ENVIRONMENTAL *made*
PROTECTION *in Germany*

NOW-GMBH.DE

Perspectives for the economic viability of environmentally friendly hydrogen and fuel cell technologies

Why is the supply of **sustainable decentralised energy** important?

In many parts of the world, the supply of energy is severely restricted by power outages or is provided off-grid, without a connection to a centralised power supply system. In most cases, environmentally harmful generators and fossil fuels, such as petrol and diesel, are used to produce electricity. With the help of **green hydrogen and fuel cell technology,** along with the expansion of local renewable energy generation, a sustainable, independent and, in the long term, economically viable decentralised energy system can be implemented. This in turn contributes to achieving the United Nationas Sustainable Development Goals (SDGs). The **Export Initiative Environmental Protection (EXI), a funding programme of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV – Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz),** supports German companies and research institutions in international pilot projects for the further development of these technologies.

Worldwide demand exists for a resilient and environmentally friendly energy supply.

Access to electricity
Around 675 million people worldwide live without access to electricity (IEA, 2023).

Power outages
1 billion people live with power outages of a total of more than 1,000 hours per year (IFC, 2019).

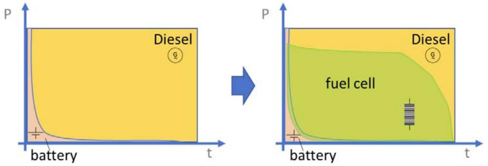
Diesel generators
The majority of energy supply in the Global South is currently provided by diesel generators (IFC, 2019).

Economic impact
Power outages cause considerable economic damage and reduced performance of companies in the affected countries (UNESCAP, 2021).

The decentralised deployment of German hydrogen and fuel cell technology enables this demand to be met economically.

The technical profile of fuel cells enables to **replace diesel generators** on a large scale.

Fuel cells represent an additional cost-effective alternative



(Clean Power Net, 2018)

Stationary fuel cells as an alternative to diesel generators provide the following advantages:

- Longevity
- Low maintenance costs
- No local pollutant emissions
- Climate-neutral depending on the fuel
- Low noise emissions
- Relatively high efficiency
- Self-sufficiency possible when coupled with electrolysis

Germany is home to many innovative companies, including small and medium-sized enterprises (SMEs), with many years of experience in these technologies.

The utilisation of these technologies contributes to the United Nations SDGs.

Access to electricity has a positive impact on economic development, employment, productivity, health, education and gender equality (UNESCAP, 2021; Tensay Hadush Meles, 2020)

When electricity supply is reliable, the positive effects on income, education and gender equality are more pronounced (World Bank, 2019).

SUSTAINABLE DEVELOPMENT GOALS

Which **environmentally friendly technology options** can replace fossil-fuelled generators?

Decentralised energy supply systems with **environmentally friendly hydrogen and fuel cell technologies** (also in combination with battery storage), which are powered by renewable energy sources, are a **sustainable alternative** to fossil-fuelled generators. In order to provide uninterrupted energy supply, for example during longer-term absence of sun or wind or in the event of a grid failure, fuel cell systems can be operated with **green hydrogen and used to generate electricity.** The green hydrogen required for this can be **produced locally from renewable electricity** in times of sufficient availability of solar or wind energy, stored and made available when needed. Alternatively, it can be supplied from external sources.

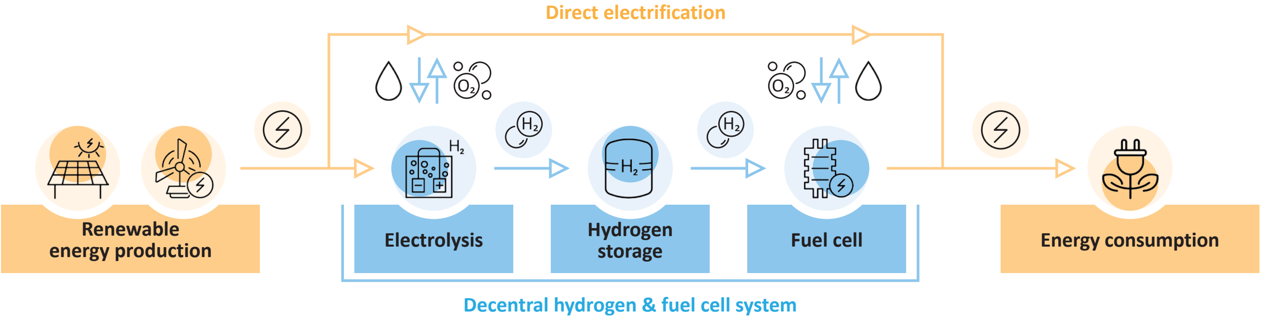
Hydrogen and fuel cell systems for decentralised energy supply systems can be divided into two categories:

Self-sufficient systems

Energy systems with local production of green hydrogen using electricity from renewable energy sources, i.e. wind or sun, and its reconversion into electricity using fuel cells.

Depending on where they are used, self-sufficient systems often also are grid-connected and can play an important role in the wider energy system.

