REPUBLIC OF KENYA

MINISTRY OF ENERGY AND PETROLEUM

GREEN HYDROGEN STRATEGY AND ROADMAP FOR KENYA

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September 2023

With abundant geothermal, wind, solar and hydro renewable energy sources Kenya holds an advantage in the emerging green hydrogen economy.

FOREWORD

The energy sector is a key enabler in the pursuit of nationally set goals as espoused in the Kenya Vision 2030 and internationally set obligations that include the sustainable development goals (SDGs), climate agreements like the Paris Agreement and Africa Agenda 2063. Kenya has also made improvement of livelihoods and welfare of its citizens a top priority through the Bottom-Up Economic Transformation Agenda. Development of green hydrogen and its derivatives aligns with these national objectives. As the world navigates the evolving landscape of sustainable energy solutions, this green hydrogen strategy stands as a beacon of innovation and commitment towards a greener and more resilient future.

Through meticulous research, collaboration, and forward-thinking insights, this strategy charts a course towards harnessing the potential of green hydrogen as a key driver of our energy transition. The analysis showed that Kenya has sufficient renewable energy resources that are available in the country for large scale production of green hydrogen without harming the availability and supply to electricity consumers.

This comprehensive approach underscores the strategy's commitment to nurturing a shared vision, elevating green hydrogen to a pivotal cross-cutting factor in Kenya's development agenda. By acting as a catalyst for sustainable socio-economic advancement, the strategy harmonizes with the nation's steadfast pursuit of sustainable growth.

This commitment to sustainable advancement is palpable in the strategy's objectives, prudently crafted to prioritize economic expansion, the creation of job opportunities, and the promotion of environmental stewardship. As both a visionary framework and a pragmatic guide, it articulates our collective ambition while concurrently providing tangible direction to navigate the passage from conception to realization.

Davis Chirchir
Cabinet Secretary
Ministry of Energy and Petroleum

PREFACE

The significance of green hydrogen production and its multifaceted applications are deeply woven into Kenya's ambitious green economy agenda. Four pivotal areas have been identified where the focus will be resolute: the formulation of an all-encompassing green hydrogen strategy and a roadmap; secondly, the cultivation of an environment conducive to growth facilitated through the establishment of regulatory and policy frameworks that will enable and propel green hydrogen endeavours; thirdly, the facilitation of financial mechanisms and technical guidance to foster its deployment; and finally, the dynamic exploration and testing of cross-sector applications that capitalise on the potential of green hydrogen.

Kenya's green hydrogen strategy is the product of concerted effort by the Green Hydrogen Working Group comprising officials from government, development partners, private sector and academia. I would like to extend special thanks to European Delegation to Kenya who supported the development of the Strategy by availing the Technical Assistance Facility (TAF) team of consultants. Special thanks also to the continued support of the German government through GIZ in supporting the development of the green hydrogen baseline study and contributing to the strategy and roadmap development process and finalisation.

I would like to express deep appreciation to the Technical Working Group, all parties and stakeholders who have wholeheartedly supported the development of the strategy and roadmap. Their unwavering commitment and valuable contributions have been pivotal in crafting a comprehensive Green Hydrogen Strategy and Roadmap towards a greener and sustainable energy future for Kenya.

Alex K. Wachira
Principal Secretary
State Department for Energy

ACKNOWLEDGEMENTS

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

Government ministries and public sector institutions:

- Ministry of Agriculture and Livestock Development
- Ministry of Investments, Trade, and Industry
- Ministry of Roads and Transport
- The National Treasury and Economic Planning
- 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 Electricity Transmission Company (KETRACO)
- Kenya Power and Lighting Company (KPLC)
- Rural Electrification and Renewable Energy Corporation (REREC)

Private sector associations:

- Kenya Private Sector Alliance (KEPSA)
- Electricity Sector Association of Kenyan (ESAK)

Academia:

- Jomo Kenyatta University of Agriculture and Technology
- Kenyatta University
- Strathmore University
- Machakos University
- Technical University of Kenya

Development finance institutions:

- European Investment Bank (EIB)
- Agence Française de Développement (AfD)
- Kreditanstalt für Wiederaufbau (KfW)
- Japan International Cooperation Agency (JICA)
- Foreign, Commonwealth & Development Office (FCDO)

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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	African Hydrogen Partnership
ASAL	Arid and Semi-Arid Lands
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 Limited
Btu	British Thermal Unit
CAN	Calcium Ammonium Nitrate
CAPEX	Capital Expenditure
CBAM	Carbon Border Adjustment Mechanism
CBO	Community Based Organisations
CFD	Contract-For-Difference
CIDP	County Integrated Development Plan
CO2	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)
e.g.	For example
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 Organisation
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 Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GTAF	Global Technical Assistance Facility
GW	Gigawatt
GWEC	Global Wind Energy Council
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
kg	Kilogramme
KNBS	Kenya National Bureau of Statistics
KNTC	Kenya National Trading Corporation

KPLC	Kenya Power and Lighting Company
KRA	Kenya Revenue Authority
Ksh	Kenya shillings
KTDA	Kenya Tea Development Agency
kWh	Kilowatt Hour
kWp	Kilowatt peak
LCOE	Levelised Cost of Electricity
LCOH	Levelised Cost of Hydrogen
LCPDP	Least Cost Power Development Plan
LT-LEDS	Long-Term Low Emissions and Development Strategy
m	Metre
M&E	Monitoring and Evaluation
MTBE	Methyl Tert-Butyl Ether
MDB	Multilateral Development Bank
MITI	Ministry of Investments, Trade and Industry
MoALD	Ministry of Agriculture and Livestock Development
MoE	Ministry of Education
MoEAC	Ministry of East African Community, the ASALs, and Regional Development
MoECCF	Ministry of Environment, Climate Change and Forestry
MoEP	Ministry of Energy and Petroleum
MoPSGAA	Ministry of Public Service, Gender, 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
Mt	Million Tons
MTP	Medium Term Plan
MTPA	Metric Ton Per Annum
MW	Megawatt
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 Organisation
NITA	National Industrial Training Authority
NKE	Non-Key Expert
NLC	National Land Commission
NZE	Net Zero Emissions

OPEX	Operational Expenditure
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PTC	Production Tax Credit
PtX	Power-to-X
PV	Photovoltaic
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 Dollar
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital
WARMA	Water Resource Management Authority
WRA	Water Resources Authority

EXECUTIVE SUMMARY

In line with Kenya's Vision 2030, which seeks to accelerate sustainable growth and transform the country 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. Recognising the significance of green hydrogen beyond its role as an energy source, Kenya now aims to harness its transformative potential as a cross-cutting enabler for the country's development agenda and as a catalyst for sustainable socio-economic development.

Recent years have witnessed a growing sense of urgency to transition to sustainable and clean energy sources driven by the pressing challenges of climate change and the imperative to reduce carbon emissions. Africa holds more than 10,000 GW in renewable energy potential, positioning the continent as a powerhouse that can contribute to keeping global temperature rise within the 1.5 ^{o}C objective of the Paris Agreement.[1] A particularly promising avenue that has gained traction is the use of green hydrogen derived from renewable energy sources. Green hydrogen has the potential to play a pivotal role in global energy transformation, offering substantial opportunities to decarbonise 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 finds itself uniquely positioned to capitalise on the unprecedented political and business momentum surrounding this nascent industry. With a remarkable track record in developing a diversified power generation mix, approximately 90% of Kenya's electricity is currently sourced from renewable energy sources.[2] The country has vast untapped renewable energy potential - including a leading position in geothermal power within Africa.

Exploring options for producing green hydrogen from green electricity is a logical next step in building a green economy in Kenya and is driven by a robust culture of innovation and a long-standing commitment to sustainable development. This juncture presents a unique window of opportunity for Kenya to pursue business opportunities in the emerging green hydrogen industry. By doing so Kenya can drive green economic growth, contribute to the profound socio-economic transformation of the country, and play a proactive role in global collaborative efforts to tackle the impacts of climate change. The vibrant private sector that is actively pursuing multiple green hydrogen projects in Kenya provides compelling evidence of the country's preparedness and potential in the field of green hydrogen.

1 AfDB. *Africa's Climate Opportunity: Adapting and thriving.* (2015). https://www.afdb.org/fileadmin/uploads/afdb/Documents/Events/COP21/The_African_Development_Bank_at_the_UNFCCC_COP21_meeting.pdf

2 EPRA. *Biannual Energy and Petroleum Statistics Report, Financial Year 2022/2023.* (2023). https://www.epra.go.ke/biannual-energy-and-petroleum-statistics-report-for-the-financial-year-2022-2023/

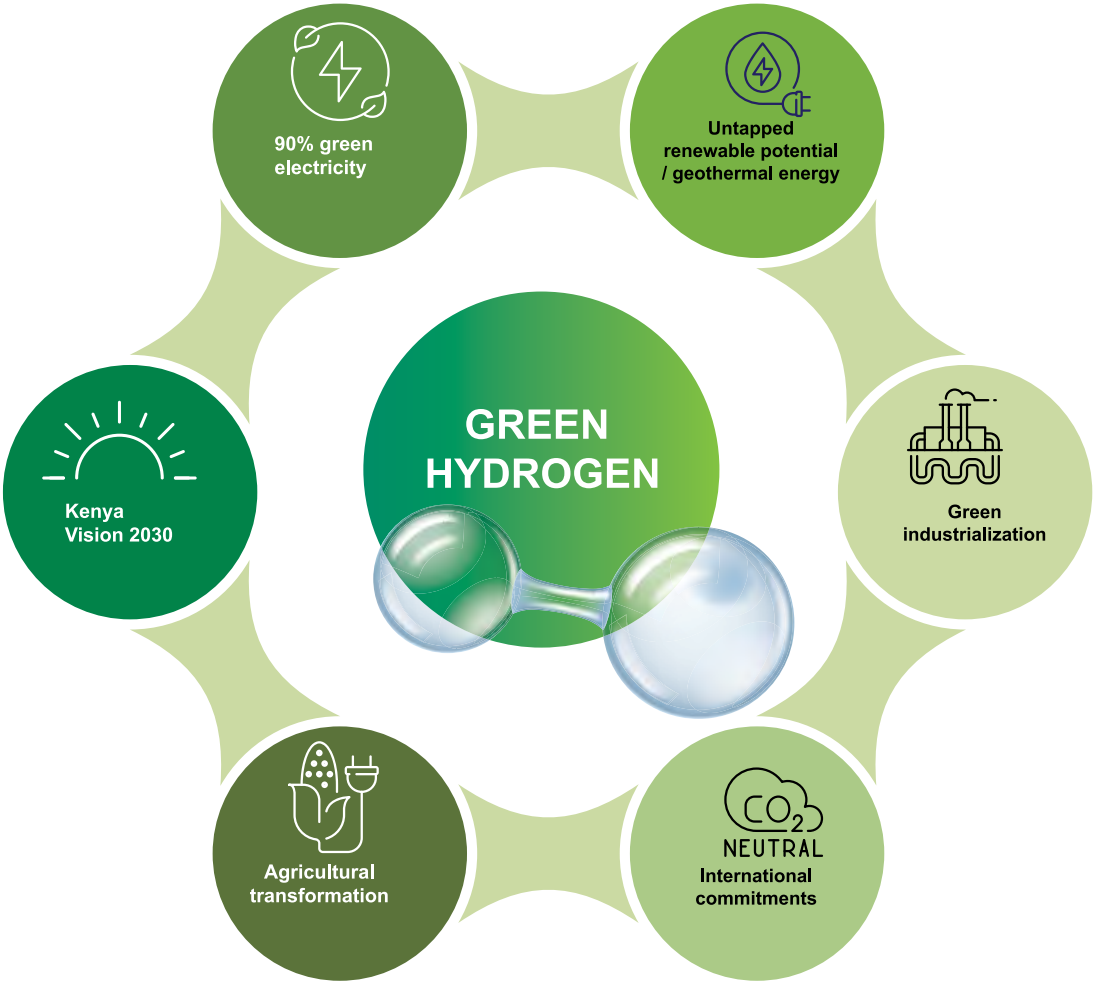


Figure 1: Kenya's unique window of opportunity in green hydrogen – sustainable economic transformation and green growth

Green hydrogen has potential applications across several important 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 fertilisers) and methanol. Additionally, hydrogen can play a role in decarbonising the road transport sector, and its derivatives can decarbonise 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. However, to accelerate the establishment of a green hydrogen industry in Kenya, it is advisable to prioritise those specific applications of hydrogen that not only yield significant advantages for the country but also align with its overarching developmental objectives and broader development goals. Concurrently, these applications should demonstrate the highest potential for short-term commercial viability.

Identifying the most promising green hydrogen use cases naturally brings the agricultural sector into focus. The agricultural sector is the cornerstone of Kenya's economy, providing livelihood and employment for most 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 fertilisers, leading to substantial government expenditure and subsidies on fertiliser imports and making it susceptible to fluctuations in global commodity prices, as observed in 2021 and 2022. So, investing in the agricultural value chain and establishing a domestic fertiliser production industry based on green hydrogen and ammonia represents a no-regret option for Kenya.

More generally, by substituting hydrogen commodity imports like fertiliser 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 utilisation of green hydrogen therefore presents a promising pathway to unlock opportunities for sustainable manufacturing and drive industrialisation, aligning with the objectives of Kenya's Vision 2030, the development blueprint for the country.

Despite the growing momentum surrounding hydrogen, the vision of green hydrogen, although technically feasible, has yet to achieve commercial viability. Building a green hydrogen economy presents challenges that are present in every country seeking to embrace this energy source. The development of a market for green hydrogen and its derivatives, whether domestically or internationally, presents challenges that Kenya is not immune to. A crucial factor in any hydrogen strategy is the ability to identify early off-takers; the primary risk revolves around uncertainties related to market demand and pricing (affordability and willingness to pay) for green hydrogen and its derivative products. However, Kenya possesses a unique and advantageous starting position due its endowment with geothermal energy with its high capacity factor. More than this, with abundant wind, solar and hydro renewable energy sources, Kenya holds a further advantage in the emerging green hydrogen economy.

While green hydrogen requires long-term commitment, 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, will reduce Kenya's imports of hydrogen-based commodities like nitrogen fertiliser and methanol. Once a domestic market for green hydrogen derivatives has been established, this will also open opportunities for export, taking advantage of Kenya's strategic geographic position as a regional trading hub. Ultimately, this will 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 fertiliser. Fertilisers play a critical role in boosting agricultural productivity. Establishing a domestic fertiliser production industry can significantly improve the availability and accessibility of fertilisers to Kenyan farmers, leading to increased agricultural output. The use of green fertilisers that are produced

in Kenya will also promote sustainable agricultural practices and add value to agricultural produce. This self-sufficiency will also help mitigate the impact of international commodity market fluctuations, further reinforcing resilience in the agricultural sector.

3. **Green industrialisation and decarbonisation:** Green hydrogen can serve as a catalyst for industrialisation 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 decarbonisation 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 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.

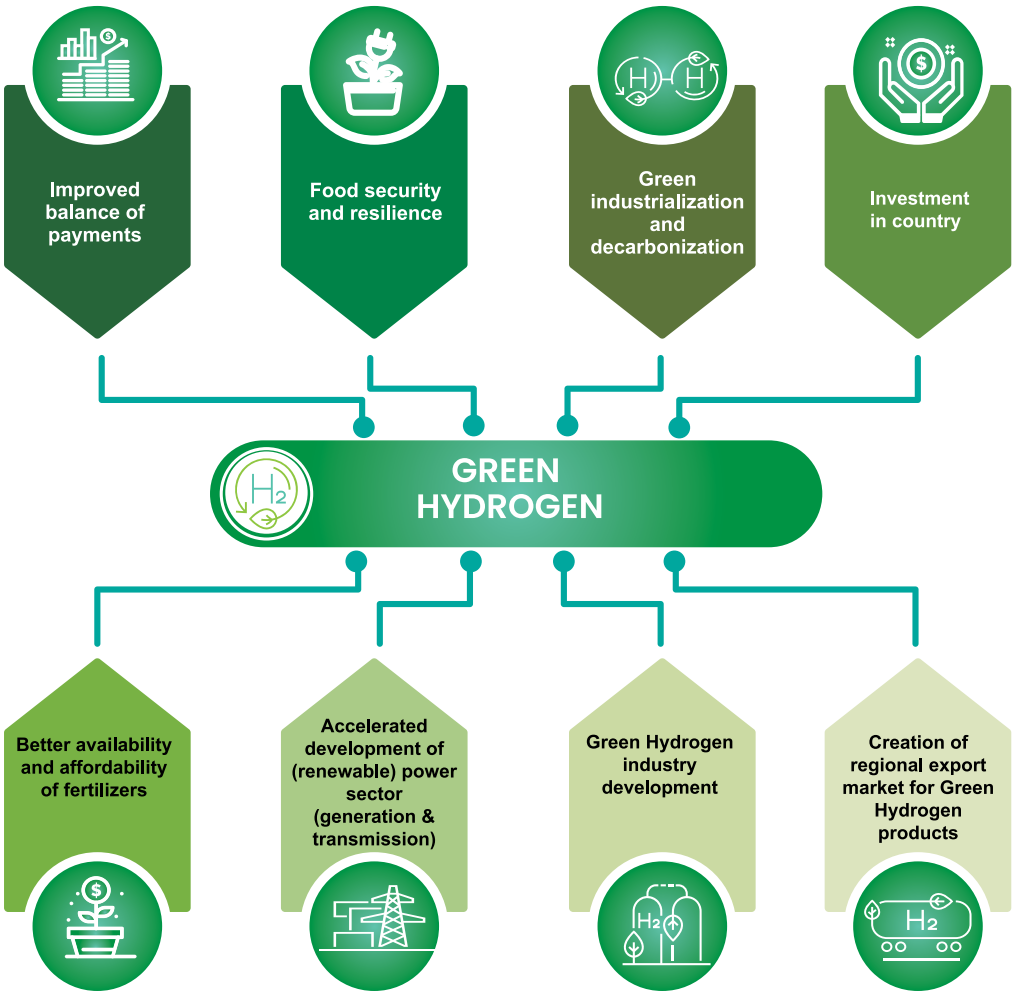


Figure 2: Objectives and outcomes of Kenya's green hydrogen vision

This is therefore an opportune moment for Kenya to launch this *Green Hydrogen Strategy and Roadmap for Kenya* and align itself with global trends in technology, applications, policy, and regulation, while also capitalising on available funding opportunities. This dedicated national hydrogen strategy is essential for Kenya, as 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.

The Green Hydrogen Strategy and Roadmap for Kenya 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 utilising 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 for Kenya* aligns closely with the country's national climate action plans and its commitment to the global targets outlined in the Paris Agreement.

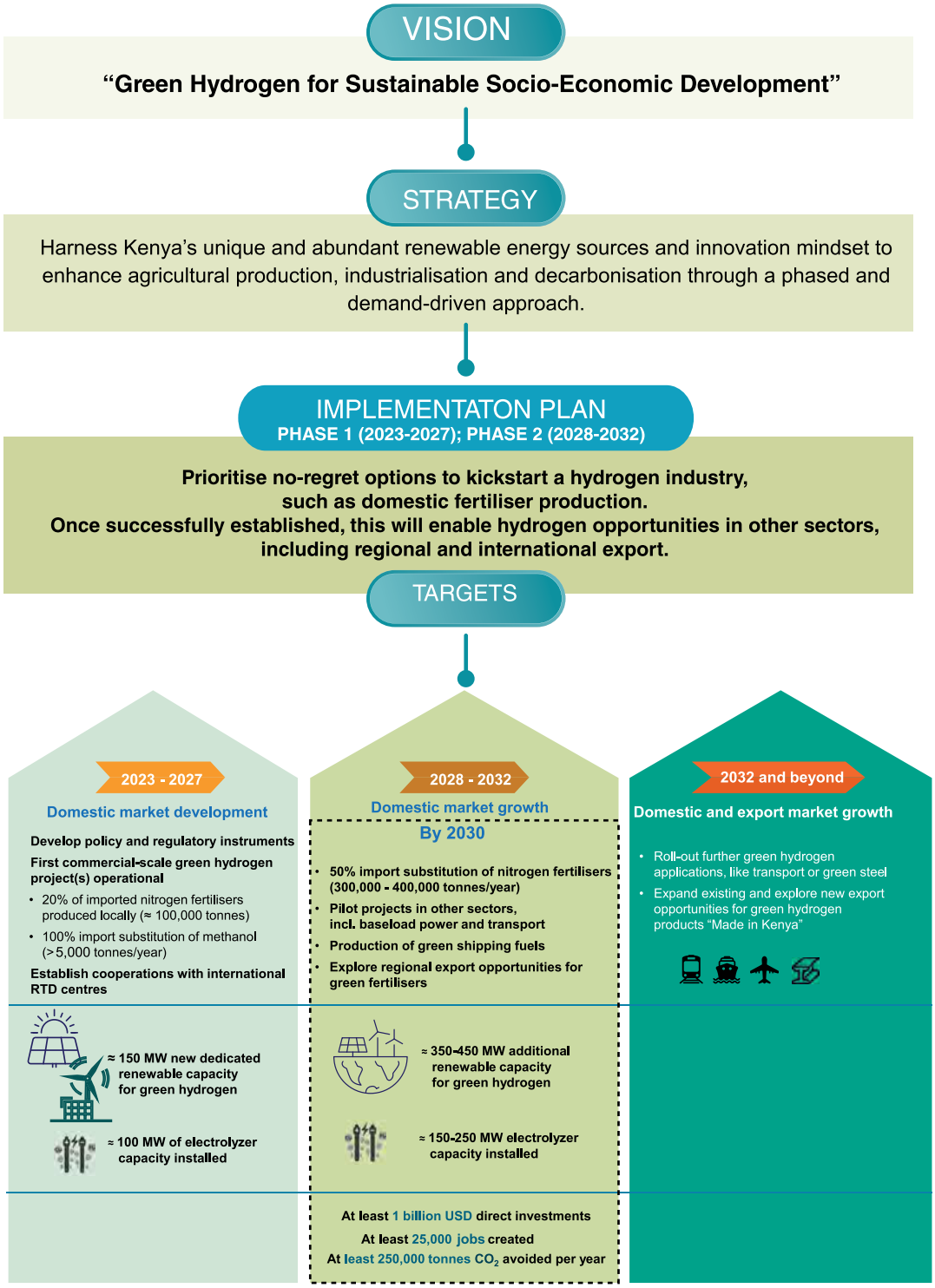


Figure 3: Kenya's green hydrogen vision and targets

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 Strategy and Roadmap for Kenya* to achieve its green hydrogen vision.

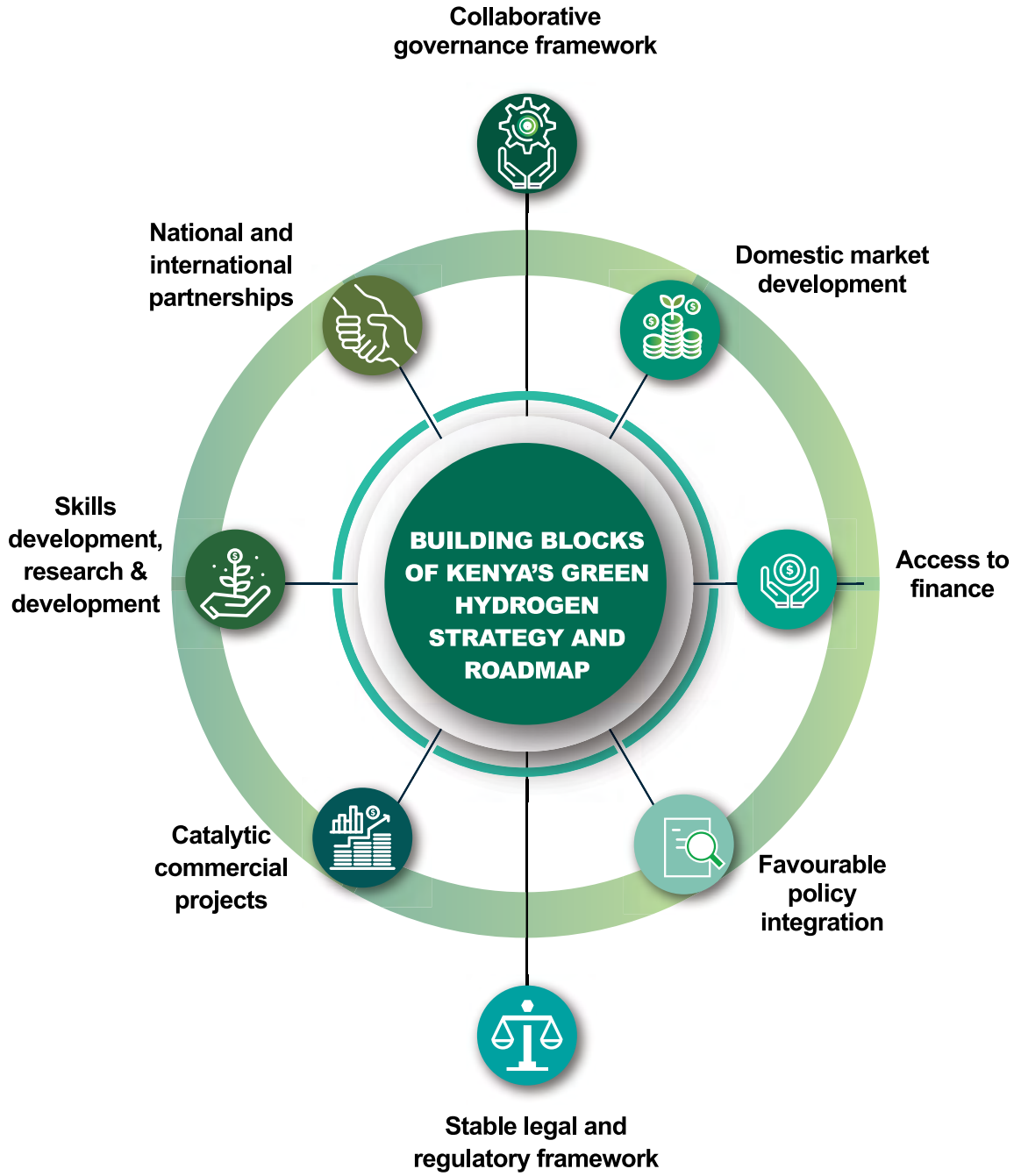


Figure 4: Building blocks of Kenya's green hydrogen vision

Translating the strategy into specific actions, milestones, and timelines helps to coordinate and guide the efforts of implementing it and provides a path for stakeholders to follow 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 are 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 for Kenya:*

PRIORITY ACTIONS

Q1 2024 - Q3 2024

- 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 Monitoring and Evaluation Plan
- Develop a green hydrogen strategy and roadmap resource mobilization 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’s Olkaria green hydrogen demonstration project.

Q3 2024 - Q3 2025

- Develop a green hydrogen stakeholder engagement and communication plan.
- Establish local and international partnerships to scale up training and capacity building.

Q3 2024 - Q4 2026 and beyond

- Expand regional and international cooperation and partnerships on green hydrogen.

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 split into two five-year phases, allowing for incremental learning and a gradual scale-up of initiatives as the supportive environment for green hydrogen matures. It is important to highlight that Kenya’s phased green hydrogen implementation plan closely aligns with the government’s developmental planning process, particularly Medium Term Plans IV (MTP IV). This alignment aims to connect priority actions for establishing a green hydrogen economy to national development planning. The initial phase (2023-2027) of the plan, corresponding to MTP IV, will primarily focus on cultivating domestic demand and implementing the first catalytic commercial projects to kickstart the hydrogen industry. Following this, during the second phase (2028-2032), the plan will consider market developments and other external factors to leverage the lessons learnt from the initial phase to explore new hydrogen opportunities such as 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 provide a powerful demonstration of Kenya’s capabilities in the field of green hydrogen and will bolster its regional and international reputation as a prime location to grow a green hydrogen industry. It will also enable Kenya to develop essential expertise, explore and foster partnerships, and make informed decisions about its involvement in the green hydrogen value chain. Moreover, it will catalyse the interest and participation of other local and international private sector players in the hydrogen industry in Kenya.

Considering 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 must establish an effective and fit-for-purpose regulatory and institutional framework that stimulates demand for green hydrogen and creates an inviting investment environment. This will, in turn, 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 by adopting effective de-risking measures for projects and market functioning. Initiatives have already emerged and others are being tuned to support the development of the green hydrogen sector globally. The European Union has announced the establishment of the Hydrogen Bank facility, while it also 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 the market functioning of green hydrogen and derivatives.

Blended financing and innovative financial instruments will play a crucial role in spurring green hydrogen investments in Kenya. 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.

Kenya's agricultural sector relies entirely on fertilizer imports: in total, Kenya imported some 850 kt of fossil fuel based fertilisers in 2021.

1

INTRODUCTION

1.1. BACKGROUND AND OBJECTIVES

Globally, there is a growing sense of urgency around the need to shift towards sustainable and clean energy sources, driven by the pressing challenges of climate change and the need to reduce carbon emissions. Countries worldwide are actively seeking innovative, clean solutions to meet their energy needs. The use of green hydrogen derived from renewable energy sources is seen as particularly promising and has gained traction. Green hydrogen has the potential to play a central role in global energy transformation, offering significant potential to decarbonise various sectors, enable sustainable industrial processes, and facilitate the transition to a low-carbon future.

Kenya stands uniquely positioned to capitalise on the unprecedented political and business interest in this nascent green hydrogen industry. With vast untapped renewable energy potential, Kenya already boasts around 90% of its electricity coming from renewable sources.[3] The country 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 commitment to sustainable development, Kenya is positioning to seize the unique business opportunities in the green hydrogen industry and to use these to drive green economic growth, contribute to the country's socio-economic transformation as aspired to in Vision 2030 the national development blueprint, and to participate actively in global collaborative efforts to tackle the impacts of climate change.

