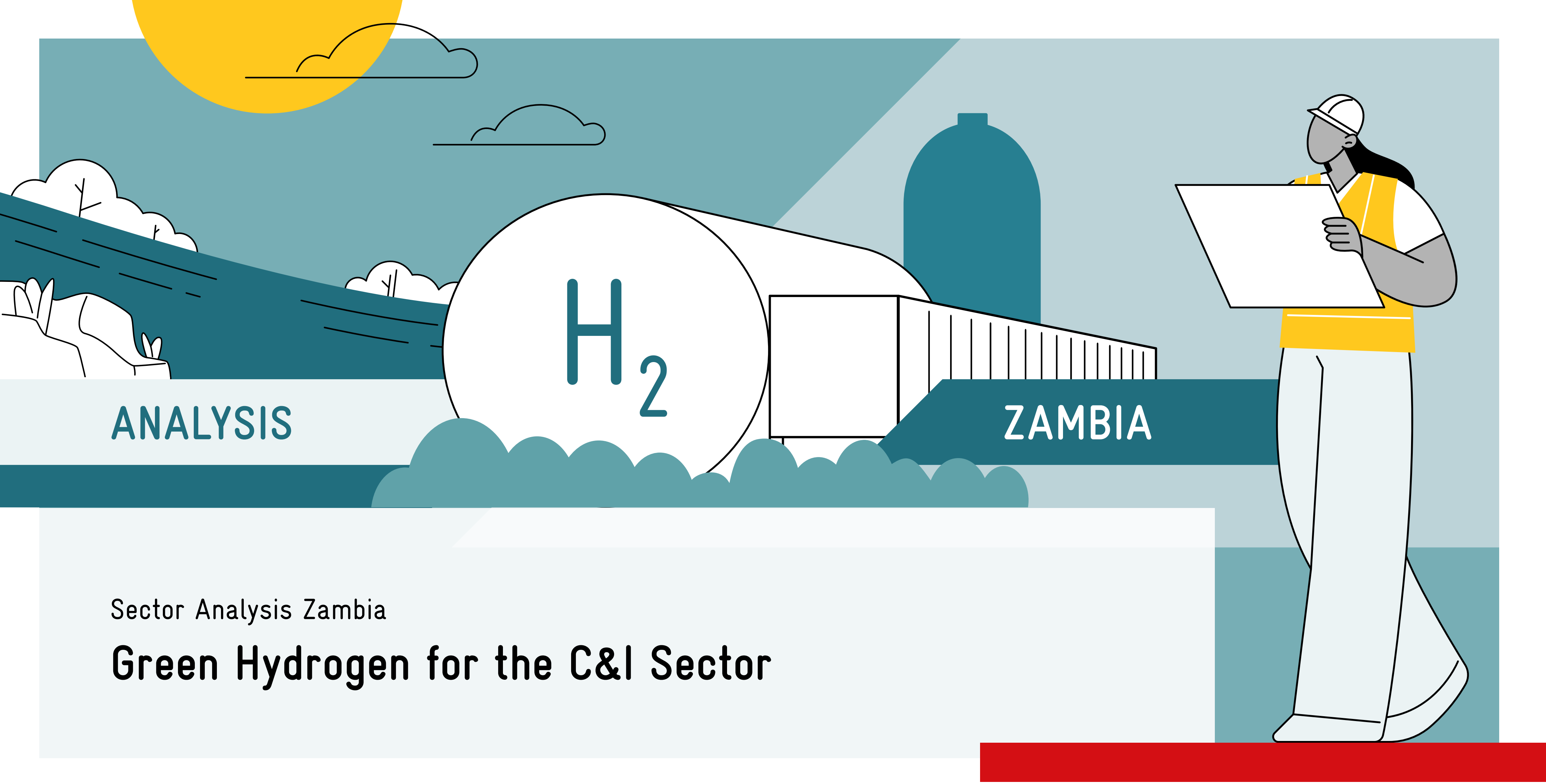


ANALYSIS

ZAMBIA

Sector Analysis Zambia

Green Hydrogen for the C&I Sector

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

This publication was commissioned by the German Energy Solutions Initiative of the German Federal Ministry for Economic Affairs and Energy (BMWE)

TABLE OF CONTENTS

TABLE OF CONTENTS

List of figures

List of tables

Currency units

ZMW	Zambian kwacha
USD	United States dollar

Currency units and conversion rate as of 05.09.2024

EUR 1 = ZMW 0.03435
ZMW 1 = EUR 29.109

EUR 1 = USD 0.92275
USD 1 = EUR 1.0838

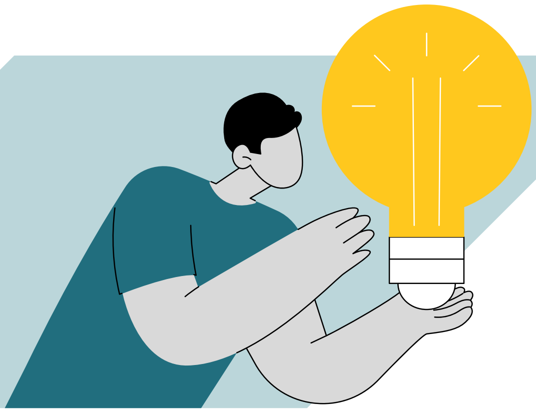
Source: Exchange-Rates.org, 2024

Technical units

bbl	Barrels (plural)
EJ	Exajoule (10^6 TJ)
GW	Gigawatt
GWh	Gigawatt hour
kBOE/d	Thousand barrels of oil equivalent per day
kTPA	Thousand tonnes per annum
Mt	Million tonnes
MTPA	Million tonnes per annum
MW	Megawatt
MWh	Megawatt hour
TJ	Terajoule (10^12 joule)

Abbreviations/acronyms

AEC	Alkaline electrolysis
AEMEC	Anion exchange membrane electrolysis cell
AN	Ammonium nitrate
ASU	Air separation unit
AU	African Union
BMWE	Bundesministerium für Wirtschaft und Energie (German Federal Ministry for Economic Affairs and Energy (BMWE))
BT	Benzyl toluene
CAN	Calcium ammonium nitrate
CCU	Carbon capture and use
CH_2	Compressed hydrogen
CHP	Combined heat and power
CO_2	Carbon dioxide
DAC	Direct air capture
DAP	Diammonium phosphate
DME	Dimethyl ether
DRI	Direct reduced iron
EIA	Environmental impact assessment
ERB	Energy Regulation Board
ETS	Emission trading scheme
EU	European Union
FiT	Feed-in tariff
GH_2	Green hydrogen
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
HB	Haber-Bosch
IEA	International Energy Agency
IRP	Integrated Resource Plan
LH_2	Liquid hydrogen
LOHC	Liquid organic hydrogen carrier
MAP	Monoammonium phosphate
MCH	Methylcyclohexane
MeOH	Methanol
MTBE	Methyl tertiary butyl ether
MTG	Methanol-to-gasoline
MTO	Methanol-to-olefins
NCZ	Nitrogen Chemicals of Zambia
NDC	Nationally Determined Contribution
NH_3	Ammonia
NPV	Net present value
PDP	Project Development Programme
PEMEC	Proton exchange membrane electrolysis cell
PPA	Power purchase agreement
PPP	Public-private partnership
PSA	Pressure swing adsorption
PtX	Power-to-X (power-to-anything)
PV	Photovoltaic
R&D	Research and development
SADC	Southern African Development Community
SME	Small and medium-sized enterprise
SMR	Steam methane reforming
SOEC	Solid oxide electrolysis cell
UAN	Urea ammonium nitrate
UMCIL	Universal Mining and Chemical Industries
VAT	Value-added tax
WACC	Weighted average cost of capital



ENERGY SOLUTIONS – MADE IN GERMANY

The German Energy Solutions Initiative

The German Energy Solutions Initiative of the German Federal Ministry for Economic Affairs and Energy (BMWE) aims to globalise German technologies and expertise in climate-friendly energy solutions.

Years of promoting smart and sustainable energy solutions in Germany have led to a thriving industry known for world-class technologies. Thousands of specialised small and medium-sized enterprises (SMEs) focus on developing renewable energy systems, energy efficiency solutions, smart grids, and storage technologies. Cutting-edge energy solutions are also built on emerging technologies such as power-to-gas, fuel cells, and green hydrogen. The initiative's strategy is shaped around ongoing collaboration with the German business community.

The initiative creates benefits for Germany and the partner countries by:

- boosting global interest in sustainable energy solutions
- encouraging the use of renewables, energy efficiency technologies, smart grids, and storage technologies, while facilitating knowledge exchange and capacity building
- enhancing economic, technical and business cooperation between Germany and partner countries

THE PROJECT DEVELOPMENT PROGRAMME (PDP)

PDP is a key pillar of the German Energy Solutions Initiative and is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. It connects development cooperation with private-sector engagement and supports climate-friendly energy solutions in selected developing and emerging countries, enabling local businesses to adopt solutions in energy efficiency, electricity and heat supply, and hydrogen, while facilitating market access for German solution providers.

Developing and emerging economies offer promising business potential for climate-friendly energy solutions but also pose challenges for international business partners. The PDP team works closely with local industries to develop financially viable projects by providing technical expertise, financial guidance, and networking opportunities.

It identifies project leads, collects and analyses energy consumption data, and assesses projects from both a technical and economic perspective. This includes outlining the business case, calculating payback periods, and evaluating profitability. Companies can then choose to finance projects using their own funds or explore leasing and other financing options. PDP provides cost-free advice to local companies and connects them with German solution providers for project implementation.

Additionally, by offering training, organising reference project visits, and publishing studies on the potential of climate-friendly solutions and on navigating regulatory frameworks, the programme supports market development and fosters private-sector cooperation.

Executive summary

GREEN HYDROGEN FOR THE C&I SECTOR

The H_2 sector analysis for Zambia aims to assess the potential for green hydrogen development in the country, providing a foundation for future reference projects. This analysis is part of a series to offer market insights and support pre-development efforts to generate both local and international interest in the green hydrogen economy.

The analysis explores the feasibility of introducing green hydrogen into Zambia's commercial and industrial sectors, evaluating specific use cases and providing techno-economic estimates for stakeholders – particularly companies based in Germany. The objective is to identify viable opportunities, address key challenges, and outline a pathway for green hydrogen integration that aligns with Zambia's broader energy and industrial development goals.

Zambia has abundant renewable energy resources, with hydropower contributing over 85% of its electricity generation and a strong mining sector that could substantially drive hydrogen demand. Growing investments in solar PV and battery storage further strengthen the country's renewable energy base, which could support hydrogen production via electrolysis.

However, Zambia also faces immediate energy challenges, including a low electrification rate and power shortages that impact industrial growth.

Zusammenfassung

GRÜNER WASSERSTOFF FÜR DEN C&I-SEKTOR

In der vorliegenden H_2-Sektoranalyse für Sambia wird das Potenzial für die Entwicklung grünen Wasserstoffs in Sambia untersucht. Mit der Analyse wird die Grundlage für zukünftige Referenzprojekte gebildet. Die Analyse ist Teil einer Publikationsreihe, die Markteinblicke liefert und Vorentwicklungsmaßnahmen unterstützt, um sowohl lokales als auch internationales Interesse an einer Grüner-Wasserstoff-Wirtschaft zu fördern.

Im Fokus der Analyse steht die Frage, inwiefern grüner Wasserstoff in den sambischen Industrie- und Gewerbesektor eingeführt werden kann. Dabei werden Anwendungsfälle analysiert und technoökonomische Einschätzungen bereitgestellt – insbesondere für Unternehmen mit Sitz in Deutschland. Ziel dessen ist es, tragfähige Chancen zu identifizieren, zentrale Herausforderungen zu benennen und mögliche Wege zur Integration grünen Wasserstoffs aufzuzeigen – im Einklang mit Sambias übergeordneten Energie- und Industrieentwicklungszielen.

Sambia verfügt über reichlich viele Quellen für erneuerbare Energie: über 85 Prozent des Stroms stammen aus Wasserkraft. Zudem besitzt das Land einen starken Bergbausektor, der künftig erheblichen Wasserstoffbedarf generieren könnte. Zunehmende Investitionen in Photovoltaik und Batteriespeicher stärken die Basis für erneuerbare Energie zusätzlich und schaffen günstige Voraussetzungen für die wasserstoffbasierte Elektrolyse.

Gleichzeitig steht Sambia vor akuten energiebezogenen Herausforderungen: Die niedrige Elektrifizierungsrate und Stromengpässe behindern das industrielle Wachstum und unterstreichen den Bedarf an langfristig tragfähigen Energielösungen.

Despite these challenges, green hydrogen presents an opportunity for local industrial development, particularly in sectors such as:

- **Mining and mineral processing,** where hydrogen could support cleaner operations and reduce reliance on imported fuels.
- **Ammonia and fertiliser production,** leveraging hydrogen for agricultural inputs.
- **Transport and logistics,** with long-term potential for hydrogen-based mobility solutions.

Additionally, investments in hydrogen infrastructure – such as renewable power generation, water supply, and transport networks – could provide broader benefits beyond industry, improving essential services for local communities.

Zambia's emerging hydrogen economy offers several opportunities for German companies, particularly SMEs in renewable energy, electrolysis, industrial applications, and infrastructure development.

Trotz dieser Herausforderungen bietet grüner Wasserstoff Chancen für die industrielle Entwicklung Sambias, insbesondere in folgenden Sektoren:

- **Bergbau und Mineralverarbeitung:** Hier trägt Wasserstoff zu saubereren Prozessen bei und kann die Abhängigkeit von importierten Brennstoffen verringern.
- **Ammoniak- und Düngemittelproduktion:** Nutzung von Wasserstoff als Rohstoff für landwirtschaftlichen Gebrauch
- **Transport und Logistik:** Mit langfristigem Potenzial für wasserstoffbasierte Mobilitätslösungen

Darüber hinaus könnten Investitionen in wasserstoffrelevante Infrastrukturen wie die für die Erzeugung erneuerbarer Energie, die Wasserversorgung oder Transportnetze nicht nur der Industrie, sondern auch der allgemeinen Versorgung zugute kommen und essenzielle Dienstleistungen für lokale Gemeinschaften verbessern.

Die aufkommende Wasserstoffwirtschaft Sambias eröffnet vielfältige Chancen für deutsche Unternehmen – insbesondere für KMU aus den Bereichen der erneuerbaren Energien, Elektrolyse, industriellen Anwendungen und Infrastrukturentwicklung.

KEY ADVANTAGES INCLUDE

- **Renewable energy potential:** Zambia's hydropower dominance, combined with an expanding solar sector, creates a solid foundation for green hydrogen production. German firms specialising in electrolysis, hydrogen storage, and renewable energy solutions can contribute to scaling up these technologies.
- **Industrial integration:** Green hydrogen could support decarbonisation in mining and mineral processing, sectors that play a critical role in Zambia's economy. German companies with expertise in industrial applications can lead pilot projects and technology deployment.
- **Infrastructure and development benefits:** The push for green hydrogen production could drive investments in energy infrastructure, water supply systems, and transport networks, creating business opportunities while delivering long-term socioeconomic benefits for local communities.

While there is potential for green hydrogen production, Zambia faces several hurdles:

- **Economic challenges:** High production costs and limited local demand remain key obstacles. German companies can support cost-effective solutions, investment partnerships, and policy advocacy to improve economic feasibility.

ZENTRALE VORTEILE FÜR KMU

- **Potenzial erneuerbarer Energien:** Sambias dominierende Wasserkraft und der wachsende Solarsektor bilden eine solide Grundlage für die Produktion grünen Wasserstoffs. Deutsche Unternehmen mit Spezialisierung auf Elektrolysetechnologie, Wasserstoffspeicherung und integrierte Energielösungen können beim Hochskalieren entsprechender Technologien eine zentrale Rolle spielen.
- **Industrielle Integration:** Grüner Wasserstoff könnte zur Dekarbonisierung des Bergbaus und der Mineralverarbeitung beitragen – zwei Schlüsselbranchen der sambischen Wirtschaft. Deutsche Firmen mit Erfahrung in industriellen Wasserstoffanwendungen können Pilotprojekte initiieren und den Technologieeinsatz vorantreiben.
- **Infrastruktur und Entwicklung:** Die geplante Entwicklung der Wasserstoffproduktion kann Investitionen in Energieinfrastruktur, Wasserversorgung und Verkehrsnetze anstoßen und dabei nicht nur wirtschaftliche Chancen schaffen, sondern lokalen Gemeinschaften langfristige sozioökonomische Vorteile ermöglichen.

Trotz des Potenzials für die Produktion grünen Wasserstoffs steht Sambia vor Herausforderungen:

- **Wirtschaftliche Hürden:** Hohe Produktionskosten und eine bislang begrenzte lokale Nachfrage stellen zentrale Hemmnisse dar. Deutsche Unternehmen können durch kosteneffiziente Lösungen, Investitionspartnerschaften und politische Begleitprozesse zur Verbesserung der wirtschaftlichen Machbarkeit beitragen.

- **Energy and water infrastructure:** Zambia's rising electricity demand requires parallel investments in renewable energy capacity to ensure a reliable power supply for hydrogen production. Additionally, efficient water management is crucial for sustainable electrolysis.
- **Regulatory framework:** Clear policies and safety regulations are needed to attract investment and facilitate cross-border trade. Aligning Zambia's hydrogen policies with international standards will be key to unlocking market potential.

Zambia's combination of renewable energy potential and industrial demand presents early-stage opportunities for German companies to contribute to green hydrogen development while supporting broader infrastructure and industrial growth. By addressing economic, technical, and regulatory challenges through innovation, investment, and policy collaboration, German firms can play a pivotal role in shaping Zambia's green hydrogen future, driving both commercial success and long-term sustainability.

- **Energie- und Wasserinfrastruktur:** Der steigende Strombedarf Sambias erfordert parallel Investitionen in Kapazitäten der erneuerbaren Energie, damit eine verlässliche Stromversorgung für die Wasserstoffproduktion sichergestellt ist. Darüber hinaus ist ein effizientes Wassermanagement essenziell für eine nachhaltige Elektrolyse.
- **Regulatorischer Rahmen:** Klare politische Vorgaben und Sicherheitsstandards sind notwendig, um Investitionen anzuziehen und den grenzüberschreitenden Handel zu ermöglichen. Die Angleichung der sambischen Wasserstoffpolitik an internationale Standards wird entscheidend sein, um das Marktpotenzial Sambias zu erschließen.

