Quality Infrastructure for Green Hydrogen project

Tunisia case study presentation

Acknowledgements

About IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation; a centre of excellence; a repository of policy, technology, resource, and financial knowledge; and a driver of action on the ground to advance the transformation of the global energy system. A global intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy and geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security, and low-carbon economic growth and prosperity. www.irena.org

Disclaimer

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Contents

Glossary

- ANM — Agence Nationale de Métrologie (Tunisia)
- BIPM — Bureau international des poids et mesures
- BMZ — Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
- CETIME — Centre Technique des Industries Mécaniques et Électriques (Tunisia)
- CMC — Calibration and measurement capacities
- CTMCCV — Building Materials, Ceramics and Glass Technical Center (Tunisia)
- CNCC — Centre National du Cuir et de la Chaussure (Tunisia)
- CO2 — carbon dioxide
- CRTEn — Center for Energy Research and Technology (Tunisia)
- DEF-NAT — Laboratoire de métrologie du Ministère de la Défense Nationale (Tunisia)
- DGIIT — Direction Générale de l'Infrastructure Industrielle et Technologique (Tunisia)
- DGETE — Direction Générale de l'Electricité et de la Transition Energétique (Tunisia)
- EURAMET — European Association of National Metrology Institutes
- GHG — greenhouse gas

Glossary (cont.)

- Gt — gigatonne
- GW — gigawatt
- INRAP — National Institute of Research and Physical and Chemical Analysis
- IRENA — International Renewable Energy Agency
- IAF — International Accreditation Forum
- IEC — International Electrotechnical Commission
- IECEE — IEC System of Conformity Assessment Schemes for Electrotechnical Equipment
- IECEx — International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres
- ILAC — International Laboratory Accreditation Cooperation
- INNORPI — Institut National de la Normalisation et de la Propriété Industrielle (Tunisia)
- ISO — International Organization for Standardization
- LCAE — Central Laboratory for Analysis and Testing (Tunisia)
- MIME — Ministry of Mines, Industry and Energy (Ministère de l'Industrie, des Mines et de l'Energie)

Glossary (cont.)

- Mt million tonnes
- OIML International Organization of Legal Metrology (Organisation Internationale de Métrologie Légale)
- PTB Physikalisch-Technische Bundesanstalt
- PV photovoltaic
- R&D research and development
- QI quality infrastructure
- STEG Tunisian Company of Electricity and Gas
- TC Technical Committee
- TUNAC Conseil National d'Accréditation (Tunisia)
- WTO World Trade Organization

1 Project overview

Need for a full value chain approach - IRENA's recent hydrogen analysis

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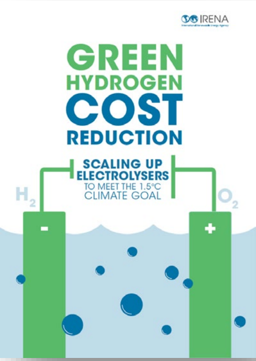
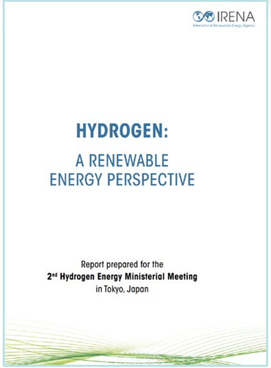
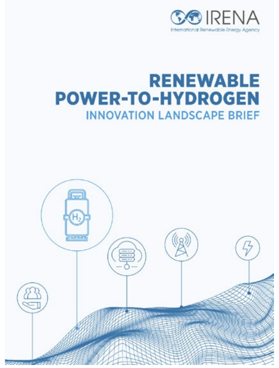
Supply