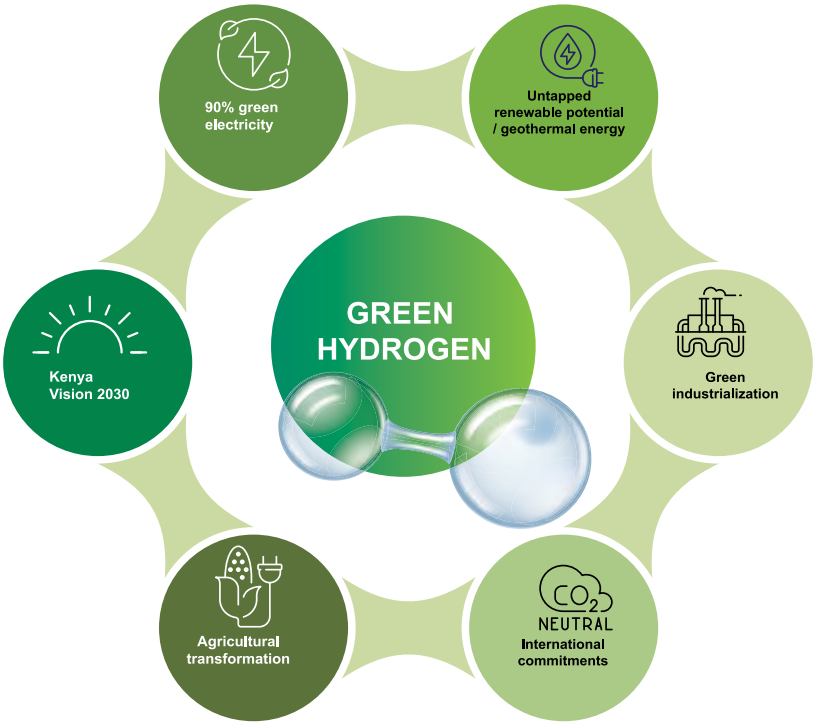


Figure 5: Kenya's unique window of opportunity in green hydrogen – sustainable economic transformation and green growth

3 EPRA. *Biannual Energy and Petroleum Statistics Report, Financial Year 2022/2023.* (2023). https://www.epra.go.ke/biannual-energy-and-petroleum-statistics-report-for-the-financial-year-2022-2023/

A vibrant private sector is pursuing multiple green hydrogen projects in Kenya, and provides further evidence of the country's potential in the field of green hydrogen.

A dedicated national hydrogen strategy is crucial for any country seeking to establish a hydrogen industry, as it provides a clear vision, direction, and framework for development of the hydrogen sector. By defining targets, prioritising use cases, outlining favourable and consistent policies, regulations, and financial incentives, a national hydrogen strategy lays the foundation for a stable and predictable business environment. This is crucial for building investor confidence and supporting industry players and will also catalyse the growth of a domestic hydrogen market.

Taking it a step further to create a roadmap by translating the strategy into a set of tangible actions and milestones will further facilitate coordination and provide guidance for all stakeholders, and ensure achievement of the stated objectives. The roadmap also establishes a structured framework for collaboration among government agencies, the private sector, and civil society.

Presently, around 40 countries have developed or are in the process of developing national hydrogen strategies. Kenya now joins them with the launch of this strategy and roadmap. The knowledge and expertise gained from implementing the roadmap can further support Kenya's broader industrialisation objectives and drive socio-economic development. Moreover, the development of a *Green Hydrogen Strategy and Roadmap for Kenya* aligns closely with national climate action plans and 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. A Green Hydrogen Technical Working Group was set up by the Ministry of Energy in 2020 comprising representatives of diverse ministries, departments, state agencies and development partners, all working to explore the possibilities for development of a green hydrogen industry in Kenya. As work on the strategy evolved, academia and the private sector were also co-opted.

Initially, the process drew inspiration from successful examples and international best practice and incorporated the International Energy Agency (IEA) hydrogen policy framework.[4] It later incorporated recommendations and lessons from 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.

Thereafter, the *Green Hydrogen Strategy and Roadmap for Kenya* was formulated through an inclusive process that brought in various stakeholders. Extensive consultations were conducted with representatives from ministries and public sector institutions, development finance institutions (DFIs), private companies, and academia. These consultations took the form of workshops, and

4 IEA. *Global Hydrogen Review 2022.* https://www.iea.org/reports/global-hydrogen-review-2022

bilateral or multilateral 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 guidance throughout the development 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. The consultations aimed to expand understanding of the stakeholder landscape, identify the most promising hydrogen use cases specific to Kenya for the short, medium and long term, and to align stakeholders on a shared vision for the green hydrogen sector.

In addition, an analysis of the strengths, weaknesses, opportunities, and threats (SWOT) associated with implementing a green hydrogen industry in Kenya was conducted as part of the roadmap development process. The SWOT analysis enabled a comprehensive understanding of the internal and external factors that will potentially influence the green hydrogen industry.

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

The development of the *Green Hydrogen Strategy and Roadmap for Kenya* was supervised by the Ministry of Energy and Petroleum. It was governed by a senior-level cross-government steering committee to ensure high-level coordination and oversight to drive the successful implementation of the roadmap's recommendations and proposed actions.

2

GREEN HYDROGEN – GLOBAL CONTEXT AND TRENDS

Green hydrogen,[5] derived from renewable sources of electricity, is expected to contribute significantly to achieving the goal of net-zero emissions by 2050 and limiting the global temperature rise to 1.5 °C.[6] Africa's untapped renewable energy potential currently stands at over 10,000 GW and will play a crucial role in keeping global temperature rise within the 1.5 °C objective of the Paris Agreement.

Green hydrogen has potential applications across various sectors, including industry, transport, and power. One notable advantage of green hydrogen is its versatility as an energy carrier and industrial feedstock, enabling the decarbonisation of hard-to-abate sectors.

Hydrogen can play an important role in decarbonising the transport sector. It can be used as a direct fuel for road freight, and its derivatives can decarbonise shipping (using ammonia or methanol) and aviation (using sustainable aviation fuels, SAF). 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, global hydrogen consumption reached a total of 94 million tonnes, almost entirely sourced from fossil fuels. Natural gas continues to account for around two-thirds of global production.[7] Approximately half of the hydrogen produced globally is used in refineries while slightly over 35% is used as feedstock for the synthesis of ammonia.[8]

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 can serve as feedstock to produce various chemical products, including synthetic fuels, and 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 to connect various sectors of the economy, including electricity, transportation, and industry. This means that power generated in the electricity sector can be separated and used in other sectors, thereby enabling the decarbonisation of hard-to-abate sectors like chemicals, iron and steel, and cement, as well as specific segments of transportation like heavy-duty traffic, shipping, and aviation.

5 Hydrogen is commonly categorised 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, it becomes crucial to acknowledge and recognise the broader significance of clean hydrogen, defined as hydrogen produced with very low or zero carbon emissions in the transition to a full green hydrogen economy.

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

7 IEA. *Global Hydrogen Review 2022*. https://www.iea.org/reports/global-hydrogen-review-2022

8 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.

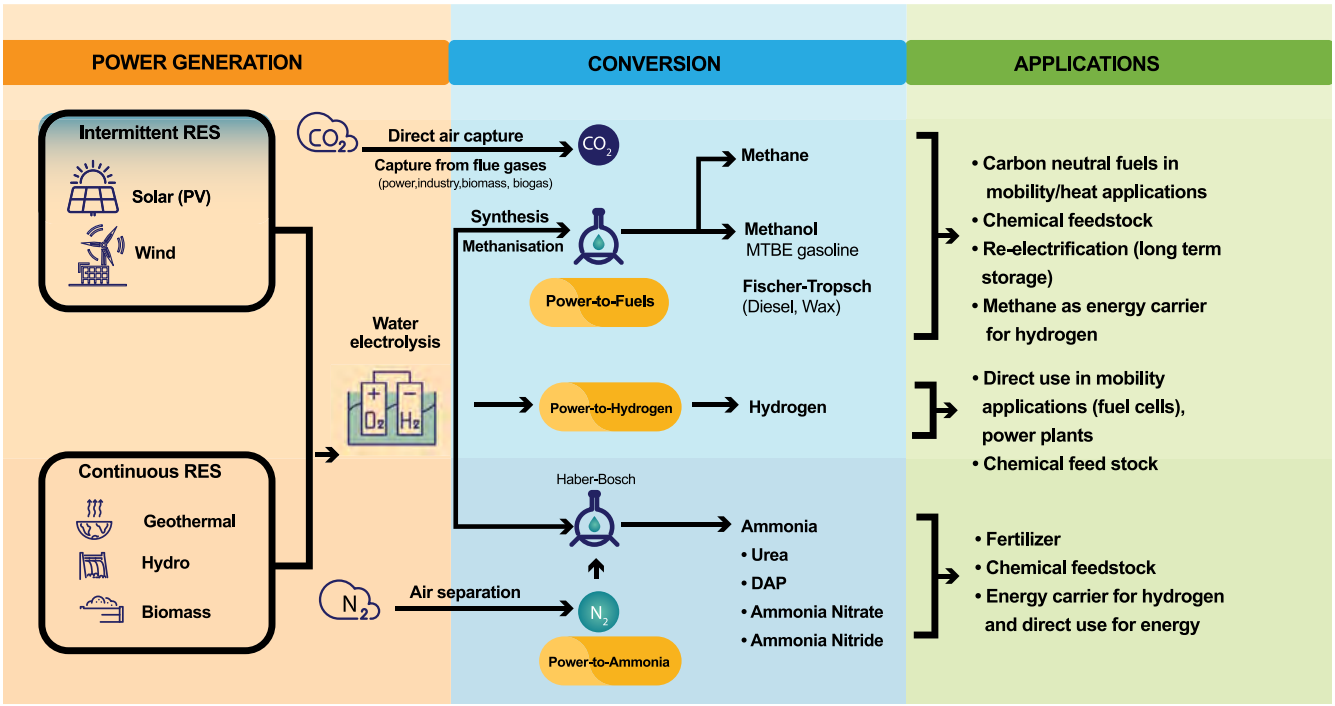


Figure 6: Hydrogen and Power-to-X (PtX) – conversion of renewable power into various forms of chemical energy carriers (Source: World Energy Council Innovation Insights Brief: New Hydrogen Economy - Hope or Hype? 2019)[9]

Power-to-hydrogen, power-to-ammonia, and power-to-fuel are processes that use 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 serves as feedstock for various industrial processes in the chemical industry and 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 used as feedstock for various types of nitrogen fertiliser but also serves as a carbon-free fuel.

Power-to-fuel refers to the conversion of electrical energy into various fuel types. It involves the use of renewable energy sources to generate hydrogen through electrolysis. Hydrogen produced in this way can be used directly as fuel or combined with carbon dioxide (CO_2) from the atmosphere or from industrial processes to produce 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. Methanol or synthetic methane can also be produced in this way.

9 World Energy Council. *Innovation Insights Brief. (2019)*. https://www.worldenergy.org/assets/downloads/WEInnovation-Insights-Brief-New-Hydrogen-Economy-Hype-or-Hope.pdf

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.

2.2. GLOBAL HYDROGEN SCENE IN 2023

2.2.1. Market outlook

Hydrogen is a versatile, clean energy carrier that offers great potential in addressing global energy and environmental challenges. As countries strive to achieve low-carbon economies and a reduction in their greenhouse gas (GHG) emissions, hydrogen emerges as an ideal energy carrier that can be produced from diverse sources - including renewables - and its potential for zero-emission applications across multiple sectors. The growing recognition of this potential role of hydrogen in decarbonising 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).*

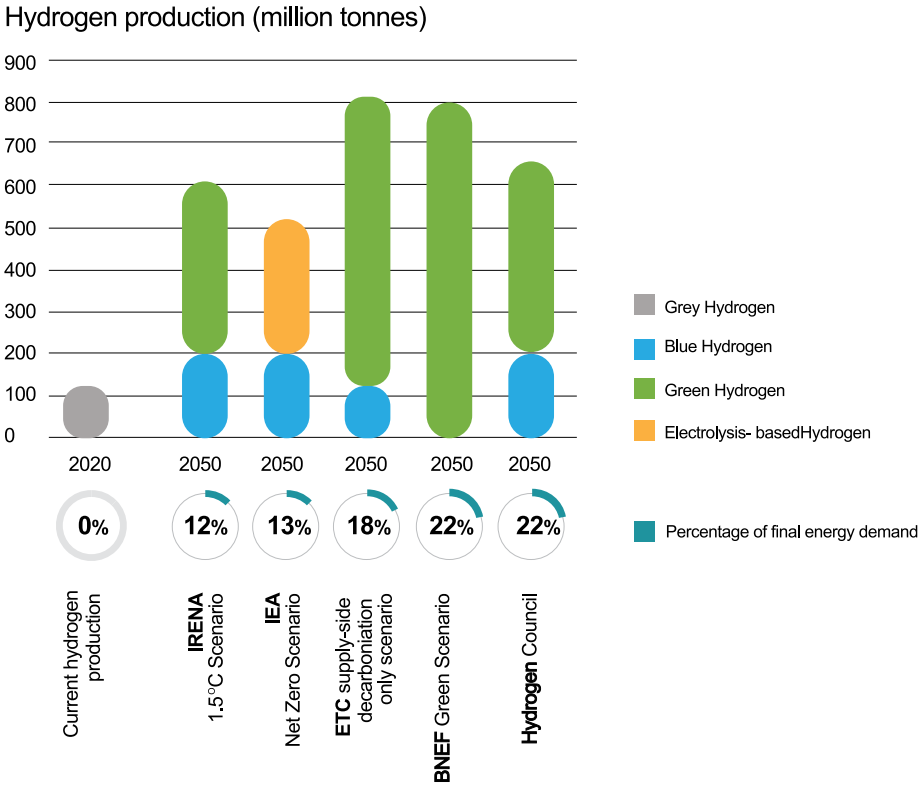


Figure 7: Estimates for global hydrogen demand in 2050
(Source: IRENA, Geopolitics of the Energy Transformation – the Hydrogen Factor, 2022)[10]

According to the net-zero emissions (NZE) scenario by the IEA, hydrogen is expected to find applications in multiple sectors, particularly in industry, ammonia production, and the production of synthetic fuels (synfuels). In the NZE scenario, the estimated installed capacity of electrolysers reaches an impressive 3,600 GW by 2050.

10 IRENA. (2022). *Geopolitics of the Energy Transformation: The Hydrogen Factor*. https://www.irena.org/publications/2022/Jan/Geopolitics-of-the-Energy-Transformation-Hydrogen

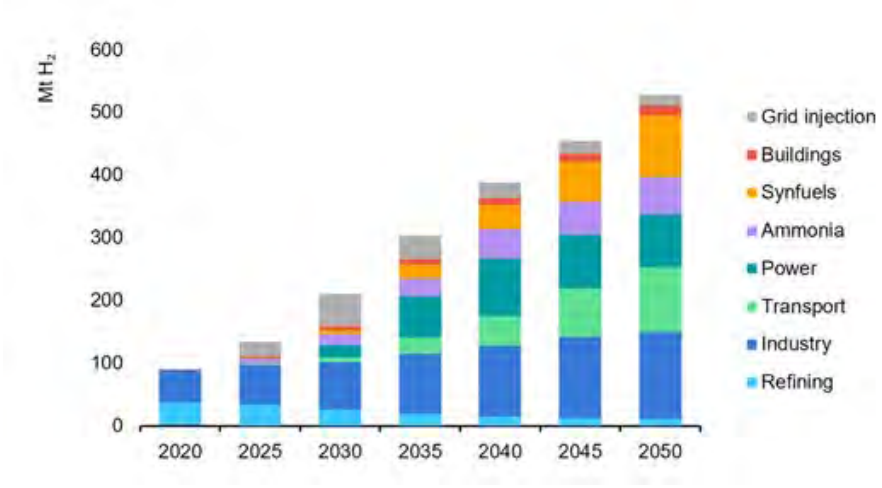


Figure 8: Global demand for hydrogen by sector according to IEA's net-zero emissions scenario (Source: IEA, Global Hydrogen Review, 2021)[11]

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 MW electrolysis capacity) 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).*

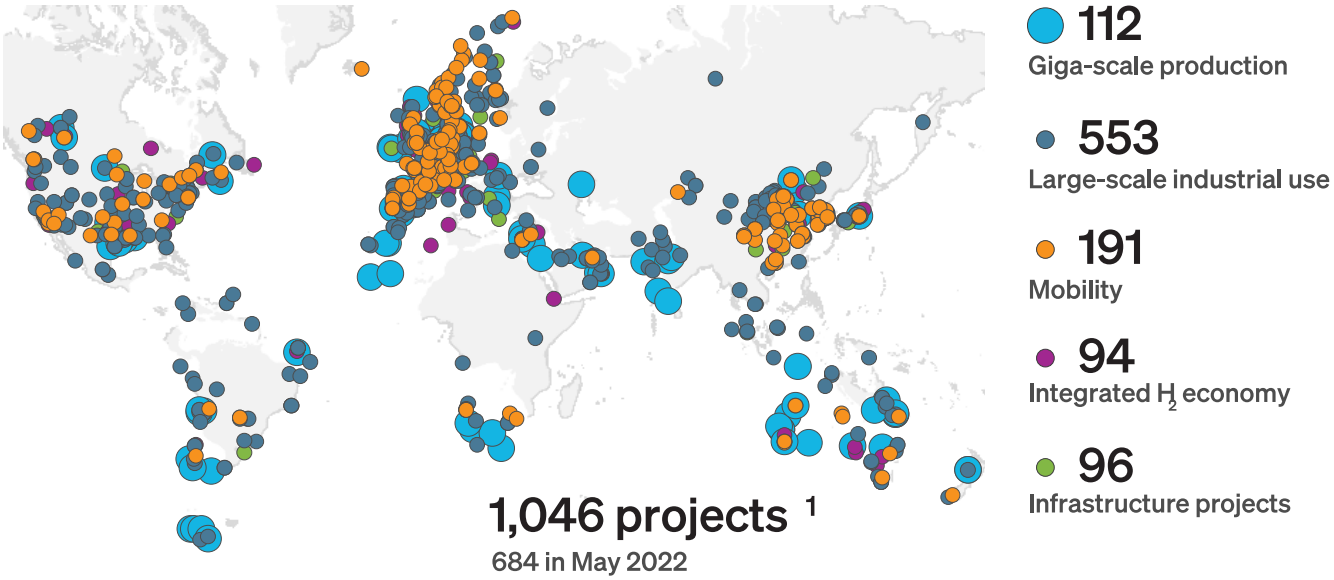


Figure 9: Geographic distribution of announced clean hydrogen projects. (Source: Hydrogen Council & McKinsey & Company, Hydrogen Insights 2023, 2023)

11 IEA. *Global Hydrogen Review 2021*. https://www.iea.org/reports/global-hydrogen-review-2021

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. deployed today (less than 3%) *(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.

Cumulative production capacity announced Mt p.a

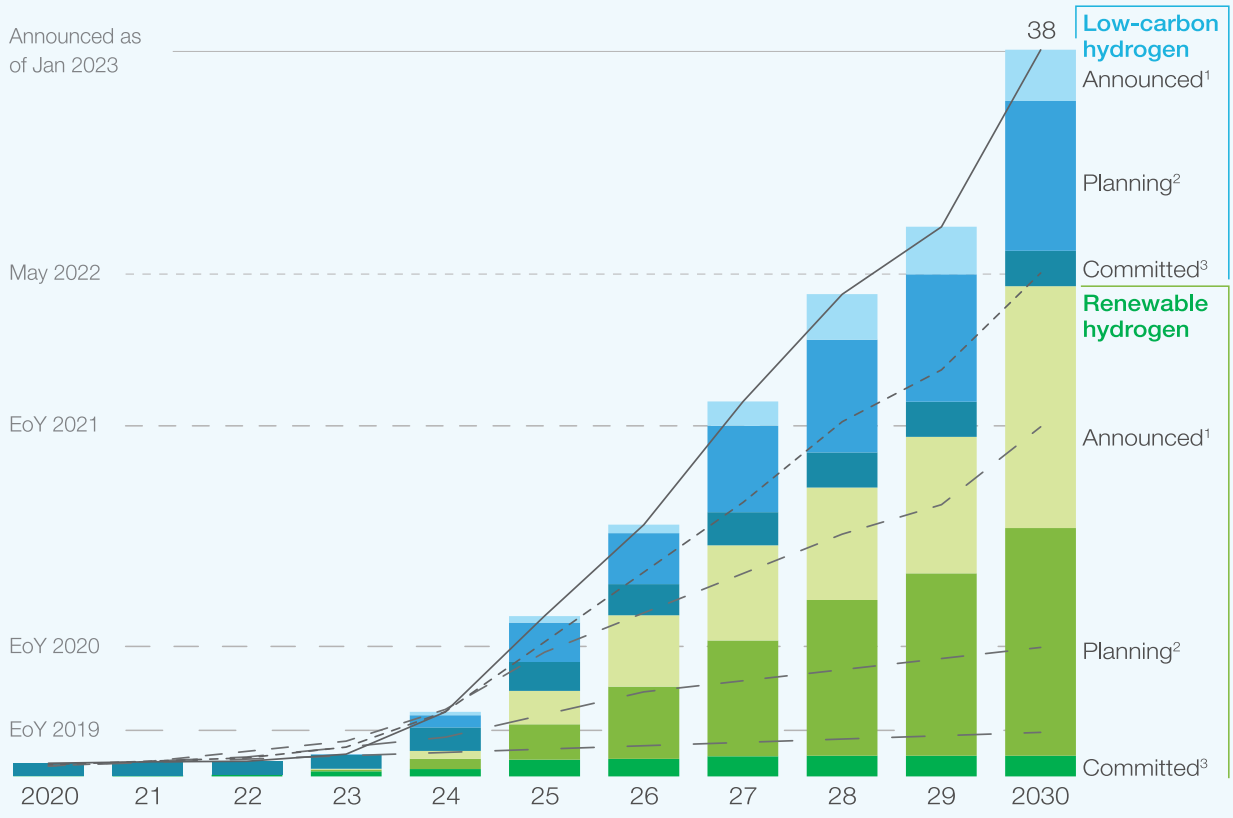


Figure 10: Announced hydrogen production volumes globally
(Source: Hydrogen Council & Mckinsey & Company, Hydrogen Insights,2023)

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.[12] These strategies and roadmaps are part of broader climate and clean energy related goals, and enable countries to decarbonise, exploit renewable energy resources and to develop key sectors and trade partnerships in specific markets. The strategies and roadmaps capture the renewable energy and hydrogen production potential, local demand, and access to hydrogen markets, along with each country's level of industrialisation, energy needs and dependencies.[13]

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. The strategies often focus on government funding and support for research and development, measures for demand creation and financial support for manufacturing and infrastructure development.[14]

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

Today, more than 40 countries have published a national hydrogen strategy and/or roadmap *(Figure 11)*, all of which are distinct and tailored to the specific conditions of each country.

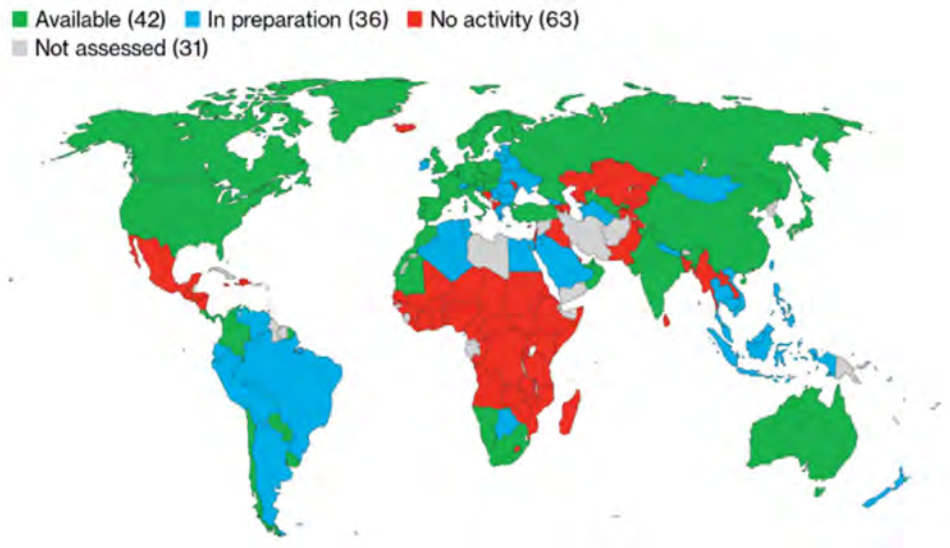


Figure 11: Overview of hydrogen strategies globally (March 2023)
(Source: Bloomberg BNEF, Global Hydrogen Strategy Tracker)

12 Van de Graaf, T., Overland, I., Scholten, D. & Westphal, K. (2020, December). The new oil? The geopolitics and international governance of hydrogen. *Energy Research & Social Science*, https://doi.org/10.1016/j.erss.2020.101667

13 Threlfall, R., (n.d.). *National Hydrogen Strategies: An update on recent progress in the hydrogen markets*. https://kpmg.com/xx/en/home/insights/2021/08/national-hydrogen-strategies.html

14 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 reducing 25% of carbon emissions by 2050 through reduction of the country's reliance on fossil fuels in the mining, transport, and agricultural sectors.

Colombia: Become a regional leader in energy transition thanks to Colombia's privileged geographic location and a stable regulatory and political framework capable of attracting long term investments and adapting the use of hydrogen into all 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 leading to significant decarbonisation of the economy, reduced dependence on fossil fuel imports and enabling India to assume technology and market leadership in green hydrogen.

Japan: Attract public and private investments into the hydrogen and ammonia supply chain sector, with a goal of more than ¥15 trillion (USD 107 billion) over the next 15 years, to speed up decarbonisation and increase domestic hydrogen supply sixfold from the current level of 2 million tonnes to 12 million tonnes by 2040.

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, decarbonise the 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 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 infrastructure and a regulatory ecosystem must be established to support delivery of renewable power, and for storage, transportation and utilisation of green hydrogen for various applications. This requires 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.[15]

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 of financial assistance. The main objective of these initiatives is to expedite the implementation of projects that promote the commercialisation and widespread adoption of hydrogen and its derivatives, build a hydrogen value chain, and establish the required infrastructure. Many of these efforts are collaborative public-private partnerships. Globally, allocated government funding for hydrogen to the year 2030 is significant and has reached USD 146 billion, 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.[16]

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.

15 Hydrogen Council/McKinsey & Company. (2023, May). *Hydrogen Insights 2023: An update on the state of the global hydrogen economy, with a deep dive into North America.* https://hydrogencouncil.com/wp-content/uploads/2023/05/Hydrogen-Insights-2023.pdf

16 Bloomberg. (2023, March). *Bloomberg, 1H 2023 Hydrogen Market Outlook - US takes the lead,* https://www.bnef.com/

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

Initiative/Scheme	Relevance to green hydrogen
H2 Global Instrument	H2Global is a competition based instrument 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.[17] 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 possible price.Both prices are detrmined through competitive processes. 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 jointly develop a European auction targeting international hydrogen imports.[18] The first pilot auction will be based on €800 million drawn from the EU's Innovation Fund, fed by the EU's carbon market.[19]
The US Inflation Reduction Act (IRA)	The IRA was passed by the United 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.[20] 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.[21]

17 H2 Global Stiftung. https://www.h2-global.de/

18 *Joint statement by Commissioner Simson and German Minister Habeck on energy issues*. (2023, May 31). https://energy.ec.europa.eu/news/joint-statement-commissioner-simson-and-german-minister-habeck-energy-issues-2023-05-31_en

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

20 US EPA. (2022, November 21). *Summary of Inflation Reduction Act provisions related to renewable energy*. https://www.epa.gov/green-power-markets/summary-inflation-reduction-act-provisions-related-renewable-energy

21 Gardner, G. (2023, January 3). *Can the Inflation Reduction Act unlock a green hydrogen economy? - International Council on Clean Transportation.* https://theicct.org/ira-unlock-green-hydrogen-jan23/

Initiative/Scheme	Relevance to green hydrogen
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.[22] The Green Hydrogen Organisation will work to ensure green hydrogen is prioritised within this new programme.[23]
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.[24,25] In accordance with the manifesto, focus will be 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.[26]
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."[27]

22 World Bank. (2022, November 15). *World Bank Group Announces International Low-Carbon Hydrogen Partnership.* https://www.worldbank.org/en/news/press-release/2022/11/15/hydrogen-for-development-partnership-h4d-launch

23 GH2. (2023, April 13). *Getting the right blend: Innovative development finance for the large-scale renewable and green hydrogen economy.* Green Hydrogen Organisation. https://gh2.org/publication/getting-right-blend

24 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.

25 *Project - IPCEIs on hydrogen.* (n.d.). https://commission.europa.eu/projects/ipceis-hydrogen_en

26 *Internal Market, Industry, Entrepreneurship and SMEs - IPCEIs on hydrogen.* (n.d.) https://single-market-economy.ec.europa.eu/industry/strategy/hydrogen/ipceis-hydrogen_en

27 KfW. (n.d.). *The PtX-platform: Integrated financing for green hydrogen - a perfect fit and from a single source.* KfW Development Bank. 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, demographic and technological transformation to build a more resilient and sustainable future.[28] EBRD has provided a USD 80 million loan to Egypt Green to develop the country's first green hydrogen facility.[29]
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:[30] the resources from the fund will come from domestic and international partners, including an initial USD 40 million contribution from the Dutch government.[31] The fund has wide participation including funding 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.[32]

In addition to initiatives to support market uptake, the EU has put in place measures to prevent entry of carbon intensive products into the EU territory.

Table 2: *Examples of initiatives and schemes supportive of green hydrogen (Continued)*

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."*[33] 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.[34]

28 EBRD. (n.d.). *The EBRD's Strategic and Capital Framework*. https://www.ebrd.com/what-we-do/strategy-capital-framework

29 Green Hydrogen Organisation. (2023, April 13). *Getting the right blend: Innovative development finance for the large-scale renewable and green hydrogen economy*. https://gh2.org/publication/getting-right-blend

30 *Launch of 'SDG Namibia One Fund' at COP27 targets the development of a green hydrogen economy in Namibia. (2022,* November 9). 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/

31 *Global Trade Alert.* (2022, November). Intervention 119533: Namibia: Launch of the Green Hydrogen and Derivatives Strategy. https://www.globaltradealert.org/intervention/119533/local-content-requirement/namibia-launch-of-the-green-hydrogen-and-derivatives-strategy

32 Green Hydrogen Organisation. (2023, April 13). *Getting the right blend: Innovative development finance for the large-scale renewable and green hydrogen economy*. https://gh2.org/publication/getting-right-blend

33 CSIS. (2023, February). *Analyzing the European Union's carbon border adjustment mechanism*. https://www.csis.org/analysis/analyzing-european-unions-carbon-border-adjustment-mechanism

34 ERCST. (2023). *The inclusion of hydrogen in the EU CBAM.* https://ercst.org/the-inclusion-of-hydrogen-in-the-eu-cbam/

A few green hydrogen projects have successfully secured funding or are currently in the implementation phase. Two exceptional examples of projects from Spain and Saudi Arabia are detailed in *Box 2.*

Box 2: Examples of green hydrogen projects post final investment decision (FID)

In **Spain,** Iberdrola - a multinational electric utility company - has taken the lead in 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 electrolyser. With an investment of €150 million, this initiative is expected to generate up to 1,000 employment opportunities while preventing emissions of 48,000 tonnes of CO_2 per year. The green hydrogen produced at this facility will be used at the Fertiberia fertiliser 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 tonnes per year.[35] To support this project, Iberdrola has secured a loan of €53 million from the European Investment Bank (EIB).[36] 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.[37]

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.[38] 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 tonnes of green hydrogen annually, equivalent to more than 1.2 million tonnes of renewable ammonia.