Die Kombination aus hohem Potenzial bei erneuerbaren Energien und industriellem Bedarf macht Sambia zu einem attraktiven Zielmarkt für erste Aktivitäten im Bereich des grünen Wasserstoffs. Deutsche Unternehmen können frühzeitig zur Entwicklung des Wasserstoffsektors beitragen und gleichzeitig die größere Infrastruktur- und Industrieentwicklung im Land unterstützen. Durch gezielte Innovationsansätze, Investitionen und die Mitwirkung an politischen Rahmenbedingungen können deutsche Firmen eine zentrale Rolle bei der Gestaltung von Sambias Wasserstoffzukunft spielen – um sowohl den wirtschaftlichen Erfolg als auch die langfristige Nachhaltigkeit voranzutreiben.

1

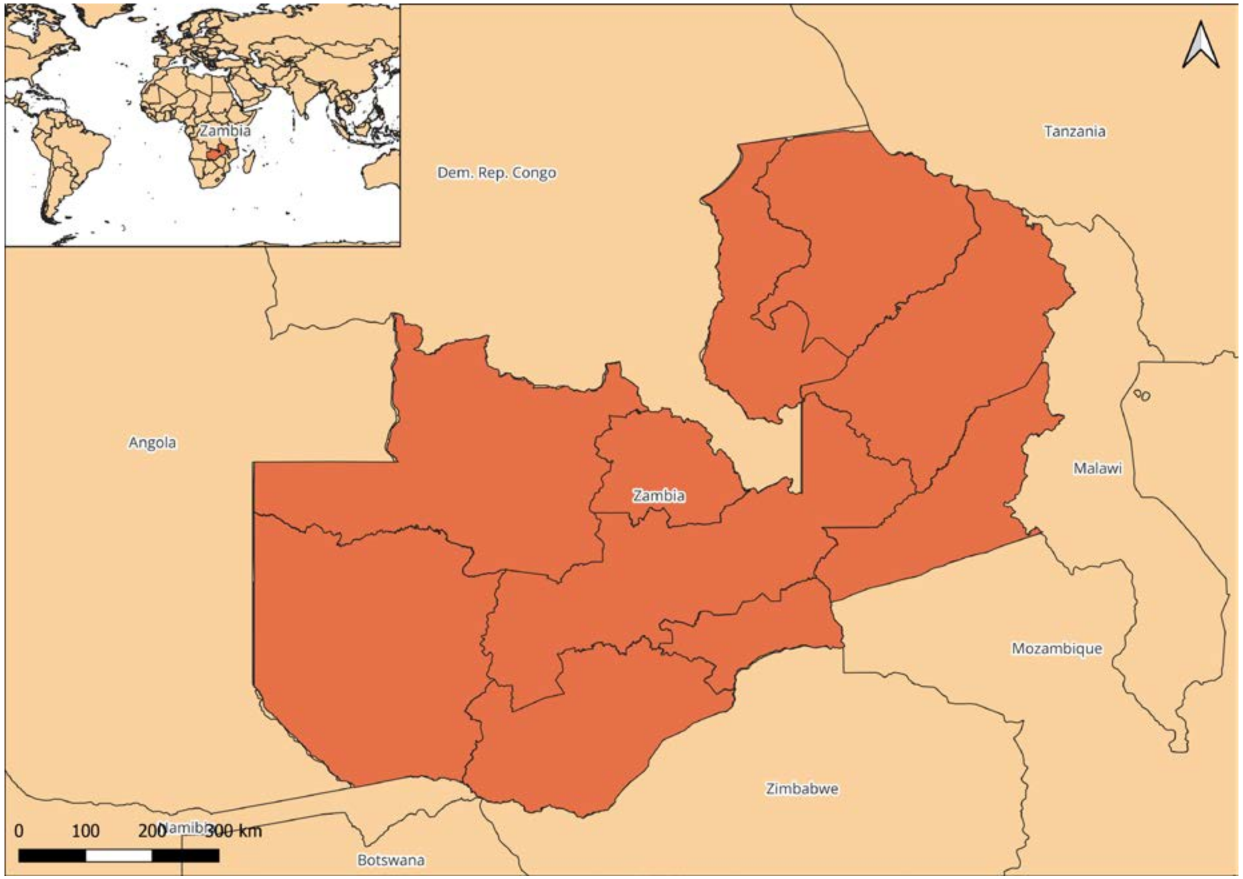
Outline of the current context

1.1 General country information

Zambia is a landlocked country located in Southern Africa (see Figure 1). The country has an area of approximately 743,390 km^2 and a population of about 21 million as of 2023 (World Bank, 2024a). Its economy is largely driven by copper mining. Zambia's GDP reached USD 28 billion in 2023, equating to USD 1,369 per capita. As of 2022, on average 48% of the population had access to electricity (World Bank, 2024a); in urban areas 87% of citizens had access to electricity while only 15% of rural areas were electrified.

Zambia's economy is heavily dependent on exporting copper articles (64.2%) and precious stones, metals & pearls (9.4%). From an import perspective, fertilisers, pharmaceutical products, inorganic chemicals, and chemical products (totalling 19.5%) represent the major share, followed by machinery, mechanical appliances & parts, and electrical machinery and electronics (totalling 19.1%). In 2022, the total export and import volumes reached USD 14.8 billion and USD 10.2 billion respectively.

FIGURE 1. Location of Zambia



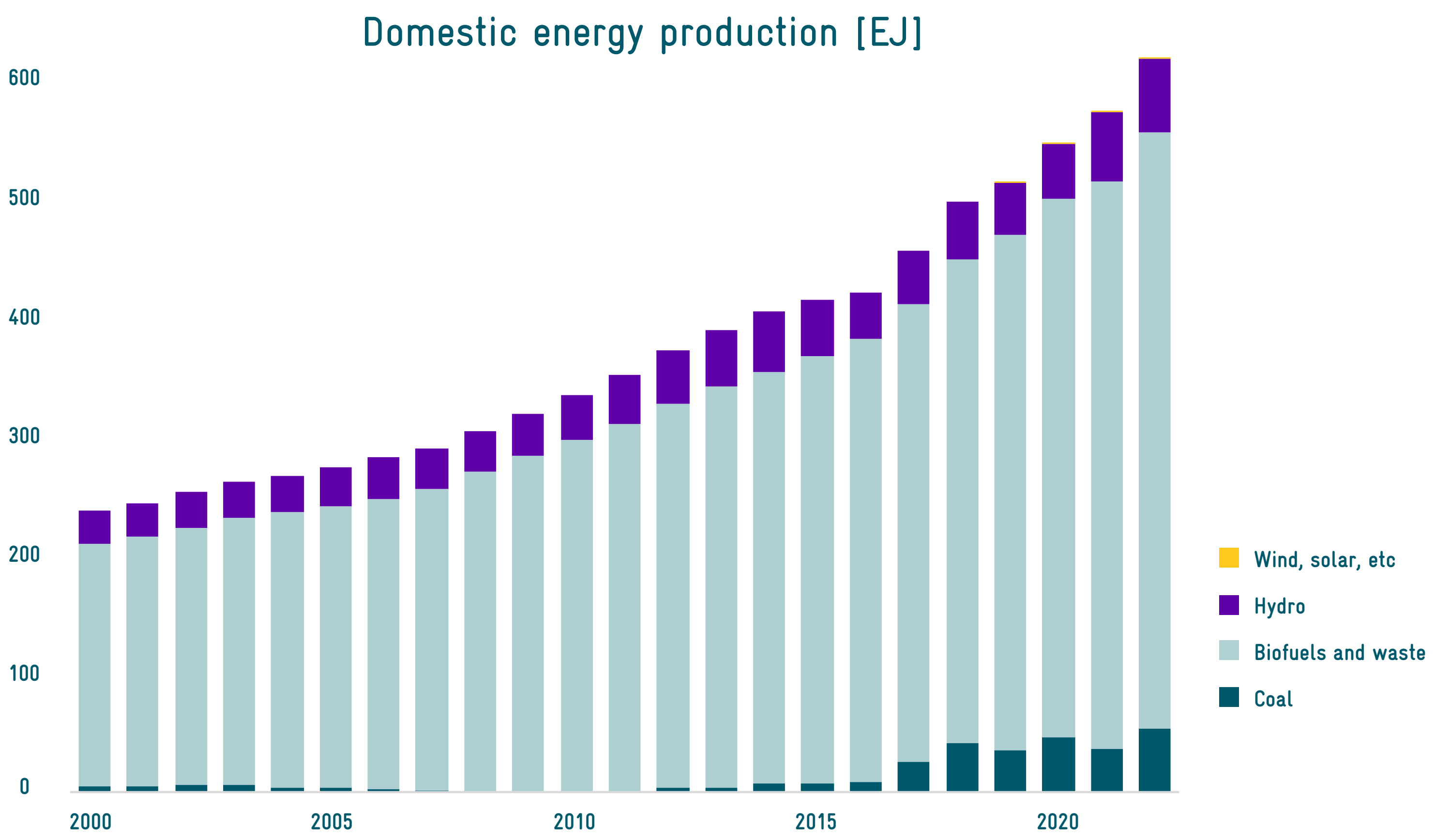
Source: Authors' own compilation, Fichtner (2024) based on (OpenStreetMap, 2024)

1.2 National energy sector analysis

1.2.1 Evolution of the energy sector to the present

Figure 2 shows the evolution of Zambia's energy production (in exajoules, EJ = 10^6 terajoules, TJ), which is highly dependent on biofuels and waste, representing 81% of domestic energy production in 2022. This is due mainly to the traditional (non-sustainable) use of biomass, resulting in high deforestation rates (FAO and the Ministry of Energy of Zambia, 2020). The second-largest source of domestic energy production is hydro, representing 10%, closely followed by coal with 9%. Zambia has produced coal for a long time, but there has been a steep increase from just 24 TJ in 2010 to more than 50 EJ in 2022. In the last four years the first solar photovoltaic (PV) plants have entered operation, but they still represent a very small share of Zambia's energy production (<0.1%).

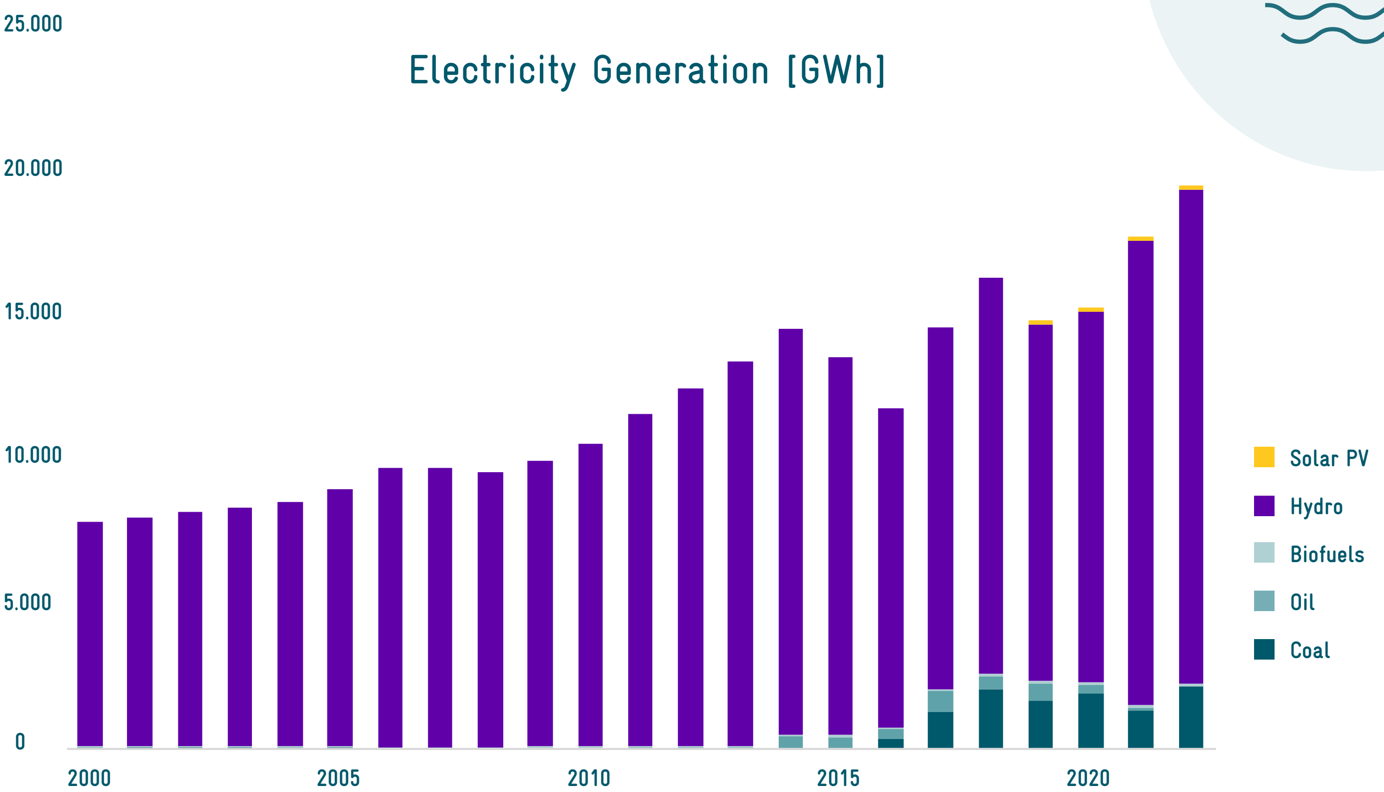
FIGURE 2. Evolution of domestic energy production in Zambia since 2000 (in EJ)



Source: Authors' own compilation, Fichtner (2025) based on (IEA, 2024a)

As shown in Figure 3, electricity generation is based mainly on hydro. Of the total electricity generation of 19,472 gigawatt hours (GWh) in 2022, hydro represents 88%, followed by coal with 11%. In line with higher extraction rates for coal, electricity generation based on coal has increased since 2016, when it accounted for only 3% of electricity generation. Biofuels and solar PV together make up 1%. Electricity generation from hydro is highly dependent on rainfall patterns, and is therefore prone to be affected by changes in climatic conditions. In 2024, due to a severe drought Zambia faced prolonged power cuts, known locally as load shedding, which lasted as long as several days and affected economic and daily activities (africanews, 2024).

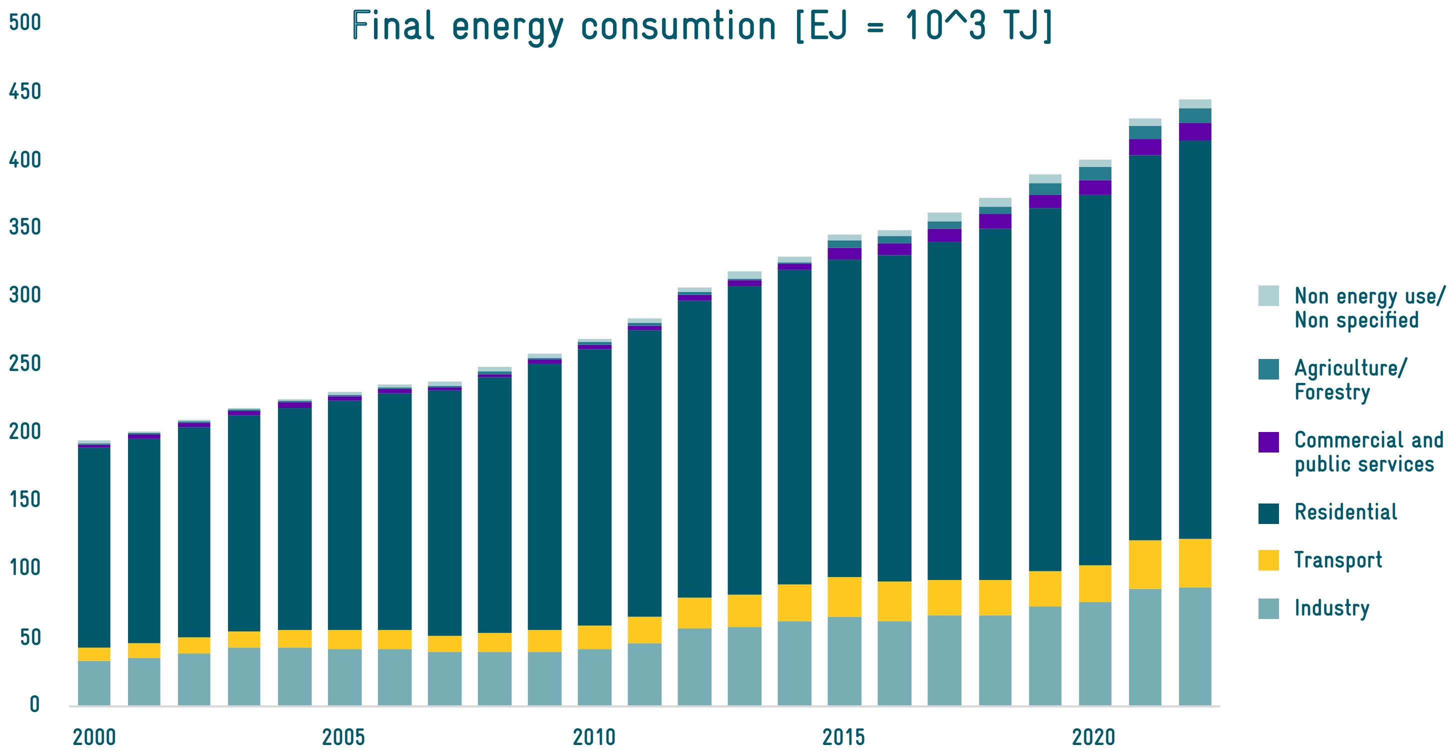
FIGURE 3. Evolution of electricity generation by source in Zambia since 2000 (in GWh)



Source: Authors' own compilation, Fichtner (2025) based on (IEA, 2024a)

Regarding final energy consumption, Figure 4 shows that it has steadily increased, more than doubling since 2000. It reached about 450 EJ in 2022, with the residential sector accounting for 65%. Industry consumes 20% of total final energy, while 8% is used by the transport sector. Other sectors include commercial and public services, agriculture and forestry, and non-specified or non-energy use; together they make up 8% of final energy consumption.

