Green Hydrogen Strategy and Roadmap for Kenya

July 2023

Table of Contents

Table of Tables

Table of Figures

Table of Boxes

Abbreviations

ADC	Agricultural Development Corporation
AFA	Agriculture and Food Authority
AfCTA	African Continental Free Trade Area
AGs office	Office of the Attorney General
AGHA	Africa Green Hydrogen Alliance
AHP	Africa Hydrogen Partnership
ASAL	Arid and Semi-Arid Land
ASTGS	Agricultural Sector Transformation and Growth Strategy
BAU	Business As Usual
BESS	Battery Energy Storage System
BETA	Bottom-up Economic Transformation Agenda
BNEF	Bloomberg New Energy Finance
CAN	Calcium Ammonium Nitrate
CAPEX	Capital Expenditure
CBAM	Carbon Border Adjustment Mechanism
CBO	Community Based Organizations
CFD	Contract-For-Difference
CIDP	County Integrated Development Plan
CO_2	Carbon Dioxide
DAP	Diammonium Phosphate
DFI	Development Finance Institution
DRI	Direct Reduced Iron
DSM	Demand Side Management
EBRD	European Bank for Reconstruction and Development
EFTA	European Free Trade Association (Iceland, Liechtenstein, Norway, Switzerland)
EHB	European Hydrogen Bank
EIB	European Investment Bank
EPRA	Energy and Petroleum Regulatory Authority
ERC	Energy Regulatory Commission
ESAK	Electricity Sector Association of Kenya
ETC	Energy Transitions Commission
EU	European Union
EUD	EU Delegation
EV	Electric Vehicle
FAFB	Fertilizer and Animal Foodstuffs Board
FAO	Food and Agriculture Organization
FCC	Fuel Energy Cost
FERFA	Foreign Exchange Rate Fluctuation Adjustment
FFI	Fortescue Future Industries
FID	Final Investment Decision
FiT	Feed-in-Tariff
GDC	Geothermal Development Company
GH2	Green Hydrogen
GH2-PCC	Green Hydrogen Program Coordination Committee
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
H4D	Hydrogen for Development
HDV	Heavy Duty Vehicle
HINT.CO	Hydrogen Intermediary Company GmbH
IA	Inflation Adjustment
IEA	International Energy Agency
IFC	International Finance Corporation
IPCEI	Important Project of Common European Interest
IPP	Independent Power Producer
IPS	Industrial Promotion Services
IRA	Inflation Reduction Act
IRENA	International Renewable Energy Agency

ISO	International Organization for Standardization
KALRO	Kenya Agricultural and Livestock Research Organization
KAM	Kenya Association of Manufacturers
KCAA	Kenya Civil Aviation Authority
KE	Key Expert
KEBS	Kenya Bureau of Standards
KenGen	Kenya Electricity Generating Company
KEPHIS	Kenya Plant Health Inspectorate Service
KEPSA	Kenya Private Sector Alliance
KEREA	Kenya Renewable Energy Association
KETRACO	Kenya Electricity Transmission Company
KfW	Kreditanstalt für Wiederaufbau
KNBS	Kenya National Bureau of Statistics
KNTC	Kenya National Trading Corporation
KPLC	Kenya Power and Lighting Company
KRA	Kenya Revenue Authority
KTDA	Kenya Tea Development Agency
LAPPSET	Lamu Port-South Sudan-Ethiopia Transport
LCOE	Levelized Cost of Electricity
LCOH	Levelized Cost of Hydrogen
LCPDP	Least Cost Power Development Plan
LT-LEDS	Long-Term Low Emissions and Development Strategy
M&E	Monitoring and Evaluation
MTBE	Methyl Tert-Butyl Ether
MDB	Multilateral Development Banks
MITI	Ministry of Investments Trade and Industry
MoALF	Ministry of Agriculture, Livestock, Fisheries and Co-operatives
MoE	Ministry of Education
MoEAC	Ministry of East African Community, Arid and Semi-Arid Lands, and Regional Development
MoECCF	Ministry of Environment, Climate Change & Forestry
MoEP	Ministry of Energy and Petroleum
MoGPSAA	Ministry of Gender, Public Service and Affirmative Action
MoICT	Ministry of Information, Communications and the Digital Economy
MoLPWH	Ministry of Lands, Public Works, Housing, and Urban Development
MoRT	Ministry of Roads and Transport
MoWSI	Ministry of Water, Sanitation and Irrigation
MoYASA	Ministry of Youth Affairs, Sports and the Arts
MTP	Medium Term Plan
MTPA	Metric Ton Per Annum
MW	Mega Watt
NCA	National Construction Authority
NCCAP	National Climate Change Action Plan
NCPB	National Cereals and Produce Board
NDC	Nationally Determined Contribution
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
NITA	National Industrial Training Authority
NKE	Non-Key Expert
NLC	National Land Commission
OPEX	Operational Expenditures
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PTC	Production Tax Credit
PtX	Power-to-X
PV	Photovoltaics
RDI	Research, Development and Innovation
RE	Renewable Energy
RER	Rural Electrification Program
REREC	Rural Electrification and Renewable Energy Corporation

SAF	Sustainable Aviation Fuels
SDG	Sustainable Development Goal
SEZ	Special Economic Zone
SGR	Standard Gauge Railway
SWOT	Strengths, Weaknesses, Opportunities, Threats
TAF	Technical Assistance Facility
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollars
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital
WARMA	Water Resource Management Authority
WRA	Water Resources Authority

REMARKS FROM PRINCIPAL SECRETARY, MINISTRY OF ENERGY AND PETROLEUM

[Placeholder for MoEP]

REMARKS FROM EU AMBASSADOR / FOREWORD

(please download photo in high resolution - https://drive.google.com/drive/folders/1CTu93g8gWOAXR3jU4hda35UnjkQXmZ9y?usp=sharing)

In this era marked by the urgent need to address climate change collaboratively, Kenya emerges as a shining example. Through its updated Nationally Determined Contribution (NDC), Kenya is demonstrating firm determination to reduce greenhouse gas emissions by a third by 2030. By taking proactive measures, Kenya establishes itself as a frontrunner in sustainable practices, inspiring hope for a greener and more sustainable future.

Kenya is overall well placed to lead this essential green transition, given its substantial advances in renewable energy development. Kenya was a first mover in green energy transition and has made significant advancements, especially in electricity production, with over 90% of its electricity derived from renewable resources. Kenya has furthermore vast untapped renewable energy resources especially in geothermal.

The European Union (EU) and Kenya's vibrant and long-term partnership has special focus on accelerating investments in clean energy infrastructure and Team Europe members are ready, through the Global Gateway strategy, to support Kenya's commitment to achieve a 100% renewable electricity system by 2030. Together, we will strive towards an energy transition for low-carbon climate resilient economies that are providing affordable renewable electricity and offers new employment opportunities for the people of Kenya and beyond.

At the heart of this joint vision lies the utilization of green hydrogen, a unique transformative energy carrier with the potential to revolutionize multiple sectors while minimizing carbon emissions. The EU's long and extensive expertise in renewable energy technologies, combined with Kenya's wealth of renewable resources, create an ideal platform for collaboration, knowledge-sharing and spearheading joint investments in this crucial domain.

This Green Hydrogen Strategy and Roadmap for Kenya has been developed under the EU Global Technical Assistance Facility for Sustainable Energy and the work has been steered and managed by the Ministry of Energy and key Kenyan stakeholders.

We sincerely hope that this strategy and roadmap will allow Kenya to capitalize on the vast potential of the emerging green hydrogen sector. The EU stands ready to collaborate with Kenya and actively support initiatives aimed at facilitating the early adoption of green hydrogen in the country.

Henriette Geiger

Ambassador of the European Union to Kenya

ACKNOWLEDGMENTS

The Green Hydrogen Strategy and Roadmap for Kenya has been developed by the **European Union Global Technical Assistance Facility** (TAF) for Sustainable Energy, in close cooperation with the **Delegation of the European Union to Kenya** (EEAS), the Kenyan **Ministry of Energy and Petroleum** (MoEP), and **Deutsche Gesellschaft für Internationale Zusammenarbeit** (GIZ). A special thanks goes to:

Nikos Sakellariou (TAF)

Michael Ball (TAF)

Joao Nicolau (TAF)

Paul Okan-Adjetey (TAF)

Clarice Wambua (TAF)

Evan Wanjiru (TAF)

Andris Piebalgs (TAF)

Federico Villatico (TAF)

Martin Andersen (EEAS)

Davide Danelli (EEAS)

Eng. Isaac Kiva (MoEP)

Eng. Benson Mwakina (MoEP)

Eng. Kihara (MoEP)

Edna Mutevu (MoEP)

Mercy Kimwa (MoEP)

Kevin Mwangi (GIZ)

Hanna Salian (GIZ)

Furthermore, the process benefitted from extensive support from a diverse range of stakeholders, including the Green Hydrogen Working Group (co-chaired by MoEP and EEAS), government ministries, public sector institutions, academia, development finance institutions (DFIs), the private sector, as well as the Green Hydrogen Organisation.

Government Ministries and public sector institutions:

- Ministry of Agriculture, Livestock, Fisheries and Co-operatives
- Ministry of Investments, Trade, and Industry
- Ministry of Roads and Transport
- The National Treasury
- Energy and Petroleum Regulatory Authority (EPRA)
- Geothermal Development Company (GDC)
- Kenya Association of Manufacturers (KAM)
- Kenya Bureau of Standards (KEBS)
- Kenya Electricity Generating Company (KenGen)
- Kenya Private Sector Alliance (KEPSA)
- Kenya Electricity Transmission Company (KETRACO)

- Kenya Power and Lighting Company (KPLC)
- Rural Electrification and Renewable Energy Corporation (REREC)

Academia:

- Jomo Kenyatta University of Agriculture and Technology
- Kenyatta University
- University of Nairobi
- Strathmore University

Development Finance Institutions:

- European Investment Bank (EIB)
- Agence Française de Développement (AfD)
- Kreditanstalt für Wiederaufbau (KfW)

EXECUTIVE SUMMARY

Aligning with Kenya's Vision 2030, which seeks to accelerate sustainable growth and transform Kenya into a competitive and prosperous country with a high quality of life, Kenya has made improving the livelihoods and welfare of its citizens a top priority through the Bottom-Up Economic Transformation Agenda. Recognizing the significance of green hydrogen, Kenya aims to harness its potential as a cross-cutting enabler for the country's development agenda and as a catalyst for sustainable socio-economic development.

In recent years, the world has witnessed a growing sense of urgency to shift towards sustainable and clean energy sources, driven by the pressing challenges of climate change and the imperative to reduce carbon emissions. One particularly promising avenue that has gained significant traction is green hydrogen derived from renewable energy sources. Green hydrogen has the potential to play a pivotal role in the global energy transformation, offering significant potential to decarbonize various sectors, enable sustainable industrial processes, and facilitate the transition to a low-carbon future.

Amidst this global wave of interest in green hydrogen, Kenya stands uniquely positioned to capitalize on the unprecedented political and business momentum surrounding this nascent industry. Kenya has achieved remarkable success in developing a well-diversified power generation mix, with approximately 90% of its electricity sourced from renewable energy sources[1]. The country possesses a vast untapped renewable energy potential, including a leading position in geothermal power within Africa.

With a strong innovation culture and a commitment to sustainable development, exploring options for producing green hydrogen from green electricity is a logical next step in building a green economy in Kenya. This presents a unique window of opportunity for Kenya to pursue tangible business opportunities in the nascent green hydrogen industry to drive green economic growth, contribute to the country's socio-economic transformation and actively participate in the global collaborative efforts to tackle the impacts of climate change. The vibrant private sector with project developers actively pursuing green hydrogen projects in Kenya serves as compelling evidence of the country's potential in the field of green hydrogen.

Figure 1: Kenya's unique window of opportunity in green hydrogen – sustainable economic transformation and green growth

[1] Energy & Petroleum Regulatory Authority (EPRA), Energy & Petroleum Statistics Report 2022, 2022

Green hydrogen has potential applications across various sectors in Kenya, including industry, transport, and power. Green hydrogen is a versatile feedstock in the chemical industry, specifically for the production of ammonia (used in nitrogen fertilizers) and methanol. Additionally, hydrogen can play a role in decarbonizing the road transport sector, and its derivatives can decarbonize shipping (via ammonia or methanol) and aviation (via Sustainable Aviation Fuels, SAF). Furthermore, hydrogen offers a means of energy storage and can provide baseload power in the electricity sector. But to catalyze the development of a green hydrogen industry in Kenya, it is advisable to prioritize those hydrogen use cases that offer substantial benefits to the country and align with Kenya's broader development goals, while simultaneously showing the highest potential for short-term commercial viability.

Identifying the most promising applications for green hydrogen naturally brings the agricultural sector into focus. The agricultural sector is the cornerstone of Kenya's economy, providing livelihood and employment for the majority of the population, while generating a large share of export earnings. The sector additionally contributes to value addition and job creation through linkages to other sectors such as manufacturing and agro-processing industries. Moreover, the agricultural sector relies entirely on imported fertilizers, leading to substantial government subsidies on fertilizer imports and making it susceptible to fluctuations in global commodity prices, as observed in 2021/2022. Hence, investing in the agricultural value chain and establishing a domestic fertilizer production industry based on green hydrogen and ammonia represents a no-regret option for Kenya.

More generally, by substituting hydrogen commodity imports like fertilizer or methanol with domestically produced green alternatives, Kenya can foster the emergence of new industrial processes, mitigate supply risks, and reduce the uncertainties linked to market price volatility. The utilization of green hydrogen therefore presents a promising pathway to unlock opportunities for sustainable manufacturing and drive industrialization in Kenya, aligning with the objectives of Kenya's Vision 2030.

Nevertheless, despite the growing momentum surrounding hydrogen, the vision of green hydrogen, although technically feasible, has yet to achieve commercial viability on a global scale. Building a green hydrogen economy presents challenges that are present in every country seeking to embrace this vision. The primary risk lies in the offtake, revolving around uncertainties related to market demand and pricing (i.e. affordability and willingness to pay) for green hydrogen and its derivative products. The development of a market for green hydrogen and its derivatives, whether domestically or internationally, is a challenge to overcome. A crucial factor for success in any hydrogen strategy is the ability to identify early off-takers. Kenya is no exception to these challenges. However, it possesses a unique and advantageous starting position due its endowment with geothermal energy with its high capacity factor. But more than this, with the abundance of wind, solar (but also hydro) renewable energy sources, Kenya holds a further advantage in the emerging green hydrogen economy. Green hydrogen requires a long-term commitment, but Kenya stands to gain substantial benefits across four key dimensions from the successful establishment of a green hydrogen industry:

1. **Improved balance of payments**: Producing green hydrogen for use as feedstock in industrial processing plants, Kenya will reduce imports of hydrogen-based commodities (like nitrogen fertilizer or methanol). Once a domestic market for green hydrogen derivatives has been successfully established, this will also open up opportunities for export, taking advantage of its strategic geographic position as a regional trading hub. This will ultimately enhance Kenya's balance of payments.
2. **Food security and resilience**: Green hydrogen has the potential to improve food security and enhance resilience by enabling the local production of nitrogen fertilizers. These fertilizers play a critical role in boosting agricultural productivity. Establishing a domestic fertilizer production industry can significantly improve the availability and accessibility of fertilizers to Kenyan farmers, thereby leading to increased agricultural output. The use of green fertilizers "made in Kenya" will also promote sustainable agricultural practices and eventually add value to the agricultural produce. This self-sufficiency also helps mitigate the impact of international commodity market fluctuations, further reinforcing resilience in the agricultural sector.
3. **Green industrialization and decarbonization**: Green hydrogen can serve as a catalyst for industrialization as it enables the establishment of manufacturing value chains dedicated to

producing green hydrogen and its derivatives. This, in turn, fosters the development of various downstream industries and creates employment opportunities across the entire green hydrogen value chain. Additionally, the green hydrogen industry can act as an "anchor off-taker" providing the demand reliability necessary to drive the expansion of the power grid, accelerate the growth of the renewable energy sector, and ultimately improve access to electricity services for the people of Kenya. Replacing conventional hydrogen commodities derived from fossil fuels with sustainable alternatives will also contribute to global decarbonization efforts and pave the way for the development of new export markets for low-carbon products.

4. **Investment in the country**: Green hydrogen has the potential to attract substantial public and private investments to Kenya, with the primary objective of establishing a green hydrogen value chain that spans across various sectors and industrial applications, including power generation and transmission, hydrogen production, and related downstream industrial facilities. Investing in this value chain will lead to economic diversification, job creation, and industrial growth.

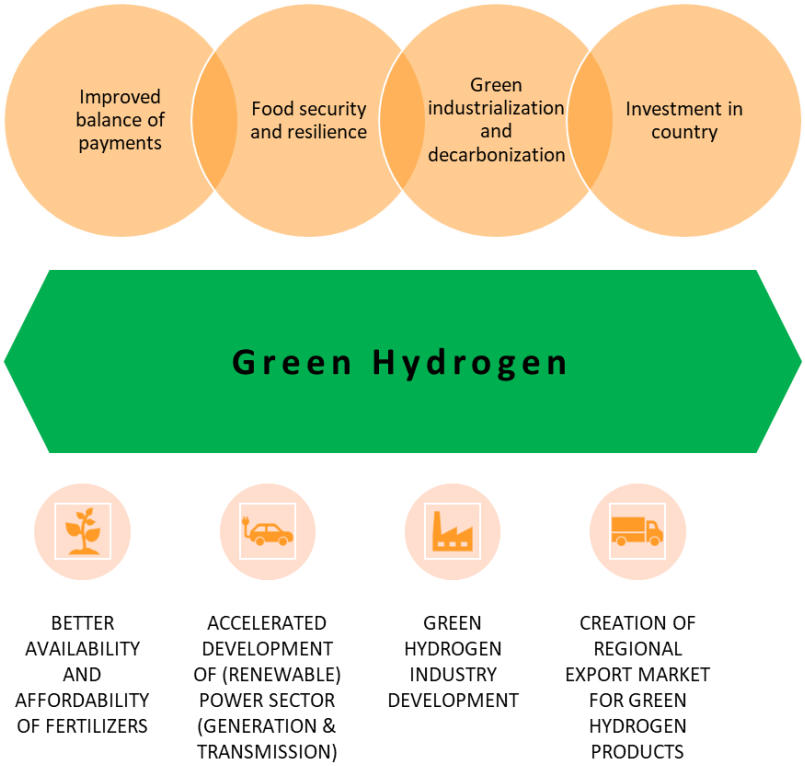


Figure 2: Objectives and outcomes of Kenya's Green Hydrogen Vision

This is therefore an opportune moment for Kenya to launch this **Green Hydrogen Strategy and Roadmap** and align itself with global trends in technology, applications, policy and regulation, and capitalize on available funding opportunities. This dedicated national hydrogen strategy is essential for Kenya, like for any country in the world aiming to establish a robust hydrogen industry, as it provides a clear vision, direction, and framework for the development of the hydrogen sector.

Kenya's Green Hydrogen Strategy and Roadmap has been informed by a thorough analysis of the country's dynamics, potential and opportunities in conjunction with extensive stakeholder consultations. It highlights the country's shared Green Hydrogen Vision for developing and utilizing green hydrogen as a cross-cutting enabler for Kenya's development agenda and as a catalyst for sustainable socio-economic development. Moreover, the development of the Green Hydrogen Strategy and Roadmap aligns closely with Kenya's national climate action plans and its commitment to the global targets outlined in the Paris Agreement.

VISION

"Green Hydrogen for Sustainable Socio-Economic Development"

STRATEGY

Harness Kenya's unique and abundant renewable energy sources and innovation mindset to enhance agricultural production, industrialization and decarbonization through a phased and demand-driven approach.

IMPLEMENTATION PLAN

Phase 1 (2023-2027); Phase 2 (2028-2032)

Prioritize no-regret options to kickstart a hydrogen industry, such as domestic fertilizer production.
Once successfully established, this will enable hydrogen opportunities in other sectors, including regional and international export.

TARGETS

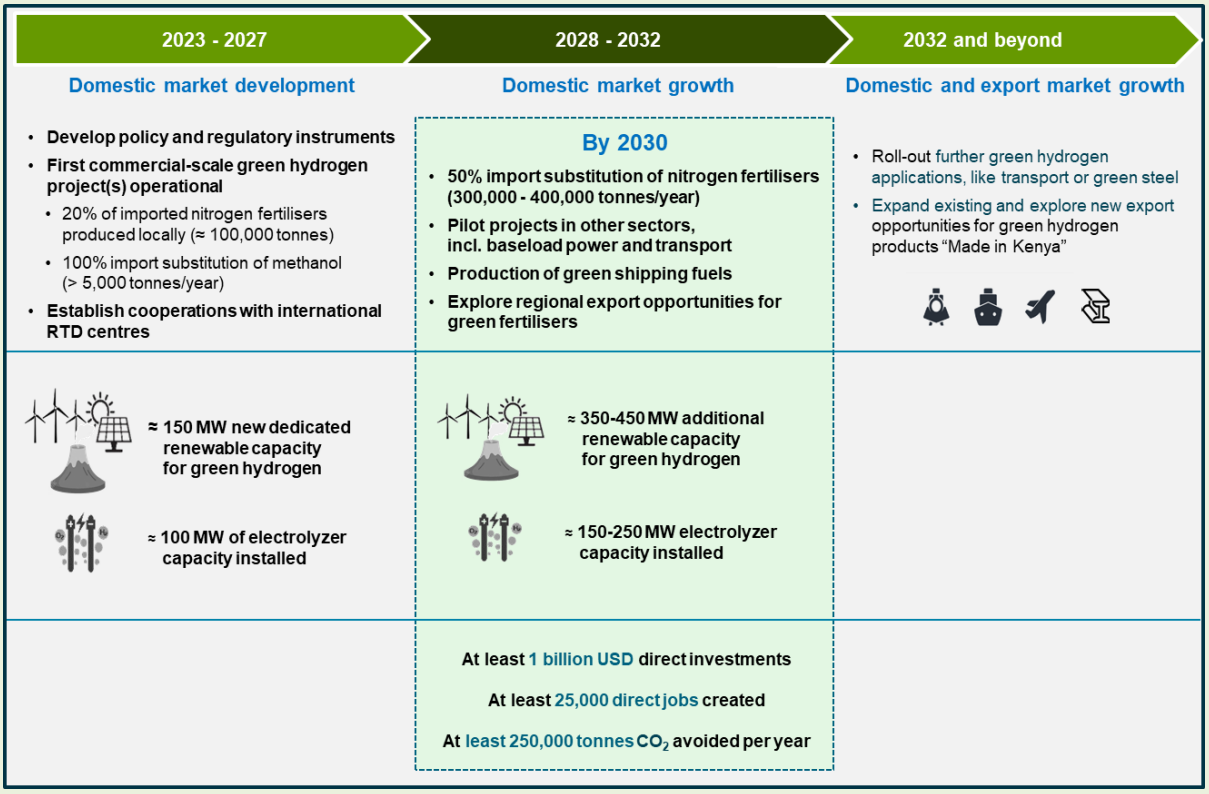


Figure 3: Kenya's Green Hydrogen Vison and Targets

The establishment of a green hydrogen industry in Kenya requires a clear and focused enabling and supportive environment based on strong and well-aligned pillars, the **building blocks / enablers**. These enablers collectively provide the necessary foundation, support, and conducive environment for the implementation of the green hydrogen roadmap for Kenya to achieve its green hydrogen vision.

Figure 4: Building blocks of Kenya's Green Hydrogen Vision

Translating the strategy into specific actions, milestones, and timelines helps to coordinate and guide the efforts of implementing the strategy and provides a path for stakeholders to follow in order to achieve the stated objectives. This process puts in place a structured framework for collaboration among all stakeholders, from government agencies to private sector participants. By proposing a concrete action plan and establishing short-term priorities, the Strategy and Roadmap is meant to serve as a practical guide for decision-making within the Kenyan Government and a solid foundation for the establishment of a green hydrogen industry in the country. A set of priority actions have been identified to operationalise the Green Hydrogen Strategy and Roadmap:

PRIORITY ACTIONS

- Establish a high-level "**green hydrogen program coordination committee**".
- Establish a green hydrogen **secretariat** to operate as a "one-stop-shop".
- Organize National **Green Hydrogen roundtables** on finance and green fertilizer.
- Develop a green hydrogen strategy and roadmap **resource mobilization plan**.
- Develop a **Monitoring and Evaluation Plan**
- Include dedicated provision on green hydrogen in the national energy policy.
- Support / fast track **catalytic projects** that demonstrate commercial viability, including implementation of KENGEN-Olkaria green hydrogen pilot project.
- Expand regional and **international cooperation and partnerships on green hydrogen**.
- Develop a green hydrogen stakeholder engagement and communication plan.
- Establish local and international partnerships to scale up training and capacity building.

Given the nascent state of green hydrogen and the rapidly evolving nature of the industry, the strategy will be implemented in a phased manner over an initial ten-year period. This period will be divided into two five-year phases, allowing for incremental learning and the gradual scaling up of initiatives as the enabling environment for green hydrogen is established. It is crucial to note that Kenya's phased green hydrogen implementation plan is closely aligned with the government's developmental planning process, particularly Medium-Term Plans 4 (MTP 4). This alignment aims to connect priority actions associated with initiating a green hydrogen economy to national development planning.

The initial phase (2023-2027) of the implementation plan, corresponding to MTP 4, will primarily focus on creating domestic demand and implementing the first catalytic commercial projects to kickstart the hydrogen industry. Subsequently, during the second phase (2028-2032), the plan will consider market developments and other external factors to leverage the lessons learned from the initial phase to explore new hydrogen opportunities, for instance around regional export.

To ensure the success of the roadmap, it is crucial to deliver a pioneering commercial project in Kenya within the next five years. This achievement will serve as a powerful demonstration of Kenya's remarkable capabilities in the field of green hydrogen and will effectively enhance its visibility and reputation both internationally and within Africa as a prime location to grow a green hydrogen industry. It will also enable Kenya to develop essential expertise, explore partnerships, and make informed decisions about its involvement in the green hydrogen value chain. Moreover, it will serve as a catalyst to inspire other local and international private sector players to pursue hydrogen prospects in Kenya.

Given the current early stage of the green hydrogen market, coordinated efforts, ambitious political targets, strategic partnerships, and active engagement with the private sector are pivotal in harnessing the potential of green hydrogen for Kenya. Specifically, Kenya needs to establish an effective and fit-for-purpose regulatory and institutional framework that stimulates demand for green hydrogen and creates an enabling and attractive investment environment. This, in turn, will attract private sector investment into green hydrogen initiatives within the country.

To ensure the commercial viability and bankability of green hydrogen projects and enable their successful implementation, it is essential to mitigate project and market risks through adopting effective de-risking measures for projects and market functioning. Already initiatives have emerged and others are tuned to support the development of the green hydrogen sector globally. The European Union has already announced the establishment of the **Hydrogen Bank** facility, while it supports the development of projects through the **Global Gateway** strategy to boost smart and sustainable investments including green hydrogen, the **EU-EDFI facility** (EEDF) to support investments through the European Development Fund (EDF), or the **EFSD+** guarantee facility, whereas the **H2-Global** instrument aims to bridge cost gaps and facilitate GH2 and derivatives market functioning.

The use of blended financing and innovative financial instruments will play a pivotal role in catalysing green hydrogen investments in the country. As highlighted in the *Nouakchott Message*, Development Finance Institutions (DFIs), with their wealth of experience in successfully scaling up investments in renewable energy development, can play a vital role in deploying effective financing strategies and instruments to enable initial commercial projects and drive the growth of the green hydrogen industry in Kenya.

1. INTRODUCTION

1.1. BACKGROUND AND OBJECTIVES

In recent years, the world has witnessed a growing sense of urgency to shift towards sustainable and clean energy sources, driven by the pressing challenges of climate change and the imperative to reduce carbon emissions. As a result, countries worldwide are actively seeking innovative “clean” solutions to meet their energy needs. One particularly promising avenue that has gained significant traction is green hydrogen derived from renewable energy sources. Green hydrogen has the potential to play a central role in the global energy transformation, offering significant potential to decarbonize various sectors, enable sustainable industrial processes, and facilitate the transition to a low-carbon future.

Amidst this global wave of interest in green hydrogen, Kenya stands uniquely positioned to capitalize on the unprecedented political and business momentum surrounding this nascent industry. Kenya possesses a vast untapped renewable energy potential, with already around 90% of its electricity coming from renewable sources;[2] more than that, Kenya holds Africa's leadership position in geothermal energy, both in terms of resource potential and development of power generation capacity. With an ambitious vision and a commitment to sustainable development, Kenya aims to seize unique business opportunities in the green hydrogen industry to drive green economic growth, contribute to the country's socio-economic transformation as aspired by Kenya’s **Vision 2030**, and actively participate in the global collaborative efforts to tackle the impacts of climate change.

Figure 5: Kenya’s unique window of opportunity in green hydrogen – sustainable economic transformation and green growth

A vibrant private sector with several green hydrogen projects being actively developed and pursued in Kenya serves as compelling evidence of the country's potential in the field of green hydrogen.

A dedicated national hydrogen strategy is crucial for a country seeking to establish a hydrogen industry, as it provides a clear vision, direction, and framework for the development of the hydrogen sector. By

[2] Energy & Petroleum Regulatory Authority (EPRA), Energy & Petroleum Statistics Report 2022, 2022

defining targets, prioritising use cases, outlining favourable and consistent policies, regulations, and financial incentives, a national strategy can lay the foundation for the development of a stable and predictable business environment, crucial for attracting investors and industry players; at the same time, it can act as a catalyst driving and stimulating the development of a domestic hydrogen market.

Formulating a roadmap by translating the strategy into a set of tangible actions and milestones helps coordinating and guiding the efforts for all stakeholders involved, in order to achieve the stated objectives. The roadmap also puts in place a structured framework for collaboration among all stakeholders, ranging from government agencies to the private sector and civil society.

Currently, some 40 countries have already developed or are currently developing their hydrogen strategy, and Kenya is now joining them with this **Green Hydrogen Strategy and Roadmap**. The knowledge and expertise gained from implementing the roadmap can further support Kenya's broader industrialization objectives and drive its socio-economic development. Moreover, the development of a Green Hydrogen Strategy and Roadmap aligns closely with Kenya's national climate action plans and its commitment to the global targets outlined in the Paris Agreement.

1.2. APPROACH AND METHODOLOGY

The development of the Green Hydrogen Strategy and Roadmap for Kenya followed a systematic approach.

Firstly, the roadmap drew inspiration from successful examples and best practices of other countries and incorporated the International Energy Agency (IEA) hydrogen policy framework.[3] Additionally, it built upon the Ministry of Energy / Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) *Baseline Study on the Potential for Power-to-X / Green Hydrogen in Kenya* (2022), further enhancing its foundation.

Secondly, the Green Hydrogen Strategy and Roadmap were formulated through an inclusive process that involved various stakeholders in Kenya. Extensive consultations were conducted with representatives from ministries and public sector institutions, Development Finance Institutions (DFIs), private companies, as well as academia. These consultations took the form of workshops, as well as bilateral or multi-lateral meetings, ensuring that a broad range of perspectives and expertise were considered. A pivotal role was played by the Technical Working Group that was set up to support and provide its guidance throughout the development process of the roadmap. The primary objective of these stakeholder consultations was to harness the knowledge and insights of local stakeholders, enabling a comprehensive country assessment and competitive analysis. It aimed to understand the stakeholder landscape thoroughly and identify the most promising hydrogen use cases specific to Kenya in the short, medium and longer term. Moreover, these consultations aimed to align all stakeholders on a shared vision for the green hydrogen sector in the country.

In addition to the aforementioned steps, a ‘Strengths, Weaknesses, Opportunities, Threats’ (SWOT) analysis was conducted as part of the roadmap development process, which helped identify the strengths, weaknesses, opportunities, and threats associated with implementing a green hydrogen industry in Kenya, enabling a comprehensive understanding of the internal and external factors influencing its success.

Subsequently, a gap analysis was conducted, focusing on policy, regulation, and finance aspects related to developing the green hydrogen sector in Kenya. Its findings informed the development of a concrete action plan, an integral part of the strategy and the roadmap. This document is meant to serve as a practical guide for decision-making within the Kenyan Government, providing a solid foundation for the establishment of the country’s green hydrogen industry.

The development of the Green Hydrogen Strategy and Roadmap was carried out under the supervision of the Ministry of Energy and Petroleum and was governed by a senior-level cross-government steering

[3] IEA, 2022, https://www.iea.org/reports/global-hydrogen-review-2022

committee. This ensured high-level coordination and oversight to drive the successful implementation of the roadmap's recommendations and actions.

2. GREEN HYDROGEN – GLOBAL CONTEXT AND TRENDS

Green hydrogen[4], derived from renewable sources of electricity, is expected to contribute significantly in achieving the goals of net-zero emissions by 2050 and limiting the global temperature rise to 1.5 °C.[5]

Green hydrogen has potential applications across various sectors, including industry, transport, and power. One of its notable advantages is its versatility as an energy carrier and industrial feedstock, enabling the decarbonization of hard-to-abate sectors, i.e. sectors of the economy that cannot directly be electrified with renewable energy, whereas it can be produced using locally available renewable energy resources.

Hydrogen can play an important role in decarbonizing the transport sector. It can be used as a direct fuel for road freight, and its derivatives can decarbonize shipping (via ammonia or methanol) and aviation (via Sustainable Aviation Fuels, SAF). Furthermore, hydrogen offers a compelling solution for the storage of electricity on a large scale and for extended periods, which becomes increasingly crucial with the growing share of intermittent renewables in the electricity generation mix.

In 2021, the global hydrogen consumption reached a total of 94 million tonnes, almost entirely sourced from fossil fuels; natural gas accounts for around two-thirds of the global production.[6] Approximately half of the hydrogen produced globally is used in refineries, while slightly over 35% are utilized as a feedstock for the synthesis of ammonia.[7]

2.1. THE HYDROGEN VALUE CHAIN

Green hydrogen plays a pivotal role in the Power-to-X (PtX) process, which involves harnessing renewable electricity to convert water into hydrogen through electrolysis. This hydrogen can be used directly in mobility applications or serve as a feedstock for the production of various chemical products, including synthetic fuels, as well as diverse forms of chemical energy carriers like ammonia or methanol (*Figure 6*). Through PtX, hydrogen effectively facilitates sector coupling, acting as a versatile energy carrier that can connect various sectors of the economy, including electricity, transportation, and industry. This means that power generated in the electricity sector can be separated and be utilized in other sectors, thereby enabling the decarbonization of hard-to-abate sectors like chemicals, iron and steel, or cement, as well as certain segments of transportation like heavy-duty traffic, shipping, or aviation.

[4] Hydrogen is commonly categorized into different colours, such as green, grey, blue, or turquoise, depending on its production process and the associated greenhouse gas (GHG) emissions. The Green Hydrogen Strategy and Roadmap for Kenya specifically focuses on green hydrogen, which refers to hydrogen produced exclusively from renewable electricity. However, when discussing the global hydrogen landscape as a whole, it becomes crucial to acknowledge and recognize the broader significance of *clean* hydrogen, defined as hydrogen produced with very low or zero carbon emissions, during the transition to a full green hydrogen economy.

[5] IEA, Net Zero by 2050 – A Roadmap for the Global Energy Sector, October 2021 (4th revision), https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

[6] IEA, Global Hydrogen Review, 2022, https://www.iea.org/reports/global-hydrogen-review-2022

[7] Ammonia is the starting point for all mineral nitrogen fertilisers, which account for around 70% of global ammonia demand; the remaining ammonia demand is for a wide range of industrial applications, including explosives or synthetic fibres. Producing one tonne of ammonia requires around 180 kg of hydrogen. Total production of ammonia was around 190 million tonnes in 2021.

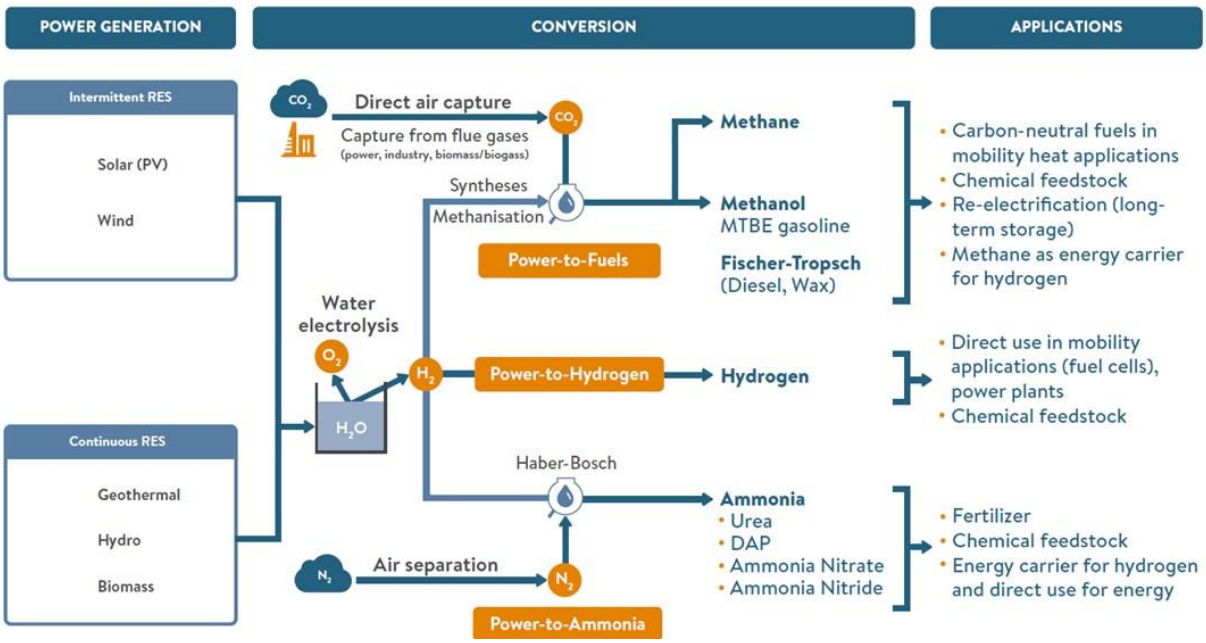


Figure 6: Hydrogen and Power-to-X (PtX) – conversion of renewable power into various forms of chemical energy carriers

(Source: World Energy Council Innovation Insights Brief: New Hydrogen Economy - Hope Or Hype?, 2019)[8]

Power-to-hydrogen, Power-to-ammonia, and Power-to-fuels are processes that utilize electricity to convert renewable energy into different forms of energy carriers or fuels.

Power-to-hydrogen focuses specifically on generating hydrogen from electricity. Hydrogen serves as a versatile energy carrier suitable for various applications. It can be used as a fuel for fuel cell vehicles, particularly in heavy-duty transportation. Moreover, hydrogen is a feedstock for various industrial processes in the chemical industry and serves as a means of electricity storage.

Power-to-ammonia involves the combination of hydrogen with nitrogen extracted from the air to produce ammonia. This process, known as Haber-Bosch synthesis, has several applications. Ammonia can be utilized as a feedstock for various types of nitrogen fertilizers but also serves as a carbon-free fuel.

Power-to-fuels refers to the conversion of electrical energy into various fuel types. It involves the utilization of renewable energy sources to generate hydrogen through electrolysis. The produced hydrogen can be utilized directly as a fuel or combined with Carbon Dioxide (CO_2) captured from the atmosphere or industrial processes. This combination results in the production of liquid synthetic hydrocarbon fuels (commonly known as *e-fuels*) such as gasoline, diesel, or jet fuel (also referred to as *SAF*) through a process called Fischer-Tropsch synthesis. Additionally, methanol or synthetic methane can also be produced.

Another direct application of green hydrogen is as a reducing agent, allowing for the direct reduction of iron ore, also known as Direct Reduced Iron (DRI), to produce green steel.

[8] World Energy Council, 2019, https://www.worldenergy.org/assets/downloads/WEInnovation-Insights-Brief-New-Hydrogen-Economy-Hype-or-Hope.pdf

2.2. GLOBAL HYDROGEN SCENE IN 2023

2.2.1. Market outlook

As a versatile and clean energy carrier, hydrogen has the potential to help addressing various energy and environmental challenges. As countries strive to transition to a low-carbon economy and reduce greenhouse gas (GHG) emissions, hydrogen has emerged as a promising solution due to its ability to be produced from diverse sources, including renewables, and its potential for zero-emission applications across multiple sectors. The growing recognition of the role of hydrogen in decarbonizing transportation, industry, and power generation is reflected in all major global energy scenarios, with projections ranging from 500 to 800 million tonnes a year, the majority being green hydrogen (*Figure 7*).