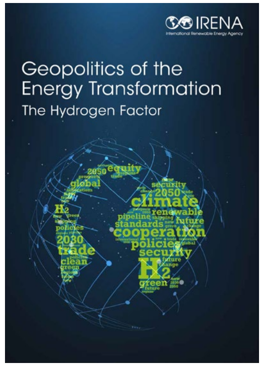


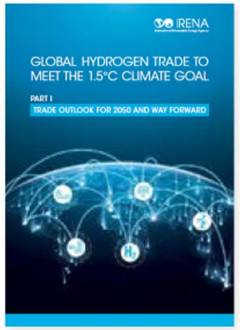
Sector coupling

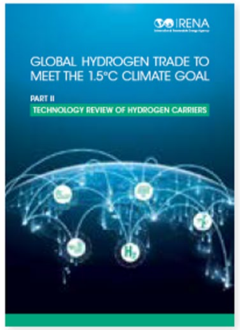


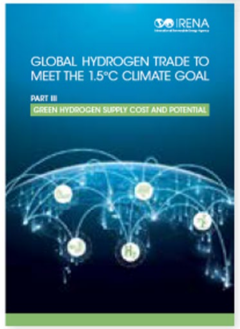


Trade

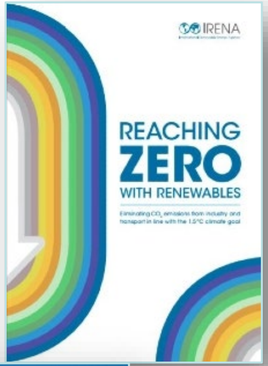


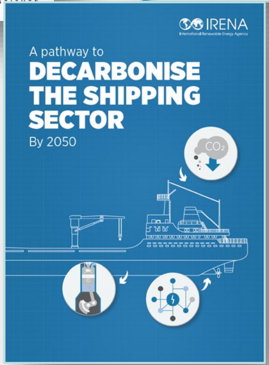




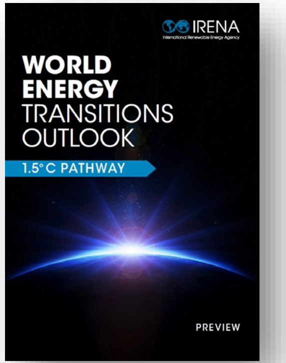


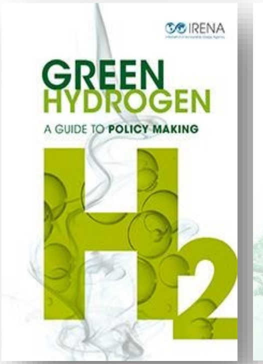
Demand

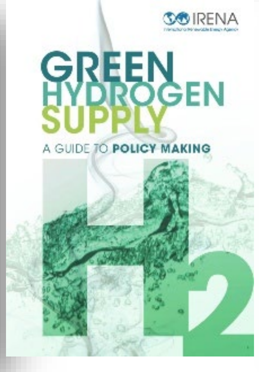


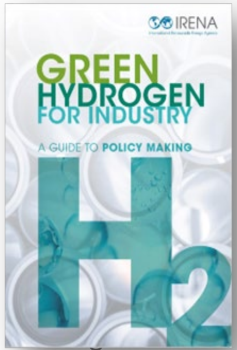


Cross cutting & Innovation Frameworks and Policies









What is quality infrastructure (QI)

- QI is the **national system of organisations, policies, legal frameworks and practices required to assure the quality, safety and sustainability of products and services**.
- The key pillars of QI are **metrology, standardisation, accreditation and conformity assessment** (including testing, certification and inspection).
- QI creates the technical basis for the development of the green hydrogen sector as it **reduces safety, financial and reputational risks** in the sector, while simultaneously supporting the **achievement of the intended positive sustainability impacts of investments**.
- The integration of clean hydrogen into a low carbon economy will require additional and improved QI services.

Standard	A standard Is defined as **“a document, established by consensus and approved by a recognised body, which provides for common and repeated use, rules, guidelines, or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context”**.
Metrology	Metrology is the “**the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology”**. The key objectives of metrology are the definition of measurement units, realisation of units by scientific measurement, and establishment of measurement traceability chains.
Testing	Testing determines the **characteristics of a product in comparison with the requirements of a standard**. The tests can vary from a simple visual evaluation to a destructive evaluation, or a combination of both.
Certification	Certification is the **formal verification that a product, service and management system of an organisation, or the competence of a person, corresponds to the requirements of a standard**. The certification is realised by conformity assessment bodies, which demand recognition of their technical competence by an internationally recognised accreditation body.
Inspection	Private clients, organisations or government authorities can conduct inspections. **They examine the design of products, services, procedures or installations and evaluate their conformity or non-conformity with requirements**, which exist in the form of laws, technical regulations, standards and specifications.
Accreditation	Accreditation provides an **independent confirmation of the technical competence of an individual or an organisation delivering services**.

Source: *IRENA (2015), Quality infrastructure for renewable energy technologies: Guidelines for policy-makers.*

IRENA QI for Green Hydrogen project overview

Outcome: The major stakeholder groups have sustainably increased co ordination amongst each other, are informed about the role of QI and support the development of QI in line with identified priority areas for the sustainable production and trade of global green hydrogen and selected derivatives.

Output 1: Quality Infrastructure Roadmap.

Output 2: National Case Study and Action Plan

Output 3: Stakeholder network established.

Activity cluster 1: Desk study conducted

A desk study on the production and trade of global green hydrogen and selected derivatives is conducted: Quality, sustainability and safety requirements and challenges along the value chain, national and international markets and market trends, global stakeholders, necessary contributions of QI to the development of the sector, with emphasis on QI services unique to green hydrogen vs services needed in general for hydrogen, are known and documented. (**Deliverable**: Internal document on desk study results)

Activity cluster 2: One national case study and recommended action plan piloted

The global information from the desk study (Activity 1) is piloted and applied in a national context. This information creates the basis for national workshops with the relevant stakeholders, in which specific quality, sustainability and safety challenges are identified along the value chain and a national action plan developed to overcome the challenges identified. (**Deliverable**: Documentation of national case study, including action plan.)

Activity cluster 3: Roadmap is developed

The information created under Activity 1 and Activity 2 is summarised in a publication on the contribution of QI to the development of green hydrogen production and trade. The publication includes a roadmap and recommends concrete measures to support the development of the required QI considering different national framework conditions. The national case study is included as an example. (**Deliverable**: Roadmap is published.)

Activity cluster 4: Ad-hoc advice provided on how to implement recommendations of developed action plan

Advice is offered to support the pilot country stakeholders in the implementation of first recommendations (follow-up from Activity 2). Advice provided includes advice on policies required, and the adoption of international standards or related technical regulations. Additionally, at least two follow-up meetings with the pilot country stakeholders are organised. (**Deliverable**: Documentation of follow-up meetings and record of advice provided, including results.)

Activity cluster 5: Communication strategy developed and implemented

A communication strategy is developed early in the project to communicate the role of QI in the development of green hydrogen production and trade. The strategy will use the results obtained during the various stages of the project as a basis for communication of the role and uses of QI. Specific requirements and preferences of the target group will be identified, and suitable dissemination formats proposed

Deliverable: Document describing the communication strategy, documentation of communication measures.

Activity cluster 6: Stakeholder network created

In parallel to and as a means to support the other activities, a global network of stakeholders is created, and members continuously engaged. A consultative process is conducted.