35 *Iberdrola commissions the largest green hydrogen plant for industrial use in Europe.* (n.d.). Iberdrola. https://www.iberdrola.com/about-us/what-we-do/green-hydrogen/puertollano-green-hydrogen-plant

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

37 Currie, C. (2023, June 8). *Spain awards €100m to seven green hydrogen projects*. H2 View. https://www.h2-view.com/story/spain-awards-e100m-to-seven-green-hydrogen-projects/

38 *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.* (2023, May 22). https://www.neom.com/en-us/newsroom/neom-green-hydrogen-investment

2.2.4. Economics of green hydrogen

Green hydrogen is still twice as expensive as fossil or grey hydrogen, with a cost of around 4-5 USD/kg compared to less than 2 USD/kg for grey hydrogen *(Figure 12).*[39] However, the cost of green hydrogen is expected to decline significantly over the next decade.[40]

Recent trends and analyses suggest that the cost of green hydrogen production is falling 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 cost of renewable energy sources also plays a significant role in the overall reduction of green hydrogen production costs. Meanwhile, major economies, such as the EU, the US and Australia are implementing ambitious national strategies to promote the adoption of green hydrogen. These concerted efforts enhance the competitiveness of green hydrogen, and it is anticipated that green hydrogen will soon achieve cost-competitiveness with fossil hydrogen in specific industry applications including, refineries, ammonia production, and green steel among others.

Production cost of hydrogen, $ per kilogram

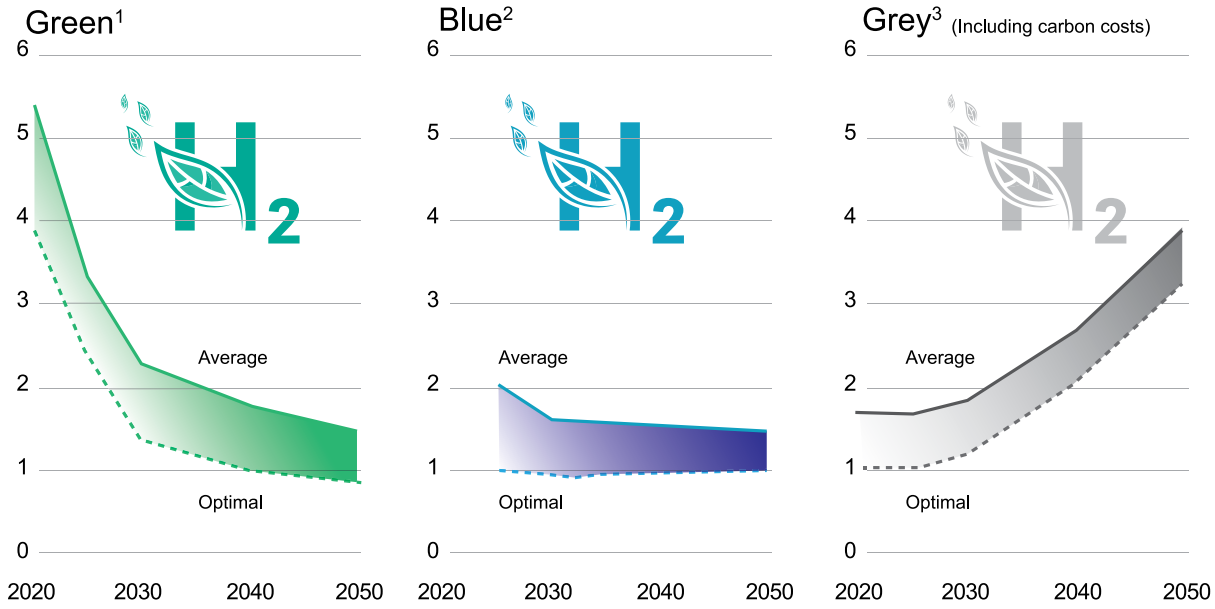


Figure 12: Overview of hydrogen production costs
(Source: McKinsey & Co, Five charts on hydrogen's role in a net-zero future, October 2022)

39 Several factors influence the economics of hydrogen production, including the cost and efficiency of electrolysers, their utilisation 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).

40 For a discussion of long-term cost trends for green hydrogen see the report by 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 the report from ETC, Making the Hydrogen Economy Possible: Accelerating Clean Hydrogen in an Electrified Economy. (2021, April). In Energy Transitions Commission website. https://www.energy-transitions.org/publications/making-clean-hydrogen-possible/#download-form

However, according to the baseline study conducted by the MoEP and GIZ, *"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*."[41] 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

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, countries that are not able to meet their demand fully 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 will apply, for example, where domestic hydrogen supply is constrained by available renewable capacity and is a likely scenario in major future demand regions, including Europe, Japan, and South Korea where inability, to meet demand at competitive costs, may force them to resort to importing low-cost hydrogen and/or derivatives. It is important to note that pure hydrogen is a neighbourhood business, meaning that hydrogen can be predominantly sourced domestically or piped from nearby regions and is only shipped if these options are not feasible. Hydrogen derivatives, such as ammonia, however, can easily be shipped around the world in conventional tankers.[42]

Both McKinsey[43] and the International Renewable Energy Agency (IRENA)[44] 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

41 Ministry of Energy, Kenya & GIZ. (2022). *Baseline Study On The Potential For Power-To-X/ Green Hydrogen in Kenya*. https://energypedia.info/images/6/65/PtX-Baseline_Study-KE_Report.pdf

42 For a discussion of technology options for long-distance shipping of hydrogen see the report by 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

43 Hydrogen Council/McKinsey & Company. (2022, October). *Global Hydrogen Flows: Hydrogen trade as a key enabler for efficient decarbonization*. https://hydrogencouncil.com/wp-content/uploads/2022/10/Global-Hydrogen-Flows.pdf

44 IRENA. (2022). *Global hydrogen trade to meet the 1.5 °C climate goal: Part I - Trade outlook for 2050 and way forward*. International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Global_hydrogen_trade_part_1_2022_.pdf

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.

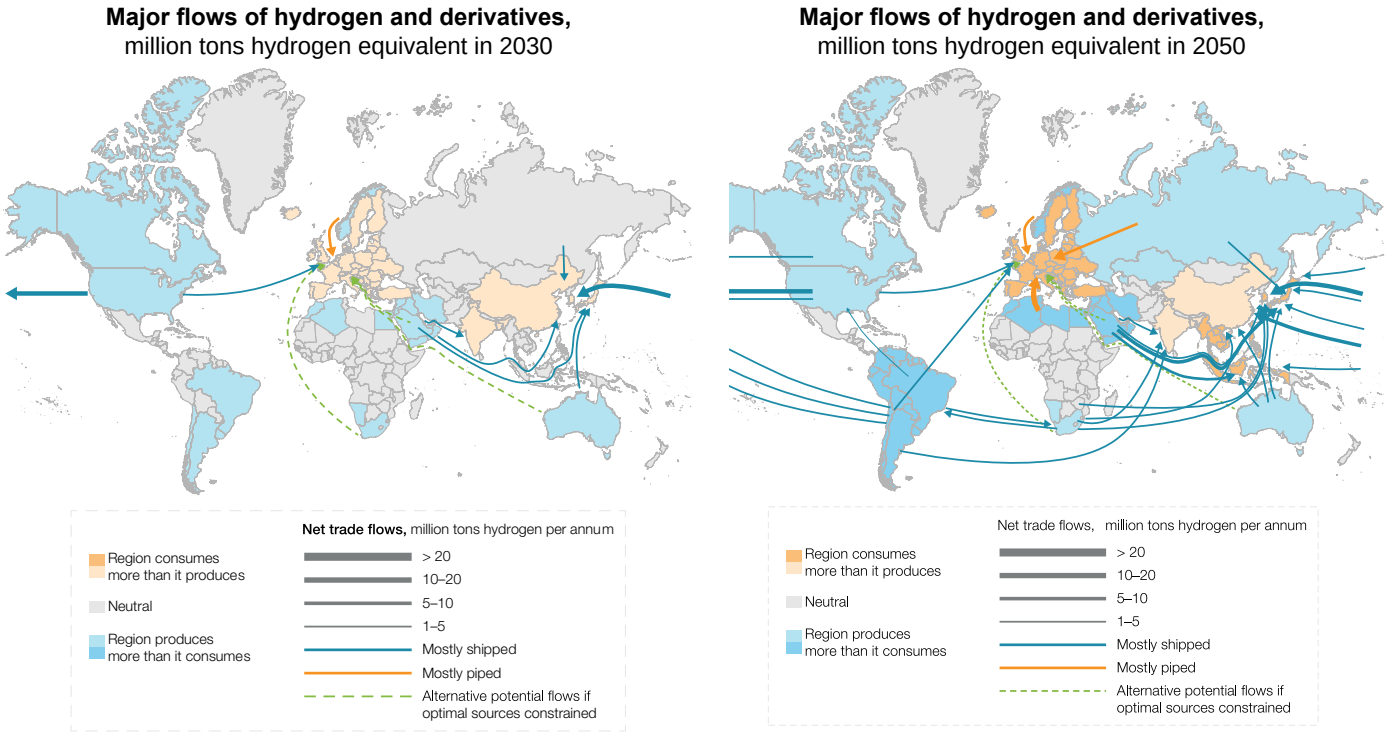


Figure 13: Expected major flows of hydrogen and derivatives; Kenya is not an obvious early (and competitive) exporter of hydrogen derivatives.
(Source: Hydrogen Council and McKinsey & Company, Global hydrogen flows: Hydrogen trade as a key enabler for efficient decarbonisation, October 2022)

2.4. AFRICA HYDROGEN INITIATIVES

As outlined above, Europe and North America are currently 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.[45] 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 some 50 million tonnes of green hydrogen and some 160 million tonnes of green fertiliser could be produced across the African continent by 2035.[46] The development of green hydrogen infrastructure and value chains would also foster job creation, economic development, and regional integration.

45 Hydrogen Council/McKinsey & Company. (2023, May). Hydrogen Insights 2023: *An update on the state of the global hydrogen economy, with a deep dive into North America*. https://hydrogencouncil.com/wp-content/uploads/2023/05/Hydrogen-Insights-2023.pdf
46 EIB. (2022). *Africa's Extraordinary Green Hydrogen Potential*. https://www.eib.org/attachments/press/africa-green-hydrogen-flyer.pdf

Several African countries have recognised 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. 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 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.[47] Most of these projects aim at exports of ammonia (as a hydrogen carrier) to Europe, which targets imports of 10 million tonnes of renewable hydrogen by 2030.[48]

Green Hydrogen production in Africa, split by country (million tonnes, as of February 2023)

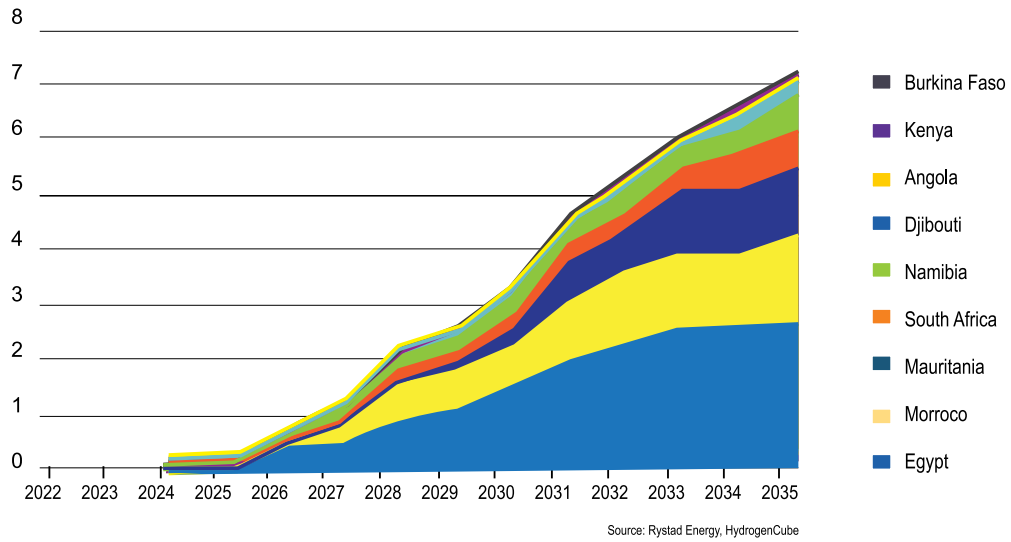


Figure 14: Overview of announced green hydrogen production capacities in Africa. (Source: National News, Africa could be a key green hydrogen supplier to Europe amid energy crisis, Rystad says)[49]

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

48 European Commission. (2022). *Energy: Hydrogen.* https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en

49 Benny, J. (2023, August 27). *Africa could be a key green hydrogen supplier to Europe amid energy crisis, Rystad says.* The National News. https://www.thenationalnews.com/business/energy/2023/03/24/africa-could-be-a-key-green-hydrogen-supplier-to-europe-amid-energy-crisis-rystad-says/

A number of regional/African organisations have been set up to promote green hydrogen on the continent, including the Africa Green Hydrogen Alliance (AGHA), which Kenya is seeking to join, and the African Hydrogen Partnership (AHP).

Africa Green Hydrogen Alliance

AGHA was launched in 2022 by Egypt, Mauritania, Morocco, Namibia and South Africa and others, *"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*".[50]

African Hydrogen Partnership (AHP)[51]

The AHP is an initiative aimed at promoting the development and utilisation 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 decision makers and stakeholders in Africa and other continents. It brings together governmental organisations, industry players, and financial institutions.

50 Green Hydrogen Organisation, Africa Green Hydrogen Alliance (AGHA). (2022, May). *The Africa green hydrogen alliance: Realising Africa's green hydrogen potential through government leadership.* Green Hydrogen Organisation. https://gh2.org/africa-green-hydrogen-alliance-agha

51 African Hydrogen Partnership (AHP). https://www.afr-h2-p.com

3

KENYA COUNTRY CONTEXT

33

3.1. ECONOMY

Kenya ranks among 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 (2022) displaying a continuous and almost uninterrupted growth.[52] 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 *(Figure 15*). The major agricultural exports 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 in the country's economic development and job creation; the sector is dominated by food and agro processing, textiles, and garments. The services sector including financial services, tourism, and telecommunications accounts for around 60% of GDP, and is also a significant contributor to the Kenyan economy.

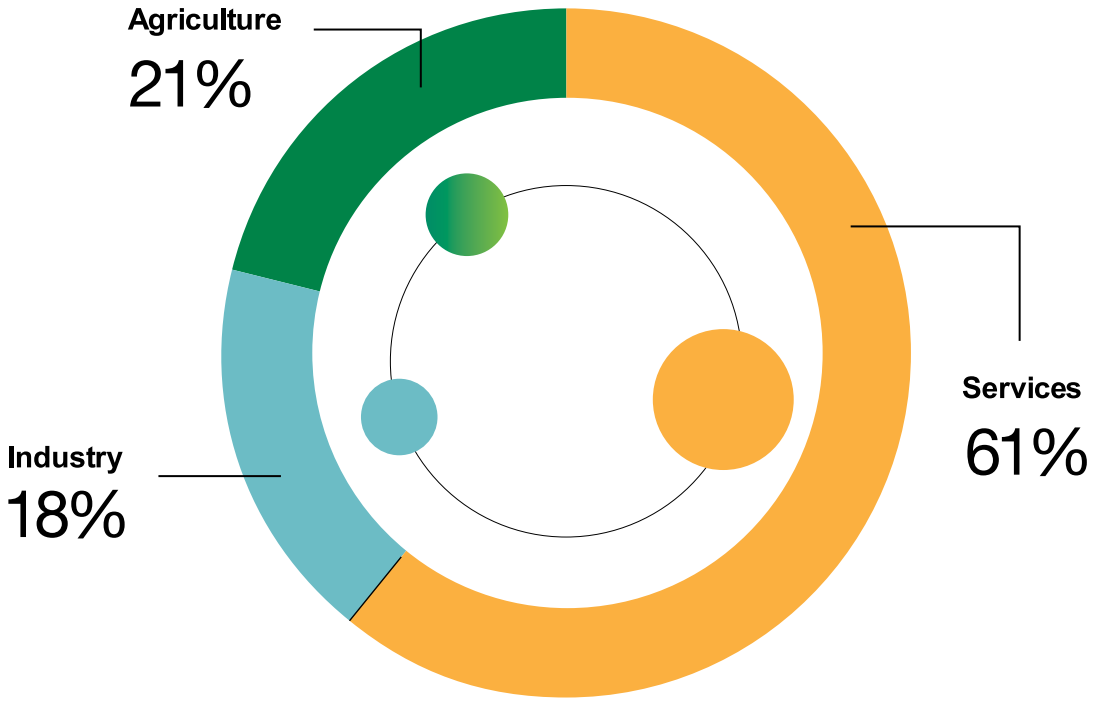


Figure 15: The Kenya economy - agriculture is the main driver. Industrialization can drive further growth. (Source: Kenya National Bureau of Statistics, Economic Survey 2023[53])

52 Kenya GDP (current US$) - World Bank national accounts data, and OECD National Accounts data files. World Bank Open Data. https://data.worldbank.org

53 KNBS. (2023, May 3). *Economic Survey 2023*. https://www.knbs.or.ke/download/economic-survey-2023/

In recent years, Kenya has faced several external challenges, including impacts of the COVID-19 pandemic, recurring droughts, and 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. Not only does it promote agricultural transformation and add value to agricultural products, it also fosters industrial development while bolstering the country's research and development capabilities.

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.[54] 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 world class geothermal, wind and solar resources allow the country to meet its Vision 2030 for a *"clean, secure and sustainable environment"*, and to support its industrialisation. The country's renewable energy potential for production of green hydrogen and derivatives can support its development, its decarbonisation goals and make Kenya a regional champion.

Geothermal energy

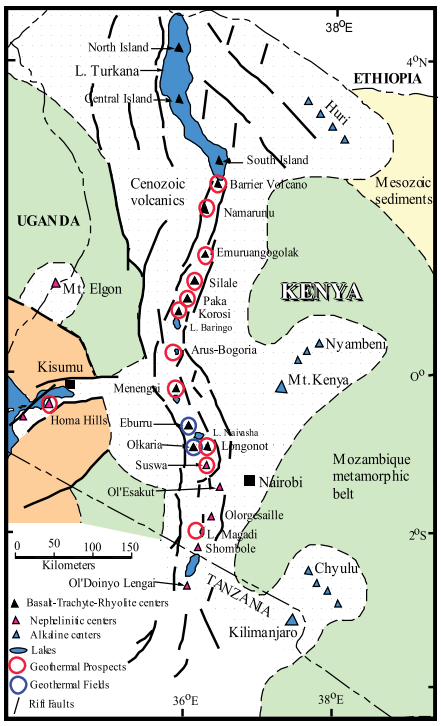
Kenya began geothermal exploration in 1952 commissioning the first 15 MW geothermal plant in 1981 and has since increased its installed geothermal capacity to over 950 MW, and stands in eighth position among geothermal electricity-producing countries worldwide, and top position in Africa.[55] Currently, geothermal power generation is concentrated in the Olkaria and Eburru fields, while several other prospective fields are under development within the Kenyan Rift Valley. With an estimated geothermal potential of 10 GWe[56] distributed in about 14 sites *(Figure16)* 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,[57] or close to 8 million tonnes of ammonia per year.

54 EPRA. (2023). *Biannual Energy and Petroleum Statistics Report, Financial Year 2022/2023*. https://www.epra.go.ke/biannual-energy-and-petroleum-statistics-report-for-the-financial-year-2022-2023/

55 IRENA. (2023, February 16). *Global geothermal market and technology assessment.* https://www.irena.org/Publications/2023/Feb/Global-geothermal-market-and-technology-assessment

56 Ministry of Energy, Kenya. Updated Least Cost Power Development Plan, 2022-2041, June 2022.

57 That is, about 15% of the EU's renewable hydrogen production target for 2030. See https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen_en



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

Figure 16: Geothermal potential in Kenya
(Source: Ministry of Energy, Least Cost Power Development Plan, 2021-2030)

Kenya's geothermal power plants boast an average capacity factor of over 90% and provide a stable electricity supply. When this is considered together with the relatively low and non-volatile cost of geothermal electricity[58] Kenya stands primely suited to embrace the emerging green hydrogen economy alongside other countries with significant geothermal resources like Iceland and New Zealand.

Although geothermal development in Kenya carries various inherent risks, the primary challenges are the high upfront costs for scientific studies, exploration and appraisal drilling.[59] 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 government-owned entity tasked with the responsibility of exploring and developing steam fields, and selling geothermal steam for electricity generation to Kenya Electricity Generating Company (KenGen) or Independent Power Producers (IPPs), who are then able to focus solely on power generation.[60]

58 The levelised cost of electricity (LCOE) from geothermal power projects in Kenya averages 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's Global geothermal market, and technology assessment, 2023).

59 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.

60 85% of the geothermal capacity is operated by KenGen and 15% by IPPs (EPRA, 2022).

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

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 data from the Ministry of Energy. The International Finance Corporation (IFC) estimates that in areas where wind speed is above 8.5 m/s Kenya's technical wind potential can reach 140 GW.[61] The best wind sites are found in the North of the country, mainly around Lake Turkana *(Figure 17)*, highlighting the promise of this region for future wind power development, and for hydrogen production. The 310 MW Lake Turkana wind public-private partnership (PPP) project with an annual average capacity factor of over 60%[62] offers an excellent example of Kenya's exceptional wind conditions.

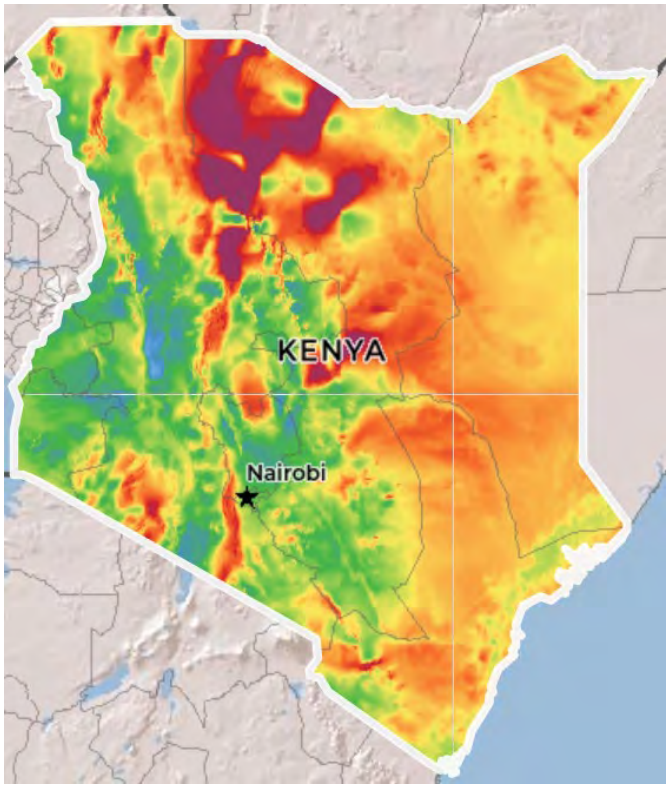


Figure 17: Kenya's wind energy potential
(Source: World Bank Group et al., Global Wind Atlas, 2023, https://globalwindatlas.info/en)

61 GWEC. (2020). *Exploring Africa's Untapped Wind Potential*. https://gwec.net/wp-content/uploads/2021/04/IFC-Africa-Wind-Technical-Potential-Oct-2020-1.pdf

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

Solar energy

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

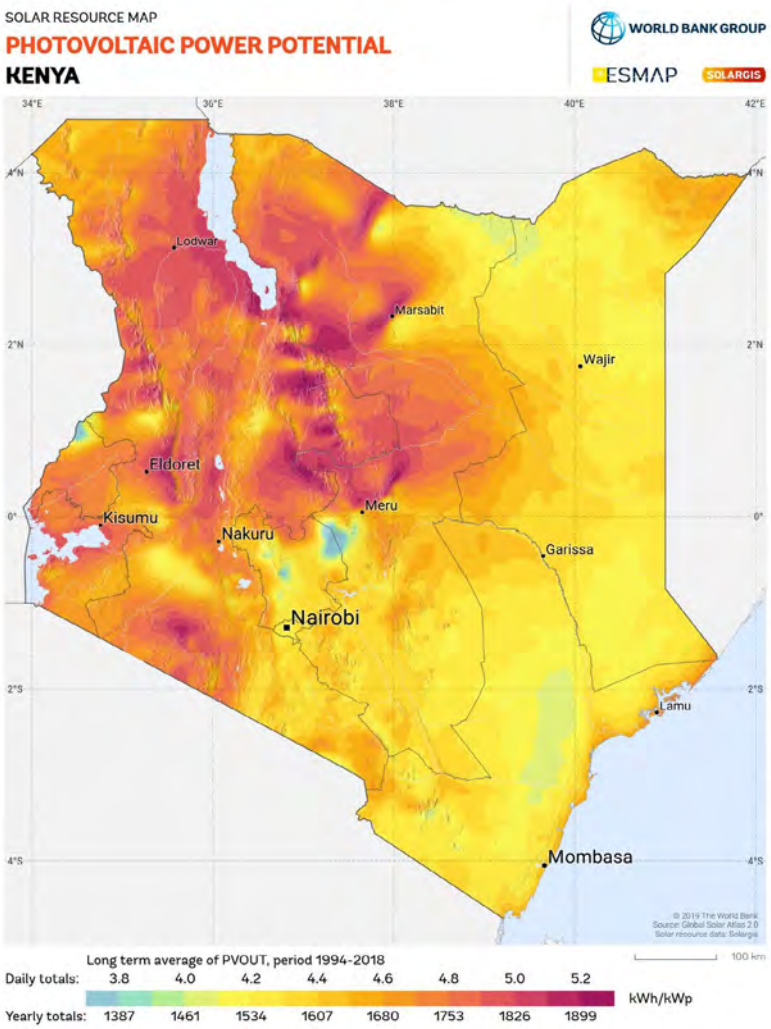


Figure 18: Solar resource map for Kenya
(Source: World Bank Group, Global Solar Atlas, 2023, https://globalsolaratlas.info/map)

Hydroelectric power

Kenya's potential for hydro stands in the range of 3,000 - 6,000 MW,[63] with over 800 MW already exploited mainly in large installations owned by KenGen. There are plans to develop additional large hydro projects although the share of hydropower in Kenya's electricity mix continues to decline and is constantly affected by adverse climate impacts, such as severe droughts. Hydro power is, therefore, not regarded as a priority source for hydrogen production in the frame of this roadmap but should remain in focus for future hydrogen developments.

63 Ministry of Energy, Kenya. Updated Least Cost Power Development Plan, 2022-2041, June 2022.

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. 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 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 at Lake Turkana having a capacity of 310 MW. The country also has 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.

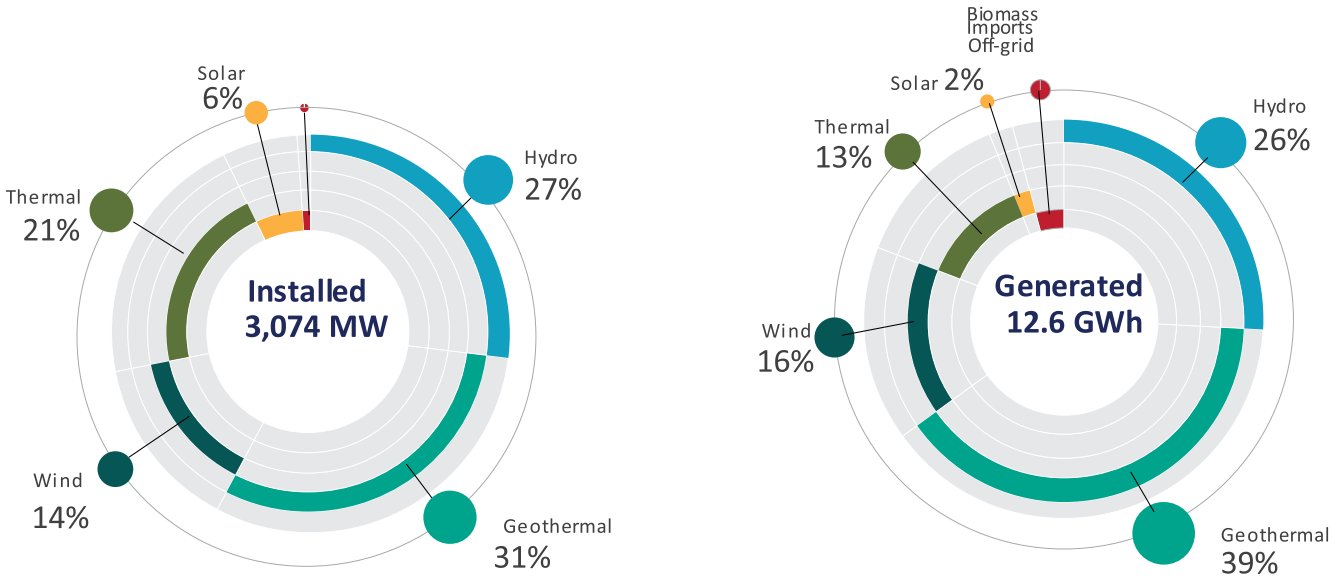


Figure 19: Kenya's power mix – installed capacity and electricity generation by source (Source: Energy & Petroleum Regulatory Authority (EPRA), Energy & Petroleum Statistics Report 2022)

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

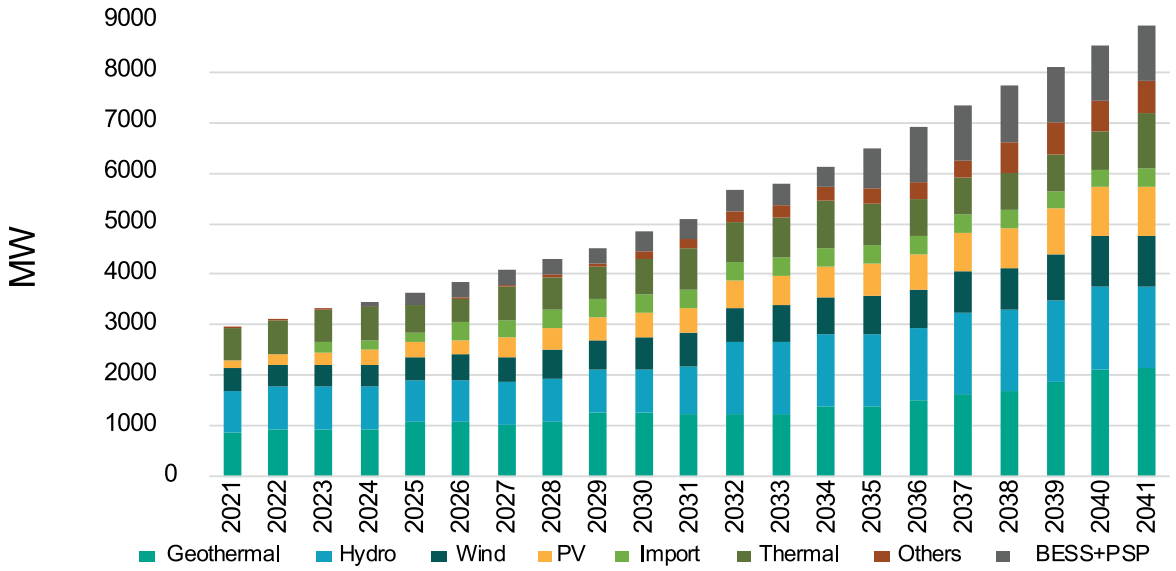


Figure 20: Planned generation expansion (net capacity), own representation (Source: Own analysis according to LCPDP 2022-2041)

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 MW to 1,900 MW (in 2022) *(Figure 21)*. The peak period for electricity consumption in Kenya is relatively short, lasting up to five hours *(Figure 21).* During the nighttime, as peak demand drops by about half from 7pm[64] 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.[65] 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 GWhel originated from geothermal sources was curtailed (with another 41 GWh wind power curtailed in the same period) as per the Energy and Petroleum Regulatory Authority (EPRA) 2022 statistics.

