Ministry of Economic Affairs,
Innovation, Digitalization and Energy of the
State of North Rhine-Westphalia

North Rhine-Westphalia Hydrogen Study

Executive summary

www.wirtschaft.nrw

NORTH RHINE-WESTPHALIA HYDROGEN STUDY

EXECUTIVE SUMMARY

AN EXPERT REPORT FOR THE MINISTRY OF ECONOMIC AFFAIRS, INNOVATION, DIGITALISATION AND ENERGY OF THE STATE OF NORTH RHINE-WESTPHALIA

Jan Michalski

Matthias Altmann

Ulrich Bünger

Werner Weindorf

May 2019

ludwig bölkow systemtechnik

BACKGROUND AND OBJECTIVES:

What is the economic and climate-related potential of hydrogen in a future energy system?

As a result of the expansion of renewable energies and the increasing interconnection between the electricity, heat, transport and industrial sectors, the German energy system is undergoing a fundamental transformation. This transformation not only makes a decisive contribution to climate protection, it also delivers economic opportunities through new jobs, economic growth and reduced dependence on the import of fossil resources. Hydrogen, which will primarily be produced by electrolysis using renewable electricity, can make an important contribution to the energy transition as a universal energy source for the above sectors and as a long-term storage medium for large amounts of energy.

The main objective of this study is to investigate the economic and climate-related impact potential of hydrogen in a future energy system in North Rhine-Westphalia and Germany as a whole. To this end, the use of hydrogen from water electrolysis is systematically modelled and analysed within the framework of a comprehensive interconnection of sectors (electricity, heat, transport and industry) in the future energy system with an increasing share of renewable energies. In addition to the economic opportunities and challenges hydrogen presents to the relevant energy infrastructures, the focus will also be on possible value creation potentials and the transferability of the results to the federal level.

The detailed investigation of the energy system in North Rhine-Westphalia and Germany as a whole is carried out with the help of an integrated modelling approach by Ludwig-Bölkow-Systemtechnik GmbH (LBST). A total of six scenarios are examined in detail, which are characterised using greenhouse gas (GHG) reduction targets of -55% by 2030 and -80% to -95% by 2050. For each of these climate protection targets, a distinction is also made between a scenario focusing on electrification (electricity as the main source of energy for predominantly electrical end-use applications) and a scenario focusing on hydrogen (with dedicated H_2 pipelines for predominantly H_2 end-use applications) in order to derive the costs and benefits of hydrogen from the comparison of the two scenarios.

KEY FINDINGS

Ambitious climate protection goals require large electrolysis capacities, seasonal storage and extensive energy transport.

The optimal design and functioning of the energy system depend to a large extent on the respective climate protection targets and the share of renewable energies. For a GHG target of -80%, natural gas power plants play a key role in power generation and in covering peak power loads until 2050. This reduces the demand for additional seasonal energy storage. An ambitious climate protection target of -95% fundamentally changes the energy system. Because of the unavoidable residual emissions from industry and agriculture, the transport and heating sectors, as well as energy supply, must become GHG-neutral. To compensate for fluctuating and seasonal electricity generation, large capacities of up to 90 GW for power generation based on hydrogen and 40-60 TWh of H_2 storage are added in the relevant scenarios.

As shown in Figure 1 the optimum capacity of electrolysis in Germany moves within a relatively wide range. For a GHG reduction target of 55%, it is at 25-100 GW and it rises to 75-210 GW in the -80% scenarios. For an ambitious climate protection target of -95%, the required electrolysis capacity is 150-250 GW. In North Rhine-Westphalia, particularly large consumer-oriented electrolysers (up to 40 GW) and H_2 pipe storage facilities will be installed in the long term in the scenario with a focus on electrification, as demands for H_2 in the Ruhr region may be very high because of the steel industry. The steel industry may therefore play an important role in the development of the H_2 infrastructure in NRW and can be regarded as a potential game changer. In all the scenarios electrolysis also has a relatively good utilisation rate of 4,000-5,000 FLH[1]/a. This is because, in the optimum case, it is cheaper to curtail surplus feed-in from renewable energies rather than further expanding electrolysis.