FIGURE 4. Evolution of final energy consumption by sector in Zambia since 2000 (in EJ)

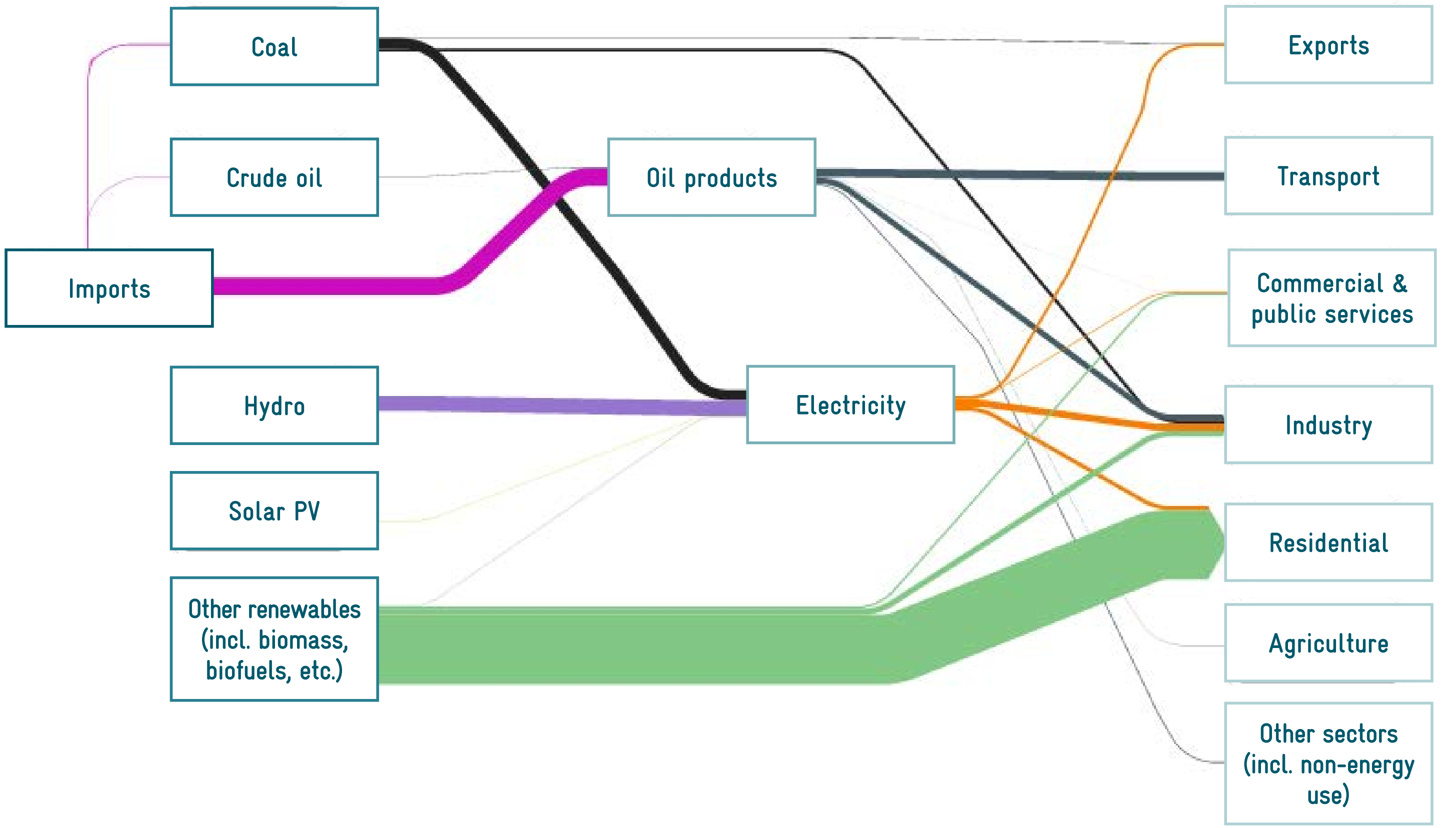


Source: Authors' own compilation, Fichtner (2025) based on (IEA, 2024a)

The Sankey diagram in Figure 5 is based on IEA statistics (IEA, 2024a) and summarises the energy flows from primary energy sources to secondary sources and to different end users' sectors for 2022. Total primary energy available was 622 EJ. The main primary energy sources were biomass, waste and biofuels (80%), and hydro and coal with 10% and 9% respectively. Large volumes of oil products are imported, while electricity is generated domestically, with some exports. Final energy consumption is led by the residential sector, relying mainly on biomass, which is mostly treated to produce charcoal in a traditional way. The industry and transport sectors are next, primarily utilising oil products and electricity. Other sectors, such as agriculture and public services, make up smaller portions of the final energy use.

As indicated in the Sankey diagram, Zambia exports a small share of generated electricity to neighbouring countries as well as some coal, but it is a net importer of energy, mainly of oil products, since it has no proven reserves of crude oil.

FIGURE 5. Energy flow in Zambia in 2022



Source: Authors' own compilation, Fichtner (2025) based on (IEA, 2024a)

Energy prices

Indicative energy prices for the main energy sources are listed in Table 1. The prices serve only as an indication of current levels since there might be variations over time. It must be highlighted that there is extensive use of traditional biomass, which is processed to charcoal. This is a relevant source of income for households, but no market price is available. Electricity prices are regulated by the Energy Regulation Board (ERB), ensuring that the tariffs are cost-reflective while also taking account of consumer affordability and economic impacts. Electricity tariffs are defined for six different groups (including distribution) and different levels of consumption within these, and are approved annually; minimum and maximum values for each category are presented in the table. Neither a carbon tax nor an emission trading scheme (ETS) is available in Zambia.

TABLE 1. Indicative energy prices for Zambia

Energy source		Price [ZMW]	Price [USD]	Unit	Date
Coal	Steam coal	3,782	140.8	/ t	24.10.2024
	Domestic use	Not available	–	–	–
Crude oil	Not available	–	–	–	–
Natural gas	Not applicable	–	–	–	–
Electricity	Residential	min. 440 max. 2,440	min. 17 max. 91	/ MWh / MWh	2024
	Commercial	min. 780 max. 2,280	min. 29 max. 85	/ MWh / MWh	2024
	Social services	min. 690 max. 1,250	min. 26 max. 47	/ MWh / MWh	2024
	Water pumping stations	min. 560 max. 1,720	min. 21 max. 64	/ MWh / MWh	2024
	Maximum demand	min. 700 max. 1,090	min. 26 max. 41	/ MWh / MWh	2024
ETS/CO_2	Not applicable	–	–	–	–

Source: Authors' own compilation, Fichtner (2025) based on (Coal Price, 2024), (ERB, 2024)

1.2.2 Current infrastructure

Zambia's transportation infrastructure consists of a mix of primary and secondary roads (67,671 km in total, with about 15% paved) (Logistics Cluster LCA, 2024). There are 6 trunk roads, with the designation T, and 20 main roads, with the designation M. These are mostly asphalted but often only single lane. 87% of the paved Trunk, Main and District (TMD) road network in Zambia is in good condition (GIZ, 2023).

Zambia has a total railway network of 2,217 km. There is one longer railway line in Zambia. This runs from Mulobezi in the south-west of the country to Lusaka, and from there to the Copperbelt Province in the north of the country, to Chingola near the border with the Democratic Republic of Congo. The railway network is connected to other African countries and has access to ports in East and South Africa (GIZ, 2023). However, there have been concerns about the efficiency of the rail system given its aged infrastructure, which has impacted on delivery times.

The national electricity grid serves mainly urban areas. Rural areas, however, often lack reliable access, and more than half of the population is estimated to be without access to grid electricity (World Bank, 2024b). The distribution of oil products relies on road transport. The Tazama pipeline, which is 1,710 km long, transports diesel from the port of Dar-es-Salaam in Tanzania to Indeni Petroleum Refinery in Ndola (DW, 2023). There is no gas infrastructure. Zambia features numerous water bodies but faces significant water risk challenges and a high overall water risk (Aqueduct, 2024). Access to safe water is particularly difficult in rural regions.

1.2.3 Forecast evolution of the energy sector

In February 2024 the country launched its Integrated Resource Plan (IRP) (Ministry of Energy, 2024b), which sets out a 30-year strategy for electricity generation, transmission, and distribution infrastructure designed to ensure national energy sufficiency. Two key aspects of the IRP are growth in electricity demand and the diversification of generation. Electricity demand is expected to grow by 121% by 2030 and by 349% by 2050, from 2020 levels (2.5 GW peak demand), driven by significant increases in the agriculture, mining, and residential sectors and in power exports. Generation capacity is expected to grow from 3.7 GW in 2023 to 10.0 GW by 2030, and to 23.2 GW by 2050.

The country is considering the use of fossil fuels in its generation capacity, but the major share will come from renewable energy, combining conventional hydro generation with non-conventional sources comprising mainly solar PV and wind, with smaller shares from geothermal and biomass. The IRP targets universal electricity access by 2030, 56% on-grid and 44% off-grid. It furthermore identifies the investments required not only in generation but in additional infrastructure, such as transmission and distribution networks and off-grid access, totalling USD 11.6 billion by 2030 and USD 31.0 billion by 2050.

These ambitious targets will require huge investments in a short timeframe, which might be challenging if international resources are not made available. Nonetheless, these investments will be essential for implementing an energy system that increases access and is reliable, allowing commercial and industrial activities to develop.

1.3 Legislative and regulatory framework

Zambia's legislative and regulatory framework covering renewable energy, climate change, and emerging sectors such as GH_2 is developing in response to both domestic energy needs and international climate commitments. Key national laws and regulations guiding Zambia's energy transition are outlined here.

Environmental Management Act (Act No. 12 of 2011) (Ministry of Water Development, Sanitation and Environmental Protection, 2011)

OVERVIEW:

This act provides a comprehensive framework for environmental governance and sustainable management of natural resources in Zambia.

KEY PROVISIONS:

- **Environmental impact assessments (EIAs):** Mandates EIAs for projects that may impact the environment, ensuring mitigation of adverse effects.
- **Climate change adaptation:** Requires the formulation of policies to address climate change impacts, including strategies for emissions reduction.
- **Public participation:** Promotes stakeholder engagement in environmental decision-making processes.

Renewable Energy Feed-in Tariff (REFiT) Strategy (Ministry of Energy, 2017)

OVERVIEW:

This policy aims to promote investment in renewable energy by providing a fixed payment for electricity generated from renewable sources.

KEY PROVISIONS:

- **Tariff structure:** Establishes different tariff rates for various renewable energy technologies, encouraging diverse investments.
- **Long-term contracts:** Guarantees long-term contracts to support project financing and reduce investment risks.

Electricity Act (No. 11 of 2019) (Ministry of Energy, 2019a)

OVERVIEW:

This act governs the electricity sector in Zambia, facilitating the expansion and modernisation of the electricity supply system.

KEY PROVISIONS:

- **Licensing and regulation:** Outlines the processes for obtaining licenses for electricity generation, distribution, and supply.
- **Consumer access:** Aims to improve access to electricity across the country, particularly in rural and underserved areas.

Renewable Energy Act (Act No. 4 of 2019) (Ministry of Energy, 2019b)

Overview:

This act provides the legal framework for the development and promotion of renewable energy in Zambia. It aims to enhance energy security and promote sustainable energy practices.

Key provisions:

- **Renewable energy targets:** Aims to achieve at least 30% of the energy mix from renewable sources by 2030.
- **Incentives:** Includes fiscal incentives such as tax exemptions and duty-free imports for renewable energy technologies and equipment.
- **Feed-in tariffs (FiTs):** Establishes a system of guaranteed tariffs for electricity generated from renewable sources.
- **Support for small-scale projects:** Encourages community-based renewable energy initiatives to increase access to energy in rural areas.

Energy Regulation Act (No 12 of 2019) (Ministry of Energy, 2019d)

OVERVIEW:

It aims at regulating the energy sector, replaces earlier legislation and enhances the role of the Energy Regulation Board (ERB) to oversee and enforce energy policies, promote efficient energy use, and support renewable energy development.

KEY PROVISIONS:

- **Energy Regulation Board:** The ERB is empowered to regulate the production, transmission, distribution, and supply of energy, including electricity, petroleum, and renewable energy sources.
- **Licensing and compliance:** Energy service providers must obtain licences from the ERB. The ERB can issue, modify, suspend, or revoke licences based on compliance with regulatory requirements.
- **Tariff setting:** The ERB has the authority to set and periodically review tariffs for energy services to ensure they are cost reflective.

National Energy Policy (2019) (Ministry of Energy, 2019c)

OVERVIEW:

This policy outlines Zambia's strategic direction for energy sector development, focusing on renewable energy and energy efficiency.

KEY PROVISIONS:

- **Renewable energy development:** Sets targets for expanding renewable energy capacity, including solar, wind, and biomass.
- **Energy access:** Aims to enhance access to affordable and reliable energy, particularly in underserved areas.
- **Energy efficiency:** Promotes measures to improve energy efficiency across various sectors, reducing overall energy demand.

Zambia's Nationally Determined Contribution (NDC) (Ministry of National Development Planning, 2021)

OVERVIEW:

Zambia's updated NDC outlines the country's climate goals under the Paris Agreement, emphasising both mitigation and adaptation.

KEY PROVISIONS:

- **GHG emissions target:** Commitment to reduce greenhouse gas emissions by 47% by 2030 compared to a business-as-usual scenario.
- **Sectoral focus:** Prioritises actions in the energy, agriculture, and forestry sectors for emissions reductions.

Electricity Net Metering Regulations (Ministry of Energy, 2024a)

OVERVIEW:

Establishes a framework to support integration of renewable energy generation by consumers, referred as 'prosumers'.

KEY PROVISIONS:

- **Participation criteria:** Prosumers must generate electricity from renewable sources, with generation capacity divided into four categories, up to 5 MW.
- **Application process:** Consumers must sign a net metering supply agreement and net metering connection agreement with ZESCO or other licensed distributors.

- **Billing and credits:** Prosumers receive credits for excess electricity fed into the grid. Credits can offset future electricity bills (no cash payments). Tariffs are categorised on the basis of the percentage of generated electricity exported, with different compensation rates.

Zambia's legislative and regulatory framework supports the development of renewable energy sources and climate change mitigation efforts. The government has established ambitious targets and implemented policies to attract investment, promote clean energy deployment, and enhance energy access. The country's political stability ensures the continued evolution and implementation of long-term policies that reduce risks for investors. As the country continues its energy transition, there are a variety of opportunities for domestic and international companies to engage in the renewable energy sector and contribute to Zambia's sustainable development trajectory.

2

Industrial applications of hydrogen

Global hydrogen demand reached 97 million tonnes per annum (MTPA) in 2023 and remains concentrated in traditional uses such as refining and industry applications, mainly ammonia and methanol production and steel manufacturing (IEA, 2024b). Considering current (or traditional) and potential new uses of hydrogen as a decarbonisation solution, this demand is expected to increase significantly to 200-600 MTPA by 2050, depending on the analysis and scenario selected, which should be covered primarily by clean hydrogen (produced either by electrolysis powered by renewable energies, so-called green hydrogen, or by reforming of fossil fuels combined with CCS, referred to as blue hydrogen).

2.1 Hydrogen production methods

Hydrogen can be produced through different processes according to the energy source and technology used, as summarised in the following table. The hydrogen used to meet current demand comes almost exclusively from the processing of fossil fuels (natural gas and coal) within methane reforming and coal gasification.

TABLE 2. Production methods of hydrogen

Production process	Energy source	Technology options	Products	CO_2 emissions
Methane reforming	Natural gas	• Steam methane reforming (SMR) • Autothermal reforming (ATR)	H_2, CO, CO_2, N_2	• High CO_2 emissions • Potential combination with CCS to reduce CO_2 emissions
Coal gasification	Coal	• Gasification/reaction with O_2 and steam at high pressure and temperatures	H_2, CO, CO_2, N_2	
Methane pyrolysis	Natural gas	• Thermal decomposition at high temperatures without O_2	H_2, CO, CO_2	
Biomass gasification	Biomass	• Heating with limited oxygen	H_2, CO, CO_2	• Low to zero CO_2 emissions
Electrolysis	Electricity	• Electrolysis (AEC, PEMEC, SOEC, AEMEC)	H_2, O_2	• CO_2 emissions depend on electricity source • Low to zero for renewable energy sources

CCS	Carbon capture and storage
AEC	Alkaline electrolysis cell
PEMEC	Proton exchange membrane electrolysis cell
SOEC	Solid oxide electrolysis cell
AEMEC	Anion exchange membrane electrolysis cell

Source: Authors' own compilation, Fichtner (2025)

2.2 Hydrogen uses

Hydrogen is a key component of the global energy and industrial landscape, with similar applications worldwide. The data presented in this section reflects the global context of hydrogen and is location independent.

Hydrogen demand reached 97 MTPA in 2023, with the largest consumers of hydrogen being refining (44%), ammonia production (33%), and methanol production (17%). Some 5% of hydrogen is used for direct reduced iron (DRI) in the iron and steel sector and small amounts are used in other segments such as glassmaking, electronics, and metal processing, accounting for 1 MTPA or 1% of current global hydrogen demand (IEA, 2024b).

Other minor current uses of hydrogen include aerospace, as a propellant, and energy storage for balancing renewable energy supply and demand.

TABLE 3. Current uses of hydrogen

Current uses	Main processes / products	Specific requirements
Refining[1]	• Hydrocracking, hydrotreating and desulphurisation	• Depends on refinery complexity and oil quality: 8–14 kg hydrogen/ton refined product
Ammonia	• Fertiliser production • Chemical production: e.g. nitric acid, amines, explosives • Refrigeration	• Stochiometric: 178 kg H_2/ton ammonia
Methanol	• Fuel: Methyl tertiary butyl ether (MTBE) • Solvent • Antifreeze • Chemical feedstock: e.g. formaldehyde, acetic acid	• Stochiometric: CO_2 hydrogenation: 189 kg H_2/ton methanol CO hydrogenation: 126 kg H_2/ton methanol
Chemical industry	• Oxo alcohols	• Depends on olefin, process and product, stoichiometrically between 10–30 kg H_2/ton oxo alcohol
	• Fatty alcohols	• Depends on production process and product, stoichiometrically between 10–20 kg H_2/ton fatty alcohol
	• Hydrogen peroxide (H_2O_2)	• Stochiometric: 59 kg H_2/ton H_2O_2
	• Cyclohexane (C_6H_{12})	• Stochiometric: 71 kg H_2/ton cyclohexane
	• Hydrochloric acid (HCl)	• Stochiometric: 55 kg H_2/ton HCl
	• Caprolactam	• Depends on the production process, between 30–50 kg H_2/ton caprolactam
	• Phenol production*	• Depends on the production process, between 10–30 kg H_2/ton phenol
	• Acetone production* via hydrogenation of isopropyl alcohol	• Stochiometric: 34 kg H_2/ton acetone
	• 1,4-butanediol (BDO)	• Stochiometric: 23 kg H_2/ton BDO
	• Fine chemicals and pharmaceuticals as reducing agent	• Depends on processes and products

1 In refineries, hydrogen is required for hydrocracking and hydrotreating, but it is also generated, mainly during catalytic reformulation: 18 kg of hydrogen / ton of crude oil (Fuel Cells and Hydrogen Observatory, 2021).