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). 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 used, leading to potentially lower geothermal electricity generation costs in the country.

64 The period between midnight and 4:30 am experiences the lowest demand; during these hours demand is mainly from industries operating 24 hours a day.

65 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.

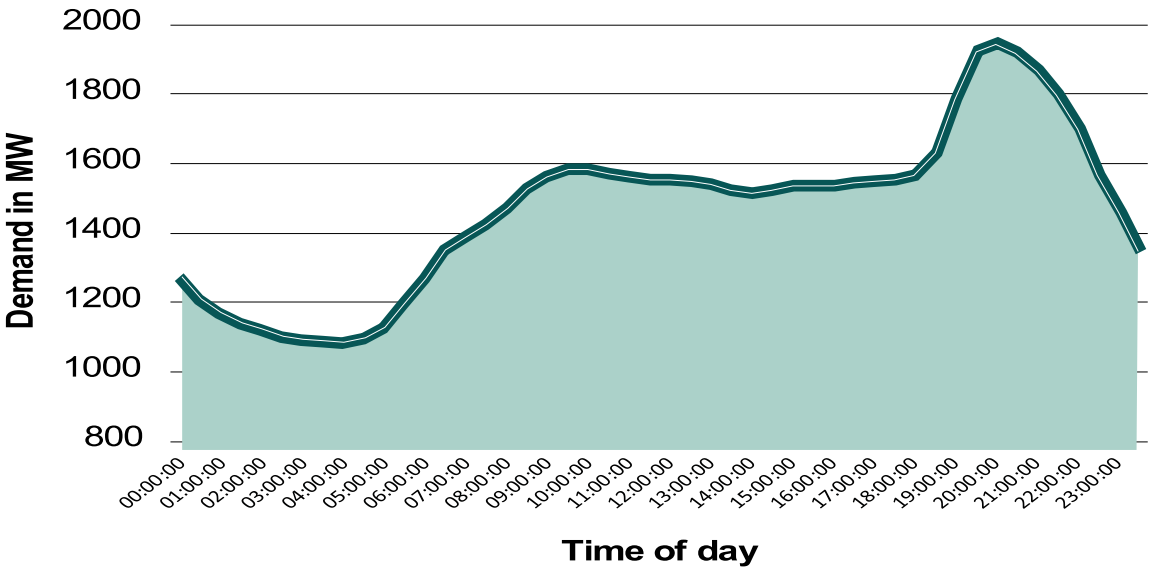


Figure 21: Average daily demand curve 2022
(Source: EPRA, 2023)

During periods of generation curtailment, vented steam, that is, 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%).

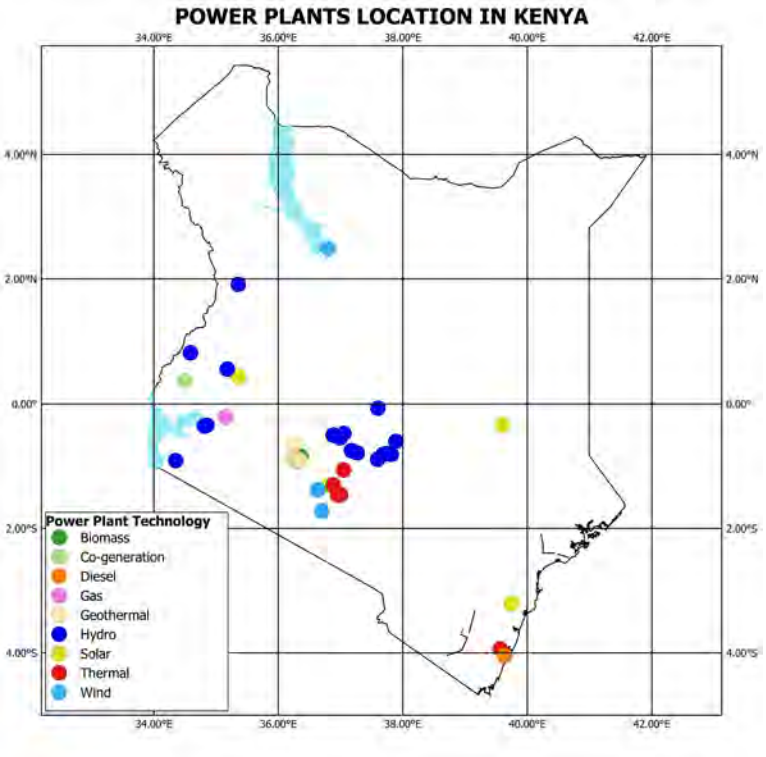


Figure 22: Power plants location in Kenya
(Source: LCPDP 2022-2041)

3.2.3. Power infrastructure

The transmission and distribution network in Kenya has seen 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 owned by state-owned companies Kenya Power and the Kenya Electricity Transmission Company (KETRACO), with shares of 52% and 48%, respectively;[66] the transmission substation capacity is at 5,455 MVA.[67]

The KETRACO Transmission Masterplan proposes to implement transmission projects to match the generation plan and demand forecast as per the LCPDP. In determining the availability of transmission capacity, KETRACO 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 capacity 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.[68] The planned evolution/expansion of the transmission grid (2023 vs. 2027) is displayed in *Figure 23*.

66 KETRACO Transmission Masterplan 2020-2040.

67 Ministry of Energy, Kenya. Updated Least Cost Power Development Plan, 2022-2041, June 2022.

68 In addition to technical adequacy of the infrastructure, such a case requires clear provisions in the regulatory framework (e.g., wheeling charges).

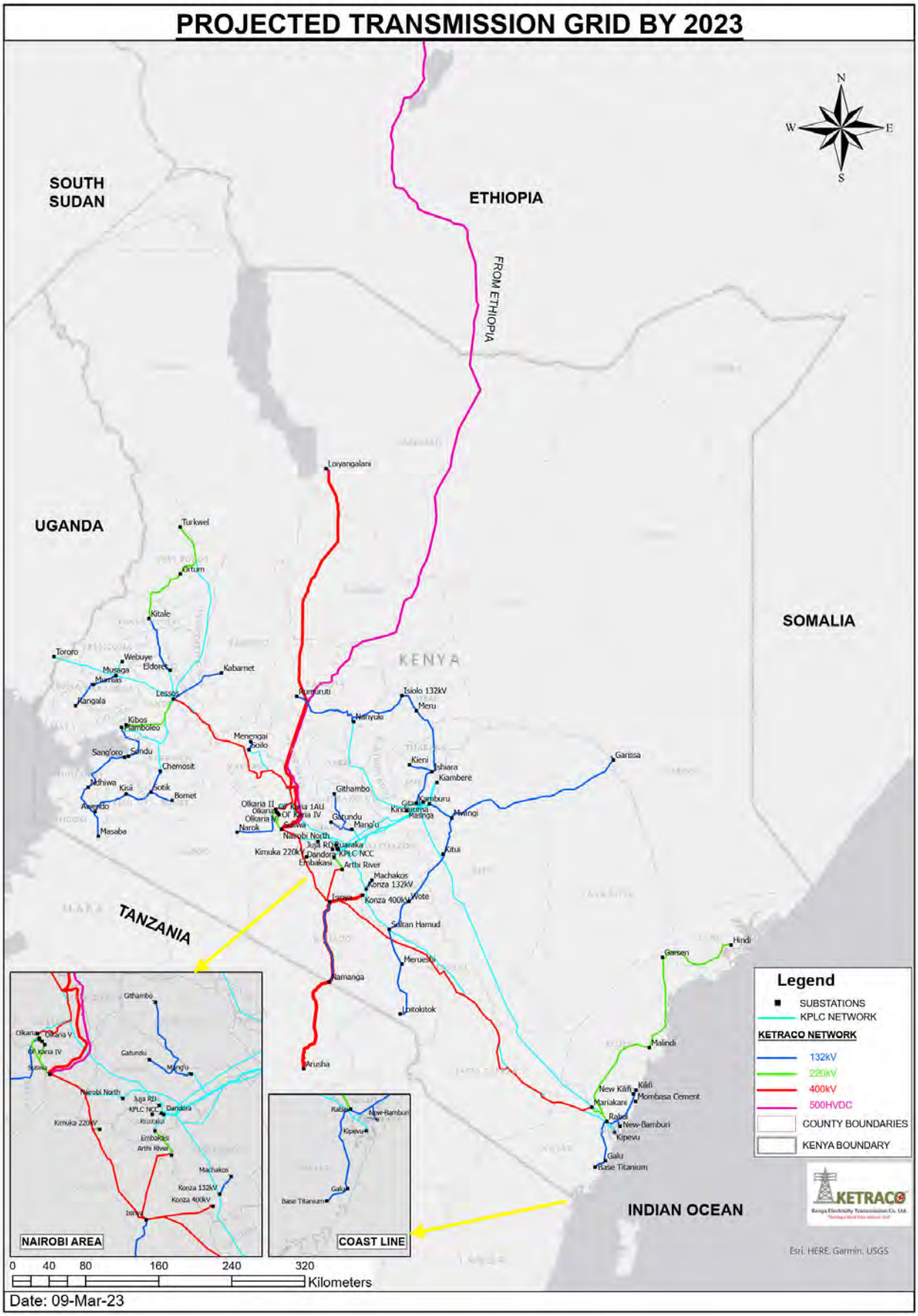


Figure 23 (i): Kenya's transmission grid – 2023
(Source: KETRACO Transmission Masterplan 2020-2040)

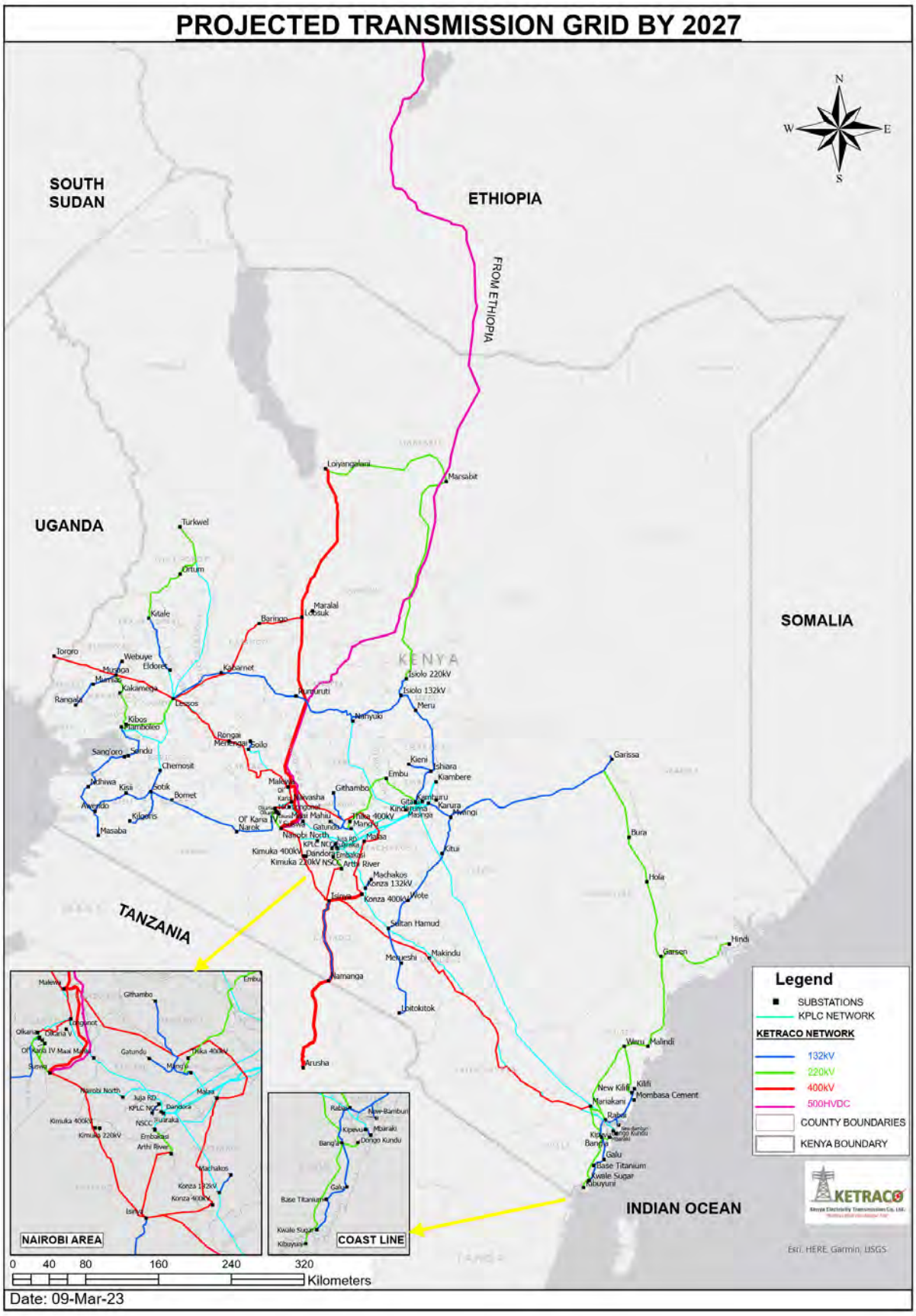


Figure 23 (ii): Kenya's transmission grid projection until 2027
(Source: KETRACO Transmission Masterplan 2020-2040)

3.2.4. Electricity tariffs

EPRA is responsible for establishing electricity tariffs in Kenya. 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 24, left side).* The energy charge, which includes generation, transmission, and distribution, contributes 93 USD/MWh or close to 50% of the overall tariff. There are additional charges, taxes, and fees imposed on this.[69]

Kenya has established industrial clusters and Special Economic Zones (SEZs) across the country to encourage industrialisation, enhance competitiveness, and promote investments through incentives and government support. As per the latest 2023 EPRA tariff review,[70] a special SEZ category exists within the new tariff structure: investors domiciled in the 15 SEZs will pay a harmonised special tariff (energy charge) of Ksh10/kWh (77 USD/MWh) to entice more firms to set up in these designated zones, although the same *"additional fees and taxes"* will still apply.

In conclusion, it can be stated that the grid electricity tariffs in Kenya are generally high, and are prohibitively high if applied to the viability and competitiveness of green hydrogen projects. 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 (that is, Power Purchase Agreements, PPAs), range between 57 USD/MWh and 65 USD/MWh and have been considered as a proxy for the LCOE of these particular sources in Kenya. It is important to note, though, that developers of green hydrogen projects are free to develop captive renewable power projects at potentially lower costs. 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 to lower electricity costs for hydrogen production.

69 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.

70 *Retail electricity tariff review for the 2022/23-2025/26 4th tariff control period (TCP) effective 1st April 2023.* (2023, March 24). EPRA https://www.epra.go.ke/retail-electricity-tariff-review-for-the-2022-23-2025-26-4th-tariff-control-period-tcp-effective-1st-april-2023/

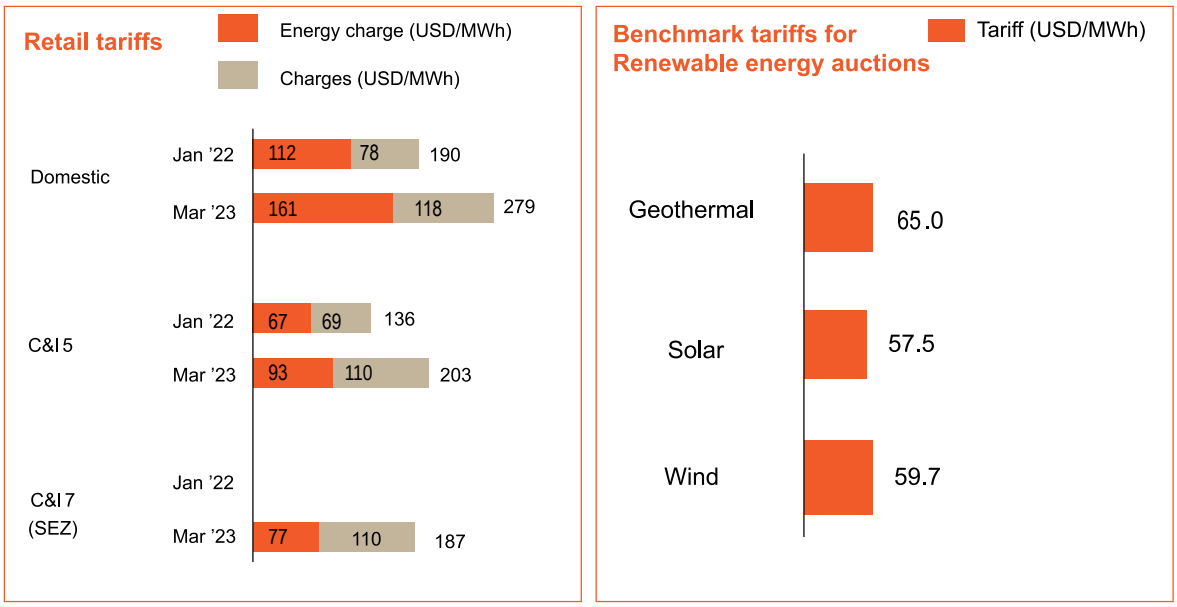


Figure 24: Power price analysis
(Source: Own analysis, https://www.stimatracker.com, The Kenya Gazette, November 23, 2021)
Notes: Jan '22 113 Ksh/USD; Mar '23 130 Ksh/USD

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 for future power demand and how best they can be met at least cost. The updates also 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 is important for stimulating demand for green hydrogen.

In addition to the above existing policy framework, there are significant policy developments underway in Kenya's energy sector that could contribute to the further development of a green hydrogen economy. For example, the country is in the process of developing a 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 decentralised and sustainable energy landscape in Kenya. Kenya is also in the process of developing an **Energy Sector Roadmap 2040 (Kenya Energy White Paper)** which aims to outline the path that the country will take to achieve its energy goals and bring unprecedented growth to the energy sector. The proposed Energy Sector roadmap recognises that Kenya's new energy technologies space - including the green hydrogen industry - is attractive to entrepreneurs, and highlights the need 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 operationalisation 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. Vision 2030 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 realisation by 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 realise its ambitious goals. Vision 2030 is implemented through five-year Medium Term Plans (MTPs), and Kenya is currently implementing MTP IV, which runs from 2023 to 2027 makes provisions for green hydrogen.

- **The Bottom-up Economic Transformation Agenda (BETA):** BETA spans the period 2022-2027 and comprises the government's overarching development agenda for the set 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, bears the brunt of climate change impacts, such as droughts and floods, and the associated socio-economic losses.[71] 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 priority mitigation activities that Kenya is committed to undertaking include the increase 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 recognises the need to increase the use of renewable energy for electricity generation and increase the energy sector's climate resilience. NCCAP 2023-2027 is currently being developed and will 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 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 of having electric vehicles comprise 30% of all vehicles on the road by 2050. The strategy also aims to replace 40% of coal with hydrogen in the production of cement, and replace 15% of heavy fuel oil used in food and beverage manufacturing with electricity and hydrogen. It also recognises the need to increase the use of green hydrogen in large industries such as those producing chemicals, paints, steel, and pharmaceuticals.

71 Government of Kenya, Kenya's Updated Nationally Determined Contribution, 2020.

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 harmonised with the objective of fostering the growth of Kenya's green hydrogen industry.

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 much 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[72]

- **Contributes >20% 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 most Kenyans. Most 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

72 FAO, Kenya at a glance, https://www.fao.org/kenya/fao-in-kenya/kenya-at-a-glance/en/; Ministry of Agriculture and Livestock *Agricultural, Sector Transformation and Growth Strategy, 2019-2029*, https://www.agck.or.ke/Downloads/ASTGS-Full-Version-1.pdf; National Treasury, *Kenya 2023 Budget Policy Statement*, https://www.treasury.go.ke/wp-content/uploads/2023/02/2023-Budget-Policy-Statement.pdf; Central Bank of Kenya, *Agriculture Sector Survey of November 2022*, https://www.centralbank.go.ke/2022/11/25/agriculture-sector-survey-of-november-2022/.

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".[73] Moreover, the implementation and utilisation of green hydrogen presents 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 fertilisers - opportunities and challenges

Fertilisers 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. Fertilisers 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 plants demand the most, for example, for photosynthesis, protein production, and growth. Hence, nitrogen-based fertilisers play a vital role in food production and nutrition.

Kenyan farmers use a variety of inorganic fertilisers 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 fertiliser use over the last five years was 720 thousand tonnes (kt) or an equivalent of approximately 65 kg per hectare of arable land as compared to a world average of 146 kg/ha,[74] indicating a considerable potential for future demand growth. To address the under-fertilisation issue, which can hinder crop growth and lead to decreased agricultural output, it is essential to explore strategies that can enhance fertiliser availability and affordability for Kenyan farmers. This may involve measures such as promoting local fertiliser production, further improving distribution networks, and implementing targeted support measures to assist farmers in accessing fertilisers at reasonable prices.

Approximately 90% of the fertilisers used in Kenya are nitrogen-based fertilisers, such as calcium ammonium nitrate (CAN) or diammonium phosphate (DAP).[75] Kenya relies entirely on fertiliser imports: in total, Kenya imported some 850 kt (2021) of fertilisers (fossil fuel based), the majority of which came from Saudi Arabia, Europe, Russia, and Qatar; five fertiliser importers hold over 75% of market share.[76] Of the imported quantity, around 100 kt were exported to neighbouring countries.

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73 World Bank. (2022 December). 26th Kenya Economic Update: Continued Rebound, but Storms Cloud the Horizon - Policies to Accelerate the Productive Economy for Inclusive Growth. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099400212072220291/P1797690ba796602b092ba0149f48220ed7

74 World Bank Open Data. Fertiliser consumption (kilogrammes per hectare of arable land). https://data.worldbank.org/indicator/AG.CON.FERT.ZS

75 NPK fertilisers are fertilisers that contain the three primary nutrients: nitrogen (N), phosphorus (P), and potassium (K), which are essential for plant growth. (NPK fertilisers are formulated to provide a balanced supply of these primary nutrients to meet the specific nutrient needs of different plants or crops. The ratio of N, P, and K in the fertiliser will vary depending on the specific requirements of the plants being grown.) Nitrogen is consumed in the largest volume of the three nutrients 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 to produce nitrogen-based fertiliser (as a substitute for fossil hydrogen). There are several types of nitrogen-based fertilisers commonly used in agriculture, the most common ones including urea, ammonium nitrate, calcium ammonium nitrate (CAN) as well as ammonium phosphate fertilisers, such as diammonium phosphate (DAP).

76 KfW. Study on Green Hydrogen Fertilizers in Kenya, 2021.

Over the past five years, Kenya has spent on average about USD 290 million annually for fertiliser imports. The surge of commodity prices in international markets in 2021 resulted in Kenya spending USD 355 million to import fertilisers.[77] To mitigate fertiliser price increases and ensure that fertilisers remain affordable and accessible to farmers, *"the government has availed Ksh 3.55 Billion (≈ USD 30 million), to subsidise 71,000 Mt (1.42 million x 50 kg bags) of fertiliser".*[78] As a consequence, the government has been encouraging private sector investment in the fertiliser manufacturing industry to expand domestic production and reduce dependency on imports.

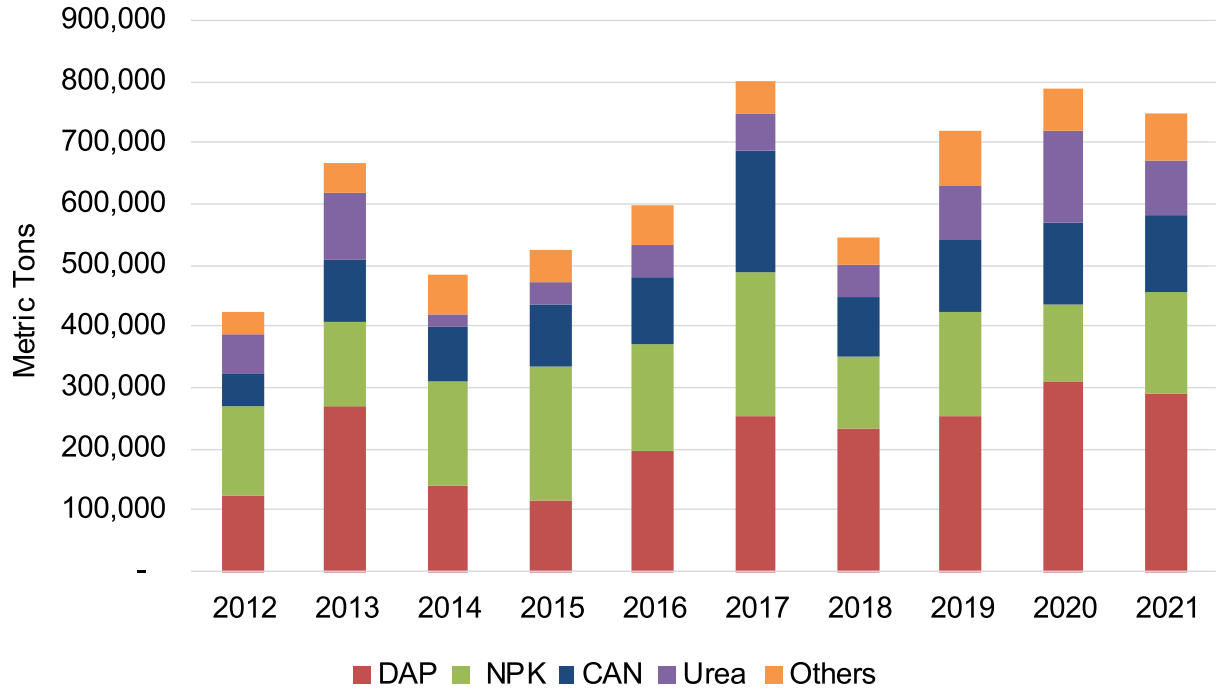


Figure 25: Evolution of fertilizer consumption in Kenya (Source: Ministry of Agriculture)

77 *Kenya Imports of Fertilizer.* Trading Economics. https://tradingeconomics.com/kenya/imports/fertilizers

78 *Fertilizer Subsidy 2022.* Ministry of Agriculture and Livestock Development. https://kilimo.go.ke/fertilizer-subsidy-2022/

Box 4: The fertiliser 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)[79] 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.

79 World Bank Open Data. Fertiliser consumption (kilogrammes per hectare of arable land). 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:[80]

1. **Agro processing:** This sector includes food and beverage processing, milling, dairy products, meat processing, and other related activities. Agro processing is 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 textiles and apparel industry plays a crucial role in Kenya's manufacturing sector. It encompasses the production of fabrics, garments, and related products. The sector is recognised 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 fertilisers, paints, detergents, and pharmaceuticals. The sector is identified as a key sector with growth potential driven by both domestic demand and export opportunity.

4. **Construction Materials:** The manufacture of construction materials such as cement, steel, bricks, and roofing materials is identified as a significant sector. A sector report published by the Kenya Association of Manufacturers highlights continuing demand for construction materials due to infrastructure development, urbanisation, and housing construction in Kenya.

5. **Plastics and Rubber:** The production of plastic and rubber products is 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 products.

Kenya, like many other developing countries, faces challenges in developing a robust manufacturing sector, with 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 that underscore the significance of the sector 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 including the implementation of policy reforms, investment in infrastructure, promotion of skills development, and fostering innovation.

80 KAM. (2018). "*Manufacturing in Kenya Under the "Big 4 Agenda":* A sector deep-dive report. Kenya Association of Manufacturers. https://kam.co.ke/kam/wp-content/uploads/2018/10/KAM-Manufacturing-Deep-Dive-Report-2018.pdf

The expanding domestic market offers a ready customer base for locally produced goods and is a key advantage. Moreover, emerging sectors such as agro processing, textiles, and production of construction materials all present untapped opportunities for Kenya's manufacturing sector. Capitalising 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 total GDP.[81] 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 the significance of this transport system.

The **railway sub sector** 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. Proposals to extend this railway line to Malaba to reach the Ugandan border have been mentioned.[82] 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 decarbonise the aviation sector.[83] Kenya Airways became the first African airline to use SAF for a long-haul flight, showcasing a commitment to sustainability.[84]

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 for Kenya but also for 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 Northern corridor, is part of Kenya's Vision 2030 and is expected to expand the region's port activities. Leveraging the turnover of shipping, there is an opportunity to supply green fuel. Kenya Ports Authority is implementing the Green Port Policy, which includes the shore-to-ship power strategy to make operations more sustainable.

81 Ministry of Transport/GIZ. (2021). *Transport sector in Kenya's Nationally Determined Contribution* . Changing Transport. https://changing-transport.org/wp-content/uploads/2021_GIZ_Factsheet_Transport-in-Kenyas-NDC.pdf

82 Omondi, D. (2023, May 15). *Grand Sh2.1trn plan to expand SGR to Kisumu, Malaba, Isiolo*. Business Daily. https://www.businessdailyafrica.com/bd/economy/grand-sh2-1trn-plan-to-expand-sgr-to-kisumu-malaba-isiolo-4234772

83 KCAA, Sustainable Aviation Fuels (SAF) Workshop with GIZ. (2022, August 3). https://www.kcaa.or.ke/about-us/media-center/gallery/sustainable-aviation-fuels-saf-workshop-giz

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

The transport sector is the largest consumer of petroleum products in Kenya 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.[85]

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.[86] 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 present transport sector strategy, there are potential long-term applications that could emerge. These include green hydrogen fuel for vehicles used in port operations, exploration of the use of hydrogen-powered locomotives on railway lines, and production of SAFs in-country. These efforts would contribute to reducing emissions and promoting a sustainable and environmentally friendly transport sector in Kenya.