The expansion of renewable energies means that the demand for electricity grid expansion is significantly higher than the forecast in the current grid development plan, especially in ambitious scenarios with a focus on electrification. In the scenarios that focus on hydrogen, the expansion requirement for the power grids is significantly reduced, as the bulk of the electrolysis capacity is built near high-potential energy sites (e.g. wind energy in the north) and the H_2 piping system is used for primary energy transport. Traditionally, the transport of energy from north to south through North Rhine-Westphalia is noteworthy due to the existing gas pipeline capacities.

[1] FLH: full load hours

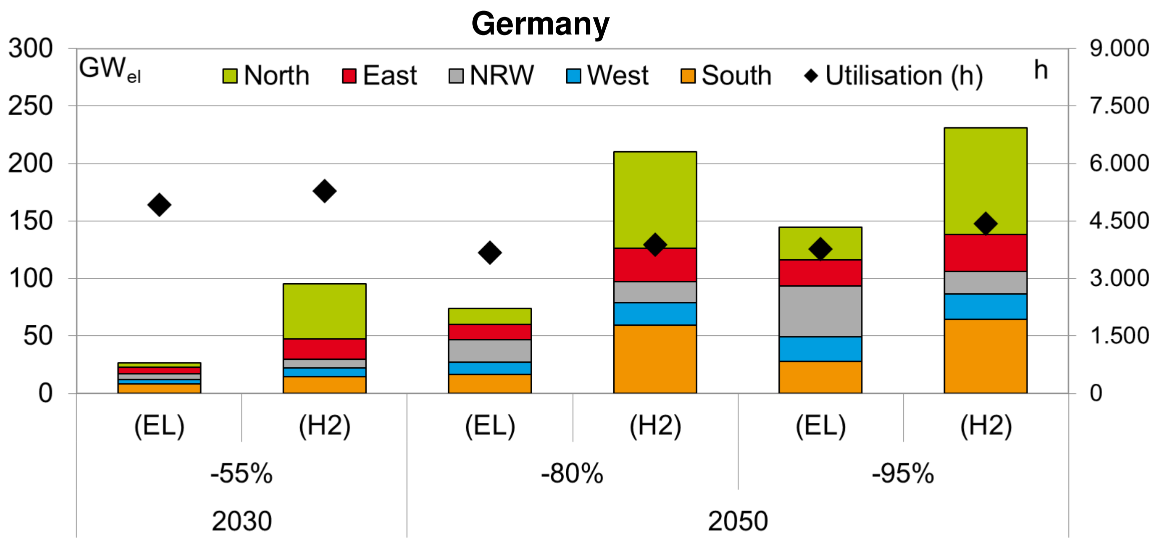

Figure 1: **Installed capacity and electrolysis capacity utilisation in Germany in GW or full load hours**

The increased use of hydrogen will minimise system costs in the long term and promote the integration of renewable energies.

Overall, the minimal costs in an energy system with a high share of renewable energies can be understood as a compromise between the costs of integrating renewable energies into the grid and system flexibility. In the medium term, until 2030, and in the long term, until 2050, given a GHG reduction target of -80%, an energy system with a lower H_2 share is more advantageous in the scenarios focusing on electrification. However, for an ambitious GHG target of -95%, the ratio is reversed and the system with a focus on hydrogen has significantly lower overall costs. It should however be noted that in the -80% scenario with a focus on hydrogen, a significantly larger amount of renewable energy is fed into the grid with system costs remaining the same and the climate protection target set as the upper limit is exceeded. It can therefore be concluded that a long term increased use of H_2 favours the integration of renewable energies and the increasing GHG neutrality of the energy system. Furthermore, the average generation costs for electricity and hydrogen are reduced in the corresponding scenarios.