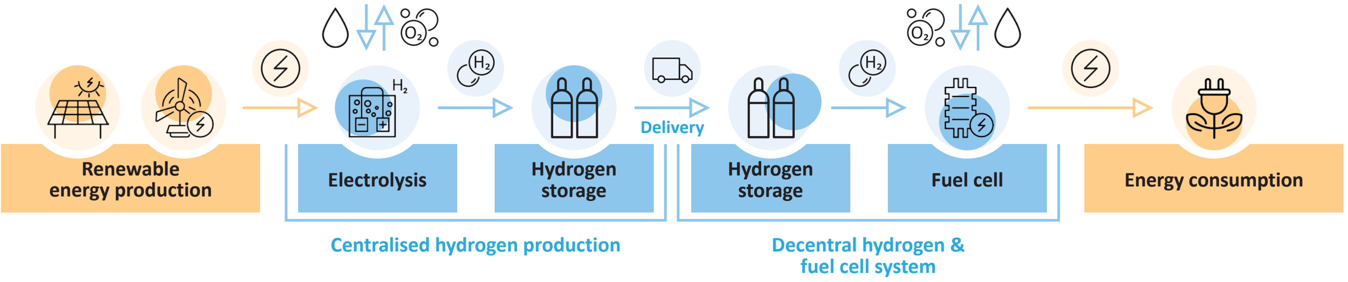
Within these systems, the water produced during reconversion in the fuel cell can be fed back into the electrolysis process after an integrated water treatment stage. Thus, self-sufficient systems can be operated with a nearly closed water cycle. As there is no significant water consumption, self-sufficient systems can therefore also be operated in regions with water scarcity.



Delivery-supplied systems

Energy supply systems that are provided with green hydrogen that is produced at another location using electricity from renewable energy sources, i.e. wind or sun, and is locally reconverted to electricity using fuel cells.

If electrolysis and reconversion using fuel cells are separated locally, the water cycle is also interrupted. The water produced from the reconversion process can no longer be fed into the electrolysis process but is returned to the ecosystem elsewhere.



Which **areas of application** exist for green hydrogen and fuel cell technologies in decentralised energy supply?

The application of green, sustainable hydrogen and fuel cell technologies for the decentralised supply of energy is versatile and suitable wherever fossil-fuelled generators are currently in use or renewable-based microgrids can be expanded. With this technology, it is possible to implement a reliable **decentralised primary energy supply,** as well as a **backup power supply** for grid-connected consumption or off-grid **semistationary energy supply** in temporary applications. Depending on the requirements of the application, the use of a self-sufficient energy supply system with local hydrogen production from renewable energies or a fuel cell system supplied with hydrogen or hydrogen derivatives is an option.

Type of system

- **Self-sufficient systems**
- **Delivery-supplied systems**

Exemplary use cases

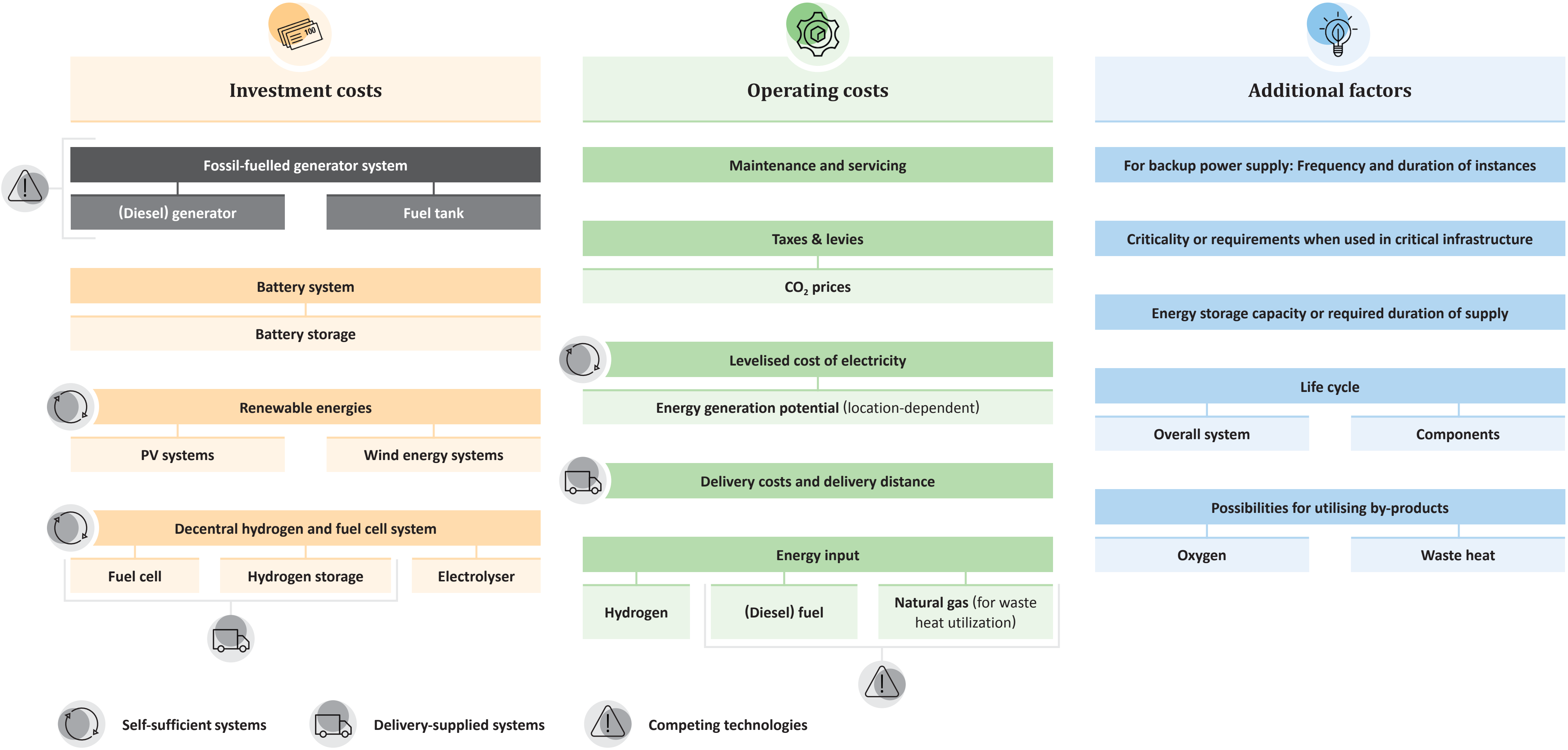
- **Industry**
- **Microgrids**
- **Farms or mines**
- **Educational institutions** e.g. schools, universities
- **Medical care** e.g. hospitals
- **Critical infrastructure** e.g. telecommunications
- **Commercial enterprises**
- **Communities** e.g. local neighbourhoods, tourist facilities

Type of decentral energy supply

- **Off-grid primary energy supply**
- **Backup power supply**
- **Semi-stationary energy supply**

Which **factors** influence the **economic viability** of hydrogen and fuel cell technologies in decentralised energy supply?