85 Ministry of Transport, Infrastructure, Housing, Urban Development and Public Works. (2020). T*ransport Sector Climate Change Annual Report 2019/2020*. https://changing-transport.org/wp-content/uploads/Kenya-transport-annual-report_Jan-2021.pdf

86 EED. (2022). *Roadmap to e-Mobility Kenya.* EED Advisory. https://eedadvisory.cdn.prismic.io/eedadvisory/d39c4750-7489-4fb3-937a-f50618805b7e_RoadMap-to-e-Mobility-in-Kenya.pdf

Flamingoes on Lake Nakuru, Kenya.

4

KENYA'S OPPORTUNITIES IN GREEN HYDROGEN

Small Geothermal Power site in the Hell's Gate National Park, Kenya

4.1. HYDROGEN USE CASES FOR KENYA

Kenya's considerable renewable energy potential provides a strong basis from which to drive the country into the green hydrogen space. Several compelling opportunities have been identified globally for the short, medium, and long term *(Figure 26).* These opportunities range from the development of the full value chain for fertilisers to the production of chemical feedstock and clean transportation fuel for the road, maritime, and aviation sectors.[87] This section elaborates on 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.[88] These studies are complemented by further analysis and extensive stakeholder consultations that took place in the course of the development of this Roadmap.

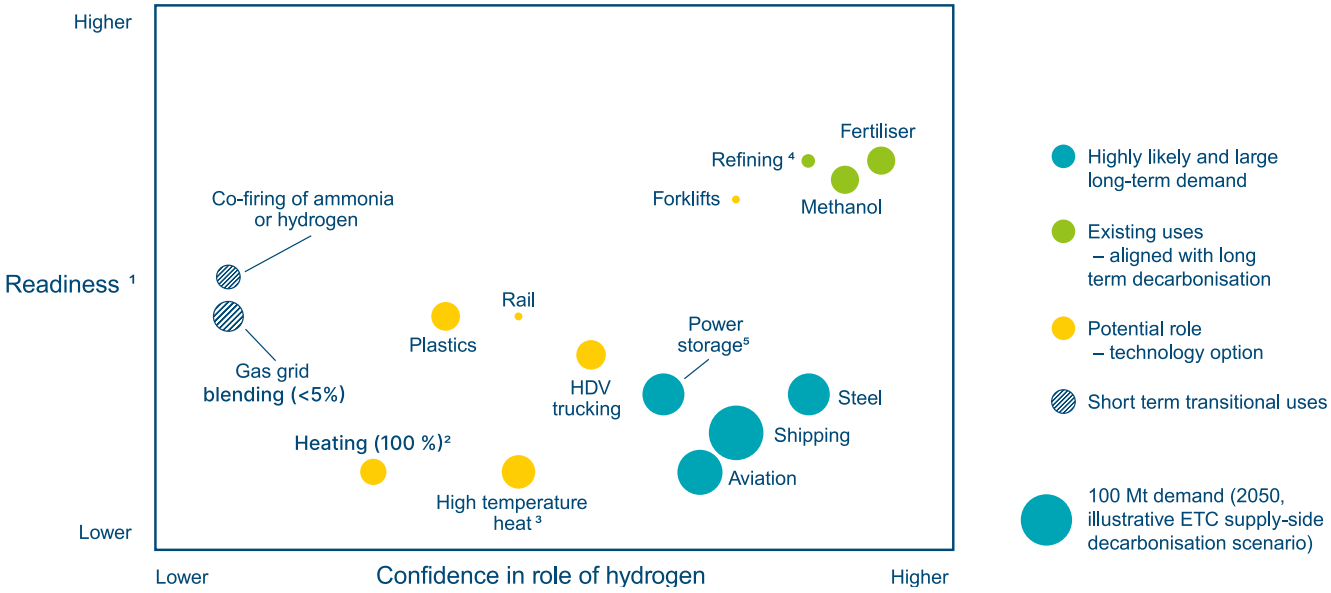


Figure 26: Potential uses of hydrogen in a low-carbon economy[89]

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

88 Ministry of Energy, Kenya & GIZ. (2022). *Baseline Study on The Potential For Power-To-X/ Green Hydrogen in Kenya.* Ministry of Energy, Kenya.

89 ETC. (2021, April). *Making the Hydrogen Economy Possible: Accelerating Clean Hydrogen in an Electrified Economy.* https://www.energy-transitions.org/publications/making-clean-hydrogen-possible/#download-form

The case of ammonia/fertilisers

Ammonia serves as the fundamental building block for all mineral nitrogen fertilisers, playing a crucial role in agricultural practices globally. Among the three essential nutrient categories for plants, namely nitrogen, phosphorus, and potassium, nitrogen stands out as the most vital element and the one consumed in largest quantities. Ammonia makes an indispensable contribution to global agricultural systems through its use in nitrogen fertiliser production.[90]

Today, nitrogen fertilisers 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 decarbonisation.[91] With Kenya being fully dependent on imported fertiliser, the local production of green ammonia/fertiliser from green hydrogen 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 fertilisers from green hydrogen can **reduce exposure to price volatility of international markets,** and save on import subsidies.
2. Domestic fertiliser production can potentially increase the amount of fertiliser available in the country and offer an opportunity to **overcome "under-fertilisation".** (See section on the Agricultural sector). An increase in Kenya's consumption of fertiliser approaching the world average (per unit of arable land), would significantly improve crop yields, by as much as double the current level;
3. Kenya also exports fertiliser to neighbouring countries, and domestic production of fertiliser or green ammonia could lead to the **development of new regional export opportunities** and strengthen the country's position and strategic location as a major trade hub within the Eastern Africa region.
4. The use of Kenya-made green fertilisers will promote adoption of sustainable agricultural practices and add value to agricultural produce by lowering the lifecycle carbon footprint.
5. While ammonia is primarily used in fertiliser production, there are potential emerging markets for green ammonia derived from green hydrogen including its use as a transportation medium for long-distance shipping of hydrogen or its direct use as a clean fuel for the maritime industry.[92]

90 IEA. (2021, October). *Ammonia Technology Roadmap: Towards more sustainable nitrogen fertiliser production*. https://iea.blob.core.windows.net/assets/6ee41bb9-8e81-4b64-8701-2acc064ff6e4/AmmoniaTechnologyRoadmap.pdf

91 WEF. (2022, July 28). *The Net-Zero Industry Tracker: An interactive guide for executives*. World Economic Forum. https://www.weforum.org/reports/the-net-zero-industry-tracker/in-full/ammonia-industry/

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

Substituting Kenya's total consumption of imported nitrogen fertilisers (which amounts to 600-700 kt per year) with local production would require the production of **170-280,000 tonnes of ammonia** and up to **50,000 tonnes of green hydrogen per year.** To produce this amount of hydrogen would require electrolysers with capacity in the range of **350-450 MW** 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 to 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 Saudi Arabia).[93] Methanol is used as 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 feedstock for the chemical industry. Green methanol is gaining attention as a promising clean fuel option for commercial shipping (alongside ammonia) and momentum for its use is expected to build in the coming years.[94]

Import substitution of methanol would result in a potential hydrogen production (= indirect product import) of around 1,000 tonnes of hydrogen per year. To produce 5,000 tonnes of methanol would require an electrolysers' capacity of 10-15 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 feedstock for producing green ammonia or green methanol, both of which are considered potential clean solutions for commercial shipping, green hydrogen also holds promise for decarbonising other segments of the transportation sector including the road sector and aviation. An example is its direct use in fuel cell vehicles, including trucks and forklifts, may also be considered in the long term, contingent upon 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 use of green hydrogen as a reducing agent to produce direct induced iron (DRI), which can then be used to make steel in conjunction with an electric arc furnace. While DRI plants using natural gas as a reducing agent have been employed

93 GIZ. (2023). Sector Analysis Study.

94 Methanol Institute. (2023, May). *Marine Methanol: Future-proof shipping fuel.* https://www.methanol.org/wp-content/uploads/2023/05/Marine_Methanol_Report_Methanol_Institute_May_2023.pdf

commercially for some time, large-scale commercialisation of hydrogen DRI plants is pending. Hydrogen-DRI represents the only method available for fully decarbonising steel production.

The case for renewable baseload power

Key challenges associated with solar and wind energy are intermittency and variability due to natural daily and seasonal fluctuations. However, these challenges can be addressed by implementation of energy storage solutions. For instance, excess solar energy generated during the day can be converted and stored in the form of hydrogen and 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. Hydrogen and electrolysers 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 for entering the green hydrogen market, the potential end-use applications of hydrogen must be prioritised and matched to the country’s unique characteristics. Prioritisation should consider factors such as technical feasibility, economic viability, scalability, and alignment with national energy and development goals. It is also important to recognise that market dynamics change as technology advances, and new opportunities arise, and the prioritisation of hydrogen use cases may evolve over time. Project priorities must face continual assessment and adaptation based on the evolving hydrogen landscape so that Kenya maximises the benefits and impact of its early hydrogen initiatives. The phased approach of the *Green Hydrogen Strategy and Roadmap for Kenya* considers 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 will do well to concentrate on identifying opportunities often referred to as “low-hanging fruits”, opportunities that pose few entry barriers, are lower risk, offer quick returns and easy rewards. 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 coming into Kenya indicate that there is potential for local production and deployment of PtX technologies- most notably for **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 would not only cultivate a thriving manufacturing sector, but also fuel industrialisation, unlock research and development prospects, and generate employment opportunities.

Fertiliser production for the agriculture sector holds significant promise for the development of green hydrogen in Kenya. It stands out as the most relevant entry point for multiple reasons including potential competitiveness when considering import replacement and transport costs, foreign exchange considerations, supply risks, and replacement of 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, local production of fertiliser from green hydrogen would play an essential role in sustaining the agricultural sector, which provides employment and food for a majority of Kenyans. However, given the presence of established players in trade, blending, and distribution, the successful establishment of a domestic fertiliser manufacturing plant necessitates close collaboration with the existing fertiliser 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 fertilisers, Kenya's focus on green methanol would position it at the forefront of efforts to find effective solutions to decarbonise maritime transport, particularly at the Mombasa Port. Additionally, the adoption of methanol as a clean cooking fuel will also open up new opportunities within the country.

However, even if Kenya chooses to prioritise fertiliser and methanol production, it is crucial to uphold an open-minded approach towards exploring other emerging applications and their potential advantages; 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 and its derivatives, competition is expected among countries that will be driven by factors such as the cost and supply volumes of the product. 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 for international markets of hydrogen derivatives in the immediate future, but has the opportunity to become a regional player by establishing a hydrogen sector that will develop around its competitive advantages - such as its resource potential, its developing economy with a rising industrial/manufacturing sector, and its geographic location with well-established trade routes. To accelerate Kenya's journey towards becoming a regional player, it is crucial for the country to prioritise the establishment of a strong domestic market, reaping the benefits that come with it, as it strategically plans for future expansion.

4.3. ECONOMICS OF GREEN HYDROGEN IN KENYA

Several key factors influence the economics of green hydrogen production, namely, capital expenditure (CAPEX) for electrolysers, the cost of electricity to feed the electrolysers, their utilisation rate (or capacity factor) and the weighted average cost of capital (WACC). A calculation of the levelised 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 electrolysers

The cost of electrolysers and the potential benefits of economies of scale play a significant role. If the CAPEX for electrolysers 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.

Utilisation rate

Optimising the utilisation rate (load factor) of hydrogen production facilities is vital as well. By maximising 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 utilisation rate can vary greatly between grid-connected and captive generation projects. In the case of captive power, the utilisation rate is directly determined by the specific renewable energy source being used. Utilisation rates can differ substantially, with solar typically ranging around 20%, wind reaching approximately 60%, and geothermal achieving as high as 85% in Kenya. Higher utilisation 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.

Cost and availability of water

Water access is an important factor 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, may be an option to overcome constraints in water-stressed regions. Water from desalination plants can be delivered to nearby areas with limited freshwater resources through over-dimensioning of desalination plants. In any case, the cost attributed to water in the final cost of hydrogen is negligible, being around 0.08 USD/kg hydrogen.[97]

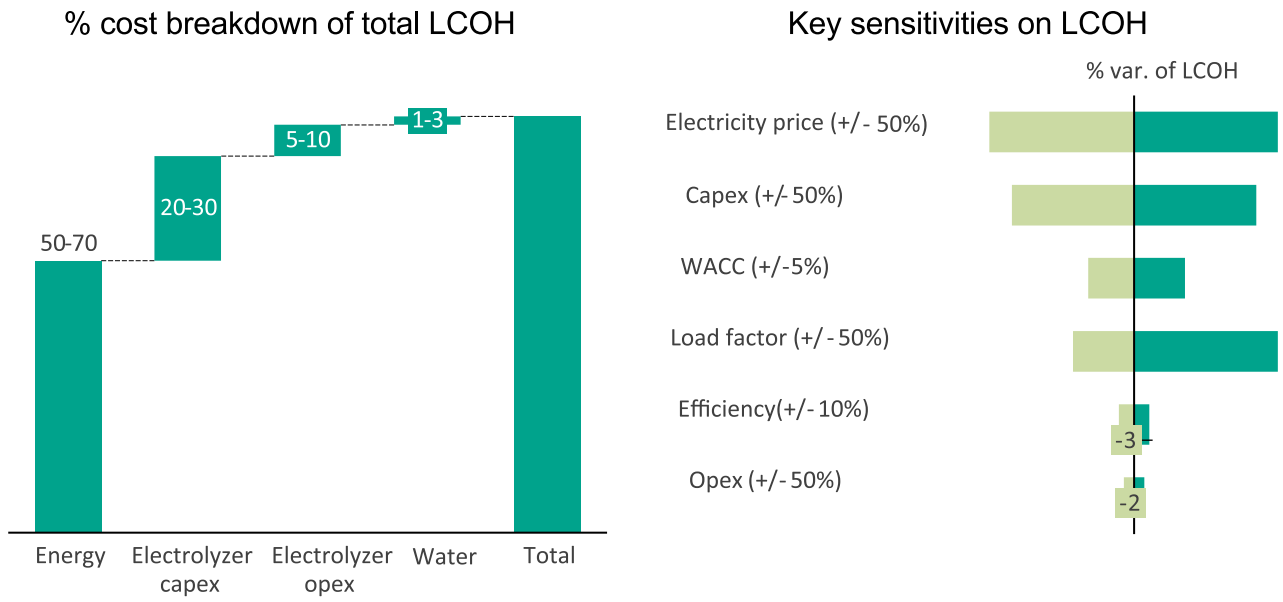


Figure 27: Economic sensitivity analysis of green hydrogen production costs (Source: Analysis of TAF Team) [98]

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. 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 of the impact of water (availability) on the production of hydrogen see the report by IRENA, *Global hydrogen trade to meet the 1.5 °C climate goal: Part III – Green hydrogen cost and potential, 2022.* International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Global_hydrogen_trade_part_1_2022_.pdf

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

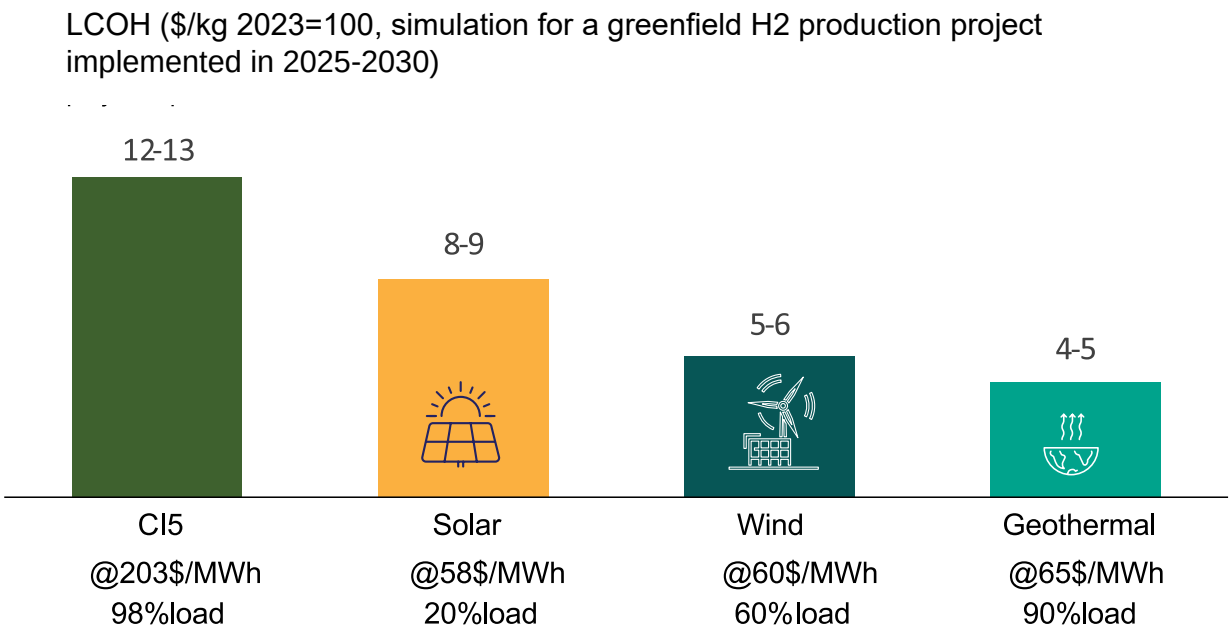


Figure 28: LCOH for green hydrogen from different sources in Kenya (Source: Analysis of TAF Team)[99]

In Kenya, geothermal energy, with its relatively low cost 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.[100] Nevertheless, 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 USD/MWh to 30 USD/MWh (assuming no financial support measures are in place). Through optimisation of the geothermal development process (for example, by shortening the geothermal development cycle), it is expected to further lower the cost of generating geothermal power in Kenya.

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 which case the lower cost of green hydrogen could potentially improve its competitiveness.

99 Simulation for a greenfield H2 production project implemented in 2025-2030 (in $2023). 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.

100 This range is also confirmed by GIZ. (2023, May). *A Geothermal Approach to Power-to-X - in El Salvador, Chile and Kenya*. International PtX Hub. https://ptx-hub.org/wp-content/uploads/2023/05/International-PtX-Hub_202305_A-geothermal-approach-to-PtX.pdf

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 fertiliser. 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 fertiliser costs.[101] 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 fertiliser costs.[102] Nevertheless, in the foreseeable time horizon, green ammonia will reach parity with grey/blue ammonia and become cost competitive, replacing grey/blue ammonia as feedstock *(Figure 29).*[103]

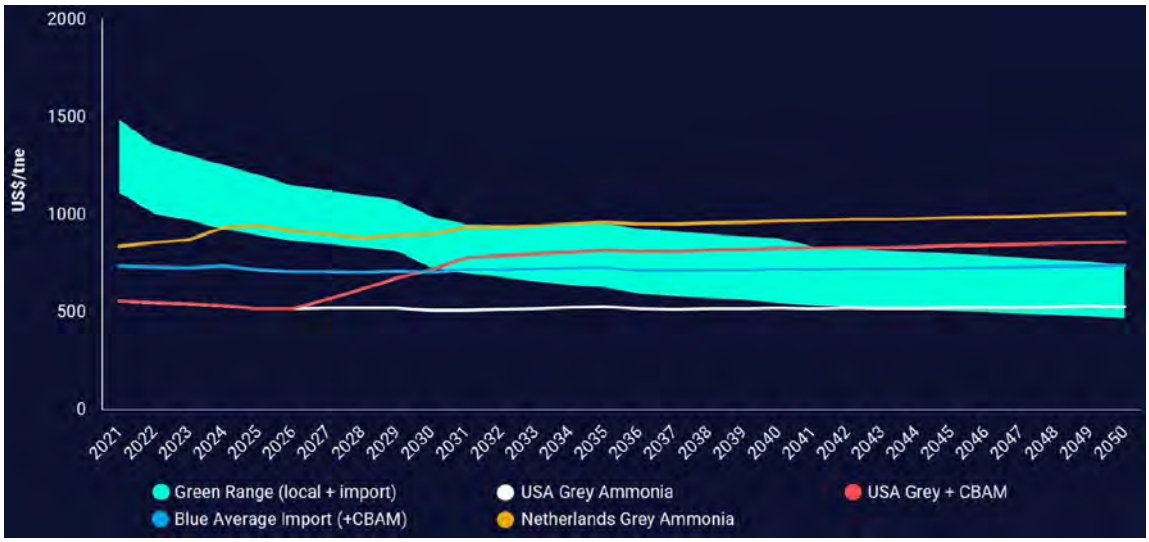


Figure 29: Ammonia cost comparisons (green vs blue vs grey)

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 fertiliser) or automotive retail prices (in case of green steel) would be negligible.[104]

101 MET Development

102 The cost of producing green ammonia in Kenya today is estimated to be in the range of 1,000 – 1,400 USD/tonne.

103 *News release: Power facilities to potentially use 100 Mt of low-carbon ammonia as feedstock by 2050.* (2022, November 17). Wood Mackenzie. https://www.woodmac.com/press-releases/power-facilities-to-potentially-use-100-mt-of-low-carbon-ammonia-as-feedstock-by-2050/

104. ETC. (2021, April). *Making the Hydrogen Economy Possible: Accelerating Clean Hydrogen in an Electrified Economy.* https://www.energy-transitions.org/publications/making-clean-hydrogen-possible/#download-form

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 for 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 for a successful transition towards a greener economy in Kenya.

International and local private sector players and developers offer their knowledge of the market and provide valuable insights into business models and approaches that could integrate green hydrogen into the Kenyan market. They also bring knowledge, expertise, experiences, and best practices from developing green hydrogen in other countries.

Collaboration between the private sector and the government will be crucial in the implementation of green hydrogen projects in Kenya. The private sector brings industry-specific expertise and capital investment, while the government provides 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 described briefly below.

Current project initiatives

KenGen

KenGen is developing a demonstration project for ammonia production, with the first step being a feasibility study.[105] The feasibility study aims to assess the technical, financial, economic, environmental, and social viability of green hydrogen production, specifically for conversion to ammonia/fertiliser. The study will result in a bankable blueprint for the development of a commercial-scale project, considering market conditions, relevant laws and regulations. Based on the findings of the feasibility study, a 5 MW green hydrogen demonstration plant and fertiliser production facility will be designed and installed in Olkaria, Naivasha. The demonstration plant could be scaled up to a commercial capacity of 100 MW or more, depending on the findings of the study. The project will use geothermal energy as an energy source and its completion is planned for 2025.

Fortescue Future Industries (FFI)

FFI aims to develop a 300 MW capacity generation green hydrogen, ammonia/fertiliser project by 2025/26. Fertiliser production will primarily cater to the domestic market, with the possibility of export. Power generated by the project will be made accessible to the national grid during peak-load hours. The government of Kenya recently signed an investment support and implementation agreement with FFI, accelerating the framework agreement signed during COP27.

105 Feasibility study for green hydrogen, ammonia, and fertilizer production pilot plant at Olkaria, Naivasha.

HDF Energy

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 the night) 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 are working together on a green power-to-fertiliser project with the aim of producing 200,000 tonnes of nitrogen fertiliser 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 fertiliser project aims to support the agricultural sector by increasing availability and affordability of fertiliser and will also create more than 300 permanent jobs.

SOWITEC

SOWITEC Kenya, a subsidiary of the SOWITEC Group, is aiming for local production of clean methanol, targeting an annual volume of 8,000 tonnes. Power for production will be sourced from a combination of 12 MW solar and/or geothermal power. Feasibility studies have indicated the viability of the venture with the aim of substituting 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. CFAO is focusing 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 energy needs for various uses including 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 30)*. While there is impressive momentum, this overview also highlights the need for alignment and central coordination of stakeholders across different disciplines. Important to mention in this regard is the Green Hydrogen 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 of promoting the development and utilisation of green hydrogen in Kenya through collaborative effort.

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 AND PETROLEUM REPUBLIC OF KENYA	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 utilisation 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.
Ministry of Investments, Trade and Industry State Department for 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 Seamless Connectivity	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 and 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 REPUBLIC OF KENYA	The National Treasury and Economic 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, mobilising investments, and incorporating green hydrogen initiatives into the national development plans to support the transition towards a sustainable and low-carbon economy in Kenya.

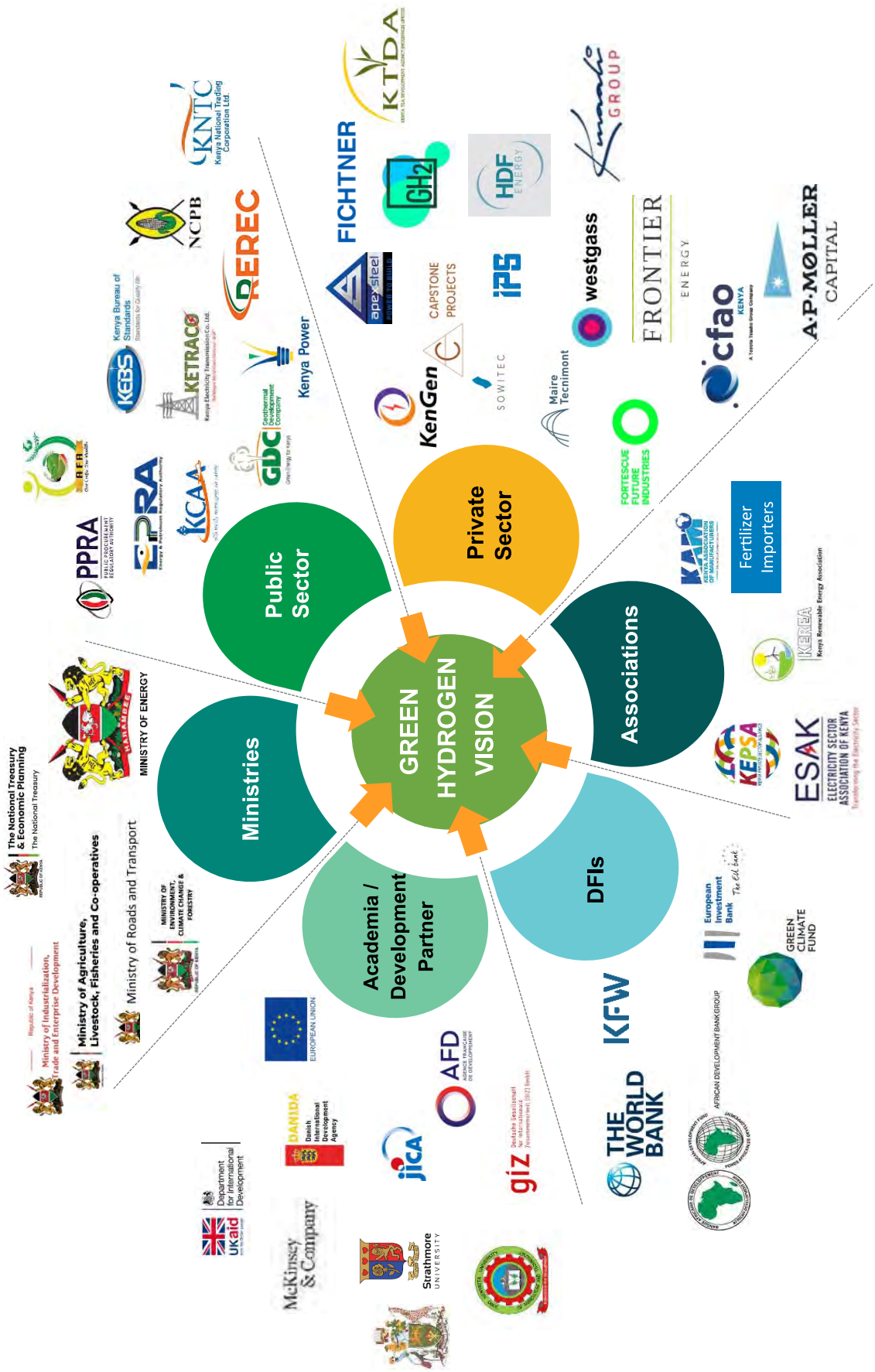


Figure 30: Mapping of green hydrogen stakeholders in Kenya

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, specialising 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 is exploring the integration of green hydrogen as an alternative energy source and supports the development of infrastructure and mechanisms for the distribution and utilisation 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 utilisation of green hydrogen in Kenya.
nema mazingira yetu | uhai wetu | wajibu wetu	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 promoting 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.