* The most common production process for phenol and acetone is the cumene process. This process does not require hydrogen directly, but it can be required for refining acetone (removal of impurities).

Current uses	Main processes / products	Specific requirements
Iron and steel	• As reducing agent in direct reduced iron (DRI) • As reducing atmosphere in annealing process in steel roll mills	• Depends on iron ore quality: ~60 kg H_2/ton steel
Glass	• Glass melting as reducing agent to improve quality • Specialty glasses to control optical properties • Alternative fuel or furnaces to replace e.g. natural gas	• As reducing agent: 0.4 kg H_2/ton float glass
Electronics	• Chemical vapor deposition, mainly, e.g. for semiconductor manufacturing and LED production. • Reduction agent	• 45–90 kg H_2/ton semiconductor
Food industry	• Hydrogenation of oils (fats) and fatty acids	• Depends on oil/fat, required product and process: 5–100 kg H_2/ton unsaturated fat processed
Metal processing	• Pure or in a mixture as shielding gas for welding processes	• Depends on process

Source: Authors' own compilation, Fichtner (2025) based on (Bressan, L. et all, 2009), (Fuel Cells and Hydrogen Observatory, 2021), (Wasserstoff Kompass, 2022), (Semiconductor Digest, 2018)

Additionally, hydrogen is produced within different production processes as a by-product.

In 2023, some 25% of hydrogen was produced as a by-product in refineries and petrochemicals production (IEA, 2024b). The main products that generate hydrogen as a by-product are listed in Table 4.

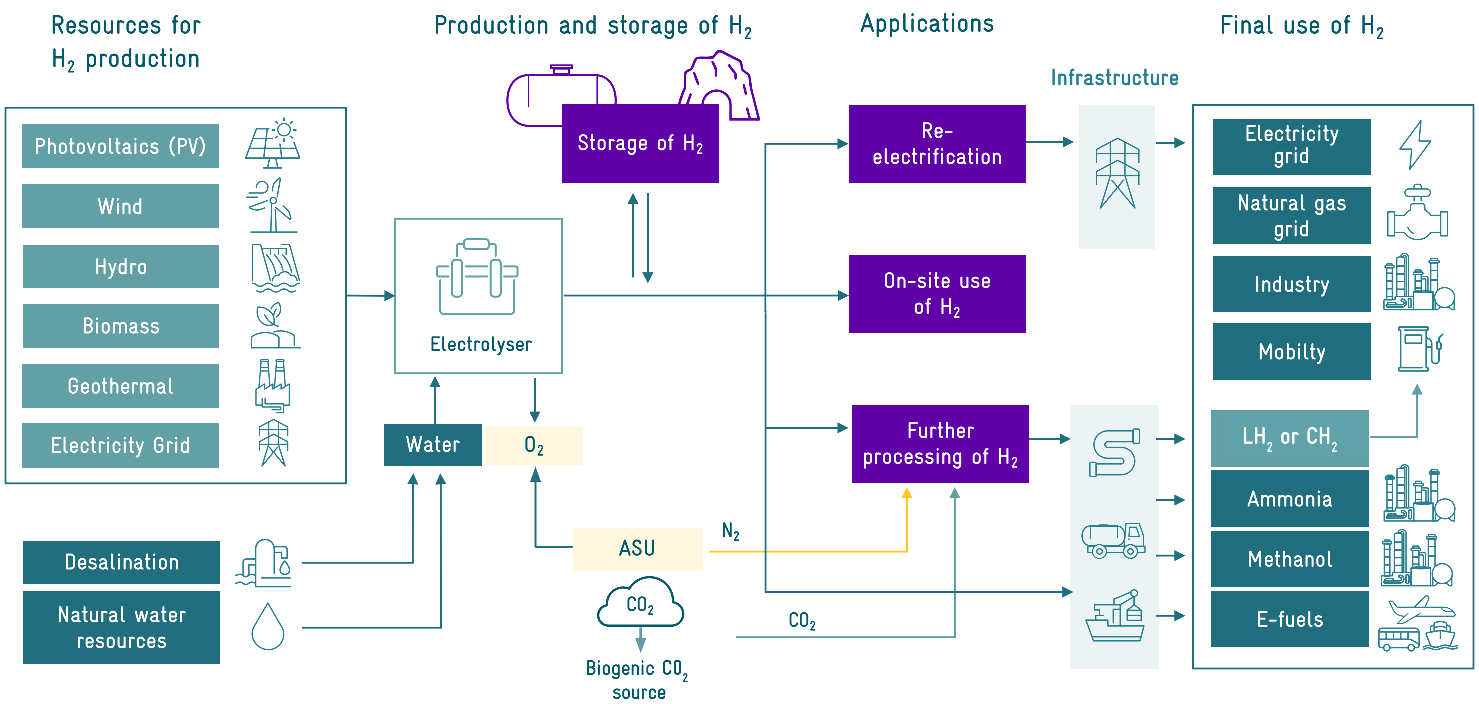
TABLE 4. Hydrogen generation as a by-product

Final product	Typical use of H_2 by-product	Specific H_2 generation
Ethylene	• On site as feedstock for other processes	190 Nm³ H_2/tonne ethylene (11 kg H_2/tonne ethylene)
Styrene		220 Nm³ H_2/tonne styrene (20 kg H_2/tonne styrene)
Chlorine (via chlor-alkali process)	• Fuel for heat boilers and/or combined heat and power (CHP) units	270–300 Nm³ H_2/tonne chlorine (24–27 kg H_2/tonne chlorine
Acetylene	• On site as feedstock for other processes	3,400–3,740 Nm³ H_2/tonne acetylene (305–336 kg H_2/tonne acetylene)
Cyanide		2,470 Nm³ H_2/tonne cyanide (222 kg H_2/tonne cyanide)

Source: Authors' own compilation, Fichtner (2025) based on (Fuel Cells and Hydrogen Observatory, 2021)

Demand for hydrogen has been concentrated in refining and some industrial applications, but the adoption of clean hydrogen in new applications will play a key role in the energy transition. This will include the replacement of current hydrogen demand with green hydrogen produced via electrolysis (as shown in Figure 6), for example, but also new areas of use such as mobility (road, air, and maritime transport), electricity generation, production of synthetic fuels (e-fuels), and high-temperature heat generation, among others. The switch from conventional production processes to electrolysis for hydrogen generation will require additional feedstocks for derivatives production, including a nitrogen source for ammonia production and a sustainable CO_2 source for methanol and synthetic fuel production.

FIGURE 6. Value chain of potential applications of green hydrogen



Storage: In tanks or geological.

H_2	Hydrogen
LH_2	Liquefied hydrogen
CH_2	Compressed hydrogen
ASU	Air separation unit

Source: Authors' own compilation, Fichtner (2025)

These pplications provide a first indication of how green hydrogen might be used in the future. Which applications gain traction will largely depend on possible alternative technologies with which hydrogen will have to compete, on national and international decarbonisation targets and commitments, and on available energy sources in the individual countries.

Furthermore, the production of hydrogen by electrolysis generates 8 kg oxygen (O_2)/kg H_2 as a by-product. Some typical applications of high-purity liquified oxygen include water treatment, medical purposes, and industry (metallurgy, pulp & paper, chemical, etc.). Nonetheless, taking into consideration that current technologies for oxygen production (air separation unit, ASU; pressure swing adsorption, PSA) are mature, easily scalable, and applicable to on-site oxygen generation, the use of oxygen generated by electrolysis in an economic feasible way is quite restricted and very location dependent.

2.3 Most common hydrogen downstream products

2.3.1 Ammonia and fertilisers

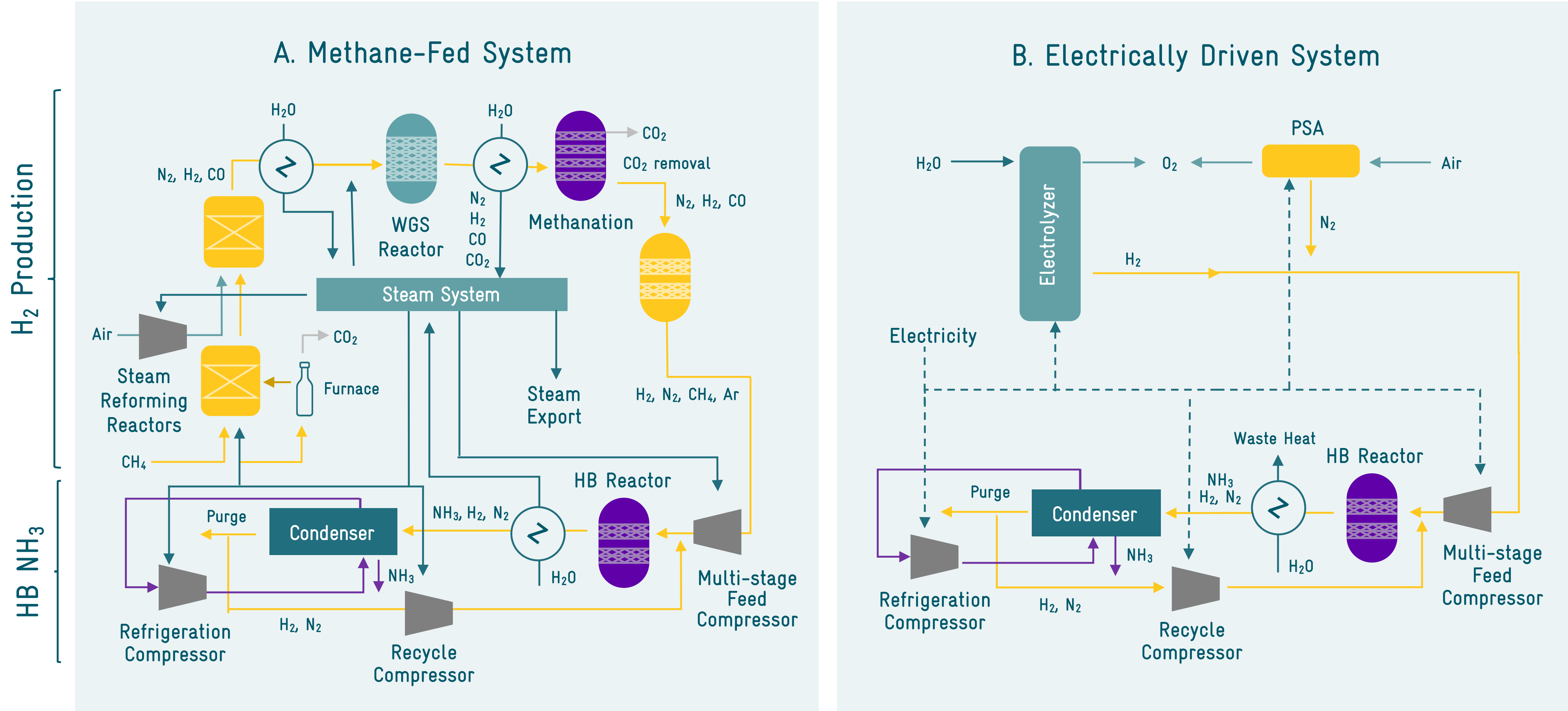
Ammonia production is the second-largest current use of hydrogen, accounting for 33% of total hydrogen demand. Ammonia is a key precursor in the industry and is mainly used for nitrogen-based fertilisers (around 70-80%), and other industrial applications such as plastic and explosive production.

Ammonia is synthetised via the Haber-Bosch (HB) process, in which hydrogen (H_2) reacts with nitrogen (N_2) to form ammonia (NH_3) under high pressures and high temperatures. A schematic of the conventional HB process as well as a green hydrogen-based process is shown in Figure 7. Conventional ammonia production is based on steam methane reforming (SMR), a process using steam where nitrogen is sourced directly from air. In the green ammonia option, an electrically driven system, an external source of nitrogen is required (e.g. from air through an air separation unit, ASU) and the compressors that are steam-driven in the conventional process are mainly electrically driven. Little to no steam is used in the green ammonia production process.

Ammonia is a key ingredient in nitrogen fertilisers and as such is critical for crop growth. Table 12 in the annex presents an overview of some commonly used fertilisers.

It should be noted that the production processes of some of the fertilisers require a carbon source, which needs to be sustainable in order to obtain green fertilisers. Possible solutions are direct air capture (DAC), carbon capture and use (CCU) from unavoidable industrial sources, or biomass treatment processes. Globally, only few industrial or commercial-scale projects are currently available for sustainable carbon sourcing.

FIGURE 7. Schematic of conventional (A) and green (B) Haber-Bosch process



Source: Smith, 2019

2.3.2 Methanol

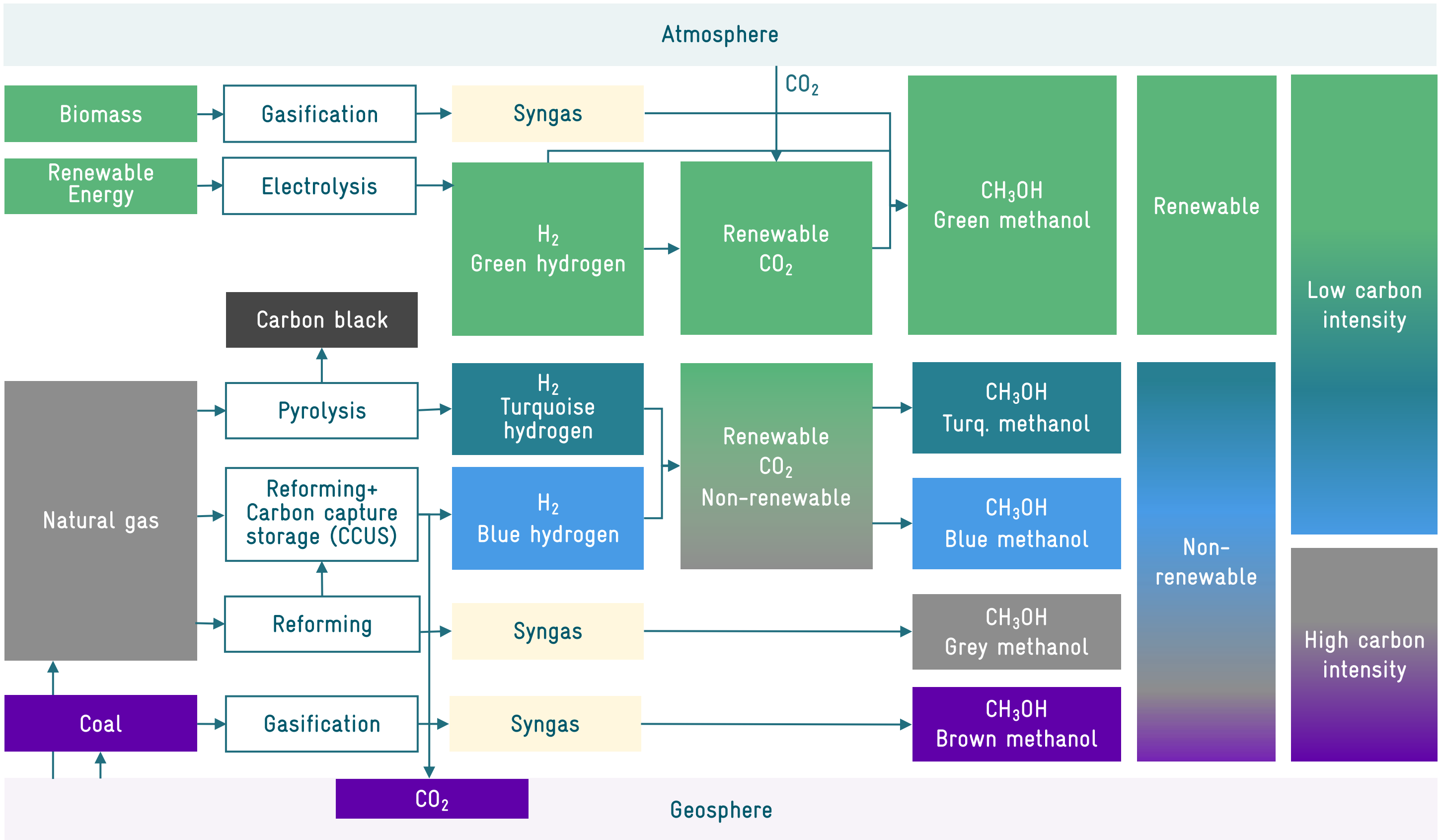
Methanol production is another major current use of hydrogen, accounting for 17% of hydrogen demand. Methanol is a widely used chemical whose main uses include the production of basic chemicals (e.g. formaldehyde, acetic acid; 52%), olefins (e.g. polyethylene; 31%) and fuels/fuel additives (e.g. dimethyl ether (DME); 17%) (Methanol Institute, 2024).

Today's methanol production depends mainly on natural gas consumption to produce hydrogen as well as the necessary CO_2 (see Figure 8). The mixture of hydrogen, CO_2 and CO generated in a steam methane reforming (SMR) reactor is passed over a catalyst at high pressure and moderate temperatures, with two key reactions:

$CO + 2H_2 \rightarrow CH_3OH$ and
$CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$

In the case of green methanol, the hydrogen is generated by electrolysis and an additional source of carbon is required for the synthesis process. The sourcing of sustainable carbon and the deployment of technologies such as DAC or CCU at large scale might be limiting factors. The following table offers an overview of the main uses of methanol.

FIGURE 8. Pathways of methanol production



Source: Authors' own compilation, Fichtner (2025) based on (IRENA, 2021)

TABLE 5. Key methanol uses

Application	Precursors
Fuel	As a fuel, either directly or blended with gasoline. Methanol fuel cells are a promising technology.
Solvent	As a solvent in various industrial processes, including paint thinners and adhesives.
Formaldehyde	Formaldehyde production, which is used in resins, plastics and textiles.
Acetic acid	Acetic acid production, which is used in the production of vinegar, plastics and synthetic fibres.
Methyl tertiary butyl ether (MTBE)	MTBE production, which is used as an oxygenate added to gasoline to reduce emissions.
Biodiesel	Used in the transesterification process to produce biodiesel from vegetable oils or animal fats as a substitute for conventional diesel.
Methanol-to-olefins (MTO)	Conversion into light olefins such as ethylene and propylene, for the production of plastics and synthetic fibres.
Methanol-to-gasoline (MTG)	Transformation into high-octane gasoline through a series of catalytic reactions.
Dimethyl ether (DME)	Dehydration to form DME, which can be used as a substitute for diesel.

