example, whereby we focus on green hydrogen. We therefore consider the involved numbers, e.g., the commodity demand for building enough wind mills or the corresponding needed investment demand. Our calculations show that even if technologies are (almost) ready for installation on a scalable and economically sustainable price level, which is hardly realistic even in a very optimistic setup, we face a significant CO2 bow wave. To switch from gray, blue, or turquoise to 100% green hydrogen, a substantial investment into green power generation—including a new distribution infrastructure (H2 pipeline and electricity grid)—is necessary. This includes a substantial amount of new wind turbines, solar power panels, power cables, hydrogen tankers, etc., which all have to be produced first. Even if we assume some effects from previously installed green devices, most of the production will be done with conventional technologies. All of these undertakings will produce CO2. This greenhouse gas is a stock pollutant, which means we will have to pay a heavy price for these construction efforts as it turns out not to be simply an investment into fewer emissions later. Such assumptions are a wrong understanding of intertemporal dynamics. A key element of a successful green deal will be to reduce emissions in heavy industries as quickly and cheaply as possible to provide a sustainable path towards a true green economy. According to our calculations it is reasonable to apply blue or turquoise hydrogen as an immediate carbon-saving technology that helps lower the impact of all efforts to set up a green hydrogen infrastructure. Note that doubts on this hypothesis are not new and there is a wide discussion going on in public and the science community.

2.Background

Besides the mentioned CO2 effects, there is also the issue of keeping public spending down. Considering the current developments on the commodity markets it is a reasonable assumption that, within the next 10 years, the price of each megaton of CO_2 not produced due to green hydrogen will be multiple of a megaton of CO_2 avoided using a 'multi-color' hydrogen approach. Both wind turbines and solar panels are high-tech products involving rare earths and common materials like concrete or steel. Already now economists discuss the issue of resource/commodity availability as well as prices and therefore implied inflation and stability of the macro economy. Currently, we see a massive increase of the prices for critical materials such as platinum, rhodium, copper, lithium, cobalt, or iron. Since also an additional build-up of production sites have to be done this will likely hit the market for steel, concrete, and aluminum. To avoid such a price squeeze and later on an also disastrous sudden price drop in the aftermath of the demand peak, a social input management is necessary, which especially includes existing technologies and production sites, e.g., (as mentioned above) blue and turquoise hydrogen. Besides, this resource run may cause significant CO_2 emissions in mining and transportation, although the quantity is hard to estimate. To conclude: according to estimates (e.g., by Greenpeace Energy), green technologies will be competitive from around 2040–2050 onwards. In order to avoid the above mentioned financial and carbon bow wave bridge technologies such as turquoise hydrogen or blue hydrogen plus CCS are required.

Keywords

hydrogen;wind power;electrolyzer;bow wave