The **economic viability of a hydrogen and fuel cell system in decentralised energy supply** is influenced by various factors. Lower investment and operating costs for hydrogen and fuel cell systems compared to competing technology options, in particular fossil-fuelled generators, favour their economic viability. As part of a comprehensive analysis, **application-specific and location-dependent techno-economic factors** were compiled for techno-economic modelling. The central objective was to investigate the economic viability of selfsufficient and delivery-supplied hydrogen and fuel cell systems. The presentation below illustrates the most important influencing parameters.



Investment costs

- **Fossil-fuelled generator system**
  - (Diesel) generator
  - Fuel tank
- **Battery system**
  - Battery storage
- **Renewable energies**
  - PV systems
  - Wind energy systems
- **Decentral hydrogen and fuel cell system**
  - Fuel cell
  - Hydrogen storage
  - Electrolyser

Operating costs

- **Maintenance and servicing**
- **Taxes & levies**
  - CO_2 prices
- **Levelised cost of electricity**
  - **Energy generation potential** (location-dependent)
- **Delivery costs and delivery distance**
- **Energy input**
  - Hydrogen
  - (Diesel) fuel
  - **Natural gas** (for waste heat utilization)

Additional factors

- **For backup power supply: Frequency and duration of instances**
- **Criticality or requirements when used in critical infrastructure**
- **Energy storage capacity or required duration of supply**
- **Life cycle**
  - Overall system
  - Components
- **Possibilities for utilising by-products**
  - Oxygen
  - Waste heat

Self-sufficient systems

Delivery-supplied systems

Competing technologies

Which prospects were identified in the modelling for the **economic use** of green hydrogen and fuel cell technology in decentralised energy supply?

Based on the influencing techno-economic factors, the location-dependent economic prospects of green hydrogen and fuel cells in decentralised energy supply were modelled for different applications. Depending on the application, location and the type of system – delivery-supplied or self-sufficient – **economically competitive operation for primary energy or backup power supply** can be realised in the **medium term.**

Due to limited data availability for international application examples the first results were calculated **for Germany.** These show that green hydrogen and fuel cell systems can have a competitive advantage over environmentally harmful fossil-fuelled generators in certain areas of use and applications in the future. International locations with a higher renewable energy generation potential should therefore offer even better prospects with regard to a system's economic viability.

Primary energy supply

For primary energy supply applications, green hydrogen and fuel cell systems represent an economically viable technology option in the long term.

Wind power-based, self-sufficient hydrogen and fuel cell systems have the **lowest levelised cost of electricity in Germany** in the area of primary energy supply across all technology options and applications analysed.

Hydrogen systems that are supplied from local photovoltaic or wind power plants have **lower levelised cost of electricity than corresponding systems with lithium-ion battery storage.**

In the application case for the primary energy supply of remote, off-grid households and communities in Germany, wind power-based, self-sufficient hydrogen and fuel cell systems show a higher economic viability than diesel generators in the long term. For photovoltaic-based hydrogen and fuel cell systems, a **significant reduction in the investment costs for the hydrogen storage system and the fuel cell** offers the perspective of economic viability.

(E4tech, 2023)

Semi-stationary energy supply

Fuel cell systems supplied with green hydrogen can achieve **competitiveness compared to conventional diesel technology** in **semi-stationary applications,** such as construction sites or events.

A closer look at a use case for temporary power and heat supply in the use case of civil protection shows that even with falling diesel prices or higher costs for fuel cell components, delivery-supplied **hydrogen systems are the more economical technology option in the long term.**

(E4tech, 2023)

Backup power supply

Diesel generators are still the most competitive technology option for **backup power supply.** The higher investment costs of supplied hydrogen and fuel cell systems at locations with low utilisation, such as Germany, are only spread over a few operating hours and thus lead to **comparatively high levelised cost of electricity.**

The exemplary use case for critical, unregulated backup power supply (such as at a data centre) shows that **falling investment costs for the fuel cell or hydrogen storage system,** could lead to competitiveness. If the price of diesel rises sharply, generators in turn become economically unviable.

(E4tech, 2023)

How can **information and data** on potential applications of green hydrogen and fuel cell technology in decentralised energy supply also be **collected abroad?**

Understanding local conditions and having access to data is essential for planning and implementing international projects. Thus, dialogue-based exchange of knowledge is one of EXI's goals, which is driven forward by the **cooperation between NOW GmbH and DIHK Service GmbH within the scope of "Chambers for GreenTech".** Among its objectives is to develop the topic of decentralised energy supply with hydrogen and fuel cell technologies in the **network of German Chambers of Commerce Abroad (AHKs)** in specific local projects and to exchange information between German and foreign stakeholders.