Hydrogen has positive economic impacts by creating additional value, avoiding energy imports and creating jobs.

The analyses show the positive value creation effects of hydrogen. Overall, depending on the scenario, an additional value of 10-50 billion €/a can be generated in Germany by using H_2, approx. 1-10 billion €/a of which is generated in North Rhine-Westphalia. The indirect added value generated by power production from renewable energies for H_2 production is a major factor in this, followed by electrolysis. In NRW, the production of H_2 pipe storage facilities and H_2 transport also play an important role. Further potentials for the local economy may result from H_2 application technologies regardless of where they are utilised, i.e. regardless of whether these products are used in NRW or exported.

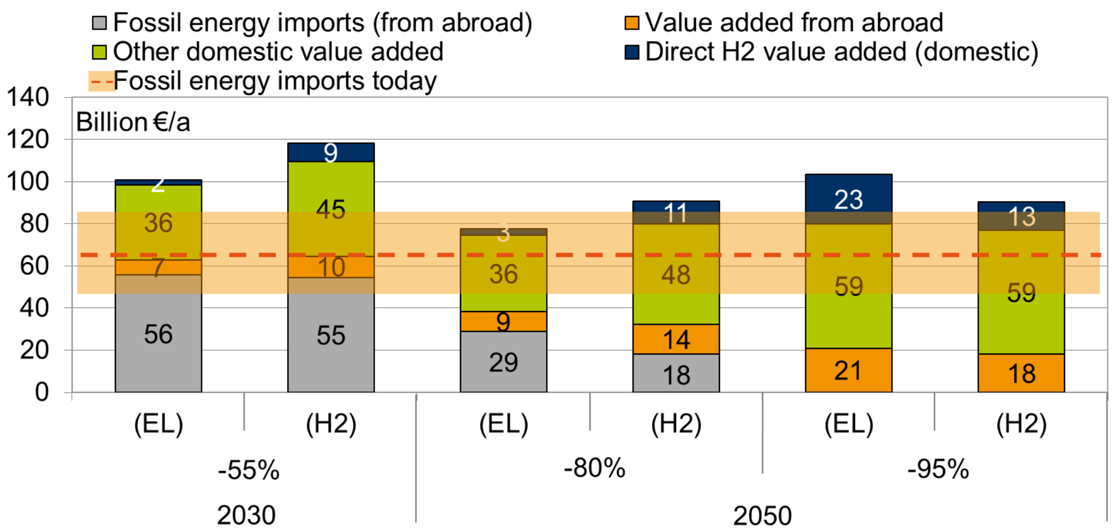

Figure 2: Total annual costs of the German energy system compared with current energy imports in billion €/a

In a largely GHG-neutral energy system, fossil energy imports to Germany of up to 10 billion €/a by 2030 and up to 65 billion €/a by 2050 can be avoided (see Figure 2). What is more, the system costs adjusted for domestic value added are already in the same order of magnitude in the medium term, until 2030, for hydrogen as for electrification. In the long term, until 2050, the scenarios that focus on hydrogen have a clear advantage. The job effects are generally comparable to domestic value added. The use of hydrogen can generate approx. 20,000 to 130,000 jobs in NRW.

RECOMMENDATIONS FOR ACTION:

Electricity and hydrogen are already the perfect partners for the creation of a GHG-neutral energy system of the future

Even though hydrogen's strengths can be utilised best when there is a high share of renewable energies, an intelligent energy transition requires cross-sector approaches and infrastructures which prepare and establish the integration of hydrogen into the energy system today. This is the only way to avoid bad investments and unnecessary lock-in effects. In this context, the two energy sources hydrogen and electricity are already the perfect partners for the creation of a GHG-neutral energy system of the future. The following recommendations for action regarding hydrogen as an energy source were compiled based on the results of the analyses.