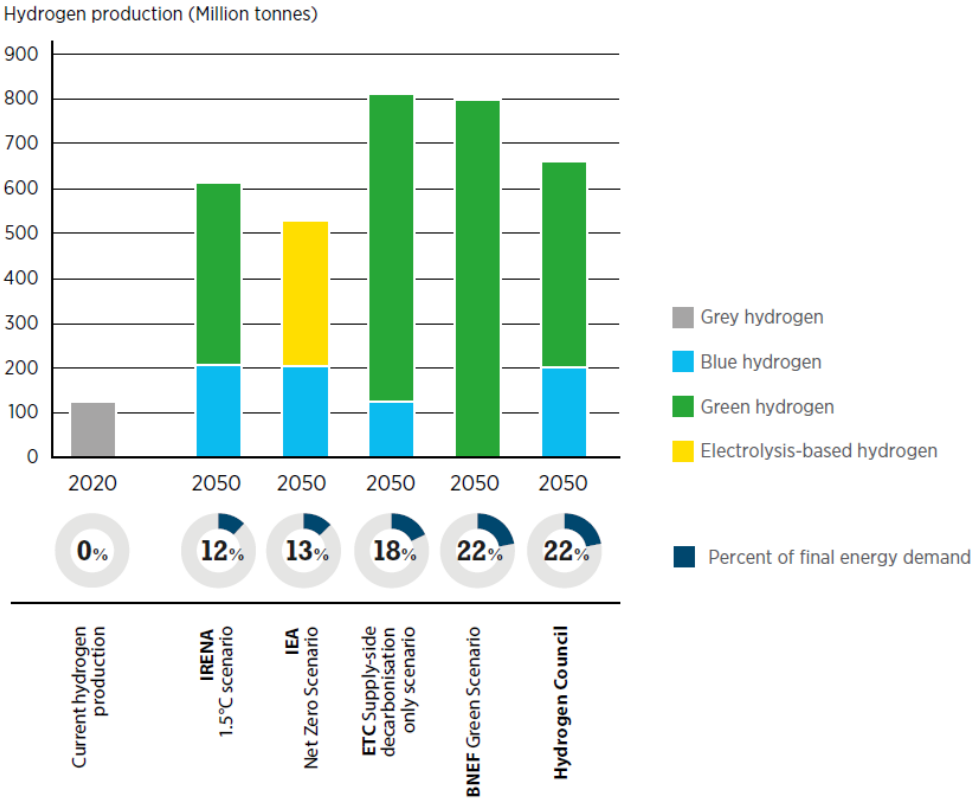


Figure 7: Estimates for global hydrogen demand in 2050

(Source: IRENA, Geopolitics of the Energy Transformation – the Hydrogen Factor, 2022[9])

According to the Net Zero Emissions (NZE) scenario by the IEA, hydrogen is expected to find significant applications in various sectors, particularly in industry, ammonia production, and the production of synthetic fuels (synfuels). In the NZE scenario, the estimated installed capacity of electrolyzers reaches an impressive 3,600 GW by 2050.

[9] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Geopolitics_Hydrogen_2022.pdf

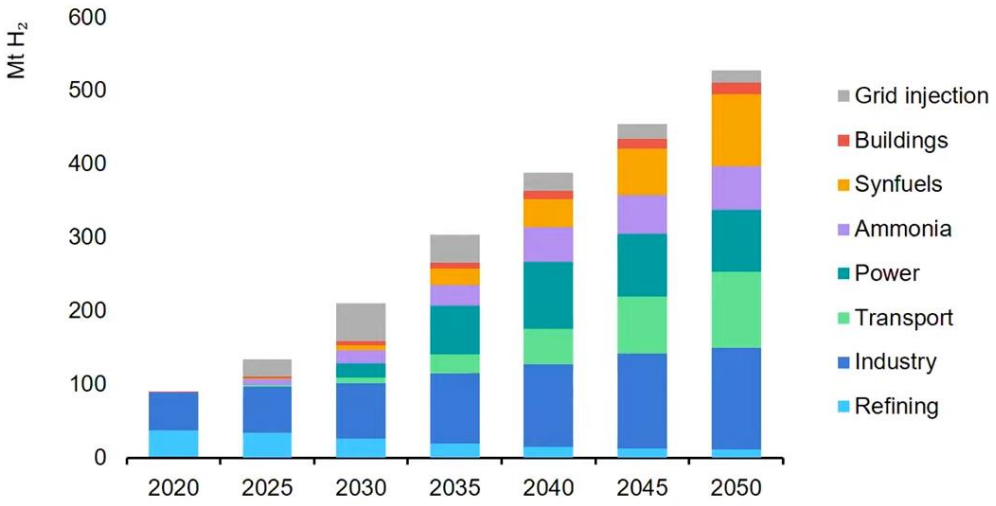


Figure 8: Global demand for hydrogen by sector according to IEA's Net-Zero Emissions scenario

(Source: IEA, Global Hydrogen Review, 2021[10])

Across the globe, both public and private stakeholders are actively pursuing opportunities to develop and implement green hydrogen projects. Their collective objective is to unlock the immense potential of green hydrogen and contribute to global efforts in achieving climate goals, establishing sustainable energy systems, enhancing energy security, and fostering economic growth.

Global interest in hydrogen is gaining momentum with the number of announced hydrogen project proposals (> 1 megawatt (MW)) hitting a record high of 1,046 projects at the end of January 2023. Europe plays a leading role in this race with Latin America and North America following (Figure 9).

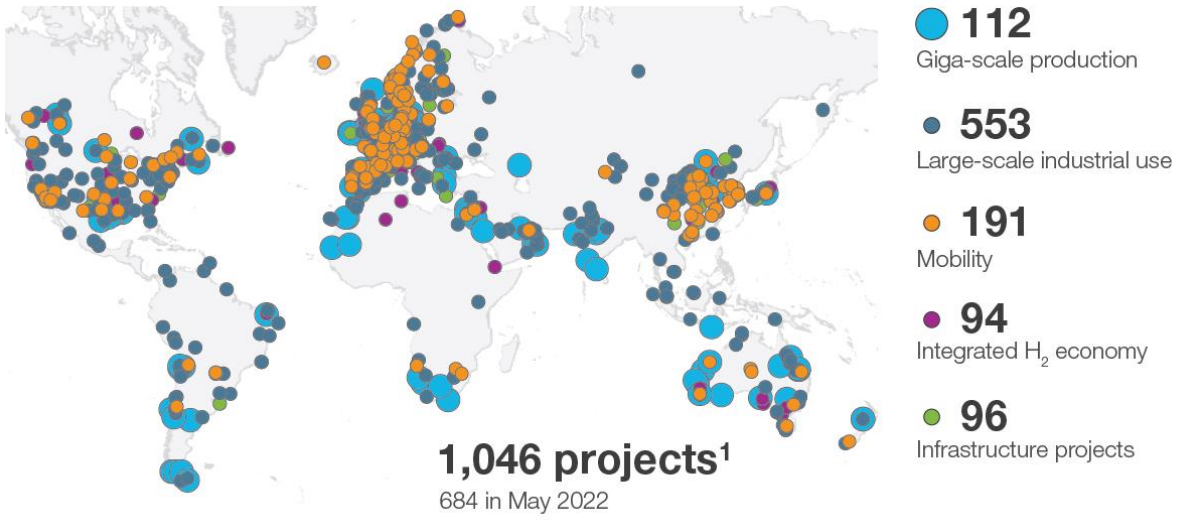


Figure 9: Geographic distribution of announced clean hydrogen projects

(Source: Hydrogen Council & McKinsey & Company, Hydrogen Insights 2023, 2023)

[10] https://iea.blob.core.windows.net/assets/5bd46d7b-906a-4429-abda-e9c507a62341/GlobalHydrogenReview2021.pdf

CURRENT STATE OF PLAY

- Hydrogen will play a key role in reaching net-zero emissions by 2050.
- The momentum behind hydrogen has been accelerating and is continuing to grow, but actual deployment and investment decisions are lagging:
    - **>1,000 hydrogen project proposals** announced globally, 795 of which plan full or partial deployment by 2030;
    - **USD 320 billion** direct investments into hydrogen projects announced through 2030, of which USD 29 billion have passed the final investment decision (FID);
    - **38 Mt p.a.** clean hydrogen supply announced globally 2030, less than 1 Mt p.a., which is less than 3%, deployed today (see Figure 10).
- A key challenge for project developers is the lack of demand for green hydrogen.
- Joint action by the public and private sectors is required to move from project proposals to actual investments.

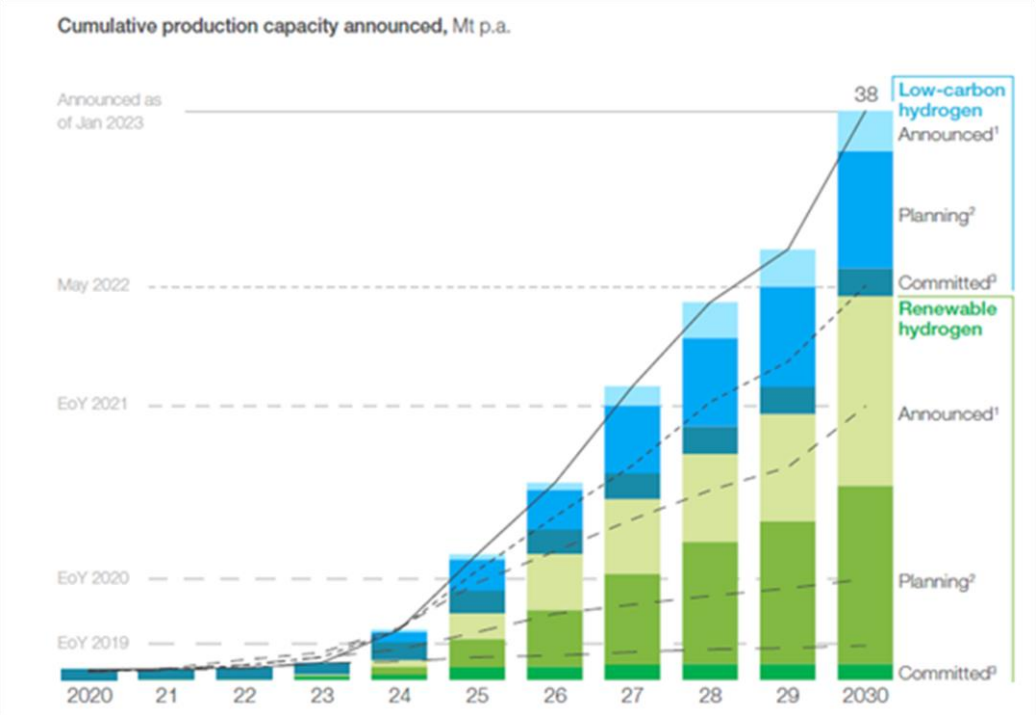


Figure 10: Announced hydrogen production volumes globally

(Source: Hydrogen Council & McKinsey & Company, Hydrogen Insights 2023, 2023)

2.2.2. Overview of hydrogen strategies globally

Many countries around the world have developed hydrogen strategies and roadmaps laying out ambitious plans for the development of their respective hydrogen economies.[11] These strategies and roadmaps are part of their broader climate and clean energy related goals, and enable countries to decarbonize, exploit their renewable energy resources and develop key sectors and trade partnerships in specific markets. The strategies and roadmaps capture the countries' renewable energy and hydrogen production potential, local demand and access to hydrogen markets, coupled with each country's level of industrialization, energy needs and dependencies.[12]

National hydrogen strategies largely seek to tackle the common underlying challenges of scaling up green hydrogen production, enhancing hydrogen use across sectors, developing technologies, and designing enabling policies and regulations. There is often a focus on government funding and support for research and development, measures for demand creation and financial support for manufacturing and infrastructure development.[13]

With the significant geo-political and geo-economic potential that hydrogen holds, it is expected that the number of countries with interest, resources and the potential to develop their green hydrogen sector will increase as the global market for hydrogen continues to grow.

Today, more than 40 countries have published a national hydrogen strategy and/or roadmap (**Error! Reference source not found.**), all of which are distinct and tailored to the specific conditions of each country.

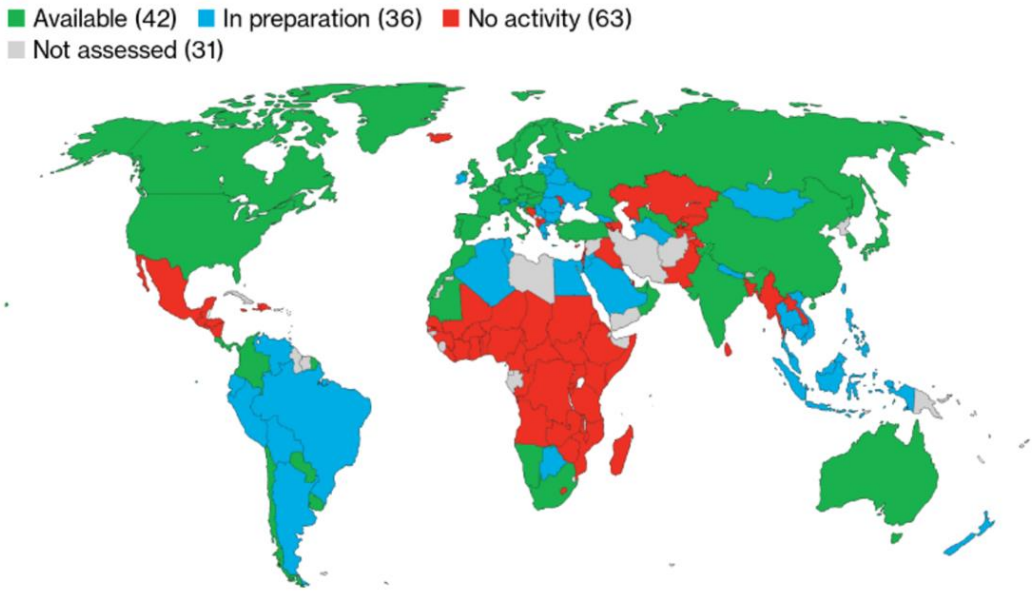


Figure 11: Overview of hydrogen strategies globally (March 2023)

(Source: Bloomberg BNEF, Global Hydrogen Strategy Tracker)

[11] Van de Graaf et al., 'The new oil? The geopolitics and international governance of hydrogen', Energy Research and Social Science 70, 2020.

[12] Threlfall, R., 'National Hydrogen Strategies: An update on recent progress in the hydrogen markets,' KPMG, https://kpmg.com/xx/en/home/insights/2021/08/national-hydrogen-strategies.html.

[13] Government of India, Ministry of New and Renewable Energy, National Green Hydrogen Mission, 2023, https://mnre.gov.in/img/documents/uploads/file_f-1673581748609.pdf

***Box 1**: National Hydrogen Ambitions / Visions (selection)*

Chile: Become a clean energy provider for a carbon-neutral planet by developing a competitive green hydrogen industry and reduce 25% of carbon emissions by 2050 through reducing the country's reliance on fossil fuels in the mining, transport and agricultural sectors.

Colombia: Become a regional leader in energy transition thanks to its privileged geographic location and a stable regulatory and political framework capable of attracting long term investments and adapt the use of hydrogen into all its economic sectors.

Egypt: Become a global hub for green hydrogen production and export by developing a regulatory framework for the green hydrogen sector, investing in green hydrogen production and export facilities and promoting the use of green hydrogen in the transportation, industry, and power sectors.

France: Achieve mass production of hydrogen gas to promote carbon free hydrogen fuelled heavy mobility and to develop a fully integrated and competitive hydrogen production and use sector.

India: Become a global hub for production, usage and export of green hydrogen and its derivatives which will lead to significant decarbonisation of the economy, reduced dependence on fossil fuel imports and enable India to assume technology and market leadership in green hydrogen.

Mauritania: Become a major producer and exporter of green hydrogen and reap the benefits of the use of green hydrogen in its environmental, economic and social sectors.

Morocco: Provide a high level of green hydrogen production to satisfy local demand, optimise the use of national potential, particularly through exports, and create an economic and industrial sector around green molecules, namely hydrogen, ammonia, and methanol.

Namibia: Produce cost-effective electricity from green hydrogen, that could boost both local and regional energy supply and develop four hydrogen derivative products for export: ammonia, methanol, e-kerosene, and green hydrogen-based hot briquetted iron.

South Africa: Become a major producer and exporter of green hydrogen, capturing 4% of the global market share by 2050, decarbonize its economy and pursue a just transition away from coal.

Spain: Identify the challenges and opportunities for robust development of renewable hydrogen to provide a series of measures aimed at boosting investment positioning Spain to be a global technological leader in the field of green hydrogen.

United States of America: Increase clean hydrogen production and reduce its total GHG emissions by 10% by 2050 relative to 2005, by adopting hydrogen production and use in its industry, transport and energy sectors.

2.2.3. Hydrogen support initiatives and schemes

Support initiatives and schemes are crucial for developing a green hydrogen economy. Rapid deployment of renewable energy and electrolyser capacity is required to achieve economies of scale, and associated infrastructures and a regulatory ecosystem needs to be established to support delivery of renewable power, and for storage, transportation and utilization of green hydrogen for various applications, requiring substantial investment. Whereas total announced hydrogen investments until 2030 have increased by 35% from USD 240 billion to USD 320 billion in less than a year, committed capital must increase more than twentyfold to meet net-zero goals by 2030.[14]

To attain commercial feasibility, the hydrogen sector will require substantial support through public investment. Worldwide, there is a growing trend of introducing support initiatives and schemes aimed at hydrogen development. These measures may take the form of grants, dedicated funds, or other forms

[14] Hydrogen Council and McKinsey, Hydrogen Insights 2023: An update on the state of the global hydrogen economy, with a deep dive into North America, 2023.

of financial assistance. The main objective of these initiatives is to expedite the implementation of projects that promote the commercialization and widespread adoption of hydrogen and its derivatives, build a hydrogen value chain, and establish the required infrastructure. Many of these efforts are carried out through collaborative public-private partnerships. Globally, allocated government funding for hydrogen is significant and has reached 146 USD billion until 2030 and continues to grow; by far the largest budgets for national subsidies open to green hydrogen projects are found across the European Union and in the United States.[15]

Support initiatives and schemes play a critical role in enhancing research and development programmes, advancing understanding of the hydrogen market, supporting the development and dissemination of new technologies, enabling technical consultations and peer-to-peer dialogues, providing demonstration projects to test and showcase green hydrogen technologies, developing standards and certification schemes to ensure the quality and reliability of hydrogen products and services, capacity building and supporting the development of policy frameworks to provide a conducive environment for the growth of the hydrogen sector. As the global value chain for green hydrogen is in its nascency, international cooperation and engagements are particularly necessary for further bolstering national efforts. Hydrogen support initiatives and schemes are therefore crucial not only at the national level, but also at the regional and international level, enabling coordinated multi-jurisdictional efforts across all domains.

Table 1: Examples of initiatives and schemes supportive of green hydrogen

Initiative/Scheme	Relevance to green hydrogen
H2Global Funding Instrument	H2Global is a support scheme created by the German government to support producers and off-takers of green hydrogen by bridging the difference between the cost of clean production and the market price through the use of public funding.[16] This is through an intermediary, the Hydrogen Intermediary Company GmbH (HINT.CO), which is established as the government backed off-taker to buy through a competitive bidding process hydrogen derivatives on a long- term basis at the lowest possible price, and sell them on a short-term basis at the highest price. The instrument therefore stimulates both hydrogen production and demand.
European Hydrogen Bank (EHB)	The EHB is an instrument implemented by the European Commission, based on four pillars: (i) domestic market creation; (ii) imports to the European Union (EU); (iii) transparency and coordination; and (iv) financing mechanisms to support renewable hydrogen production within the EU and internationally. The EHB and H2Global have entered into an agreement opening up H2Global to all EU member states interested in running their own hydrogen tenders. The Bank and H2Global will also jointly develop a European auction targeting international hydrogen imports.[17] The first pilot auction will be based on €800 million drawn from the EU's Innovation Fund, fed by the bloc's carbon market.[18]

[15] Bloomberg, 1H 2023 Hydrogen Market Outlook - US takes the lead, March 2nd, 2023.

[16] H2Global Stiftung, https://www.h2-global.de/

[17] European Commission, Joint statement by Commissioner Simson and German Minister Habeck on energy issues, 31 May 2023, https://energy.ec.europa.eu/news/joint-statement-commissioner-simson-and-german-minister-habeck-energy-issues-2023-05-31_en

[18] European Commission, Questions and Answers: The Net-Zero Industry Act and the European Hydrogen Bank*, 16 March 2023, https://ec.europa.eu/commission/presscorner/detail/en/QANDA_23_1666

Initiative/Scheme	Relevance to green hydrogen
The US Inflation Reduction Act (IRA)	The IRA was passed by the Unites States (US) in 2022 and provides financial support through a lucrative set of tax credits intended to accelerate the deployment of clean energy technologies such as green hydrogen.[19] Under the IRA, producers can receive a tax credit of up to USD 3 per kg of hydrogen depending on the greenhouse gas (GHG) footprint of the hydrogen produced and further conditions, guaranteed for a 10-year period.[20]
The Hydrogen for Development (H4D) Partnership	The H4D Partnership was launched by the World Bank at COP27 in 2022 to boost the deployment of low-carbon hydrogen in developing countries. The partnership aims to raise and allocate blended finance for low-carbon hydrogen production and distribution projects and foster capacity building and regulatory solutions, business models, and technologies toward the rollout of low-carbon hydrogen in developing countries. Through the H4D Partnership, developing countries will gain further access to concessional financing and technical assistance to scale up hydrogen projects.[21] The Green Hydrogen Organisation will work to ensure green hydrogen is prioritized within this new program.[22]
EU Important Projects of Common European Interest (IPCEIs) in the hydrogen sector manifesto	*In December 2020, 22 EU countries and Norway signed a manifesto paving the way for a clean hydrogen value chain and committing to launch* IPCEIs in the hydrogen sector.[23,24] *In accordance with the manifesto the countries focus on projects that cover the full clean hydrogen value chain from production to storage, transmission and distribution, and the use of hydrogen particularly in industry. 76 clean hydrogen projects located in 15 European countries received approval in 2022 and will be provided with up to €10.6 billion in public funding. This is expected to unlock an additional €15.8 billion in private investments.*[25]
The Kreditanstalt für Wiederaufbau (KfW) Power to-X PtX Development Fund and the PtX Growth Fund	KfW Development Bank launched the world's first promotional platform for financing green hydrogen, the PtX Development Fund and the PtX Growth Fund. The PtX Development Fund aims "to support the establishment of local value chains and the use of hydrogen and derivatives in developing countries and emerging economies and to enable their connection to a technology of the future. Thus, the fund contributes to a social-ecological economic transformation in these countries and to a "Just Transition". The PtX Growth Fund is intended to support projects outside the EU/ European Free Trade Association (EFTA) with the participation of European companies based or operating in Germany. The aim is to promote the international market ramp-up of green hydrogen".[26]

[19] United States Environmental Protection Agency, Summary of Inflation Reduction Act provisions related to renewable energy, 2023.

[20] The International Council on Clean Transportation, Can the Inflation Reduction Act Unlock A Green Hydrogen Economy?, 2023.

[21] The World Bank, Press Release: World Bank Group Announces International Low-Carbon Hydrogen Partnership, 2022.

[22] Green Hydrogen Organisation, Getting the right blend Innovative development finance for the large-scale renewable and green hydrogen economy, 2023.

[23] IPCEIs are strategic instruments aimed at facilitating the emergence of large-scale cross-border projects of significant benefit to the EU economy and its citizens by addressing important market failures in strategic value chains.

[24] European Commission, Project: IPCEIs on hydrogen, https://commission.europa.eu/projects/ipceis-hydrogen_en#:~:text=In%20December%202020%2C%2022%20EU,IPCEIs)%20in%20the%20hydrogen%20sector

[25] European Commission, Project: IPCEIs on hydrogen, <https://single-market-economy.ec.europa.eu/industry/strategy/hydrogen/ipceis-hydrogen_en>

[26] KfW, Integrated financing for green hydrogen - a perfect fit and from a single source, https://www.kfw-entwicklungsbank.de/Our-topics/PtX/

Initiative/Scheme	Relevance to green hydrogen
The European Bank for Reconstruction and Development (EBRD) Green Hydrogen Loan Finance	EBRD offers financing to projects whose objectives align with the Paris Agreement. Its main objective is to finance environmental, demographics and technological transformation to build a more resilient and sustainable future.[27] EBRD has provided a USD 80 million loan to Egypt Green to develop the country's first green hydrogen facility.[28]
The Sustainable Development Goal (SDG) Namibia One Fund	The Fund, an innovative blended finance platform launched to facilitate and accelerate the development of a green hydrogen sector and economy in Namibia, was created through a partnership between the Environmental Investment Fund of Namibia (owned by the Namibian Government), Climate Fund Managers and the Dutch Invest International. The fund will provide capital for the development, construction and operations of hydrogen projects[29]; the resources from the fund will come from domestic and international partners, including an initial USD 40 million contribution from the Dutch government.[30] The fund has wide participation including from the European Investment Bank (EIB) which has signed a joint declaration with the Namibian government on a potential loan of up to €500 million financing renewable hydrogen and renewable energy investments.[31]

The European Union (EU), in addition to the initiatives to support market uptake has put in place the Carbon Border Adjustment Mechanism (CBAM) to prevent form entering in the EU territory products with carbon content.

Table 2: Examples of initiatives and schemes supportive of green hydrogen

European Union (EU) Carbon Border Adjustment Mechanism (CBAM)	The EU CBAM mechanism is an import tariff on carbon-intensive goods applied as an import tax paid by an importer when products enter the EU, specifically through the purchase of certificates representing embedded emissions in the goods. "*By assigning such a carbon price to imports, the CBAM aims to level the playing field by taxing foreign production with less-stringent emissions regulations and reducing the risks of carbon leakage*".[32] The EU CBAM mechanism applies to hydrogen, in addition to other products. However, as the scope of coverage for hydrogen in the CBAM currently involves only direct emissions, renewable hydrogen will be considered as having zero emissions and therefore, imports of this type will not incur CBAM charges, unlike other forms of hydrogen.[33]

[27] EBRD, The EBRD's Strategic and Capital Framework.

[28] Green Hydrogen Organisation, Getting the right blend: innovative development finance for the large-scale renewable and green hydrogen economy, 2023.

[29] Climate Fund Managers, Launch of the new 'SDG Namibia One Fund' at COP27 targets the development of a green hydrogen economy in Namibia, November 9, 2022, https://climatefundmanagers.com/2022/11/09/launch-of-the-new-sdg-namibia-one-fund-at-cop27-targets-the-development-of-a-green-hydrogen-economy-in-namibia/

[30] Global Trade Alert, Namibia: Launch of the Green Hydrogen and Derivatives Strategy.

[31] Green Hydrogen Organisation, Getting the right blend Innovative development finance for the large-scale renewable and green hydrogen economy, 2023.

[32] CSIS, Analyzing the European Union's Carbon Border Adjustment Mechanism, 2023.

[33] ERCST, The Inclusion of Hydrogen in the EU CBAM, 2023.

Very few green hydrogen projects have yet successfully secured funding or are currently in the implementation phase. Two notable examples of such projects are detailed below for Spain and Saudi Arabia.

***Box 2:** Examples of green hydrogen projects post Final Investment Decision (FID)*

In **Spain**, Iberdrola has taken the lead by commissioning a plant that produces green hydrogen specifically for industrial use. The plant, located in Puertollano, comprises a 100 MW photovoltaic (PV) solar plant, a lithium-ion battery system with a storage capacity of 20 MWh, and a 20 MW electrolyzer. With an investment of €150 million, this initiative is expected to generate up to 1,000 employment opportunities while preventing emissions of 48,000 tons of CO_2 per year. The green hydrogen produced at this facility will be utilized at the Fertiberia fertilizer plant in Puertollano, making it the first European company in the sector to develop significant expertise in large-scale green ammonia production, with a capacity exceeding 200,000 tons per year.[34] To support this project, Iberdrola has secured a loan of €53 million from the European Investment Bank (EIB).[35] In addition, the Spanish Government has recently granted €100 million in aid to seven projects aiming to integrate electrolysers into industrial settings for green hydrogen production.[36]

In **Saudi Arabia**, the NEOM Green Hydrogen Company has successfully reached financial close for the world's largest carbon-free green hydrogen plant, representing a total investment value of USD 8.4 billion.[37] The company is an equal joint venture between ACWA Power, Air Products, and NEOM. The plant, scheduled for operation in 2026, will use 4 GW of wind and solar energy to produce over 200,000 tons of green hydrogen annually, equivalent to more than 1.2 million tons of renewable ammonia.

2.2.4. Economics of green hydrogen

Currently, around the globe, green hydrogen is generally still more than twice as expensive as fossil or grey hydrogen, with green hydrogen costing around 4-5 USD/kg compared to less than 2 USD/kg for grey hydrogen (Figure 12).[38] However, the cost of green hydrogen is expected to decline significantly over the next decade.[39]

Recent trends and analyses suggest that the cost of green hydrogen production is decreasing thanks to several factors. Advancements in electrolyser technology and improved efficiency are important contributors to this cost reduction. Additionally, as the industry scales up, the costs of electrolysers are decreasing due to economies of scale. Furthermore, the continuous decline in the costs of renewable energy sources is playing a significant role in the overall reduction of green hydrogen production costs. On top of this, major economies such as the EU, the US or Australia are implementing ambitious national strategies to promote the adoption of green hydrogen. This concerted effort further enhances the competitiveness of green hydrogen, and it is anticipated that in the near future, green hydrogen will

[34] Iberdrola, Puertollano Green Hydrogen Plant: Iberdrola commissions the largest hydrogen plant for industrial use in Europe, https://www.iberdrola.com/about-us/what-we-do/green-hydrogen/puertollano-green-hydrogen-plant

[35] EIB, Spain: EIB and ICO sign first joint financing for green hydrogen development with Iberdrola, April 4, 2022, https://www.eib.org/en/press/all/2022-189-eib-and-ico-sign-first-joint-financing-for-green-hydrogen-development-with-iberdrola

[36] H2 View, Spain awards €100m to seven hydrogen projects, June 8, 2023, https://www.h2-view.com/story/spain-awards-e100m-to-seven-green-hydrogen-projects/

[37] NEOM, NEOM green hydrogen company completes financial close at a total investment value of USD 8.4 billion in the world's largest carbon-free green hydrogen plant, May 22, 2023, https://www.neom.com/en-us/newsroom/neom-green-hydrogen-investment

[38] Several factors influence the economics of hydrogen production, including the cost and efficiency of electrolysers, their utilization rate, the prevailing electricity cost (or average electricity purchase price during operation), as well as the cost of financing (for a discussion of green hydrogen production costs in Kenya see Chapter 4.3).

[39] For a discussion of long term cost trends for green hydrogen see IRENA, Global hydrogen trade to meet the 1.5 °C climate goal: Part III – Green hydrogen cost and potential, 2022, https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost; or ETS, Making the Hydrogen Economy Possible, 2021, https://energy-transitions.org/wp-content/uploads/2021/04/ETC-Global-Hydrogen-Report.pdf

achieve cost-competitiveness with fossil hydrogen in specific industry applications including, among others, refineries, ammonia production, and green steel.

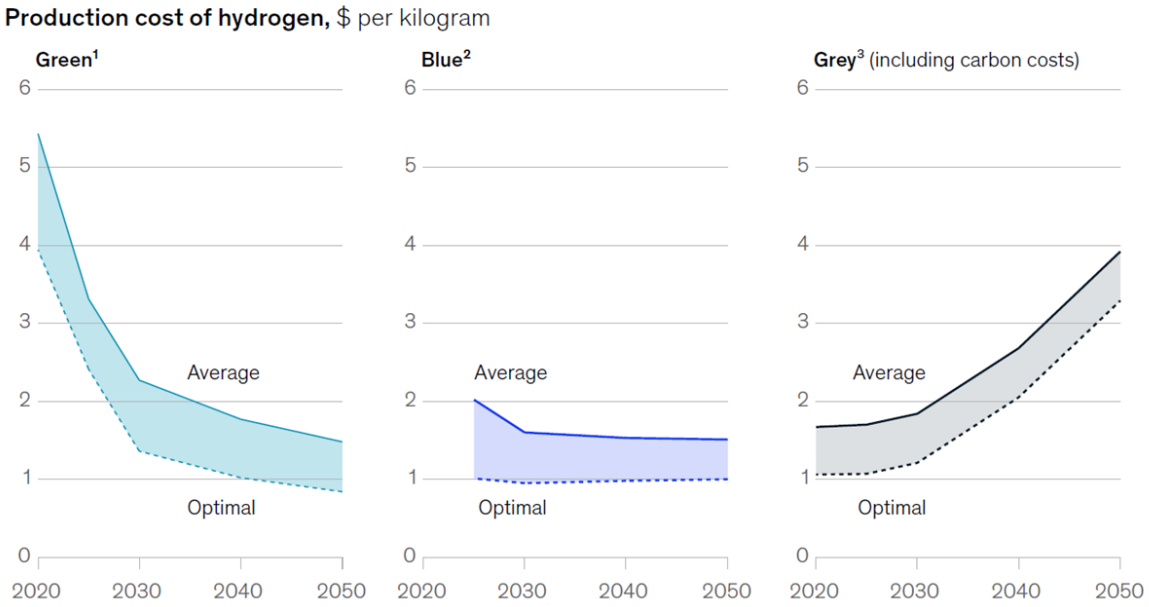


Figure 12: Overview of hydrogen production costs

(Source: McKinsey & Co, Five charts on hydrogen's role in a net-zero future, October 2022)

However, according to the Baseline study, "*the long-term sustainability of new green hydrogen products / applications in a competitive global market with established trade networks is uncertain, as the introduction of these products could potentially harm the interests and revenue of established market players. Despite their lower carbon footprint, the commercial viability of green hydrogen products will depend on the emergence of a market that values and is willing to pay a premium for low-carbon alternatives*".[40] To ensure the commercial viability of green hydrogen products, it will be necessary to provide short-term financial and market incentives to stimulate production and promote the adoption of hydrogen applications.

2.3. HYDROGEN TRADE FLOWS

The asymmetries in expected demand and production capabilities for green hydrogen, in different countries and regions, will drive international trade of hydrogen and its derivatives like ammonia or methanol. In other words, many countries not being able to meet their demand fully (for instance, as domestic hydrogen supply is constrained by available renewable capacity) and/or *cost-effectively* through domestic production will rely on partnerships with countries that have abundant renewable resources to close supply gaps (at potentially lower costs). This is likely to apply to some of the major future demand regions, including Europe, Japan, and South Korea, to meet their demand at competitive costs, thus having to resort to importing low-cost hydrogen and/or derivatives. It is important to note that pure hydrogen is a "neighbourhood" business, meaning hydrogen can be predominantly sourced domestically

[40] Ministry of Energy, GIZ, Baseline Study on the Potential for Power-to-X / Green Hydrogen in Kenya, 2022, https://energy.go.ke/wp-content/uploads/2022/04/Baseline-Study-on-the-Potential-for-Power-to-X-Green-Hydrogen-in-Kenya_Final-Report.pdf

or piped from nearby regions and is only shipped if these options are not feasible. Hydrogen derivatives, such as ammonia, however, can be easily shipped around the world in conventional tankers.[41]

Both McKinsey[42] and the International Renewable Energy Agency (IRENA)[43] have analysed scenarios on expected global hydrogen trade flows (Figure 13). According to McKinsey, by 2030, early trade routes will have been established: around ten trade routes will comprise volumes of more than one metric ton per annum (MTPA) of piped imports into Europe and shipped derivatives, while a variety of other smaller trade routes will begin to emerge. In addition, global clean ammonia demand will drive shipped exports from Australia, the Middle East, and North America, as well as initial flows from competitive production locations such as Latin America, North Africa and Southern Africa will start to emerge. By 2050, extensive and deep trade links could connect the globe, with more than 40 different trade routes with capacities between 1 to more than 20 MTPA. According to the analysis, Europe will primarily be supplied by pipelines, while Asia will be supplied by ships.

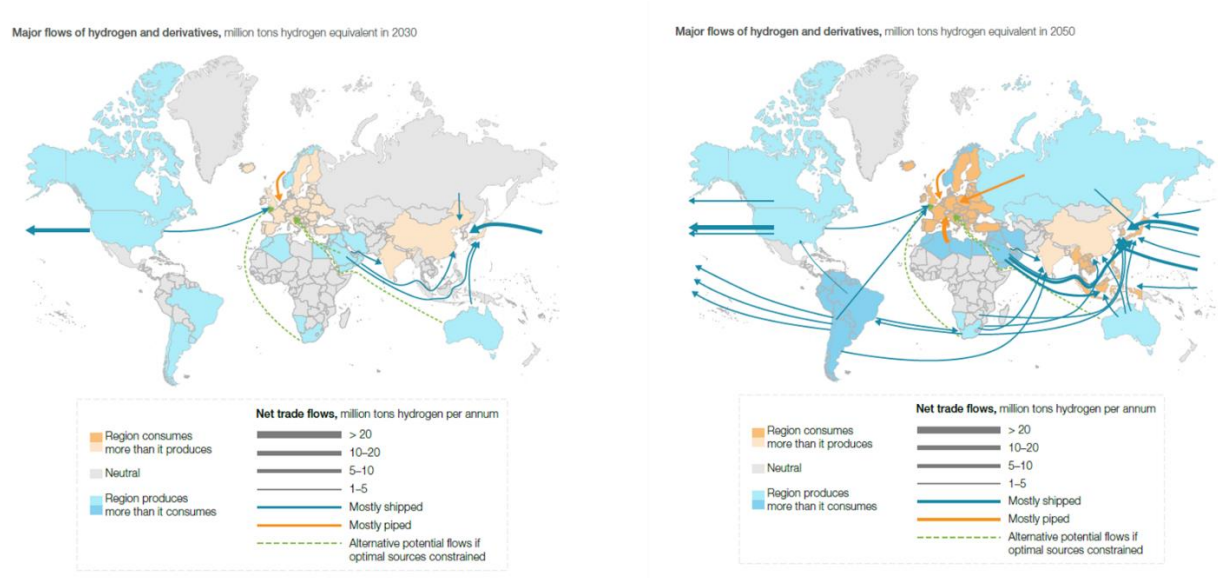


Figure 13: Expected major flows of hydrogen and derivatives; Kenya is not an obvious early (and competitive) exporter of hydrogen derivatives

(Source: Hydrogen Council and McKinsey & Company, Global hydrogen flows: Hydrogen trade as a key enabler for efficient decarbonization, October 2022)

2.4. AFRICA HYDROGEN INITIATIVES

As outlined above, today Europe and North America are still the global leaders in announced hydrogen projects, but Africa is fast emerging as a significant player in the realm of green hydrogen opportunities. The African continent has announced over 200% of new hydrogen production capacity over the last year[44]. With its abundant renewable energy resources, the continent has immense potential to harness the power of green hydrogen as a clean and sustainable energy solution. Africa's extraordinary green hydrogen potential has also been highlighted by the European Investment bank (EIB) which estimates

[41] For a discussion of technology options for long-distance shipping of hydrogen see IRENA, Global hydrogen trade to meet the 1.5 °C climate goal: Part II – Technology review of hydrogen carriers, 2022, https://www.irena.org/publications/2022/Apr/Global-hydrogen-trade-Part-II

[42] Hydrogen Council and McKinsey & Company, Global hydrogen flows: Hydrogen trade as a key enabler for efficient decarbonization, October 2022, https://hydrogencouncil.com/wp-content/uploads/2022/10/Global-Hydrogen-Flows.pdf

[43] IRENA, Global hydrogen trade to meet the 1.5 °C climate goal: Part I – Trade Outlook for 2050 and way forward, 2022, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Global_hydrogen_trade_part_1_2022_.pdf

[44] Hydrogen Council and McKinsey & Company, Hydrogen Insights 2023, 2023, https://hydrogencouncil.com/en/hydrogen-insights-2023/

some 50 million tons of green hydrogen and some 160 million tonnes of green fertilizer that could be produced across the African continent by 2035.[45] Additionally, the development of green hydrogen infrastructure and value chains can foster job creation, economic development, and regional integration.

Several African countries have recognized this potential and are actively pursuing green hydrogen initiatives. For instance, Morocco, Namibia and South Africa are exploring their green hydrogen opportunities and have embarked on ambitious green hydrogen strategies, aiming to produce green hydrogen for export as well as domestic use. Furthermore, partnerships and collaborations are being formed between African nations and international entities to leverage expertise, technology, and investment in the green hydrogen sector.

However, it is important to acknowledge that the journey towards a thriving green hydrogen sector in Africa is still in its early stages. Challenges such as infrastructure development, technology adoption, investment requirements, and regulatory frameworks need to be addressed. Nonetheless, with a concerted effort from governments, the private sector, and the international donor and financing community, Africa has the potential to leapfrog and harness the vast opportunities presented by green hydrogen.

More than 52 green hydrogen projects have been announced in different African countries, with production set to reach 7.2 million tonnes of green hydrogen by the end of 2035, according to Rystad Energy[46]. Most of these projects aim at exports of ammonia (as hydrogen carrier) to Europe, whose target is to import 10 million tonnes of renewable hydrogen by 2030[47].

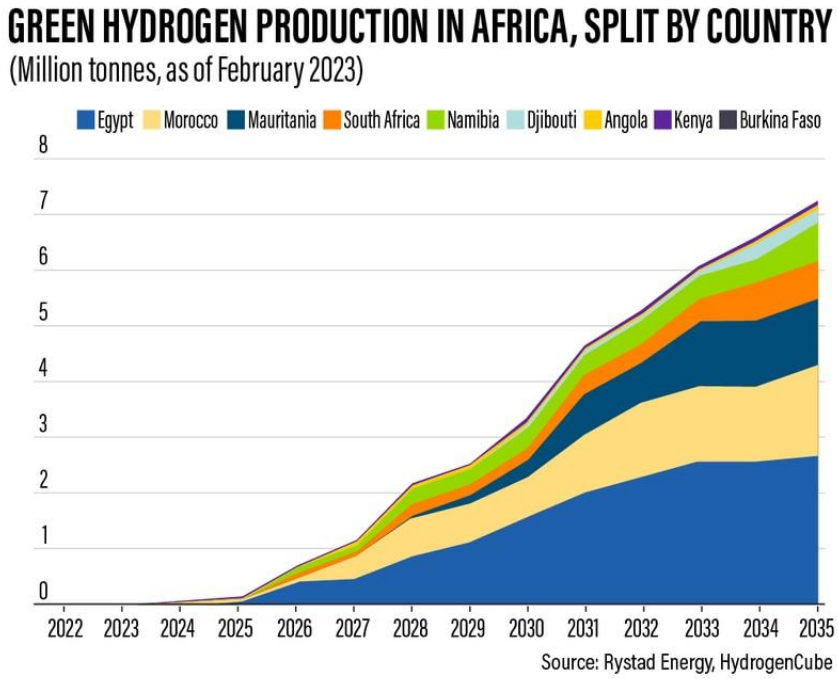


Figure 14: Overview of announced green hydrogen production capacities in Africa

(Source: National News, Africa could be a key green hydrogen supplier to Europe amid energy crisis, Rystad says, March 24, 2023[48])

[45] EIB, 2022, https://www.eib.org/attachments/press/africa-green-hydrogen-flyer.pdf

[46] Rystad Energy, Press Release: Africa and Europe set to be the dynamos for the global green hydrogen economy, March 21, 2023, https://www.rystadenergy.com/news/africa-and-europe-set-to-be-the-dynamos-for-the-global-green-hydrogen-economy

[47] European Commission, Hydrogen, https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en

[48] National News, Africa could be a key green hydrogen supplier to Europe amid energy crisis, Rystad says, March 24, 2023, https://www.thenationalnews.com/business/energy/2023/03/24/africa-could-be-a-key-green-hydrogen-supplier-to-europe-amid-energy-crisis-rystad-says/

In addition to that, a number of regional / African organisations have been set up to promote green hydrogen on the continent, including the Africa Green Hydrogen Alliance (AGHA), of which Kenya is an active member, and the Africa Hydrogen Partnership (AHP).