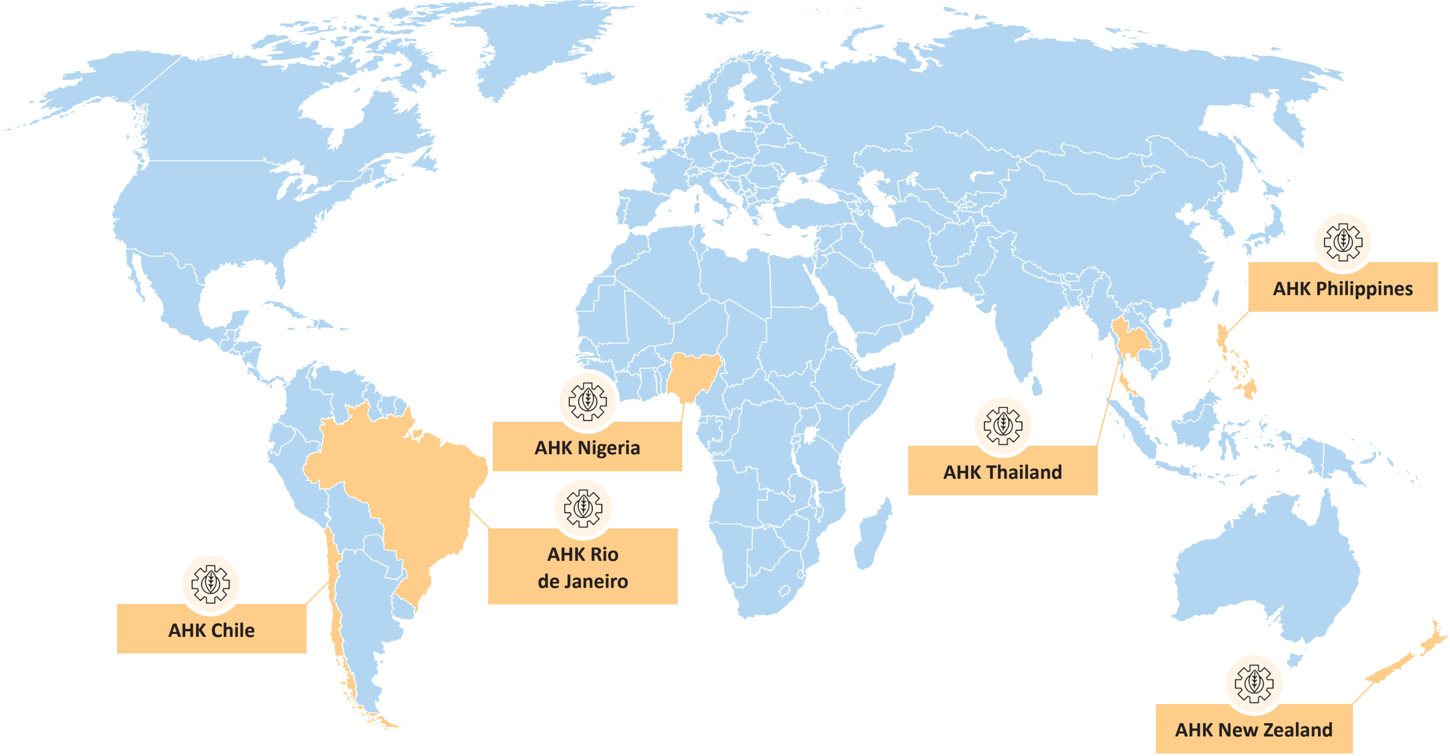
DIHK Service GmbH

AHK German Chambers of Commerce Abroad

CHAMBERS FOR GREENTECH

With their extensive **knowledge of the legal, political and cultural characteristics in their partner countries,** the AHKs can provide excellent support. They supply information and analyses on pressing environmental problems, establish networks with the key players and bring them together with suitable local and German experts. The DIHK Service GmbH thereby acts as an **intermediary for the network** and manages the programmatic cooperation.

In the field of decentralised energy supply with hydrogen and fuel cell technologies, **seven projects** have been implemented or are currently being implemented in AHKs (see map). Most of the projects are concerned with **economic analyses and the identification of possible locations for decentralised energy supply systems** (Chile, Nigeria, the Philippines, Thailand and New Zealand). Together with the AHK Brazil (branch Rio de Janeiro), possibilities to produce green hydrogen in sewage treatment plants are currently analysed, taking into account technical, economic and ecological aspects. In sum, the AHK projects contribute to **a broader understanding of the economic perspectives.**



Microgrids in Chile already offer **economically viable prospects** for the use of green hydrogen and fuel cell technology.

With its great potential for renewable energies and its ambitions to establish a green hydrogen economy, Chile is **a suitable location for the use of hydrogen and fuel cell technologies in decentralised energy supply.** There are long-term plans to drive electrification with renewable energies forward and to **decarbonise decentralised power grids, which are currently largely supplied by diesel generators.** As part of EXI, the AHK Chile has investigated the potential and economic prospects for the use of green hydrogen in microgrids and smaller island grids to replace diesel generators for use in the Melinka microgrid and the Molino de Oro fish farm.

Electricity supply
75,000 people in around 25,000 homes in Chile still have no access to electricity (AHK Chile, 2021).

Diesel generators
More than 5,000 diesel generators with a power output of between 10 and 3,000 kW are estimated to be imported into Chile every year (AHK Chile, 2021).

Microgrids in Chile
There are 129 small electricity grids in Chile that supply over 15,000 households. Of these, 72 grids do not have a 24-hour supply. These microgrids are operated by private or municipal cooperatives and companies (AHK Chile, 2021).