Source: Authors' own compilation, Fichtner (2025)

2.4 The hydrogen industry in Zambia

2.4.1 Overview of the national industry

Zambia's hydrogen industry is in its early stages of development, as key sectors that typically drive hydrogen demand – such as crude oil refining, large-scale chemical manufacturing, and fertiliser production – are not yet established.

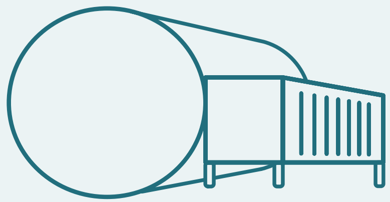
The state-owned company Nitrogen Chemicals of Zambia (NCZ), commissioned in 1970, was originally intended to produce ammonium nitrate for both fertilisers and explosives in the mining industry, but they stopped the production of AN in 2019. The hydrogen requirements associated with ammonia-based explosives for the mining sector remain unclear due to a lack of available statistical data on local production capacities and product specifics.

In terms of hydrogen derivatives, Zambia has imported an average of 450 kTPA of fertilisers in recent years, including mineral and chemical fertilisers. Additionally, small volumes of other chemical products, such as hydrogen peroxide or methanol, are also imported.

Despite the current limited hydrogen demand, several potential future consumers can be identified:

- NCZ may consider refurbishing and recommissioning its ammonium nitrate production plant, which would generate an estimated hydrogen demand of approximately 3 kTPA, assuming no capacity expansion.
- United Capital Fertilizer Zambia Company is constructing the country's first ammonia and urea production plant, set to be commissioned in the second half of 2025. This facility is expected to require approximately 32 kTPA of hydrogen.
- Universal Mining and Chemical Industries (UMCIL) operates a DRI furnace that could transition to green hydrogen in the future, with an estimated hydrogen demand of around 15 kTPA.
- The food industry, particularly the hydrogenation of edible oils – currently refined locally – could generate hydrogen demand ranging from 1 to 24 kTPA, depending on the scale and type of production.

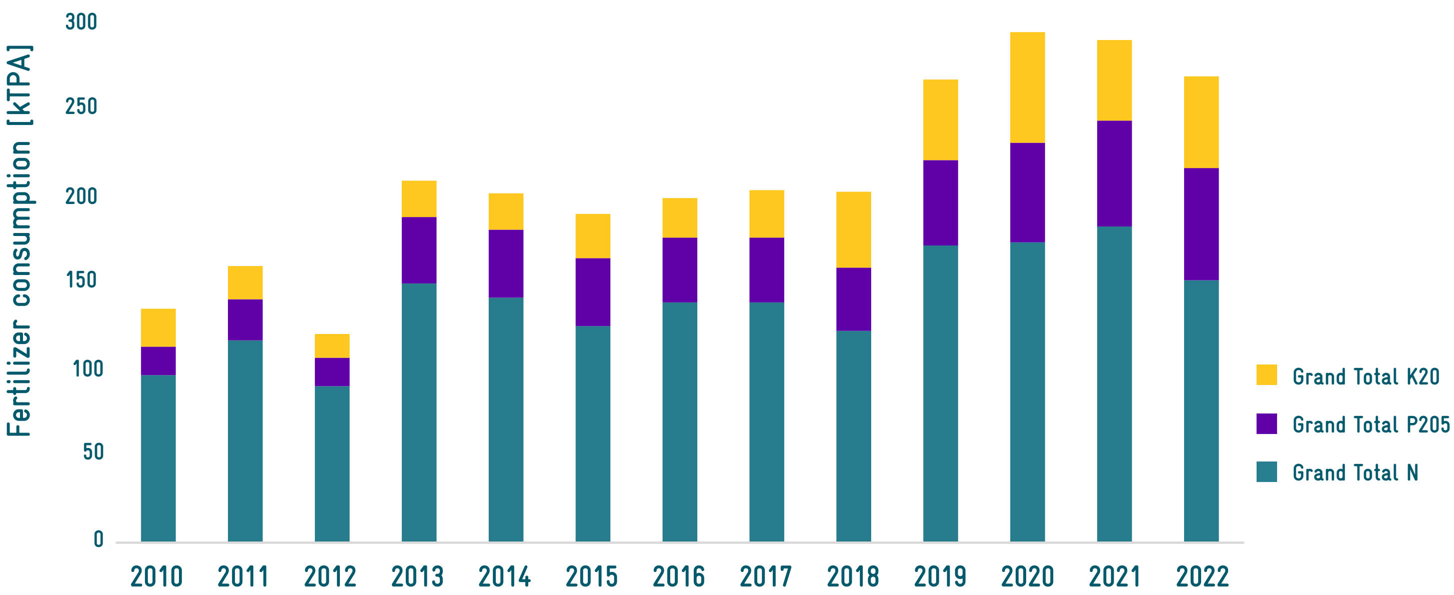
Further details are provided in the following sections.



2.4.2 The fertiliser industry

The fertiliser industry in Zambia is a rapidly growing sector, fuelled by the country's agricultural needs and supported by both local and international investments. Agriculture plays a significant role in Zambia's economy, and fertiliser is crucial for enhancing crop yields and ensuring food security. As shown in Figure 9, apparent fertiliser consumption almost doubled between 2010 and 2022. Nitrogen-based fertilisers are the main fertilisers used in Zambia, with a share of more than 55%.

FIGURE 9. Apparent fertiliser consumption in Zambia



Source: Authors' own compilation, Fichtner (2025) based on (IFA, 2025)

The main players in the fertiliser sector are focused on processing (or blending) fertilisers based on imported materials and not on local production. Two key players include the state-owned Nitrogen Chemicals of Zambia (NCZ), whose original aim was to produce ammonium nitrate for explosives and fertiliser production but stopped production in 2019, and the United Capital Fertilizer Zambia Company, which is planning an ammonia and urea production facility in the country, expected to enter into operation in the second half of 2025 (Wonderful Group, 2024). Table 6 lists the main players in the sector including their locations and processing capacities.

Since the current plants focus on blending, there is no hydrogen demand associated with this processing.

The lack of local production capacity for fertilisers makes Zambia dependent on imports to cover national demand. Fertiliser is one of the most imported products in Zambia. Annual imports have been around 450 kTPA in recent years, but the distribution of products varies: whereas 136 kTPA of mineral or chemical fertilisers (with nitrogen), 184 kTPA of urea, and 108 kTPA of ammonium nitrate were imported in 2022, in 2023 the corresponding amounts were 55 kTPA, 287 kTPA, and 131 kTPA, respectively (WITS, 2025a).

TABLE 6. Main fertiliser companies in Zambia

Company	Location	Capacity [kTPA]	Estimated hydrogen demand [kTPA]
Zambian Fertilizers Limited	Lusaka	22	Blending not producing
Nitrogen Chemicals of Zambia	Kafue	Current: NPK: 400, AN: 65	NPK: Blending not producing Non-operational (if in operation, requirement will be 3 for AN)
		Planned:	New blending plant
Fert Seed & Grain	Lusaka	745	Blending not producing
United Capital Fertilizer Zambia Company	Chilanga District	Current: Urea, DAP, NPK: 300	Blending not producing
		Planned: urea + NH_3: 300 + 180	For NH_3: 32

Source: Authors' own compilation, Fichtner (2025) based on (AfricaFertilizer, 2024) and (United Capital Fertilizer, 2024), (Milling Middle East & Africa, 2024)

2.4.3 The chemical industry

Zambia's chemical sector relies mainly on imports to cover local demand and is largely shaped by its mining sector. The country is an exporter of sulphuric acid, for example, which is produced as a by-product in copper mining. As there is no crude oil industry in the country, there is also no associated petrochemical industry. Currently no hydrogen demand is identified for the chemical industry.

Small volumes of chemicals such as hydrogen peroxide and hydrochloric acid are imported: around 1,000 tonnes of each in 2023 (WITS, 2025b). Methanol requirements are also covered by imports, since no production facilities are currently operated in the country. Imports of methanol were 744 tonnes in 2022 (WITS, 2024).

2.4.4 The steel and metallurgy industry

Zambia has a small but growing steel industry. However, it still lacks large-scale integrated steel production and depends on scrap recycling and imports for raw materials. Even though Zambia has iron ore reserves, production is limited. Some key players are presented in Table 7, showing their location and capacity.

There are many other companies in the steel and metallurgy industry that import raw steel and process it into various products (e.g. nuts and bolts, nails, bars, etc.). Most of these companies are located in Lusaka, and include, among others, Wireforce, SteelTech Investment, Akaal Engineering, Continental Steel Industries, and Oriental Steel.

UMCIL's direct iron reduction plant currently uses coal for its production process. In future, it could be possible to switch the process to use green hydrogen, resulting in an estimated hydrogen demand of about 15 kTPA.

TABLE 7. Main steel and metallurgy companies in Zambia

Company	Location	Capacity [kTPA]
Good Time Steel	Lusaka	72
Universal Mining and Chemical Industries (UMCIL)	Kafue	250
PDV Metals	Lusaka	300

Source: Authors' own compilation, Fichtner (2025) based on (Africa Outlook, 2015), (UMCIL, 2024), (PDV Metals, 2025), (Bizbwana, 2021)

2.4.5 The oil and mining industry

Zambia does not currently have an operational oil refinery. The Indeni Petroleum Refinery located in Ndola had a capacity of 24,000 bbl/d but it was shut down in July 2022 (African Energy, 2022). Zambia therefore relies on imports of refined oil products to cover national demand and does not have a hydrogen demand related to crude oil refining.

Zambia's mining sector is the backbone of its economy, contributing more than 60% of export earnings. The industry is dominated by copper mining, mainly in the Copperbelt, but there is also production of cobalt, nickel, gold, manganese, and gemstones. Major mining companies include First Quantum Minerals, Barrick Gold, Konkola Copper Mines, Mopani Copper Mines, and Kagem Mining.

Directly related to the mining sector, there is a demand for explosives. AECI claims to be one of the main producers and suppliers of commercial explosives in Zambia, but it does not publish any statistics or data on production capacities or products. Another key player is Ideal Mining Services Ltd. (Copperbelt), which has a total production capacity of 165 kTPA of various explosives (Ideal Mining Services, 2025). Other active companies in the sector include Austin Powder (locally known as Nash Explosives) and Orica Mining Services.

Most mining and industrial explosives require ammonia-based ammonium nitrate (AN), resulting in a hydrogen demand that could be covered by green hydrogen. The hydrogen demand depends on the explosive; taking ammonium nitrate as the precursor, the specific requirement would be between 0.25 and 0.94 tonnes of AN per tonne of explosive, resulting in 10 to 38 kg of hydrogen per tonne of explosive.

2.4.6 The food industry

Despite efforts to boost local production, Zambia continues to be a net importer of certain food products, including edible oils. Key players in the sector include Mount Meru Millers Zambia Limited, a subsidiary of the Mount Meru Group, which produces edible oils and holds approximately 45% of the domestic edible oil market (Enterprise Zambia, 2020), as well as Zamanita, alongside other smaller producers. Table 8 outlines the main players in the sector, including their locations and production capacities.

Additionally, Agroline Industries Limited plans to construct a refinery for edible oil in Chipata District, with a production capacity of 36.5 kTPA (Agroline Industries Limited, 2024).

Standard vegetable oil refining does not require hydrogen; however, further processing into semi-solid or solid fats necessitates hydrogenation. Its hydrogen requirement depends on the final product. If the total installed refining capacity listed in the table above (239 kTPA) undergoes hydrogenation, the hydrogen requirement would range from 1 to 24 kTPA.

TABLE 8. Main edible oil processing companies in Zambia

Company	Location	Capacity [kTPA]
Mount Meru Millers Zambia Limited	Katuba	140
Zamanita	Lusaka	73
Unified Chemicals Zambia Limited	Lusaka	24
Savenda (Refined Oil Products)	Lusaka	2.2

Source: Authors' own compilation, Fichtner (2025) based on (Enterprise Zambia, 2020), (ETG, 2020), (Africa Business, 2025), (Savenda, 2022)

2.4.7 Other industries

Hydrogen is increasingly recognised as a critical enabler for decarbonising industries that are challenging to electrify, particularly those that require high temperatures. The shift to green hydrogen in sectors such as cement, glass, and ceramics may take time and depend on technological advancements (including the transition to new processes). However, the potential for hydrogen in these industries should be carefully considered moving forward.

Zambia's cement industry has several key players, which include Dangote Cement Zambia, Chilanga Cement (formerly Lafarge), and Sinoma Cement Zambia. In 2023 Zambia exported about 1.0 MTPA (WITS, 2025c); the country is a net exporter of cement.

The glass industry in Zambia is characterised by companies that only import glass and make finished products. There used to be a glass manufacturing company, Kapiri Glass, which is no longer operating.

The ceramics industry in Zambia is relatively small, with several manufacturers such as Marcopolo Tiles, Ceraite, and Keda Zambia Ceramics Company, all located in Lusaka. Other active players in the sector act as distributors but have no production facilities in the country.

TABLE 9. Main cement companies in Zambia

Company	Location	Capacity [kTPA]
Dangote Cement Zambia	Ndola	1500
Chilanga Cement	Chilanga & Ndola	1500
Sinoma Cement Zambia	Lusaka	1000
Zambezi Portland Cement	Ndola	800
Amaka	Lusaka	900

Source: Authors' own compilation, Fichtner (2025) based on (Dangote Cement, 2024), (Chilanga Cement, 2022), (CN Cemnet, 2019), (Zambezi Portland, 2025)

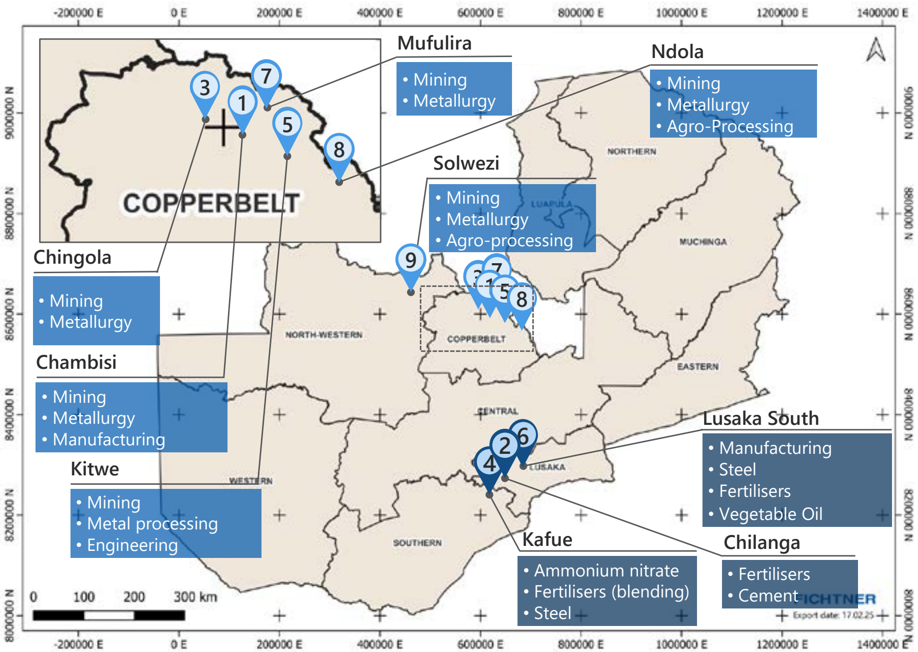
2.5 Industrial clusters and enabling infrastructure

The main industrial clusters in Zambia are depicted in Figure 10. Most of the clusters are concentrated in two provinces, Copperbelt and Lusaka, highlighting once again how closely linked Zambia's industrial activity is with the mining sector. More details of the industrial clusters can be found in Annex 1 Details of industrial clusters.

Of the nine industrial clusters listed, there is a higher likelihood of hydrogen use in three of them, with a corresponding potential for transitioning from grey to green hydrogen, as follows:

- **Cluster 2 in Chilanga:** United Capital Fertilizer is currently building an ammonia and urea production plant, which will require hydrogen once commissioned (expected for second half of 2025). The project foresees a coal gasification plant, but it would be feasible in future to integrate green hydrogen into the process.
- **Cluster 4 in Kafue:** NCZ could resume ammonium nitrate production at the existing plant, with a refurbishment and recommissioning plan to increase local production capacity. Additionally, in the steel sector, UMCIL operates a DRI furnace, which would have the potential to use green hydrogen in future.
- **Cluster 6 in Lusaka:** This is one of the main industrial clusters of the country and presents potential for hydrogen use in the processing of edible oils, if there are hydrogenation processes in place or plans for adoption.

FIGURE 10. Main industrial clusters in Zambia



	Company	[kTPA]
2	**United Capital Fertilizer** (Various Fertilizer) **Chilanga Cement** (Cement)	300 1,500
3	**Ideal Mining Services Ltd.** (Explosives)	165
4	**UMCIL** (Steel) **Nitrogen Chemicals of Zambia** (various Fertiliser)	250 465
6	**Zamanita** (Edible Oils) **PDV Metals** (Steel) **Fertilizer Seed & Grain** (Fertiliser)	73 300 745
7	**AECI** (Explosives)	-

Prioritized clusters

Other clusters

Source: Authors' own compilation, Fichtner (2025)

Most of the clusters located in Copperbelt Province are related to mining activities, for which there might be demand for hydrogen to produce explosives. Other products and processes, such as iron and steel (not DRI) or cement, are not prioritised due to the current state of the technology, which will require major adaptations to current processes and which, in some cases, still has to prove its technological readiness.