Deliverable: Documentation of stakeholder network meetings.

Project duration: Apr 2022 – Nov 2024

In partnership with:

Physikalisch-Technische Bundesanstalt Braunschweig und Berlin National Metrology Institute

With funding from:

Federal Ministry for Economic Cooperation and Development

Stakeholder network for this project (non-exhaustive)

	Standards	Certification	Metrology
	IEC ISO DNV cen GH2 Green Hydrogen Organisation GOV.UK Guidance UK Low Carbon Hydrogen Standard: emissions reporting and sustainability criteria	IECEx™ SIEMENS energy CertifHy® TÜVRheinland® Precisely Right. AMMONIA ENERGY ASSOCIATION DVGW	EURAMET VSL National Metrology Institute PTB Physikalisch-Technische Bundesanstalt National Metrology Institute
Knowledge repository	MI CLEAN HYDROGEN MISSION FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING FCHO FUEL CELLS AND HYDROGEN OBSERVATORY	H2 HydrogenTools dena Deutsche Energie-Agentur IPHE	ENERGY.GOV Hydrogen Program » Annual Merit Review Presentation Database

2

National case study – objective

Rationale and expectations in preparing the case study

- The country (Tunisia) will benefit from this project by receiving analytical application, development of recommendations, and a tailored and country-specific QI action plan aligned with national goals, and promote the need for increased political support and buy-in.

- The national case study will aim to cover the following:

  - National market and export potential for hydrogen.
  - Relevant national stakeholders.
  - National quality, sustainability and safety requirements.
  - Status of QI in the country.

- The national stakeholder engagement process will be supported by a national country partner (Direction Générale de l'Infrastructure Industrielle et Technologique), supporting the identification and inclusion of the relevant stakeholders, and taking care of the organisation of meetings and co ordination with stakeholders.

General methodology followed in the preparation of this case study

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1 Desk research

- Leverage existing IRENA analysis as well as additional literature resources to determine green hydrogen development trends for Tunisia.
- Analyse draft and confidential national strategy shared with IRENA by PTB and MIME.

2 QI services

- Research QI services available publicly and/or by contacting international bodies (ISO, IEC, IAF).
- Leverage findings from scoping mission undertaken by PTB in October 2023 for their bilateral Tunisia QI GH2 project.

3 Interviews

- Undertake virtual interviews with government institutions (such as DGETE, STEG), development agencies working in Tunisia (such as GIZ), and national QI stakeholders (such as INNORPI, TUNAC).

4 Stakeholder workshops

- Two workshops (one physical and one virtual) will be organised to validate findings and recommendations.

Case study workshop organised in May 2024

- The national case study created the basis for a small workshop (30-40 participants) with the relevant stakeholders (hydrogen sector actors along the value chain, QI organisations, sector associations and other enablers).

- The in-person workshop covered the following topics:
  - Results of the global and national desk studies.
  - Presentation on the national QI system and its potential contribution.
  - Identification of relevant stakeholders as well as quality and sustainability challenges along the value chain.
  - Definition of QI services required to overcome existing challenges along the value chain.
  - Presentation of the draft national QI action plan to relevant stakeholders for feedback.

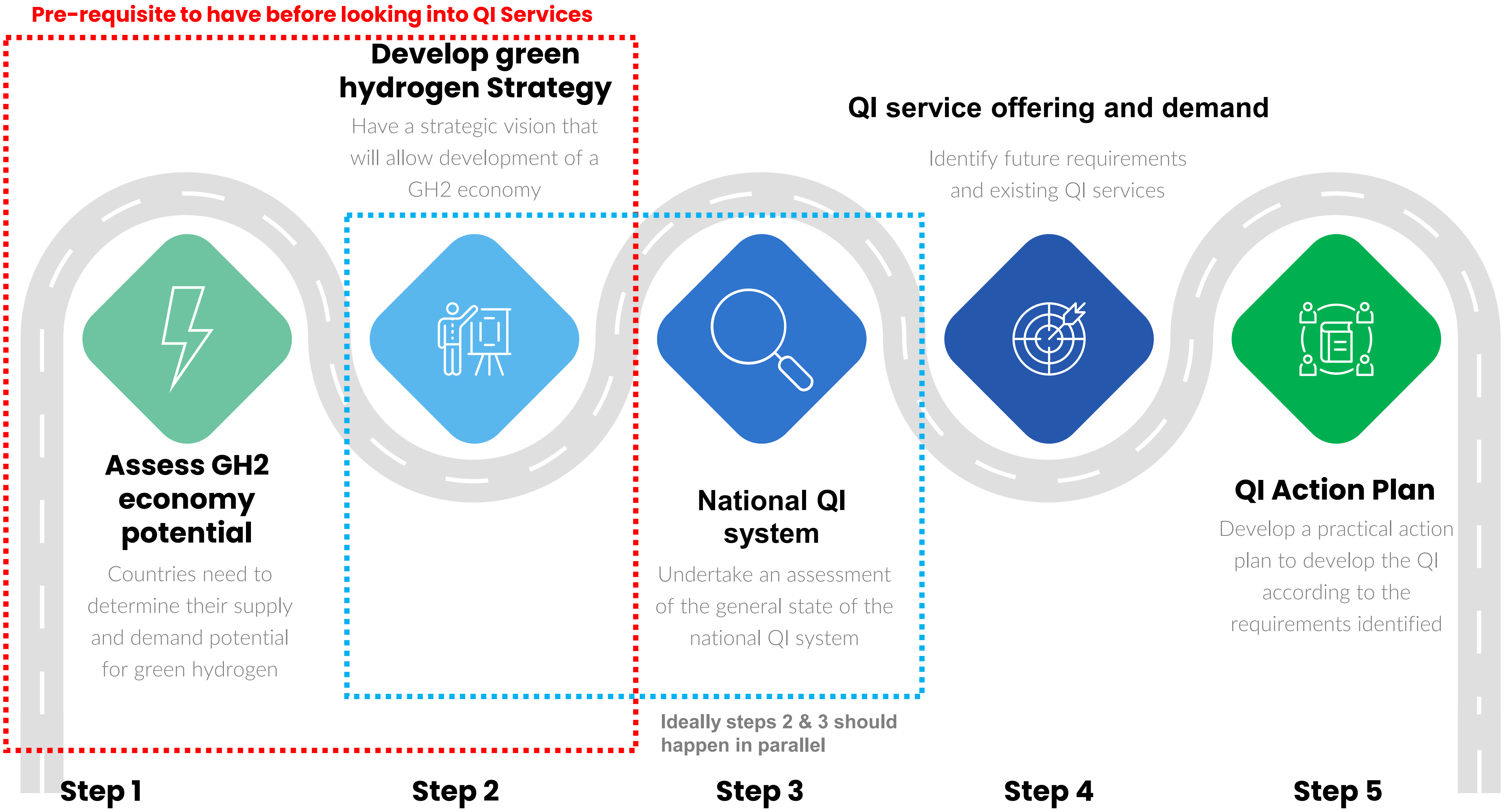
- Participants suggested additional activities, inclusion of quick-win measures and ad hoc consultancy requirements.