Case Example

Melinka microgrid

Microgrid for supplying electricity to a population of 1,329 people

Power supply status quo
1,660 MWh annual electricity consumption
1.4 MW output from 4 diesel generators
0.31 USD/kWh levelised cost of electricity

Techno-economic modelling

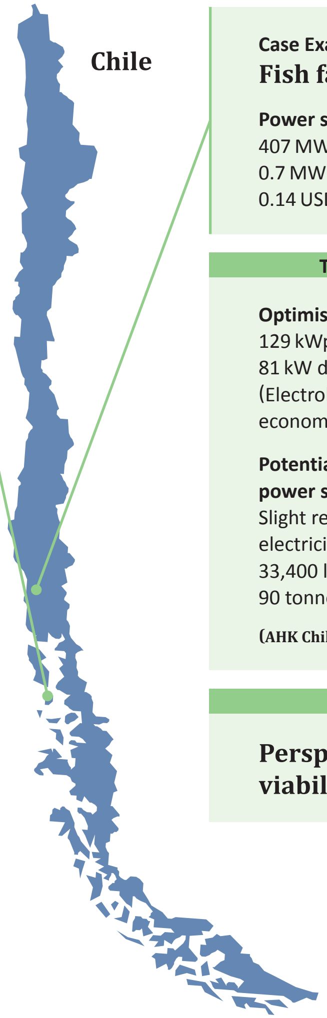
Optimised power supply
600 kWp photovoltaics & 574 kW wind
33 kW electrolysis & 18 kg H_2 storage
38 kW fuel cell
249 kW diesel generator (-82 %)

Potential benefits of the optimised power supply
Reduction in levelised cost of electricity
400,000 litres of diesel saved per year
1,123 tonnes of CO_2 saved annually

(AHK Chile, 2021)

Result

Perspective for economic viability given



Case Example

Fish farm in Molino de Oro

Power supply status quo
407 MWh annual electricity consumption
0.7 MW output from 4 diesel generators
0.14 USD/kWh levelised cost of electricity

Techno-economic modelling

Optimised power supply
129 kWp photovoltaics
81 kW diesel generator
(Electrolysis and fuel cell not economically viable)

Potential benefits of the optimised power supply
Slight reduction in levelised cost of electricity
33,400 litres of diesel saved per year
90 tonnes of CO_2 saved annually

(AHK Chile, 2021)

Result

Perspective for economic viability not yet given

AHK Deutsch-Chilenische Industrie- und Handelskammer
Cámara Chileno-Alemana de Comercio e Industria

How can hydrogen and fuel cell systems become economically viable in this case?

Increasing diesel price
If the price of diesel rises, an increasing share of renewable energies is more economical. If the price of diesel is more than USD 1.0 per litre, the use of hydrogen and fuel cell technologies becomes economical.

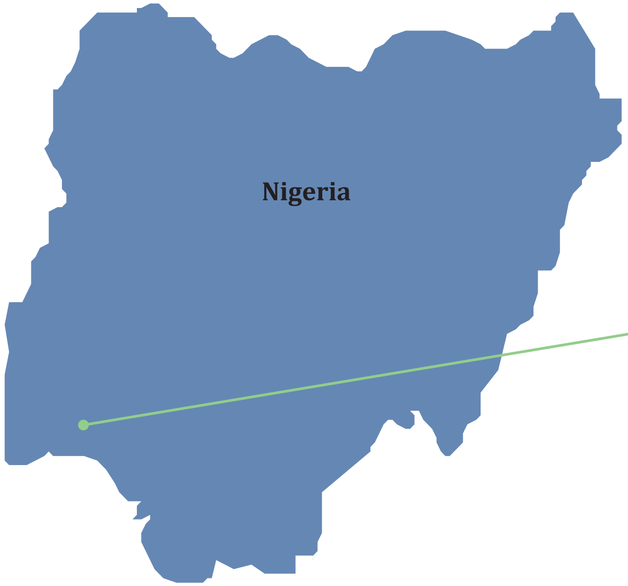
Utilisation of oxygen
The oxygen that is produced as a byproduct during electrolysis could be used in this application to enrich the water and improve the perspective of economic viability.

Replacing diesel generators with green technologies can **improve the economic viability of microgrids in Nigeria.**

The volatile power grid and the sparse power plants in Nigeria only contribute a small part to its overall energy supply. According to the International Finance Corporation (IFC), Nigeria is one of the countries in the world with the lowest installed grid capacity per capita. The majority of the **power supply comes from decentralised generators** and increasingly also from micro or mini-grids fed by photovoltaics. As part of EXI, the Delegation of German Industry and Commerce in Nigeria (DGIC Nigeria) used a case example to analyse the economic potential offered by the complete or partial replacement of an existing diesel generator in a mini-grid in Nigeria.

Electricity supply
In Nigeria, 40.5 per cent of the population – more than 80 million people – have no access to electricity. The majority of them live in rural areas (IEA, 2023).

Diesel generators
With 3 million diesel generators, Nigeria is among the countries with the most fossil-fuelled generators. On average, there is one generator for every 60 people or 12 households. In West Africa, expenditures on fuel to operate generators equal the expenditures on electricity from the grid, and even higher in Nigeria (IFC 2019).