General recommendations:

- Preparation of a detailed and comprehensive H_2 roadmap for NRW to ensure that the H_2 infrastructure is as efficient as possible;
- Identification and analysis of early business cases for hydrogen in different application areas including possible synergy effects;
- Awareness and information campaigns to increase public acceptance of hydrogen;
- The initiation of an ongoing political discourse about future energy self-sufficiency and energy import levels;
- The use of structural resources for the phase-out of coal to establish H_2 technology as a strong new industry in NRW;
- Funding for concrete projects for the implementation of H_2 systems with the potential for later commercial use;
- Monitoring technical developments and innovations and, if necessary, promoting them in good time. New developments should be accompanied by continuous adaptation of the regulatory framework;
- Establishing partnerships with other countries (such as the Netherlands) regarding possible H_2 imports, cross-border knowledge sharing and the synergistic expansion of H_2 gas infrastructures.

Recommendations for H_2 production:

- Promotion of H_2 production through tax exemptions (e.g. EEG apportionment) in the procurement of electricity for electrolysis;
- Creation of a certification system for H_2 guarantees of origin;
- Development and implementation of market mechanisms (e.g. in the form of capacity markets) that reward the system flexibility offered by hydrogen.

Recommendations for an H_2 infrastructure:

- Adapting the regulatory framework to benefit the grid-supporting use of H_2 technology by network operators;
- Promotion of binding and uniform regulations on adding H_2 to the gas network at distribution and transport network level;
- Coordination on the expansion of renewables as well as electricity, gas and heat networks;
- More detailed examination and implementation of the storage function of gas distribution grids;
- Integration of short-term storage and long-term storage in one energy system.

Recommendations for H_2 demand:

- Further expansion of H_2 service stations in NRW and across Germany to encourage the use of hydrogen for transport;
- Public sector procurement of fuel cell vehicles (e.g. as fleet vehicles) to generate additional demand for H_2.

Imprint

Publisher:

Ministry of Economic Affairs, Innovation, Digitalisation and Energy of the State of North Rhine-Westphalia

Berger Allee 25
40213 Düsseldorf
Germany
Tel.: +49 (0) 211/61772-0
Fax: +49 (0) 211/61772-777
Email: poststelle@mwide.nrw.de
Internet: www.wirtschaft.nrw

Department VII.5 "Future Energy Systems; climate protection in industry"

This study was conducted by Ludwig-Bölkow-Systemtechnik GmbH on behalf of the Ministry of Economic Affairs, Innovation, Digitalisation and Energy of the state of North Rhine-Westphalia.

Ludwig-Bölkow-Systemtechnik GmbH
Daimlerstrasse 15
85521 Ottobrunn
Germany
Tel.: +49 (0) 89 608110-0
Email: info@lbst.de

Picture credits:

© shutterstock.com/de/g/kodda (front cover), Csaba Mester (back cover)

The publication can be accessed as a PDF document on the website of the Ministry of Economic Affairs, Innovation, Digitalisation and Energy of the State of North Rhine-Westphalia at www.wirtschaft.nrw/broschuerenservice.

Please note:

This publication is published as part of the public relations work of the state government of North Rhine-Westphalia. It may not be used by political parties, candidates or election workers for canvassing purposes during an election campaign.

This also applies to state, federal and local elections and to the election of members of the European Parliament.

Its distribution at party information stands during election events and inserting, printing or affixing it to party-political information or advertising material in particular is deemed improper use. Its distribution to third parties for the purposes of political canvassing is also prohibited.

The use of this publication by any party or supporting organisation for the sole purpose of informing its own members shall remain unaffected. Irrespective of when, by what means and in what number this publication reached the recipient, it may not be used in a way that could be misconstrued as the state government's partisanship in favour of individual political groups, even without reference to a forthcoming election.

Ministerium für Wirtschaft, Innovation,
Digitalisierung und Energie
des Landes Nordrhein-Westfalen
Berger Allee 25, 40213 Düsseldorf
www.wirtschaft.nrw