- The main outcome from this workshop was for IRENA to use the information/feedback gathered from the discussions to refine the draft national action plan.

3 General quality infrastructure for Green Hydrogen Roadmap approach

QI for Green Hydrogen Roadmap

This is the general roadmap approach that IRENA is proposing that any country should follow to ensure that they can develop a QI ecosystem for the safe and sustainable production of green hydrogen. This approach has been applied to this case study.



Step 1: Analysing the potential for green hydrogen economy (prerequisite)

Before embarking on the development of QI considerations for GH2, a country should first undertake an **assessment of the potential supply and demand** for hydrogen and its derivatives. Key assessment variables to consider include (but are not limited to):

Renewable energy potential

Leverage national energy data, international reports and energy models to determine the country's potential renewable energy resources available

Applications

Undertake assessment of how GH2 can be used in the country in **industry** (steel, methanol, ammonia); **transport** (road, shipping); and **electricity** (grids and heating)

Downstream

Assess existing regulation, mechanisms to support early movers (finance), demand creation tools (certifications, green procurement), value chain integration (clusters and hubs)

Midstream

Look into assessing the **readiness of existing transport and distribution infrastructure** as well as associated financing for new infrastructure requirements

Upstream

Attract investors to support GH2 production; investigate **procurement of electricity for electrolysers** and manufacturing options

Market assessment

Undertake an assessment on how national GH2 market potential fits with international market requirements to determine **potential trade opportunities**

Source: (IRENA, UNIDO and IDOS, 2024)

Step 1: Analysing the potential for GH2 economy – factors to consider

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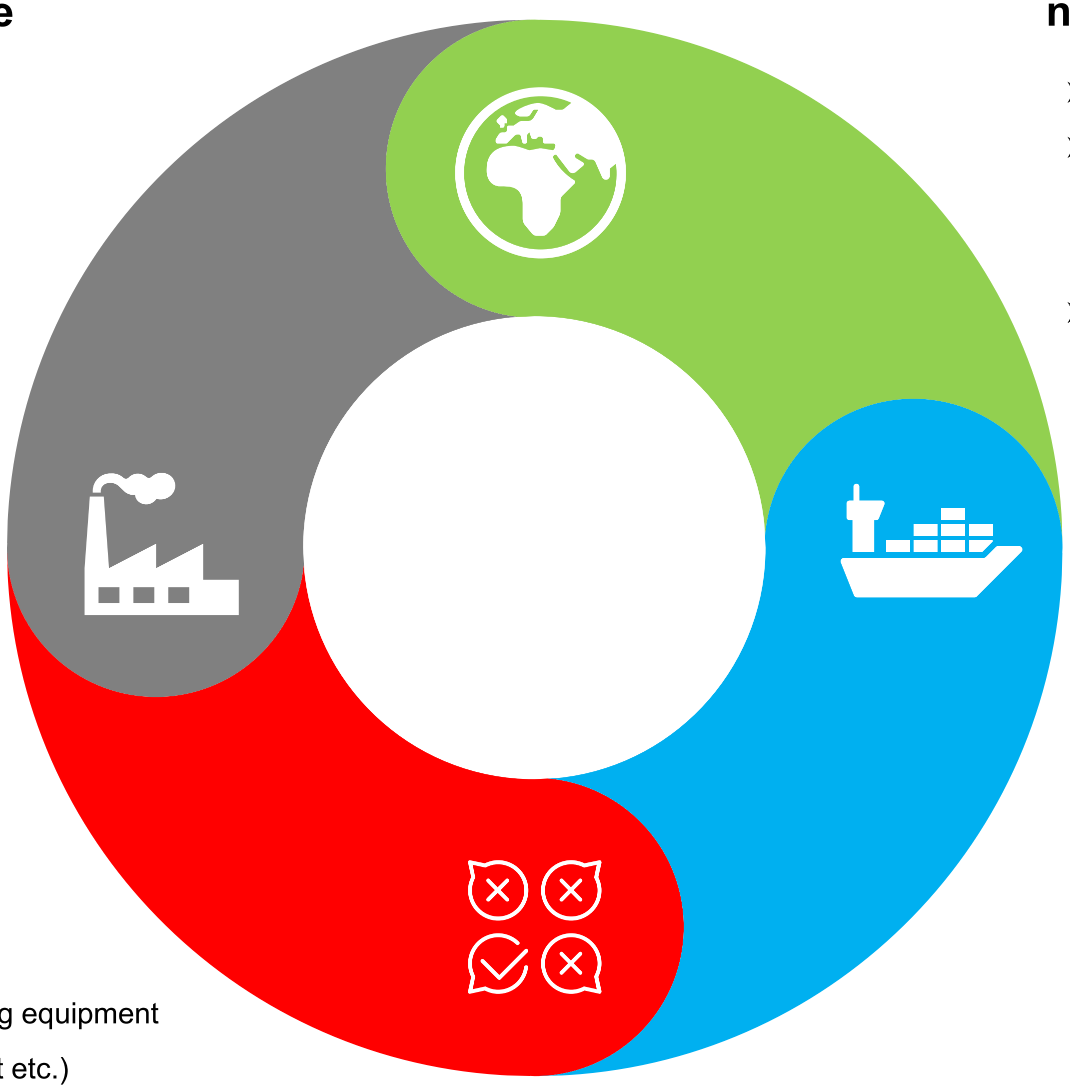
Map the existing (grey) hydrogen consuming industries. These are typically:

- Fertiliser plants (Haber-Bosch produced ammonia)
- Petrochemical refineries (hydrogen used for desulphurisation and cracking)
- Chemical plants (methanol, olefin, acids, synthetic resins and other chemical synthesis)
- Glass production
- Food processing (hydrogenation of oils and fats)

Map potential new uses, starting with projected demand from hard-to-abate sectors:

- Steel production
- Aviation
- Maritime bunkering
- Long-term energy storage
- Long-distance road transport (freight) and mining equipment
- Other industries (cement, high-temperature heat etc.)
- Natural gas blending



Identify potential regional trade with neighbouring states

- Potential nearby demand centres
- Infrastructure for nearby transport:
  - Roads (tube trailers)
  - Existing (natural) gas pipelines
- Identify potential trade barriers and/or incentives (trade agreements on tariffs for hydrogen and/or derivatives)

Identify potential for long-distance trade with remote states

- Potential demand from remote centres (Europe, Asia)
- Infrastructure for long-distance transport:
- Port capacity (for hydrogen but also to handle derivatives like ammonia, methanol, LOHCs)
- Pipelines for long-distance transport (more for medium range)

Step 2: Develop a green hydrogen strategy (prerequisite)

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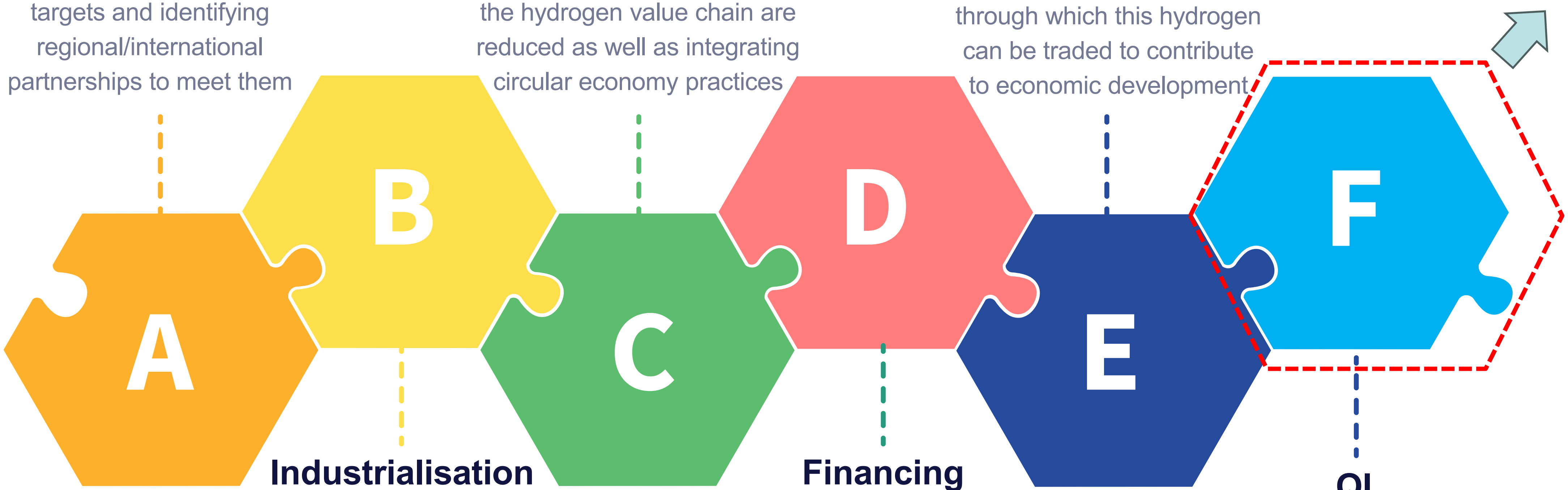
➢ Decide which opportunities to develop and prioritise them in a coherent hydrogen strategy that can guide the implementation of the most important facets within the GH2 economy. Some of the key tenets necessary in these strategies are as follows:

Ambition and collaboration
Having clear production targets and identifying regional/international partnerships to meet them

Sustainability
Ensuring that emissions across the hydrogen value chain are reduced as well as integrating circular economy practices

Trade potential
Having a clear map and overview of the channels through which this hydrogen can be traded to contribute to economic development

Often overlooked



Industrialisation
Viewing hydrogen as a conduit to drive industrial development by integrating with other sectors

Financing
Explicitly identifying tangible mechanisms through which finance for GH2 can be attracted

QI
Ensuring the safety, sustainability and reliability of this energy carrier and access to different markets

Source: IRENA, UNIDO and IDOS 2024

Step 3: Assessment of the national QI system

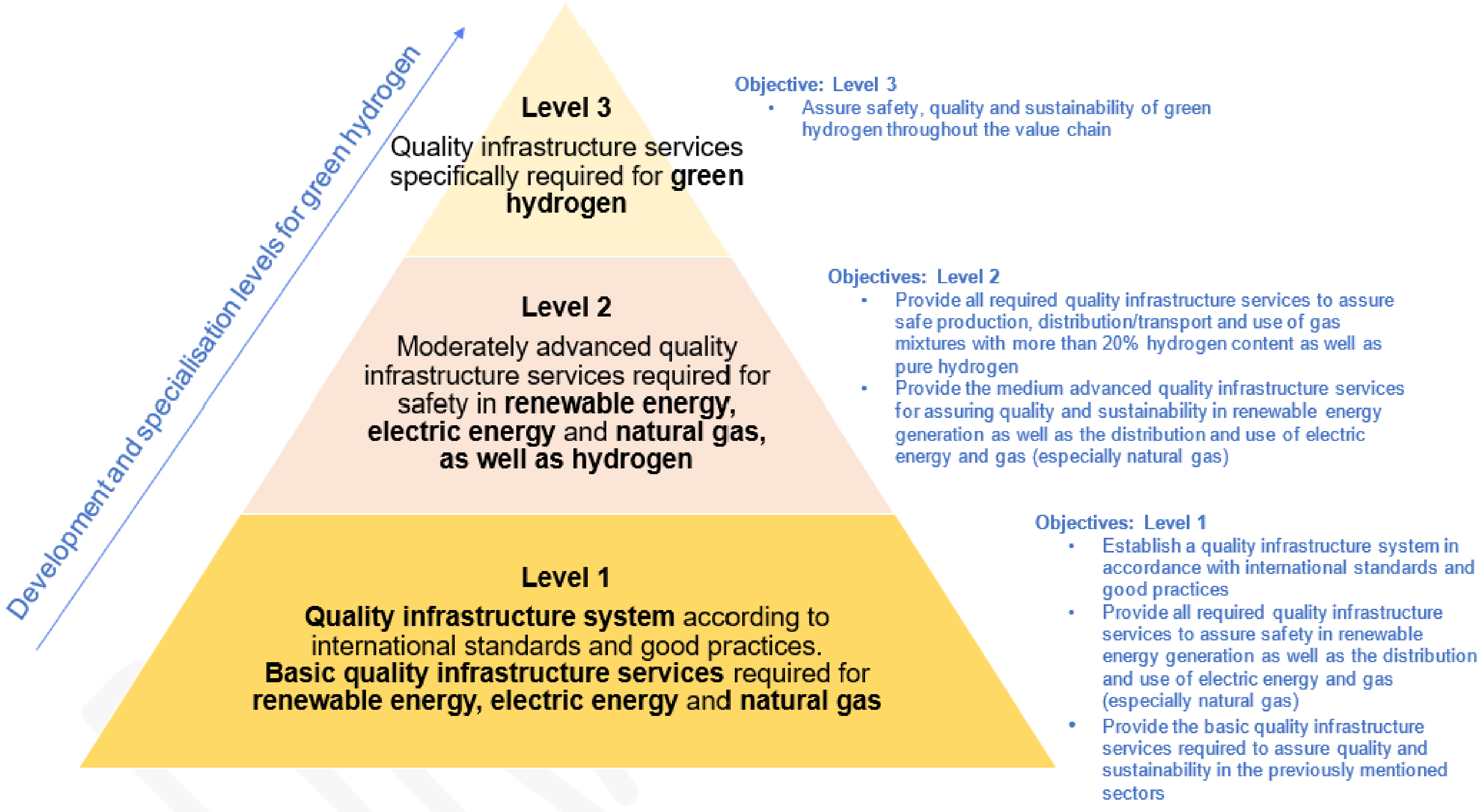
- The national QI system is required to guarantee the safe and sustainable implementation of the national green hydrogen strategy, at the same time assuring high levels of quality.
- In Step 3 the general status of the national QI system is analysed to identify strengths and areas to be further developed by the system. This general analysis is not sector specific, but relevant for all areas of public interest.
- The analysis can be based on the "Rapid Diagnostic Tool" developed by PTB and World Bank.
- Using existing strengths and systematically closing gaps in the overall system will create the basis required for the development of concrete services relevant for the green hydrogen sector (in Step 4).
- The assessment of the national system is conducted by analysing the QI organisations as well as the relevant legal and institutional framework based on previously established criteria. These criteria are based on the related standards and international good practice in the following areas:
    - Legal and institutional framework
    - Administration and infrastructure
    - Service delivery and technical competency
    - External relations and recognition

Step 4: QI service offering and demand assessment

- Following the assessment of the national QI system (in Step 3), concrete services required for the development of the green hydrogen sector are analysed.
- As in most countries the demand for specific services for the green hydrogen sector will evolve over several years; the offering and demand assessment is based on the following steps:
  - Level 1: Basic QI services with current demand in related sectors and services required for the assurance of gas and energy safety.
  - Level 2: Medium-advanced QI services with current demand in related sectors and specific services required for hydrogen safety.
  - Level 3: Advanced QI services specifically required for green hydrogen.
- Not all services need be built up nationally. Depending on current and future demand, access to existing services in other countries may be possible.
- Before developing new services, existing services should be evaluated and the measures for quality assurance further improved (depending on the service, e.g. via introduction of management systems, training, accreditation, calibrations, round robin tests).
- The QI service offering and demand assessment are based on a service checklist developed using desk research and stakeholder engagement.