AHK
Delegation der Deutschen Wirtschaft in Nigeria
Delegation of German Industry and Commerce in Nigeria

Case Example

Gbamu Gbamu mini-grid

Mini-grid to supply electricity to 5,000 inhabitants in 550 households

Power supply status quo
550 MWh annual electricity consumption
85 kWp photovoltaics
288 kWh battery storage
53 kW Diesel generators
25 % renewable energy share
0.24 euros / kWh levelised cost of electricity

(DGIC Nigeria, 2022)

Techno-economic modelling

Scenario I

Optimised power supply with diesel generator
156 kWp photovoltaics
288 kWh battery storage
17 kW electrolysis
6 kg H_2 storage
5 kW fuel cell
53 kW diesel generator

Potential benefits of the optimised power supply with diesel generator
Significant reduction in levelised cost of electricity
22,566 litres of diesel saved per year
61 tonnes CO_2 saved annually
80 % renewable energy share

(DGIC Nigeria, 2022)

Scenario II

Optimised power supply without diesel generator
276 kWp photovoltaics
288 kWh battery storage
33 kW electrolysis
30 kg H_2 storage
12 kW fuel cell

Potential benefits of the optimised power supply without diesel generator
Slight reduction in the levelised cost of electricity
27,700 litres of diesel saved per year
75 tonnes CO_2 saved annually
100 % renewable energy share

(DGIC Nigeria, 2022)

Result

Perspectives for economic viability given for both scenarios

In the Philippines, diesel generators are already being replaced by **fuel cells for decentralised backup power supply.**

Many of the Philippine islands are dependent on an off-grid energy supply with electricity from fossil-fuelled generators. A number of **hybrid mini-grids are currently planned,** in which photovoltaics will replace part of the power supply from diesel generators. A further increase in the share of renewable energy utilisation through hydrogen and fuel cell technology is certainly possible here. In addition to the untapped potential, there are **already applications of fuel cell technology** in the Philippines, e. g. in the backup power supply of telecommunications facilities. The AHK Philippines previously analysed the potential for the use of green hydrogen and and is currently assessing the economic prospects in a follow-up project.

AHK
Deutsch-Philippinische
Industrie- und Handelskammer
German-Philippine Chamber
of Commerce and Industry

Electricity supply
The Philippines have one of the highest electricity prices in Asia. The off-grid and grid-connected areas in the Philippines show strong disparities in terms of electricity supply duration, security and electricity prices. Even within the grid, there can be supply bottlenecks in peripheral areas (AHK Philippines, 2022).

Microgrids in the Philippines
There are 281 microgrids in the Philippines, which are generally supplied by diesel generators and operated by the state-owned National Power Corporation.

Oftentimes the diesel generators used are old and have a low level of efficiency when generating electricity (AHK Philippines, 2022).

Fossil fuels
Around 5 % of diesel consumption and 2 % of petrol consumption in the Philippines is used to operate generators (AHK Philippines, 2022).

Diesel generators
Up to now, around 10,000 diesel generators have been sold annually in the Philippines. By 2030, more than 17,000 diesel generators will be required annually.

The power class between 17 and 75 kW is particularly in demand for use in households, industry and trades such as retail, telecommunications, hospitals, hotels and offices (AHK Philippines, 2022).

Techno-economic analysis in follow-up projects of the AHK Philippines

Wind microgrid| Calayan
Electricity supply to 1,350 households

1,309 MWh annual electricity consumption
236 kW peak load

PV microgrid| Lubang
Electricity supply to 6,700 households

7,139 MWh annual electricity consumption
1,340 kW peak load

PV microgrid| Maripipi
Electricity supply to 1,550 households

1,448 MWh annual electricity consumption
261 kW peak load

Backup power supply | various locations
In remote areas with unreliable power supply, Philippine telecommunications companies' radio masts are operated with fuel cells in the 5 to 15 kW power class and an upstream reformer instead of diesel generators. This means that easily transportable methanol can be used as a fuel for backup power supply and can be readily replaced by climate-neutral, green methanol as soon as it becomes available (AHK Philippines, 2022).

What will it take for environmentally friendly hydrogen and fuel cell technologies to achieve a **global breakthrough** in decentralised energy supply?

The use of green hydrogen and fuel cell technology in decentralised energy supply is complex. The realisation of corresponding international projects requires an **integrated and systemic approach** in order to make the best possible use of the economic and socio-ecological potential of the technologies. **Close cooperation between different stakeholders** is crucial in order to adapt the framework conditions, link information and thereby improve the understanding of the perspectives for the economic viability of environmentally friendly energy systems.

Technological developments alone are not enough.

Investment costs
Research and development in the field of component manufacturing and the industrialisation of production processes in order to reduce the manufacturing costs of fuel cell and electrolysis systems, contribute to lowering investment costs and consequently to achieving a solid economic perspective.

Hydrogen infrastructure
Delivery-supplied hydrogen and fuel cell systems particularly benefit from easy availability of green hydrogen and the network effects of shared hydrogen infrastructure.

Regulation and funding
The ramp-up of hydrogen and fuel cell technologies in decentralised energy supply must be accompanied by political support mechanisms as part of a transition phase. Instruments such as CO_2 pricing, local emission restrictions, but also project funding and environmental protection subsidies can be applied here.

Investment in training
The availability of competent local partners is necessary for the successful installation, commissioning and operation of decentralised systems. The training of qualified personnel contributes to embedding the system locally and to creating added value.

Gathering experience from project implementation
Specific projects can be used to gather experience and collect data. Pooling this data and sharing it with interested stakeholders supports the development of business models. The results can in turn be used to raise further funding.

Technical characteristics and overall systemic benefits contain opportunities.

Different economic viability factors
Local conditions in combination with specific applications and fuel cell or electrolysis technologies result in widely differing economic conditions.

Competitiveness already exists
Decentralised hydrogen and fuel cell systems today are already beneficial in certain applications compared to fossil technologies, e. g. when diesel prices are high or volatile.

Economic viability through hybridisation
Gradual hybridisation with other storage technologies and existing fossil energy systems, e. g. diesel generators that are already in use locally or the use of the systems to serve the grid, can create a perspective for economic viability.

