Quality infrastructure for sustainable hydrogen solutions in Namibia

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Abstract. To ensure a sustainable and economically sound hydrogen supply, the ramp-up of hydrogen production in regions with large incident solar radiation is critically needed. Plans of the Republic of Namibia to set up a new infrastructure from scratch aiming at the export of ammonia as hydrogen carrier co-address questions with respect to the associated quality infrastructure (QI). Here, a regulatory framework is envisaged to define safety requirements and quality objectives for hydrogen generation, operating conditions of production facilities, and subsequent transportation. Standardization should secure access to the current level of technology and cover dynamic technological developments at the national and international level. New capacities will be required for services in metrology and accreditation, testing, certification, inspection and for monitoring the environmental impact. We present an overview of the essential components of a QI cooperation aimed at sustainable hydrogen production and export with project partner countries Namibia and Germany providing a case study. This article tackles technical requirements in the context of QI and showcases the cooperation between Namibia and Germany demonstrating how metrology supports both countries achieving their technical and economic goals.

1 Introduction

As part of the global transition to sustainable energy consumption, hydrogen will play a key role. Namibia is a country with high potential for renewable energy production. Currently, Namibia lacks the regulatory framework and quality infrastructure (QI), that shall go alongside the production of hydrogen and its derivatives. QI is also needed to ensure mutual accounting fairness. To address this gap, German and Namibian authorities are working together in a bilateral institutional partnership – a new instrument to share best practices of administration and to help establish efficient institutions.

1.1 Green Hydrogen Development

To be in line with the Paris Agreement and to "limit the temperature increase to 1.5°C above pre-industrial levels", the world needs to decarbonize its energy consumption. One promising field is the sustainable generation and use of hydrogen and its derivatives, such as ammonia and methanol. The ramp-up of this new technology opens up chances for industrialisation in countries with high solar irradiation and constant wind speeds like Namibia. Hydrogen has to be handled carefully, due to its explosive nature, molecular size, and related safety measures.

1.1.1 Namibian Hydrogen Strategy

Located on the western coast, in the south of the African continent, the Republic of Namibia offers ideal conditions for the use of renewable energy: About 300 sunny days and over 3,000 sun hours per year lead to solar irradiation values of 2,200 to 2,400 kWh/m². The southern coastline also offers constant wind speeds, which might yield around 2,800 MWh per installed MW of wind power. With *its Green Hydrogen and Derivatives Strategy*, the Namibian government sets the ambitious goal of producing "an estimated 140 mtpa of hydrogen equivalent in 2030 to 660 mtpa in 2050". This is estimated to be 5 to 8 percent of the worldwide green hydrogen production.[1]

Namibia's ambitions in establishing a green hydrogen industry were first laid out by Dr. Hage Geingob, the late President of Namibia, and his advisor James Mnyupe in 2019. Since then, the hydrogen strategy has become a part of the second *Harambe Prosperity Plan* and aims "to make a major contribution to solving the global climate crisis while also building broad-based prosperity for our citizens". It focuses on the production of four hydrogen-derivative products for export: ammonia, methanol, e-kerosene, and hot briquetted iron. In 2023, the Namibia Green Hydrogen Programme, led by James Mnyupe, was established by the Namibian government to implement the strategy.

Central to the Namibian Green Hydrogen Strategy is the question of sustainability, which shift the primary goal of merely energy production to implementing

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management controls that respond to climate change, government regulations, and customer demand for cleaner energy solutions. Production of green hydrogen in Namibia will therefore require a comprehensive and effective legal and regulatory framework that will help to manage sustainable production. This horizon therefore compels organizations to explore ways through which they can demonstrate environmental, social, and economic sustainability of their operations. This evolution highlights the growing importance for expanding its QI in response to the unique needs of this emerging industry

1.1.2 Hydrogen Strategies in Germany

In order to decarbonise its energy-intensive industry and the transport sector, the EU has set itself the goal of covering around 10 % of its energy needs by renewable hydrogen until 2050.[2] The *German Hydrogen Strategy* assumes an annual national need of up to 130 TWh of hydrogen by 2030, including hydrogen derivatives. With local electrolyser capacities aimed at 10 GW, the missing difference will have to be imported.[3]

1.2 Hyphen Pilot Project in Namibia

In 2021, the Namibian government announced Hyphen Hydrogen Energy as the successful bidder to develop its most ambitious green hydrogen and ammonia plant. The project proposal includes a combined hydrogen and power plant, water and hydrogen pipelines, electricity transmission and further processes at an industrial port site in the town Lüderitz on the south coast. The port will include facilities for water desalination, air separation and ammonia synthesis. The wind turbines, solar panels, as well as batteries and electrolysers will be installed in the nearby Tsau ǁKhaeb National Park in the Namib desert. Through pipelines, desalinated water will be supplied for electrolysis, and the green hydrogen routed back to the port. The targets are 7 GW renewable energy and 3 GW of electrolysis in 2030, and two million tonnes of green ammonia produced. Excess energy and potable water will go into the Namibian infrastructure.[4]