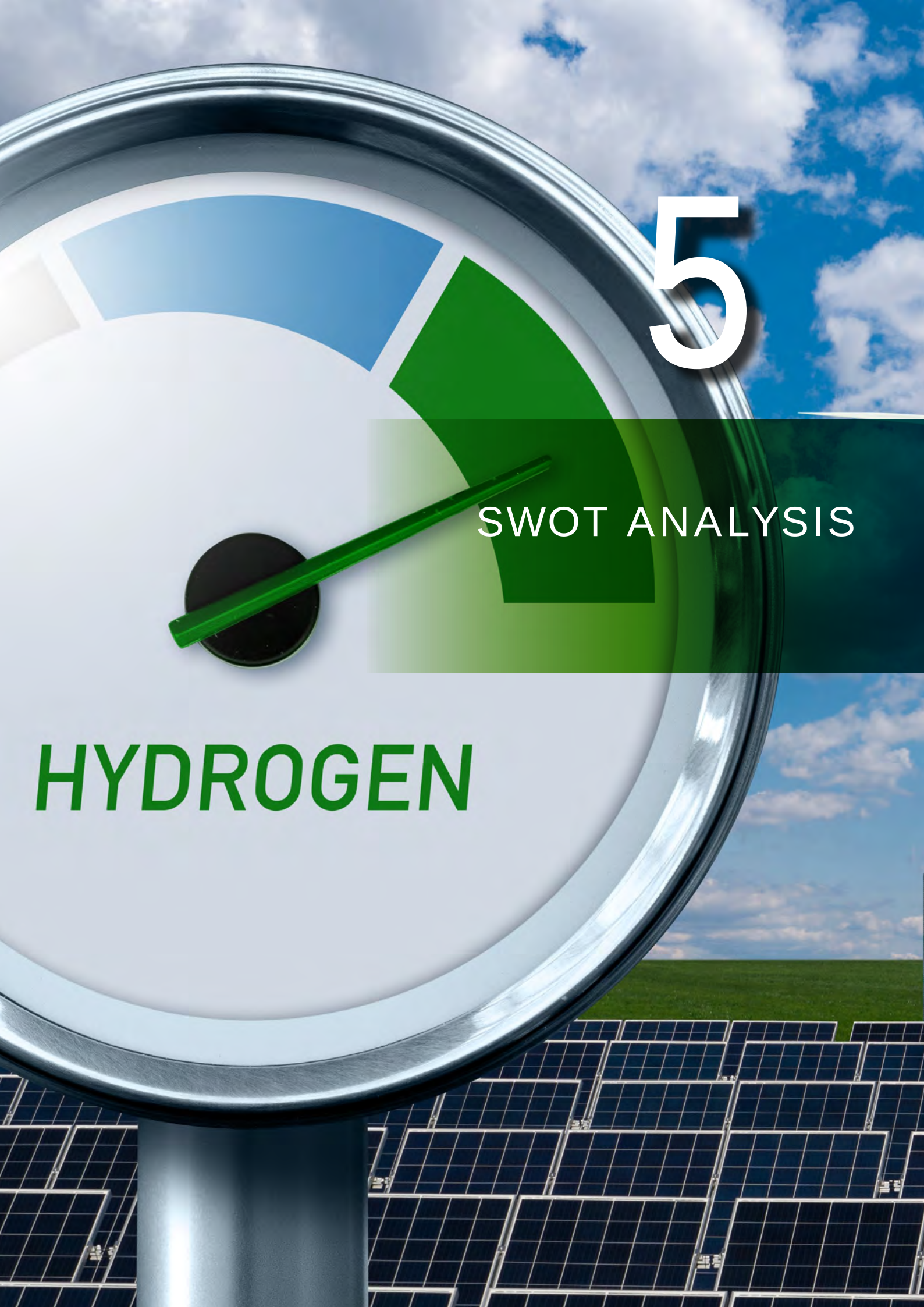
GDC Geothermal Development Company Green Energy for Kenya	The Geothermal Development Company (GDC) is a government-owned company operating under the MoEP and mandated to develop geothermal resources in Kenya by undertaking surface exploration of geothermal fields, exploration, appraisal and production drilling and management of proven steam fields. These fields 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 (KE TRACO), operates 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 power from the generation plants to designated load centres at 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 utilisation of green hydrogen as a renewable energy source.
KNTC Kenya National Trading Corporation Ltd.	The Kenya National Trading Corporation (KNTC), operating under the Ministry of Industrialization, Trade, and Industry, 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.
KALRO Kenya Agricultural & Livestock Research Organization	The Kenya Agricultural and Livestock Research Organisation (KALRO), operating under the Ministry of Industrialization, Trade, and Industry, 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 fertiliser.
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 fertilisers 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 fertilisers produced from green hydrogen, while supporting sustainable agricultural practices in Kenya.
AFA Our Crops, Our Wealth	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 fertiliser in Kenya.
KCAA efficiently managing air safety	The Kenya Civil Aviation Authority (KCAA), operating under the Ministry of Roads and Transport, 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 KENYA PRIVATE SECTOR ALLIANCE	The Kenya Private Sector Alliance (KEPSA) is the umbrella organisation representing the private sector in Kenya. Within KEPSA the Green Hydrogen Sub Sector Working Group focuses on the development and promotion of the green hydrogen sector. KEPSA, along with affiliated organisations such as the Kenya Renewable Energy Association (KEREA), the Kenya Association of Manufacturers (KAM), the Electricity Sector Association of Kenya (ESAK), 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 KENYA ASSOCIATION OF MANUFACTURERS 60+ Years OF ADDING VALUE	Established in 1959, the Kenya Association of Manufacturers (KAM) represents manufacturing and value-add industries in Kenya. The Association is a dynamic, vibrant, and credible organisation 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 organisation composed of stakeholders in the electricity sector ranging from Independent Power Producers (IPPs) project developers, consultants, contractors, legal practitioners, finance organisations working across different sub sectors of the electricity space in Kenya.
KTDA KENYA TEA DEVELOPMENT AGENCY (MS) LIMITED	The Kenya Tea Development Agency (KTDA) is an organisation 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 KENYA	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 A Toyota Tsusho Group Company	Toyota Tsusho Corporation CFAO Kenya Ltd is a leading trading and investment firm in Africa, which has had a 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 IPS westgass	MET Development S.p.A. is the project development company of Maire Tecnimont Group which is developing a green fertiliser project in Kenya through a consortium with IPS and Westgass Hydrogen. Industrial Promotion Services (IPS) is 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 is a 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 is an Italian company, active in the licensing, engineering, and construction of processing plants (having realised more than 200 fertiliser plants, globally), and co-developer and technical partner.
FORTESCUE FUTURE INDUSTRIES	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 requires comprehensive understanding of the dynamics operating in the country, the opportunities present, as well as the challenges likely to be encountered at different levels. This understanding will enable Kenya to enter and operate successfully in a hydrogen economy. To this end, a SWOT analysis has been conducted with the participation of stakeholders to inform the development of the Green Hydrogen Strategy and Roadmap for Kenya. The SWOT process benefited from the active participation of the Technical Working Group, who offered insights on 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 unique strengths that can enable the development of the green hydrogen sector and position it as a sector leader among African countries. These strengths encompass its renewable energy potential and green economy profile, supported by well-oriented policies and an enabling environment.

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 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 recognised 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 an asset 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 freshwater**

   Kenya's inland freshwater resources and access to seawater along the country's long coastline, provide a distinct advantage for production of green hydrogen.

5.2. WEAKNESSES

There are areas of weakness that the country must consider and address as it engages with the opportunities presented by the hydrogen economy.

1. **Limited awareness and technical know-how of green hydrogen**

   There is limited awareness and technical know-how on green hydrogen, because 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 the new field of green hydrogen in Kenya is still fragmented with unclear administrative processes and procedures (for project developers). It will be important to establish a centralised platform for decision-making and coordination.

3. **Limited access to subsidised 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 asking domestic fertiliser buyers to pay a premium for higher-cost green products presents challenges.

5. **No existing industrial use of hydrogen**

   Kenya lacks an existing chemical or petrochemical industry, limiting the obvious and immediate demand and utilisation of green hydrogen in the country.

6. **No existing hydrogen-specific policy and regulation**

   There is no specific policy and regulatory framework for hydrogen in place, resulting in uncertainties and challenges to businesses aiming to become active in the green hydrogen sector.

7. **High country risk premium**

   Kenya's 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 that promise positive impact across several sectors of the country's economy and society.

1. **Improved balance of payments**

   Domestic manufacturing of green hydrogen products will allow the government to reduce expenditure on 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 fertiliser from green hydrogen can potentially reduce under-fertilisation of land, increase availability and improve affordability of fertiliser, and thereby increase overall crop yields and improve food security.

4. **Creation of domestic fertiliser market and elimination of import subsidies**

   In Kenya, a largely untapped fertiliser market coincides with the national goal of reducing imports and promoting local production. Embracing green hydrogen-based fertiliser as a substitute for imported nitrogen fertiliser can support the growth of Kenya's domestic fertiliser market while saving costs on fertiliser imports, reducing the need for government subsidies and enhancing 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 decarbonisation efforts, contribute to the achievement of its sustainable development goals and drive green industrialisation in the country.

6. **Catalyst for sustainable domestic downstream industries**

   Green hydrogen could catalyse domestic downstream industries and value chains around fertiliser production or green shipping fuels, spurring sustainable 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 fertiliser, ammonia, or methanol.

8. **Domestic upstream supply chains**

   Kenya's exceptional renewable energy resources not only enable the development of new business opportunities in the production of green hydrogen and associated products and may also facilitate the establishment of upstream supply chains within the country, adding significant local content in the green hydrogen industry.

9. **A supportive external environment**

   With green hydrogen emerging as a crucial strategic priority for various DFIs and the EU, Kenya has a valuable opportunity to capitalise on existing strategic energy partnerships. This would make available funding and technical assistance, and offer benefits from private sector preparedness and philanthropists' willingness to invest in green hydrogen.

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

    Investment in green hydrogen infrastructure, renewable energy projects, and associated industries can stimulate economic activity, attract domestic and foreign investment, 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 fertiliser 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 and optimise the further development of geothermal, wind or solar projects 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 paves the way for exploring and developing strategies that take cognisance of potential pitfalls.

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 finance 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 fertiliser is not cost-competitive when measured against conventional fertiliser, it will fail to address the financial limitations of smallholder farmers and fall short in delivering the desired benefits for Kenyan farmers, the agricultural sector and the economy.

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

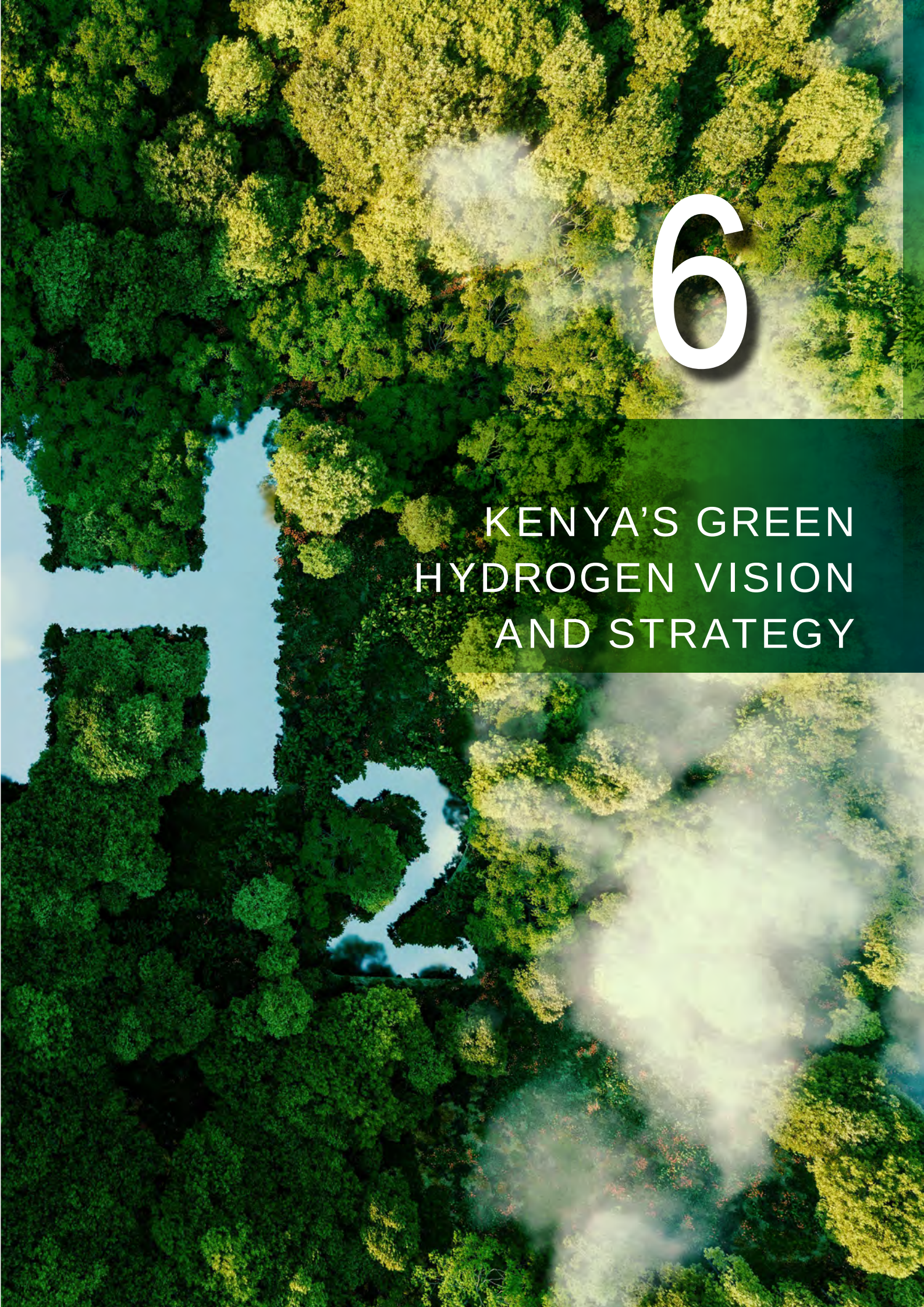
   The diversion of finance and investments to the US under the Inflation Reduction Act (IRA) (and to some extent to the EU), coupled with limited DFI finance for large-scale projects, may reduce the availability of funding for green hydrogen projects in Kenya.

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, may pose challenges for the successful implementation of projects.

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

   Several African countries stand ahead of Kenya in the green hydrogen race. Kenya may miss out on early-mover advantages and investment opportunities, impacting market position and potential economic benefits, with the additional risk of private sector developers withdrawing. However, by adopting a fast follower approach, Kenya can leverage the lessons learnt 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

This Green Hydrogen Strategy and Roadmap for Kenya is informed by extensive stakeholder consultation and highlights the country's vision for developing the sector and utilising green hydrogen as a cross-cutting enabler and as a catalyst for sustainable socio-economic development *(Figure 32)*. The vision statement "green hydrogen for sustainable socio-economic development" is informed by Kenya's pursuit for development that balances the social, economic, and environmental dimensions of development to meet present-day needs without compromising the ability of future generations to do the same. By embracing green hydrogen, Kenya strives to catalyse profound economic growth and bolster societal well-being. This commitment exemplifies Kenya's steadfast dedication to decarbonisation and the pursuit of a low-carbon, climate-resilient development path in accordance with the Paris Agreement,[106] and positions Kenya as a pivotal player in the attainment of the sustainable development goals (SDGs).[107]

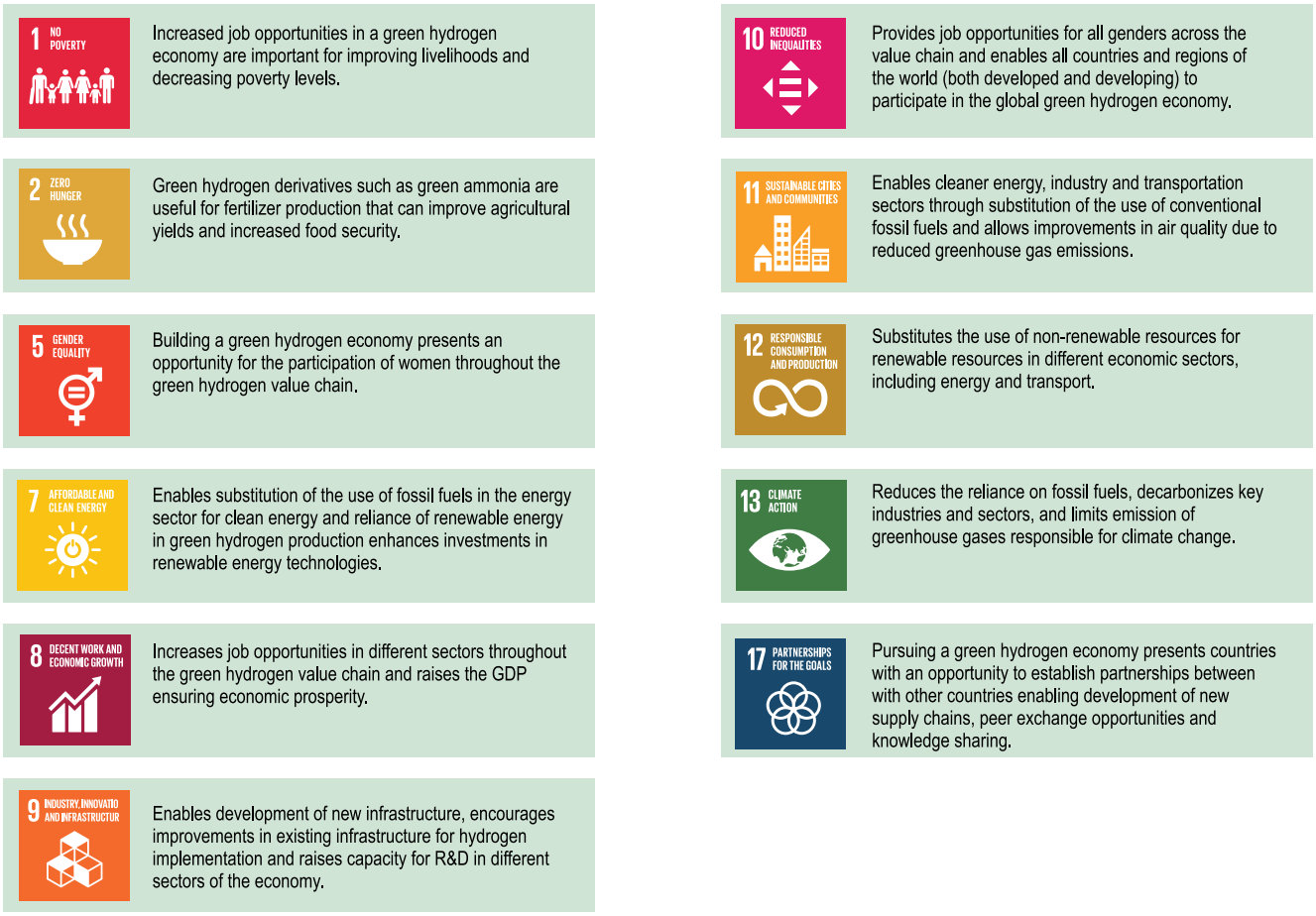


Figure 31: Green hydrogen and the sustainable development goals

106 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. https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/FCCC_CP_2015_10_Add.1.pdf

107 *UN General Assembly Resolution 70/1 (2015) - Transforming our world: the 2030 Agenda for Sustainable Development*. (2020, April 30). European Union Agency for Fundamental Rights. http://fra.europa.eu/en/law-reference/un-general-assembly-resolution-701-2015-transforming-our-world-2030-agenda

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 to transform Kenya into a newly industrialising, middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment. 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 various sectors including industry 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.[108] 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.

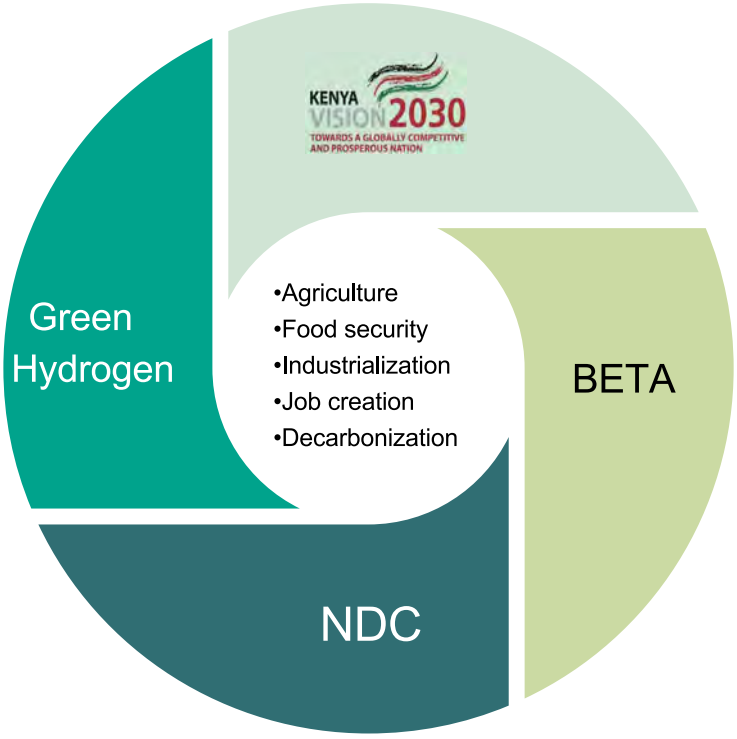


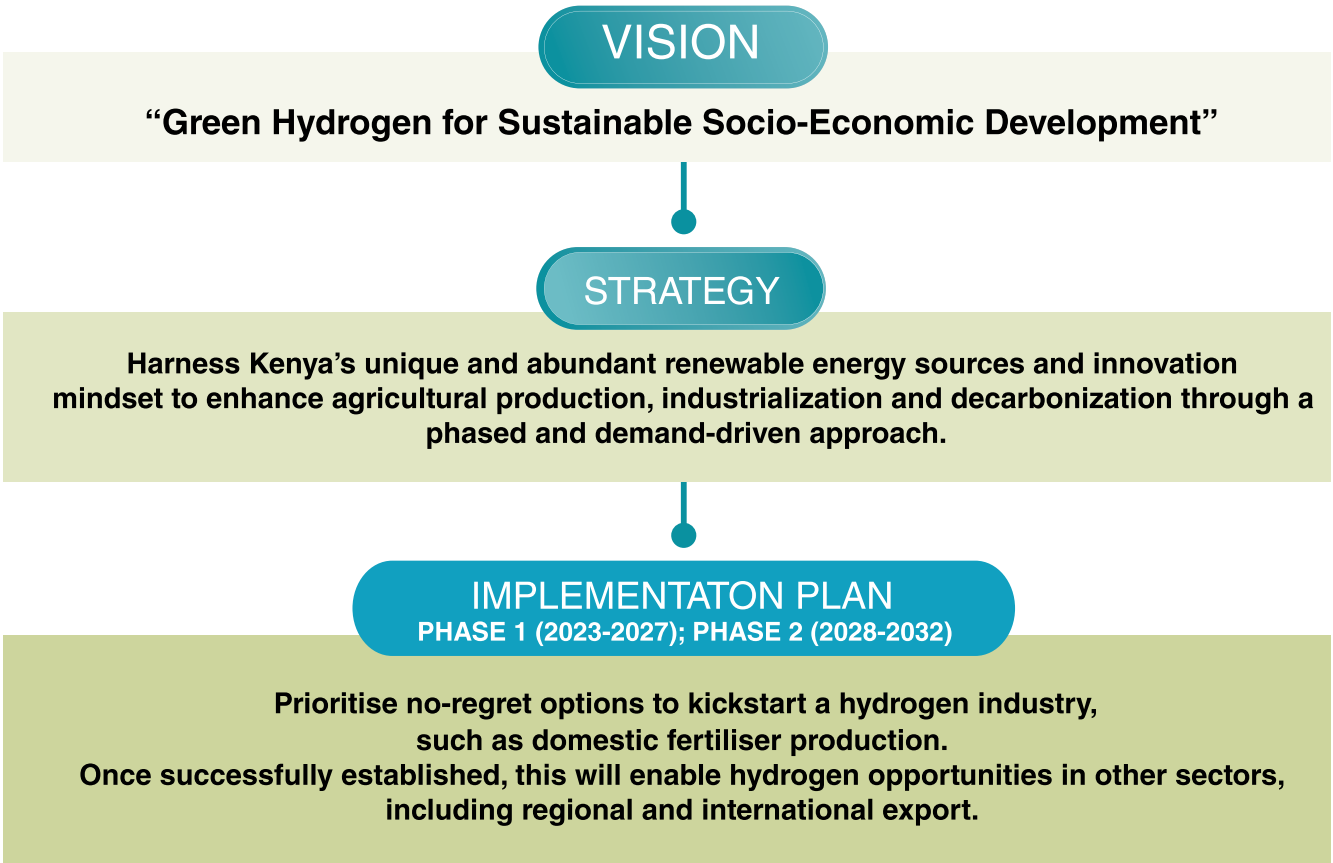
Figure 32: Green hydrogen – a cross-cutting enabler for Kenya's development agenda

108 *Bottom-Up Economic Transformation Agenda (BETA)*. State Department for Economic Planning. http://new.planning.go.ke/bottom-up-economic-transformation-agenda-beta/

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, industrialisation and decarbonisation 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.[109] Kenya's green hydrogen strategy adopts a broad perspective aimed at stimulating demand for diverse uses for green hydrogen. These include green hydrogen to enhance agricultural production, for industrialisation and decarbonisation.

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 and Roadmap 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



109 Kenya is ranked as one of the top three innovation economies in Sub-Saharan Africa. *Global Innovation Index 2022 - GII 2022 results* . WIPO. https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000-2022-section3-en-gii-2022-results-global-innovation-index-2022-15th-edition.pdf

Considering the nascent status of the sector and the rapidly evolving profile of the industry, the vision and strategy are to be operationalised through a phased implementation process set out over a ten-year period that is divided into 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 government's development 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 IV, will focus on creating domestic demand and prioritise 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 to include amongst others, the pursuit of green hydrogen to produce domestic green (nitrogen) fertiliser, hinged on a prioritised national development goal of developing agriculture, enhancing food security, and eradicating hunger.[110]

Depending upon the evolution of costs and market demand, the **second phase** (2028-2032) will build on these foundational activities and utilise 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.

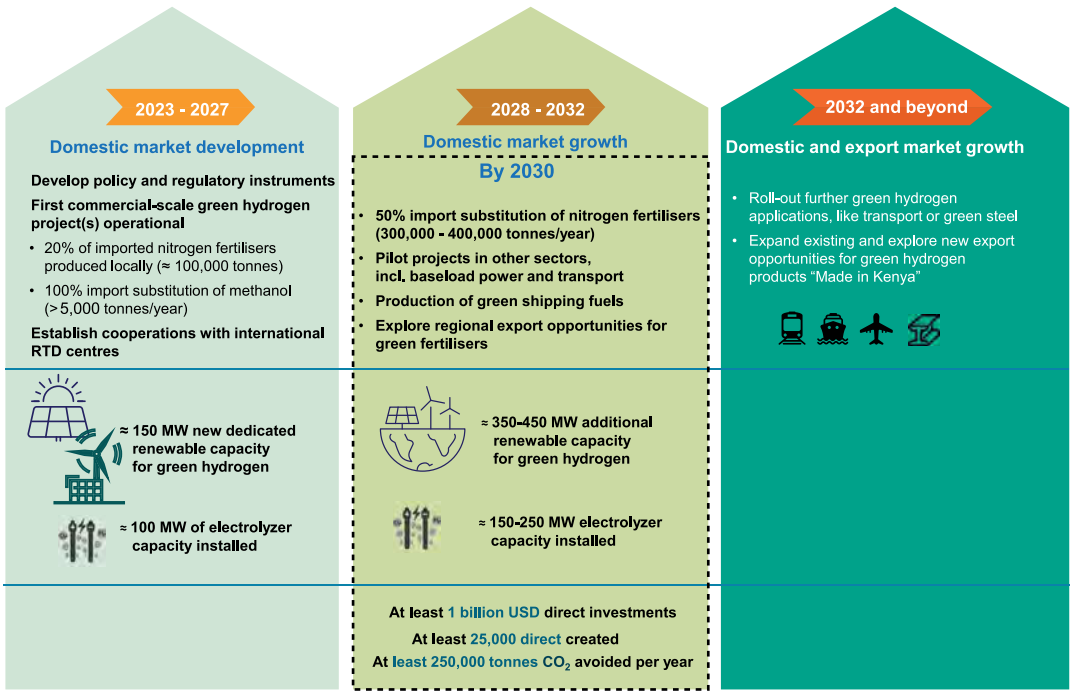


Figure 33: Kenya's Green Hydrogen Vision and Targets

110 Government of Kenya. (2007). Kenya Vision 2030: A Globally Competitive and Prosperous Kenya https://vision2030.go.ke/ Government of Kenya. (2022). Kenya's Bottom-Up Economic Transformation Plan, 2022-2027 http://new.planning.go.ke/bottom-up-economic-transformation-agenda-beta/

6.2. LOGICAL FRAMEWORK AND BUILDING BLOCKS

To establish a strong 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 on the previously outlined green hydrogen vision and strategy, ensuring clear definition of objectives, outcomes, outputs, as well as enablers *(Figure 34)*.

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 for Kenya.

6.2.1. Objectives

Objectives are the high-level goals that support the strategy 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. In the short run, the country will be better placed to absorb internationally induced shocks, such as the recently experienced natural gas price hikes which drove up the cost of fertilisers, and consequently save on payment of subsidies on imported fertilisers. In the longer term, the country will be in a position to benefit from exports of hydrogen derivatives to regional and international markets.
- **Food security and resilience:** Green hydrogen can contribute to improving food security and resilience through local production and accessibility of nitrogen fertilisers, which are crucial for the further improvement of agricultural productivity.
- **Green industrialisation and decarbonisation:** The roadmap seeks to promote the growth of green industries and decarbonise 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 fertilisers:** The roadmap envisions the widespread adoption of green hydrogen-based fertilisers, ensuring their availability, affordability, and contribution to increased agricultural productivity and a reduction in fertiliser 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 the growth of the renewable energy sector; green hydrogen has the potential to stimulate accelerated development of power generation and transmission infrastructure, from which the country at large can benefit, supporting - in parallel - the further improvement of electricity services offered to all Kenyans.
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 opportunities for industrial applications throughout the value chain, such as the manufacturing of electrolysers, thereby fostering economic diversification, job creation and industrial growth. The active participation of academia in this process of green hydrogen led industrialisation can propel Kenya to 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 is well 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 desired outcomes. Eight key outputs are expected from implementation of the strategy:

1. **Collaborative governance framework:** Establishing a collaborative and inclusive governance framework involving stakeholders from all relevant government agencies, development partners, industry, the 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 one-stop-shop as a centralised coordination and governance mechanism for the green hydrogen sector. 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:** Comprehensive strategies and support business cases can be used to stimulate domestic market demand for green hydrogen, encourage private sector developers and investors, and to drive market growth.

3. **Access to finance (and enhancement of project bankability):** A financial framework that facilitates access to finance and capital markets, investment incentives, and risk mitigation mechanisms to enhance project bankability and financial viability, will be established as a condition precedent to attract public and private investments in green hydrogen projects and related industries.
4. **Favourable policy integration:** Green hydrogen will be integrated 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 will enhance access to financial markets by removing barriers, establishing regulatory clarity and promoting investor protection, while providing market confidence and predictability for private sector project developers.
5. **Stable legal and regulatory framework (including fiscal incentives):** A stable and fit-for-purpose legal and regulatory framework that includes fiscal incentives to attract investments in the green hydrogen sector will become established. Regulation will also ensure 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:** High-impact/flagship projects identified and implemented to 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:** A skilled workforce and local capacity will be fostered in the green hydrogen sector by leveraging Kenya's innovation culture and investing in skills development programs, vocational training as well as research and development initiatives.
8. **National and international partnerships:** Strategic partnerships and collaborations at the national and international levels will be established with governments, institutions, and industry players to promote knowledge sharing and leverage expertise, resources, and market opportunities.