Economic viability through by-products
The economic and ecological potential arising from the use of by-products of electrolysis and reconversion, such as oxygen, heat or water, should ideally always be utilised and taken into account when initially selecting the location of the facilities.

Economic viability through standardisation
The ongoing development of standardised energy systems based on hydrogen and fuel cell technologies helps to create a broadly diversified perspective for economic viability.

German manufacturers and system providers hold innovation potential at home and abroad.

Opportunities in international markets
International markets offer many opportunities for German manufacturers and system providers in the field of decentralised energy supply with hydrogen and fuel cell technologies. These opportunities can be tapped into through ongoing international networking and support from existing networking partners in the target countries, such as the AHKs.

Environmental benefits as competitive advantage
With environmental benefits and sustainability, German companies have the opportunity to stand out internationally. The use of decentralised energy supply with hydrogen and fuel cell technologies spans an arc from German innovation policy potential to value creation at the place of use.

How can international **projects** for the use of hydrogen and fuel cell technology in decentralised energy supply receive funding?

With its EXI funding programme, the BMUV supports **German green tech companies, including SMEs,** in the **internationalisation of their green innovations, products and services.** Modern and resource-efficient technologies are not only drivers of growth and innovation. They also help to **raise environmental standards, disseminate environmental knowledge and improve local ecological foundations and living conditions.** On behalf of the BMUV, NOW GmbH is responsible for the theme of green hydrogen as one of the programme's priority areas. As part of this role, NOW GmbH offers prospective and currently funded projects content-related **support** regarding decentralised energy supply with green hydrogen and fuel cell technology.

Thematic focus

In EXI's green hydrogen priority area, international projects relating to decentralised energy supply with green hydrogen and fuel cell technology are supported. The aim is to locally produce green hydrogen and use it in local applications for decentralised energy supply in the partner countries. The additional utilisation of by-products such as oxygen or waste heat and the supply of electrolysis with water from sustainable resources are examples of useful content extensions of a funding project. The contribution of a project to achieving the SDGs of the United Nations can be supplemented by concepts for knowledge transfer or the training of locals.

Funded measures

The funding framework covers pilot and demonstration projects as well as feasibility studies. Project proposals implemented by SMEs based in Germany and involving a research institution are granted subsidies of 40 to 80 per cent (depending on the composition of the consortium) of the eligible costs and should include an investive component in order to ensure sustainability. Feasibility studies are funded with up to 50 per cent. In principle, the funding programme is subject to the General Block Exemption Regulation (GBER, in German: AGVO – Allgemeine Gruppenfreistellungsverordnung). Both de minimis funding and R&D funding are possible (AGVO Section 4).

Supported stakeholders

EXI funding is primarily aimed at SMEs located in Germany and research institutions based in Germany. International partners can contribute their services to the projects on behalf of the German partners. Ideally, a project consortium is formed – consisting of for example a research institution, one or more component manufacturers and / or a project developer. The project partners should have the goal of establishing themselves internationally and creating sales markets worldwide. The gained knowledge should be made available for cross-project knowledge transfer.