2 Institutional Partnership

To establish a safe and reliable green hydrogen infrastructure, as well as ensure accounting fairness, the concurrent establishment of quality infrastructure services and a regulatory framework for explosion protection is needed. To support the Namibian Ministries and Authorities in these tasks, an institutional partnership was agreed upon in 2023. Bilateral institutional partnerships are a tool of the German Federal Ministry for Economic Affairs and Climate Action (BMWK) to deliver advice in the setup of local authorities and support in adapting laws, guidelines and procedures as well as their implementation. To achieve this, training and further education of employees of partner institutions can also be provided.[5]

2.1 Partner institutions

On the Namibian side, two ministries are involved in the partnership: the Ministry for Industrialisation and Trade (MIT) and the Ministry of Mines and Energy (MME). Further institutions include the Namibian Standards Institution (NSI), an MIT agency, and the Energy Control Board (ECB), an MME agency. The NSI encompasses the Namibian National Metrology Institute as well as departments for Standards Development & Coordination, Testing & Inspection and Certification. The ECB is responsible for regulating the Namibian electricity supply industry with regard to efficiency and safety. Another partner is the University of Namibia (UNAM) with its Green Hydrogen Research Institute. The Namibian Green Hydrogen Programme is also involved in the partnership.

On the German side, the partnership is led by the German Federal Ministry for Economic Affairs and Climate Action (BMWK), which is also funding the partnership. Two of its subordinated agencies are taking part: The Federal Institute for Materials Research and Testing (BAM) and German National Metrology Institute (PTB), both of which are involved in hydrogen research and standardization. The fourth partner is the German Institute for Standardization (DIN), the national standards body in Germany. DIN has worked on the recently released German *Standardization Roadmap for Hydrogen Technologies* and is currently taking part in projects aimed at closing gaps in hydrogen standardization.[6]

2.2 Goals of this partnership

The aim of this institutional partnership is the development of quality infrastructure for the green hydrogen economy in Namibia. This includes the development of a regulatory framework to guarantee safety and quality during the production, distribution, transport, storage and utilisation of hydrogen, as well as its derivatives. Due to the explosiveness of hydrogen, special emphasis must be placed on proper explosion protection. Currently, no such regulation exists.

The second component concerns PTB and NSI. It includes an evaluation, which structural services should be provided by the metrology department of the NSI. Based on this, recommendations are developed for capacity building regarding physical equipment, as well as personnel training.

A further aspect of the Institutional Partnership is the advancement of national standardization efforts and participation in international standardization. This component is handled by DIN and NSI and includes the formation of a local Technical Committee (TC) on hydrogen technologies, mirroring the ISO/TC 197 of the International Organization for Standardization (ISO). Finally, UNAM and BAM are developing a system for welding capacity building. Both of these activities are outside the scope of this paper.

2.3 Prior developments

The institutional partnership builds on experiences gained during an earlier EU Twinning Project, intended to strengthen Namibia's participation in international trade agreements. It focused on improving standardization, accreditation and metrology related to fishery laboratories. Twinning project partners included MIT and NSI from Namibia and BMWK, PTB and DIN from Germany, as well as other institutions. During this project, the need for further advise on safety regulation was identified and consolidated into the proposal for an institutional partnership.

3 Hydrogen Metrology in Namibia

The overarching goal for the cooperation between the National Metrology Institutes is the establishment of new metrological services in Namibia, that help ensuring trust in the hydrogen industry.

3.1 Services for the hydrogen industry

During the different steps along the green hydrogen value chain, a variety of data will be measured and recorded – from wind speeds and solar irradiation, via purity and quantity of water and hydrogen, to temperature and calculations of efficiency. Together with the International Renewable Energy Agency (IRENA), PTB has developed *A Quality Infrastructure Roadmap for green hydrogen*, providing a comprehensive overview of all necessary steps in establishing required infrastructure services. It includes a checklist of over 30 metrological services, ultimately required in the green hydrogen sector.[7]

Currently, NSI has demonstrated calibration and measurement capabilities (CMCs) in mass and related quantities, as an associate member of the International Bureau of Weights and Measures (BIPM). It also offers accredited calibration services for the areas mass, dimension, temperature, and length/volume. Finally, NSI successfully undertakes comparisons in mass, dimension, and temperature to ensure credible and reliable metrology services to industries.[8]

3.2 Developing an action plan

To provide useful recommendations for addressing service gaps, a comprehensive overview of the planned hydrogen industry is needed. PTB is providing a desk study, detailing questions and factors to be considered in mapping out a strategy. One crucial aspect is the demand from stakeholders in industry, to avoid duplicated services as well as gaps in verification and calibration. Existing international cooperations with other National Metrology Institutes, e. g. in the framework of the CIPM MRA can be utilized or even expanded, especially for services that will rarely be used.[9] Further input is needed from the Namibian administration with respect to its priorities.