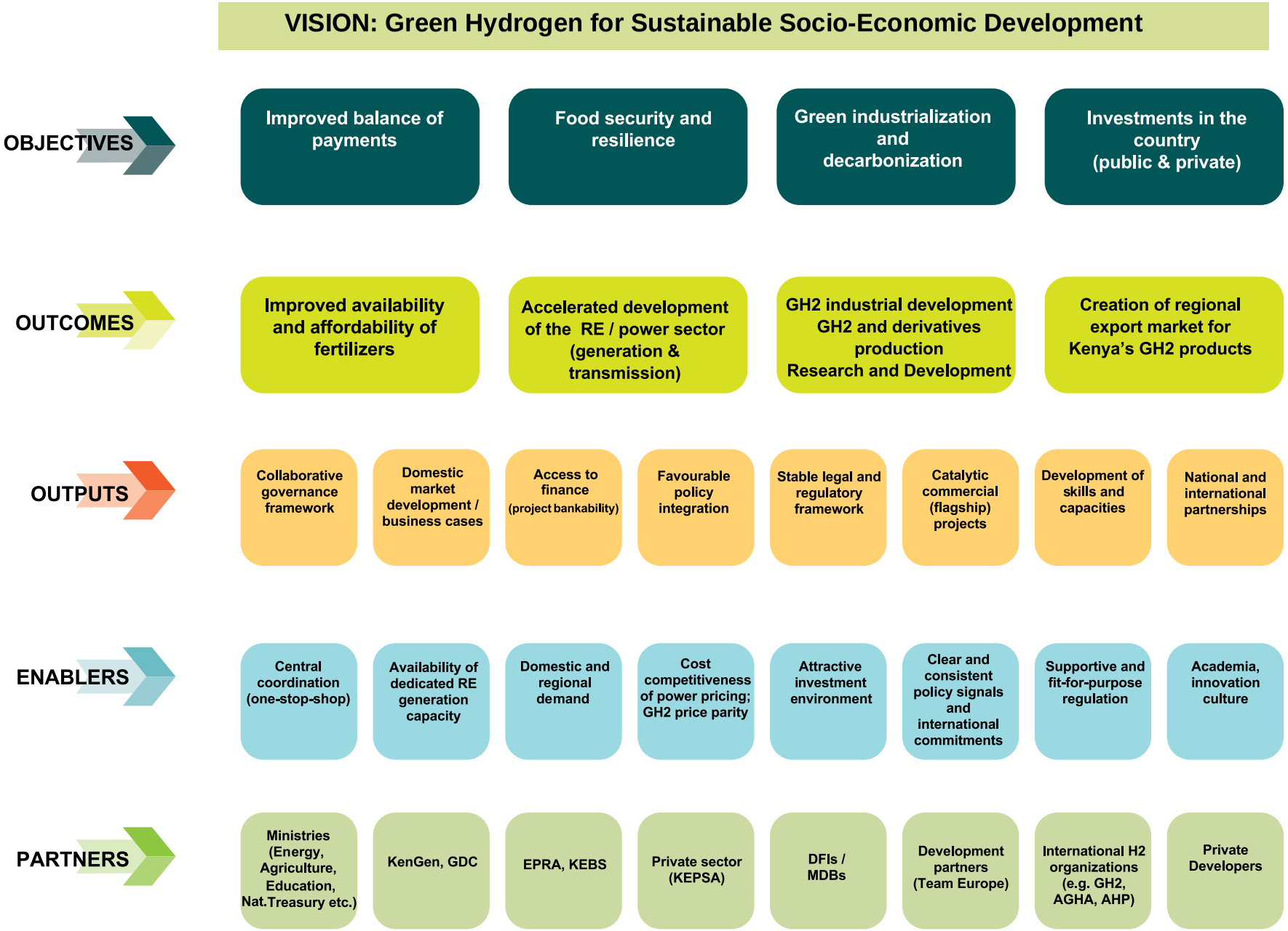


Figure 34: Logical framework for the Green Hydrogen Strategy and Roadmap for Kenya

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 Strategy and Roadmap for Kenya and will support the achievement of the green hydrogen vision.

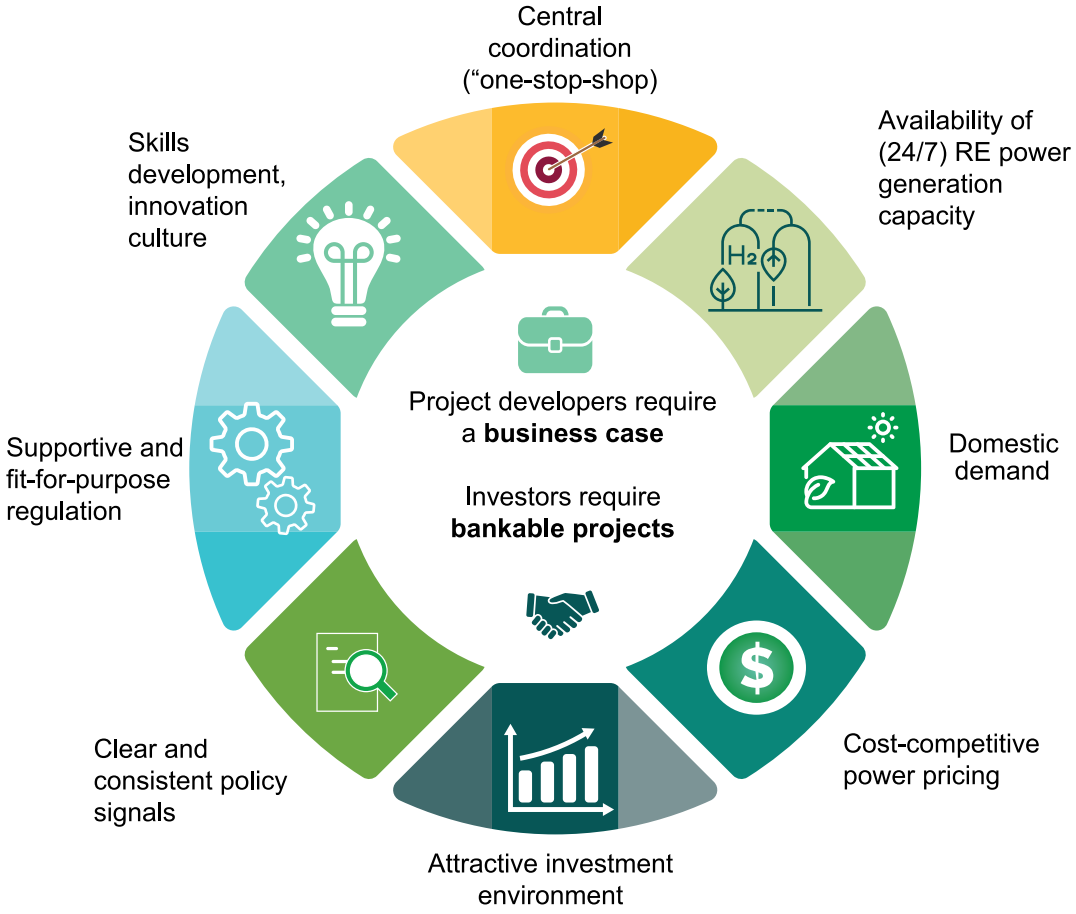


Figure 35: Enablers for a successful green hydrogen industry in Kenya

Central coordination ("one-stop-shop")

Effective coordination among public and private stakeholders, spanning multiple national government departments as well as county governments, 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 centralised 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.

The “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 will create a level playing field for all project developers and ensure 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 so that implementation of renewable energy capacity grows in tandem with transmission infrastructure.

This approach will 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, and ensure that all elements and requirements of the development process are effected in a timely way; the coordinated approach will also have the mandate to fast track strategic projects through approvals, thus shortening development timelines reducing project risks and costs. As the first point of contact for project developers, such an entity will also play a crucial role in promoting collaboration and alignment among private sector players.

A key lesson learnt from the solar sector is that the approval and development of projects must 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, power generation capacity should be available continuously or with a high-capacity factor as is the case with geothermal energy, to ensure optimal asset utilisation of the electrolysers and lowest 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 if it is to meet local demand for hydrogen. In this context, the right policies and a conducive regulatory framework stimulate rapid development of the sector. The establishment of clear targets for 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 utilising green hydrogen but also instil confidence among investors and project developers in the domestic market.

To effectively promote the use of green hydrogen, raising awareness about the numerous applications and benefits of green hydrogen is a crucial first step and must reach industry, consumers and all relevant public institutions. This is especially vital considering that Kenya's hydrogen strategy places emphasis on the role of the agricultural sector in the entire fertiliser value chain. By generating awareness, stakeholders will better understand the potential advantages of green hydrogen. Comprehensive understanding of market demands, including supply volumes and corresponding product specifications is also imperative. This knowledge becomes particularly relevant in the context of producing nitrogen fertiliser from green hydrogen as it allows for the optimisation of crop impact.

Consequently, both government and industry must collaborate to create the early demand that will enable suppliers of hydrogen derivatives (like green fertiliser or e-methanol) to achieve project bankability. Creation of market demand will also be 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, with major impact on hydrogen production costs. Irrespective of the renewable power source, a long-term stable and secure supply of green electricity sourced at competitive and predictable 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 will result in cost reduction of green hydrogen production and bring it closer to price parity with fossil hydrogen enhancing its market competitiveness, encouraging widespread adoption and driving further investment in green hydrogen infrastructure. As with other enablers, policies have an important role to play in driving and incentivising lower costs of renewable power, as does the regulatory framework governing the development and implementation of renewable energy projects. At the same time, establishing pricing policies that are transparent, fair, and inclusive is a condition for social acceptance of green hydrogen.

Attractive investment environment

Green hydrogen projects require significant capital investments, and an attractive investment environment to pull in 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 incentivise capital flow into the green hydrogen sector.

Access to 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. Collaboration with DFIs and international organisations to create tailored financial instruments that attract investment and reduce the cost of capital for green hydrogen projects is an opportunity Kenya should grasp. This enabler also recognises the need to explore innovative financial instruments, mechanisms, and off-take agreements to make projects bankable.

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

Clear and consistent policy signals

Strong policy signals on Kenya's green hydrogen commitment are important enablers for attracting investors and financiers. Firstly, clear and robust policies provide a stable investment environment, reduce risk and uncertainty for potential investors and enhance general market confidence. Secondly, demonstration of a strong commitment to green hydrogen signals that Kenya is actively pursuing sustainable and low-carbon energy solutions, which can attract investors focused on environmental, social, and governance (ESG) considerations. By demonstrating a clear commitment to green hydrogen, Kenya positions 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 example through inclusion of green hydrogen in its NDCs.

Strong policies also play a crucial role in shaping the domestic landscape for green hydrogen and providing a supportive environment in which the green hydrogen industry can thrive. Policies provide clarity and consistency to 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 utilisation 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 that position Kenya as a credible player in the green hydrogen market. Carryover 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 challenges and opportunities associated with the entire green hydrogen value chain, from power generation to hydrogen production, storage, and transportation, to the manufacturing and use of green hydrogen derivatives, such as ammonia or methanol. Importantly, the regulatory framework should be designed with the objective of promoting market efficiency, enhancing competition and ensuring a level playing field for all public and private project developers.

Regulations specifying technical requirements, environmental standards, and safety considerations for the hydrogen sector should, for instance, include safety standards for technologies such as electrolysers used in the country to ensure they meet international norms and standards. They should also address the risks associated with the use, transport, and storage of hydrogen and follow international guidelines and operational procedures. The technical regulatory framework should also extend to 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 should involve establishing clear guidelines, reducing bureaucratic barriers, and providing a predictable and efficient pathway for project developers to navigate regulatory requirements. More specifically, regulation should account for the different types of supply location archetypes (as described in Section 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 - such as 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 characterised by a dynamic and entrepreneurial spirit, with initiatives such as M-Pesa revolutionising mobile payments and financial services in the country. In addition, Kenya has several universities where many young Kenyans are pursuing higher education. Kenya also 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 in research and development initiatives, focused on hydrogen technologies, renewable energy, and related disciplines; or, the establishment of a green hydrogen centre of excellence (CoE), a one-stop-shop for green hydrogen innovation, as proposed by Endeva ii2030.[111] As has been learnt from 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. Platforms such as the AGHA can facilitate information exchange and collaboration among African countries pursuing green hydrogen initiatives, support the expansion of market opportunities and the collective search for solutions to common challenges.

Skills development also 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 the first capacity needs assessment developed in 2021.[112]

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 theroadmap. By engaging 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.

111 Engels, S.Tewes-Gradl, C. (2023, July 11). *The Green Hydrogen Center of Excellence (CoE): A multi-functional innovation hub to support Kenya's Green Hydrogen Ecosystem.* https://endeva.org/blog/the-green-hydrogen-center-of-excellence-coe-a-multi-functional-innovation-hub-to-support-kenyas-green-hydrogen-ecosystem

112 Ministry of Energy, Kenya. (2021). Draft Report, Rapid Capacity Needs Assessment for Green Hydrogen Technology Development in Kenya

6.4. MACROECONOMIC IMPACTS OF GREEN HYDROGEN

Kenya has been a frontrunner in developing renewable energies for many years and has acquired a leading position globally. The abundance of renewable energy sources (geothermal, wind, solar or hydro) gives the country the possibility of planning its energy future and entering the hydrogen and derivatives economy by building on this potential and the competencies it has developed. Beyond building a decarbonised economy the country has the objective of developing a more resilient economy.

Kenya can reap multiple benefits from entering the hydrogen economy to become a significant player in Africa.

Recent unease experienced in global energy markets has resulted in unprecedented increase in the prices of derivatives, like ammonia and fertilisers which has in turn had a marked impact on economies. The price of fertilisers more than doubled in the period 2021-2022, forcing governments to introduce heavy subsidies to protect their agricultural product and support farmers and their agricultural capital. It is estimated that the subsidy announced by the government of Kenya in 2022 would eventually amount to an outlay of Ksh 45.5 billion (close to USD 300 million) to cover the full demand for fertilisers.[113]

This is not the first time that international fertiliser prices have hit record highs. The same situation was experienced between 2008 and 2010 *(Figure 36)* when natural gas prices reached levels above 10 USD/million Btu *(Figure 37)*. Such market disturbances are not easy to forecast and may well appear in the future.

Kenya now has a prime opportunity to take effective mitigation measures against international market price volatilities by developing its hydrogen sector and setting up domestic hydrogen supply chains. This will also have positive impacts on the country's budget as well as positive repercussions for agricultural production and food security. Although fertiliser imports are a small fraction of the country's imports (approx. 1.8%).[114] building on local production capacities will potentially improve and ease balance of payments and release financial resources to address other national priorities.

113 Okadia. , F., (2022, September 23). The Pros and Cons of the Ksh 3500 Fertilizer Subsidy. Institute for Economic Affairs, Institute for Economic Affairs, Kenya. https://ieakenya.or.ke/blog/the-pros-and-cons-of-the-ksh-3500-fertilizer-subsidy/

114 *Kenya Imports by Category 2021*. Trading Economics. https://tradingeconomics.com/kenya/imports-by-category

Figure 36: Monthly index prices for key nitrogen, phosphatic and potassic fertilisers. [115]

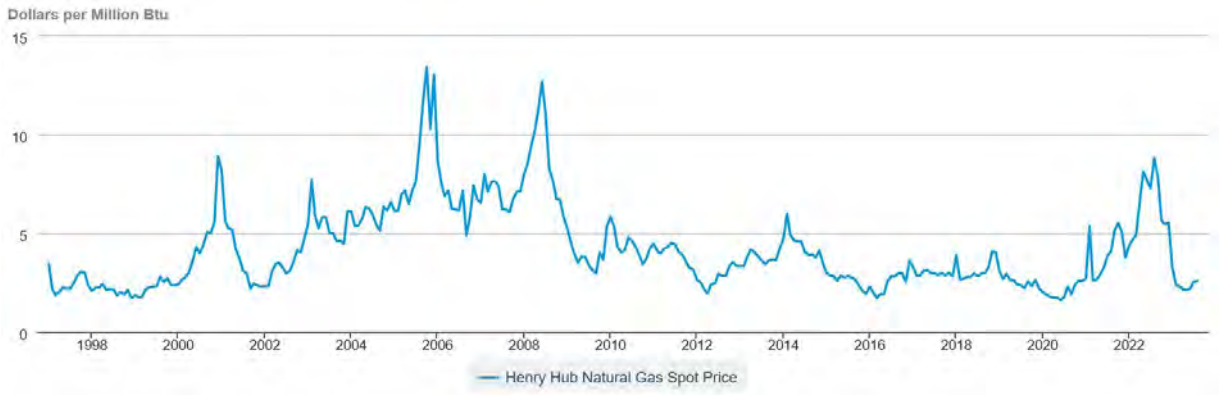


Figure 37: Henry Hub natural gas spot price (Dollars per Million Btu)[116]

The development of the hydrogen sector will require investments along the value chain, including investments in renewable energy, production of ammonia, fertilisers, methanol, or sustainable aviation fuels (SAF) to mention a few.

All these translate into new opportunities to create jobs in support of the sector. By 2030 more than 25,000 new permanent jobs for skilled women and men will be created as targets of this Green Hydrogen Strategy and Roadmap for Kenya are met with investments in green ammonia, methanol and renewable projects reaching or surpassing the USD 1 billion level, expanding the growth of green electricity and the young hydrogen industry. Opportunities opening for academia to support

115 *Impacts and Repercussions of Price Increases on the Global Fertilizer Market.* (2022, June 30). USDA Foreign Agricultural Service. https://www.fas.usda.gov/data/impacts-and-repercussions-price-increases-global-fertilizer-market

116 Henry Hub Natural Gas Spot Price (Dollars per Million Btu). https://www.eia.gov/dnav/ng/hist/rngwhhdM.htm

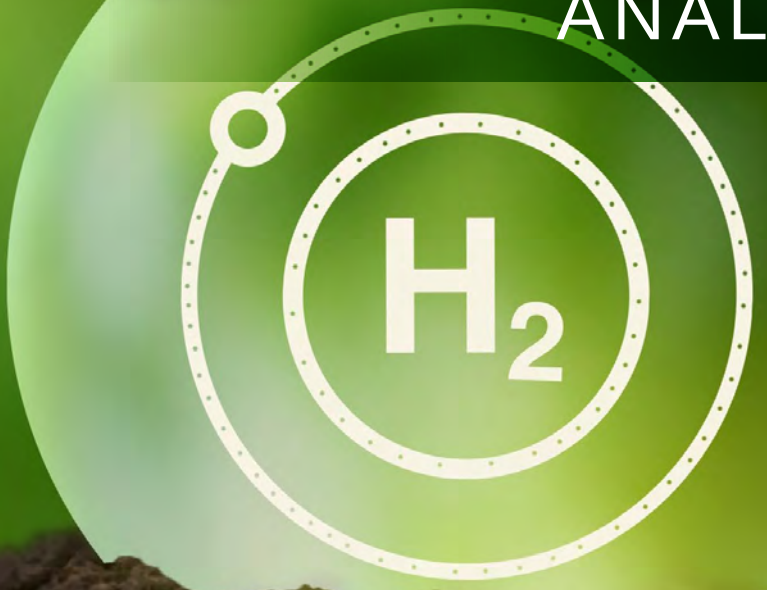
the sector's development are substantial. Academia will play a leading role in the development and improvement of skills and improved capacities, while contributing to Kenya's growth as a research and development hub in the region.

The capacity development will be supported by exchanges with European and international institutions and collaboration to promote the research and technological development underpinning the industry. The European Union, including individual member states, already have in place programmes, initiatives, and instruments to support the development of a hydrogen economy that Kenya can benefit from.

Building on the sector, and as a regional commercial hub, Kenya can carve a niche as an exporter of hydrogen derivatives to neighbouring countries. Moreover, the exports of green agricultural products, such as coffee, to international markets are expected to achieve better acceptance and provide added value yielding higher income to farmers in markets that value the "green label".

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. Going into the green hydrogen economy, Kenya can build and go through the full market development trajectory, from market creation, building on its potential and opportunities, through market growth, to a fully developed mature market.

While several potential policy and regulatory measures can promote hydrogen development, it is necessary to determine, and develop or strengthen, those 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 38* below:

Figure 38: 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 fertiliser for domestic consumption. This has the potential to significantly decrease Kenya's dependence on imported fertiliser. 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 use 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 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 or pillars,[117] that are crucial for designing effective green hydrogen policies.[118] 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 recognises the unique needs and circumstances of the Kenyan people, emphasises the importance of nurturing and developing skills, supported by provisions for local content.

117 *Policy Toolbox for Low Carbon and Renewable Hydrogen: Enabling low carbon and renewable hydrogen globally.* (2021, November). Hydrogen Council. https://hydrogencouncil.com/wp-content/uploads/2021/11/Hydrogen-Council_Policy-Toolbox.pdf

118 For further discussion about green hydrogen policy making see IRENA, *Green Hydrogen: A Guide To Policy Making, 2020*; and , specifically , for supply-side measures see IRENA, *Green Hydrogen Supply: A guide to policy making, 2021*

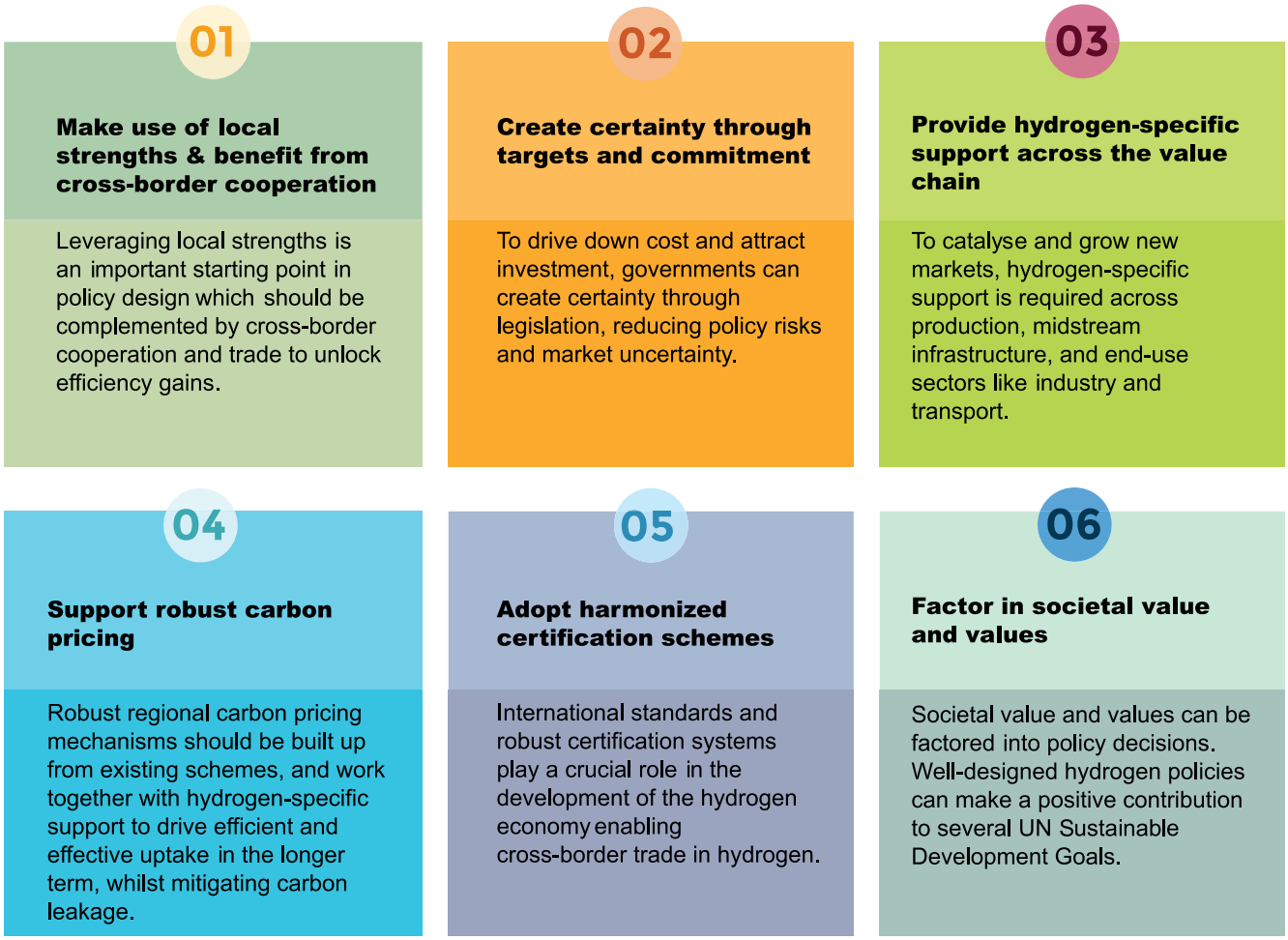


Figure 39: Six pillars of efficient policy design for low carbon and renewable hydrogen (Source: Hydrogen Council and McKinsey, Policy Toolbox for Low Carbon and Renewable Hydrogen - Enabling low carbon and renewable hydrogen globally, November 2021)

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, standardisation, and collaboration, are overarching and impact the entire value chain, regardless of market maturity. 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 synchronised to effectively tackle interdependencies along both dimensions.

The development of Kenya's green hydrogen sector has to build on lessons learnt and insights from the success of the country's renewable energy sector, including reflecting on learnings from sources such as the report of the presidential task force that reviewed PPA's which provides relevant recommendations with a bearing on, among others, green hydrogen off-take agreements.[119] Salient

119 Government of Kenya. (2021, September 29). *Report of the Presidential Task Force on the Review of Power Purchase Agreements (PPAS)*. (2021, September 29). Kenya Power & Lighting Company. https://kplc.co.ke/img/full/28102021_210-The-Report-of-the-Presidential-Taskforce-on-PPAs.pdf

recommendations include that off-take 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 off-take pricing; and clear guidelines and standards for green hydrogen off-take 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 categorised into supply-side and demand-side measures. Supply-side measures 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. Demand-side policies seek to stimulate the market for green hydrogen products, for example nitrogen fertiliser 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 on which Kenya can enhance the promotion of renewable energy to produce green hydrogen. The policy facilitates open access to the transmission and distribution networks, supports public private partnerships in the development, operation and maintenance of energy infrastructure and delivery systems and provides 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 a 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 draft Renewable Energy Auctions Policy for example will 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 sectors to ensure the sustainable use of energy by implementing different energy conservation measures. For example, the agriculture and industry sectors are 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 fertiliser but does 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 initiatives 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 growth that the government can support by developing an enabling environment to foster investment in this sub-sector.
- **Land Use Policy, 2017:** The policy recognises 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 and demand for green hydrogen and its derivatives.

There are also pending policies that will be important for stimulating demand for green hydrogen if adopted. 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 to 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 fertiliser use and soil management practices. The draft therefore creates an opportunity for enhancing the use of green ammonia in fertiliser production.

Vision 2030 through its pillars and their foundational cross cutting policies, implicitly supports the development of green hydrogen. For instance, the economic pillar recognises the need for increasing renewable energy generation, highlights the significance of sustainable industrialisation in driving Kenya's socio-economic progress and sets targets that encompass the establishment of local fertiliser 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 in development that have the potential to serve as a framework to support the development of the green hydrogen sector in Kenya. Building on these existing policies will potentially save time and resources compared to developing an entirely new dedicated policy framework. It will also 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 summarised in *Table 6.*

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 prioritised 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 a 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 agriculture is the driving force of Kenya's economy. In the short term, the agricultural sector can also play a pivotal role as off-takers of green hydrogen fertiliser. The symbiotic relationship between the prosperity of Kenya's agriculture sector and its overall economy underscores the significance of including green hydrogen in the 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. Relying on this policy, green hydrogen project development areas may be designated as green hydrogen hubs encouraging production and use. These areas could then 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 in 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 fertilisers. This will encourage demand for and production of fertiliser 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 a 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 bidding 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 operationalise 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 prioritisation should align with the phased implementation timelines outlined in the strategy 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 industrialisation to pave the way for new hydrogen use cases, such as 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.[120] A well-designed legal and regulatory framework can support the attainment of several SDGs related to green hydrogen,[121] 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. 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, and (C) consumption of green hydrogen (by stimulating demand for local use and export of green hydrogen and its derivatives).

120 Gilles, F. & Brzezicka, P. (2022, May 10). *Unlocking the hydrogen economy - stimulating investment across the hydrogen value chain.* European Investment Bank. https://doi.org/10.2867/847677

121 Ministry of Energy, Kenya & GIZ. (2022). *Baseline Study on The Potential For Power-To-X/ Green Hydrogen in Kenya*.

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 favourable conditions for the generation of renewable electricity.[122] The existing framework, however, needs to be further stimulated and adapted to facilitate increased electricity generation for green hydrogen production, through laws and regulations that incentivise generation including dedicated additional generation capacity. Key issues for consideration include:

- **Duration of geothermal exploration licences:** 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 licences but does not set a period of exclusivity of geothermal exploration licences. 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 the feasibility stage for wind and solar sites under the country's regulatory framework, leaving this to the contracting between the landowner and project developer. Bankability of projects may however be enhanced through a set period of exclusivity during the feasibility stage for renewable energy project;[123]
- **Streamlined licensing:** Streamlined licensing requirements and procedures are necessary. Licence under the Energy Act is one of many required from various agencies and the green hydrogen permitting, and approvals process is 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 where the establishment and operation of any 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 licence acquisition (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.[124]);

122 Energy Act, Act No.1 (2019) (Kenya).

123 Ministry of Energy, Kenya & GIZ. (2022). *Baseline Study on The Potential For Power-To-X/ Green Hydrogen in Kenya.*

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

- **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.[125] 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 (that is, frequency and voltage control), amongst others. An ancillary services compensation model is however necessary under Kenya's Energy Act and regulations thereunder, to enable monetisation 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 40)*[126]:

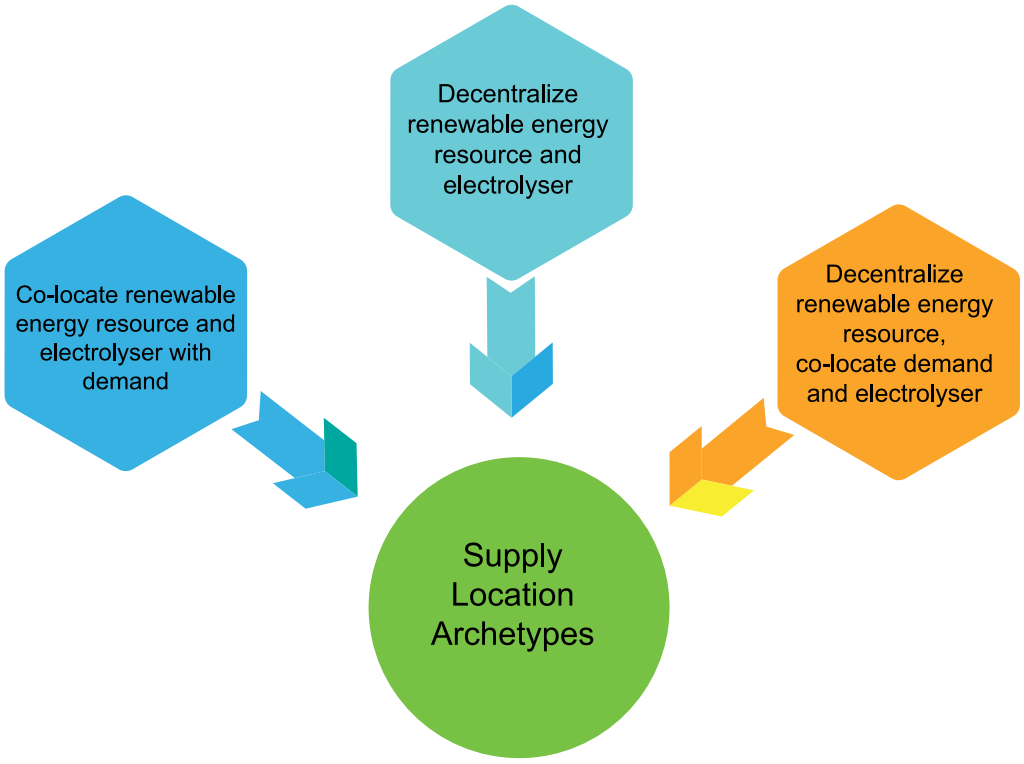


Figure 40: Green hydrogen supply location archetypes
(Source: Adapted from Republic of South Africa, Proposed South African Green Hydrogen (GH2) Commercialisation Strategy: Summary of the Green Hydrogen Commercialisation Panel Report, 30 November 2022)

125 Energy Act No. 1 (2019)(Kenya). Section 138 (1) (c).
126 Republic of South Africa: Proposed South African Green Hydrogen 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.[127] The existing regulatory framework for SEZs can also enable location of 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;[128]
2. **Decentralise 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.[129]" As such "hydrogen" (that is, its definition) should be introduced in the Energy Act to provide clarity on requirements for its evacuation.
3. **Decentralise 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

127 Part III of Kenya's 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 governments have the power to declare an area as a special planning area, where that area has been identified as suitable for intensive and specialised 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.