Step 4: QI service offering and demand assessment

- Use the QI service checklist to identify the services required nationally on the three levels of the pyramid – see next slides.
- Complete and specify the service checklist if required.
- Consider services required along the value chain to assure safety, quality and sustainability.
    - ❖ Aspects to be covered for the required services identified:
    - ❖ Current demand.
    - ❖ Future market potential.
    - ❖ Potential income generation and financing requirements to develop and maintain the services of the QI.



The following pyramid model summarises the levels and objectives recommended for the analysis and subsequent development of the QI service

Step 4: QI service offering and demand assessment

The offering and demand assessment should consider the required focus of QI development, depending on the priorities of a country's Green Hydrogen Strategy (see Step 2). The following overview summarises three scenarios, which can be applicable separately or combined.

Renewable energy generation	Production			Distribution and transport	Utilisation
	Electro-lysis	Conversion into derivatives	Storage		

Scenario C: National production, use and export of green hydrogen

- Quality infrastructure (QI) services considering the results of the QI analysis for: renewable energy generation, electric safety, gas (especially natural gas) as well as production, distribution/transport and utilisation of green hydrogen and its derivatives.
- Technical regulation on safety, human health and environmental aspects along the entire value chain.

Scenario B: National green hydrogen production for export

- QI services considering the results of the QI analysis for: Renewable energy generation, electric safety, gas (especially natural gas) as well as production and distribution/transport of green hydrogen and its derivatives.
- Technical regulation on safety, human health and environmental aspects along the value chain, excepting use of green hydrogen.

Scenario A: Import of green hydrogen for national use

- QI services considering the results of the QI analysis for: electric safety, gas (especially natural gas) as well as distribution/transport and utilisation of green hydrogen and its derivatives.
- Technical regulation on safety, human health and environmental aspects with focus on import/market surveillance, distribution/transport and utilisation of green hydrogen and its derivatives.

Step 5: National Action Plan to develop QI Services

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- Based on the information collected from Steps 1-4, develop action plans that focus on the development of **general QI services** and **specific QI services for green hydrogen**.

General development of QI, improving the gaps identified in the QI analysis (see Step 3).

Activity	Budget	Responsible	Date
Legal and institutional framework			
……	……	…..	…..
Administration and infrastructure			
Service delivery and technical competency			
External relations and recognition			

Development of QI services according to national priorities

Activity	Budget	Responsible	Date
Metrology			
……	……	…..	…..
Testing			
Standardisation			
Certification and inspection			
Accreditation			
Technical Regulation			