Africa Green Hydrogen Alliance (AGHA)

In 2022, AGHA was launched, amongst others by Egypt, Mauritania, Morocco, Namibia and South Africa, "*to intensify collaboration and supercharge development of green hydrogen projects on the African continent. The Alliance focuses on public and regulatory policy, capacity building, financing and certification needs to mobilise green hydrogen production for domestic use and export. (…) The alliance is a platform for collaboration with the private sector, DFIs and civil society*".[49] Kenya is considering to formally join AGHA.

Africa Hydrogen Partnership (AHP)[50]

The **AHP** is an initiative aimed at promoting the development and utilization of green hydrogen energy and advancing related business opportunities across the African continent. It is a platform for knowledge sharing, business intelligence, exchange and networking across various segments of the industry as well as for interacting with decisionmakers and stakeholders in Africa and other continents, and brings together governmental organizations, industry players, and financial institutions.

[49] Green Hydrogen Organisation, The Africa Green Hydrogen Alliance (AGHA), https://gh2.org/africa-green-hydrogen-alliance-agha

[50] African Hydrogen Partnership, https://www.afr-h2-p.com/

3. KENYA COUNTRY CONTEXT

3.1. ECONOMY

Kenya belongs to the group of the largest and most developed economies in Africa. Agriculture, manufacturing, and the services sectors are the main contributors to its Gross Domestic Product (GDP), which has risen to USD 113 billion in 2022 displaying a continuous and almost uninterrupted growth.[51] Agriculture is the backbone of the Kenyan economy, employing over 75% of the workforce and contributing over 20% of the country's GDP in 2022 (see Figure 15). The major agricultural exports for which Kenya is known are tea, coffee, cut flowers, and other horticultural products.

The industry sector, including manufacturing and transport, has been growing rapidly in recent years. It contributes 18% to Kenya's GDP and plays a crucial role for the country's economic development agenda and job creation; the sector is largely dominated by food / agro-processing, textiles, and garments. The services sector including financial services, tourism, and telecommunications accounts for around 60% of GDP, being a significant contributor to the Kenyan economy.

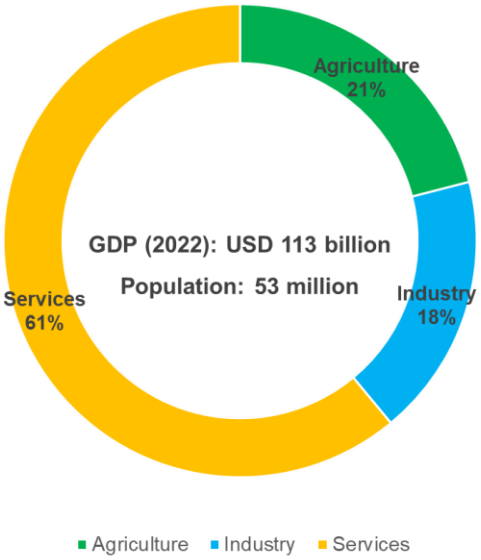


Figure 15: The Kenya economy - agriculture is the main driver; industrialization can drive further growth

(Source: Kenya National Bureau of Statistics, Economic Survey 2023[52])

In recent years, Kenya has faced several external challenges, such as the COVID-19 pandemic, recurring droughts, and the unpredictable fluctuations in global commodity prices. These factors have significantly impacted the country's economy. However, they have also provided opportunities to develop solutions and strategies to effectively address externally-induced economic shocks and promote the growth and resilience of Kenya's economy.

In this context, green hydrogen emerges as a significant opportunity for Kenya. It not only promotes the agricultural transformation and adds value to agricultural products but also fosters industrial development while bolstering the country's research and development capabilities.

[51] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=KE

[52] Kenya National Bureau of Statistics (KNBS), Economic Survey 2023, https://www.knbs.or.ke/download/economic-survey-2023/

3.2. POWER SECTOR

3.2.1. Kenya's renewable energy potential

Kenya enjoys an abundance of renewable energy sources, including geothermal, wind, solar and hydro, which together already have a share of close to 90% in the overall generation mix.[53] With a focus on transitioning further towards a green economy, the government has placed priority on the development of its renewable energy resources. Kenya's worldclass geothermal, wind and solar resources allow the country not only to meet its "Vision 2030" for a "clean, secure and sustainable environment", but also to support its industrialisation. The country's renewable energy potential is a great asset for the production of green hydrogen and derivatives, to support its development and decarbonisation goals and make Kenya a regional champion.

Geothermal energy

Kenya began geothermal exploration in 1952, commissioning the first 15 MW geothermal plant in 1981, and has since increased its installed geothermal capacity to over 950 MW, being number eight among geothermal electricity-producing countries worldwide, and the number one in Africa[54]. Currently, geothermal power generation is concentrated in the Olkaria and Eburru fields, while several other prospective fields are under development within the Kenya Rift Valley. Having an estimated geothermal potential of 10 GW_e[55] distributed in about 14 sites (see Figure 16) Kenya emerges as an important candidate to produce green hydrogen. Kenya's geothermal potential alone could theoretically produce up to 1.5 million tonnes of green hydrogen[56], or close to 8 million tonnes of ammonia per year.

With Kenya's geothermal power plants boasting an average capacity factor of over 90% and providing a stable electricity supply, coupled with the relatively low and non-volatile cost of geothermal electricity[57], Kenya stands as a prime candidate for embracing the emerging green hydrogen economy (together with other countries having significant geothermal resources like Iceland and New Zealand).

Although geothermal development in Kenya encounters various inherent risks, the primary challenges are the high upfront costs for scientific studies, and exploration and appraisal drilling.[58] To accelerate the development of the sector and de-risk the exploitation of geothermal resources, the Geothermal Development Company (GDC) was established in 2008. GDC is a fully government-owned entity tasked with the responsibility of exploring and developing steam fields, as well as selling geothermal steam for electricity generation. The buyers of this steam are either Kenya Electricity Generating Company (KenGen) or Independent Power Producers (IPPs), who can focus solely on power generation.[59]

---

[53] Energy & Petroleum Regulatory Authority (EPRA), Energy & Petroleum Statistics Report 2022, 2022

[54] IRENA, Global geothermal market and technology assessment, 2023, https://www.irena.org/Publications/2023/Feb/Global-geothermal-market-and-technology-assessment

[55] Ministry of Energy, Updated Least Cost Power Development Plan, 2022-2041, June 2022.

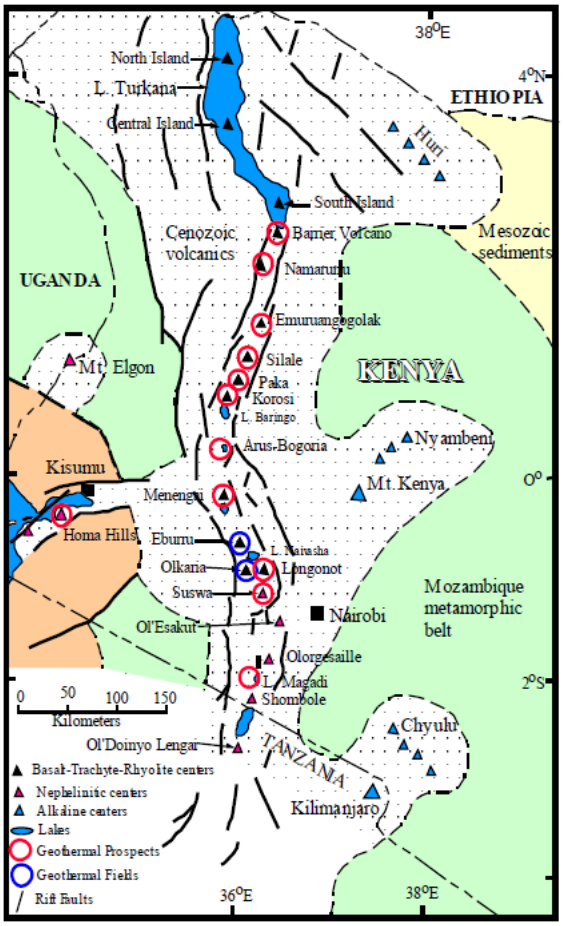
[56] i.e. about 15% of the EU's renewable hydrogen production target for 2030. See https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en

[57] The levelized cost of electricity (LCOE) from geothermal power projects in Kenya average between USD 0.04 and USD 0.14 per kWh (over 25 years), according to Kenya Electricity Generating Company (KenGen); globally, the LCOE for geothermal remained largely within the range of USD 0.05-0.07 per kWh over the last decade (IRENA, Global geothermal market and technology assessment, 2023).

[58] The cost for drilling a single geothermal well to between 2,000 m to 3,000 m ranges from USD 3 to 5 million, and a minimum of three exploration wells are required to prove the resource; typical costs for geothermal power plants range from USD 1,870 to USD 5,050 per kW, noting that binary plants are normally more expensive than dry steam and flash plants (according to KenGen). Geothermal power development in Kenya has historically focused on large-scale projects that involve extensive drilling, steam gathering and delivery systems, and the construction of large geothermal power plants, taking 7 to 10 years to complete. This approach has faced challenges in resource viability and financing, and driving up the cost of geothermal power. A more modular approach, breaking down development into smaller steps, may offer flexibility, reduce financial risk, and allow for incremental resource validation, potentially leading to faster completion and lower LCOE.

[59] 85% of the geothermal capacity is operated by KenGen and 15% by IPPs (EPRA, 2022).

GDC holds the production license and incorporates a profit model when selling the geothermal steam. Geothermal power licenses in Kenya typically have a duration of 30 years, and there is a possibility of renewing them for an additional five-year period.



Rift Region (MW)	Potential
Central Rift	
Menengai	1,600MW
Eburru	250MW
	1,850MW
South Rift	
Olkaria	2,000MW
Longonot	750MW
Suswa	600MW
Lake Magadi	100MW
	3,450MW
North Rift	
Lake Baringo	200MW
Korosi	450MW
Paka	500MW
Silali	1,200MW
Emuruangogolak	650MW
Namarunu	400MW
Barrier	450MW
Arus Bogoria	400MW
	4,250MW
Nyanza	
Homa Hills	100MW
Akira	350MW

Figure 16: Geothermal potential in Kenya

(Source: Ministry of Energy, Least Cost Power Development Plan, 2021-2030)

Wind energy

Kenya's wind potential is among the best in Sub-Saharan Africa with 73% of the country experiencing wind speeds above 6 m/s or higher at 100 m above ground level (according to the Ministry of Energy). The International Finance Corporation (IFC) has estimated that for the areas where wind speed is above 8.5 m/s Kenya's technical wind potential can reach 140 GW.[60] The best wind sites are found in the North of the country, mainly around Lake Turkana (see Figure 17), making this region promising for future wind power development (including for hydrogen production). The 310 MW Lake Turkana wind Public-Private Partnership (PPP) project with an annual average capacity factor of over 60%[61] is an excellent proof of Kenya's exceptional wind conditions.

[60] IFC, Exploring Africa's Untapped Wind Potential, 2020.

[61] Finnfund, Finnfund sells its shares in Lake Turkana Wind Power to BlackRock, March 16, 2023, https://www.finnfund.fi/en/news/finnfund-sells-its-shares-in-lake-turkana-wind-power-to-blackrock/

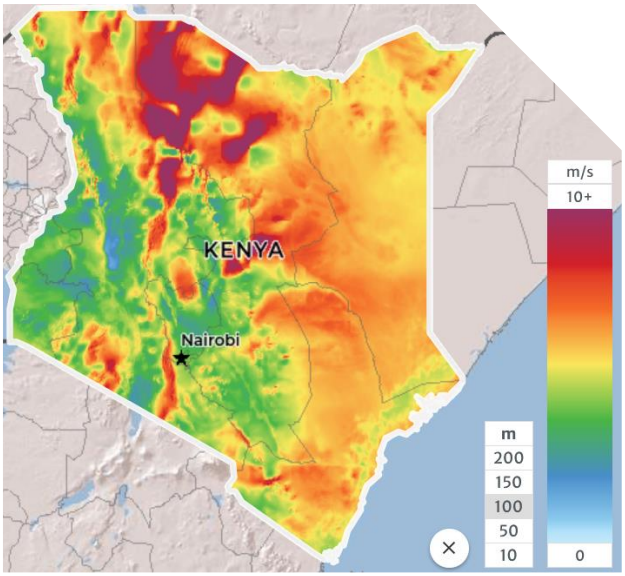


Figure 17: Kenya's wind energy potential

(Source: World Bank Group et al., Global Wind Atlas, 2023, https://globalwindatlas.info/en)

Solar energy

Kenya also has a vast potential for solar energy, which is hardly tapped. Kenya's excellent solar conditions in some parts of the country, with average yields in the range of 1,700-1,800 kWh/kWp (Figure 18) and capacity factors of around 20% constitute a significant energy asset of the country, with potentially very low levelized cost of electricity (LCOE).

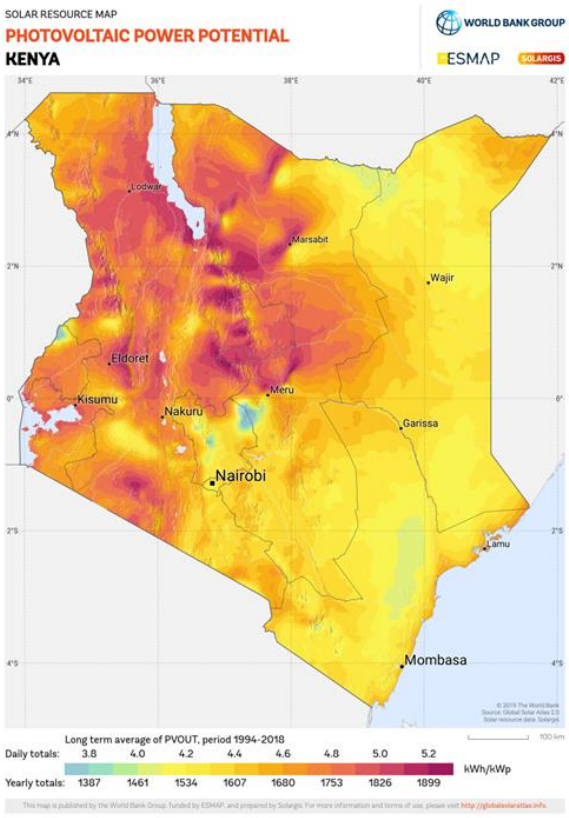


Figure 18: Solar resource map - Kenya

(Source: World Bank Group, Global Solar Atlas, 2023, https://globalsolaratlas.info/map)

Hydroelectric power

Kenya's potential for hydro stands in the range of 3,000 - 6,000 MW[62], with over 800 MW already exploited mainly in large installations owned by KenGen. There are plans to develop new large hydro projects, however, the share of hydropower in Kenya's electricity mix has been continuously declining and keeps being affected by adverse climate impacts, such as severe droughts. To this end, hydro power is not considered as a priority source for hydrogen production in the frame of this roadmap, but should stay in focus of future hydrogen developments.

3.2.2. Electricity supply and demand

Kenya's total installed electricity generation capacity exceeds 3,000 MW, up from around 2,300 MW in 2016. The total annual electricity generation is 12.6 GWh, with close to 90% coming from renewable energy sources, including geothermal, hydro, solar, and wind power (Figure 19Figure 19). Geothermal energy accounts for 31% of the total installed capacity, with well over 950 MW, and nearly 40% of the total electricity generation. Kenya has an installed wind capacity of approximately 435 MW, with the largest wind farm, Lake Turkana, having a capacity of 310 MW. The country has also four operational utility-scale solar photovoltaic power plants, ranging from 40-50 MW in capacity. This significant reliance on renewable energies puts Kenya in a unique position for green economic growth and exploring opportunities related to the production of green hydrogen.

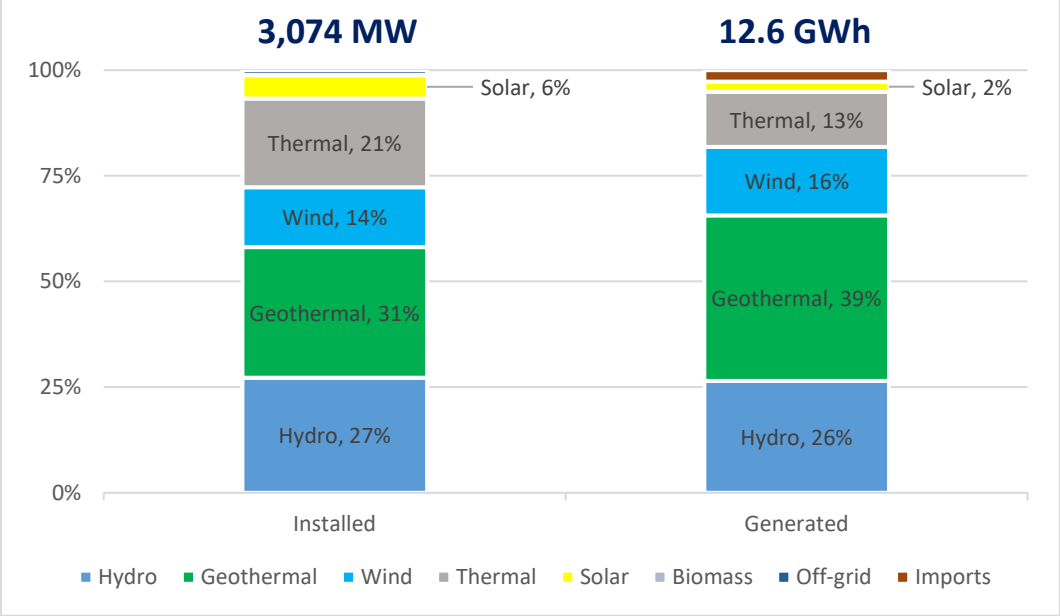


Figure 19: Kenya's power mix – installed capacity and electricity generation by source

(Source: Energy & Petroleum Regulatory Authority (EPRA), Energy & Petroleum Statistics Report 2022)

As per the latest Least Cost Power Development Plan (LCPDP) 2022-2041 developed by the Ministry of Energy and Petroleum, the planned expansion of generation capacity up to 2041 will mainly be based on renewable energy (see Figure 20) and is expected to follow the expansion trends displayed in the recent past, when between 2016 and 2021 peak load demand rose from 1,636 MW to 2,036 MW, showcasing an average growth rate of approximately 5%.

[62] Ministry of Energy, Updated Least Cost Power Development Plan, 2022-2041, June 2022.

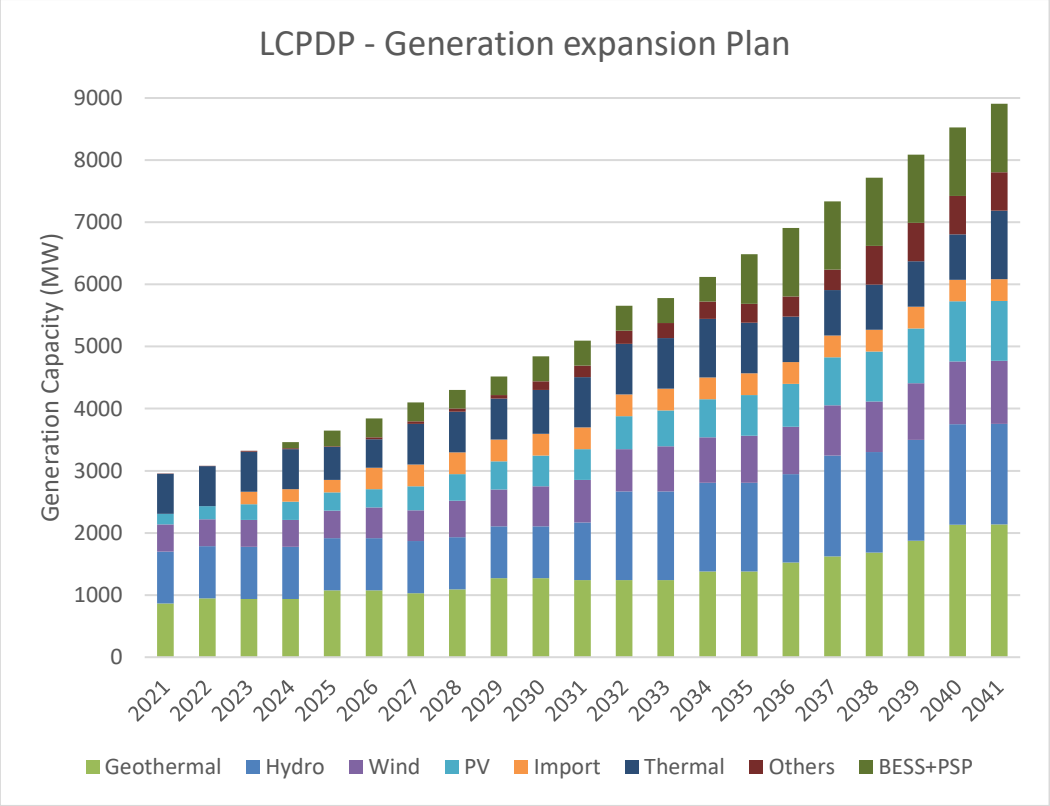


Figure 20: Planned generation expansion (net capacity), own representation

(Source: own analysis according to LCPDP 2022-2041)

The daily shape of the electricity demand curve remains relatively consistent throughout the year, but shows significant variations in diurnal demand ranging from 1,100 to 1,900 MW (in 2022) (Figure 21). In Kenya, the peak period for electricity consumption is relatively short, lasting only up to five hours (*Figure 21*). During the night time, as peak demand drops by about half from 7pm[63], there is considerable spare capacity available due to the inherent characteristics of Kenya's electricity system, which is marked by excess baseload, provided predominantly by geothermal power at night.[64] As demand falls below the available generation capacity, electricity curtailment is implemented, mainly by venting geothermal steam. For instance, in the period from July 2021 to June 2022, a total of 244 GWh_{el} originated from geothermal sources was curtailed (another 41 GWh wind power was curtailed in the same period) as per the Energy and Petroleum Regulatory Authority (EPRA) 2022 Statistics report.

Curtailment of geothermal power during hours of low demand is expected to persist in the future. The latest LCPDP acknowledges this situation and proposes the implementation of battery energy storage systems (BESS) and pumped-storage plants to accommodate surplus steam (while also catering for peaking capacity gaps). In an effort to “flatten” the electricity demand profile, efforts are being made to encourage industries, through Demand Side Management (DSM) measures, to adopt different demand patterns. As a result, vented steam may eventually be utilized, leading to potentially lower geothermal electricity generation costs in the country.

[63] The period between midnight and 4:30am experiences the lowest demand, mainly coming from industries operating 24 hours a day.

[64] It should be noted that geothermal plants in Kenya primarily employ single flash technology, which lacks the technical ability to provide flexible power and can lead to steam resource depletion through venting (as per LCPDP 2022-2041). To enhance operational flexibility, there is potential for future geothermal plants to adopt load following and load regulation technologies, such as binary systems, which will reduce the amount of steam being vented.

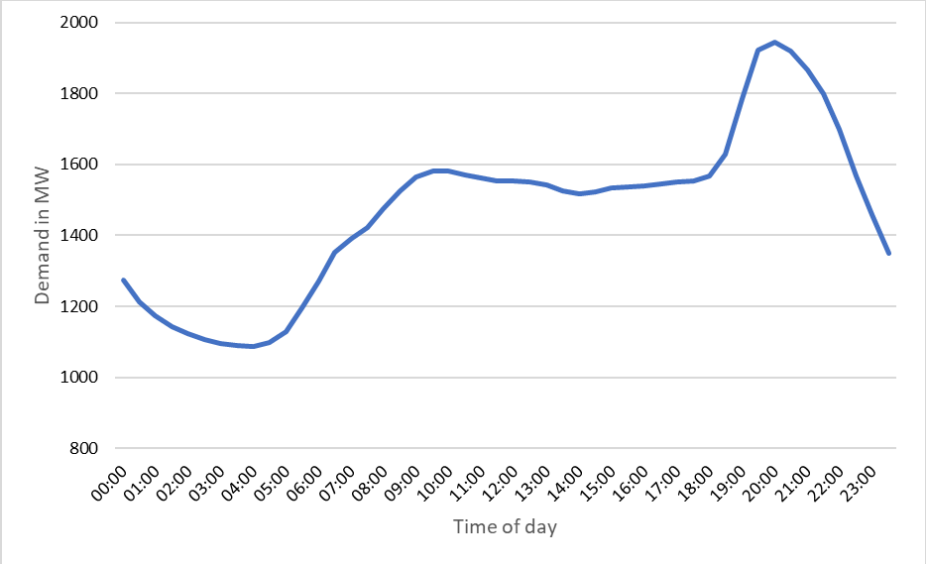


Figure 21: Average daily demand curve 2022

(Source: EPRA, 2023)

During periods of generation curtailment, vented steam, i.e. geothermal electricity (at minimal marginal cost) could potentially be used for producing hydrogen, albeit with the electrolyser operating at a very low capacity factor (well below 20%).

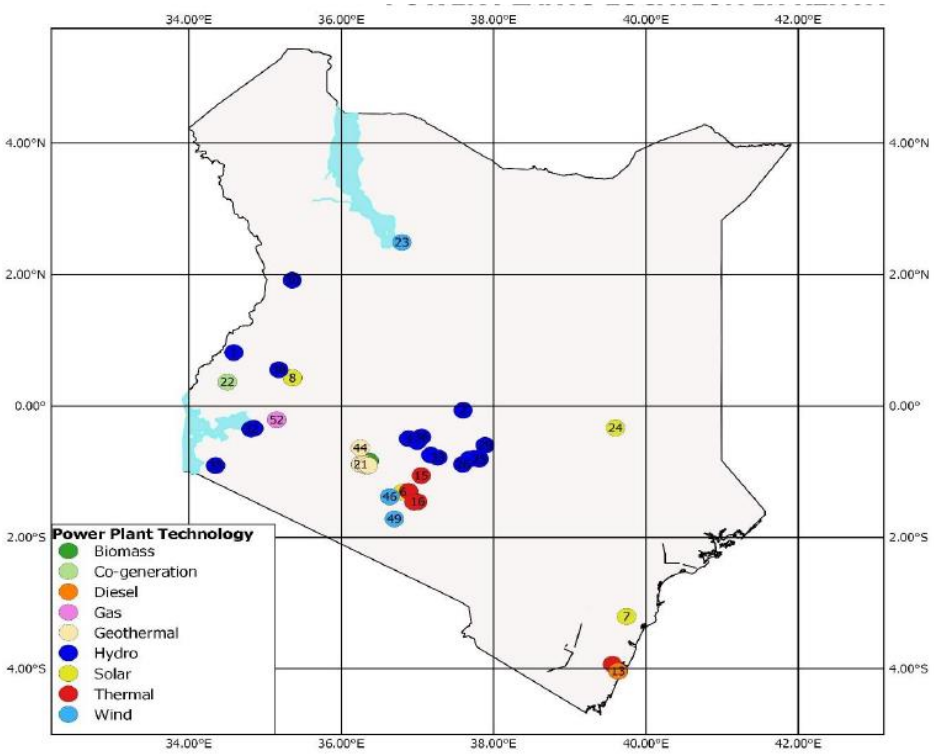


Figure 22: Power plants location in Kenya

(Source: LCPDP 2022-2041)

3.2.3. Power infrastructure

The transmission and distribution network in Kenya has seen a significant expansion in recent years due to consistent efforts by the Government. As of 2021, the transmission network length (comprising 400 kV, 220 kV, and 132 kV lines) was approximately 7,220 km and is owned by the two state-owned companies Kenya Power and the Kenya Electricity Transmission Company (KETRACO), with shares of 52% and 48%, respectively[65]; the transmission substation capacity is at 5,455 MVA[66].

The KETRACO Transmission Masterplan plans for transmission projects to match the generation plan and demand forecast as per the LCPDP. In determining the availability of transmission capacity, KETRACO therefore considers the location of the planned projects, capacity, and the existing grid constraints among other factors. In cases where there is no availability of capacity, new transmission infrastructure or reinforcement of the existing one will be needed (at the cost of the project investor); availability of transmission capacity is therefore project specific, as may be the case for green hydrogen projects, especially if electricity generation is not co-located with the electricity demand by the electrolysers[67]. The planned evolution / expansion of the transmission grid (2023 vs. 2027) is displayed in Figure 23.

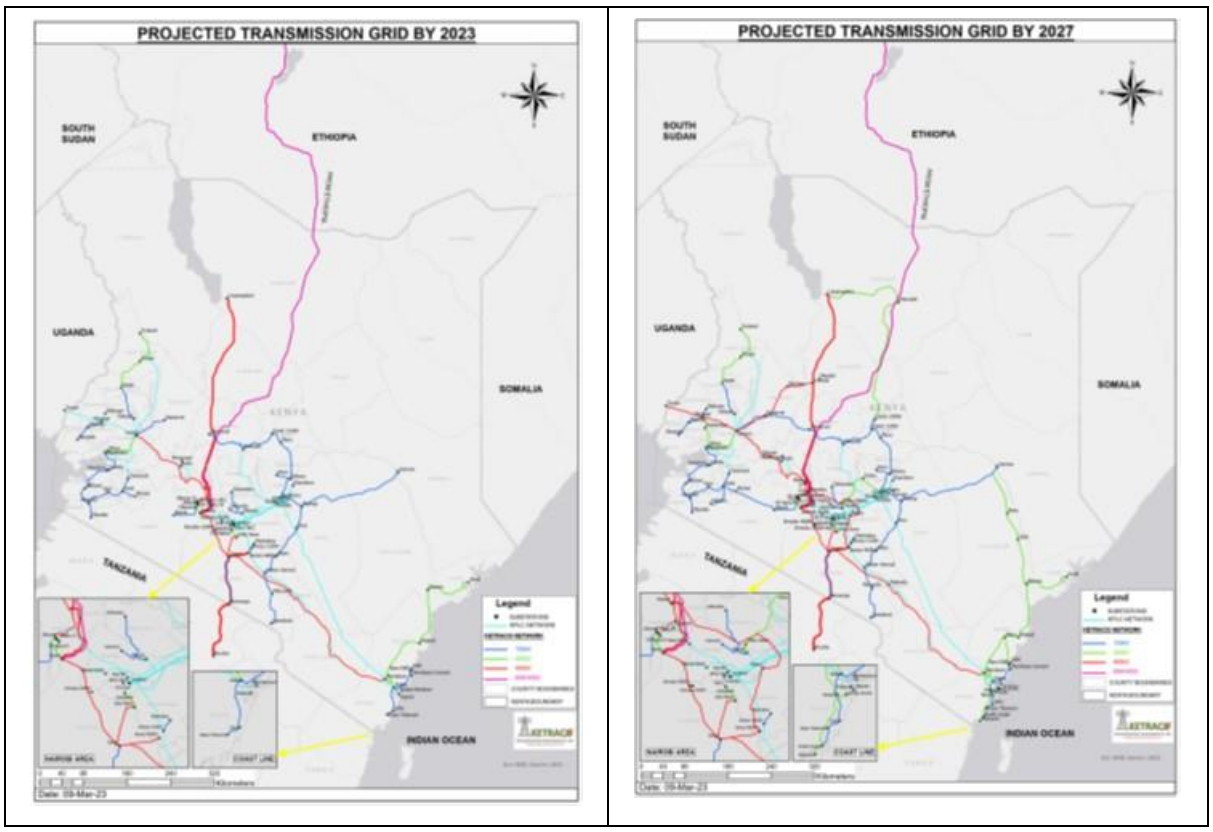


Figure 23: Kenya's transmission grid – 2023 and projection until 2027

(Source: KETRACO Transmission Masterplan 2020-2040)

[65] KETRACO Transmission Masterplan 2020-2040.

[66] LCPDP 2022-2041.

[67] Such a case requires, besides the technical adequacy of the infrastructure, clear provisions (e.g. wheeling charges) in the regulatory framework.

3.2.4. Electricity tariffs

EPRA in Kenya is responsible for establishing electricity tariffs in the country. Over the course of one year, retail electricity tariffs on a USD basis in Kenya have increased by 40-60%. This increase has particularly affected commercial and industrial clients, with tariffs reaching over 200 USD/MWh for the largest consumers (Figure 24Figure 24, left side). The energy charge, which includes generation, transmission, and distribution, contributes 93 USD/MWh or close to 50% of the overall tariff. Additionally, there are additional charges, taxes, and fees imposed on top of this.[68]

Kenya has established industrial clusters and Special Economic Zones (SEZs) across the country to encourage industrialization, enhance competitiveness, and promote investments through incentives and government support. As per the latest 2023 EPRA tariff review[69], a special SEZ category exists within the new tariff structure: investors domiciled in the 15 SEZ will pay a harmonised special tariff (energy charge) of Sh10/kWh (77 USD/MWh) to entice more firms to set up in these designated zones, but with the same "additional fees and taxes" applied on top.

In conclusion, it could be stated that the grid electricity tariffs in Kenya are generally high, being prohibitively high for the viability and competitiveness of green hydrogen projects, if applied. Benchmark tariffs for grid-connected renewable energy auctions for geothermal, solar, and wind in Kenya are displayed in Figure 24 (right side). These benchmark tariffs, which represent an upper limit or ceiling for the pricing of renewable energy projects (i.e. Power Purchase Agreements, PPAs), range between 57 and 65 USD/MWh, and have been considered as a proxy for the LCOE of these particular sources in Kenya. Important to note though is the fact that developers (of green hydrogen projects) are free to develop captive renewable power projects at potentially lower costs. To lower electricity costs for hydrogen production, in addition to captive power projects or corporate PPAs, it is worth exploring alternative options such as setting up SEZs dedicated to hydrogen sites or implementing waivers for taxes and other charges or fees.

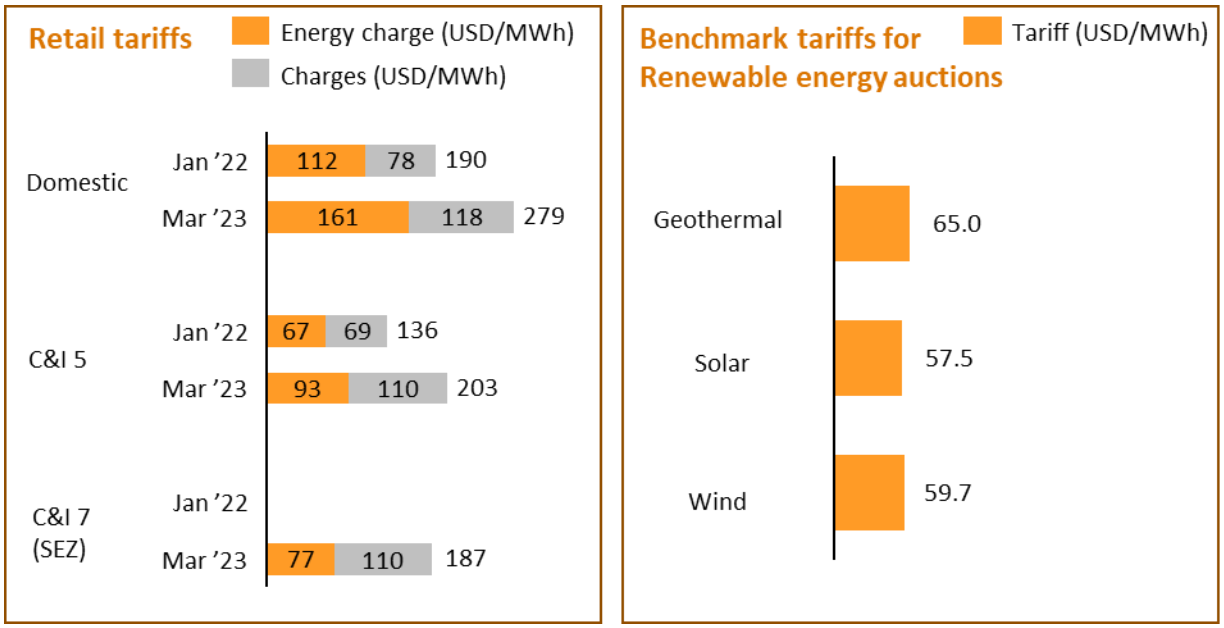


Figure 24: Power price analysis

(Source: own analysis, https://www.stimatracker.com, The Kenya Gazette, November 23, 2021)

[68] Charges include FCC (Fuel Energy Cost), FERFA (Foreign Exchange Rate Fluctuation Adjustment), IA (Inflation Adjustment), WARMA (Water Resource Management Authority), ERC (Energy Regulatory Commission), RER (Rural Electrification Program), VAT (Value Added Tax). There are also demand charges applicable to certain categories of users.

[69] https://www.epra.go.ke/retail-electricity-tariff-review-for-the-2022-23-2025-26-4th-tariff-control-period-tcp-effective-1st-april-2023/

Notes: Jan '22 113 Khs/USD; Mar '23 130 Khs/USD

3.2.5. Key energy policies, plans and strategies

The overarching goal of Kenya's energy policy framework is to achieve universal access to affordable, reliable, and modern energy services to improve socio-economic well-being. Key energy policies, plans and strategies include:

- The **National Energy Policy, 2018:** This is Kenya's umbrella policy for the energy sector, focused on among others, promoting renewable energies and private sector participation in the energy sector. It highlights the need for the provision of incentives for the uptake of renewable energy technologies, and highlights the responsibility of the national government to inter alia, develop an Integrated National Energy Plan support development of new transmission lines and facilitate open access to the transmission and distribution network, which would be instrumental for green hydrogen. This policy thus forms the basis for the creation of an enabling regulatory framework for the integration of green hydrogen in national development;
- **LCPDP, 2022-2041:** The LCPDP is Kenya's long-term strategic roadmap that outlines the optimal and cost-effective development of the country's power sector. The LCPDP is updated biennially to account for changes in the macroeconomic environment, introduction and application of new technologies and changes in national priorities. These biennial updates identify existing potential in generation, possible investments in transmission, forecasts future power demand and how best it can be met at least cost, and provide an opportunity for the further inclusion of green hydrogen in Kenya's power planning;
- **Kenya's National Energy Efficiency and Conservation Strategy, 2020:** The strategy is a key framework policy document of the Government to enhance its efforts and effectiveness in reducing the demand for fossil fuels and related GHG emissions, by enhancing the potential of renewable energy sources to meet the country's energy needs. The strategy is also crucial for setting quantitative targets on energy efficiency improvements in key economic sectors and identifying specific actions to achieve them, which would be important to stimulate demand for green hydrogen.

In addition to the above existing policy framework, there are significant policy developments underway in Kenya's energy sector that would contribute to the further development of a green hydrogen economy. For example, the country is in the process of developing its draft **Captive Power Policy** which would allow large energy consumers, such as industrial and commercial entities, to generate their own electricity for self-consumption therefore facilitating a more decentralized and sustainable energy landscape in Kenya. Kenya is also in the process of developing its **Energy Sector Roadmap 2040 (Kenya Energy White Paper)** which aims to outline the path that Kenya needs to take to achieve its envisioned energy goals and bring unprecedented growth to the energy sector. The roadmap recognises that Kenya is attractive to entrepreneurs with regards to new energy technologies such as green hydrogen, and highlights that Kenya needs to develop industrial applications for hydrogen, tap into its renewable energy resources and actively take steps to lead the region in the adoption of a fully green energy pathway. Further to this, Kenya has also drafted the **Renewable Energy Auctions Policy, 2021** which is designed to procure renewable energy capacity at competitive prices by promoting the development of renewable energy projects through a transparent and competitive bidding process. The policy which is currently pending operationalization has the potential to lower costs of electricity for green hydrogen production.

Development planning in Kenya also has a significant bearing on the energy sector. Key energy-related policy documents in this regard include:

- **Vision 2030:** This is the country's long-term development blueprint. It was launched in 2008 with the objective of transforming Kenya into a middle-income country by the year 2030. The vision aims to achieve sustainable economic growth, social equity, and improved quality of life for all Kenyans. It focuses on three key pillars: economic, social, and political governance and highlights the crucial role the energy sector plays in driving economic growth and social development. The energy sector's policies and initiatives are aligned with the overall vision and contribute to its realization. achieving reliable, affordable, and sustainable energy for all Kenyans;

- **Medium Term Plans:** The implementation of Vision 2030 involves collaboration between the government, private sector, and civil society, with a strong emphasis on innovation, investment, and infrastructure development to realize its ambitious goals. Kenya's Vision 2030 is implemented through five-year Medium Term Plans (MTPs), and Kenya is currently implementing MTP 4, from 2023 until 2027, which makes provision on green hydrogen;
- **The Bottom-up Economic Transformation Agenda (BETA)**: The BETA Plan spans the period 2022-2027 and comprises the government's overarching development agenda for the set-out period. BETA recognises the vital role that electricity plays in the economic and social sectors and its importance in ensuring a good quality of life for all citizens. It further recognises the need to upgrade Kenya's electricity distribution and transmission network to increase its power responsiveness to consumers. BETA further recognises that Kenya is rich in the resources necessary to produce renewable energy and that its integration into the energy grid could help make energy distribution and supply more efficient.