Based on the outcome of these discussions, recommendations for specific metrological services will be developed. To realise the services, the next step should be the development of an action plan, exploring funding possibilities and matching them with identified priorities. It is envisioned to include concrete recommendations for needed measurement equipment, as well as a recruitment and training plan for personnel.

4 Regulatory Framework for Explosion Protection

Regulations regarding explosion protection ensure that hydrogen is handled safely, and hydrogen plants are designed and used without harm. At the moment, no such regulations exist in Namibia. Recommendations will consider the specific needs of the country and allow for purposive, easy and fast implementation. A key focus must be the safety of workers – avoiding accidents, which otherwise might negatively affect the public acceptance of hydrogen infrastructures. Still, any regulations should also be oriented on the intended international trade and should not hinder for wide market access around the world. Monitoring and enforcing the compliance with regulatory requirements and standards will require governmental institutions – expanding existing bodies or establishing new ones.

4.1 Model legislation

First published by the United Nations Economic Commission for Europe (UNECE) in 2011, the document *A Common Regulatory Framework for Equipment Used in Environments with an Explosive Atmosphere* offers a comprehensive model for national regulation, aligned with internationally harmonized best practices. It references international standards and conformity assessment procedures developed by the International Electrotechnical Commission (IEC) and ISO. Relying on "a full life cycle approach", it covers selection, installation, maintenance, inspection, and repairs of equipment used in explosive atmospheres.[10]

The UNECE framework encompasses six Common Regulatory Arrangements (CRA). Similar to the European ATEX directives (from French "atmosphères explosibles" for "explosive atmospheres"), requirements for explosion protection are divided into two arrangements: Placing products on the market (like Directive 2014/34/EU) and safe use of the equipment and safety of service (like 1999/92/EC).[11, 12] To provide the presumption of conformity with this regulation, a reference list of ISO and IEC standards is given as the third arrangement.

Two further arrangements concern the recognition of conformity assessment bodies and market surveillance to ensure and monitor compliance with the requirements. Finally, a UNECE Steering Committee was proposed to update the regulation model, as well as an international system to distribute information about recently detected risks or faulty products. Both have not been instituted.

4.2 Fast and easy implementations

By using the international system of ISO and IEC standards the legislative system is relieved from detailing and constantly updating technical aspects of protection concepts. Large parts of the proposed list refer to standards developed in the IEC TC 31 Equipment for explosive atmospheres, where Namibia is already an affiliate member.

To further simplify the implementation of explosion protection principles, compliance with the IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx System) can be accepted as proof of conformity assessment, when installing equipment. Membership in the IECEx system is not mandatory but enables participation in its development.

4.3 Development of an institutional framework

Still, to monitor and enforce the compliance with regulatory requirements government bodies, institutions responsible for market surveillance and inspections are needed. Its tasks should include the fields of explosion protection, occupational safety and environmental protection, with inspections due before plant commissioning, after maintenance, repairs, and changes of the setup.

PTB is providing an overview of the needed aspects of explosion protection in regulatory frameworks with a desk study. After initial discussions and workshops on the topic, it has become clear, that more parties need to be involved in developing the needed regulations. Under the guidance of the MME the Namibian administration is thus setting up an extend working group with members from the Ministry of Justice, Ministry of Labour, Industrial Relations and Employment Creation and the Ministry of Works and Transport.

5 Discussion

The process of developing and implementing recommendations regarding explosion protection and metrology for a hydrogen infrastructure has been slower than initially expected. While some of the project partners have already worked together within the EU Twinning Project, the scope and processes in an institutional partnership are different. Additionally, new authorities and personnel have been brought in and needed onboarding.

The National Metrology Institute of Namibia, NSI, is dedicated to offering and extending its metrological services. Yet, due to the multitude of possible additions choosing the relevant services to be developed in a timely manner remains a challenge. Here, guidance from stakeholders and a clear vision of planned projects will be needed. Another key aspect is the current lack of funding for equipment. Establishing a long-term funding perspective has to be pursued, too.

While the general scope of recommendations for a regulatory framework in explosion protection was clear from the beginning, the intended circle of stakeholders proved to be too small. As laws and regulation in this field especially concern the health of workers, and not only encompass plants, but also e. g. transportation guidelines, more ministries and authorities need to be aligned with the project.

Some of the recommendations are expected to be easier implemented than others. Adopting the IECEx system for conformity assessment has already been done in other countries and provides a fast, safe and reliable solution. Also, the UNECE model legislation is supplemented by openly accessible guidelines and blue guides to aid national implementations. Establishing new administrative bodies or expanding existing ones to encompass new responsibilities is a challenge and further requires intensive training in the field of explosion protection. A fast decision and implementation will need a clear political vision.

Unforeseen delays to the partnership were also caused by the 2024 Presidential and National assembly election in Namibia. The year was also marked by the sudden passing of His Excellency the Namibian President Dr. Hage Geingob, who had spearheaded the green hydrogen initiative, in February 2022. Despite these challenging events, the Namibian Government has remained committed to the continued implementation of hydrogen strategies with the German Government.

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