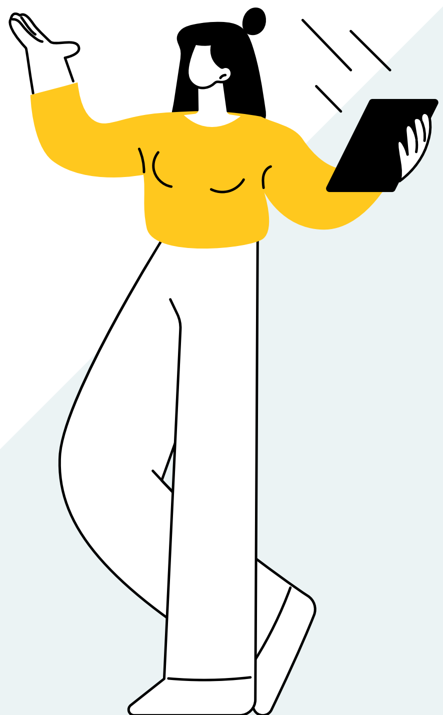
Regarding enabling infrastructure for the three selected clusters, the following remarks apply:

- **Grid connection:** The main 330 kV line in Zambia connects Lusaka to Copperbelt Province. Lusaka, Chilanga and Kafue are connected to Zambia's national grid, allowing electricity supply for industrial activities. Most of these industrial clusters are supplied at distribution voltages of 66 kV and 33 kV or lower in some cases. While the power supply is generally robust when electricity is available, Zambia's heavy reliance on hydropower makes it vulnerable to fluctuations in rainfall patterns. Often this dependency can lead to power shortages and load shedding, as observed in the 2024-2025 period.
- **Water supply:** Zambia has enormous water resources. All clusters have access to adequate water supply for industrial activities, e.g. via Lusaka's water utility (Lusaka Water and Sanitation Company). Where utilities do not provide water, private boreholes or direct bulk sources (e.g. from the Kafue river) are used for supply.
- **Transport infrastructure:** Road conditions influence transport capacities and related costs, being a key driver of competitiveness for the clusters. The selected clusters have a good road network, either as part of the Great North Road or of the Great East Road. Additionally, the three locations have good access to the rail network, facilitating the transport of bulk goods.

2.6 Pilot projects

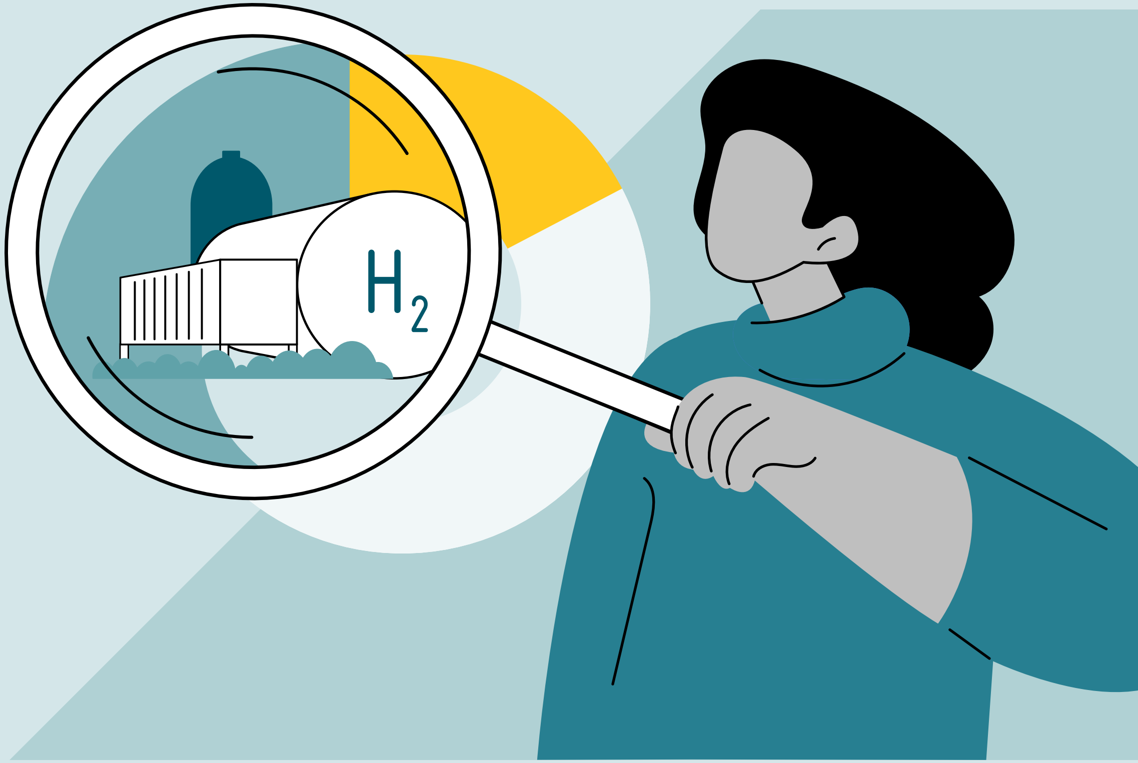
Zambia is promoting green electricity and hydrogen initiatives with multinational corporations as well as for local use (e.g. transportation), but it has not implemented any pilot projects yet as it is in the very early stages of hydrogen industry development.

In 2022, the Ministry of Energy granted GEI Power rights to develop a large-scale GH_2 project in Chikankata (GEI Power Limited, 2022). In the projects portfolio of GEI Power, one GH_2 project is listed, the Matta Green Hydrogen in Kafue with 100 MW electrolysis for the production of ammonia for fertilisers and mine blasting (GEI Power, 2024).



3

Green hydrogen potential in Zambia and use cases



Zambia is at a very early stage in developing a green hydrogen economy. While current hydrogen demand is modest – largely linked to niche uses in mining explosives – the nation's abundant renewable resources offer significant potential. By leveraging its established hydropower assets, emerging solar capacity, and well-located industrial clusters, Zambia could not only meet its domestic needs but also gradually transition key sectors towards low-carbon processes.

3.1 Renewable resource potential within Zambia

Zambia's renewable energy landscape is primarily dominated by hydropower, which forms the backbone of the nation's electricity generation. Major installations, such as the Kariba Dam and other river-fed plants, capitalise on the country's abundant water resources to deliver low-carbon electricity. While seasonal fluctuations and periods of drought can impact overall output, these assets remain a critical component of Zambia's energy mix and provide a strong foundation for scaling up renewable energy production. There is potential to expand hydropower production to support gigawatt-scale hydrogen projects, albeit with significant capital investment required for new facilities and enhanced grid infrastructure. Such expansion must address environmental and social considerations through rigorous impact assessments and the development of mitigation strategies.

It is necessary to consider a diversification of the renewable energy mix to diminish the country's high dependency on hydropower, which affects electricity availability due to fluctuation in rainfall patterns. High solar irradiation in many parts of the country supports the development of utility-scale PV projects such as the Mansa and Chipili projects with 150/200 MW of solar power capacity. Hybrid solutions – integrating solar power and energy storage (e.g. battery or pumped storage) – could further help counteract hydrological variability.

Assessments of wind power potential in Zambia indicate that, although certain regions exhibit wind speeds suitable for small-scale projects such as Muchinga Escarpment and Viphya Mountains, the overall wind power density is modest and mostly below 500 kWh/kWp. Consequently, wind energy is not expected to play a major role in the nation's renewable portfolio.

Despite Zambia's strong hydropower base, recent drought-related challenges with electricity generation highlight the need for a diversified renewable energy mix. The country's abundant solar energy and ample water resources provide a solid foundation for sustainable green hydrogen production. However, Zambia's relatively limited wind potential may pose economic challenges compared to nations with both strong wind and solar resources. To support gigawatt-scale hydrogen projects, a comprehensive investment strategy is essential – one that focuses on expanding solar capacity, enhancing grid stability, integrating energy storage solutions, and optimising hydropower performance to ensure a reliable energy supply for electrolysis.

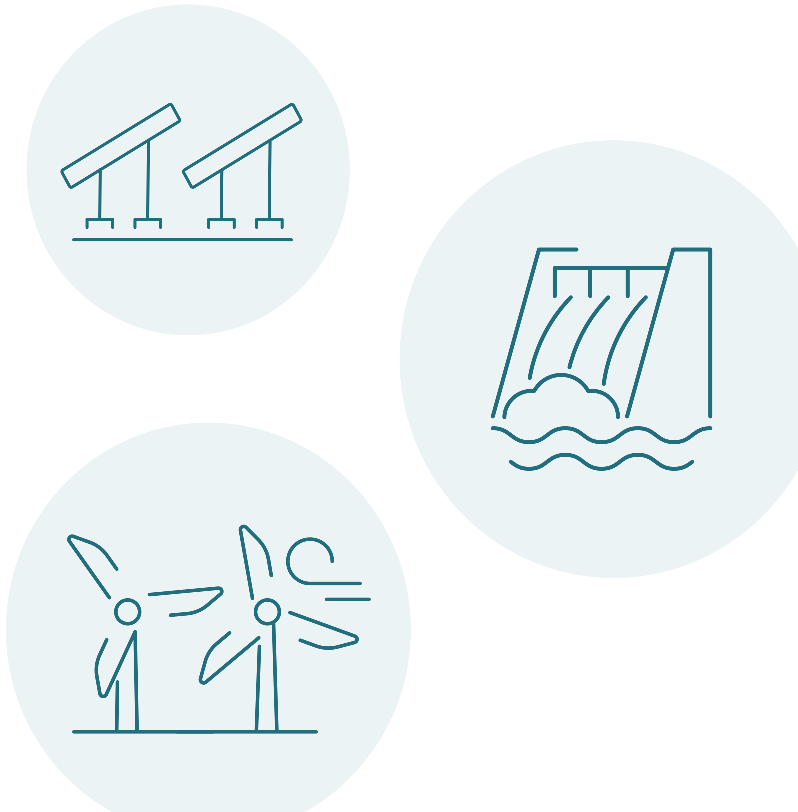
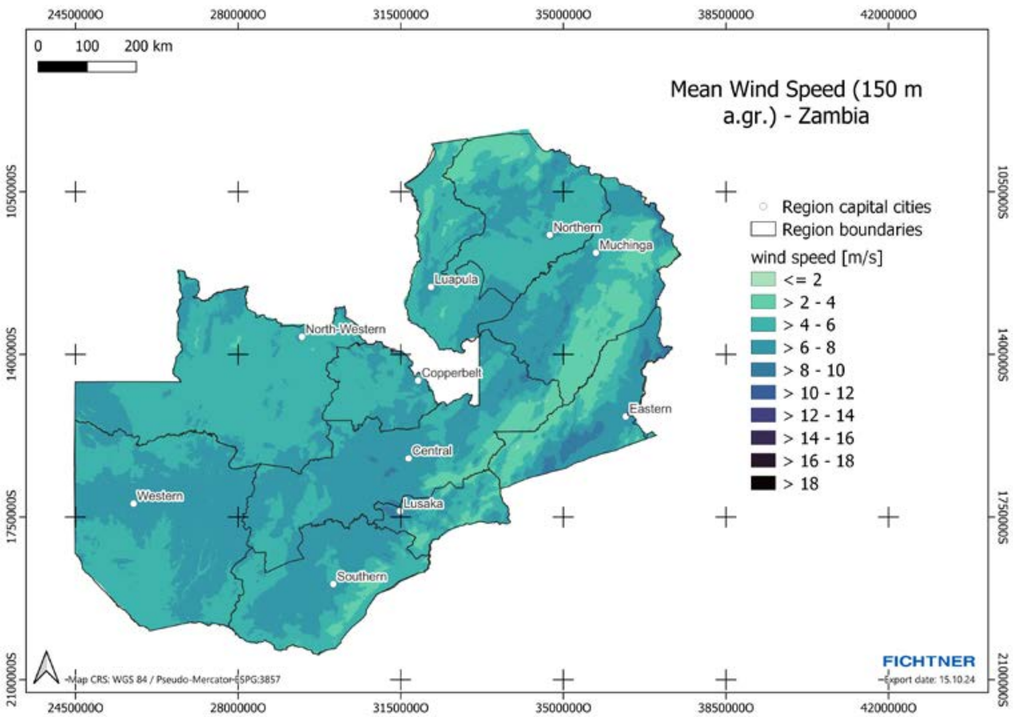
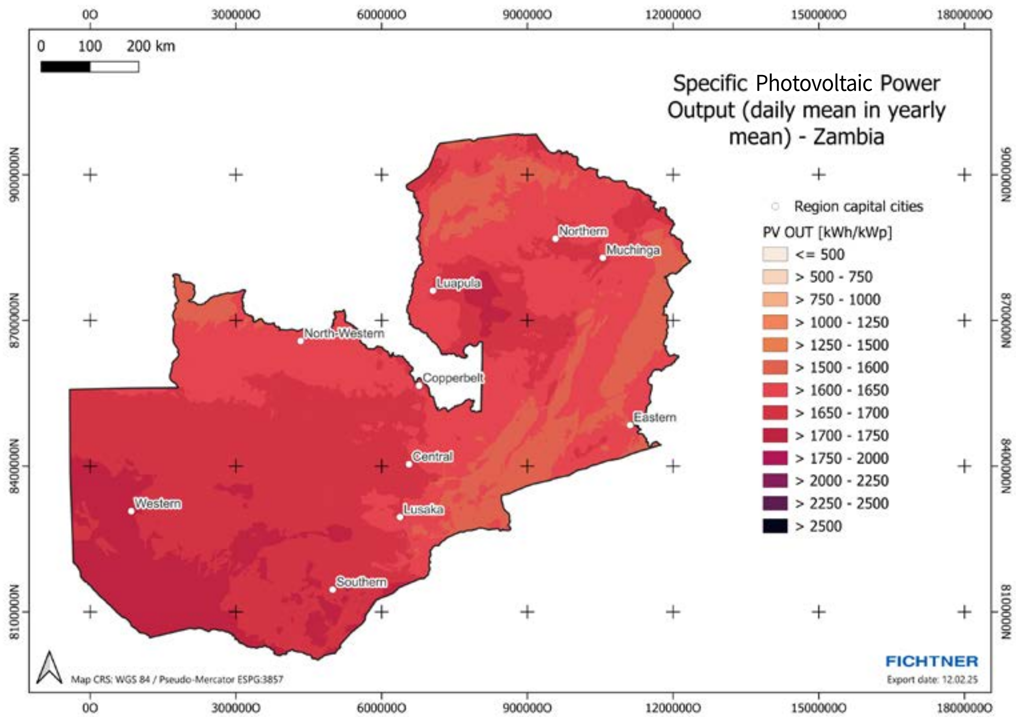


FIGURE 11. Mean wind speed and specific photovoltaic power output for Zambia



Source: Authors' own compilation, Fichtner (2025) based on (Neil N. Davis, 2024)[2]



Source: Authors' own compilation, Fichtner (2025) based on (Global Solar Atlas, 2024)[3]

2 Data obtained from the Global Wind Atlas version 3.3, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU). The Global Wind Atlas version 3.3 is released in partnership with the World Bank Group, utilising data provided by Vortex, using funding provided by the Energy Sector Management Assistance Programme (ESMAP). For additional information: https://globalwindatlas.info

3 Data obtained from the Global Solar Atlas 2.0, a free, web-based application developed and operated by Solargis s.r.o. on behalf of the World Bank Group, utilising Solargis data, with funding provided by the Energy Sector Management Assistance Programme (ESMAP). For additional information: https://globalsolaratlas.info

3.2 Potential use cases

Within Zambia's industrial sector, the integration of green hydrogen is seen as a targeted opportunity in select applications rather than a broad market prospect. In the short term, both **small-scale and large-scale** initiatives offer viable pathways for advancing sustainable hydrogen practices.

Small-scale use cases (electrolyser capacity: 1+ MW)

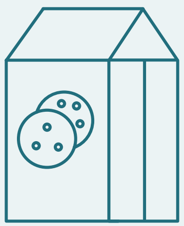
Small-scale green hydrogen projects serve industries with moderate hydrogen demand or decentralised production needs. These setups prioritise on-site or near-site generation to minimise logistics costs and seamlessly integrate with existing processes.

Electrolysers will then typically be powered by local wind or solar PV plants, supported by battery energy storage or hydrogen storage to manage fluctuations in electricity supply and hydrogen demand. In most cases, the hydrogen is consumed directly on site, ensuring efficiency and reliability.

Typical small-scale applications include electronics, specialty glass production, welding processes, and the food industry – either for hydrogenation or as protective gas in food packaging. In Zambia, the range of potential small-scale applications is relatively limited as industries with hydrogen demand are rare in the country. There are a few potential future targets that could serve as initial pilot projects for green hydrogen integration. These include:

1. **Food industry**

   Local edible oil refining and processing often requires hydrogenation to modify fats or for use as a protective gas in packaging; this represents a notable opportunity. These applications could help improve product quality and shelf life, serving as a practical starting point for green hydrogen integration.



Large-scale use cases (electrolyser capacity: 10 MW and above)

Large-scale green hydrogen projects serve industries with high and continuous hydrogen demand, maximising economies of scale through larger electrolyser installations and the utilisation of optimal wind and solar resources.

These projects typically feature large renewable energy facilities paired with nearby large-scale electrolysers, supported by infrastructure for electricity transmission, water supply, wastewater management, and hydrogen storage and transport to off-takers or ports. Extensive hydrogen storage is essential either to balance production fluctuations without disrupting downstream processes or to accommodate the periodic nature of maritime transport for export-oriented projects.

Unlike smaller-scale projects, large electrolysers are housed in dedicated buildings, as containerised solutions are more common for smaller installations. In some cases, desalination units may be required to ensure a sustainable water supply, depending on local availability.

Typical large-scale applications include ammonia and fertiliser production, chemicals (including methanol), and crude oil refining. In the future, iron & steel and cement may also emerge as major hydrogen consumers.

In Zambia, the primary opportunities could include:

1. **Fertiliser production**

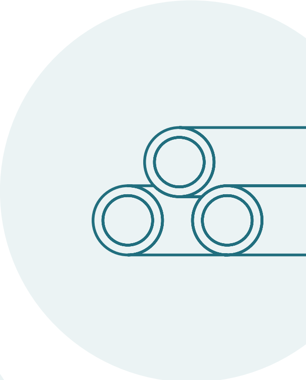
   The most prominent opportunity lies in the fertiliser sector. Zambia is developing an ammonia and urea production facility, which is scheduled for commissioning in the second half of 2025, by United Capital Fertilizer Zambia Company. This facility is projected to require approximately 32 kTPA of hydrogen, offering a clear target for the replacement of fossil-based hydrogen with green hydrogen. Since coal gasification is foreseen for the project, the potential for green hydrogen will be reduced but still technically feasible.

2. **Steel and metallurgy**

   There is potential within the steel industry as well. For instance, Universal Mining and Chemical Industries currently operates a DRI furnace at its Kafue Steel facility, which could, in the future, transition to using green hydrogen to support decarbonisation efforts in the local steel production process.

3. **Mining explosives**

   Additionally, in the mining sector, hydrogen could serve as a feedstock for producing ammonia-based explosives. Given the importance of mining to Zambia's economy, this specialised application represents another avenue for green hydrogen adoption.



Techno-economic calculations of the use cases

Based on the previous analysis, potential use cases for hydrogen in Zambia will primarily focus on production for fertilisers.