Kenya, like other countries in the region, is bearing the brunt of climate change impacts, such as droughts and floods, and the associated socio-economic losses.[70] In response to these challenges, Kenya has developed a robust climate policy framework that also has a bearing on the energy sector. Policies, plans and strategies relevant to green hydrogen include:

- The **Nationally Determined Contribution (NDC):** Kenya submitted its Updated First NDC to the United Nations Framework Convention on Climate Change (UNFCCC) in 2020 as part of its commitment under the Paris Agreement to mitigate GHG emissions and adapt to climate change. Under the NDC, Kenya has committed to reducing its GHG emissions by 32% by 2030 (relative to the Business as Usual (BAU) scenario). Some of the priority mitigation activities that Kenya is committed to undertake is increasing of renewables in the electricity generation mix of the national grid and the use of clean, efficient and sustainable energy technologies to reduce over-reliance on fossil and non-sustainable biomass fuels;
- **National Climate Change Action Plans (NCCAPs):** Kenya develops NCCAPs every five years, which aim to foster a low-carbon climate resilient economy and set out the national plan for action. NCCAP 2018-2022 recognizes the need to increase the use of renewable energy for electricity generation and increase the energy sector's climate resilience, and the country is currently in the process of developing NCCAP 2023-2027 to further mainstream climate change in all sectors of the economy and at all levels of government;
- **The national Long Term Low Emission Development Strategy (LT-LEDS)**: Kenya is in the final stages of developing its LT-LEDS to set out the most viable path towards net zero by 2050 building upon the commitments in the country's NDC. The LT-LEDS calls for a transition from the use of fossil fuels in the transport sector to electric and hydrogen fuelled vehicles with a goal to have 30% of all vehicles on the road to be electric by 2050. The strategy also aims to replace 40% of coal with hydrogen in the production of cement, replace 15% of heavy fuel oil used with electricity and hydrogen in food and beverage manufacturing. It also recognizes the need to increase the use of green hydrogen in large industries such as those producing chemicals, paints, steel and pharmaceuticals.

The policies, strategies, and plans outlined above form the comprehensive policy framework guiding the advancement of Kenya's energy sector. Many of these initiatives mention renewable energy and clean technology and they serve as valuable foundations that can be harmonized with the objective of fostering the growth of Kenya's green hydrogen industry.

[70] Government of Kenya, Kenya's Updated Nationally Determined Contribution, 2020.

3.3. AGRICULTURAL SECTOR

3.3.1. The importance of the agricultural sector for Kenya

As outlined above, agriculture is the cornerstone of Kenya's economy and remains a vital sector contributing over 20% of the GDP, providing livelihoods for the majority of the population, particularly those living in rural areas, employing a large portion of the population and contributing to both domestic consumption and exports.

Box 3: *The agricultural sector*[71]

- **Contributes >21% of GDP**: Agriculture is a vital sector in Kenya's economy, accounting for about one quarter of the country's GDP, thus being a significant contributor to the overall economic growth of the country.
- **Provides livelihood for >80% of Kenyans**: Agriculture is the backbone of Kenya's economy, highlighting its importance in sustaining the well-being of the majority of Kenyans. Most of the people engaged in agriculture are small-scale farmers who rely on it for food and income, thereby directly impacting the cost of living.
- **Employs >40% of total population**: Beyond farmers, the agricultural sector is a significant employer in Kenya and provides jobs for more than 40% of the country's population, through linkages to other sectors such as manufacturing and agro-processing industries, distribution and services.
- **Employs >70% of rural population**: In rural areas, agriculture provides employment for more than 70% of the population, making agriculture a crucial sector in reducing rural poverty and promoting rural development.
- **Accounts for 65% of export earnings**: Agriculture is a significant earner of foreign exchange for Kenya, accounting for about 65% of the country's total export earnings and enhancing the country's trade balance. This includes exports of cash crops such as tea, coffee, and flowers, as well as horticultural products, vegetables, and fruits.
- **Agro-processing accounts for >50% of the manufacturing GDP**: Agro-processing is an important sub-sector of Kenya's manufacturing industry and involves processing agricultural products into finished goods, creating additional value and job opportunities in the economy.

"*Kenya can further leverage the agriculture sector to spur growth, poverty reduction, and food security; supporting farmer groups to link into sustainable value chains will also help to better feed Kenya during periods of drought and boost food resilience*".[72] Moreover, the implementation and utilization of green hydrogen present a significant opportunity for Kenya to shift to greener and more sustainable practices and enhance the value of its agricultural products and strengthen its export orientation.

3.3.2. The role of fertilizers - opportunities and challenges

Fertilizers are crucial for agriculture as they replenish essential nutrients in the soil and enhance crop growth, increase yields, and contribute to improved food production and food security. Fertilizers with nitrogen content are the dominant products worldwide displaying continuous growth trends, expected to continue in the future, as nitrogen is one of the three primary nutrients for plant growth and the one

[71] FAO, Kenya at a glance, https://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/; National Treasury, 2023 Budget Policy Statement; Central Bank of Kenya, Agriculture Sector Survey, November 2022; Agricultural Sector Growth and Transformation Strategy 2019-2029

[72] World Bank Group, Kenya Economic Update, Edition No. 26, December 2022

plants demand the most e.g. for photosynthesis and protein production and growth. Hence, nitrogen-based fertilizers play a vital role in food production and nutrition.

Kenyan farmers use a variety of inorganic fertilizers for production of different crops, as displayed in Figure 25 and, despite year-on-year variations (from 400-800 kt), there has been a general growth trend, amounting to a total apparent consumption in 2021 of 750 kt. The average fertilizer use over the last five years was 720 thousand tons (kt) or an equivalent of approximately 65 kg per hectare of arable land as compared to a world average of 146 kg/ha[73], indicating a considerable potential for future demand growth. To address the "under-fertilization" issue, which can hinder crop growth and lead to decreased agricultural output, it is essential to explore strategies that can enhance fertilizer availability and affordability for Kenyan farmers. This may involve measures such as promoting local fertilizer production, further improving distribution networks, and implementing targeted support measures to assist farmers in accessing fertilizers at reasonable prices.

Approximately 90% of the fertilizers used in Kenya are nitrogen-based fertilizers, such as Calcium Ammonium Nitrate (CAN) or Diammonium Phosphate (DAP).[74] Kenya relies entirely on fertilizer imports: in total, Kenya imported some 850 kt (2021) of fertilizers (fossil fuel based), the majority of which from Saudi Arabia, Europe, Russia, and Qatar; five fertilizer importers hold over 75% of market share[75]. Of the imported quantity around 100 kt were exported to neighbouring countries.

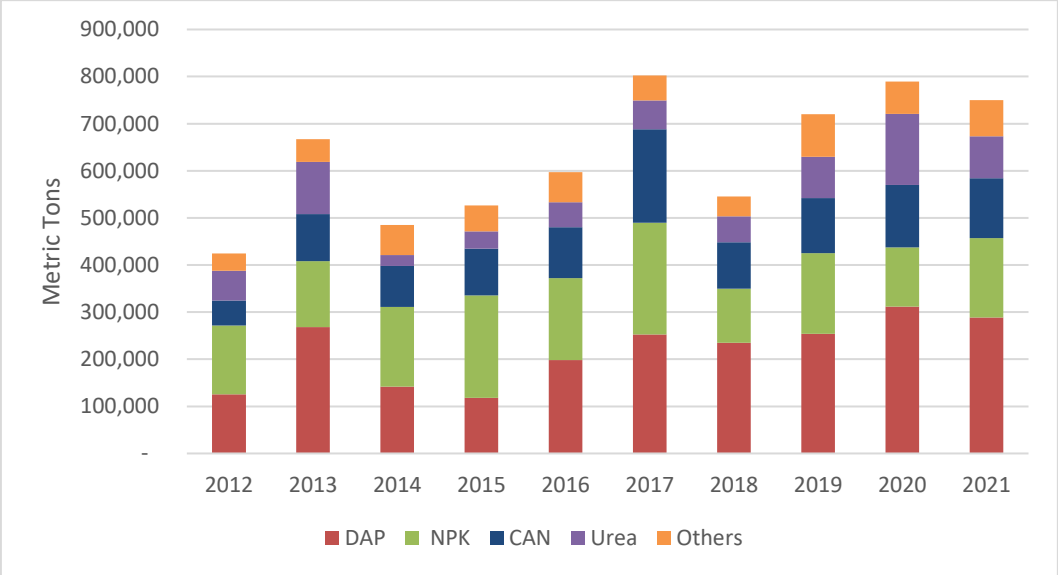


Figure 25: Evolution of fertilizer consumption in Kenya

(Source: Ministry of Agriculture)

Over the past five years, Kenya has spent annually on average about USD 290 million for fertilizer imports. The surge of commodity prices in international markets in 2021 resulted in Kenya spending

[73] World Bank, Fertilizer consumption (kilograms per hectare of arable land), https://data.worldbank.org/indicator/AG.CON.FERT.ZS

[74] NPK fertilizers are fertilizers that contain the three primary nutrients: nitrogen (N), phosphorus (P), and potassium (K), which are essential for plant growth. (NPK fertilizers are formulated to provide a balanced supply of these three primary nutrients to meet the specific nutrient needs of different plants or crops; therefore, the ratio of N, P, and K in the fertilizer will vary depending on the specific requirements of the plants being grown.) Nitrogen is consumed in the largest volume of the three nutrient categories and it is also the most energy-intensive to produce. The starting point for all nitrogen-based fertilisers is ammonia, which is produced using hydrogen as feedstock; hence, green hydrogen can only be used for the production of nitrogen-based fertilizer (as a substitute for fossil hydrogen). There are several types of nitrogen-based fertilizers commonly used in agriculture, the most common ones including Urea, Ammonium Nitrate, Calcium Ammonium Nitrate (CAN) as well as Ammonium Phosphate fertilizers, such as Diammonium Phosphate (DAP).

[75] KfW, Study on Green Hydrogen Fertilizers in Kenya, 2021.

USD 355 million to import fertilizers[76]. To mitigate fertiliser price increases and ensure that fertilizers remain affordable and accessible to farmers, "*the Government has availed Ksh 3.55 Billion (≈ 30 million USD), to subsidize 71,000 Mt (1.42 million x 50 kg bags) of fertilizer*"[77]. As a consequence, the government has been encouraging private sector investment in the fertilizer manufacturing industry to expand domestic production and reduce dependency on imports.

Box 4: *The fertilizer supply chain in Kenya*

The fertilizer supply chain in Kenya involves several stages and actors, each playing a crucial role in ensuring the availability and distribution of fertilizers to farmers.

The industry is mainly driven by the private sector and includes importers/traders, blenders, distributors/wholesalers and retailers.

Government agencies include the National Cereals and Produce Board (NCPB), the Agricultural Development Corporation (ADC), and the Kenya Agricultural and Livestock Research Organization (KALRO). The Kenya National Trading Corporation (KNTC) negotiates with fertilizer manufacturers to directly supply farmers through the NCPB and KNTC network.

Fertilizer regulations in Kenya are under the mandate of the Ministry of Agriculture, Livestock, Fisheries and Co-operatives, Kenya Plant Health Inspectorate Service (KEPHIS), and Kenya Bureau of Standards (KEBS). The Fertilizer and Soil Amendments Committee of KEBS develops standards for fertilizers used Kenya and includes representatives from a.o. the fertilizer industry, the Ministry of Agriculture, universities, KALRO and KEPHIS.

Throughout the supply chain, stakeholders collaborate to ensure the availability of fertilizers, maintain quality standards, manage pricing, and provide technical assistance to farmers. The government regulates the industry, implements subsidy programs, and formulates policies to promote sustainable fertilizer use and agricultural productivity.

Successfully implementing structural changes to the fertilizer sector, such as import substitution, requires the involvement of all relevant stakeholders, not only because they possess valuable expertise and insights that can contribute to informed decision-making and effective implementation of new practices or policies, but their inclusion is crucial to foster collaboration, promote transparency and buy-in, and ensure that the interests and concerns of all relevant parties are considered.

Kenya's below-average fertilizer usage of around 65 kg per hectare of arable land, compared to the global average of 146 kg per hectare (2020) ([78]) creates ample room for growth, offering the potential to enhance agricultural productivity and yields. The recently experienced spikes in fertilizer prices and their volatility underscore the benefits of developing a local and sustainable fertilizer production. Moreover, promoting domestic fertilizer production will enhance food security, reduce import costs, create employment opportunities, and support the country's agricultural sector, while -in parallel- facilitating the development of relevant value-added industrial and manufacturing sectors.

Green hydrogen use to produce fertilizers has emerged as an opportunity for Kenya. Existing supply chains can potentially switch to green fertilizers. The group of importers and wholesalers have the capacity and expertise to handle large quantities of fertilizers to distribute through the existing supply channels. Due to the quantities involved they can become anchor off-takers and “offer” security to local production in addition to being protected (and -in turn- protect final consumers) against price volatility.

[76] Trading Economics, Kenya Imports of Fertilisers, https://tradingeconomics.com/kenya/imports/fertilizers

[77] Ministry of Agriculture& Livestock Development, September 2022, https://kilimo.go.ke/fertilizer-subsidy-2022/

[78] The World Bank, Fertilizer Consumption, https://data.worldbank.org/indicator/AG.CON.FERT.ZS

3.4. MANUFACTURING SECTOR

The manufacturing sector in Kenya can broadly be categorised into five main sub-sectors:[79]

1. **Agro-processing**: This sector includes food and beverage processing, milling, dairy products, meat processing, and other related activities. Agro-processing was highlighted as a significant area of opportunity, given Kenya's abundant agricultural resources and potential for value addition in the agricultural value chain;
2. **Textiles and Apparel**: The textile and apparel industry plays a crucial role in Kenya's manufacturing sector. It encompasses the production of fabrics, garments, and related products. The sector was recognized for its potential to contribute to export earnings, employment generation, and skills development;
3. **Chemicals and Pharmaceuticals**: This sector involves the production of various chemical products, including fertilizers, paints, detergents, and pharmaceuticals. It was identified as a key sector with growth potential, driven by both domestic demand and export opportunities;
4. **Construction Materials**: The manufacturing of construction materials such as cement, steel, bricks, and roofing materials was identified as a significant sector. The report highlighted the demand for construction materials due to infrastructure development, urbanization, and housing construction in Kenya;
5. **Plastics and Rubber**: The production of plastic and rubber products was identified as another important sector in Kenya's manufacturing landscape. This sector includes the manufacturing of packaging materials, pipes, hoses, and various plastic and rubber components.

Kenya, like many other developing countries, has faced challenges in developing a robust manufacturing sector, with its growth primarily driven by the agriculture and services sectors. However, there are several promising factors that contribute to a positive outlook for Kenya's manufacturing sector and underscore its significance in achieving the country's development agenda. These factors include a growing domestic market, favourable government policies, and potential opportunities in emerging sectors such as agro-processing, textiles, and construction materials. Nonetheless, strategic interventions are necessary to enhance the performance and competitiveness of Kenya's manufacturing sector. This entails implementing policy reforms, investing in infrastructure, promoting skills development, and fostering innovation.

One key advantage lies in the expanding domestic market, which offers a ready customer base for locally produced goods. Moreover, emerging sectors such as agro-processing, textiles, and construction materials present untapped opportunities for Kenya's manufacturing sector. Capitalizing on these sectors can drive economic growth, create employment opportunities, and boost exports. The agro-processing industry, for instance, can leverage Kenya's agricultural abundance to produce value-added products, thereby increasing its contribution to the overall manufacturing output.

3.5. TRANSPORT SECTOR

Kenya's transport sector contributes approximately 8% to its total GDP.[80] The sector encompasses various subsectors, including road, rail, aviation, and maritime, facilitating the movement of goods and people to drive economic activities. Among these subsectors, the **road subsector** handles over 80% of traffic and 76% of freight, highlighting a significant transport system.

The **railway subsector** has experienced significant growth in recent years. Currently, Kenya operates three rail systems, all powered by diesel locomotives. Notably, the standard gauge railway (SGR) connecting Mombasa, Nairobi, and Naivasha aims to shift freight transport from road to rail. Construction

[79] KAM, Manufacturing in Kenya – Under the 'Big 4 Agenda' – A Sector Deep-Dive Report, 2018, https://kam.co.ke/kam/wp-content/uploads/2018/10/KAM-Manufacturing-Deep-Dive-Report-2018.pdf

[80] GIZ, Transport Sector in Kenya's Nationally Determined Contribution, 2021, https://changing-transport.org/wp-content/uploads/2021_GIZ_Factsheet_Transport-in-Kenyas-NDC.pdf

is also supposed to extend to Malaba, reaching the Ugandan border.[81] This project is a crucial component of the East African Railway Master Plan.

Kenya boasts a thriving **aviation sector**, with Jomo Kenyatta International Airport ranking as the fourth largest airport in Sub-Saharan Africa. The Kenya Civil Aviation Authority (KCAA) collaborates with GIZ to promote the use of SAF and decarbonize the aviation sector. [82] Kenya Airways became the first African airline to utilize SAF for a long-haul flight, showcasing their commitment to sustainability.[83]

Kenya is the main trade gateway to East Africa and the **maritime sector** serves as a vital pillar of the Kenyan economy, with its Indian Ocean Port of Mombasa acting as a gateway for cargo not only in Kenya but also in neighbouring countries. Mombasa stands out as the leading port in the East African region for import and export activities. Additionally, the development of the alternative port of Lamu, which is part of the Lamu Port-South Sudan-Ethiopia Transport (LAPPSET) corridor, is part of Kenya's Vision 2030 and expected to additionally contribute to the region's port activities. Leveraging the turnover of ships, there is an opportunity to supply (green) fuel. The Kenya Ports Authority is currently implementing the Green Port Policy, which includes the shore-to-ship power strategy to make operations more sustainable.

The transport sector in Kenya is the largest consumer of petroleum products, making it a significant contributor to GHG emissions. In 2019, the sector emitted around 12.3 Mt CO_2e, accounting for about two thirds of Kenya's energy-related CO_2 emissions.[84]

To address these challenges, Kenya's transport NDCs include both mitigation and adaptation measures. Mitigation efforts focus on implementing low-carbon and efficient transportation systems, while adaptation measures involve enhancing infrastructure resilience and incorporating climate-proofing strategies.

In line with its commitment to climate action, Kenya has taken steps to promote a shift from road to rail transportation for passengers and freight. In 2021, the country introduced an **e-mobility roadmap**, outlining Kenya's strategy to transition to electric vehicles (EVs) and promote sustainable transportation[85]. More specifically, the e-mobility roadmap aims to foster the adoption of EVs, establish charging infrastructure, enact supportive policies, integrate renewable energy sources, build partnerships, and raise public awareness about e-mobility.

While green hydrogen is not explicitly part of Kenya's transport sector strategy at present, there are potential long-term applications that could emerge. These include considering green hydrogen as a fuel for vehicles used in port operations, exploring the use of hydrogen-powered locomotives on railway lines, and producing SAFs within the country. These efforts would contribute to reducing emissions and promoting a more sustainable and environmentally friendly transport sector in Kenya.

[81] https://www.businessdailyafrica.com/bd/economy/grand-sh2-1trn-plan-to-expand-sgr-to-kisumu-malaba-isiolo-4234772

[82] KCAA, Sustainable Aviation Fuels (SAF) Workshop with GIZ, https://www.kcaa.or.ke/about-us/media-center/gallery/sustainable-aviation-fuels-saf-workshop-giz

[83] ENI, Kenya Airways operating the first flight from Africa using Eni Sustainable Mobility's aviation biofuel, May 25, 2023, https://www.eni.com/en-IT/media/press-release/2023/05/kenya-airways-operating-first-flight-from-africa-using-eni-sustainable-biofuel.html

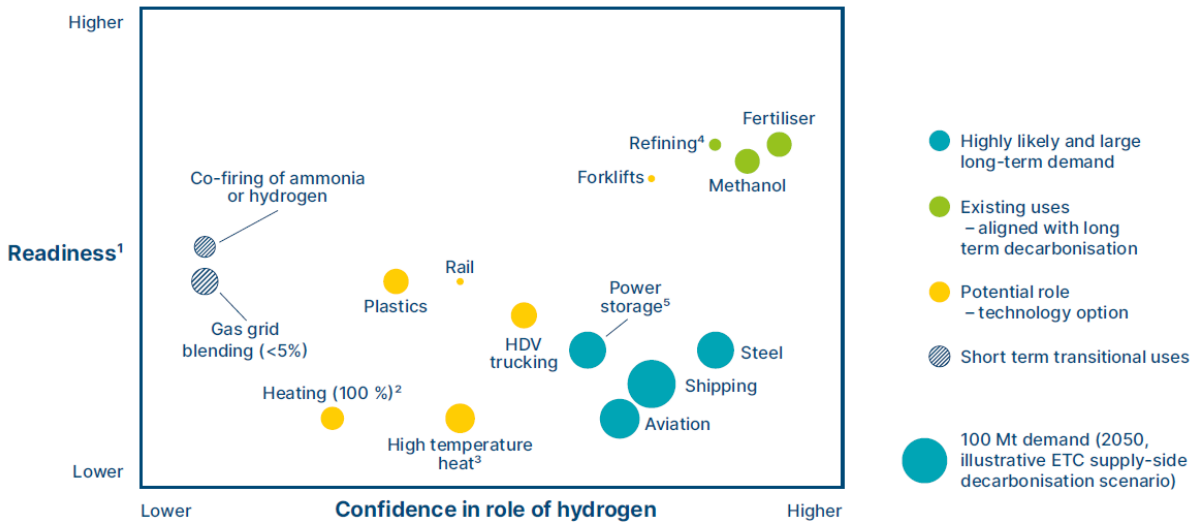
[84] Government of Kenya – Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works, Transport Sector Climate Change Annual Report 2019-2020: Performance and Implementation of Climate Change Actions, 2020, https://changing-transport.org/wp-content/uploads/Kenya-transport-annual-report_Jan-2021.pdf

[85] Roadmap to e-mobility Kenya, https://eedadvisory.com/wp-content/uploads/2022/01/RoadMap-to-e-Mobility-in-Kenya.pdf

4. KENYA'S OPPORTUNITIES IN GREEN HYDROGEN

4.1. HYDROGEN USE CASES FOR KENYA

Kenya's considerable renewable energy potential can drive the country's journey into the green hydrogen space. Several compelling opportunities in the short, medium, and longer term have been identified globally (*Figure 26*). These opportunities range from the development of the full value chain for fertilizers to the production of chemical feedstocks and clean transportation fuels for the road, maritime, and aviation sectors.[86] This section elaborates on the most promising hydrogen use cases in Kenya, which have been identified in the Baseline and Sector Analysis studies performed with the support of GIZ in 2022 and 2023, respectively.[87] These studies have been complemented by further analysis and extensive stakeholder consultations that took place in the course of the development of this Roadmap.



NOTES: [1] Readiness refers to a combined metric of technical readiness for clean hydrogen use, economic competitiveness and ease of sector to use clean hydrogen. [2] 'Heating (100%)' refers to building heating with hydrogen boilers via hydrogen distribution grid, [3] 'High temperature heat' refers to industrial heat processes above ca. 800°C [4] Current hydrogen use in refining industry is higher due to greater oil consumption. [5] Long-term energy storage for the power system.

Figure 26: Potential uses of hydrogen in a low-carbon economy[88]

The case of ammonia / fertilizers

Ammonia serves as the fundamental building block for all mineral nitrogen fertilizers, playing a crucial role in agricultural practices globally. Among the three essential nutrient categories for plants, namely

[86] It is worth noting that Kenya does not currently possess any operational hydrogen production facilities, nor is it utilizing pure hydrogen as a feedstock in any processing industry. As a consequence, there are no industries, such as refineries or chemical industry, that could become early stage off-takers to substitute their "grey" hydrogen feedstock. (The last refinery stopped operations in Kenya in 2013.)

[87] Ministry of Energy, GIZ, Baseline Study on the Potential for Power-to-X / Green Hydrogen in Kenya, 2022, https://energy.go.ke/wp-content/uploads/2022/04/Baseline-Study-on-the-Potential-for-Power-to-X-Green-Hydrogen-in-Kenya_Final-Report.pdf; GIZ, Sector Analysis Study, 2023

[88] ETS, Making the Hydrogen Economy Possible, 2021, https://energy-transitions.org/wp-content/uploads/2021/04/ETC-Global-Hydrogen-Report.pdf

nitrogen, phosphorus, and potassium, nitrogen stands out as the most vital element and the one consumed in largest quantities. Ammonia, therefore, makes an indispensable contribution to global agricultural systems through its use for nitrogen fertilizers.[89]

Today, nitrogen fertilizers are derived exclusively from "fossil" hydrogen through the intermediate product of ammonia. Ammonia stands out as the largest emitter within the chemical sector, responsible for 1.3% of global CO_2 emissions and the industry is facing mounting pressure to take action and embark on a path towards decarbonization.[90] With Kenya being fully dependent on imported fertilizer, the local production of green ammonia / fertilizer from green hydrogen therefore emerges as a realistic opportunity not only to shift the value chain to Kenya, but to actively participate in the global transformation of the ammonia industry. This will benefit Kenya in five major ways:

1. Local production of fertilizers from green hydrogen can **reduce exposure to price volatility of international markets**, and as a consequence, save on import subsidies;
2. A domestic fertilizer production industry can potentially increase the amount of fertilizers available in the country and therefore offer an opportunity to **overcome "under-fertilization"** (see section on the Agricultural sector). If Kenya's consumption of fertilizers were close to the world average (per unit of arable land), crops yield would be significantly improved, even close to becoming double from the current levels;
3. Kenya is also an exporter of fertilizers to neighbouring countries, and domestic production of fertilizer/green ammonia could lead to the **development of new regional export opportunities** and strengthen the country's position and strategic location as main trade hub within the Eastern African region;
4. The use of green fertilizers "made in Kenya" will promote the adoption of sustainable agricultural practices and eventually add value to the agricultural produce, by lowering the lifecycle carbon footprint;
5. While ammonia is currently primarily utilized in fertilizer production, there are potential emerging markets for green ammonia derived from green hydrogen. These markets could include its use as a transportation medium for long-distance shipping of hydrogen or its direct use as a clean fuel for the maritime industry.[91]

Substituting Kenya's total consumption of imported nitrogen fertilizers (i.e., some 600-700 kt per year) with local production would require the production of **170-280,000 tons of ammonia** and up to **50,000 tons of green hydrogen per year**. To produce this amount of hydrogen an **electrolyzers with capacity in the range of 350-450 MW** would be required and about **600-1000 MW of renewable electricity generation capacity**, depending on the energy source. The investment required for the full value chain, including power generation, would be around **USD 1.5-2 billion**.

The case of methanol

The second largest indirect use of hydrogen and the primary hydrogen-based commodity imported into Kenya is methanol, with an annual import volume of around 5,000 tonnes (primarily from Egypt and

[89] IEA, Ammonia Technology Roadmap - Towards more sustainable nitrogen fertiliser production, 2021, https://www.iea.org/reports/ammonia-technology-roadmap

[90] https://www.weforum.org/reports/the-net-zero-industry-tracker/in-full/ammonia-industry/

[91] Compared to methanol, ammonia has the advantage of not requiring a CO_2 input for its production.

Saudi Arabia)[92]. Methanol is currently used as a chemical feedstock in the production of plastics, acetic acid and formaldehyde among others. The production of green methanol in Kenya has the potential to unlock new opportunities for the country's industry, extending beyond its traditional use as a feedstock for the chemical industry. Green methanol is currently gaining attention as a promising clean fuel option for commercial shipping (next to ammonia) and it is expected to gain momentum in the coming years ([93]).

Import substitution of methanol would result in a potential hydrogen production (= indirect product import) of 1,500-2,000 tonnes of hydrogen per year (some 15 MW electrolyser capacity). To produce 5,000 tons of methanol would require an electrolyzers' capacity close to 10 MW and a renewable energy capacity of 15-20 MW depending on the source of renewable electricity. The investment required for the full value chain, including power generation, would be around USD 35-40 million.

The case for transport

In addition to its role as a feedstock for producing green ammonia or green methanol, both of which are being considered as potential clean solutions for commercial shipping, green hydrogen also holds promise for decarbonizing other parts of the transportation sector. This includes the road and aviation sectors, where green hydrogen could emerge as a viable solution for reducing carbon emissions. One such example is its direct use in fuel cell vehicles, including trucks and forklifts, which could be employed in locations like the port of Mombasa. Therefore, the production of SAF can be considered in the long term and be linked to the availability of biogenic CO_2 sources.

The case of green steel

Today, the predominant method for steel production is the carbon-intensive blast furnace-basic oxygen furnace process, which relies on coal (coke) as a reducing agent to produce iron and subsequently steel. An alternative approach involves utilizing green hydrogen as a reducing agent to produce DRI, which can then be used to make steel in conjunction with an electric arc furnace. While DRI plants utilizing natural gas as reducing agent have been commercially utilized for some time, large-scale commercialization of hydrogen DRI plants is still pending. But currently, hydrogen-DRI represents the only available method for fully decarbonizing steel production.

The case for renewable baseload power

One of the key challenges associated with solar and wind energy is their intermittency and variability due to natural daily and seasonal fluctuations. However, this challenge can be addressed through the implementation of energy storage solutions. For instance, excess solar energy generated during the daytime could be converted into hydrogen. This allows the electricity to be stored in the form of hydrogen, which can be converted back into power (i.e. "re-electrified") at night using fuel cells (a process also referred to as "Power-to-Power"). In this way, green hydrogen can provide reliable baseload power through a combination of solar power, electrolysis and fuel cell technology. In addition to that, hydrogen and electrolyzers can also offer a diverse range of power system balancing and ancillary grid services, such as frequency and voltage control.

4.2. LOW-HANGING FRUITS FOR GREEN HYDROGEN USE

To ensure the effectiveness of Kenya's strategy to enter the green hydrogen market, it is crucial to prioritize the potential end-use applications of hydrogen while considering the country's specific characteristics. This prioritization should take into account factors such as technical feasibility, economic

[92] GIZ, Sector Analysis Study, 2023.

[93] https://www.methanol.org/wp-content/uploads/2023/05/Marine_Methanol_Report_Methanol_Institute_May_2023.pdf

viability, scalability, and alignment with national energy and development goals. It is important to recognize that as technology advances, market dynamics change, and new opportunities arise, the prioritization of hydrogen use cases may evolve over time. Hence, it is essential to continually assess and adapt project priorities based on the evolving hydrogen landscape. By doing so, Kenya can maximize the benefits and impact of its early hydrogen initiatives. The phased approach of the Green Hydrogen Strategy and Roadmap takes into account this differentiation of use cases over time.

Which are today's low-hanging fruits for green hydrogen use in Kenya?

In the early stages of developing a hydrogen industry, Kenya should concentrate on identifying specific opportunities, often referred to as 'low-hanging fruits'. By focusing on these no-regret options, Kenya can attain the most immediate benefits and pave the way for further expansion in the hydrogen sector.

The consistent, if modest, import volumes of hydrogen and its derivative products indicate that there is potential for local production and deployment of PtX technologies, **particularly for introducing green ammonia (for the production of nitrogen fertilizers) and methanol into Kenya's economy**. Replacing hydrogen commodity imports with domestically produced green substitutes would enable the development of new industrial processes, reduce supply and mitigate risks associated with market price fluctuations. Moreover, establishing new domestic supply chains not only cultivates a thriving manufacturing sector, but also fuels industrialization, unlocks research and development prospects, and generates employment opportunities.

The combined sector of agriculture and fertilizer production holds significant promise for the development of green hydrogen in Kenya. This particular sector stands out as the most relevant due to various factors, including its potential competitiveness when considering import and transport costs, foreign exchange considerations, supply risks, and existing subsidies. Moreover, it offers additional advantages such as bolstering food security, enhancing agricultural productivity, and creating job opportunities across the value chain. Most importantly, fertilizers play an essential role in sustaining the agricultural sector, which provides employment and food to the majority of Kenyans. However, given the presence of established players in trade, blending, and distribution, the successful establishment of a domestic fertilizer manufacturing plant necessitates close collaboration with the existing fertilizer distribution network and other relevant stakeholders. This cooperative approach is essential since the introduction of a new plant would impact the income and interests of various stakeholders in the sector.

In addition to fertilizers, Kenya's focus on green methanol positions it at the forefront of efforts to find effective solutions to decarbonize maritime transport, particularly with its Mombasa Port. Additionally, the adoption of methanol as a clean cooking fuel opens up new opportunities within the country.

However, as Kenya places importance on fertilizers and methanol, it is crucial to uphold an open-minded approach towards exploring other emerging applications and their potential advantages to the country; for instance, considering mobility applications in the port of Mombasa, or exploring green hydrogen for baseload power which can bring additional benefits to the power grid.

Can Kenya become an exporter of green hydrogen and derivatives?

Regarding the international trade of hydrogen or its derivatives, competition is expected among countries that will be driven by factors such as the cost and supply volumes of the end products. This competition will be particularly intense among countries located near future large-scale demand centres. In light of this situation, Kenya may not be a cost-competitive exporter (to international markets) of hydrogen derivatives in the immediate future, but has the opportunity to become a regional player through establishing its hydrogen sector, that will develop around its competitive advantages, like its resource potential, its developing economy with a rising industrial/manufacturing sector, and its geographical location with established trade routes. To accelerate Kenya's journey towards becoming a regional player, it is crucial for the country to prioritize the establishment of a strong domestic market, reaping the benefits that come with it, and strategically plan for future expansion.

4.3. ECONOMICS OF GREEN HYDROGEN IN KENYA

Several key factors influence the economics of green hydrogen production: capital expenditure (CAPEX) for the electrolysers, the cost of electricity to feed the electrolyzers, their utilization rate (or capacity factor) and the weighted average cost of capital (WACC). A calculation of the levelized cost of hydrogen (LCOH) has been performed to obtain a better understanding of how each factor influences the cost of produced hydrogen in Kenya.

Cost of electrolyzers

The cost of electrolyzers and the potential benefits of economies of scale play a significant role. If the **CAPEX** for electrolyzers is lower and economies of scale can be achieved, it enhances the economic feasibility of green hydrogen projects. Economies of scale are equally important for downstream processing facilities, including for ammonia production.

Cost of electricity

The **cost of electricity** used in the electrolysis process is the most crucial factor affecting the overall cost of producing green hydrogen (accounting for 50-70% of total costs, see Figure 27:) and its competitiveness compared to other energy sources; therefore, a continuous and uninterrupted supply of affordable and reliable (renewable) electricity is crucial for the efficient and cost-effective production of green hydrogen.

Utilization rate

Optimizing the **utilization rate** (load factor) of hydrogen production facilities is vital as well. By maximizing the operating time of these facilities, it becomes possible to make more efficient use of the capital investment and reduce fixed costs per unit of hydrogen produced. The utilization rate can vary greatly between grid-connected and captive generation projects. In the case of captive power, the utilization rate is directly determined by the specific renewable energy source being utilized. The utilization rates can differ substantially, with solar typically ranging around 20%, wind reaching approximately 60%, and geothermal achieving as high as 85% in Kenya. Higher utilization rates can significantly improve the economic viability of green hydrogen projects (see Figure 28).

Weighted average cost of capital (WACC)

Lastly, the country's WACC is important, especially for capital-intensive projects, which is the case for green hydrogen projects. The WACC considers factors such as interest rates, risk profiles, and the investment climate specific to a country. A lower WACC can lower the financing costs, which, in turn, translates into lower hydrogen production costs and improves the overall economic viability of green hydrogen projects in Kenya. The latest LCPDP considers a WACC of 13% (real terms) for the calculation of the LCOE of several power generation technologies. Given the higher intrinsic risks of green hydrogen, the same WACC could be assumed for hydrogen projects in Kenya.

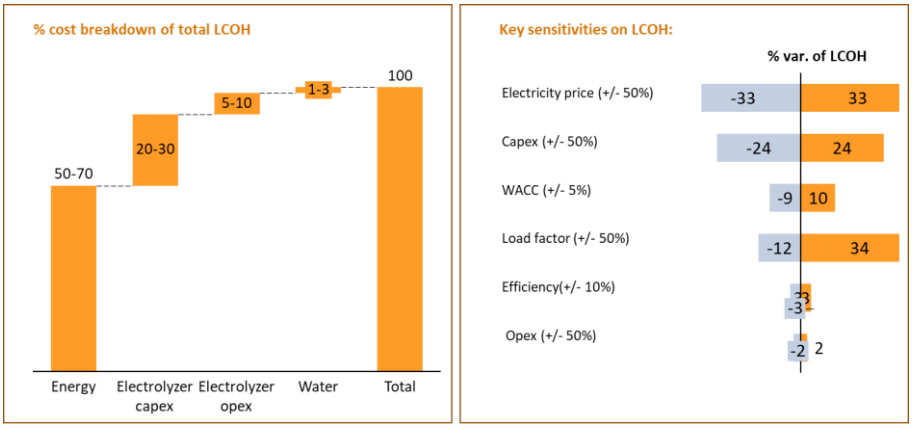


Figure 27: Economic sensitivity analysis of green hydrogen production costs

(Source: Analysis of TAF Team[94])

Cost and availability of water

Water access is an important factor to be taken into account when planning hydrogen production projects.[95] Electrolysis has a minimum water requirement of 9 litres per kg hydrogen, which could be freshwater[96] or desalinated sea water. The use of seawater, where feasible, can be an option to overcome constraints in water-stressed regions. Water from desalination plants can be delivered in nearby areas with limited freshwater resources through over-dimensioning of desalination plants. In any case, the cost attributed to water in the final cost hydrogen is negligible, being around 0.08 USD/kg hydrogen.[97]

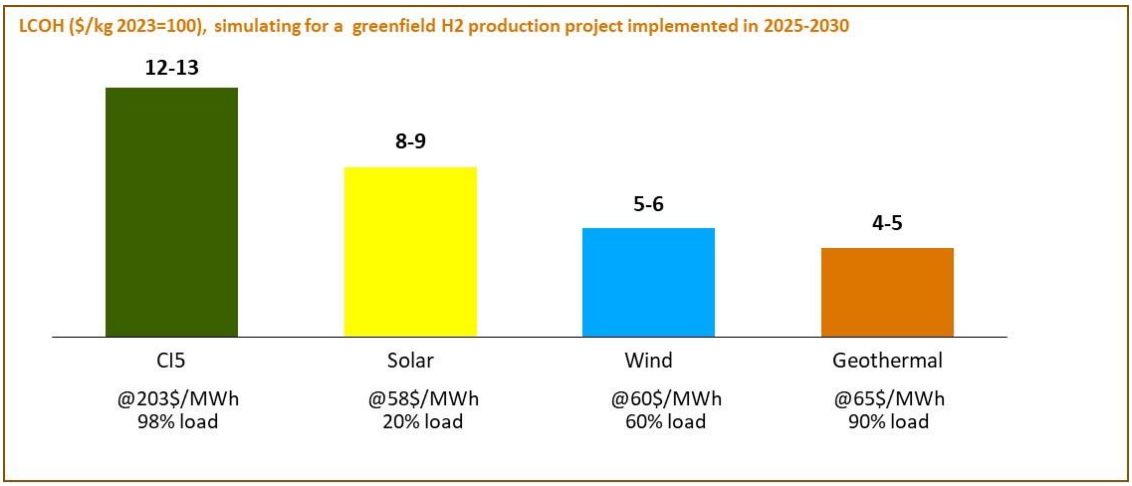


Figure 28: LCOH for green hydrogen from different sources in Kenya[98]

(Source: Analysis of TAF Team)

---

[94] Assumptions Base Case: CAPEX electrolyzer: USD 0.8 million/MW; operational expenditures (OPEX): 2.5% of CAPEX; load factor: 66%; efficiency: 54 kWh/kg; power cost: 60 USD/MWh; lifetime electrolyzer: 20 years; stack lifetime: 10 years; WACC: 13% (real terms).

[95] IEA, Global Hydrogen Review 2022, https://www.iea.org/reports/global-hydrogen-review-2022

[96] Lake Naivasha is one of the few freshwater lakes in East Africa. Using for instance just 0.1% of Lake Naivasha's freshwater could produce some 70,000 tonnes of hydrogen per year, equivalent to some 500 MW installed electrolyser capacity (according to analysis of TAF Team).

[97] For a discussion about the impact of water (availability) on the production of hydrogen see IRENA, Global hydrogen trade to meet the 1.5 °C climate goal: Part III – Green hydrogen cost and potential, 2022, https://www.irena.org/publications/2022/May/Global-hydrogen-trade-Cost

[98] The LCOH calculations are based on the benchmark tariffs for renewable energy auctions in Kenya, serving as a proxy for the LCOE associated with the various power sources. It is worth noting that captive power projects have the potential to yield lower LCOE, thereby lowering the cost of hydrogen.

In Kenya, geothermal energy, with its relatively low costs and high load factor above 90%, appears to be the most favourable option for green hydrogen production, achieving LCOH in the range of 4-5 USD/kg (see Figure 28).[99] Nevertheless, in order to reach cost parity with the current cost of fossil hydrogen, which is approximately 2 USD/kg, the cost of geothermal electricity would need to fall within the range of 25-30 USD/MWh (assuming no financial support measures are in place).