128 Special Economic Zones Act No. 16 (2015)(Kenya). Section 4. 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

129 Energy Act, Act No. 1 (2019) (Kenya), Section 2.

and reasonable transmission or wheeling charges as shall be prescribed in regulations.[130] However, the wheeling regulations envisioned by the Act are not yet enacted in Kenya, though a draft Bill is under development.[131] There is a need for the finalisation 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 water to feed the electrolysis process include the use of freshwater resources, flood water or desalination of seawater. In Kenya, the applicable regulatory framework comprises the Water Act, 2016,[132] which grants water rights, and includes a set of regulations covering water services, water resources harvesting and storage.[133] Permits are required for the use of water from a water resource,[134] with minimal exemptions to permitting provided.[135]

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 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[136]. 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.

130 Energy Act, Act No. 1 (2019)(Kenya). Section 136 (1) (c).
131 Draft Energy (Electricity Market, Bulk Supply and Open Access) Regulations, 2021
132 The Water Act No 43 (2016)(Kenya).
133 Water Service Regulations (2021); Water Resources Regulations (2021); and Water Harvesting and Storage Regulations (2021).
134 The Water Act No 43 (2016)(Kenya). Section 36.
135 The Water Act, Act No 43 (2016)(Kenya). Section 37.
136 Physical and Land Use Planning Act (2019)(Kenya); Environmental Management and Co-ordination Act, Act No.8 (1999)(Kenya).

B. Storage and Distribution

Green hydrogen projects require the availability of suitable infrastructure (pipelines, conversion plants for processing, distribution, and storage). Kenya 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.[137]

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.[138] 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;[139] 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,[140]
- **Kenya standards on transport of dangerous goods,**[141] identifying and classifying dangerous goods for road and rail transport as well as general standards on hydrogen fuel.[142]

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.[143]

137 Energy Act, Act No. 1 (2019)(Kenya). Section 2 and Section 170.

138 Eljack, F. & Kazi, M. K. (2020, December 18). *Prospects and Challenges of Green Hydrogen Economy via Multi-Sector Global Symbiosis in Qatar.* Frontiers. https://doi.org/10.3389/frsus.2020.612762

139 Environmental Management and Coordination Act, Act No 8 (1999)(Kenya).

140 Occupational Safety and Health Act, Act No 15 (2007)(Kenya).

141 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.

142 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.

143 Ministry of Energy, Kenya & GIZ. (2022). *Baseline Study on The Potential For Power-To-X/ Green Hydrogen in Kenya.*

C. Consumption and 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 the development of the green hydrogen sector will put the country on track to operate as both a self-sufficient and exporter country. It highlights Kenya's intent to "prioritise no-regret options to kick-start a hydrogen industry, such as domestic fertiliser production and, once successfully established, to leverage this to enable hydrogen opportunities in other sectors, including (regional/international) export of hydrogen derivatives". 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 and later 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.[144] 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 (such as those 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 used 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 fertiliser other than a substance declared by rules made under the Act to be an approved fertiliser, and requires that the fertiliser conforms to the standard or specification prescribed by such rules.[145] To stimulate the market for locally produced green ammonia, green fertiliser mandates requiring an increasing proportion of fertilisers to be green can be elaborated under the Act,[146] as also addressed by the draft Fertilizers and Animal

144 *Policy Toolbox for Low Carbon and Renewable Hydrogen: Enabling low carbon and renewable hydrogen globally.* (2021, November). Hydrogen Council. https://hydrogencouncil.com/wp-content/uploads/2021/11/Hydrogen-Council_Policy-Toolbox.pdf

145 Fertilizers and Animal Foodstuffs Act, Act No 23 (1962)(Kenya). Section 3. Approved fertilisers under the Fertilizers and Animal Foodstuffs (Approved Fertilizers) Rules (1972) include sulphate ammonia, calcium ammonium nitrate and ammonium sulphate nitrate.

146 Fertilizers and Animal Foodstuffs Act No.23 (1962)(Kenya). 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 fertilisers.

Foodstuffs (Fertilizers) Regulations 2022. Locally produced green fertiliser can also be exported regionally, aligning with the National African Continental Free Trade Area (AfCTA) Implementation Strategy (2022-2027) which prioritises, among others, the sale and export of fertilisers within Africa;[147]

- **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 incentivise 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" of these critical consumer industries. This can be anchored on the Energy Act which empowers the Cabinet Secretary to enforce efficient use of energy and its conservation,[148]
- **Transport:** Enabling the transition from fossil fuel to hydrogen-fuelled vehicles is a key means of 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 can also be enhanced by driving demand for hydrogen-powered heavy-duty trucks through regulatory mandates and by 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

Environmental 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 Environmental Management and Co-ordination Act and regulations thereunder set out elaborate provisions on environmental and social impact assessment that will need to be complied with.[149]

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.

147 Government of Kenya. *Policy Brief: National African Continental Free Trade Area (AfCTA) Implementation Strategy (2022-2027)*. State Department for Trade, Kenya. https://trade.go.ke/sites/default/files/AfCFTA_Policy_Brief_Final.pdf

148 Energy Act, Act No. 1 (2019)(Kenya). Section 190.

149 Environmental Management and Coordination Act (1999)(Kenya); the Environmental (Impact Assessment and Audit) Regulations (2003)(Kenya).

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 rely on the existing regulatory framework which emphasises public participation and equitable sharing of resources.[150] Development of frameworks defining parameters for local community participation and access to benefits, will also be necessary.[151]

Local content

Kenya has several 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 on the job training for Kenyans, to build national capacity, capabilities, and investment in the local workforce, services, and supplies.[152]

There is, however, currently no synergy in the local content legal framework, creating challenges in ensuring that industries investing in the country adopt measures to promote local content.[153] 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.

150 Constitution of Kenya, 2010.

151 Waters-Bayer, A. & Tadicha Wario, H. (2022, May). Pastoralism and large-scale renewable energy and green hydrogen projects. Heinrich-Böll-Stiftung. https://www.boell.de/en/2022/05/18/pastoralism-and-large-scale-renewable-energy-and-green-hydrogen-projects

152 Energy Act, No. 1 (2019)(Kenya). Section 206.

153 Government of Kenya, Local Content Policy (2020).

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[154], 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.[155]

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 are 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 governments in providing approvals including for industrial land use for power generation.[156] Commercial-scale production of green hydrogen may cross county boundaries and will need multiple approvals leading to additional time delays and overhead costs.[157] 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 any green hydrogen investments.[158]

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,[159] though no domestic trading scheme or exchange is in place yet. Kenya is 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

154 Energy Act, No. 1 (2019)(Kenya). Part VII.
155 Land Act, No 6 (2012)(Kenya); Land Registration Act, No. 3 (2012)(Kenya); and Community Land Act, No. 27 (2016)(Kenya).
156 Physical and Land Use Planning Act (2019)(Kenya). Section 26(5), Section 33(1), Section 41 and Section 50.
157 Ministry of Energy, Kenya & GIZ. (2022). *Baseline Study on The Potential For Power-To-X/ Green Hydrogen in Kenya.*
158 Ministry of Energy, Kenya & GIZ. (2022). *Baseline Study on The Potential For Power-To-X/ Green Hydrogen in Kenya.*
159 Finance Act No 22 (2022)(Kenya) 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.

the draft Climate Change (Amendment) Bill)[160] and regulations to operationalise 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 of signing of the project agreement[161] which, it is hoped, will focus and drive parties to implementation. There are concerns that the period does not reflect the inevitably drawn-out nature of project feasibility research and negotiations to achieve bankability. The Act also provides that a project agreement should not be for a period exceeding 30 years[162], although extension is allowed under limited circumstances.[163] For a more robust framework, draft regulations enabling the full implementation of the Act and guidelines envisioned by the PPP Directorate within the National Treasury need to be developed with consideration made for how these can enhance conditions for green hydrogen projects, for example, in determining the duration of a PPP agreement.[164]
- **Tax incentives:** Targeted fiscal incentives are necessary to stimulate initial investments in the green hydrogen economy. There are currently several fiscal incentives for green technologies in Kenya that focus on renewable energy such as the exemption from VAT on specialised equipment for solar and wind energy (including solar panels or batteries). Kenya needs to facilitate and incentivise 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 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 a need to coordinate efforts 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. A set of concrete **actions** that should be considered is highlighted in *Table 7.*

160 Climate Change (Amendment) Act (2023)(Kenya).
161 Public Private Partnerships Act, No. 14 (2021)(Kenya). Section 61 (2)
162 Public Private Partnerships Act, No. 14 (2021)(Kenya). Section 21 (2).
163 Public Private Partnerships Act, No. 14 (2021)(Kenya). Section 23 (3).
164 Public Private Partnerships Act, No. 14 (2021)(Kenya). Section 23 (2).

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. This will allow salient provisions of the Energy Act to be applied to green hydrogen, such as provisions on gas infrastructure.
Lack of streamlined licensing requirements and procedures for the development of green hydrogen projects	Develop regulatory guidelines that provide clear and concise guidance on requirements for green hydrogen project development and make these available from a central coordinating entity. This will support project developers in their submission of plans and proposals.
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	Finalise and enact the draft Energy (Electricity Tariff) Regulation to provide an enabling framework for tariff computation and the creation of economic upsides from monetising 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 for Kenya to reap the benefits of green hydrogen.
Absent regulatory provisions stimulating market demand for green ammonia	Finalise and enact the draft Fertilizers and Animal Foodstuffs (Fertilizers) Regulations to increase market for locally produced green ammonia by promoting local capacity in green fertiliser manufacturing and blending.

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 the feasibility stage for renewable energy projects (solar and wind) on public land.
Unclear and inadequate detail on geothermal project development requirements	Finalise 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 codes, standards, and certification schemes along the green hydrogen value chain. The certification scheme for green hydrogen and derivatives must 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 operationalise the Climate Change Act and leverage green hydrogen for carbon finance, thus strengthening the pursuit of low carbon development.

The recommended regulatory actions set out in *Table 7* should be implemented as priority in the short-term, that is Phase 1 of the Green Hydrogen Strategy and Roadmap for Kenya (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 from its current levels of approximately 4-5 USD/kg and reach cost parity - or even fall lower than that of fossil-derived hydrogen, currently at around 2 USD/kg (despite the recent surge in prices during the period 2021-2022). Reduction in the cost of green hydrogen will be attributed to two main factors: declining cost 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, reduction of such cost differential 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 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 significait 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 opportunityfor 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 glo bally 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

Green hydrogen projects are complex investments both technically and financially requiring several distinct challenges, risks and uncertainties to be addressed as given in *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 nascent stage) as well as the pricing of green hydrogen and its derivative products. The production cost of green hydrogen is currently higher than that of hydrogen produced conventionally 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 posing 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 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 in operation.

In addition to risks associated with inherently high capital costs as well as country-specific regulatory and policy uncertainties there is a significant hurdle that green hydrogen projects encounter everywhere in the world - the commercial risks linked to off-take 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 long-term financial viability of green hydrogen initiatives. The mitigation of off-take risks, coupled with the establishment of commercially viable and bankable off-take 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), among other demand-side schemes, can assist in mitigating these off-take risks.

Contracts for difference (CFDs)

A CFD is a financial contract that helps mitigate risks associated with an off-take agreement by protecting the hydrogen producer's revenues and/or its buyer's costs against off-take 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:

Market price payer: An entity that pays the prevailing market price for the hydrogen;

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 off-take. 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.

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.

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 incentivise 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. The successful implementation of measures like VAT exemptions and import duty waivers in the solar industry 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 considers 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 insurance or foreign currency liquidity facilities.

However, to address the complex development challenges associated with green hydrogen projects, it will be crucial to scale up **innovative financing instruments**. Instruments such as concessional (low interest) loans and blended financing will play a pivotal role in catalysing green hydrogen investments. Moreover, the utilisation of innovative climate financing mechanisms (such as the Green Climate Fund established within the framework of the UNFCCC)[165] will be vital in advancing green hydrogen applications. **Blended financing** presents a particularly compelling solution that can harness the strengths and resources of multiple stakeholders, including collaboration among governments, DFIs, philanthropic organisations, 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.

165 See *Green Climate Fund*. https://unfccc.int/process/bodies/funds-and-financial-entities/green-climate-fund Other 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).

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 creating a market where investors can support environmentally friendly projects and earn returns by trading credits.

With a maturing market for green hydrogen products, the sector will gradually attract a broader range of lenders, including commercial banks specialising in project finance, private equity firms, and issuers of green bonds. Green bonds can be instrumental in facilitating the shift towards a greener economy, with a notable illustration being the **EU Global Green Bond Initiative.**[166] This initiative specifically focuses on attracting private investments in climate finance for developing economies and aims 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 concessional loans, equity investments, and guarantees, while export credit agencies can extend support through loans and guarantees specific to their respective countries.

DFIs 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 lending credibility and stability to the industry and instilling confidence in potential financiers.

Furthermore, DFIs can explore opportunities to become anchor investors in a diverse portfolio of smaller projects rather than focusing solely on larger ventures. This approach allows for broader participation and increased resilience within the green hydrogen sector.

166 *European green bond standard.* (2023, February 28). 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).

Timely and targeted support from DFIs is even more important, as there is also global competition for finance in the hydrogen sector driven by the increasing demand for hydrogen. While policies like the US IRA[167] aim to incentivise 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 off-take agreements with credit-worthy buyers often in the form of take-or-pay commitments, financiers may prioritise 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. Mobilising diverse funding sources and mitigating financial risks, will be crucial success factors for establishing a green hydrogen sector in Kenya.

To capitalise on the growing momentum surrounding hydrogen finance, it is imperative that Kenya promptly tackles 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, organising 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 s**trategy 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-Globa**l instrument aims to bridge cost gaps and facilitate the market functioning of green hydrogen and derivatives.

167 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_2 e/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 emphasised in the *Nouakchott Message*, underscoring the urgency and importance of their support.[168] Similarly, by mobilising resources and aligning their efforts, these stakeholders have a significant role to play in contributing to the success of green hydrogen initiatives in Kenya.

168 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 IMPLEMENTATION

The action plan through which implementation of the Green Hydrogen Strategy and Roadmap for Kenya will be realised is outlined in this section. This action plan serves as the foundation for the strategy and roadmap to unfold and move forward and outlines targeted measures and initiatives to bridge existing gaps. To this end, it aims to facilitate development of the green hydrogen sector in Kenya. The action plan considers the regulatory, policy, and finance gaps and incorporates valuable insights obtained from the SWOT analysis.

8.1.1. The Action Plan

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

It 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. Focus is on short-term actions that will be taken during the first phase of implementation of the roadmap from 2023-2027. Actions have been grouped according to the enabling pillars identified during the development of the strategy and roadmap for Kenya.

Box 7: IEA policy support pillars[169]

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

169 IEA. *Global Hydrogen Review 2022*. International Energy Agency. https://www.iea.org/reports/global-hydrogen-review-2022

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 progress regarding implementation of the strategy and roadmap	Ministry of Energy and Petroleum (MoEP)	Ministry of Agriculture and Livestock Development (MoALD); 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"	Institutionalises (operationalises) and co-ordinates the development of the green hydrogen sector and implementation of the Green Hydrogen Strategy and Roadmap for Kenya. 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	Institutionalises 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	Organise 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, DFIs and other financial institutions	Q1 2024-Q3 2024
1.5	Develop a monitoring and evaluation framework	To track progress in achieving objectives, identify areas for improvement, and provide feedback for decision-makers	MoEP		Q2 2024-Q3 2024
1.6	Review Green Hydrogen Strategy and Roadmap for Kenya (after two years of adoption)	Provides opportunity to revise the strategy and roadmap, consider 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, the 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 fertiliser use (including innovative finance and local market frameworks)	Promotes affordable green fertiliser 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 fertiliser	Defines specifications of nitrogen fertiliser.	MoALD	Kenya Agricultural and Livestock Research Organization (KALRO); KEBS; academia; non-governmental organisations (NGOs); community based organisations (CBOs)	Q3 2024-Q4 2024
2.4	Mandate national blending quotas for locally produced green fertiliser	Increases local sale and manufacture of green fertiliser.	MoALD	Fertilizer and Animal Foodstuffs Board of Kenya (FAFB); MITI; KEBS; private sector (manufacturers of green fertiliser); 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 least-cost green hydrogen production plants (from geothermal, solar and wind power)	Identifies strategies to improve cost-competitiveness of geothermal, wind and solar power and subsequently optimise the cost of hydrogen (including inter alia aspects such as financial de-risking, project development timelines, profit margins on steam, feasibility period exclusivity or licensing timelines).	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 or 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 and facilities for green hydrogen project development, (for example, 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 for Kenya resource mobilisation plan (including pricing of actions and budgeting for their implementation)	Mobilises funding for implementation of the Green Hydrogen Strategy and Roadmap for Kenya.	National Treasury	MoEP; private sector developers; DFIs; development partners	Q12024-Q3 2024
4.4	Implement KenGen Olkaria green hydrogen demonstration 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 the government of Kenya's optimal fiscal incentives and revenue and 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., 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 optimise public private partnerships 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 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 (There is currently no dedicated green hydrogen policy in Kenya).	MoEP	EPRA; private sector	Q2 2024-Q3 2024
5.4	Include Green Hydrogen Strategy and Roadmap for Kenya 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 fertiliser in upcoming review of the flagship projects of the Agricultural Sector Transformation and Growth Strategy (ASTGS)	Endorses added value of green fertiliser for transformation and growth of the agriculture sector.	MoALD	County government; KALRO; academia; private sector; community farmer organisations	Q2 2024-Q3 2024
5.6	Include green hydrogen in draft Agricultural Soil Management Policy (Fertiliser)	To enable the use of green fertiliser, define tailor made products and boost agricultural yield.	MoALD	County government; KALRO; academia; private sector; community farmer organisations	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 fit-for-purpose guidelines for approval of green hydrogen projects (to fast-track the development of regulations)	Establishes a level playing field for early project developers and enables the market to start opening up before necessary regulations are approved.	One-stop-shop	EPRA; NEMA; National Construction Authority (NCA); WRA; county governments; project developers	Q2 2024-Q3 2024
6.4	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
6.5	Enact open access (wheeling) regulation	Enables implementation of corporate power purchase agreements (PPAs).	EPRA	AGs Office; MoEP; private sector	Q1 2024-Q3 2024
6.6	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 governments	Q4 2024-Q2 2025
6.7	Develop guidelines for submission of project development plans and 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
6.8	Finalise 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
6.9	Develop and enact carbon market regulations	Clarifies processes and procedures for monetising 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
6.10	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
6.11	Finalise and enact the Draft Fertilizers and Animal Foodstuffs (Fertilizers) Regulations	Promotes local green fertiliser manufacturing and blending.	MoALD	AGs Office; private sector	Q2 2024-Q4 2024
6.12	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; AGs Office; project developers	Q1 2024-Q1 2024
6.13	Finalise 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 for Kenya)	Promotes research and development, technology development and an entrepreneurial ecosystem around green hydrogen, and increases the pool of skilled (technical and professional) locals (including youth and women) accessing emerging job opportunities around green hydrogen.	MoEP	Ministry of Education (MoE); Ministry of Public Service, Gender, and Affirmative Action (MoPSGAA); 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 fertiliser value chain	Enhances social acceptance and capacity building; helps stimulate demand for green fertilisers and other green hydrogen products; increases gender and youth inclusivity.	MoEP	Ministry of Information, Communications and the Digital Economy (MoICT); MoALD; MoPSGAA; MoYASA; DFIs and development partners	Q3 2024-Q2 2025
7.3	Develop and 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 and multilateral international co-operation partnership frameworks	Broadens available funding sources for green hydrogen projects (for example,. 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

	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 a high-level green hydrogen programme 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 and evaluation framework														
	1.6	Review the Green Hydrogen Strategy and Roadmap for Kenya														
DOMESTIC, REGIONAL AND 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 PRICIN	3.1	Design model least cost green hydrogen production plants														
	3.2	Adopt the pending Renewable Energy Auction Policy (REAP)														
	3.3	Designate SEZs for green hydrogen projects														
ATTRACTIVE INVESTMENT ENVIRONMENT	4.1	Conduct site selection study for green hydrogen projects														
	4.2	Earmark dedicated funds for green hydrogen project development														
	4.3	Develop resource mobilisation plan														
	4.4	Implement KenGen Olkaria green hydrogen pilot project														
	4.5	Conduct cost-benefit analysis for government finance support package														
	4.6	Identify funds/finance models for green hydrogen projects														
	4.7	Review/optimise PPP process for green hydrogen projects														
CLEAR AND CONSISTENT POLICY SIGNALS	5.1	Include green hydrogen in Kenya's NDCs														
	5.2	Designate green hydrogen project development areas														
	5.3	Include dedicated provision on green hydrogen in NEP, 2018														
	5.4	Include green hydrogen strategy in LCPDP														
	5.5	Include green fertilizer as flagship projects of the ASTGS														
	5.6	Include green hydrogen in draft National Agricultural Soil Management 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 fit-for-purpose guidelines for approval of green hydrogen projects														
	6.4	Develop codes, standards and certification schemes														
	6.5	Enact open access (wheeling) regulation														
	6.6	Embed green hydrogen in local content regulation														
	6.7	Develop guidelines for project development plans														
	6.8	Finalise and enact the Draft Energy (Electricity Tariff) Regulations														
	6.9	Develop and enact carbon market regulations														
	6.10	Develop regulatory framework for water desalination														
	6.11	Enact Draft Fertilizers and Animal Foodstuffs Regulations														
	6.12	Clarify the exclusivity period for renewable energy projects development on public														
	6.13	Finalise 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 green hydrogen stakeholder engagement/communication plan														
	7.3	Develop/revise green hydrogen capacity needs assessment														
	7.4	Establish green hydrogen campuses (Centres of Excellence)														
PARTNERSHIPS AND COLLABORATION	8.1	Expand regional and international cooperation and partnerships														
	8.2	Include green hydrogen in bilateral/multi-lateral co-operation frameworks														
	8.3	Establish partnerships for training and capacity building														

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

8.1.2. Monitoring and evaluation

To track the progress made by Kenya towards realising and meeting the objectives of its Green Hydrogen Strategy and Roadmap for Kenya a monitoring and evaluation (M&E) framework will be developed detailing the approach needed to measure progress, evaluate the effectiveness of the roadmap in achieving its objectives, identify areas for adjustment or improvement, 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 will include objectives, key performance indicators (KPIs), targets, sources for data 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 CO_2 emissions avoided, the number of research programmes developed at universities and the number of research and 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 outline the data sources, and the collection, and analysis procedures. Bi-yearly evaluation reports will provide a systematic overview of the progress towards the set targets. In addition, evaluation of the effectiveness of the strategy will be performed, including recommendations for improvements and/or amendments. The M&E plan will be subject to periodic reviews to ensure that it remains relevant and effective in assessing the progress made and also considering potential future revisions of the strategy.

8.1.3. Priority actions

Priority actions that have been identified to establish the building blocks and kick-start the process of operationalisation and implementation of the Green Hydrogen Strategy and Roadmap include:

- Establish a high-level **"green hydrogen program coordination committee"**.
- Establish a green hydrogen **secretariat** to operate as a "one-stop-shop".
- Organise national **green hydrogen roundtables** on finance and green fertiliser.
- Develop a Green Hydrogen Strategy and Roadmap for Kenya r**esource mobilisation plan**.
- Develop a **monitoring and evaluation** plan.
- Include dedicated provision on green hydrogen in the national energy policy.
- Support and fast track **catalytic projects** that demonstrate commercial viability, including implementation of KenGen's Olkaria green hydrogen demonstration 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.

Implementation timelines of these priority actions are given below.

No.	Action	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
1.1	Establish high-level "GH2 Program Coordination Committee"														
1.2	Establish a Green Hydrogen Secretariat														
1.4	Organize national green hydrogen roundtables														
1.5	Develop a monitoring and evaluation framework														
4.3	Develop a resource mobilisation plan														
5.3	Include dedicated provision on GH2 in NEP, 2018														
5.5	Include green fertilizer as flagship projects of the ASTGS														
7.2	Develop a GH2 stakeholder engagement / communication plan														
8.1	Expand regional and international cooperation and partnerships														
8.3	Establish partnerships for training and capacity building														

8.2. ROADMAP GOVERNANCE FRAMEWORK

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, and 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 for Kenya after two years of implementation.

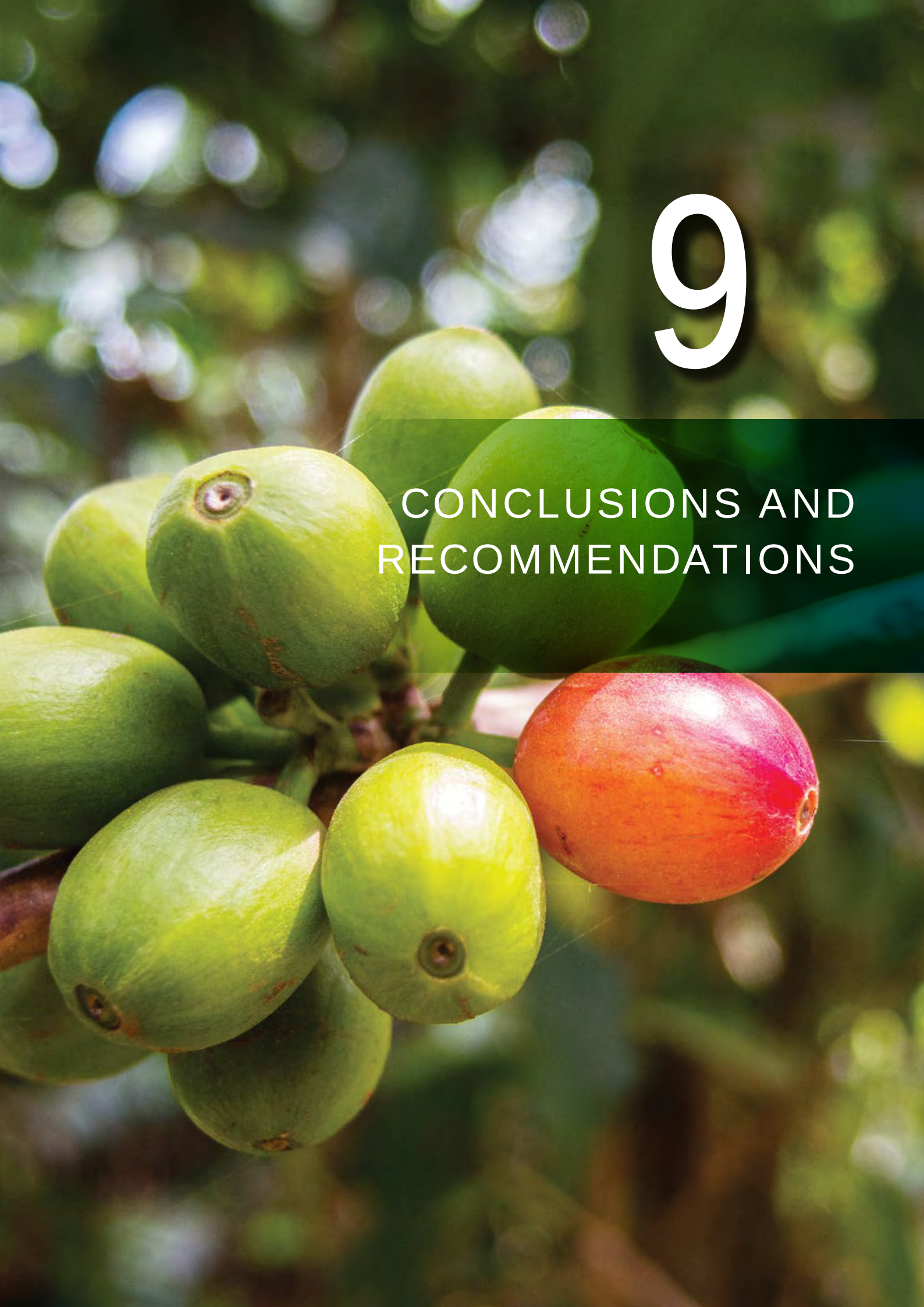
The GH2-PCC assumes the crucial role of overseeing and managing the implementation of the roadmap's objectives. This committee is tasked with evaluating and proposing any necessary amendments, including additions, adjustments, or withdrawals of specific actions outlined in the roadmap. Additionally, the committee is responsible for making any necessary recommendations to relevant authorities regarding fiscal, monetary, or regulatory interventions.

The GH2-PCC aims to enhance the synergy between the Green Hydrogen Strategy and Roadmap for Kenya and other government initiatives 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 utilisation of resources and expertise. The committee may establish thematic sub-committees consisting of domain experts to provide support whenever necessary. Additionally, the GH2-PCC will actively monitor the performance and outcomes of projects taking appropriate action when needed.

A National Green Hydrogen Advisory Group will also 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, 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 and 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 initiative and facilitate day-to-day activities related to the roadmap.

The **Roadmap Secretariat** will be led by a 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 demonstration projects and research and development initiatives and will support the GH2-PCC and the Advisory Group when required. The secretariat will continuously monitor the sector's exposure to various risks, promptly addressing and categorising 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.



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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. Recognising 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 capitalise 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 vast untapped renewable energy potential and occupies 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 and use this 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:[170]

1. Activate national planning and incentive schemes, ensuring the development of domestic policy and regulatory frameworks which mobilise 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 the country to launch this Green Hydrogen Strategy and Roadmap for Kenya and align itself with global trends in technology, applications, policy, and regulation, and to capitalise on available funding opportunities. This dedicated national hydrogen Strategy is essential for Kenya, as for any country in the world that aims to establish a robust hydrogen industry and it provides a clear vision, direction, and framework for the development of the hydrogen sector.

170 EIB. (2022). *Africa's extraordinary green hydrogen potential.* European Investment Bank. https://www.eib.org/attachments/press/africa-green-hydrogen-flyer.pdf

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