To provide a preliminary indication of techno-economic feasibility for projects of varying scales, three different scenarios were assessed for direct hydrogen use at Kafue in the Lusaka Province, where fertilisers are currently produced. Here, a transition to green hydrogen could be considered in the short term. For these scenarios, the analysis examined the levelised cost of hydrogen and ammonia based on different renewable energy mixes of PV and wind that are needed to meet a given annual hydrogen demand. Different electrolyser sizes (1 MW and 6 MW) were used. The main results of these three scenarios are summarised in the following table. These results are based on model renewable profiles at the location (lat. -15.76403 long. 28.17672) and provide an indication of the economics associated with small- and large-scale projects in the region. It should be noted that the results may vary significantly if industries in other parts of the country are chosen, for example with different wind resources nearby, or if utility-scale projects with significantly larger component sizing are planned.

TABLE 10. Techno-economic calculations for direct hydrogen use cases

Case	Small-scale H_2 (wind & PV)	Small-scale H_2 (PV only)	Large-scale H_2 (wind & PV)
Demand (H_2) in metric tons/a	45	45	450
Installed RE (capacity) in MW	PV: 2.0 Wind: 0.5	PV: 2.2	PV: 13.3 Wind: 6.0
Electrolyser size in MW	0.8	0.9	6.2
WACC in %	15	15	15
Total investment in USD million	5.0	4.8	35.8
Oxygen sales in million kg	0.37	0.37	3.7
Excess RE sales/consumed in GWh[4]	2	1	16
LCOH grey in USD/kg	7.1	7.1	7.1
LCOH proposed case/green in USD/kg	16.9	15.6	12.0
Project IRR in %	4.4	5.0	7.2
Net present value in USD million	−1.6	−1.4	−9.0
Finance gap in USD/kg	9.8	8.5	4.9

Source: Analyses performed by GIZ (2025)

4 Excess RE is calculated for the value chain including ammonia. If only H_2 is to be produced, the amount of excess renewables can be increased by ~5%.

The complete assumptions, sizing, cost breakdown, financial parameters, and results are detailed in Annex 2 Techno-economic calculations. Based on the results presented in the table above, the following can be concluded:

- **Resource utilisation and cost analysis:** The analysis reveals that wind resources at the selected location are insufficient for effective electricity generation[5], as indicated by the lower LCOH for green hydrogen in the 'small-scale H_2 (PV only)' case compared to the 'small-scale H_2 (wind & PV)' case. The green LCOH for the 'small-scale H_2 (PV only)'and 'large-scale H_2 (wind & PV)' cases are approximately 120% and 70% higher than the current grey hydrogen costs, respectively.
- **Financial viability:** With an LCOH for grey hydrogen of USD 7.1 per kg, which results from taking an external supply from a third party (no production of its own), among the analysed scenarios the 'large-scale H_2 (wind & PV)'case shows the lowest finance gap at USD 4.9 per kg of hydrogen and the highest IRR (7.2%), suggesting that it is the most financially feasible option for implementation based on these estimates. Lower LCOHs for grey hydrogen will correspondingly increase the finance gap[6]. By leveraging a single funding source or a mix of the funding sources described further in section 4.3, the finance gap might be closed to make the project economically feasible.

5 Capacity factors of wind: 5% for small scale and 9% for large scale.
6 The finance gap is defined as the difference between LCOH for green hydrogen and LCOH for grey hydrogen.

Given that current hydrogen use in Zambia is directly linked to ammonia-based fertiliser production, a complementary techno-economic analysis was conducted for three ammonia use cases that align with the hydrogen use cases presented above. The results are summarised in the following table.

TABLE 11. Techno-economic calculations for ammonia use cases

Case	Small-scale NH_3 (wind & PV)	Small-scale NH_3 (PV only)	Large-scale NH_3 (wind & PV)
Demand (NH_3) in metric tons	270	270	2,700
Installed RE (capacity) in MW	PV: 2.0 Wind: 0.5	PV: 2.2	PV: 13.3 Wind: 6.0
Electrolyser size in MW	0.8	0.9	6.2
WACC	15	15	15
Total investment in USD million	5.7	5.4	40.1
LCOA grey (USD/kg)	0.9	0.9	0.9
LCOA proposed case (USD/kg)	3.5	3.3	2.5
Oxygen sales (m kg)	0.37	0.37	3.7
Excess RE sales/consumed in GWh	2	1	16
Project IRR in %	0.1	0.7	2.8
Net present value in USD million	–2.5	–2.2	–15.2
Finance gap (USD/kg)	2.6	2.4	1.6

Source: Analyses performed by GIZ (2025)

- **Cost competitiveness:** Of these cases, the 'large-scale NH_3 (wind & PV)' scenario presents the lowest green LCOA at USD 2.5 per kg, making it more competitive relative to the alternatives.
- **Financial feasibility:** Despite having large financial gaps and negative net present values in all scenarios, the 'large-scale NH_3 (wind & PV)' case has the smallest financial gap at USD 1.6 per kg of ammonia, highlighting its potential for large-scale implementation. As with hydrogen, the remaining gap might be closed by leveraging funding mechanisms.
- **Investment returns:** Although the project IRR is modest across all cases, the 'large-scale NH_3 (wind & PV)'scenario offers the highest return at 2.8%.

Overall, and under current assumptions, the results show the general rationale of larger projects being more cost efficient than small-scale projects. Nevertheless, they also require higher initial investment and the lower LCOH is still not enough to make the project economically feasible and to reach a positive NPV. It is therefore clear that these projects are not economically feasible in the short term without intensive funding. From a funding perspective it might be more feasible to go for small-scale projects as the funding required to set up these projects is lower in terms of absolute value, but this is heavily dependent on the funding scheme that is to be used.

It is important to note that the aforementioned options provide an estimate of potential green hydrogen and ammonia costs; however, cost evaluations should be conducted on a project-by-project basis as factors such as the local renewable profile and the required industry's offtake profile (the analysis above is based on a constant profile) can significantly influence the levelised cost, particularly due to their impact on the sizing of the electrolyser and storage system required. This effect is smaller for ammonia than hydrogen as the former has significantly lower storage costs. Additionally, securing an off-taker for the produced oxygen can be challenging, as revenue from the sale of this by-product generally does not justify investment in extensive transport infrastructure. The calculation further assumes that the full amount of renewable electricity generated can be sold to the industry attached for a price of USD 55.5/MWh. It is likely that the industries will be interested in purchasing the otherwise curtailed renewable electricity, but this might not always be the case, and without the sales of excess renewables, implementation of battery storage might become an option. In certain scenarios, it may also be feasible to derive additional benefits from using the electrolyser's waste heat for applications such as district heating or industrial pre-heating processes and to conclude a PPA with other renewables, for instance to make use of the constant renewable profile of existing hydropower assets.

3.3 Analysis of hydrogen production potential

Scaling up green hydrogen production in Zambia requires the alignment of renewable energy availability, water resources, and industrial infrastructure. The country's extensive hydropower capacity – supplemented by a growing portfolio of solar projects – can provide the low-carbon electricity needed for large-scale electrolysis. Zambia's abundant water resources can support a stable supply for small to medium-scale hydrogen production. However, for large-scale production, mitigating the risk of drought may require additional measures to ensure a continuous and reliable water supply.

Nevertheless, challenges remain. Seasonal variability in hydropower generation and the substantial capital investments required for modern electrolyser installations could slow down the pace of development. On the demand side, Zambia's relatively small domestic market means that early green hydrogen initiatives will likely be focused on localised industrial applications, particularly in clusters where key consumers are concentrated. Strategic investments in grid enhancements and transport infrastructure will be essential to support both on-site industrial use and potential future exports to regional markets.

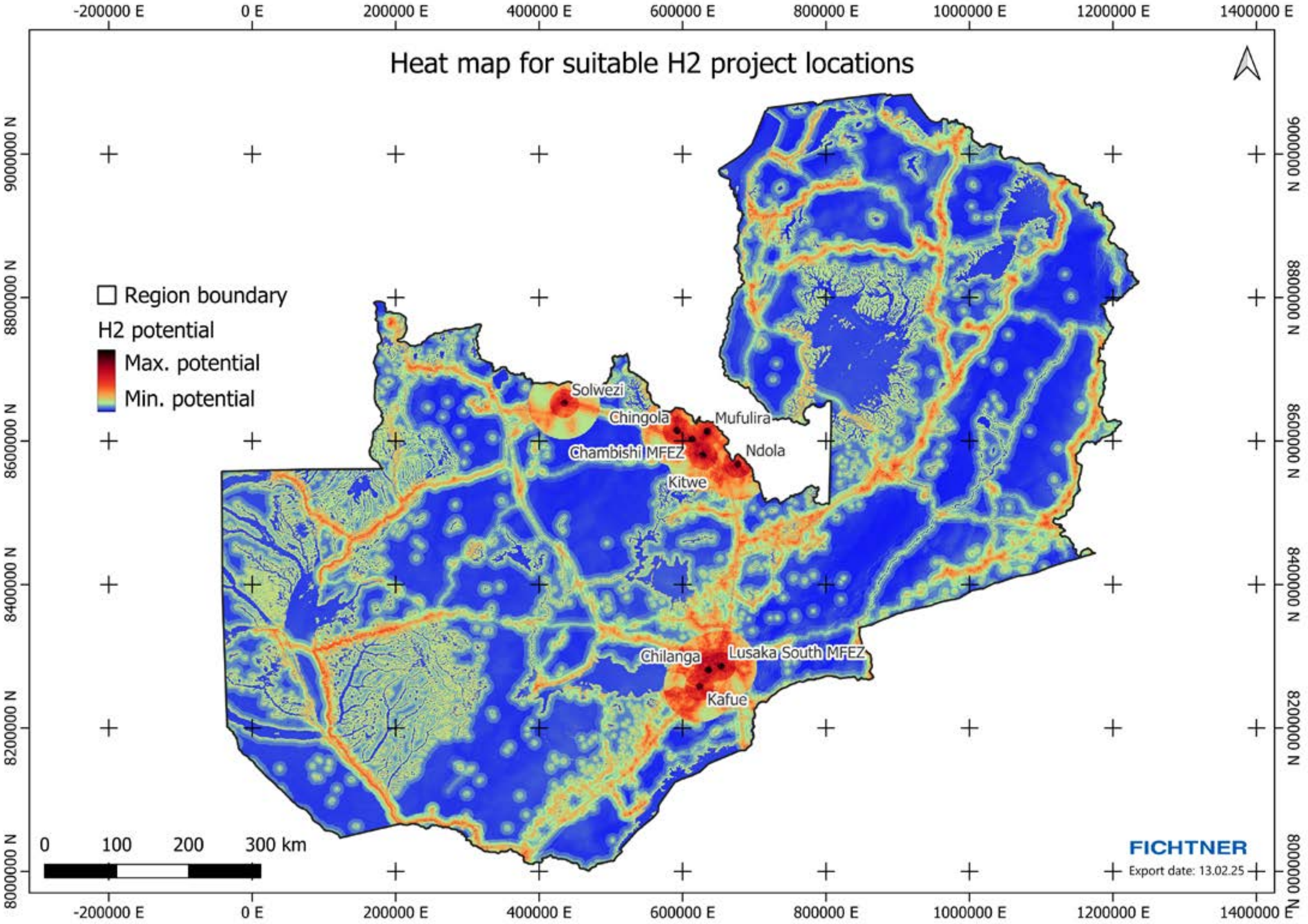
3.4 Multi-criteria assessment for small-scale hydrogen projects

A multi-criteria assessment (MCA) was carried out in order to identify optimal locations for small-scale hydrogen projects. The evaluation considered:

- Renewable energy availability (wind and solar potential)
- Proximity to industrial clusters (potential off-takers)
- Access to water resources (for electrolysis)
- Connection to existing energy and transport infrastructure

Each criterion was assigned specific scoring thresholds based on factors such as distance to off-takers, high-voltage grid connections, water sources, and roads. Industrial proximity received the highest weighting, followed by grid access, renewable resource quality, and water availability. Transportation infrastructure (roads and ports) was also factored in to assess export feasibility. The results of the MCA are visually represented in Figure 12, highlighting high-potential areas in red as prime locations for engaging industrial off-takers and initiating project development. Areas with less favourable conditions are marked in blue.

FIGURE 12. Country heat map indicating potential locations for green hydrogen pilot projects



Source: Authors' own compilation, Fichtner (2025)

4

The way forward

The analysis of Zambia's energy sector and the potential for green hydrogen adoption in industry highlights both opportunities and challenges in developing a sustainable hydrogen economy. While Zambia benefits from significant hydropower resources and a strong mining sector that could drive hydrogen demand, the country faces critical obstacles in the short term, including low industrialisation, electricity shortages, and water supply constraints.

This section highlights Zambia's main opportunities in the hydrogen sector, including harnessing its renewable energy potential, integrating hydrogen into local industries, and improving the country's overall socioeconomic conditions. It also outlines the key challenges that need to be addressed, such as unreliable electricity supply, infrastructure constraints, and economic and regulatory obstacles, in order to successfully develop a sustainable hydrogen market.

4.1 Opportunities and supporting frameworks

Zambia's energy landscape and industrial profile present some opportunities for the development of a hydrogen economy. With abundant renewable energy resources and a strong mining sector, the country has the potential to leverage green hydrogen for sustainable industrial growth in specific applications. Additionally, the implementation of green hydrogen projects could contribute to improving energy access and water infrastructure, benefiting both industry and local communities.

- **Renewable energy potential for green hydrogen production:** Zambia's electricity mix is dominated by hydropower (over 85%), which is favourable from a renewable energy standpoint but poses reliability challenges due to rainfall variability. To ensure a stable energy supply, projects incorporating solar PV and battery storage solutions are required. The implementation of green hydrogen projects could be designed to enhance electricity access for surrounding communities, promoting broader energy supply and sustainable industrial activities.
- **Opportunities for industrial integration:** While Zambia's industrial sector remains underdeveloped, integrating green hydrogen into existing processes – such as mining and mineral processing – could encourage the expansion of local production capacities in related industries.
- **Basic infrastructure development benefits:** Green hydrogen production requires investment in renewable electricity generation, water supply, and transport infrastructure. These improvements would not only support industrial activities but also provide long-term benefits to local communities by enhancing basic infrastructure and services.

Zambia will require a well-defined supporting framework to materialise the opportunities presented by a green hydrogen economy. This includes clear policies, regulatory mechanisms, and investment incentives to attract both local and international stakeholders.

- **Policy framework:** Zambia lacks a dedicated green hydrogen policy, but integrating hydrogen into current policies and plans, such as the National Energy Policy and the Integrated Resource Plan (IRP), would provide a clear roadmap for development. Further, a dedicated Green Hydrogen Strategy and Roadmap could define production targets, industrial applications, and infrastructure requirements, while aligning with Zambia's NDC commitments. Policies should focus on renewable energy expansion (e.g. solar PV, battery storage), water infrastructure, and industrial integration (e.g. mining, fertilisers, transport). Additionally, financial incentives and regulatory clarity would be crucial to attract investment, while capacity-building initiatives would ensure the necessary technical expertise for long-term success.

- **Regulatory framework:** Zambia's regulatory framework for green hydrogen should begin by integrating hydrogen into existing energy laws, such as the Energy Regulation Act and the Energy Regulation Board (ERB) regulations. Amendments should explicitly recognise hydrogen as a key energy resource and provide clear guidelines for its production, storage, transport, and quality standards. These regulations should be aligned with international best practices and regional standards to support potential cross-border trade in the long term. To foster investment, Zambia could introduce tax incentives for green hydrogen projects, such as VAT exemptions, tax holidays for production facilities, and import duty relief for key equipment. In parallel, regulatory clarity on licensing, safety standards, and environmental impact assessments should be established to ensure a streamlined process for project developers while safeguarding sustainable growth. These regulatory measures should be designed in alignment with Zambia's NDC to ensure a consistent path towards decarbonisation and economic growth.
- **Technology framework:** Zambia's renewable energy potential provides a foundation for green hydrogen development. The potential to produce green hydrogen exists, but it requires careful consideration of the existing limitations and the need for further development in both renewable energy generation and industrial infrastructure. Identifying the necessary upgrades to current infrastructure, such as the expansion of electricity grid capacity and storage facilities, will be key to ensuring reliable energy supply for hydrogen production. Zambia's industrial hubs, particularly in Lusaka and Copperbelt, could potentially host hydrogen production projects. These regions have existing infrastructure that could be adapted and expanded for hydrogen production. Pilot projects focusing on testing hydrogen production technologies (e.g. electrolysis) at smaller scales would be crucial in assessing the viability and scalability of green hydrogen in Zambia. These projects would also allow for integration with existing infrastructure, ensuring safe and efficient deployment of technologies as the sector grows.

4.2 Challenges and considerations

The implementation of hydrogen technologies in Zambia presents a range of challenges across economic, technical, and regulatory areas that must be addressed to support sustainable growth and adoption in various sectors. Key challenges that are prevalent globally and also apply to Zambia include the lack of a clear regulatory framework, insufficient financial support or incentives, limited (or non-existent) demand from off-takers willing to pay a premium for green hydrogen, and a scarcity of available technologies. Additionally, Zambia faces infrastructure limitations, with a need for significant development and expansion of energy infrastructure, including electricity access, making these challenges more pronounced compared to other countries.

- **Economic challenges:** High production costs remain a significant hurdle for green hydrogen adoption. This is also the case in Zambia, particularly given the country's limited industrial base and absence of hydrogen demand. The lack of clear policies or mandates for decarbonisation in hard-to-abate sectors creates further uncertainty about the future demand for green hydrogen. Without large-scale industrial consumers, achieving economies of scale becomes a difficult task. Additionally, more immediate priorities, such as improving electrification rates and addressing energy access challenges, are likely to take precedence, potentially delaying the focus on green hydrogen development. This puts pressure on the country's ability to attract investment in hydrogen production and related technologies.

- **Technical challenges:** Major challenges relate to the current status of infrastructure in two main areas: electricity and water. Zambia has an Integrated Resource Plan (IRP), for example, which sets out a long-term strategy for energy production and transmission. Under this strategy, electricity demand is expected to increase by 121% by 2030, due to significant increases in various sectors. The targets are ambitious and will require huge investments in a short timeframe. Zambia is therefore already facing the challenge of meeting its current and future energy needs and establishing universal access to electricity to increase the electrification rate. Supplying hydrogen production plants with further required electricity is therefore an additional challenge. The acceptance level of supplying hydrogen production plants with electricity is likely to be relatively low in the short term. Water infrastructure also poses a challenge. Zambia has enormous water resources and has low water stress. The problem is rather the correct utilisation and delivery of water to regions in Zambia. The supply situation is insufficient, and rural regions are often inadequately supplied with water The production of hydrogen in Zambia is dependent on a good supply.