While solar energy, for instance, may achieve a very low LCOE in certain locations, its capacity factor (approximately 20%) would lead to higher hydrogen production costs in a captive solar power project. As diurnal solar and wind profiles could potentially complement each other (thus improving the corresponding aggregate capacity factor), a potential solution could involve hybrid solar/wind energy supply. In that case the cost of green hydrogen could potentially improve its competitiveness.

Excursus - green hydrogen cost premium in end use applications

At the intermediate product level, applying green hydrogen to achieve decarbonisation will result in a noteworthy 'green product premium,' as illustrated by the case of fertilizer. Currently, the cost of hydrogen derived from fossil sources constitutes approximately 50% to 70% of the total cost of ammonia production, and ammonia accounts for some 50% to 60% of the final fertilizer costs.[100] Considering green hydrogen to be twice as expensive as fossil hydrogen, the cost of producing ammonia would increase by around 60%, leading to a corresponding increase in fertilizer costs.

However, it is important to note that while the use of green hydrogen today may have a significant impact on the price of intermediate products, such as ammonia or steel, the impact on final product prices in most sectors, such as food products (in case of green fertilizer) or automotive retail prices (in case of green steel) would be negligible.[101]

4.4. GREEN HYDROGEN INITIATIVES IN KENYA

Kenya has attracted the public and private sector's interest for the development of the hydrogen sector, through projects that address domestic needs with a view to potential regional expansion. These initiatives aim to support and play a role in Kenya's transitioning towards a green hydrogen economy. The comprehensive understanding of current international market dynamics and trends by international players combined with the country's forward-thinking approach, holds significant potential to facilitate a successful transition towards a greener economy in Kenya.

International and local private sector players and developers not only can offer their knowledge about the market but also can provide valuable insights into the necessary business models and approaches to integrate green hydrogen into the Kenyan market. They also bring in their knowledge, expertise, experiences, and best practices from developing green hydrogen in other countries.

Collaboration between the private sector and the government will be crucial for the implementation of green hydrogen projects in Kenya. The private sector brings industry-specific expertise and capital investment, while the government can provide supportive policies, regulations, and infrastructure to create an enabling environment for the green hydrogen sector to thrive.

The most important green hydrogen projects under development in Kenya are briefly described below:

---

[99] This range is also confirmed by GIZ, PtX Hub, A geothermal approach to Power-to-X, 2023, https://ptx-hub.org/wp-content/uploads/2023/05/International-PtX-Hub_202305_A-geothermal-approach-to-PtX.pdf.

[100] MET Development

[101] ETS, Making the Hydrogen Economy Possible, 2021, https://energy-transitions.org/wp-content/uploads/2021/04/ETC-Global-Hydrogen-Report.pdf

Current project initiatives

KenGen

KenGen has already started the development of a pilot project for ammonia production, starting from the performance of a feasibility study[102]. The feasibility study aims to assess the technical, financial, economic, environmental, and social viability of green hydrogen production, specifically for its conversion to ammonia/fertilizer. The study intends to develop a bankable blueprint for the development of a commercial-scale project, considering market conditions and relevant laws and regulations. Based on the findings of the feasibility study, a 5 MW green hydrogen pilot plant and fertilizer production facility will be designed and installed in Olkaria, Naivasha. The pilot plant could be scaled up to a commercial capacity of 100 MW or more, depending on the findings of the feasibility study. The project will use geothermal energy as energy source and its completion is planned in 2025.

Fortescue Future Industries (FFI)

FFI aims to develop a 300 MW capacity generation green hydrogen, ammonia / fertilizer project by 2025/26. The fertilizer production will primarily cater to the domestic market, while also offering the possibility of exporting. Moreover, the generated power will be made accessible to the national grid during peak-load hours. The Kenyan Government recently signed an Investment Support and Implementation Agreement with FFI, accelerating the Framework Agreement signed during COP27.

HDF

A green hydrogen baseload power plant (Renewstable®) is being developed by HDF Energy that will provide dispatchable electricity to the grid (50 MW during the day and 15 MW during night hours) as well as ancillary services. The project comprises production and storage of hydrogen and fuel cells for the generation of electricity, using solar PV (50 MW) as primary source of renewable electricity. The project will enable capacity building, employment, as well as research and development opportunities.

MET Development

Industrial Promotion Services (IPS), Westgass and Maire Tecnimont work on a green power-to-fertilizer project with the aim to produce 200,000 ton of nitrogen fertilizer per year for the local market using 100 MW of renewable (geothermal) capacity. A feasibility study has been completed, and land has been identified for the project. The fertilizer project aims to support the agricultural sector by increasing availability and affordability of fertilizer, while it will also create more than 300 permanent jobs in the region.

SOWITEC

SOWITEC Kenya, subsidiary of the SOWITEC Group, aims to local production of clean methanol, targeting an annual volume of 8,000 tons. The power required will be sourced from a combination of 12 MW solar and/or geothermal power. Feasibility studies have indicated the viability of the venture, which targets the substitution of methanol imports with local production.

Toyota / CFAO

Toyota Tsusho Corporation, through its local subsidiary CFAO Kenya Limited, is looking to develop a green hydrogen valley project in Kenya. The focus is on the Mombasa region, encompassing the Mombasa port and SEZ. The objective is to establish a dedicated green hydrogen production hub in the area to meet the energy needs of various uses such as trucks, forklifts, and port equipment. This initiative aims to develop a green port facility.

4.5. STAKEHOLDERS' LANDSCAPE

The green hydrogen landscape in Kenya includes numerous stakeholders (Figure 29:). While there is an impressive momentum, this overview also highlights the need for alignment and central coordination of stakeholders across different disciplines. Important to mention in that regard is the **Green Hydrogen**

[102] Feasibility Study for Green Hydrogen, Ammonia & Fertilizer Production Pilot Plant at Olkaria, Naivasha.

Working Group, established by the Ministry of Energy and Petroleum, which brings together stakeholders from various sectors, including public, private, bilateral and multilateral organisations, with the common goal to promote the development and utilization of green hydrogen in Kenya through a collaborative effort.

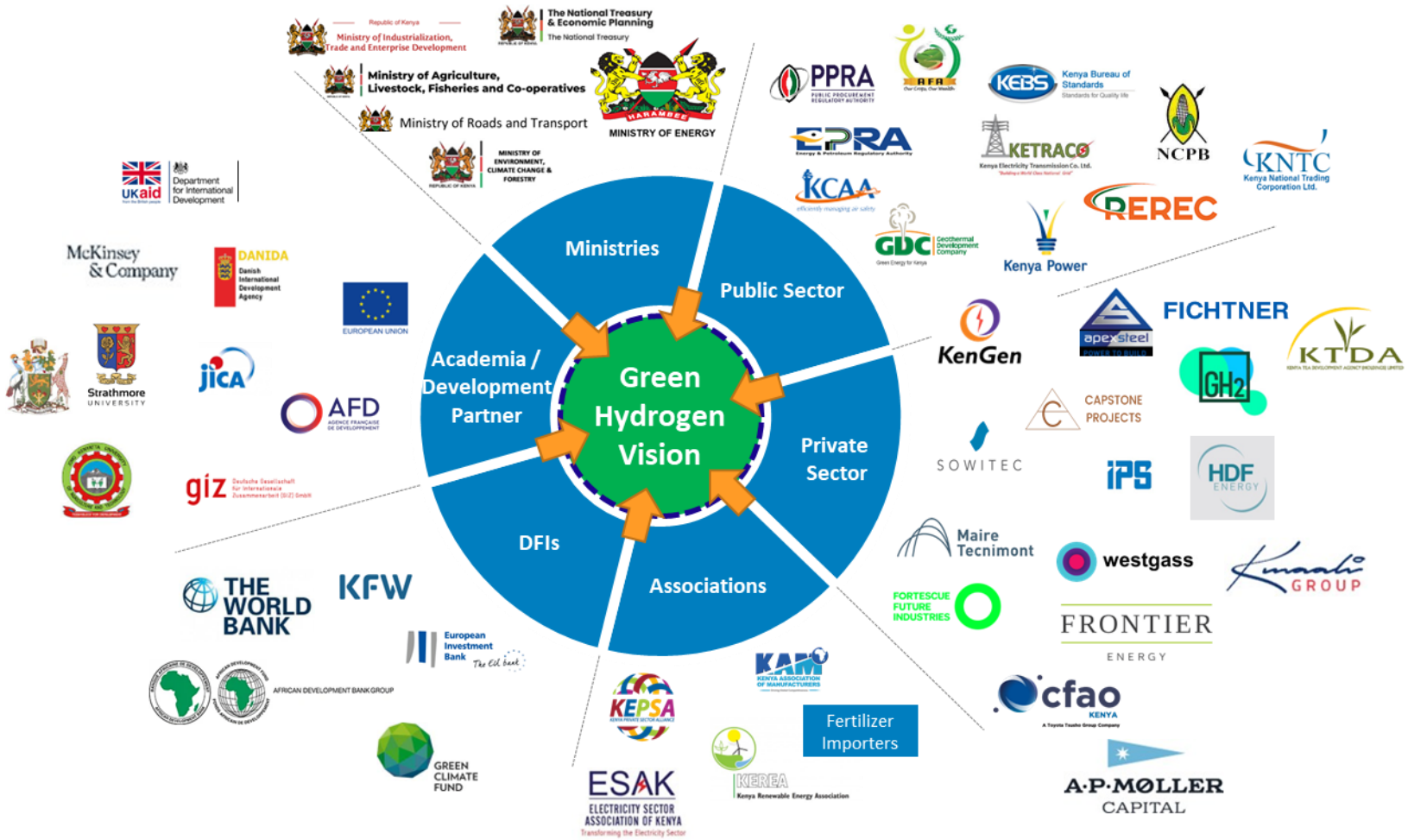


Figure 29: Mapping of green hydrogen stakeholders in Kenya

A brief description of the role and responsibilities of relevance to the hydrogen sector stakeholders is given below.

Table 3: Ministries and public sector institutions

Organisation	Description
Ministry of Energy	The Ministry of Energy and Petroleum (MoEP) is a government department responsible for energy planning, policy formulation, and implementation in Kenya. In relevance to green hydrogen, it is actively involved in developing strategies to promote the production and utilization of green hydrogen as a clean energy solution for the country's sustainable development.
Ministry of Agriculture & Livestock Development	The Ministry of Agriculture and Livestock Development in Kenya is responsible for agricultural legislation, policy formulation, and implementation. In relevance to green hydrogen, it plays a vital role in integrating sustainable agricultural practices and exploring opportunities for renewable energy integration, including the potential use of green hydrogen in agricultural processes and value chains to support a greener and more resilient agricultural sector in Kenya.
MITI MINISTRY OF INVESTMENTS, TRADE & INDUSTRY	The Ministry of Investments Trade and Industry has the mandate to develop, implement and facilitate industrial sector policies in Kenya and is responsible for promoting industrial growth, trade, and entrepreneurship in the country. In relevance to green hydrogen, it plays a crucial role in creating an enabling environment, providing support and fostering partnerships to drive the development and adoption of green hydrogen technologies in Kenya's industrial and trade sectors.
Ministry of Roads and Transport	The Ministry of Roads and Transport is responsible for transport sector policy and any related infrastructure development activities in Kenya. In relevance to green hydrogen, it is involved in exploring and implementing sustainable transportation solutions, including the adoption of green hydrogen-powered vehicles and infrastructure to reduce emissions and promote clean mobility in Kenya.
MINISTRY OF ENVIRONMENT, CLIMATE CHANGE & FORESTRY REPUBLIC OF KENYA	The Ministry of Environment, Climate Change & Forestry (MoECCF) is responsible for the protection, restoration, conservation, development and management of the environment and forestry resources for equitable and sustainable development in Kenya. In relevance to green hydrogen, it plays a vital role in formulating policies and regulations to support the adoption and implementation of green hydrogen technologies for achieving carbon neutrality and reducing greenhouse gas (GHG) emissions.
The National Treasury & Planning	The National Treasury and Planning Ministry plays a central role in formulating and implementing economic and financial policies, managing public finances, and promoting fiscal stability and sustainable economic growth. In relevance to green hydrogen, it plays a crucial role in allocating financial resources, mobilizing investments, and incorporating green hydrogen initiatives into the national development plans to support the transition towards a sustainable and low-carbon economy in Kenya.
KEBS Kenya Bureau of Standards Standards for Quality life	The Kenya Bureau of Standards (KEBS) is a key government regulatory body under the Ministry of Investments Trade and Industry (MITI), responsible for setting standards, metrology, and conformity assessment in Kenya. In relevance to green hydrogen, KEBS plays a crucial role in establishing quality standards, ensuring safety, and promoting

	conformity assessment processes for the production, storage, handling, and distribution of green hydrogen, supporting its safe and efficient adoption in Kenya's energy sector.
KenGen Energy for the nation.	Kenya Electricity Generating Company PLC (KenGen) is the leading power producer in Kenya, under the MoEP, specializing in electricity generation from various sources. In relevance to green hydrogen, KenGen is exploring the potential of green hydrogen production as a sustainable energy solution and actively engaging in research and development to integrate green hydrogen technologies into the country's energy mix, fostering a greener and more diverse energy landscape.
Kenya Power	Kenya Power and Lighting Company (KPLC) is a public/private transmission and distribution utility company operating under the MoEP and responsible for planning, maintaining, and operating the distribution, generation, and transmission infrastructure for electricity supply in Kenya. In relevance to green hydrogen, KPLC explores the integration of green hydrogen as an alternative energy source and supports the development of infrastructure and mechanisms for the distribution and utilization of green hydrogen within the country's energy system.
EPRA Energy & Petroleum Regulatory Authority	The Energy and Petroleum Regulatory Authority (EPRA), operating under the MoEP, is the regulatory body overseeing the energy and petroleum sectors in Kenya, responsible for economic and technical regulation. In relevance to green hydrogen, EPRA plays a vital role in establishing regulatory frameworks, promoting investment, and ensuring the safe and sustainable development, production, and utilization of green hydrogen in Kenya.
nema	The National Environment Management Authority of Kenya (NEMA), operates under the MoECCF. It is the government body responsible for supervising and coordinating environmental activities in the country. In relevance to green hydrogen, NEMA plays a crucial role in ensuring the safe transportation and handling of dangerous goods, including green hydrogen, by enforcing regulations and guidelines to mitigate potential environmental risks and promotes sustainable practices in the transportation sector.
WRA WATER RESOURCES AUTHORITY Accounting for every Drop!	The Water Resources Authority (WRA) operates under the Ministry of Water, Sanitation, and Irrigation (MoWSI) in Kenya and is responsible for managing and regulating water resources. In the context of green hydrogen, WRA's role includes overseeing water availability and quality for sustainable water supply needed in the electrolysis process for green hydrogen production.
GDC Geothermal Development Company Green Energy for Kenya	The Geothermal Development Company (GDC) is a fully government-owned company operating under the MoEP and mandated to develop geothermal resources in Kenya by undertaking surface exploration of geothermal fields, exploration, appraisal and production drilling and management of proven steam fields which can potentially contribute to the production of green hydrogen from geothermal power.
KETRACO KENYA ELECTRICITY TRANSMISSION CO. LTD. "Building a World Class National Grid"	Kenya Electricity Transmission Company Ltd (KETRACO) operating under the MoEP and is Kenya's Transmission System Operator mandated to plan, design, construct, maintain, own and operate all transmission infrastructure in the country. KETRACO's role in green hydrogen will be to evacuate the needed power from the generation plants to the designated load centres of the hydrogen production sites.

REREC	The Rural Electrification and Renewable Energy Corporation (REREC) operating under the MoEP is responsible for promoting and developing renewable energy resources, excluding geothermal and large hydropower, as well as implementing rural electrification projects in Kenya. In relevance to green hydrogen, REREC plays a role in supporting the integration and utilization of green hydrogen as a renewable energy source.
Kenya National Trading Corporation (KNTC)	The Kenya National Trading Corporation (KNTC), operating under the Ministry of Industrialization, Trade, and Enterprise Development, is a government-owned trading company in Kenya. In relation to green hydrogen, KNTC may play a role in facilitating the import or export of green hydrogen-related equipment and technologies.
Kenya Agricultural & Livestock Research Organization	The Kenya Agricultural and Livestock Research Organization (KALRO), operating under the Ministry of Industrialization, Trade, and Enterprise Development, is a research institution responsible for agricultural and livestock research in Kenya. In relevance to green hydrogen, KALRO may explore and develop sustainable agricultural practices that support the production of green hydrogen fertilizer.
Fertilizer and Animal Foodstuffs Board (FAFB)	The Fertilizer and Animal Foodstuffs Board (FAFB), operating under the Ministry of Agriculture and Livestock Development in Kenya, is a regulatory body responsible for overseeing the quality, importation, and distribution of fertilizers and animal feed in the country. In relevance to green hydrogen, FAFB may play a role in regulating and ensuring the quality and suitability of fertilizers produced from green hydrogen, while supporting sustainable agricultural practices in Kenya.
AFA	The Agriculture and Food Authority (AFA), operating under the Ministry of Agriculture and Livestock Development in Kenya, is a regulatory agency responsible for overseeing the agricultural sector, including crops, livestock, and fisheries. In relevance to green hydrogen, AFA may provide guidance and regulations related to sustainable agricultural practices and resource management, promoting environmentally friendly approaches that can contribute to the production of green hydrogen fertilizer in Kenya.
KCAA	The Kenya Civil Aviation Authority (KCAA), operating under the Ministry of Transport, Infrastructure, Housing, Urban Development, and Public Works, is the regulatory body overseeing civil aviation activities in Kenya. In relevance to green hydrogen, KCAA plays a role in developing regulations and guidelines for the safe use and transportation of green hydrogen in the aviation sector, ensuring compliance with international standards.

Table 4: Private sector associations advancing green hydrogen project development

Organisation	Description
KEPSA	The Kenya Private Sector Alliance (KEPSA) is the umbrella organization representing the private sector in Kenya, while the Green Hydrogen Subsector Working Group focuses on the development and promotion of the green hydrogen sector within KEPSA. KEPSA, along with its affiliated sectors such as the Kenya Renewable Energy Association (KEREA), the Kenya Association of Manufacturers (KAM), the Electricity Sector Association of Kenya (ESAK), etc., plays a crucial role in advocating for policies and initiatives that support the growth of green hydrogen technology and its integration into various industries in Kenya.

KEREA Kenya Renewable Energy Association	The Kenya Renewable Energy Association (KEREA) is an independent non-profit association dedicated to facilitating the growth and development of renewable energy business in Kenya.
KAM 60 Years KENYA ASSOCIATION OF MANUFACTURERS	Established in 1959, the Kenya Association of Manufacturers (KAM) is a representative of manufacturing and value-add industries in Kenya. The Association has grown into a dynamic, vibrant, and credible organization that unites industrialists and offers a common voice for businesses.
ESAK ELECTRICITY SECTOR ASSOCIATION OF KENYA Transforming the Electricity Sector	The Electricity Sector Association of Kenya (ESAK) was founded in 2019. ESAK is a member-based organization composed of stakeholders in the electricity sector ranging from Independent Power Producers (IPPs) project developers, consultants, contractors, legal practitioners, finance organizations all working across different sub sectors of the electricity space in Kenya.
KTDA KENYA TEA DEVELOPMENT AGENCY (HOLDINGS) LIMITED	The Kenya Tea Development Agency (KTDA) is an organization that oversees the smallholder tea sector in Kenya, supporting tea farmers and managing the tea value chain. While not directly related to green hydrogen, KTDA can play a role in promoting sustainable agricultural practices and exploring renewable energy options for tea processing facilities in Kenya, including the potential integration of green hydrogen technologies.

Table 5: International project developers active in green hydrogen in Kenya

Organisation	Description
SOWITEC	SOWITEC Kenya, a subsidiary of the German SOWITEC Group, is a renewable energy developer operating in Kenya, Zambia, and Zimbabwe. As part of its expanded focus, SOWITEC Kenya is developing a clean/green methanol project.
TOYOTA KENYA cfao Kenya Limited A Toyota Tsusho Group Company	Toyota Tsusho Corporation / CFAO Kenya Ltd is a leading trading and investment firm in Africa, which has local presence in Kenya with its group company, CFAO Kenya Limited, since 1962. It is working to expand the use of various renewable energy sources to contribute to green economic growth.
HDF ENERGY HYDROGEN POWER COMPANY	HDF Energy is a global pioneer in hydrogen power. HDF Energy develops and operates high-capacity large-scale hydrogen-to-power infrastructure to provide firm or on-demand electricity from renewable energy sources (wind or solar), combined with high power fuel cells.
Maire Tecnimont	MET Development S.p.A. is the project development company of Maire Tecnimont Group which develops a green fertilizer project in Kenya through a consortium with IPS and Westgass Hydrogen. **Industrial Promotion Services (IPS):** the industrial and infrastructure development arm of the Aga Khan Fund, present in East and West Africa and Central Asia, across a wide range of industrial and commercial activities.

	**Westgass Hydrogen**: Norwegian vertically integrated green energy company focused on the green hydrogen value chain to promote the shift from fossil fuels in Europe and emerging markets. **Maire Tecnimont S.p.A**: Italian company, active in the licensing, engineering and construction of processing plants (having realized more than 200 fertilizer plants, globally), and co-developer and technical partner.
	Fortescue Future Industries (FFI) is the renewable energy company of Fortescue Metals Group (Fortescue), from Australia. FFI is a global green energy company committed to producing green hydrogen from renewable sources.

5. SWOT ANALYSIS

The process of developing a roadmap for Kenya's entry into the hydrogen economy necessitates a comprehensive understanding of the country's dynamics and opportunities, as well as the challenges it faces at different levels. This will enable Kenya to enter and operate successfully within the hydrogen economy. To this end, a SWOT analysis has been conducted with the participation of Kenyan stakeholders to inform the development of the country's Green Hydrogen Strategy and Roadmap. The SWOT process benefited from the active participation of the Technical Working Group, who offered their insights related to developing a green hydrogen industry in Kenya. This inclusive and collaborative approach has allowed the development of a comprehensive understanding of the internal and external factors that would impact the industry's success.

5.1. STRENGTHS

Kenya possesses several unique strengths that can enable the development of the green hydrogen sector and position it in the league of the leading-the-sector countries in Africa. These strengths encompass its renewable energy potential and green economy profile, supported by well-oriented policies and an enabling environment. Additionally, the region boasts strong capacities and a dedicated pursuit of academic excellence.

1. **Vast untapped renewable energy potential**
   Kenya's abundant, untapped renewable resources, including geothermal, wind, and solar energy, showcase the country's potential for green hydrogen production.
2. **Baseload geothermal power**
   The high capacity factor of geothermal power offers a distinct advantage in delivering a reliable and stable electricity supply.
3. **A green power sector**
   Kenya's 90% green electricity grid sets an excellent precedent and provides a strong springboard for expanding renewable generation and embracing green hydrogen.
4. **Favourable doing business environment**
   Kenya has an investment-friendly environment enhanced by its geopolitical location within East Africa.
5. **Strong policy and regulatory environment**
   Kenya has a strong policy and regulatory environment establishing a firm framework for businesses to operate within clear guidelines and regulations.
6. **Political stability and strong institutions**
   Kenya is widely recognized for its political stability, bolstered by robust institutions and a firmly established legal and regulatory framework, which includes the provision of publicly accessible financial data.
7. **Skilled workforce, with track record in renewable energy projects**
   Kenya's skilled workforce and experience in developing large-scale renewable energy projects can be a valuable asset for the country as it enters the green hydrogen sector.
8. **Entrepreneurial spirit and innovative mindset**
   The entrepreneurial spirit and innovative mindset prevalent in Kenya, together with a tech-savvy and youthful population, create an environment conducive to the development of new businesses around green hydrogen.
9. **Availability of fresh water**
   Kenya's inland freshwater resources, but also seawater due to the country's long coastline, provide a distinct advantage to produce green hydrogen.

5.2. WEAKNESSES

There are certain areas that the country should consider for strengthening, in order to be in the position to tap into the opportunities the hydrogen economy brings.

1. **Limited awareness and technical know-how of green hydrogen**
   There is limited awareness and technical know-how on green hydrogen, as a consequence of which relevant efforts should be accelerated and necessary capacities be developed.
2. **Absence of streamlined governance structure around green hydrogen**
   The governance structure for green hydrogen in Kenya is still fragmented (being a new field of development), with yet unclear administrative processes and procedures (for project developers). A centralized platform for decision-making and coordination would be important to establish.
3. **Limited access to subsidized export markets**
   Kenya seems to lack competitiveness as an early exporter of green hydrogen derivatives, such as to Europe, and hence misses out on access (for the time being) to public support programs available in the EU.
4. **No green price premium within domestic market**
   Kenya lacks a domestic market for green hydrogen products and in particular, it seems challenging for domestic fertilizer buyers to afford paying a premium for higher-cost green products.
5. **No existing industrial use of hydrogen**
   Kenya lacks an existing chemical or petrochemical industry, limiting the obvious and immediate demand and utilization of green hydrogen within the country.
6. **No existing hydrogen-specific policy and regulation**
   There is no specific policy and regulatory framework for hydrogen currently in place, resulting in uncertainties and challenges for businesses aiming to become active in the green hydrogen sector.
7. **High country risk premium**
   Kenya's current low sovereign credit rating and high interest rates further amplify the risk premium on the finance side.

5.3. OPPORTUNITIES

Development of the green hydrogen sector offers an abundance of opportunities to the country, that can have a positive impact across several sectors of the economy and society.

1. **Improved balance of payments**
   Domestic manufacturing of green hydrogen products will allow the Government to reduce the expenditure for imports, to potentially collect royalties for hydrogen projects and create opportunities for export.
2. **Geothermal energy – Kenya's unique value proposition**
   Geothermal energy presents a compelling combination of low cost, high capacity factor, and the ability to generate dispatchable electricity, ensuring a reliable power supply for cost-competitive hydrogen production.
3. **Improvement of food security**
   Domestic production of nitrogen fertilizers from green hydrogen can potentially reduce "under-fertilization" of land, increase availability and improve affordability of fertilizers, and thereby increase overall crop yields and improve food security.
4. **Creation of domestic fertilizer market and elimination of import subsidies**
   In Kenya, an untapped fertilizer market coincides with the goal of reducing imports and promoting local production. By embracing green hydrogen-based fertilizer as a substitute for imported nitrogen fertilizer, Kenya can grow its domestic fertilizer market, while saving costs on fertilizer

imports, reduce need for subsidies and enhance its resilience against fluctuations in international commodity markets.

5. **Decarbonisation and green industrialisation**

   By relying on renewable energy for green hydrogen production, Kenya can significantly reduce its dependence on imported fossil hydrogen commodities. This shift would align with Kenya's decarbonization efforts and contribute to the achievement of its sustainable development goals and drive green industrialization in the country.

6. **Catalyst for domestic downstream industries**

   Green hydrogen could catalyse domestic downstream industries such as fertilizer production, steel production etc., spurring economic growth beyond primary hydrogen production.

7. **Opportunities for regional/international trade and export markets**

   With its strategic geographical location and gateway status to East Africa, together with the presence of trade corridors, Kenya is ideally positioned to serve as a prominent production and potential regional export hub for green fertilizer, ammonia, or methanol.

8. **Sustainable domestic value chains**

   Kenya's exceptional renewable energy resources not only enable the development of new business opportunities in green hydrogen production but also facilitate the establishment of sustainable value chains for associated products within the country.

9. **A supportive external environment**

   With green hydrogen emerging as a crucial strategic priority for various DFIs as well as the EU, Kenya has a valuable opportunity to capitalize on its existing strategic energy partnerships. By doing so, Kenya can access funding and technical assistance, while benefiting also from the private sector's preparedness and philanthropists' willingness to invest in green hydrogen.

10. **Job creation and local content development**

    Investments in green hydrogen infrastructure, renewable energy projects, and associated industries can stimulate economic activity, attract domestic and foreign investments, and create jobs across the value chain – from local manufacturing to research and development.

11. **Increase the value of exported products**

    The adoption of green fertilizer effectively reduces the carbon footprint of agricultural products, thereby increasing the value of exports to premium markets.

12. **A private sector with keen interest on the emerging green hydrogen sector in Kenya**

    Kenya boasts a vibrant and committed private sector keen to develop green hydrogen projects in the country.

13. **A catalyst for driving growth, reliability, and cost-competitiveness in the power sector**

    Green hydrogen has the potential to accelerate the further development of geothermal, wind or solar projects, thereby leading to lower, overall, electricity costs. Captive power projects, through exporting power to the grid, can support the electrification and development goals of the country.

5.4. THREATS

A thorough examination of the potential threats that might impede the growth of Kenya's green hydrogen sector is crucial. This examination will pave the way for exploring and developing alternative strategies, which could ultimately transform these challenges into strengths and opportunities.

1. **Competition for scarce financial resources**

   The high capital costs associated with green hydrogen projects, coupled with Kenya's substantial public debt burden, limit the options available to provide financial support or public funding for green hydrogen initiatives in the country.

2. **Green hydrogen business case not commercially viable**

   The commercial viability of green hydrogen and derivatives faces challenges globally. As a result, green hydrogen products must either be priced higher than fossil fuel alternatives to

compensate for their inherent cost disadvantage or receive dedicated support to ensure their commercial viability. Particularly, if hydrogen fertilizers are not cost-competitive with conventional fertilizers, they will fail to address the financial limitations of smallholder farmers and fall short in delivering the desired benefits for Kenyan farmers and the agricultural sector.

3. **Green hydrogen finance and investments pulled to US and EU markets**

   The diversion of finance and investments to the US under the Inflation Reduction Act (IRA) (and to some extent to EU), coupled with limited (for the time being) DFI finance for large-scale projects, may reduce the availability of funding for green hydrogen projects in Kenya.

4. **Lack of public awareness and social acceptance**

   The green hydrogen industry is still in its early stages, with relatively low levels of public awareness and social acceptance. Issues such as safety and environmental concerns, water access or land acquisition (amongst others), may pose challenges for the successful implementation of projects.

5. **Missing the unique window of opportunity**

   Several African countries are currently ahead of Kenya in the green hydrogen race. As a consequence, Kenya may potentially be missing out on early-mover advantages and investment opportunities, impacting Kenya's market position and potential economic benefits, with the additional risk of private sector developers withdrawing. However, Kenya, by adopting a fast follower approach, has the opportunity to leverage the lessons learned from others and develop a more robust and sustainable sector.

6. KENYA'S GREEN HYDROGEN VISION AND STRATEGY

6.1. KENYA'S GREEN HYDROGEN VISION

Kenya's Green Hydrogen Strategy and Roadmap have been informed by extensive stakeholder consultation and highlight the country's shared vision for developing the sector and utilizing green hydrogen as a cross-cutting enabler for Kenya's development agenda and as a catalyst for sustainable socio-economic development (Figure 31:). The vision statement "***green hydrogen for sustainable socio-economic development***" is informed by Kenya's pursuit for development that meets the needs of the present day without compromising the ability of future generations to meet their needs, through a balance of the social, economic, and environmental dimensions of development. By embracing green hydrogen, Kenya strives to catalyse profound economic growth and bolster societal well-being. This commitment not only exemplifies Kenya's steadfast dedication to decarbonization and the pursuit of a low-carbon, climate-resilient development path in accordance with the Paris Agreement, [103] but also positions Kenya as a pivotal player in the attainment of its Sustainable Development Goals (SDGs).[104]

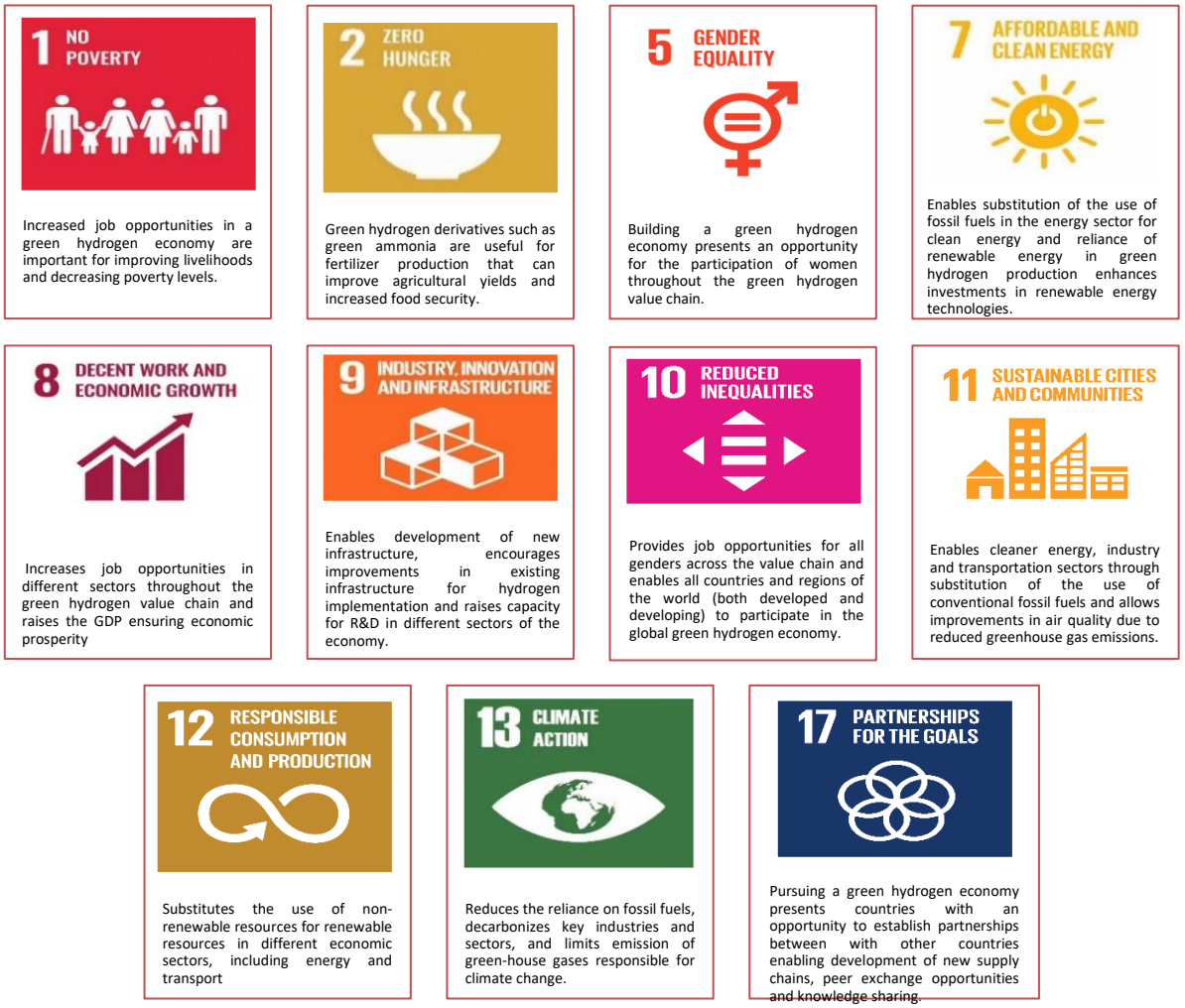


Figure 30: Green hydrogen and Sustainable Development Goals

[103] UN Doc. FCCC/CP/2015/10/Add.1 Decision 1/CP.21. Kenya signed the Paris Agreement on 22 April 2016 and ratified the Agreement on 28 December 2016.

[104] UN General Assembly, Transforming Our World: The 2030 Agenda for Sustainable Development, October 21, 2015, A/RES/70/1.

The development of green hydrogen is important in achieving Kenya's Vision 2030 goals, its commitments laid out in the NDCs, and its BETA Plan. Vision 2030 aims at transforming Kenya into a newly industrializing, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment, whilst the country's NDCs further contribute to the achievement of these goals through its focus on a low carbon development pathway with set out priority mitigation measures that include increasing the use of renewables in the national energy grid; enhancement of energy efficiency across sectors such as in industries and agriculture and climate smart agriculture. Related to Vision 2030 and the NDCs, the BETA Plan is geared towards Kenya's economic turn-around and inclusive growth through a value chain approach. "*It identifies policy priorities expected to result in [the] greatest impact on the economy and welfare of households. Specifically, the priorities address key objectives namely bringing down the cost of living, eradicating hunger, creating jobs, (…) inclusive growth, and uplifting the lives and livelihoods of those at the bottom of the pyramid. This will be achieved through targeted investments in five core pillars*", including agricultural transformation.[105] The objectives of Kenya's vision 2030, the NDC's and BETA are interrelated and efforts towards meeting them can be enhanced through the integration of green hydrogen thanks to its multiple benefits to each sector of concern.

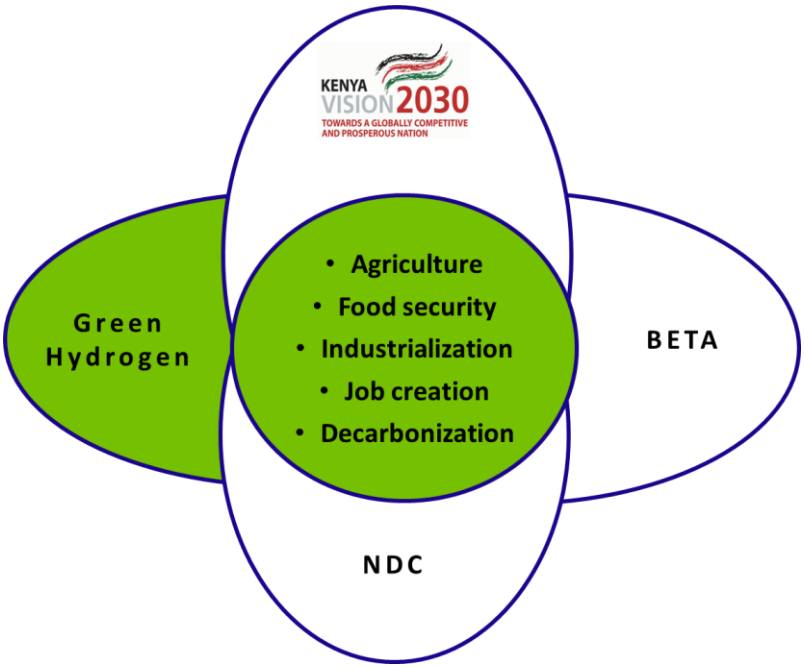


Figure 31: Green hydrogen – a cross-cutting enabler for Kenya's development agenda

The strategy underpinning Kenya's green hydrogen vision is to *"**harness Kenya's unique and abundant renewable energy sources and innovation mindset to enhance agricultural production, industrialization and decarbonization through a phased and demand-driven approach**"*. This strategy is multi-pronged and leverages the country's endowment with renewable energy sources, as well as the existence of a skilled entrepreneurial workforce that embraces technology and pushes the boundaries of innovation.[106] Kenya's green hydrogen strategy adopts a broad perspective aimed at stimulating

[105] The National Treasury and Economic Planning - State Department for Economic Planning, Bottom-Up Economic Transformation Agenda, http://new.planning.go.ke/bottom-up-economic-transformation-agenda-beta/

[106] Kenya is ranked a top three innovation economy in Sub-Saharan Africa. See WIPO, Global Innovation Index 2022 What is the future of innovation driven growth?, 2022.

demand for a diversity of uses for green hydrogen. These include green hydrogen to enhance agricultural production, for industrialization and decarbonization.

Through targeted training and capacity building, the youth as well as other less frequently represented groups in the energy sector such as women can increasingly join the pool of qualified professionals and technicians capable of working in different capacities throughout the green hydrogen value chain. The green hydrogen strategy for Kenya therefore offers opportunities for inclusivity, which is crucial for the country's sustainable socio-economic development.

***Box 5:** Kenya's Green Hydrogen Vision and Strategy*

VISION

"Green Hydrogen for Sustainable Socio-Economic Development"

STRATEGY

Harness Kenya's unique and abundant renewable energy sources and innovation mindset to enhance agricultural production, industrialization and decarbonization through a phased and demand-driven approach.

IMPLEMENTATION PLAN

Phase 1 (2023-2027); Phase 2 (2028-2032)

Prioritize no-regret options to kickstart a hydrogen industry, such as domestic fertilizer production.

Once successfully established, this will enable hydrogen opportunities in other sectors, including regional and international export.

Considering the nascent status of the sector and the rapidly evolving profile of the industry, the vision and strategy are to be operationalized through a phased implementation process set out over a ten-year period and spreads out in two five-year phases, to allow progressive learning and ramping up of action as an enabling environment for green hydrogen is developing. Importantly, Kenya's phased green hydrogen implementation plan is aligned to the governmental developmental planning process with MTPs at the national-level, and County Integrated Development Plans (CIDPs) at the county-level which are both developed every five years. This presents an opportunity to link priority actions related to building a robust green hydrogen economy with development planning at both national and county-level.

According to Kenya's green hydrogen implementation plan, the **first phase** of implementation (2023-2027), corresponding to MTP 4, will focus on creating domestic demand and prioritize low hanging fruits that present one of the most viable options for Kenya to launch its hydrogen industry. This first phase no-regrets option is set out to include amongst others, the pursuit of green hydrogen to produce domestic green (nitrogen) fertilizer, hinged on a prioritized national developmental goal of developing agriculture, enhancing food security and eradicating hunger.[107]

Depending upon the evolution of costs and market demand, the **second phase** (2028-2032) will build on these foundational activities and utilize lessons from the first phase to enable the pursuit of hydrogen opportunities in additional sectors not covered in the first phase, such as green steel or mobility applications, as well as expand from local use of green hydrogen products to regional or international export.

[107] Government of Kenya, Kenya Vision 2030: A Globally Competitive and Prosperous Kenya, 2007; Government of Kenya, Kenya's Bottom-Up Economic Transformation Plan (2022-2027), 2022.

