Analysis of water resources for green hydrogen production in Europe

Kritische Rohstoffe und Kreislaufwirtschaft

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Motivation und zentrale Fragestellung

With its Green Deal, the European Union aims to become the first climate-neutral continent by 2050 [1]. This requires substituting fossil fuels with renewable energy sources (RES) in all sectors. For hard-to-electrify applications, hydrogen and its derivates are suitable and promising solutions [2, 3]. Water electrolysis requires pure, deionized water as an input to produce hydrogen. Many types of water sources need different kinds and amounts of treatment. Fresh water is already considered a scarce resource in many regions [4, 5], and due to climate change likely becoming even more scarce [6, 7]. Therefore, the question arises which water sources will be suitable for future green hydrogen production in Europe and to what extent they are available.

Methodische Vorgangsweise

To answer the question raised in this paper, comprehensive data analysis is required in particular. First, we analyze the different types of water sources suitable for future green hydrogen production. Therefore, we gather data about specific energy requirements for the pretreatment of water from different sources and show which water sources are more advantageous than others.

In the second step, the authors investigate water availability for green hydrogen production at the European country level. Therefore, we use the water exploitation index (WEI), also called the withdrawal-to-availability ratio, and determine this WEI to a maximum of 20% [8]. A WEI greater than 20% implies water stress in the country. This is defined by the European Environment Agency [9]. Water stress has a negative ecological impact in terms of water quantity and water quality.

Further, we investigate local and seasonal limitations of water availability. Therefore, we use geographically detailed water stress data and predictions from [6]. Additionally, we compare the seasonal variability of water availability in Europe with the optimal operating times of electrolyzers from a system's perspective. Hence, we identify potential sites for electrolyzers from the water point of view.

Ergebnisse und Schlussfolgerungen

The types of water resources are mixed to different degrees with other minerals or metals and need pretreatment. Results show freshwater sources require less energy during pretreatment via reverse osmosis than seawater (cf. Figure 1).

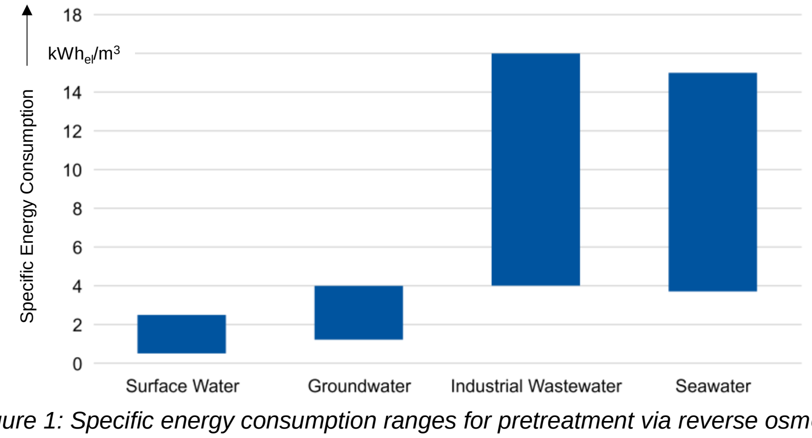

Figure 1: Specific energy consumption ranges for pretreatment via reverse osmosis

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Further, we show that on the European country level, northern European countries have higher water availability for hydrogen production than southern European countries. Some southern European countries appear to be already subject to water stress. We predict that the potential hydrogen production amount based on water availability is about 44,778 Mt, while the expected hydrogen demand in 2050 is about 69 to 100 Mt.

Nevertheless, water stress data from [6] indicate that site planning for hydrogen production requires much more detailed and specific geographical investigations. Regions in countries with economically beneficial locations for hydrogen production are the ones that may be subject to water stress (cf. Figure 2).

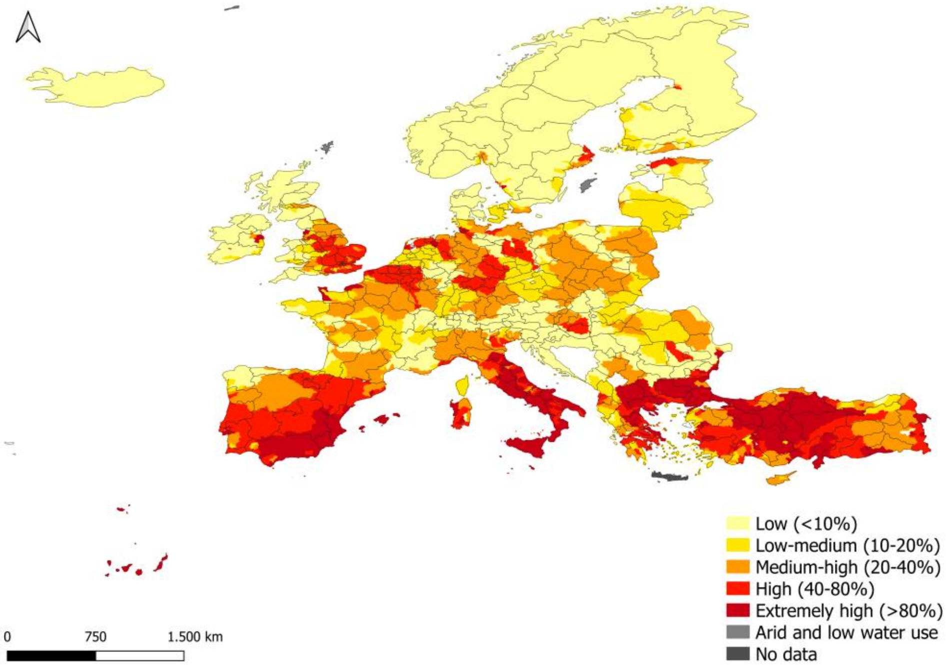

Figure 2: Water Stress in Europe 2020 [6]

Further, comparing the seasonal availability of water with the optimal operating time of electrolyzers from a system's perspective illustrates the conflict between water availability and hydrogen production. In the lack of freshwater resources, e.g., in regions in the Mediterranean Sea, seawater can represent an alternative associated with higher economic efforts.

Literatur

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