- **Regulatory challenges:** Zambia currently lacks a comprehensive regulatory framework to support hydrogen development. This therefore poses a major hurdle in efforts to develop the hydrogen energy resource as there is no policy statement to support it. It will require some engagement at the policy-making level to garner support for possible investments in hydrogen production projects. Zambia should make improvements here. In the next step, to standardise the design, installation, and maintenance of hydrogen infrastructure, Zambia should develop technical handbooks and more specific regulatory guidelines. These resources would establish safety protocols, streamline permitting processes, and provide clear operational standards, ultimately fostering industry confidence and accelerating adoption of hydrogen technologies.

4.3 Green hydrogen financing opportunities for German companies

The green hydrogen sector requires substantial financial investments to overcome high initial costs and infrastructure challenges. To address this, several funding mechanisms exist, as described in the following with selected examples:

GERMAN INSTRUMENTS FOR INVESTMENT IN THE INTERNATIONAL MARKET

- **H2Global** (H2Global Stiftung, 2025): A reverse auction-based mechanism to support green hydrogen market development, offering 10-year purchase agreements. No project size or investment limitations; non-EU hydrogen producers can participate, meeting EU sustainability standards.

- **International Hydrogen Ramp-up Programme (H2Upp)** (BMWK, 2025): Supports early-stage public-private partnerships for pilot projects, with a minimum public contribution of EUR 100,000 and total project costs of at least EUR 200,000. Companies must contribute at least 50%. Applications are currently open until March 2025 (PtX Hub, 2025), though the overall programme is expected to continue until 2026 (BMWK, 2024).

- **UFK Untied Loan Guarantees** (UFK-Garantien.de, 2025): Provides loan guarantees to reduce political and economic risks in target countries. Green hydrogen projects may be eligible if they align with Germany's energy strategy.

EUROPEAN INSTRUMENTS FOR INVESTMENT IN THE INTERNATIONAL MARKET

- **Green Hydrogen Trust Fund (GHF)** (European Investment Bank, 2025): The European Investment Bank (EIB) established this fund to support large-scale green hydrogen infrastructure projects with substantial investments (millions USD), requiring a 30-40% contribution from applicants. Zambia may be eligible based on specific criteria.

- **Clean Hydrogen Partnership** (European Union, 2025) (CHP) primarily supports the development and commercialisation of clean hydrogen technologies. No fixed limitations on project size or investment, but large, impactful projects are prioritised. Third countries may participate through specific agreements.

MULTILATERAL INSTRUMENTS

- **African Development Bank** (Sustainable Energy Fund for Africa, 2025): SEFA provides grants and concessional finance for renewable energy projects, including green hydrogen, in Africa. Zambia could potentially benefit from financing opportunities provided by SEFA to build up a sustainable hydrogen infrastructure.

- **MIGA (Multilateral Investment Guarantee Agency)** (MIGA, 2025): Offers political risk insurance and credit guarantees for hydrogen investments in developing countries, with a focus on projects with significant developmental impact. There is no strict minimum investment amount, but larger projects, especially those aligned with national development priorities, are likely to be prioritised.

- **Global Environment Facility (GEF)** (Green Climate Fund, 2025): Provides grants and concessional loans for renewable energy projects, including green hydrogen, to achieve decarbonisation and environmental goals.

- **World Bank Loans:** The World Bank promotes the implementation of renewable energies including hydrogen through various programmes and initiatives. In 2023, for example, the bank stated that it had approved USD 1.6 billion in funding for renewable hydrogen loans in that year (World Bank, 2023).

- **Climate Investment Funds (CIF)** (CIF, 2024): In 2024, CIF endorsed a USD 35 million investment plan for Zambia. The plan is designed to boost a low-carbon climate-resilient economy, agricultural productivity, and forest protection. Among other things it is looking at expanding access to green technologies.

PRIVATE FINANCE

- **Hydrogen One Capital** (HydrogenOne, 2025): A private venture fund specialising in direct or indirect investments in hydrogen infrastructure and technology.

- **Breakthrough Energy Ventures** (Breakthrough Energy, 2022): Through various programmes, Breakthrough Energy supports cutting-edge research and development by investing in companies with clean products to accelerate the clear energy transition.

- **Green Bonds:** These bonds are fixed-income financial instruments designed to fund sustainable projects such as renewable energy or clean transportation. There are different standards that can be applied, two of the most common being the Green Bond Principles issued by the International Capital Market Association (ICMA, 2025) and the Climate Bond Standards (Climate Bonds, 2025).

Zambian financing mechanisms are currently focused on improving access to electricity.

4.4 Stakeholder mapping and institutional overview

The development of Zambia's green hydrogen sector requires collaboration among a diverse range of stakeholders, including government ministries, regulatory bodies, academic institutions, non-governmental organisations, and international partners. Each stakeholder has an essential role in shaping the policy frameworks, advancing pilot projects, and creating regulations that will support the adoption of hydrogen technologies. This collaborative approach will be vital not only for developing a domestic hydrogen economy but also for establishing Zambia as a potential partner for German companies seeking to expand their green hydrogen initiatives in the region. Among the key stakeholders are:

GOVERNMENTAL INSTITUTIONS

- **Ministry of Energy:** Responsible for the development and management of energy resources in a sustainable manner through the preparation and monitoring of energy policies, strategies, plans, and programmes, and for the coordination of stakeholders in the sector.
- **Ministry of Green Economy and Environment:** Responsible for promoting the sustainable and effective use of the environment. It also plays a key role in supporting efforts to adapt to and mitigate the impacts of climate change through low-carbon development initiatives.
- **Ministry of Commerce, Trade and Industry:** Responsible for formulating and administering policies as well as regulating activities in the commercial, trade and industrial sectors in order to enhance the sectors' contribution to sustainable social economic growth.
- **Ministry of Finance and National Planning:** Responsible for performing several statutory functions that include preparation of the national budget, national planning, economic management, resource mobilisation, debt management, and public finance management.
- **Ministry of Lands and Natural Resources:** Responsible for land administration, forest management, and climate change programmes coordination.
- **Ministry of Mines and Minerals Development:** Responsible for managing the development of mineral resources, and monitoring and regulating operations in the mining industry.
- **Ministry of Water Development and Sanitation:** Responsible for the development and management of water resources, provision of clean water supply, and adequate sanitation for all
- **Zambia Development Agency:** Responsible for promoting and facilitating trade, investment, and enterprise development in the country.
- **Zambia Environmental Management Agency:** Regulatory authority, responsible for ensuring sustainable management of natural resources, protection of the environment, and prevention and control of pollution.
- **Energy Regulation Board:** Responsible for licensing energy utilities and monitoring competition.
- **Zambia Bureau of Standards:** Supports industry to implement standards that enhance the quality of products and services. It collaborates regionally to harmonise standards and conformity assessment procedures to reduce technical barriers to trade.
- **University of Zambia:** The largest university in Zambia. Relevant for research and development.

PRIVATE ASSOCIATIONS

- **Zambia Association of Manufacturers:** Business association representing the interests of the manufacturing sector and other related economic and production sectors in Zambia.
- **Zambia Chamber of Mines:** Official association for Zambia's mining industry.
- **Zambia Chamber of Commerce and Industry:** National body representing the interests of the private business sector in Zambia. Focuses on the promotion and development of trade, commerce, and industry.

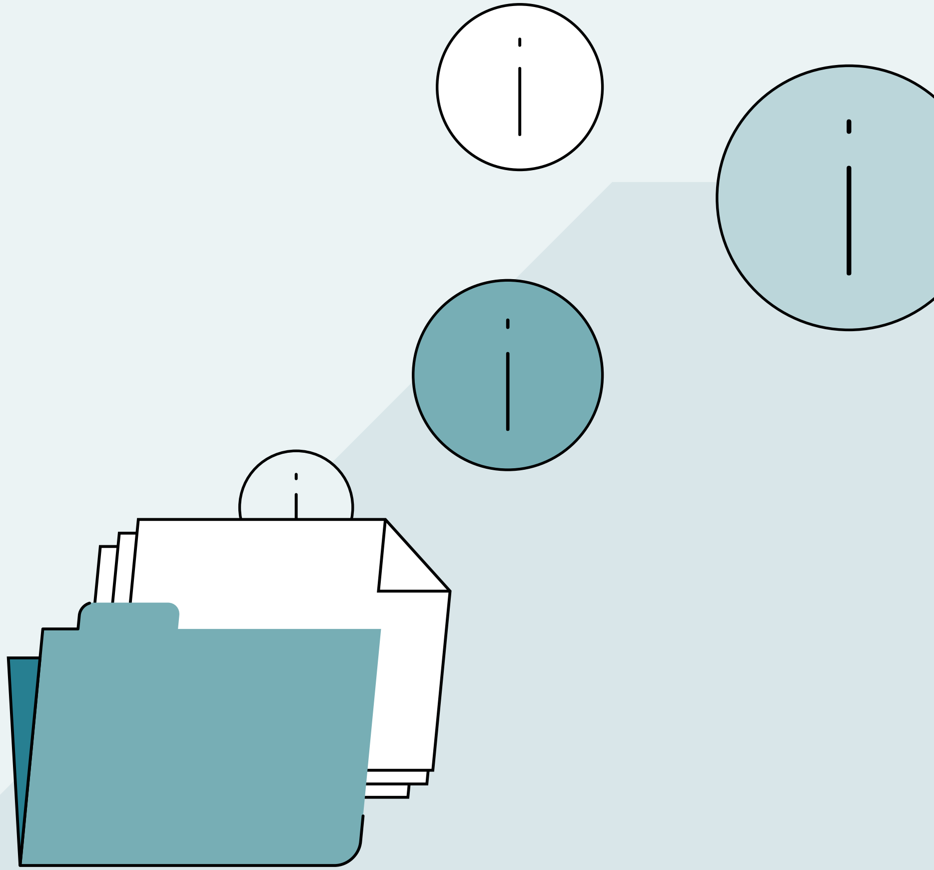
4.5 Next steps for German companies

Zambia presents limited but niche opportunities for green hydrogen, particularly in areas where the country's renewable energy resources can be harnessed. While challenges exist, German companies can explore specific sectors with potential for green hydrogen applications. Here is a roadmap for engaging with Zambia's green hydrogen market:

1. **Collaborate with government and local stakeholders:** Engage with Zambian authorities such as the Energy Regulation Board (ERB) and Ministry of Energy to stay updated on evolving policies. While Zambia lacks a dedicated green hydrogen strategy, integrating hydrogen into national energy policies could provide a clear path for development. By aligning projects with Zambia's national decarbonisation goals, German companies can shape regulatory frameworks and encourage investment.
2. **Explore green hydrogen for niche industrial applications:** Zambia's industrial base is limited, but sectors like mining (particularly copper) and mineral processing offer early opportunities for hydrogen integration. German companies can look into pilot projects focused on small-scale hydrogen production, particularly in the Copperbelt region, where there is existing infrastructure. These projects could provide a foundation for scaling hydrogen use in mining equipment and processing.
3. **Invest in renewable energy infrastructure:** Zambia's energy mix is heavily reliant on hydropower, which can be affected by rainfall variability. Therefore, supplementing hydropower with solar PV and battery storage systems to ensure a stable energy supply for hydrogen production is critical. German companies could play a role in providing technology for renewable energy projects, which could also help improve energy access in rural areas, benefiting both communities and industries.
4. **Support water and energy infrastructure development:** Green hydrogen production in Zambia depends on adequate water supply and reliable electricity. Companies should assess and invest in projects that improve water infrastructure and energy access, particularly in rural regions. A focus on developing water distribution systems for hydrogen production can have dual benefits for local communities and industries, improving both industrial capacity and quality of life.
5. **Leverage international funding and financing:** While Zambia's hydrogen sector is still in its infancy, German companies should explore funding from international financial institutions such as the World Bank, African Development Bank, and H2Global. Securing financing for pilot projects and infrastructure development can mitigate financial risks and establish a market presence.
6. **Advocate for regulatory and policy development:** German companies can support the creation of a comprehensive regulatory framework for green hydrogen in Zambia. This could include advocating for clear policies on production, storage, transportation, and quality standards. The introduction of tax incentives, such as VAT exemptions or import duty relief, could help accelerate hydrogen production projects.
7. **Foster technology transfer and local expertise:** Collaborating with local universities, research institutions, and businesses will help build technical capacity in Zambia's hydrogen sector. German companies should focus on transferring expertise related to hydrogen production technologies (e.g. electrolysis) and integrating these technologies into Zambia's existing energy and industrial infrastructure.

By pursuing these strategies, German companies can carve out a niche in Zambia's emerging green hydrogen market, focusing on small-scale, industrial-specific projects that support the country's broader energy and economic development goals.

Annexes



Annex 1 Key nitrogen fertilisers

TABLE 12. Key nitrogen fertilisers

Fertilisers	Production process	Specific H_2 requirement (stochiometric)	Global production [MTPA]
Ammonia (NH_3)	Haber-Bosch process $N_2 + 3H_2 \rightarrow 2NH_3$	177 kg H_2/t NH_3	145
Urea	NH_3 and CO_2 from HB fed into a high-pressure reactor (or urea reactor) $2NH_3 + CO_2 \rightarrow CH_4N_2O + H_2O$	100 kg H_2/t urea	234
Ammonium nitrate (AN)	Neutralisation process in which NH_3 (gas) is mixed with HNO_3 (liquid) in neutraliser $NH_3 + HNO_3 \rightarrow NH_4NO_3$	40 kg H_2/t AN	45
Calcium ammonium nitrate (CAN)	Blending of AN (solution) with limestone (calcium carbonate) in a mixing unit and granulation of product $NH_4NO_3 + CaCO_3 \rightarrow Ca(NO_3)_2 + NH_4 + CO_2 + H_2O$	50 kg H_2/t CAN	13
Urea ammonium nitrate (UAN)	Mixing solutions of urea and AN and dilution with water	7 kg H_2/t UAN	23
Ammonium sulphate (AS)	By-product of caprolactam production (raw material for nylon) $2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$	50 kg H_2/t AS	30
Diammonium phosphate (DAP)	Reaction of NH_3 with phosphoric acid and posterior granulation $H_3PO_4 + 2NH_3 \rightarrow (NH_4)_2PO_4$	46 kg H_2/t DAP	28
Monoammonium phosphate (MAP)	Reaction of NH_3 with phosphoric acid and posterior granulation $H_3PO_4 + NH_3 \rightarrow NH_4H_2PO_4$	26 kg H_2/t MAP	29

Source: Authors' own compilation, Fichtner (2025). Global annual production in 2022 based on (Statista, 2024a) and (Chemanalyst, 2023)

Annex 2 Details on industrial clusters

Table 13 lists the main industrial clusters in Zambia. The table is ordered alphabetically and includes the location of the clusters, the main sectors, key products, and the main companies in each cluster. The H_2 column indicates clusters with a higher likelihood of hydrogen demand and potential for transitioning from grey to green hydrogen.

TABLE 13. Main industrial clusters in Zambia

Industrial cluster	Location	Main sectors	Key products/main companies	H_2
1 Chambishi MFEZ	Copperbelt Province	Mining, metallurgy, manufacturing (copper and cobalt)	Copper, cobalt, metal alloys Chambishi Metals Ltd (only one large company but several areas from mining to end product), JCHX Mining Zambia	–
2 Chilanga	Lusaka Province	Fertilisers, cement	Ammonia*, urea*, blending of fertilisers, cement *Under construction United Capital Fertilizer Zambia Company, Chilanga Cement	X
3 Chingola	Copperbelt Province	Mining, metallurgy	Copper, cobalt, metal alloys Nchanga Copper Mine, Konkola Copper Mines	–
4 Kafue	Lusaka Province	Ammonium nitrate, fertilisers (blending), steel	Fertilisers (blending), steel Nitrogen Chemicals of Zambia, UMCIL	X
5 Kitwe	Copperbelt	Mining, metal processing, engineering	Steel products, machinery Konkola Copper Mines, Ideal Mining Services	–
6 Lusaka South MFEZ	Lusaka Province	Manufacturing, cement, steel, fertilisers (blending), vegetable oil processing	Fertilisers (blending and trading), cement, steel, edible oils Zambian Fertilizers Limited, Fert Seed & Grain, Good Time Steel, PDV Metals, Zamanita*, Unified Chemicals Zambia Ltd, Savenda, Amaka, Sinoma Cement Zambia* *Located in Lusaka but outside Lusaka South MFEZ	X
7 Mufulira	Copperbelt Province	Mining, metallurgy	Copper, cobalt, zinc, construction materials Mopani Copper Mines	–

Industrial cluster	Location	Main sectors	Key products/main companies	H_2
8 Ndola	Copperbelt Province	Manufacturing, steel, cement	Cement, lime, building materials, processed foods Limestone Resources Ltd., Neelkanth Lime Ltd., Chilanga Cement, Dangote Cement Zambia, Zambezi Portland Cement	–
9 Solwezi	North-Western Province	Mining, metallurgy, agro-processing	Copper, cobalt, gemstones, maize, peanuts, processed foods First Quantum Minerals, Kansanshi Mine (which is owned by FQM)	–

Source: Authors' own compilation, Fichtner (2025)

Annex 3 Techno-economic calculations

Parameter	Value
Equity cost (%)	19
Debt interest rate (%)	15
Debt tenor (years)	10
Debt-to-Equity ratio (%/%)	80/20
Project lifetime (years)	25
Electricity price (Feed in tariff) (€/kWh)	0.03
Water cost (€/ton)	2
Grey hydrogen benchmark price (€/kg)	2.1
Oxygen selling price (€/kg)	0.05
Ammonia price (€/kg)	0.55
Corporate tax rate (%)	30

Source: Analyses performed by GIZ (2025)

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Project Development Programme (PDP)
Köthener Str. 2–3
10963 Berlin, Germany
T +49 30 – 40 81 90 – 219/285
F +49 30 – 40 81 90 – 109

E pep@giz.de
I www.giz.de/en

Programme/project description
Project Development Programme (PDP)

Authors
Fichtner GmbH & Co. KG
Stuttgart, Germany

Responsible/Editor
Anja Wucke, Maxim Schultze-Moderow and Wamunyima Kangumu

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Sitz der Gesellschaft / Registered offices
Bonn und Eschborn / Bonn and Eschborn

Friedrich-Ebert-Allee 36 + 40
53113 Bonn, Deutschland / Germany
T +49 228 44 60-0
F +49 228 44 60-17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn, Deutschland / Germany
T +49 61 96 79-0
F +49 61 96 79-11 15

E info@giz.de
I www.giz.de/en