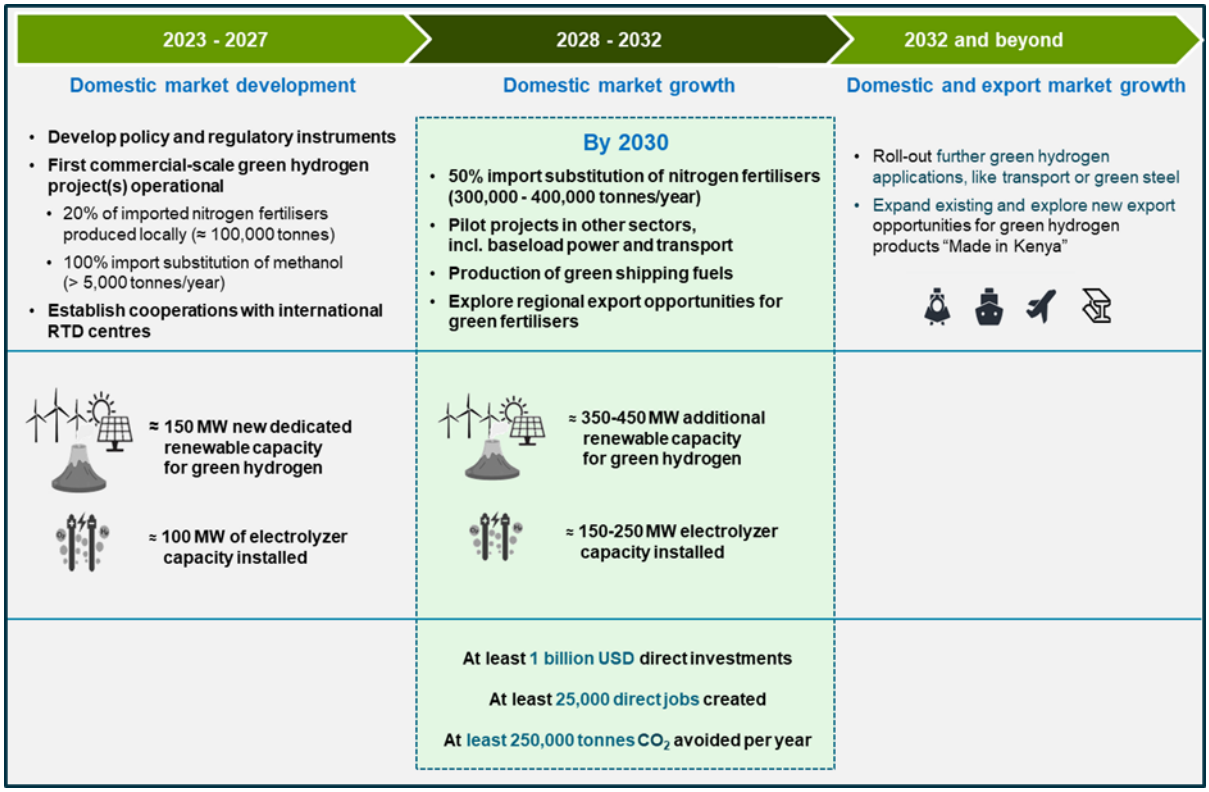


Figure 32: Kenya's Green Hydrogen Vison and Targets

6.2. LOGICAL FRAMEWORK AND BUILDING BLOCKS

To establish a stronger connection between the vision statement for green hydrogen and the process of defining and achieving the objectives, a logical framework serves as a valuable tool. By establishing essential building blocks, a logical framework provides a structured and systematic approach to developing the Green Hydrogen Strategy and Roadmap for Kenya. This framework builds upon the previously outlined green hydrogen vision and strategy, ensuring clear definition of objectives, outcomes, outputs, as well as enablers (Figure 33:).

The logical framework described below provides a common reference point for stakeholders, facilitates coordination and collaboration, and will ensure a logical and coherent approach to the implementation and evaluation of the Green Hydrogen Strategy and Roadmap in Kenya.

6.2.1. Objectives

Objectives are the high-level goals that support the vision statement. The Green Hydrogen Roadmap develops around the following objectives:

- **Improved balance of payments**: By developing a green hydrogen industry based on the establishment and operation of industrial processing plants that use hydrogen as feedstock, Kenya will reduce its dependence on imported (fossil-fuel based) commodities and improve its balance of payments, through import substitution of hydrogen-based commodities. At the same time, in the short run the country will be in a better position to absorb internationally induced shocks (like the recently experienced natural gas prices which drove up the cost of fertilizers) and consequently save from necessary subsidies (e.g. for imported fertilizers). In the longer term, the country will be in place to benefit from exports of hydrogen derivatives to regional or international markets;
- **Food security and resilience**: Green hydrogen can contribute to improving food security and resilience through local production and accessibility of nitrogen fertilizers, which are crucial for the further improvement of agricultural productivity;

- **Green industrialization and decarbonization**: The roadmap seeks to promote the growth of green industries and decarbonize the Kenyan economy by fostering the development of the green hydrogen sector and related industries, while at the same time offering numerous employment opportunities along the value chain of hydrogen and its derivatives. The academia will play a crucial role through developing skills, through research and development and international cooperations;
- **Investment in the country (public and private)**: The roadmap aims to attract both public and private investments in green hydrogen infrastructure, production facilities, and related sectors to stimulate economic growth, create jobs, and attract international investment.

6.2.2. Outcomes

Outcomes represent the anticipated changes or benefits that the green hydrogen strategy aims to achieve. Four high-level outcomes have been identified:

1. **Better availability and affordability of fertilizers**: The roadmap envisions the widespread adoption of green hydrogen-based fertilizers, ensuring their availability, affordability, and contribution to increased agricultural productivity and reduction of fertilizer import costs and subsidies;
2. **Accelerated development of (renewable) power sector**: A green hydrogen industry can serve as an “anchor off-taker”, providing the demand reliability necessary to attract investments and drive the expansion of the power grid and thus the growth of the renewable energy sector; in other words, green hydrogen has the potential to stimulate an accelerated development of the power generation (from renewable energy sources) and transmission infrastructure, from which the country at large can benefit, supporting -in parallel- the further improvement of the electricity services offered to all Kenyan people;
3. **Green hydrogen industry development**: The roadmap aims to establish a domestic green hydrogen industry encompassing production of hydrogen and hydrogen derivatives, which may unlock various opportunities for industrial applications throughout the value chain, such as the manufacturing of electrolyzers, thereby fostering economic diversification, job creation and industrial growth. Through the Academia’s active participation, Kenya can become a regional centre of excellence and a technological hub;
4. **Creation of a regional export market for Kenya's green hydrogen products**: Once a domestic market has been established, Kenya can leverage its green hydrogen capabilities and strategic geographic position to create a regional export market for green hydrogen products.

6.2.3. Outputs

The expected **outputs** are the immediate and tangible results of the activities implemented under the strategy and represent the deliverables necessary to achieve the desired outcomes:

1. **Collaborative governance framework**: Establishing a collaborative and inclusive governance framework involving stakeholders from all relevant government agencies, development partners, industry, finance sector, academia, and civil society to ensure effective coordination, decision-making, and implementation of the green hydrogen roadmap; this should also include the creation of a green hydrogen “one-stop-shop”. The framework should further promote public-private partnerships to leverage resources, expertise, and financing to accelerate the development of green hydrogen projects;
2. **Domestic market development / business cases**: Developing comprehensive strategies and support business cases to stimulate domestic market demand for green hydrogen, to encourage private sector developers and investors, and to drive market growth;
3. **Access to finance (and enhancement of project bankability)**: Creating a financial framework, which facilitates access to finance options and capital markets, investment incentives, and risk mitigation mechanisms to enhance project bankability and financial viability, as a condition precedent to attract public and private investments in green hydrogen projects and related industry;

4. **Favourable policy integration**: Integrating green hydrogen into existing policies, strategies and long-term planning frameworks, creating an enabling policy environment that promotes investment, innovation, and market competitiveness. A well-designed policy framework can also enhance access to financial markets by removing barriers, establishing regulatory clarity and promoting investor protection, while providing market confidence and predictability for private sectors project developers;
5. **Stable legal and regulatory framework** (incl. fiscal incentives): Establishing a stable and fit-for-purpose legal and regulatory framework that includes fiscal incentives to attract investments in the green hydrogen sector. Regulation also ensures the socio-economic impact by setting standards, enforcing compliance, and mitigating risks to protect public welfare, promote fair competition, and address social challenges;
6. **Catalytic commercial (flagship) projects**: Identifying and implementing flagship/high-impact projects that will catalyse the growth of the green hydrogen industry in Kenya, showcasing the commercial viability and benefits of green hydrogen use cases, and acting as drivers for market adoption, scalability, and replicability;
7. **Skills development, research and development**: Leveraging Kenya's innovation culture and investing in skills development programs, vocational training as well as research and development initiatives to foster a skilled workforce and support local capacity building in the green hydrogen sector;
8. **National and international partnerships**: Establishing strategic partnerships and collaborations at the national and international levels with governments, institutions, and industry players to promote knowledge sharing and leverage expertise, resources and market opportunities.

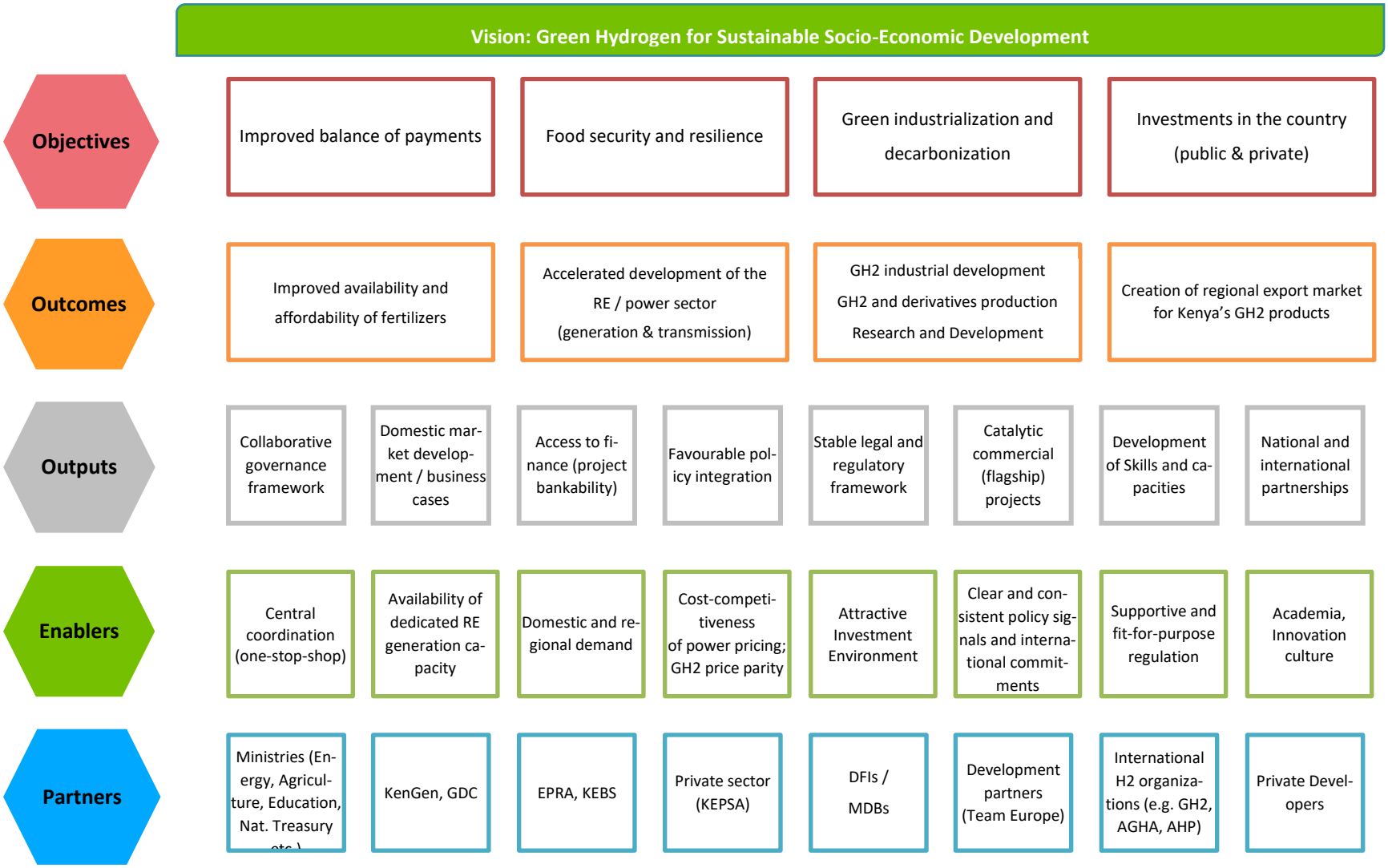


Figure 33: Logical framework for the Green Hydrogen Strategy and Roadmap of Kenya

6.3. KEY ENABLERS FOR A GREEN HYDROGEN INDUSTRY IN KENYA

The successful establishment of a green hydrogen industry in Kenya requires a clear and focused enabling and supportive environment based on strong and well-aligned pillars, **the enablers**. These enablers collectively provide the necessary foundation, support, and conducive environment for the implementation of the green hydrogen roadmap for Kenya and achieve the green hydrogen vision, as briefly described in the following paragraphs.

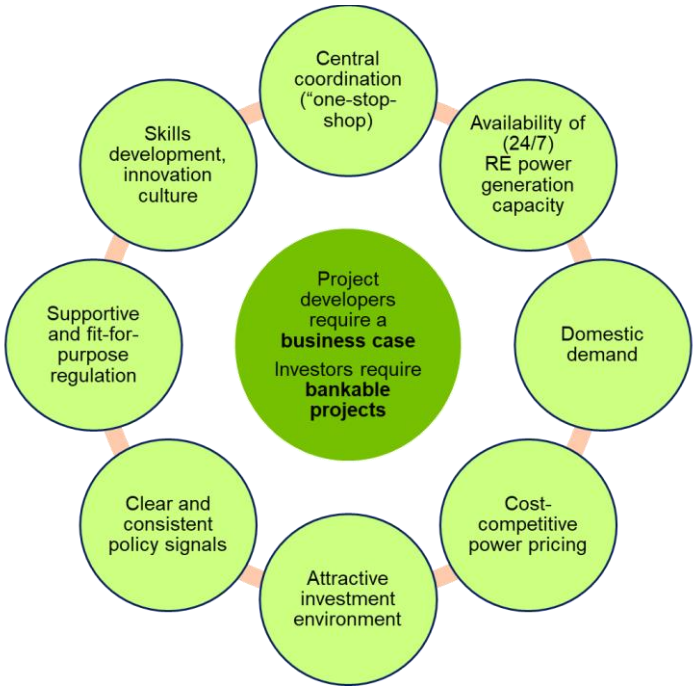


Figure 34: Enablers for a successful green hydrogen industry in Kenya

Central coordination ("one-stop-shop")

Effective coordination among public and private stakeholders, spanning multiple government departments, will be necessary to facilitate a nurturing ecosystem for the development of green hydrogen projects in the country. To achieve this, it is essential to establish a centralized coordination mechanism and provide the necessary governance (within the Kenyan government) to oversee and facilitate the development of the green hydrogen sector and the effective implementation of the roadmap.

Such a "one-stop-shop" approach promotes transparency and ensures streamlined and expedited decision-making, improved interagency collaboration and alignment, and serves as a single point of contact for all relevant stakeholders in green hydrogen. More specifically, the "one-stop-shop" should ensure the necessary alignment between the development of green hydrogen projects and the overall development of the power sector, promoting an integrated long-term planning of hydrogen and power infrastructure (i.e. implementation of renewable energy capacity and transmission infrastructure).

Consequently, the "one-stop-shop" should assist with all aspects of project planning and implementation and act as a single coordination office for all required government approvals for green hydrogen investments, so as to make sure that all elements and requirements of the development process are in place and on time; it should also have the mandate to "fast track" strategic projects through approvals (which shortens development timelines and thus reduces project risks and costs). Being the first point of contact for project developers, such an entity also has a crucial role to play in promoting collaboration and alignment amongst private sector players.

"Lessons learnt" from the solar sector is that the approval and development of projects should be managed tightly, but in a fair and transparent manner to safeguard investors against the risk of investing in non-profitable projects.

Availability of dedicated renewable energy generation capacity

A robust renewable energy sector is fundamental for establishing a green hydrogen industry. To support the production of green hydrogen, this enabler focuses on ensuring a continuous and reliable supply of renewable power. Ideally, this power generation capacity should be available 24/7 or with a high capacity factor (as in the case of geothermal energy) to ensure optimal asset utilization (of the electrolyzers) and least cost of hydrogen production. Fast tracking the development of dedicated and cost-competitive renewable power generation projects, including geothermal, wind and solar energy, is important to meet local demand for hydrogen. In this context, the right policies and a conducive regulatory framework will be stimulating rapid development of the sector. Furthermore, by establishing clear targets with regards to hydrogen-specific renewable energy demand and supply will inform and facilitate planning of the electricity sector.

Domestic demand

Developing a robust initial domestic demand for green hydrogen and its derivatives plays a pivotal role in facilitating the successful implementation of commercial projects. These projects not only demonstrate the feasibility of utilizing green hydrogen but also instil confidence among investors and project developers in the domestic market.

To effectively promote the utilization of green hydrogen, it is crucial to first raise awareness about its numerous applications and benefits within industries, among consumers, and among public institutions. This is especially vital when considering Kenya's hydrogen strategy, which places significant emphasis on the agricultural sector and its role in the entire fertilizer value chain. By generating awareness, stakeholders can better comprehend the potential advantages that green hydrogen offers. Furthermore, a comprehensive understanding of market demands, including supply volumes, and the corresponding product specifications is imperative. This knowledge becomes particularly relevant in the context of producing nitrogen fertilizer from green hydrogen, as it allows for the optimization of crop impact.

Consequently, there is a need for both government and industry to work together in creating the early demand that will enable suppliers of hydrogen derivatives (like green fertilizer or e-methanol) to achieve project bankability. Creation of market demand is also helped by strong policy signals.

Cost-competitiveness of power pricing and green hydrogen

With green hydrogen being significantly more expensive than fossil hydrogen, many of the bottlenecks to ramping up green hydrogen investment relate to the sourcing of green electricity, which has a major impact on hydrogen production costs. Irrespective of the renewable power source, a long term stable and secure supply of green electricity at a competitive and predicable price is required for a bankable project.

Achieving cost-competitiveness in terms of electricity pricing and green hydrogen production costs is a global challenge and a key enabler for a green hydrogen industry. Reducing the cost of renewable electricity generation goes a long way in making green hydrogen cost-competitive with conventional fossil hydrogen. Cost reduction of green hydrogen production to a level close to price parity with fossil hydrogen enhances its market competitiveness, encourages widespread adoption and drives further investment in green hydrogen infrastructure. As with other enablers, policies have an important role to play to drive and incentivise lower costs of renewable power, as has the regulatory framework governing the development and implementation (timelines) of renewable energy projects. At the same time, establishing pricing policies that are transparent, fair and inclusive to communities is a condition for social acceptance of green hydrogen.

Attractive investment environment

Green hydrogen projects require significant capital investments, and an attractive investment environment is necessary to attract project developers and private investors. De-risking mechanisms and risk-

sharing instruments play a vital role in mitigating financial risks associated with green hydrogen investments and enhancing project bankability. De-risking measures, such as fiscal incentives, promote private sector participation and incentivize capital flow into the green hydrogen sector.

Access to affordable (i.e., concessional) financing is another critical factor in the deployment of renewable energy projects, including green hydrogen. Lessons from the solar sector highlight the importance of exploring innovative financing mechanisms, such as green bonds, concessional loans, and public-private partnerships. Kenya should work with DFIs and international organizations to create tailored financial instruments that attract investment and reduce the cost of capital for green hydrogen projects. This enabler also recognizes the need to explore innovative financial instruments, mechanisms and offtake agreements to make projects bankable.

Beyond the financial dimension, this enabler spans a broad spectrum of activities and project development support, including feasibility, site selection and market preparation studies as well as infrastructure development (such as access to land, power, water and other relevant infrastructure).

Clear and consistent policy signals

Sending strong policy signals on Kenya's green hydrogen commitment is important to attract investors and financiers: firstly, clear and robust policies provide a stable investment environment, reduce risks and uncertainties for potential investors and enhance general market confidence. Secondly, demonstrating a strong commitment to green hydrogen sends a signal that Kenya is actively pursuing sustainable and low-carbon energy solutions, which can attract investors focused on environmental, social, and governance (ESG) considerations. What's more, by demonstrating a clear commitment to green hydrogen, Kenya can position itself as an attractive recipient for climate finance, as it shows alignment with global climate goals and the transition to a low-carbon economy, for instance by including green hydrogen in its NDCs.

On the other hand, strong policies play a crucial role in shaping the domestic landscape for green hydrogen and providing a supportive environment for the green hydrogen industry to thrive; they can provide clarity and consistency in the domestic market and enable businesses, investors, and stakeholders to understand the regulatory environment and provide long-term planning certainty. This includes policies that promote renewable energy deployment, establish hydrogen production and utilization targets, provide financial incentives, streamline permitting processes, and ensure market access for green hydrogen products. Lastly, strong policies create visibility and can help build international partnerships and cooperation, and position Kenya as a credible player in the green hydrogen market. Lessons from the solar sector also highlight the importance of clear and consistent policies and streamlined permitting processes.

Supportive and fit-for-purpose regulation

Developing a green hydrogen industry requires an enabling environment with a supportive and fit-for-purpose regulatory framework. Fit-for-purpose regulation for green hydrogen projects refers to the development and implementation of regulatory frameworks that are specifically tailored to address the unique characteristics and needs of these projects and relevant value chains. It involves creating regulations that are well-suited to the particular challenges and opportunities associated with the entire green hydrogen value chain, from power generation, hydrogen production, storage, and transportation, to the manufacturing and use of green hydrogen derivatives, such as ammonia or methanol.

In this regard, regulation should account for the specific technical requirements, environmental standards and safety considerations of hydrogen technologies, such as electrolysers, ensuring that they meet international norms and standards; for instance, safety standards should address the risks associated with the use, transport and storage of hydrogen and follow international guidelines and operational procedures. The technical regulatory framework would also need to extend to cover the production, handling and use of derivative products.

Another area of regulation concerns permitting and approval processes: fit-for-purpose regulation should streamline permitting and approval processes for green hydrogen projects. This can involve

establishing clear guidelines, reducing bureaucratic barriers, and providing a predictable and efficient pathway for project developers to navigate through regulatory requirements. More specifically, regulation needs to account for the different types of supply location archetypes (as described in Chapter 7.1), for instance to enable projects that may have to rely on power wheeling.

Lastly, regulation has a crucial role to play in creating a favourable market environment for green hydrogen projects, with appropriate market and financial incentives. This may include setting targets, establishing pricing mechanisms, providing fiscal incentives (e.g., tax credits, extension of SEZ scheme to cover green hydrogen), and ensuring fair competition among industry players.

Overall, fit-for-purpose regulation for green hydrogen projects should be forward-thinking, adaptable, and responsive to the unique characteristics and needs of the emerging hydrogen sector, while also ensuring safety, environmental sustainability, and investment attractiveness.

Skills development, innovation culture

Kenya has a strong innovation culture, which is characterized by a dynamic and entrepreneurial spirit, with initiatives such as M-Pesa revolutionizing mobile payments and financial services in the country. In addition, Kenya has several universities, with many young Kenyans pursuing higher education. Both are valuable assets for the green hydrogen sector, as there is a need for skilled labor to ensure that the green hydrogen industry can grow and expand. At the same time, Kenya has a long and successful track record in renewable energy, with substantial investments in geothermal, wind, and solar power, making it a leading renewable energy producer in Africa.

A locally skilled workforce is vital for the success and for driving the growth of the industry. Kenya should cultivate its innovation-driven culture and invest in education and skills development to nurture a qualified and adaptable workforce in the green hydrogen sector (both at technical and managerial level). This involves investing in education and vocational training programs for managers, engineers, technicians, and researchers, as well as research and development initiatives, focused on hydrogen technologies, renewable energy, and related disciplines; or the establishment of a Green Hydrogen Center of Excellence (CoE), a one-stop-shop for green hydrogen innovation, as proposed by *ii2030*.[108] Like in the case of the geothermal industry, skills development could greatly benefit from international partnerships and collaboration with countries that have advanced green hydrogen programs and can facilitate technology transfer, capacity building and sharing of best practices. In particular, platforms such as the AGHA can facilitate information exchange and collaboration among African countries pursuing green hydrogen initiatives, while collectively addressing common challenges and expanding market opportunities.

Skills development also greatly contributes to the socio-economic impact of green hydrogen through job creation, economic development, and social inclusion. The crucial need for skills development was identified early on by the Ministry of Energy, with a first capacity needs assessment done in 2021.[109]

Closely related to skills development is the promotion of social acceptance and public awareness of green hydrogen. Both are essential enabling elements for the successful implementation of the roadmap. By engaging with local communities, environmental groups (like Friends of Lake Naivasha) and industry associations, conducting public outreach programs, disseminating accurate information, and ensuring transparency and addressing concerns related to green hydrogen, Kenya will foster a supportive social environment that embraces the benefits of green hydrogen for the country.

[108] See https://endeva.org/blog/the-green-hydrogen-center-of-excellence-coe-a-multi-functional-innovation-hub-to-support-kenyas-green-hydrogen-ecosystem

[109] Ministry of Energy, Draft Report, Rapid Capacity Needs Assessment for Green Hydrogen Technology Development in Kenya, 2021.

6.4. MACROECONOMIC IMPACTS OF GREEN HYDROGEN

Kenya has for long been a frontrunner in developing renewable energies having acquired a leading position globally. The abundancy of renewable energy sources (geothermal, wind, solar or hydro) gives the country the possibility to plan its energy future and enter the hydrogen and derivatives economy through building on its potential and competencies. It is not only the country's objective to build a de-carbonised economy, but also to develop a more resilient economy.

Kenya has the opportunity to reap the benefits from entering into the hydrogen economy in numerous ways and become a significant player in Africa.

The recent, globally experienced, perturbations in the energy markets have resulted in unprecedented increases in the prices of derivatives, like ammonia or fertilisers, which in turn have heavily impacted economies. The prices of fertilisers have more than doubled in the period 2021-22, forcing governments to heavily subsidise them to protect their agricultural product, but importantly too, to support farmers and their agricultural capital. Such subsidies come at cost to the central government. It is estimated that the 2022 announced subsidy would amount to the Kenyan government around Ksh 45.5 billion (approx. 320 million USD) to cover the full demand for fertilisers ([110]).

But it is not the first time that international fertiliser prices have hit record highs. Same situation has been experienced between 2008 and 2010 (*Figure 35*) when natural gas prices have also reached levels above 10 USD/million Btu (*Figure 36*). Such market disturbances may well appear in the future and cannot be easily forecast.

Kenya has the possibility and the prime opportunity, through developing its hydrogen sector and setting up its domestic hydrogen supply chains can be important and effective mitigation measure against international market price volatilities, which not only impact the country's budget, but also have repercussions in the agricultural product and food security. Even though fertiliser imports are a small fraction of the country's imports (approx. 1.8%)[111] building on local production capacities has the potential to improve and ease, to a certain extent, balance of payments and/or direct financial resources to other priorities of the country.

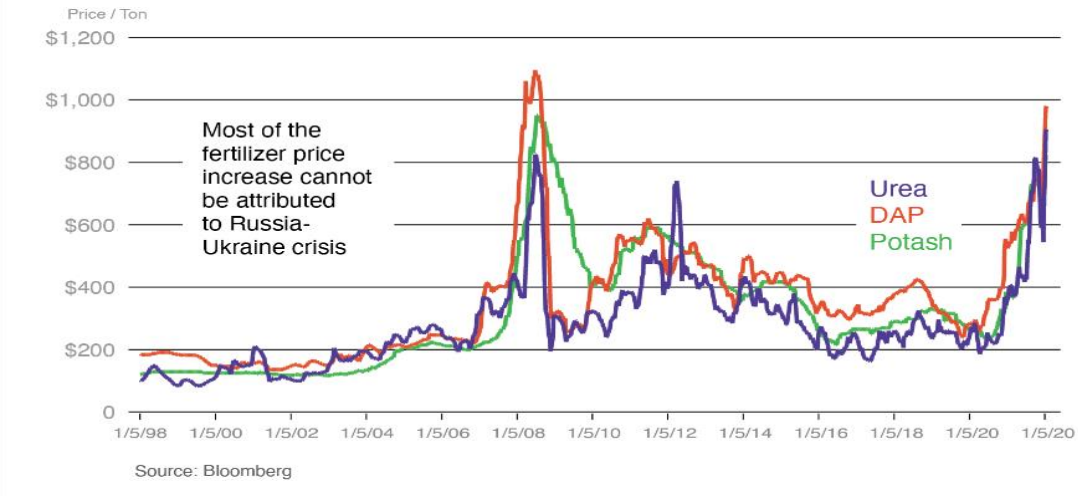


Figure 35: Monthly Index prices for key Nitrogen, Phosphatic and Potassic Fertilisers ([112])

[110] https://ieakenya.or.ke/blog/the-pros-and-cons-of-the-ksh-3500-fertilizer-subsidy/

[111] https://tradingeconomics.com/kenya/imports-by-category

[112] https://www.fas.usda.gov/data/impacts-and-repercussions-price-increases-global-fertilizer-market

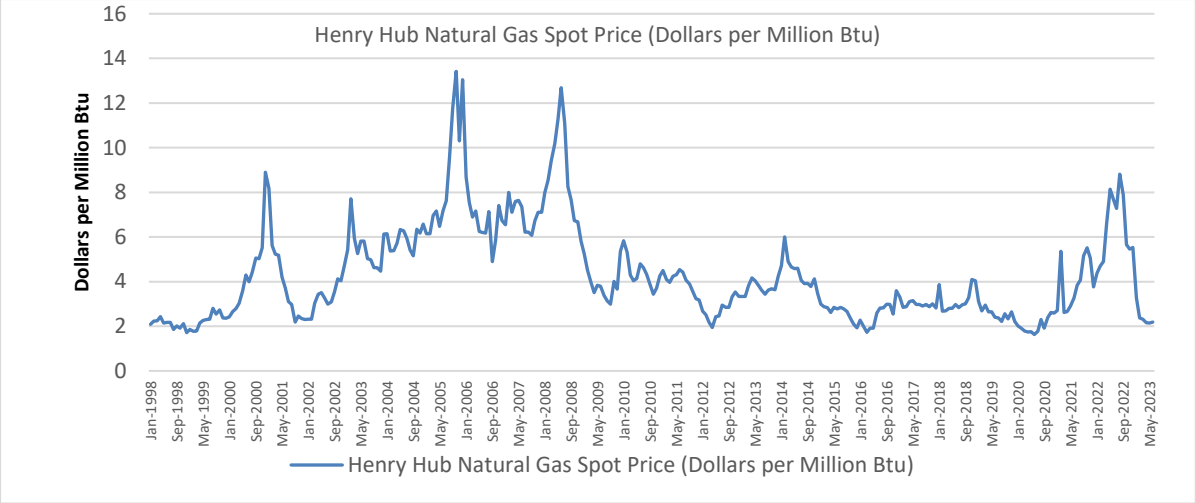


Figure 36: Henry Hub Natural Gas Spot Price (Dollars per Million Btu)([113])

The development of the hydrogen sector will require investments along the value chain, involving investments in renewable energy, production of ammonia, production of fertilisers, methanol, sustainable aviation fuels (SAF) to mention a few. All these translate into new opportunities for jobs to support the sector, where Academia will play a leading role through the development and improvement of capacities, while becoming a Research and Development hub within the region.

Until 2030 more than 25,000 new permanent jobs for skilled women and men will be created in Kenya with the accomplishment of the targets of this Green Hydrogen Strategy and Roadmap through investments that can reach or exceed the level of 1 billion USD, in green ammonia and methanol but also in renewable energy projects to feed with green electricity the hydrogen industry. To this end the opportunities opening for the Academia to support the sector's development are substantial, to develop skills, improve capacities through exchanges with European and international institutions and collaborate in promoting research and technological development. The European Union, including individual member states, has already put in place programmes, initiatives and instruments to support the development of the hydrogen economy, that Kenya can benefit from.

Building on the sector, and already being a regional commercial hub, Kenya can play a leading role in the region through exports of hydrogen derivatives to neighbouring countries. Moreover, the exports of green agricultural products (e.g., coffee) to the international markets are expected to achieve better acceptance and provide an added value (and in turn yield higher income to farmers) in markets that value "green label".

[113] https://www.eia.gov/dnav/ng/hist/rngwhhdM.htm

7. KEY INSIGHTS FROM GAP ANALYSIS

7.1. POLICY INSIGHTS

Building on its overarching development policies, Kenya is in a strong position to develop a green hydrogen market to support and be supported by its development goals. Embarking into the green hydrogen economy, Kenya has the opportunity to build and go through all market development trajectory phases, from **market creation**, building on its potential and opportunities, through **market growth**, up to a fully developed **mature market**.

While several potential policy and regulatory measures could promote hydrogen development, it is necessary to determine, and develop or strengthen, the ones that address different market trajectory priorities ensuring that the market grows and functions sustainably.

Three archetypal country groups can be distinguished, when it comes to formulating hydrogen policies: (1) self-sufficient countries; (2) exporters, and (3) importers as indicated in *Figure 37* below:

Figure 37: Three archetypal country groups

(Source: Adapted from Hydrogen Council and McKinsey, Policy Toolbox for Low Carbon and Renewable Hydrogen - Enabling low carbon and renewable hydrogen globally, November 2021)

Kenya's economy is primarily propelled by the agricultural sector, and the emergence of green hydrogen offers a remarkable opportunity to generate nitrogen fertilizer for domestic consumption. This has the potential to significantly decrease Kenya's dependence on imported fertilizer. Moreover, Kenya benefits from its distinctive access to dispatchable geothermal renewable energy, which further places the country in a distinctive position to both produce and utilize green hydrogen domestically, particularly in the short term.

Hence, Kenya's hydrogen strategy **initially targets domestic use**, positioning the country as self-sufficient. To achieve this, Kenya needs to develop the entire value chain, including upstream supply, midstream transmission and storage, distribution, and downstream demand. However, in the long term, as Kenya accumulates the necessary expertise and grows its market locally, it can mature enough to produce and trade green hydrogen regionally and internationally, becoming an exporter country too. The success of Kenya's green hydrogen endeavours hinges on the formulation of appropriate policies.

According to the Hydrogen Council, there are six key considerations, i.e. pillars[114], crucial for designing effective green hydrogen policies.[115] These pillars can guide policymakers in developing policies that promote the adoption and growth of green hydrogen.

The **first pillar** focuses on local context-specific factors, such as resource availability, energy demand, and existing infrastructure. It also encourages regional socio-economic interactions through cross-border trade.

The **second pillar** aims to nurture investor confidence and buy-in by establishing a legal framework that mitigates certain risks. Additionally, it articulates the desired outcomes and goals that the policy aims to achieve.

To accelerate the economic viability of green hydrogen, the **third pillar** focuses on "public investments". This involves providing incentives, subsidies, grants, or loans to attract private investments, reduce costs, and promote market competitiveness.

The **fourth** and **fifth pillars** are closely related and aim to establish viable pricing mechanisms through regional cooperation and partnerships that have already been fostered. These collaborations leverage global expertise, encourage knowledge sharing, and create investment opportunities. Furthermore, it is important to strive for conformity to international standards and certification to facilitate intercontinental trade, particularly in the long term. This approach would streamline regional cooperation, mitigate potential carbon leakage, which undermines the effectiveness of climate policies, address economic competitiveness concerns, and support global efforts to combat climate change.

Pillar six represents a targeted and inclusive approach that involves all relevant stakeholders. It recognizes the unique needs and circumstances of the Kenyan people, emphasizes the importance of nurturing and developing skills, supported by provisions for local content.

[114] Hydrogen Council and McKinsey, Policy Toolbox for Low Carbon and Renewable Hydrogen - Enabling low carbon and renewable hydrogen globally, November 2021.

[115] For further discussion about green hydrogen policy making see IRENA, Green Hydrogen: A Guide To Policy Making, 2020; and specifically on supply side measures see IRENA, Green Hydrogen Supply: A guide to policy making, 2021.

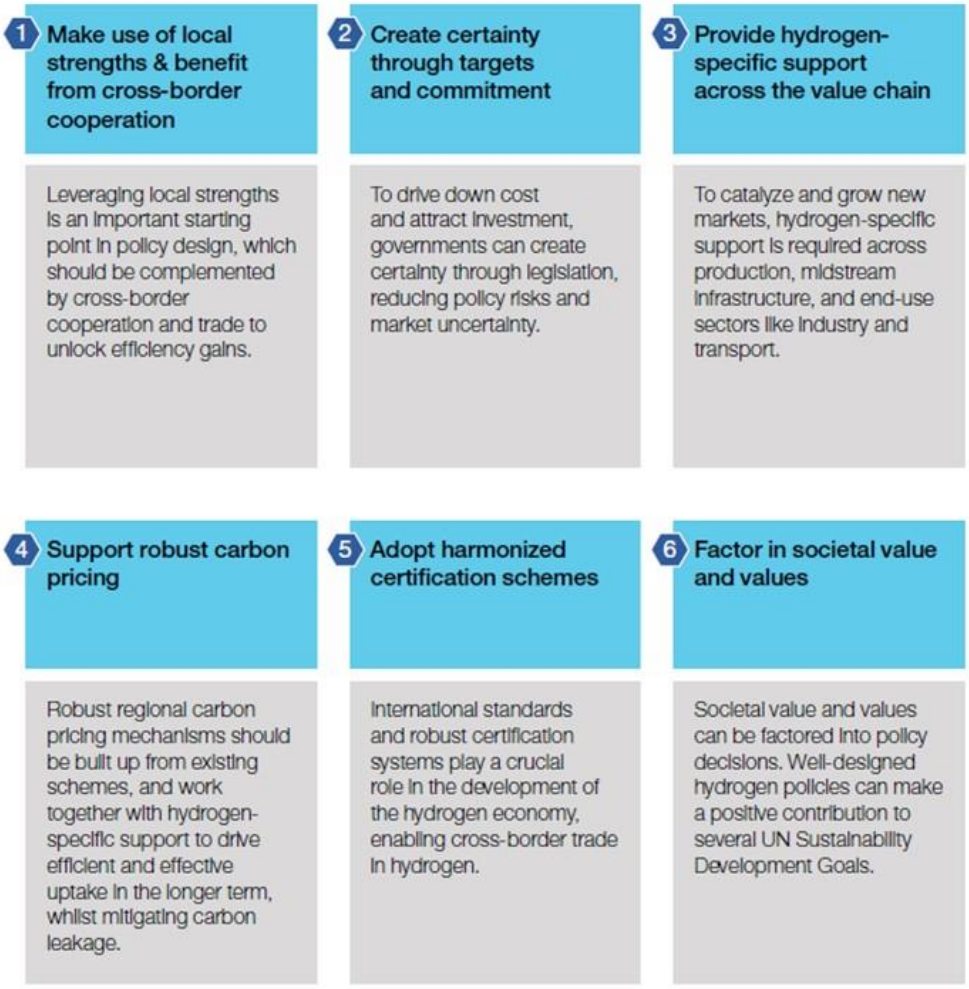


Figure 38: Six pillars of efficient policy design for low carbon and renewable hydrogen

(Source: Hydrogen Council and McKinsey, Policy Toolbox for Low Carbon and Renewable Hydrogen - Enabling low carbon and renewable hydrogen globally, November 2021)

Considering the development of Kenya's green hydrogen market, an analysis of the existing policy framework highlights both potential opportunities and challenges that must be addressed across the hydrogen value chain and throughout various stages of market maturity. However, certain barriers, such as the absence of a regulatory framework, standardization, and collaboration, are overarching and impact the entire value chain, regardless of market maturity. As a result, addressing such barriers requires tailored policies for different segments of the value chain and different phases of market maturity. Moreover, these policies need to be synchronized to effectively tackle interdependencies along both dimensions.

Further, the development of Kenya's green hydrogen sector has to build on lessons learned and insights from the success of the country's renewable energy sector, including reflecting on learnings from sources such as the Presidential PPA Taskforce Report which provides relevant recommendations with a bearing on among others, green hydrogen offtake agreements.[116] Salient recommendations include that offtake agreements should be in line with market conditions to avoid contracts that are unfavourable to the Government; transparency and competitive bidding processes are key to avoid inflated offtake

[116] Government of Kenya, Report of the Presidential Taskforce on the Review of Power Purchase Agreements (PPAS), 2021.

pricing; and clear guidelines and standards for green hydrogen offtake agreements/PPAs or for that matter renewable energy auctions, have to be established to protect the interests of the Kenyan people.

Green hydrogen policies can be categorized into supply-side measures, which aim to promote the accelerated deployment of renewable energy capacity, enhance the cost-effectiveness of renewable power and promote access to other inputs necessary for electrolysis, such as water and demand-side policies which seek to stimulate the market for green hydrogen products, as for instance nitrogen fertilizer and green methanol. There are also cross cutting policies that span both the demand and supply side. Kenya's green hydrogen related supply side policies, plans and strategies include:

- **National Energy Policy, 2018:** The National Energy Policy provides an important basis upon which Kenya can enhance the promotion of renewable energy for the production of green hydrogen. The policy facilitates open access to the transmission and distribution networks, support public private partnerships in the development, operation and maintenance of energy infrastructure and delivery systems and provide incentives for development of robust distribution networks. However, there is a need to incorporate the explicit inclusion of green hydrogen as a policy priority;
- **LCPDP,** 2022-2041**:** The LCPDP 2022-2041 provides a sound basis for the development and expansion of renewable energy generation from a variety of sources, and the development of requisite distribution and transmission infrastructure. There is need for dedicated renewable energy generation for green hydrogen to be set out in the LCDP, to ensure green hydrogen is reflected in the country's power planning framework as this is currently missing;
- **MTP IV, 2023-2027:** MTP IV is intended to implement the fourth and second-last phase of Kenya Vision 2030. It aims to accelerate Kenya's transition to clean energy, promote energy efficiency and shift to energy auctions as a successor to the feed-in-tariffs (FiT) policy to address high electricity tariffs. It provides an opportunity to incorporate policy incentives to support the implementation of green hydrogen projects as part of Vision 2030;
- **National Water Policy, 2021:** This policy promotes equitable access to water for economic uses including for industrial production, implicitly including water use for industrial electrolysis. The policy is also beneficial for green hydrogen as it aims to ensure that the pricing of water for domestic and industrial use is proportionately affordable through the moderate setting and escalation of tariffs, and further calls for desalination of sea water as an alternative to the use of freshwater sources to ensure the supply of water to seaside industrial complexes.