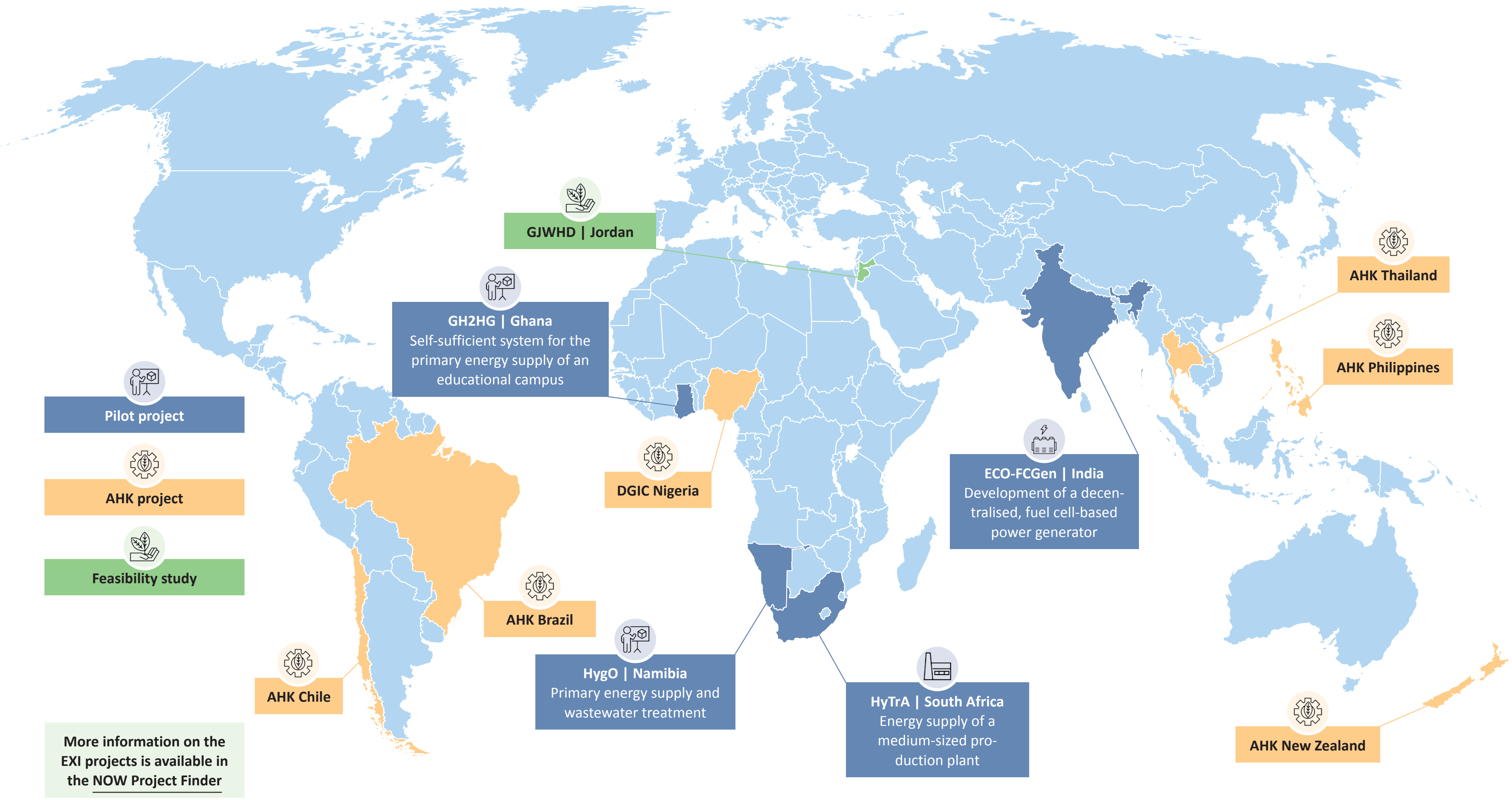
Ongoing support

Alongside the financial support provided through the funding, recipients are also supported by the project management organisation and NOW GmbH with technical expertise. NOW GmbH supports projects focusing on hydrogen and fuel cell technology in the decentralised energy supply from the project initiation to the final milestone. Networking with strong partners, such as the DIHK Service GmbH and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH also plays an important role. Stakeholders from industry and research, who are interested in participating in the programme, are cordially invited to enter into dialogue with NOW GmbH at an early stage in order to receive optimal support for their project.

The latest versions of the respective funding guidelines and information on the application process are published by the project management organisation Zukunft – Umwelt – Gesellschaft (ZUG) gGmbH via www.exportinitiative-umweltschutz.de

Where is EXI **already active?**

In the field of “green hydrogen and fuel cell technology in decentralised energy supply” EXI is already active on four continents. This includes **implementation projects** in Ghana, Namibia, South Africa and India, in each of which a pilot plant is being built on site (blue). In addition, a **feasibility study** has been conducted in Jordan (green). At a further six locations, the respective AHKs and business representatives are conducting **potential analyses** on the potential use of hydrogen (orange).



Pilot project

AHK project

Feasibility study

GJWHD | Jordan

GH2HG | Ghana
Self-sufficient system for the primary energy supply of an educational campus

DGIC Nigeria

ECO-FCGen | India
Development of a decentralised, fuel cell-based power generator

AHK Thailand

AHK Philippines

AHK Brazil

AHK Chile

HygO | Namibia
Primary energy supply and wastewater treatment

HyTrA | South Africa
Energy supply of a medium-sized production plant

AHK New Zealand

More information on the EXI projects is available in the NOW Project Finder

Imprint

Published by
NOW GmbH
Fasanenstraße 5
10623 Berlin, Germany
+49 (0)30 311 611 6100
kontakt@now-gmbh.de
www.now-gmbh.de

Authors
Tom Mikus, NOW GmbH
Sabine Ziem-Milojevic, NOW GmbH
Catharina Horn, NOW GmbH
Sammy Wittop, NOW GmbH

Design
Studio Zweibrand GmbH
August-Bebel-Straße 27
14482 Potsdam, Germany
seifert@studio-zweibrand.de
www.studio-zweibrand.de

Publication date
May 2024

Sources of images & diagrams
p.2: Clean Power Net (2018)
p.2: United Nations (2023)

Contact
exportinitiative@now-gmbh.de

References

IEA (2022): For the First Time in Decades, the Number of People without Access to Electricity is Set to Increase in 2022
IEA (2023): Tracking SDG$_7$ – The Energy Progress Report 2023
IFC (2019): The Dirty Footprint of the Broken Grid – The Impacts of Fossil Fuel Back-up Generators in Developing Countries
UNESCAP (2021): Systematic Review of the Socio-Economic Impacts of Rural Electrification
Clean Power Net (2018): Planning Guideline for Fuel Cell Back-Up Power Supplies – Uninterruptible Power Supply (UPS) and Emergency Power Systems (EPS) With Fuel Cells
Tensay Hadush Meles (2020): Impact of power outages on households in developing countries: Evidence from Ethiopia
World Bank (2019): In the Dark – How Much Do Power Sector Distortions Cost South Asia?
E4tech (2023): Potentialanalyse zu technischer Eignung und Wirtschaftlichkeit von Wasserstoff- und Brennstoffzellentechnologien in verschiedenen Anwendungsbereichen der dezentralen/netzfernen Stromversorgung
AHK Chile (2021): Einsatz von grünem Wasserstoff zur netzfernen Stromversorgung in Insel- und kleineren Stromnetzen in Chile
DGIC Nigeria (2022): Technisch-wirtschaftliche Machbarkeitsstudie: Produktion von grünem Wasserstoff für den Einsatz in netzfernen Anwendungen, Lagos – Nigeria
IEA (2023a): Population, total - Nigeria
IEA (2023b): Access to electricity (% of population) – Nigeria
IEA (2023c): Access to electricity, rural (% of rural population) - Nigeria
AHK Philippinen (2022): Grüner Wasserstoff – Umfeldanalyse Philippinen 2022
NPC (2021): NPC signifies bid for more solar hybrid facilities in its SPUG areas

ENVIRONMENTAL made
PROTECTION in Germany

NOW-GMBH.DE

On behalf of:

Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection

of the Federal Republic of Germany