Pending policies that are yet to be adopted, such as a **draft Renewable Energy Auctions Policy** and a **draft Captive Power Policy,** are also important for enhancing supply of much needed renewable energy for green hydrogen production. The Energy Auctions Policy for example will, once adopted, allow for competitive pricing leading to reduced costs of energy supply and encourage the growth of the green hydrogen production sector. The draft Captive Power Policy on its part would allow large energy consumers to generate their own electricity for self-consumption helping to meet renewable electricity supply goals for green hydrogen.

Kenya's demand side policies, plans and strategies include:

- **National Energy Efficiency and Conservation Strategy, 2020:** The strategy aims to reduce the demand for fossil fuels by enhancing the use of renewable energy to meet the country's energy needs. The strategy has set energy conservation measures for the industry, agriculture and transport sector to ensure the sustainable use of energy by implementing different energy conservation measures. For example, the agriculture and industry sector is expected to save 100 MW of power demand, 250 million litres of heavy fuel oil and 9 million litres of industrial diesel oil. Green hydrogen and derivatives such as green methanol can be used as an alternative fuel source, to help achieve these targets;
- **Kenya's Updated NDC, 2020:** The NDC recognises the need to increase the use of renewable energy in the electricity generation mix of the national grid, enhance energy efficiency across

different sectors and use clean, efficient and sustainable energy technology to reduce over-reliance on fossil fuels. It however contains no targets for green hydrogen specific activities as priority mitigation actions. There is an opportunity to update the draft to reflect green hydrogen activities in 2025 when the plan is up for revision;

- **Agricultural Sector Transformation and Growth Strategy, 2019 - 2029:** The strategy aims to ensure national food security by providing a commercial and modern agriculture sector that sustainably supports Kenya's economic development, national priorities and international commitments. The strategy contains key flagship projects that enhance demand for agricultural inputs such as fertilizer, but do not reflect the potential use of green hydrogen and its by-products in improving the quality of locally produced fertiliser. There is an opportunity to revise the flagship projects to include specific green hydrogen related ones during the draft's mid-term review;
- **National Industrialization Policy Framework for Kenya, 2012 -2030:** The policy focuses on driving industrialisation. The policy framework has identified green energy as a priority industrial sub-sector with potential for development and highlights those priority sectors promoted by the government through providing incentives for investment, encouraging clustering of industries, promoting the use of local raw materials and reviving ailing resource-based industries;
- **Land Use Policy, 2017:** The policy recognizes government's responsibility to undertake planning and land banking for industrial, commercial, agriculture and infrastructure development, enabling the designation of zones that can operate as clusters of production/demand for green hydrogen and its derivatives.

There also exist pending policies that once adopted will be important for stimulating demand for green hydrogen. The **draft LT-LEDS** for example quantifies demand for green hydrogen in various sectors. It calls for a transition from the use of fossil fuels in the transport sector to electric and hydrogen fuelled vehicles and aims to replace 40% of coal with hydrogen in the production of cement, and replace 15% of heavy fuel oil used with electricity and hydrogen in food and beverage manufacturing. It also recognises the need to increase the use of green hydrogen in large industries such as those producing chemicals, paints, steel and pharmaceuticals. In the agriculture sector, the **draft National Soil Management Policy** aims to promote sustainable soil management policies and improve soil fertility by providing a framework for the development of sustainable fertilizer use and soil management practices. The draft therefore creates opportunity for enhancing the use of green ammonia in fertilizer production.

Vision 2030 through its pillars and their foundational cross cutting policies, implicitly supports the development of green hydrogen. For instance, the *economic pillar* recognizes the need for increasing renewable energy generation, highlights the significance of sustainable industrialization in driving Kenya's socio-economic progress, and sets targets that encompass the establishment of local fertilizer manufacturing plants, all of which directly coincide with the creation of a green hydrogen industry. Likewise, the *social pillar* aligns with the imperative need for developing relevant skills for the successful implementation and operation of green hydrogen projects. Lastly, the *political pillar* underscores the importance of political will and commitment from both the Kenyan government and its people to drive economic transformation, which is also a fundamental prerequisite for the successful development of a green hydrogen economy in the country.

As highlighted in this section, there are numerous existing policies (and others under development) that have the potential to serve as a framework to support the development of the green hydrogen sector in Kenya. Building upon these existing policies can potentially save time and resources compared to developing an entirely new dedicated policy framework. Furthermore, it can accelerate the market development process. However, it is important to address gaps and challenges in the existing policy framework along the hydrogen value chain to effectively support market development. Proposed **actions** to address gaps and challenges in the current supply- and demand-side policy framework are summarized in **Error! Reference source not found.**.

Table 6: Gaps in the current supply and demand side policy framework and recommended policy actions

Gaps	Recommended Policy Actions
Lack of green hydrogen targets in Kenya's national emission mitigation targets under the Nationally Determined Contributions (NDCs)	To support the transition towards a net-zero economy, it is necessary to revise Kenya's **NDCs** to include well-articulated green hydrogen ambitions aligning with the draft LT-LEDS, thereby opening doors for prioritized climate investment in Kenya's green hydrogen initiatives.
Lack of inclusion of green hydrogen in overarching energy policy	Incorporating green hydrogen development within the **National Energy Policy** is crucial. By doing so, dedicated renewable energy generation capacity can be allocated specifically for green hydrogen, aligning with ongoing green hydrogen projects and leveraging renewable energy integration. Such an integrated approach establishes a comprehensive and coordinated strategy to propel green hydrogen advancement within Kenya's renewable energy sector.
Lack of inclusion of green hydrogen in national agricultural policy	There is need to incorporate green hydrogen in the **Agricultural Sector Transformation and Growth Strategy (ASTGS)** to reflect the benefits it presents for the agriculture sector as Kenya's economy heavily relies on agriculture as its driving force. In the short term, the agricultural sector can also play a pivotal role as off-takers of green hydrogen fertilizer. The symbiotic relationship between the prosperity of Kenya's agriculture sector and its overall economy underscores the significance of including green hydrogen in the forthcoming revision of ASTGS.
Lack of designated green hydrogen project development areas	The **Land Use Policy, 2017** envisages that the government shall undertake planning and land banking for industrial and infrastructure development projects. Reliant on this policy, green hydrogen project development areas may be designated as green hydrogen hubs encouraging production and use and these areas may be granted Special Economic Zone (SEZ) status under the **Industrialization Policy Framework for Kenya 2012 -2030**.
Lack of recognition of the potential benefits of green hydrogen to improving agricultural soil health	It is important to incorporate green hydrogen in the draft **Agricultural Soil Management Policy, 2020** to encourage its production and use in the agricultural sector due to its potential to produce higher quality fertilizers. This will encourage the demand and production of fertilizer produced with green ammonia due to its reduced costs and soil improvement properties.
Lack of inclusion of green hydrogen in the Least Cost Power Development Plan (LCPDP* 2022-2041*)	There is need to incorporate green hydrogen in the **LCPDP,** 2022-2041 to ensure its inclusion in Kenya's power planning framework. This provides an opportunity for the development and expansion of green hydrogen projects and the development of distribution and transmission infrastructure for clean energy produced from green hydrogen.
Absence of renewable energy procurement based on competitive for lowering power costs	Kenya is in the process of developing its **Renewable Energy Auctions Policy, 2021** and it is important to adopt the draft and operationalize the policy by launching auctions under a clear framework that enhances the cost competitiveness of renewable energy for lowered costs of renewable electricity.

The recommended policy prioritization should align with the phased implementation timelines outlined in the Vision Statement. Short-term priorities should focus on the period from 2023 to 2027, corresponding to MTP IV and these priorities are recommended in Table 6. Long-term priorities should target Phase 2 of the roadmap, covering the years 2028 to 2032 and these may include the development of a dedicated Green Hydrogen Policy as well as amendment of policies around transport and industrialization to pave the way for new hydrogen use cases, such as in mobility, green steel or SAF. By aligning policy priorities with these implementation phases, Kenya can effectively navigate the roadmap and ensure a coordinated approach to green hydrogen development.

7.2. REGULATORY ASPECTS

The hydrogen value chain typically comprises three stages: production, storage / distribution, and consumption / application, each requiring a supportive, streamlined, and transparent regulatory framework through laws, regulations, codes, and standards.

Development of the green hydrogen sector requires a sound framework to support investments and guide functioning of the sector. This has the potential to re-risk and facilitate investments, to drive costs down and reduce market uncertainty.

Given the multi-component structure of the hydrogen value chain, clarity on the objectives of the regulatory treatment of hydrogen is especially important.[117] A well-designed legal and regulatory framework can support the attainment of several SDGs related to green hydrogen, ensuring that technology is beneficial and presents a socio-economic gamechanger for countries.

Kenya can efficiently build on its capacity and expertise to develop an adequate enabling legal and regulatory basis for green hydrogen.[118] A regulatory opportunity / gap analysis is set out highlighting the relevant legal and regulatory requirements and interventions necessary to facilitate (A) production, (B) storage and distribution, as well as (C) consumption of green hydrogen (by stimulating demand for local use and export of green hydrogen and its derivatives).

A. Production

Electricity

Electricity from renewable energy sources is a prerequisite for green hydrogen production. Kenya's overarching energy law, the Energy Act, 2019, and regulations thereunder create favorable conditions for the generation of renewable electricity.[119] The existing framework needs however to be further stimulated and adapted to facilitate increased electricity generation for green hydrogen production, through laws and regulations that incentivize generation including dedicated additional generation capacity. Key issues for consideration include:

- **Duration of geothermal exploration licenses:** Geothermal energy is an important and fundamental resource for green hydrogen production in Kenya due to its dispatchability and cost efficiency. The Energy Act makes provision for geothermal licenses, but does not set a period of exclusivity of geothermal exploration licenses. Geothermal regulations under the Energy Act are currently under development, and as they provide a clear cut exploration period, their enactment would provide needed clarity that enhances the bankability of projects;
- **Exclusivity of feasibility period for solar /wind generation:** Solar and wind are important renewable energy resources for green hydrogen production, given their abundance and cost competitiveness in Kenya. There is however no defined exclusivity period during feasibility stage for wind and solar sites under the country's regulatory framework, leaving this to the

[117] F. Gilles and P. Brzezicka, Unlocking the Hydrogen Economy- Stimulating Investment across the Hydrogen Value Chain Investor Perspectives on Risks, Challenges and the Role of the Public Sector, European Investment Bank, 2022.

[118] Ministry of Energy, GIZ, Baseline Study on the Potential for Power-to-X / Green Hydrogen in Kenya, 2022.

[119] Energy Act, Act No. 1 of 2019.

contracting between the landowner and project developer. Bankability of projects may however be enhanced through a set out period of exclusivity during feasibility stage for renewable energy projects;[120]

- **Streamlined licensing:** Streamlined licensing requirements and procedures are necessary, as the Energy Act currently provides that licensing exemptions are only available for persons generating electricity for their own use (captive power) with a capacity not exceeding 1 MW.[121] As this license is one of many required from various other agencies, the green hydrogen permitting and approvals process is rendered lengthy and cumbersome. Larger IPPs who fall within the licensing threshold under the Energy Act would therefore benefit from the establishment of a "one-stop-shop" licensing " model, whereby the establishment and operation of a green hydrogen project is based on a streamlined and simplified licensing process under the direction of an overarching coordinating entity that assists in all aspects of the project approval, including generation license acquisition;
- **Ancillary services:** The Energy Act envisions the provision of ancillary services which the designated system operator is responsible for scheduling and dispatching throughout the country.[122] These services are essential to the management of power system security, facilitate orderly trading in electricity and ensure that electricity supplies are of acceptable quality and may be provided by hydrogen-based technologies which support power system stability (i.e. frequency and voltage control), amongst others. An ancillary services compensation model is however necessary under Kenya's Energy Act and regulations thereunder, to enable monetization of ancillary services provided by the electrolysis process;
- **Electricity transmission**: There are three supply location archetypes, each bearing specific features, which need to be addressed in the regulatory framework (Figure 39):[123]

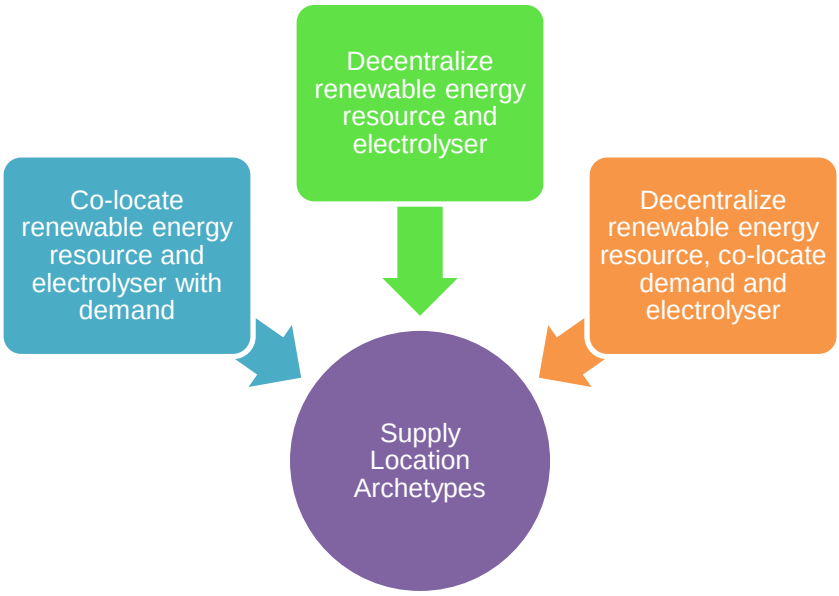


Figure 39: Green hydrogen supply location archetypes

(Source: Adapted from Republic of South Africa, Proposed South African Green Hydrogen (GH2) Commercialisation Strategy: Summary of the Green Hydrogen Commercialisation Panel Report, 30 November 2022)

[120] Ministry of Energy, GIZ, Baseline Study on the Potential for Power-to-X / Green Hydrogen in Kenya, 2022.

[121] Section 117, Energy Act, Act No. 1 of 2019. "Persons" as per Section 2 of the Energy Act means "any natural or juridical person".

[122] Section 138 (1) (c), Energy Act, Act No. 1 of 2019.

[123] Republic of South Africa, Proposed South African Green Hydrogen (GH2) Commercialisation Strategy: Summary of the Green Hydrogen Commercialisation Panel Report, 30 November 2022.

1. **Co-locate the renewable energy resource and electrolyser with demand:** This archetype ensures power generation for green hydrogen production is located at the same site as green hydrogen storage and consumption. The model requires a regulatory framework that enables supply of low-cost renewable electricity, access to water and land rights, and demand for green hydrogen and its derivatives in one location. This is based on the "hydrogen valley" concept, which aims to ensure consumption of green hydrogen and its derivatives is close to production. Kenya can adopt this approach by implementing provisions in the Physical and Land Use Planning Act that support planning for development of hydrogen hubs.[124] The existing regulatory framework for SEZs can also enable locating the production of green hydrogen and its derivatives within SEZs, allowing green hydrogen investments to benefit from sector specific incentives, business enabling policies and sector-appropriate infrastructures and utilities[125];
2. **Decentralize renewable energy resource and electrolyser:** This archetype entails co-locating renewable energy and production equipment (electrolysis process) and then evacuating the product or green hydrogen molecules, usually by pipeline, for use elsewhere. This model requires a regulatory framework that enables the transport of green hydrogen or its derivatives through requisite infrastructure. Gas pipeline infrastructure is yet to be developed in Kenya and the available gas provisions in the Energy Act do not include hydrogen. The Act defines "gas" as "methane, ethane, propane, butane or hydrocarbons which may consist of one or more of any of those gases, either in the form of gas or liquid."[126] As such "hydrogen" (i.e. its definition) should be introduced in the Energy Act to provide clarity on requirements for its evacuation;
3. **Decentralize renewable energy resource, co-locate demand and electrolyser:** This archetype entails locating production (electrolysis process) near the demand node, and evacuating renewable energy via wheeling on the national grid or dedicated grids to the electrolysis site. Since electricity generation and demand are distant, this not only requires adequate infrastructures but also a regulatory framework that sets clear rules for the transmitted electricity (including rules for ensuring that the electricity consumed is green). The Energy Act allows for a transmission licensee to provide non-discriminatory open access to its transmission system for use by any licensee or eligible consumer on payment of fair and reasonable transmission or wheeling charges as shall be prescribed in regulations.[127] However, the wheeling regulations envisioned by the Act are not yet enacted in Kenya, though a draft Bill is under development.[128] There is need for the finalization of this Bill ensuring that it includes a clear methodology for the calculation of wheeling charges to enhance green hydrogen projects.

Water

The main options available for sourcing the water to feed the electrolysis process include the use of freshwater resources, flood water, or desalination of seawater. In Kenya, the applicable regulatory

[124] Part III of the Physical and Land Use Planning Act, 2019 makes provision for National, Inter-County and County Physical and Land Use Development Plans, which can be designed to contain green hydrogen hub considerations. Further, under Section 52 of the Act, county government have the power to declare an area as a special planning area, where that area has been identified as suitable for intensive and specialized development activity, or the declaration is meant to guide the implementation of strategic national projects and this may be applied to development of green hydrogen hubs.

[125] Section 4, Special Economic Zones Act No. 16 of 2015. As of 1 April 2023, investments domiciled in SEZs benefit from the supply of energy at a special tariff of KES 10 per kilowatt hour. See EPRA, Press Release: Retail Electricity Tariff Review for the 2022/23-2025/26 4th Tariff Control Period (TCP) Effective 1st April 2023, 2023.

[126] Section 2, Energy Act, Act No. 1 of 2019.

[127] Section 136 (1) (c), Energy Act, Act No. 1 of 2019.

[128] Draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations, 2021.

framework comprises the Water Act, 2016,[129] which grants water rights, and includes a set of regulations covering Water Services, Water Resources and Harvesting and Storage.[130] Permits are required for the use of water from a water resource,[131] with minimal exemptions to permitting provided.[132]

The desalination of seawater for green hydrogen should be bolstered through the development of desalination system regulations that provide clarity on the appropriate processes and water use charges for desalination, fast-tracked timelines to obtain any permits and approvals connected to desalination for green hydrogen production. A laid-out process for the production of potable water and the procedures for transferring surpluses and certifying the quality of water for potable use is also necessary to ensure desalinated water is supplied to adjacent communities as a co-benefit of green hydrogen production in a particular location.

As desalination at large-scale is an industrial activity with an impact on the environment, siting/development permissions as well as environmental licensing and permitting is necessary to ensure disposal of liquid industrial wastes from the desalination plants are sustainably managed. The Physical and Land Use Planning Act, as well as the Environmental Management and Co-ordination Act and regulations thereunder on waste management and requirements for environmental impact assessment are instructive.[133] As the desalination process will require electricity, this electricity should be obtained from renewable sources to maintain the green credentials of the hydrogen developed in Kenya, and the regulatory framework for enhancing renewable energy supply will therefore have a bearing on desalination.

B. Storage and Distribution

Green hydrogen projects require the availability of suitable infrastructure (pipelines, conversion plants for processing, distribution, and storage). Kenya however lacks a comprehensive regulatory framework to enable the storage and distribution of green hydrogen. While the Energy Act envisions the use and application of gas in Kenya and development of relevant infrastructure such as gas pipelines, it does not explicitly make provision for hydrogen within this framework.[134]

Further, there are several safety risks associated with the handling of hydrogen gas, as due to its tiny molecules, it has a high diffusion rate which can easily penetrate small gaps and it is highly flammable, explosive, odourless and invisible and as such in the event of leakage, the same is not easily discoverable.[135] The safe storage, and transportation of green hydrogen is indirectly covered by legislation and standards, such as:

- **Environmental Management and Coordination Act** which defines as “hazardous substance” any gas likely to be injurious to human health or the environment and prohibits the release or discharge of such gases;[136] The Act also carefully controls the transport of hazardous waste;
- **Occupational Safety and Health Act** which provides for the safety, health and welfare of workers and all persons lawfully present at workplaces and makes provision for the handling of gases at the workplace,[137]

[129] Water Act, Act No 43 of 2016.

[130] Water Service Regulations 2021; Water Resources Regulations 2021; and Water Harvesting and Storage Regulations 2021.

[131] Section 36, Water Act, Act No 43 of 2016

[132] Section 37, Water Act, Act No 43 of 2016.

[133] Physical and Land Use Planning Act, 2019; Environmental Management and Co-ordination Act, Act No.8 of 1999.

[134] Section 2; Section 170, Energy Act, Act No. 1 of 2019.

[135] F. Eljack & M-K. Kazi, Prospects and Challenges of Green Hydrogen Economy via Multi-Sector Global Symbiosis in Qatar, Frontiers in Sustainability, 2021.

[136] Environmental Management and Coordination Act, Act No 8 of 1999.

[137] Occupational Safety and Health Act, Act No 15 of 2007.

- **Kenya standards on transport of dangerous goods**, [138] identifying and classifying dangerous goods for road and rail transport as well as general standards on hydrogen fuel.[139]

There is, thus, need for the development of more explicit technical regulatory frameworks for transport, and storage of green hydrogen and its derivatives, based on international guidelines, along with safety requirements to enable project implementation.[140]

C. Consumption / use of green hydrogen

Investing in green hydrogen production is a capital-intensive venture and countries require upfront clarity on the consumption and use of green hydrogen and its derivatives.

In line with Kenya's green hydrogen vision, strategy and implementation plan which highlights that Kenya will "prioritize no-regret options to kick-start a hydrogen industry, such as domestic fertilizer production, and once successfully established, this will enable hydrogen opportunities in other sectors, including (regional/international) export of hydrogen derivatives", the development of the green hydrogen sector will aim for the country to operate as both a self-sufficient and exporter country. This requires a robust regulatory framework to cover the entire value chain, initially focusing on creating domestic demand in sectors such as agriculture and industry; this should later be complemented by an export-oriented regulatory framework, adapted to comply with the requirements and specifications of regional and international markets.

To stimulate demand for green hydrogen and its derivatives for the local market and pave the way for potential exports to regional and international markets, the following need to be addressed:

- **Certification**: Hydrogen certification systems are necessary to build consumer trust and stimulate demand while enabling cross-border trade in hydrogen and fostering market liquidity.[141] Kenya needs to develop or adopt a certification scheme for green hydrogen and derivatives that will comply with international requirements. Such a framework should provide a coherent definition of what constitutes green hydrogen and green derivatives (such as green ammonia or green methanol) and develop Guarantee of Origin certification methodologies, ensuring that methodologies (e.g. for calculating the carbon intensity of products) are compliant across jurisdictions to facilitate regional and global export of the hydrogen products;
- **Agriculture**: Encouraging the application of green hydrogen and its derivatives has industrial significance for Kenya. Demand can be stimulated in various ways. For example, green ammonia can be utilized both locally as well as produced for export. The framework applicable for local use is the Fertilizers and Animal Foodstuffs Act which prohibits the manufacture, compound, mix or sell any fertilizer other than a substance declared by rules made under the Act to be an approved fertilizer, and requires that the fertilizer conforms to the standard or specification prescribed by such rules.[142] To stimulate the market for locally produced green ammonia, green fertilizer mandates requiring an increasing proportion of fertilizers to be green can be elaborated under the Act [143], as also addressed by the draft Fertilizers and Animal Foodstuffs (Fertilizers) Regulations 2022. Locally produced green fertilizer could also be exported regionally, aligning with the National African Continental Free Trade Area (AfCTA) Implementation

[138] KS EAS 949:2020 Kenya Standard — Transport of dangerous goods — Identification and classification of dangerous goods for road and rail transport, First Edition; KS EAS 950:2020 Kenya Standard — Transport of dangerous goods — Operational requirements for road vehicles, First Edition.

[139] KS ISO 14687:2019-Hydrogen Fuel- Product Specification; KS ISO 19889:2020-Hydrogen Fuel Production and Handling; KS ISO 22175:2021- Hydrogen Fuel-Storage and Distribution.

[140] Ministry of Energy, GIZ, Baseline Study on the Potential for Power-to-X / Green Hydrogen in Kenya, 2022.

[141] Hydrogen Council, Policy Toolbox for Low Carbon and Renewable Hydrogen: Enabling low carbon and renewable hydrogen globally, November 2021.

[142] Section 3, Fertilizers and Animal Foodstuffs Act, Act No 23 of 1962. Approved fertilizers under the Fertilizers and Animal Foodstuffs (Approved Fertilizers) Rules, 1972 include sulphate ammonia, calcium ammonium nitrate and ammonium sulphate nitrate.

[143] Section 19 (1)(b). The Cabinet Secretary on recommendation of the Fertilizer and Animal Foodstuffs Board of Kenya has power to make rules on the prohibition of certain substances and the limitation of percentages of certain substances in fertilizers.

Strategy (2022-2027) which prioritizes among others, the sale and export of fertilizers within Africa;[144]

- **Industry**: For green methanol/ethanol, blending mandates can be introduced to stimulate local use in cookstove fuels as well as in the petroleum sector, with fiscal incentives applied to incentivize local production. Demand for the use of green hydrogen in steel production and the cement industry can be supported by regulatory mandates, that set out a "minimum share of consumption of non-fossil energy or feedstock for certain designated consumers" specifying those in these critical industries. This can be anchored on the Energy Act which empowers the Cabinet Secretary to enforce efficient use of energy and its conservation;[145]
- **Transport**: Enabling the transition from fossil fuel to hydrogen-fuelled vehicles is a key means to increasing demand for green hydrogen. However, there currently lacks a specific regulatory framework enabling the use of hydrogen for transport, including a lack of targets for hydrogen consumption in Kenya's transport sector, such as for specific mobility applications (like fuel cell EVs) in the Port of Mombasa. The use of green hydrogen in the transport sector could also be enhanced by driving demand for hydrogen-powered heavy- duty trucks through regulatory mandates and enhancing the supply of green hydrogen through ammonia or methanol as clean maritime fuels through development of technical standards (including testing laboratories / certification) to ensure safety and sufficient quality of products.

D. Cross-cutting regulatory issues

Environment and social impact

The imperative to protect the environment and human health exists across the entire green hydrogen value chain, from production, transport and storage to application and use. The Environment Management and Co-ordination Act and regulations thereunder set out elaborate provisions on environmental and social impact assessment that would need to be complied with.[146]

There are also standards for hydrogen fuels that are applicable for environmental and social protection. However, more specific hydrogen industry and safety standards such as setting out environmental rules and technical requirements to be followed by hydrogen refuelling stations, for instance, would provide clarity on the minimum standards of design, construction, location, installation, and operation of these stations..

To remain competitive, Kenya will need to ensure its regulations, codes and standards reflect internationally and broadly accepted standards such as the International Organization for Standardization (ISO) standards, rather than adopting national or industrial technical rules of preferred partner countries. This includes updating requirements for industry and safety standards to explicitly include hydrogen, and mandating that environment and social impact studies, public health impact studies, and environmental management plans reflect key hydrogen concerns.

Importantly for a just transition, companies involved in developing Kenya's green hydrogen economy will require legitimacy and social licence to operate. To this end, meaningful community engagement is a necessity to ensure communities provide free prior and informed consent in the development of green hydrogen projects in their localities. This will require reliance on the existing regulatory framework which emphasizes public participation and equitable sharing of resources.[147] Developments of frameworks for amongst others, defined parameters for local community participation and access to benefits, will also be necessary.[148]

---

[144] Government of Kenya, National African Continental Free Trade Area (AfCTA) Implementation Strategy (2022-2027), 2022

[145] Section 190, Energy Act, Act No. 1 of 2019.

[146] Environmental Management and Coordination Act, 1999; The Environmental (Impact Assessment and Audit) Regulations, 2003.

[147] Constitution of Kenya, 2010

[148] Ann Waters-Bayer and Hussein Tadicha Wario, Pastoralism and Large-Scale Renewable Energy and Green Hydrogen Projects: Potential and Threats, Henirich Boll Stiftung, 2023

Local content

Kenya has a number of policies, legislations, and regulations that promote local content. In the energy sector, the Energy Act requires every person who carries out an undertaking within the Act to comply with local content requirements in all its operations. This entails the submission of a local content plan to EPRA, setting out details on how first consideration where applicable is given to Kenyan goods and services, as well as Kenyan on the job training, so as to build national capacity, capabilities, and investment in the local work force, services and supplies.[149]

There is however currently no synergy in the local content legal framework, creating challenges in ensuring industries investing in the country adopt measures to promote local content.[150] There are efforts to ensure that industry specific local content regulations are in place, and this provides an entry point to ensure the incorporation of green hydrogen by setting out thresholds for local content by sector (agriculture, industry, transport).

This will enable the local ownership, control and financing of activities connected with the production and use of green hydrogen and its derivatives and provide a framework to increase local value capture along the entire green hydrogen value chain. In developing the green hydrogen local content rules, it will be important for Kenya to set out clear targets that consider the practicability of the approach proposed, to ensure that requirements achieve the purpose of building local capacities. This is to ensure the requirements do not in the converse, operate as a barrier to development of a green hydrogen economy for example by having the effect of limiting the supply chain or limiting access to requisite technical skills necessary for growth.

Land rights access

Land access is a critical question to be considered in the development of a green hydrogen project, as land is the resource upon which production as well as storage and distribution is based. Renewable energy resources such as geothermal, wind and solar which are crucial for electrolysis also require land. The Energy Act makes provision for the use of land for energy resources and infrastructure,[151] and the legal framework for land ownership and management, comprising among others the Land Act, Land Registration Act, and Community Land Act also determine land rights access.[152]

Kenya's land rights system was overhauled in 2012 to simplify it and have a co-ordinated land law regime. However, there have been concerns relating to land rights particularly where titling is unclear. The lack of title compounds the risks for a project proponent making substantial investments without clarity on land ownership and security of tenure. Swift implementation of existing laws such as the Community Land Act, 2016 and regulations thereunder is required to enable legally sound projects on community land.

In addition, the Physical and Land Use Planning Act, 2019 sets out the role of the national and county government in providing approvals including for industrial land use for power generation.[153] Commercial-scale production of green hydrogen may cross county boundaries and will need multiple approvals leading to additional time delays and overhead costs.[154] This presents the requirement for obtaining approval from multiple stakeholders with differing requirements for land use. Kenya should grant large-scale green hydrogen projects strategic status that enables them to obtain approvals faster. This requires a green hydrogen “one-stop-shop” assisting with all aspects of project implementation and approvals for green hydrogen investments.[155]

---

[149] Section 206 Energy Act, Act No. 1 of 2019

[150] Government of Kenya, Local Content Policy, 2020.

[151] Part VII, Energy Act, Act No. 1 of 2019.

[152] Land Act, Act No 6 of 2012; Land Registration Act, Act No. 3 of 2012; and Community Land Act, Act No. 27 of 2016.

[153] Section 26(5), Section 33(1), Section 41, Section 50 of the Physical and Land Use Planning Act, 2019.

[154] Ministry of Energy, GIZ, Baseline Study on the Potential for Power-to-X / Green Hydrogen in Kenya, 2022.

[155] Ministry of Energy, GIZ, Baseline Study on the Potential for Power-to-X / Green Hydrogen in Kenya, 2022.

Investment related regulations

To develop a green hydrogen economy, Kenya requires a regulatory framework that allows access to investment from both public and private finance sources as well as overarching investment coordination as elaborated below:

- **Carbon finance:** Green hydrogen projects can be developed as carbon projects and the resultant carbon credits can be issued to producers or consumers, and traded in the global or domestic carbon markets, creating a source of finance flow from the adoption of green hydrogen. Tax incentives are in place for the establishment of an emissions trading scheme or carbon markets exchange,[156] though no domestic trading scheme or exchange is in place as yet. Kenya is also currently in the process of developing a legal and regulatory framework for the sale and transfer of carbon credits emanating from the country which requires enactment of the draft Climate Change (Amendment) Bill [157] and regulations to operationalize the Climate Change Act, 2016.
- **PPPs:** PPPs are generally considered to be a viable and ready solution to infrastructure projects, and the Public Private Partnership Act, 2021 contains measures intended to make PPPs a success. Some of these include the requirement for all projects to commence within 12 months after signing of the project agreement[158] which is hoped to focus and drive the parties to implementation, although there are concerns that this time period does not reflect the inevitably long, drawn-out nature of project feasibility research and negotiation to achieve bankability. The Act also provides that a project agreement should not be for a period exceeding 30 years,[159] however an extension is allowed in certain limited circumstances.[160] For a more robust framework the draft regulations enabling the full implementation of the Act need to be enacted, and the Directorate's envisioned guidelines such as on the determination of the duration of a PPP agreement should be developed,[161] with considerations made for how these can enhance conditions for green hydrogen projects.
- **Tax incentives:** Targeted fiscal incentives are necessary to stimulate initial investments in the green hydrogen economy, similar to the development of the renewable energy sector. There are currently a number of fiscal incentives for green technologies in Kenya that focus on renewable energy such as the exemption from VAT on solar and wind energy specialized equipment (e.g. solar panels or batteries). Kenya needs to facilitate and incentivize the import of electrolysers and other equipment required for integrated green hydrogen production and downstream processing plants, in the absence of local manufacturers: to this end, tax incentives such as the removal or reduction of import duties would be beneficial.

A major enabler for green hydrogen is a legal and regulatory framework that effectively governs green hydrogen production, storage / distribution, and consumption / application. From the regulatory gap analysis, Kenya has a legal and regulatory framework that can be improved on to guide the development of the country's green hydrogen ecosystem. Significant efforts are already underway to build laws, regulations and standards conducive for green hydrogen, and there is need to coordinate various efforts

[156] Finance Act No 22 of 2022. Amends the Third Schedule of the Income Tax Act Cap 470 of the Laws of Kenya. The amendment sets the tax rate for a company operating a carbon market exchange or emission trading system, that is certified by the Nairobi International Financial Centre Authority, at 15% for the first 10 years from the year of commencement of its operations.

[157] Climate Change (Amendment) Act, 2023.

[158] Section 61 (2) Public Private Partnerships Act, Act No. 14 of 2021

[159] Section 21 (2) Public Private Partnerships Act, Act No. 14 of 2021

[160] Section 23 (3) Public Private Partnerships Act, Act No. 14 of 2021

[161] Section 23 (2) Public Private Partnerships Act, Act No. 14 of 2021

in line with industry requirements and international good practice. Existing statutory approvals and permissions and procedures need to be streamlined, and new processes and regulatory mandates should be established, as required. In this context, a set of concrete **actions** should be considered as highlighted in Table 7.

Table 7: Gaps in the regulatory framework and recommended actions

Gaps	Recommended Regulatory Actions
Lack of an elaborate green hydrogen regulatory framework covering the entire value chain	Develop **regulatory objectives, implementation timelines and an implementation matrix** following a regulatory mapping exercise across the entire green hydrogen value chain, noting all cross-cutting issues including environment, health and safety requirements, as well as investment promotion options.
Missing inclusion of hydrogen as a gas under the Energy Act	Include hydrogen in the definition of "gas" in the **Energy Act** to enable the application of salient provisions within the Energy Act such as on gas infrastructure, to apply to green hydrogen.
Lack of streamlined licensing requirements and procedures for the development of green hydrogen projects	Develop **regulatory guidelines** for submission of project development plans / proposals to enable project developers to have access to clear and concise guidance on green hydrogen project development requirements from a central coordinating entity.
Absence of regulations enabling power wheeling to promote electricity transmission across locations	Update and enact the **draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations,** to include a clear methodology for the calculation of wheeling charges to enable corporate Power Purchase Agreements (PPAs) and enhance green hydrogen projects.
Lack of compensatory framework for ancillary services	Finalize and enact the **draft Energy (Electricity Tariff) Regulation** to provide an enabling framework for tariff computation and the creation of economic upsides from monetizing ancillary services provided by electrolysis process.
Unclear framework for water desalination	Develop and enact a regulatory framework under the **Water Act,** for desalination to provide clarity on the appropriate processes, procedures and charges for desalination that ensure environmental and social protections are in place.
Lack of specific local content requirements for green hydrogen	Embed green hydrogen in **local content regulation** to determine thresholds for local content by sector (agriculture, industry, transport), that should be met by green hydrogen projects in order for Kenya to reap the benefits of green hydrogen.
Absent regulatory provisions stimulating market demand for green ammonia	Finalize and enact the d**raft Fertilizers and Animal Foodstuffs (Fertilizers) Regulations** to increase market for locally produced green ammonia by promoting local capacity in green fertilizer manufacturing and blending.

Gaps	Recommended Regulatory Actions
Lack of defined exclusivity for the feasibility stage of renewable energy projects	Clarify within the purview of the **Energy Act**, the period of exclusivity during feasibility stage for renewable energy projects (solar and wind) on public land.
Unclear/ inadequate detail on geothermal project development requirements	Finalize and enact **geothermal regulations** such as the draft geothermal resources regulations, to de-risk green hydrogen project development and provide clarity on the exclusivity period for geothermal exploration licences.
Lack of relevant codes, standards and certification schemes covering the entire green hydrogen value chain	Develop of **codes, standards and certification schemes** (along the green hydrogen value chain). The certification scheme for green hydrogen and derivatives needs to comply with international requirements, defining what constitutes green hydrogen and green derivatives and develop Guarantee of Origin certification methodologies.
Unclear framework for engagement in carbon markets	Develop a legal and regulatory framework for the sale and transfer of carbon credits emanating from green hydrogen projects in the country to operationalize the **Climate Change Act** and leveraging green hydrogen for carbon finance, strengthening the pursuit of low carbon development.

The recommended regulatory actions set out in *Table 7*are to be implemented as priority within the short-term i.e. Phase 1 of the Green Hydrogen Strategy and Roadmap (2023 to 2027). Long-term priorities should target Phase 2, covering the years 2028 to 2032, and these may include environmental rules and technical requirements to be followed by refuelling stations, including minimum standards of design, construction, location, installation, and operation of stations (both inland and at Kenya's ports), regulatory mandates for use of hydrogen-powered heavy- duty trucks, and technical standards (including testing laboratories / certification) for the supply of green hydrogen through ammonia or methanol as a maritime fuel and SAF for aviation, may be developed in this period.

7.3. FINANCING OF GREEN HYDROGEN PROJECTS

Green hydrogen cost challenge

The production cost of green hydrogen is expected to progressively decrease in the future from its current levels of approximately 4-5 USD/kg and reach cost parity -and even become lower than that of fossil-derived hydrogen, currently at around 2 USD/kg (despite the recent surge in prices during the period 2021-2022). The reduction in the cost of green hydrogen will be attributed to two main factors: the declining costs of renewable electricity and the anticipated decrease in costs, alongside improved efficiency, of electrolysers due to advancements in technology.

The cost differential between green and fossil hydrogen observed globally is equally applicable to Kenya. To develop a market and establish business cases, bridging this cost gap will be essential to ensure the commercial viability of green hydrogen products. While the price of renewable electricity is the main driver of the cost of green hydrogen, it is important to consider other country-specific factors, such as fiscal and macroeconomic conditions, as they also have an impact on the overall cost. Hence, it is crucial to thoroughly assess the available and viable options within the specific context of each country, to effectively bridge this cost disparity.

***Box 6:** Specifics of green hydrogen project finance in Kenya*

When it comes to addressing the cost gap and considering Kenya's specific characteristics and prioritized hydrogen use cases, there are some important factors to be taken into account:

1. The EU as well as countries like the United Kingdom, US, and Japan, have made significant commitments to bridge the cost gap and foster the development of green hydrogen in their respective markets. They are providing substantial support (through subsidies, e.g. the US IRA, aggregation of demand or favourable off-take support structures) to encourage local supply and market growth. However, for Kenya, direct financial support to reduce the cost of hydrogen may not be the optimal choice, at present, to avoid straining the country's financial resources;
2. Taking into account its international competitiveness, while recognizing the significant benefits offered, particularly in the agricultural sector's demand for green fertilizer, Kenya has identified the domestic market as the prime opportunity (“low hanging fruit”) for utilizing green hydrogen. However, addressing the cost disparity associated with prioritizing the local fertilizer market poses certain challenges.

In the short term, it is not evident that Kenya will be able to capitalize on the benefits from access to subsidized export markets and funding mechanisms available in the EU. Moreover, it is crucial to ensure the affordability of locally produced fertilizers for the agricultural sector and farmers, who are the ultimate end-users of green hydrogen products. It is vital to avoid imposing a green premium on fertilizers that could place a financial burden on farmers.

Nevertheless, the adoption of green fertilizers presents a significant opportunity for Kenyan farmers to enhance the value of their export products, such as coffee or tea, and strengthen their position in international markets. By incorporating environmentally friendly practices, Kenyan farmers can further add "green value" to their goods, appealing to conscious consumers globally who prioritize sustainability. This has the potential to boost Kenya's agricultural sector, improve farmers' profitability, and enable them to capture a larger market share while enhancing their competitiveness in the international trade arena.

Finance risks

Finance of green hydrogen projects presents several distinct challenges and risks, and financing green hydrogen projects involves navigating through complex investments, necessitating careful consideration of certain risks and uncertainties (see *Table 8*).

Table 8: Major finance risks for green hydrogen projects

Offtake risk (market demand and pricing risk)	Offtake risk refers to the uncertainty surrounding the demand and market development of green hydrogen, which is still in its nascent stage, as well as the pricing of green hydrogen and its derivative products. Currently, the production cost of green hydrogen is higher compared to conventionally produced hydrogen (through steam methane reforming from natural gas). The successful market development of green hydrogen hinges on the willingness and ability of off-takers to pay a competitive price for green hydrogen products. The cost of renewable energy plays a crucial role in determining the competitiveness of green hydrogen.
Capital cost risk	Green hydrogen projects require scale to be profitable which results in significant upfront capital investments which pose a financial risk.

Policy and regulatory risk	The regulatory and policy landscape surrounding green hydrogen projects is still uncertain. Changes in government policies, regulations, and incentives can impact the financial viability of the projects.
Construction and operation risk	Green hydrogen projects involve technical complexity and integration risks (from renewable generation to downstream conversion processes), both during construction and operation.

In addition to the risks associated with the inherently high capital costs as well as country-specific regulatory and policy uncertainties, there is a significant hurdle that green hydrogen projects encounter anywhere in the world: the commercial risks linked to offtake agreements. These risks revolve around uncertainties concerning market demand and pricing of green hydrogen and its derivative products. As a result, few projects worldwide have progressed to the final investment decision stage.

Developing effective strategies to address these risks will be essential not only for supporting investments but also for securing the long-term financial viability of green hydrogen initiatives. The mitigation of offtake risks, coupled with the establishment of commercially viable and bankable offtake agreements between producers and customers, will be a pivotal enabler for the success of any green hydrogen project: such agreements provide hydrogen producers with predictable revenue streams, enhancing their ability to secure project financing, while ensuring a reliable supply for buyers. Contract structures like contracts-for-difference (CFDs)[162], among other demand side schemes, can assist in mitigating these offtake risks.

The inherent risks associated with green hydrogen projects have an inverse impact on the financing costs (both equity and debt), thereby increasing the hydrogen production costs. Kenya's current low sovereign credit rating and high interest rates further amplify the **risk premium** on the finance side.

Finance instruments

To ensure the commercial viability and bankability of green hydrogen projects and mitigate risks for project developers, the establishment of financial de-risking measures is essential. These measures involve implementing strategies and mechanisms aimed at reducing the financial risks associated with hydrogen projects, thereby enhancing their attractiveness to both lenders and investors. The choice of appropriate instruments depends on the market's stage and maturity.

[162] A CFD is a financial contract that helps mitigate risks associated with an offtake agreement by protecting the hydrogen producer's revenues and/or its buyer's costs against offtake price risk. It achieves this by providing an operation-support scheme compensating for the difference between supply and demand prices: If the supply price is higher than the market price, the support provider (e.g. a DFI) pays for the difference to the producer or the buyer. Conversely, if the supply price is lower than the market price, the support provider receives the difference from the buyer or seller, depending on who is the support recipient, i.e. the counterparty of the support provider (e.g. a DFI). This mechanism compensates for potential profits or losses based on the difference between the supply price and the market/reference price.

From the perspective of hydrogen producers, a CFD can be seen as equivalent to FiT because it offers a reliable method of receiving full (estimated) costs through predictable revenues. However, when compared to a FiT, the CFD scheme encourages greater participation from buyers and sellers in the market. This is particularly evident during negotiations and contract agreements, where parties can assess reference prices and settlement terms more effectively. In terms of the buyers involved, there are typically two entities:

1. Market price payer: An entity that pays the prevailing market price for the hydrogen;
2. Support provider: An entity that assumes the risk associated with the difference between the market price and the estimated cost. This entity could be a DFI, a donor institution, or entities like H2Global (Government of Germany) or the EU H2Bank.

In the case of Kenya and the production of green fertilizer, CFDs offer the advantage of being potentially set up by DFIs, as they require only a financial commitment from the DFI without direct involvement in the actual offtake. However, the CFD scheme relies on a market reference price for hedging, which is not yet established for green hydrogen; in case of green fertilizer, the fossil ammonia price could serve as reference price. As a result, a direct FiT may have the advantage of not requiring a market reference price, making it more suitable for the current stage of the market focused on pure green hydrogen. DFIs could equally consider providing a FiT for the green hydrogen products.

During the early stages, when commercial viability has yet to be established and a market for green hydrogen products is yet to emerge, **public investments** play a vital role. Incentives such as **grants**, sourced from international funding entities, can effectively incentivize the private sector to undertake pioneering projects.

During the initial phase of the market, green hydrogen investments may also be promoted through **fiscal incentives**, such as tax breaks. Similar to the successful implementation in the solar industry, measures like VAT exemptions and import duty waivers should be considered for hydrogen technologies like electrolysers. Further, such incentives could be implemented by leveraging the existing SEZ framework which allows licensed SEZ enterprises, developers and operators to benefit through an assortment of tax incentives. However, while fiscal incentives are essential for attracting investment, it is crucial to ensure that the design of these incentives takes into account their long-term fiscal implications and is effective in encouraging good performance.

In addition to fiscal incentives, the implementation of financial **risk-sharing instruments** is crucial for de-risking renewable energy and green hydrogen projects and ultimately leading to a reduction in the cost of capital. These instruments encompass guarantees, such as credit enhancement or sovereign guarantees, as well as insurances or foreign currency liquidity facilities.

However, in order to address the complex development challenges associated with green hydrogen projects, it will be crucial to scale up **innovative financing instruments**. These instruments, including concessional (low-interest) loans and blended financing, will play a pivotal role in catalysing green hydrogen investments. Moreover, the utilization of innovative climate financing mechanisms (such as the Green Climate Fund established within the framework of the UNFCCC)[163] will be vital in advancing green hydrogen applications. In particular, **blended financing** presents a compelling solution by harnessing the strengths and resources of multiple stakeholders, involving collaboration among governments, DFIs, philanthropic organizations, and private investors. By attracting diverse funding sources and mitigating financial risks, blended financing will be instrumental in unlocking investment opportunities for green hydrogen in Kenya.

As the market matures and risks associated with technology, market dynamics, regulation, and operational efficiency decrease, the need for concessional loans will diminish. At this stage, **market financing mechanisms**, such as **carbon trading mechanisms** (or mandatory quotas for green hydrogen use) are expected to become fully operational, providing additional avenues for financing in the country. These mechanisms enable the trading of carbon credits, allowing entities to buy and sell emission reductions; this creates a market where investors can support environmentally friendly projects and earn returns by trading these credits.

With a maturing market for green hydrogen products, the sector will gradually attract a broader range of lenders, including commercial banks specializing in project finance, private equity firms, and issuers of green bonds. In particular, green bonds can be instrumental in facilitating the shift towards a greener economy, with a notable illustration being the **EU Global Green Bond Initiative**.[164] This initiative specifically focuses on attracting private investments in climate finance for developing economies, aiming to address the often-limited access these countries have to capital markets.

Institutional market participants

DFIs and multilateral development banks (MDBs) play a pivotal role in supporting the economic and climate potential of the green hydrogen industry in developing economies. With their unique positioning, these institutions can provide crucial assistance through a range of financial instruments. DFIs can offer

[163] See https://unfccc.int/process/bodies/funds-and-financial-entities/green-climate-fund. Others potential funds include Zero Gap Fund, Global Environment Facility Trust Fund, NAMA facility, Climate Pledge Fund, Breakthrough Energy Ventures, Clean Investments funds etc. (see Baseline Study).

[164] https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/european-green-bond-standard_en; see also "Feasibility Study on the Issuance of Green Bonds in Kenya, March, 2023, A study commissioned by the European Union", Directorate General for International Partnerships, (DG INTPA).

concessional loans, equity investments, and guarantees, while export credit agencies can extend support through loans and guarantees specific to their respective countries.

These institutions have a wealth of experience in successfully scaling up investments in renewable energy development, making them particularly well-equipped to navigate the challenges of the green hydrogen sector. Their expertise will be vital in deploying effective financing strategies and instruments to drive the growth of the green hydrogen industry. For instance, they can contribute by providing technical assistance or project preparation facilities, ensuring that projects are well-prepared and executed.

The involvement of public and multilateral institutions like DFIs and MDBs also serves as a catalyst for attracting private banks and investors. Their participation lends credibility and stability to the industry, instilling confidence in potential financiers. Furthermore, DFIs can explore opportunities to become anchor investors in a diverse portfolio of smaller projects, rather than solely focusing on larger ventures. This approach allows for broader participation and increased resilience within the green hydrogen sector.

Timely and targeted support from DFIs is even more important, as there is also a global competition for finance in the hydrogen sector, driven by the increasing demand for hydrogen. For instance, while policies like the US IRA[165] aim to incentivize domestic renewable energy and green hydrogen industries, they inadvertently concentrate attention and resources on countries like the US, making it potentially harder for developing countries with large-scale project announcements to attract private investment. In addition, as sponsors of green hydrogen projects will rely on long-term offtake agreements with creditworthy buyers, often in the form of take-or-pay commitments, financiers may prioritize higher-priced export markets over domestic market commitments, potentially impacting the support for domestic green hydrogen markets.

Proposed actions

In conclusion, addressing the cost disparity and financing challenges of green hydrogen projects in Kenya requires a comprehensive and collaborative approach. Blending grants, concessional financing, and involvement of DFIs and MDBs are crucial steps. Simultaneously, the establishment of appropriate fiscal regimes, striking a balance between revenue interests and investment incentives while ensuring good performance, is essential. Mobilizing diverse funding sources and mitigating financial risks, will be crucial success factors for establishing a green hydrogen sector in Kenya.

In order to capitalize on the growing momentum surrounding hydrogen finance, it is imperative for Kenya to promptly tackle the cost disparities related to green hydrogen and determine the most suitable combination of financial measures and instruments needed to ensure the commercial feasibility of green hydrogen projects. To accomplish this, organizing a roundtable discussion forum, involving financial institutions and private sector developers would prove highly beneficial. This collaborative platform would foster a collective comprehension of project viability and facilitate consensus on financial strategies and strategic planning. Subsequently, conducting a thorough needs assessment would provide valuable insights for designing and implementing blended finance facilities specifically tailored to support the development of green hydrogen in Kenya.

The European Union has already announced the establishment of the **Hydrogen Bank** facility, while it supports the development of projects through the **Global Gateway** strategy to boost smart and sustainable investments including green hydrogen, the **EU-EDFI facility** (EEDF) to support investments through the European Development Fund (EDF), or the **EFSD+** guarantee facility, whereas the **H2-Global** instrument aims to bridge cost gaps and facilitate GH2 and derivatives market functioning.

---

[165] For the next ten years, the US IRA will offer a generous Production Tax Credit (PTC) for clean hydrogen production. This tax credit will be applicable to facilities that commence construction by the end of 2032. Projects meeting the criteria of having a lifecycle greenhouse gas emissions intensity of less than 0.45 kg CO_2e/kg hydrogen will be rewarded with up to 3 USD/kg of hydrogen produced. With the introduction of the IRA, the US is positioned to become one of the lowest green hydrogen production cost regions in the world. For further information see https://assets.ey.com/content/dam/ey-sites/ey-com/en_in/topics/energy-resources/2023/ey-the-inflation-reduction-act-2022.pdf or https://hydrogencouncil.com/en/hydrogen-insights-2023/.

To accomplish these objectives, it is crucial for DFIs, financiers, bilateral donors, and philanthropists to adapt their financial contributions to the specific requirements of the country and bolster their efforts in backing green hydrogen projects. Such call to action has been emphasized in the Nouakchott Message, underscoring the urgency and importance of their support.[166] Similarly, by mobilizing resources and aligning their efforts, these stakeholders have a significant role to play in contributing to the success of green hydrogen initiatives in Kenya.

[166] The Nouakchott Message is a set of recommendations calling on DFIs and their shareholders to enable the African green hydrogen economy before it is too late. It is a contribution to the wider Bridgetown Agenda on global financial reform for climate and development (see https://gh2.org/article/nouakchott-message).

8. ROADMAP AND ACTION PLAN

In the following, the action plan for the Green Hydrogen Strategy and Roadmap for Kenya is outlined. This action plan serves as the foundation for the roadmap to unfold and move forward and outlines targeted measures and initiatives to bridge existing gaps. To this end, it aims to facilitate the development of the green hydrogen sector in Kenya. The formulated action plan not only takes into account the identified regulatory, policy, and finance gaps but also incorporates valuable insights obtained from the SWOT analysis.

8.1.1. The Action Plan

The action plan for the green hydrogen sector also aligns with the five pillars of policy support proposed by the IEA to promote the growth of a green hydrogen industry.

The action plan has been informed by iterative stakeholder consultations and reflects the insights from the policy, regulatory and finance gap analyses as well as SWOT and general description of enablers. The focus is on the short-term actions, to be implemented during the first phase of implementation of the Roadmap from 2023-2027. The actions described in the action plan have been grouped as per the enabling pillars identified for the development of the strategy and roadmap for Kenya.

Box 7: *IEA policy support pillars*[167]

Establishing targets and/or long-term policy signals: A national hydrogen strategy should clearly define the role of hydrogen in the economy. It should identify priority sectors, either domestic or export, and a timeframe for scaling deployment. It should ensure coherence across key policy and planning frameworks, adhering to the ambitions of the country's NDC and national development plans.

Supporting demand creation: Portfolios should be established that set minimum targets for utilization in priority sectors, in sync with emissions and employment targets, to incubate green value chains.

Mitigating investment risks: In the face of several identified opportunities that lack clear timeframes or proof of future market demand, a nascent hydrogen sector requires investment certainty.

Promoting research and development, strategic demonstration projects and knowledge-sharing: To achieve a cost-competitive hydrogen value chain, continued investment in research and development is required to stimulate innovation in carbon-neutral hydrogen production and its applications.

Harmonizing standards and removing barriers: Appropriate standards and regulations need to be developed to govern the production, processing, and application of hydrogen.

8.1.2. Monitoring and Evaluation

The progress of the country in realizing and meeting the objectives of its Green Hydrogen Strategy and Roadmap a Monitoring and Evaluation (M&E) framework will be developed detailing the approach needed to track progress, evaluate the effectiveness of the roadmap in achieving its objectives, identify areas for adjustments or improvements, and provide feedback for decision-makers.

The M&E will originate from the logical framework which is the high-level view of the country's strategy and Roadmap and will include objectives, key performance indicators (KPIs), targets, sources for data

[167] IEA, 2022, https://www.iea.org/reports/global-hydrogen-review-2022

collection and analysis and a reporting, and evaluation framework. Indicatively, to measure the progress of the Strategy and roadmap the M&E plan will identify KPIs, including but not limited to: the developed, amended or enacted legal and regulatory interventions, the tonnes of hydrogen, ammonia or methanol produced, the installed renewable energy capacity installed and the corresponding electrolysers' capacity, the amount of green fertilisers produced, the investment attracted, the number of projects completed, the new jobs created by gender, the CO2 emissions avoided, the number of research programmes developed at Universities and the number of Research & Development programmes in collaboration with international centres, the number of students enrolled and graduated from dedicated programmes, the people trained by gender, and other performance indicators that will be defined.

The M&E plan will set targets for each KPI and will outlines the data sources, collection, and analysis procedures. Bi-yearly evaluation reports will provide a systematic overview of the progress towards the set tar-gets. In addition, evaluation of the effectiveness of the Strategy and Roadmap will be performed, including recommendations for improvements and/or amendments. The M&E plan will be subject to periodical reviews to ensure that it remains relevant and effective in assessing the progress made, in view also of potential future revisions of the Strategy and Roadmap of Kenya.

Table 9: Key Actions for Phase 1 of the Roadmap (2023-2027)

1. CENTRAL COORDINATION

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
1.1	Establish a high-level "Green Hydrogen Program Coordination Committee"	Provides strategic oversight and governance, and timely monitoring of the Strategy and Roadmap implementation progress.	Ministry of Energy and Petroleum (MoEP)	Ministry of Agriculture, Livestock; Fisheries and Cooperatives (MoALFC); Ministry of Roads and Transport (MoRT); Ministry of Investments Trade and Industry (MITI); Ministry of Environment, Climate Change and Forestry (MoECCF); Ministry of Water, Sanitation and Irrigation (MoWSI); National Treasury; Energy and Petroleum Regulatory Authority (EPRA); Development Partners	Q1 2024-Q2 2024
1.2	Establish a Green Hydrogen Secretariat to operate as a "one-stop-shop"	Institutionalizes (operationalizes) and coordinates the development of the green hydrogen sector / implementation of the Green Hydrogen Strategy and Roadmap. Its role is to enhance efficiency and support streamlined project approval processes, fast-track flagship projects, and provide market research and value chain analysis.	MoEP	MoALD MoRT; MITI; MoECCF; MoWSI; Ministry of Lands, Public Works, Housing and Urban Development (MoLPWH); National Treasury; County Governments; Development Partners	Q1 2024-Q3 2024
1.3	Establish a "Green Hydrogen Industry Association"	Institutionalizes private sector coordination and advocacy for green hydrogen and demonstrates industry commitment to a green hydrogen economy.	Private sector	Kenya Private Sector Alliance (KEPSA)	Q1 2024-Q2 2024
1.4	Organize national green hydrogen roundtables on green hydrogen finance and green hydrogen projects	Promotes common understanding of commercial and financial requirements of projects on financial strategies; enables matchmaking between project developers and finance community; promotes private sector cooperation leveraging synergies.	Office of the President; National Treasury	MoALD; MITI; MoEP; MoECCF; County Governments; Project Developers, Development Finance Institutions (DFIs); and other Financial Institutions	Q1 2024-Q3 2024
1.5	Develop a Monitoring & Evaluation framework	To track progress in achieving objectives, identify areas for improvements, and provide feedback for decision-makers	Ministry of Energy and Petroleum (MoEP)		Q2 2024-Q3 2024
1.6	Review Green Hydrogen Strategy and Roadmap (after two years of adoption)	Provides opportunity to revise Strategy and Roadmap, considering external developments and possible implementation issues.	MoEP	MoALD; MoRT; MITI; MoECCF; MoWSI; National Treasury; EPRA; Development Partners	Q4 2025-Q1 2026

2. DOMESTIC, REGIONAL AND INTERNATIONAL DEMAND

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
2.1	Conduct green hydrogen market study on emerging local and export opportunities	Identifies emerging business opportunities.	MoEP	MoRT; MITI; Ministry of East African Community, Arid and Semi-Arid Lands (ASALs), and Regional Development (MoEAC); Academia; Private Sector (Industry and Transport Stakeholders); DFIs; and Development Partners	Q3 2024-Q1 2025
2.2	Develop strategies for domestic green fertilizer use (including innovative finance and local market frameworks)	Promotes affordable green fertilizer for the local market.	National Treasury	MoALD ; MITI; Kenya Bureau of Standards (KEBS)	Q1 2024-Q3 2024
2.3	Conduct soil health studies for tailor-made green fertilizer	Defines specifications of nitrogen fertilizer.	MoALD	Kenya Agricultural and Livestock Research Organization (KALRO); KEBS; Academia; Non-Governmental Organizations (NGOs); Community Based Organizations (CBOs)	Q3 2024-Q4 2024
2.4	Mandate national blending quotas for locally produced green fertilizer	Increases local sale and manufacture of green fertilizer.	MoALD	Fertilizer and Animal Foodstuffs Board of Kenya (FAFB); MITI; KEBS; Private Sector (manufacturers of green fertilizer); Farmer Associations	Q3 2024-Q4 2024
2.5	Mandate national quotas for use of locally produced methanol	Increases local manufacture and sale of green methanol.	MoEP	MoRT; MITI; KEBS; Private Sector (green methanol producers)	Q3 2024-Q4 2024

3. COST-COMPETITIVENESS OF POWER PRICING

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
3.1	Design “model green hydrogen production plants” (including solar, wind, geothermal, to address aspects such as margins on steam, feasibility period exclusivity and license timelines)	To optimize levelized cost of hydrogen (LCOH) for different hydrogen use cases.	MoEP	EPRA; Geothermal Development Company (GDC); Kenya Electricity Generating Company (KenGen); Rural Electrification and Renewable Energy Corporation (REREC); Private Sector Developers; National Treasury	Q4 2024-Q4 2025
3.2	Adopt pending Renewable Energy Auction Policy (REAP)	Establishes renewable energy procurement based on competitive auctions for lowered costs of renewable electricity.	MoEP	EPRA	Q1 2024-Q3 2024
3.3	Designate and gazette Special Economic Zones (SEZs) for green hydrogen projects	Facilitates green hydrogen project development and leverages SEZ support services.	MITI	MoEP; SEZ Authority; Kenya Revenue Authority (KRA); Private Sector/Investors	Q2 2024-Q4 2024

4. ATTRACTIVE INVESTMENT ENVIRONMENT

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
4.1	Conduct a project siting / site selection study for green hydrogen projects (Green Hydrogen Atlas / green hydrogen site mapping)	Serves as support study for next Least Cost Power Development Plan (LCPDP); facilitates efficient and transparent access to essential information for project developers; serves to designate areas for green hydrogen project development (scope to include water availability, environmental impacts, infrastructure access, socio-economic costs, etc.).	MoEP	EPRA; MoLPWH; National Land Commission (NLC); Water Resources Authority (WRA); National Environment Management Authority (NEMA); County Governments; Development Partners	Q3 2024-Q3 2025
4.2	Earmark dedicated funds/facilities for green hydrogen project development, (e.g. for project development, feasibility studies or Environmental and Social Impact Assessments)	De-risks green hydrogen project development.	DFIs and Development Partners	National Treasury; MoEP; NEMA	Q3 2024-Q2 2025
4.3	Develop a Green Hydrogen Strategy and Roadmap resource mobilization plan (including pricing of actions and budgeting for their implementation)	Mobilizes funding for implementation of the Green Hydrogen Strategy and Roadmap.	National Treasury	MoEP; Private Sector Developers; DFIs; Development Partners	Q12024-Q3 2024
4.4	Implement KenGen Olkaria green hydrogen pilot project	Demonstrates first green hydrogen project in Kenya and creates external visibility.	KenGen	MoEP	Q4 2024-Q1 2026
4.5	Conduct cost-benefit analysis guiding government finance support package (across green hydrogen value chain)	Informs Government of Kenya's optimal fiscal incentives and revenue / royalties model across green hydrogen value chain and use cases	MoEP	National Treasury; DFIs; Development partners	Q2 2024-Q4 2024
4.6	Identify funds and innovative finance models to enable green hydrogen projects (e.g. contracts-for-difference (CFDs), green bonds, climate or impact finance)	Aims to support and de-risk green hydrogen project development and enable commercial viability of green hydrogen use cases.	National Treasury	MoEP; MoECCF; Capital Markets Authority (CMA); DFIs; Development Partners	Q3 2024-Q1 2025
4.7	Review and optimize Public Private Partnerships (PPPs) process for accelerated development of green hydrogen projects	Increases development of green hydrogen projects through PPPs	National Treasury	MoEP; Private Sector	Q4 2024-Q2 2025

5. CLEAR AND CONSISTENT POLICY SIGNALS

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
5.1	Include green hydrogen as a priority action in Kenya's Nationally Determined Contributions (NDCs)	Provides access to climate finance and quantifies potential of green hydrogen to meet NDC target.	MoECCF	MoEP; MoRT; MITI	Q1 2025-Q4 2025
5.2	Designate green hydrogen project development areas	Allows demarcation of sites or zones for hydrogen project development spanning national, county or inter-county- level.	MoLPWH	MITI; County Governments; National Land Commission; Private Sector	Q3 2024- Q4 2024
5.3	Include dedicated provision on green hydrogen in the National Energy Policy, 2018	Sets out a basis for the legal and regulatory framework around green hydrogen and provides visibility of the potential for green hydrogen in Kenya (as there is currently no dedicated green hydrogen policy in Kenya).	MoEP	EPRA; Private Sector	Q2 2024-Q3 2024
5.4	Include Green Hydrogen Strategy in LCPDP	Considers the impacts of green hydrogen on electricity demand and supply, and infrastructure planning.	MoEP	EPRA; Kenya Power and Lighting Company (KPLC); KenGen; Kenya Electricity Transmission Company Limited (KETRACO); REREC; GDC; Kenya National Bureau of Statistics (KNBS); Private Sector	Q3 2024-Q4 2024
5.5	Address green hydrogen fertilizer in upcoming review of the flagship projects of the Agricultural Sector Transformation and Growth Strategy (ASTGS)	Endorses added value of green fertilizer for transformation and growth of the agriculture sector.	MoALD	County Government; KALRO; Academia; Private Sector; Community Farmer Organizations	Q2 2024-Q3 2024
5.6	Include green hydrogen in draft Agricultural Soil Management Policy (➔ Fertilizer)	To enable the use of green fertilizer, define tailor made products and boost agricultural yield	MoALD	County Government; KALRO; Academia; Private Sector; Community Farmer Organizations	Q1 2024- Q3 2024

6. SUPPORTIVE AND FIT-FOR-PURPOSE REGULATION

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
6.1	Include hydrogen in the definition of "gas" in the Energy Act	Enables applicability of relevant provisions of the Energy Act on the production and supply of green hydrogen.	MoEP	Office of the Attorney General and Department of Justice (AGs office); Public and Private Sector	Q1 2024-Q3 2024
6.2	Develop regulatory objectives, implementation timelines and an implementation matrix	Addresses regulation of unregulated areas across the full value chain of green hydrogen and its derivatives.	One-stop-shop	MoEP; MoALD; MITI; MoRT; MoECCF; Development Partners	Q3 2024-Q4 2024
6.3	Develop codes, standards and certification schemes (along the green hydrogen value chain)	Ensures conformity to international standards and enables access to international markets.	EPRA	KEBS; NEMA; DFIs and Development Partners, Academia	Q1 2025-Q1 2026
6.4	Enact Open Access (wheeling) regulation	Enables implementation of Corporate Power Purchase Agreements (PPAs).	EPRA	AGs Office; MoEP; Private sector	Q1 2024-Q3 2024
6.5	Embed green hydrogen in local content regulation	Determines thresholds for local content by sector (agriculture, industry, transport), that should be met by green hydrogen projects	MITI	AGs Office; MoALD MoEP, County Government	Q4 2024-Q2 2025
6.6	Develop guidelines for submission of project development plans / proposals	Provides uniformity, transparency and comparability in the review process to fast track project development.	One-stop-shop	EPRA; NEMA; National Construction Authority (NCA); WRA; County Governments; Project Developers	Q2 2024-Q3 2024
6.7	Finalize and enact the Draft Energy (Electricity Tariff) Regulations	Provides an enabling framework for tariff setting and for ancillary services provided by electrolysers	EPRA	MoEP; Development partners	Q1 2024-Q4 2024
6.8	Develop and enact carbon market regulations	Clarifies processes and procedures for monetizing green hydrogen projects in the global carbon markets and increases access to carbon finance.	MoECCF	National Treasury; AGs Office; MoEP; Private Sector	Q1 2024-Q3 2024
6.9	Develop regulatory framework for water desalination	Provides regulatory clarity on the appropriate processes, water use charges, and the supply of desalinated water to local communities (as co-benefit).	MoWSI	WRA; AGs Office; NEMA; Private Sector; CBOs	Q1 2025-Q32025
6.10	Finalize and enact the Draft Fertilizers and Animal Foodstuffs (Fertilizers) Regulations	Promotes local green fertilizer manufacturing and blending.	MoAL	AGs Office; Private Sector	Q2 2024-Q4 2024

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
6.11	Clarify exclusivity period for renewable energy projects development (solar and wind) on public land	De-risks green hydrogen project development and enhances bankability.	MoEP	MoLPWH; NLC; AGss Ofice; Project Developers	Q1 2024-Q1 2024
6.12	Finalize and enact the draft geothermal resources regulations	De-risks green hydrogen project development and provides clarity on the exclusivity period for geothermal exploration licences.	MoEP	GDC; AGs Office; Project Developers	Q1 2024-Q1 2025

7. SKILLS DEVELOPMENT, INNOVATION CULTURE

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
7.1	Develop a Research, Development and Innovation (RDI) roadmap (to support the Green Hydrogen Strategy and Roadmap)	Promotes research and development, technology development and an entrepreneurial ecosystem around green hydrogen, and increases pool of skilled (technical and professional) locals (incl. youth and women) accessing emerging job opportunities around green hydrogen.	MoEP	Ministry of Education (MoE); Ministry of Gender, Public Service and Affirmative Action (MoGPSAA); Ministry of Youth Affairs, Sports and the Arts (MoYASA); MITI; Academia (Universities; Technical Colleges); Industry/Private Sector	Q4 2024-Q3 2025
7.2	Develop a green hydrogen stakeholder engagement and communication plan (to promote awareness across all sectors and key stakeholders, with focus on fertilizer value chain)	Enhances social acceptance and capacity building; helps stimulate demand for green fertilizers and other green hydrogen products; increases gender and youth inclusivity.	MoEP	Ministry of Information, Communications and the Digital Economy (MoICT); MoALFC; MoGPSAA; MoYASA; DFIs and Development Partners	Q3 2024-Q2 2025
7.3	Develop / revise (MoE 2021) green hydrogen capacity needs assessment and human capacity development strategy	Articulates clear sectoral needs and ensures adequate capacity is developed to meet local content requirements.	MoEP	National Industrial Training Authority (NITA); Development Partners; Industry/Private sector; Academia	Ongoing-Q4 2023
7.4	Establish green hydrogen campuses (Centres of Excellence)	Stimulates and co-ordinates research on green hydrogen across the entire value chain, promotes knowledge sharing and serves as demonstration centres that enable increased learning and visibility around green hydrogen.	MoEP	Academia; MoALD; MITI; MoRT; Development Partners	Q2 2024-Q1 2026

8. PARTNERSHIPS AND COLLABORATION

No.	Action	Expected impact / Rationale	Champion	Supporters	Timeline
8.1	Expand regional and international cooperation and partnerships on green hydrogen (like the Africa Green Hydrogen Alliance (AGHA) and within the African Union and East African Community)	Helps identify business opportunities, learning from best practice examples and knowledge sharing.	One-stop-shop	MoEAC; MoEP	Q3 2024-Q4 2026
8.2	Include green hydrogen in bilateral / multilateral international Co-operation Partnership Frameworks	Broadens available funding sources for green hydrogen projects (e.g. EU / EIB / AfDB / World Bank).	National Treasury	Line Ministries; DFIs; Development Partners	Q1 2024-Q4 2026
8.3	Establish local and international partnerships to scale up training and capacity building (required for green hydrogen)	Enables collaborative capacity building, peer to peer exchanges, and increased learning opportunities for all stakeholders.	MoEP	MoE; NITA; Industry/Private sector; Academia; Development Partners	Q3 2024-Q3 2025

Table 10: Gantt chart for Phase 1 (2023-2027) actions

	No.	Action	2023 Q4	2024 Q1	2024 Q2	2024 Q3	2024 Q4	2025 Q1	2025 Q2	2025 Q3	2025 Q4	2026 Q1	2026 Q2	2026 Q3	2026 Q4	2027 Q1 2023
CENTRAL COORDINATION	1.1	Establish high-level "GH2 Program Coordination Committee"		■	■	■										
	1.2	Establish a Green Hydrogen Secretariat		■	■	■	■									
	1.3	Establish a "Green Hydrogen Industry Association"		■	■	■										
	1.4	Organize national green hydrogen roundtables		■	■	■	■									
	1.5	Develop a Monitoring & Evaluation framework			■	■	■									
	1.6	Review Strategy and Roadmap									■	■				
DOMESTIC, REGIONAL & INTERNATIONAL DEMAND	2.1	Conduct green hydrogen market study				■	■	■								
	2.2	Develop strategies for domestic green fertilizer use			■	■										
	2.3	Conduct soil health studies				■	■	■								
	2.4	Mandate national blending quotas				■	■	■								
	2.5	Mandate national quotas for use of locally produced methanol				■	■	■								
COST-COMPETITIVENESS OF POWER PRICING	3.1	Design "model green hydrogen production plants"					■	■	■	■	■					
	3.2	Adopt pending Renewable Energy Auction Policy (REAP)		■	■	■	■									
	3.3	Designate SEZs for green hydrogen projects			■	■	■	■								
ATTRACTIVE INVESTMENT ENVIRONMENT	4.1	Conduct site selection study for GH2 projects				■	■	■	■	■						
	4.2	Earmark dedicated fundsfor GH2 project development				■	■	■	■							
	4.3	Develop resource mobilization plan		■	■	■	■									
	4.4	Implement KenGen Olkaria GH2 pilot project					■	■	■	■	■	■				
	4.5	Conduct cost-benefit analysis for Gvt finance support package			■	■	■									
	4.6	Identify funds/finance models for GH2 projects				■	■	■								
	4.7	Review / optimize PPP process for GH2 projects					■	■	■							
CLEAR AND CONSISTENT POLICY SIGNALS	5.1	Include GH2 in Kenya's NDCs						■	■	■	■					
	5.2	Designate green hydrogen project development areas				■	■									
	5.3	Include dedicated provision on GH2 in NEP, 2018			■	■										
	5.4	Include GH2 Strategy in LCPDP				■	■									
	5.5	Include green fertilizer as flagship projects of the ASTGS			■	■	■									
	5.6	Include GH2 in draft Agricultural Soil Mgt Policy		■	■	■										
SUPPORTIVE AND FIT-FOR-PURPOSE REGULATION	6.1	Include hydrogen in the definition of "gas" in the Energy Act		■	■	■										
	6.2	Develop regulatory timelines and implementation matrix			■	■	■									
	6.3	Develop codes, standards and certification schemes						■	■	■	■	■				
	6.4	Enact Open Access (wheeling) regulation			■	■	■									
	6.5	EmbedGH2 in local content regulation					■	■	■							
	6.6	Develop guidelines for project development plans			■	■										
	6.7	Finalize and enact the Electricity Tariff Regulations		■	■	■										
	6.8	Develop and enact carbon market regulations		■	■	■										
	6.9	Develop regulatory framework for water desalination						■	■	■						
	6.10	Enact Draft Fertilizers and Animal Foodstuffs Regulations			■	■	■	■	■	■	■					
	6.11	Clarify exclusivity period for RE projects dev. on public land		■	■	■	■	■								
	6.12	Finalize and enact the draft geothermal resources regulations		■	■	■	■									
SKILLS DEVELOPMENT, INNOVATION CULTURE	7.1	Develop a Research, Development and Innovation (RDI) roadmap					■	■	■	■						
	7.2	Develop a GH2 stakeholder engagement / communication plan				■	■	■	■							
	7.3	Develop / revise GH2 capacity needs assessment	■	■												
	7.4	Establish GH2 campuses (Centres of Excellence)			■	■	■	■	■	■	■	■				
PARTNERSHIPS & COLLABORATION	8.1	Expand regional and international cooperation and partnerships				■	■	■	■	■	■	■	■	■	■	
	8.2	Include GH2 in bilateral / multi-lateral Co-operation frameworks		■	■	■	■	■	■	■	■	■	■	■	■	
	8.3	Establish partnerships for training and capacity building				■	■	■	■	■						

8.2. ROADMAP GOVERNANCE FRAMEWORK AND IMPLEMENTATION

8.2.1. Governance

To effectively carry out the Roadmap activities, it is crucial to establish strong coordination among different Government Ministries, institutions, the private sector, and other relevant stakeholders. A governance structure that is adaptable and focused on achieving results will be developed to steer and guide the implementation of the Roadmap. This structure will include a Steering Committee called the **"Green Hydrogen Program Co-ordination Committee" (GH2-PCC)**, which will be chaired by the Cabinet Secretary. The committee will consist of Presidential Advisers, representatives from Ministries, stakeholders in the electricity sector, members from the academia, industry experts, among others. The creation of this committee is the initial step envisioned for the rollout and execution of Kenya's Green Hydrogen Strategy and Roadmap. The GH2-PCC will oversee the activities outlined in the roadmap, offer guidance, regularly monitor progress, propose policy interventions to support the mission's objectives, and initiate and conduct a review of the Green Hydrogen Strategy and Roadmap after two years of the implementation.

The **GH2 Program Co-ordination Committee** assumes the crucial role of overseeing and managing the implementation of the Roadmap's objectives. This committee is tasked with evaluating and proposing any required amendments, such as additions, adjustments, or withdrawals of specific actions outlined in the Roadmap. Additionally, they are responsible for providing recommendations to relevant authorities regarding fiscal, monetary, or regulatory interventions as deemed necessary

The GH2-PCC aims to enhance the synergy between the Green Hydrogen Strategy and Roadmap and other initiatives of the Government on hydrogen. It will foster coordinated efforts among the participating ministries as well as public and private sector institutions to ensure a cohesive approach. Through close collaboration with all relevant stakeholders, the GH2-PCC will prevent redundant activities and promote the efficient utilization of resources and expertise. As necessary, the committee will establish thematic Sub-Committees consisting of domain experts to provide support. Additionally, the GH2-PCC will actively monitor the performance and outcomes of projects, taking appropriate action whenever necessary.

A **National Green Hydrogen Advisory Group** will be established, consisting of experts from academic and research institutions, industry, and civil society. The Principal Presidential Advisor will serve as the chair of the Advisory Group. Its primary role will be to provide guidance to the GH2-PCC on all matters related to science and technology concerning the Strategy and Roadmap.

The MoEP will serve as the central coordinating body for the Strategy and Roadmap, taking responsibility for overarching policy formulation and program implementation. The ministry aims to promote the adoption of green hydrogen and its derivatives across various sectors of the Kenyan economy. Simultaneously, the ministry will support initiatives aimed at improving competitiveness and expediting the market entry of green hydrogen/derivatives. To ensure effective coordination, other ministries and public sector institutions will actively contribute to the implementation of the Roadmap, aligning with the guidance provided by the GH2-PCC. Additionally, a Roadmap Secretariat will be established at the MoEP to oversee the coordination of the program and facilitate day-to-day activities related to the Roadmap.

A **Strategy and Roadmap Secretariat** will be led by the Roadmap Director, an experienced professional with expertise in the field. The Roadmap Director will also serve as the Secretary of the GH2-PCC. The Secretariat will consist of subject matter experts and professionals. Its main responsibilities will cover coordination and monitoring of the implementation of the action plan. Additionally, the Secretariat will be involved in the evaluation, funding, and management of pilot projects and research and development initiatives. As required, it will provide assistance to the GH2-PCC and the Advisory Group. The Roadmap Secretariat will maintain continuous monitoring of the sector's exposure to various risks, promptly addressing and categorizing them with guidance from the GH2-PCC. A designated portion of the **Roadmap budget** will be allocated to support program management activities undertaken by the Secretariat.

9. CONCLUSIONS AND RECOMMENDATIONS

Aligning with Kenya's Vision 2030, which seeks to accelerate sustainable growth and transform Kenya into a competitive and prosperous country with a high quality of life, Kenya has made improving the livelihoods and welfare of its citizens a top priority through the Bottom-Up Economic Transformation Agenda. Recognizing the significance of green hydrogen, Kenya aims to harness its potential as a cross-cutting enabler for the country's development agenda and as a catalyst for sustainable socio-economic development.

Amidst this global wave of interest in green hydrogen, Kenya stands uniquely positioned to capitalize on the unprecedented political and business momentum surrounding this nascent industry. Kenya has achieved remarkable success in developing a well-diversified power generation mix, with approximately 90% of its electricity sourced from renewable energy sources. The country possesses a vast untapped renewable energy potential, including a leading position in geothermal power within Africa.

With a strong innovation culture and a commitment to sustainable development, exploring options for producing green hydrogen from green electricity is a logical next step in building a green economy in Kenya. This presents a unique window of opportunity for Kenya to pursue tangible business opportunities in the nascent green hydrogen industry to drive green economic growth, contribute to the country's socio-economic transformation and actively participate in the global collaborative efforts to tackle the impacts of climate change. The vibrant private sector with project developers actively pursuing green hydrogen projects in Kenya serves as compelling evidence of the country's potential in the field of green hydrogen.

The European Investment Bank (EIB) defines three key success factors for harvesting Africa's extraordinary green hydrogen potential:[168]

1. Activate national planning and incentive schemes, ensuring the development of domestic policy and regulatory frameworks which mobilize private sector investment and innovation to develop and integrate domestic value chains.
2. Successful pilot projects at demonstration and commercial scale involving key private and public sector stakeholders in all aspects of the green hydrogen value chain.
3. Aggregate mass scale off-take and demand, both domestically and internationally.

This is therefore an opportune moment for Kenya to launch this Green Hydrogen Strategy and Roadmap and align itself with global trends in technology, applications, policy and regulation, and capitalize on available funding opportunities. This dedicated national hydrogen strategy is essential for Kenya, like for any country in the world aiming to establish a robust hydrogen industry, as it provides a clear vision, direction, and framework for the development of the hydrogen sector.

Certain priority actions have been identified to establish the building blocks and kick-start the process of operationalization and implementation of the Green Hydrogen Strategy and Roadmap:

- Establish a high-level "**green hydrogen program coordination committee**".
- Establish a green hydrogen **secretariat** to operate as a "one-stop-shop".
- Organize National **Green Hydrogen roundtables** on finance and green fertilizer.
- Develop a green hydrogen strategy and roadmap **resource mobilization plan**.
- Develop a **Monitoring and Evaluation** Plan
- Include dedicated provision on green hydrogen in the national energy policy.

[168] EIB, 2022, https://www.eib.org/attachments/press/africa-green-hydrogen-flyer.pdf

- Support / fast track **catalytic projects** that demonstrate commercial viability, including implementation of KENGEN-Olkaria green hydrogen pilot project.
- Expand regional and **international cooperation and partnerships on green hydrogen**.
- Develop a green hydrogen stakeholder engagement and communication plan.
- Establish local and international partnerships to scale up training and capacity building.