Tunisia national case study preliminary findings

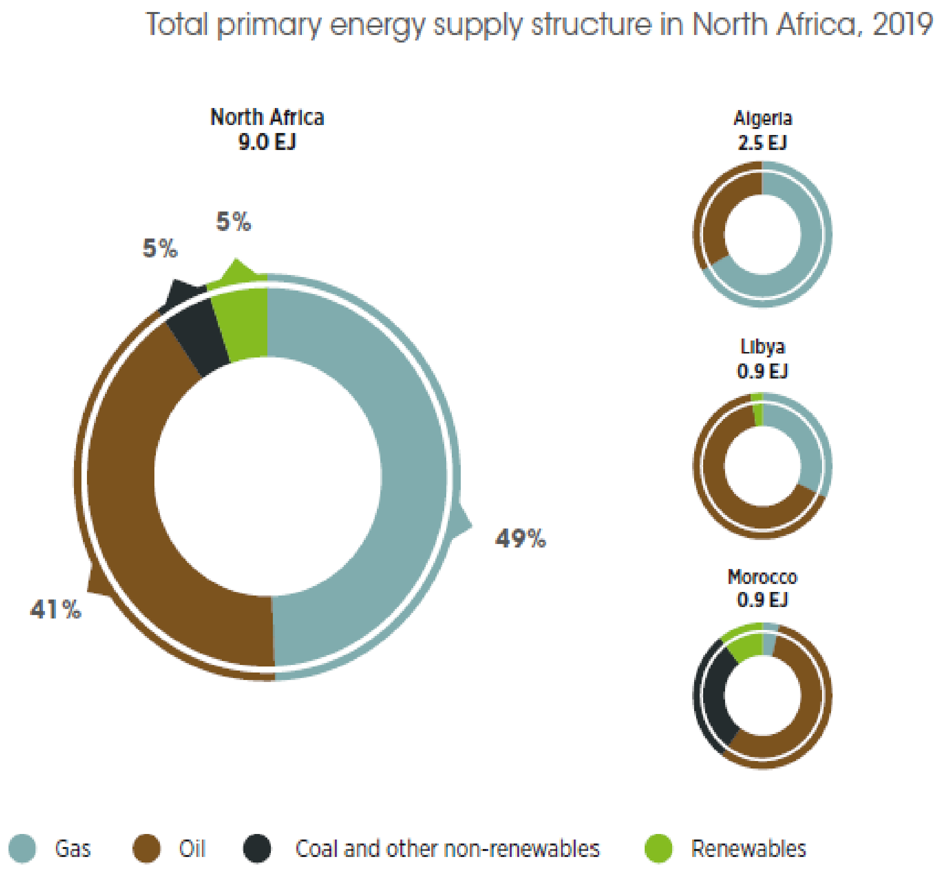
4

Tunisia green hydrogen economy potential

Roadmap step 1

Setting the scene: Tunisia energy context

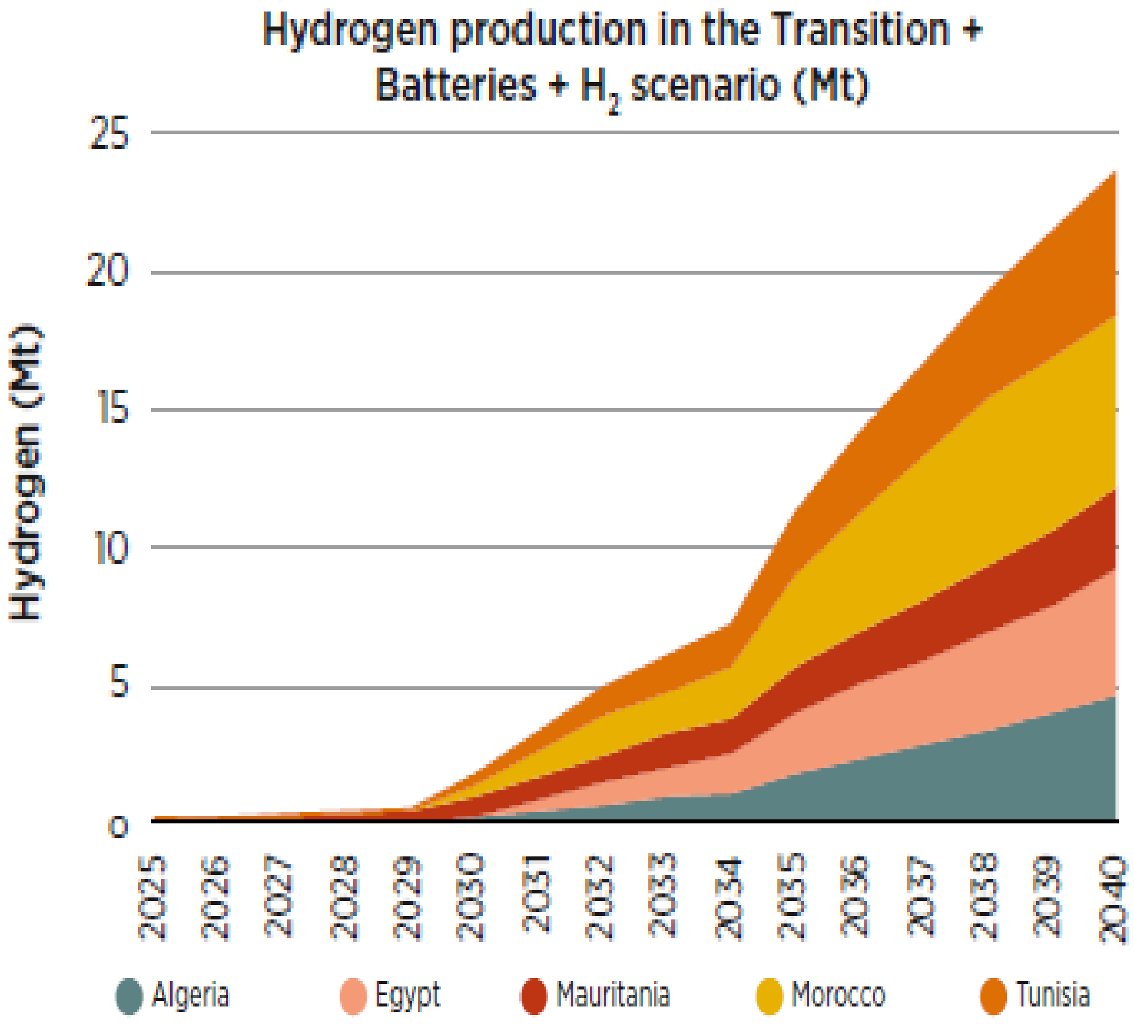
- With domestic natural gas production, Tunisia has historically been an energy exporter.
- Since 2000, Tunisia has been a net energy importer, with roughly half its primary energy supply coming from natural gas.
- Renewable energy projects make up 39% of planned investment in the Tunisian energy system for the period 2021-2025. In this context, electricity plays a growing role in addressing energy demand in the country.
- 2.6% of Tunisian electricity came from renewable sources in 2020, and under Paris Agreement-aligned nationally determined contributions, the country is targeting 30% by 2030.
- An interconnector between Tunisia and Italy is already planned to facilitate the export of renewable electricity.



Source: IRENA Planning Prospects for North Africa, Figure 1.1, 2023.

Sources: IRENA 'Planning Prospects for North Africa', 2023; GIZ 'Study on the Opportunities of "Power-to-X" in Tunisia', 2021.

- Tunisia has good potential for the production of cost-effective green hydrogen. Like other countries in the region, Tunisia benefits from high solar irradiance and wind availability and the synergy of these resources can provide low-cost energy inputs with high capacity factors.
- Land availability is also a factor that may facilitate a competitive advantage for low-cost hydrogen production in Tunisia. This is especially true where land is already available in areas with good renewable resources.
- Water availability is expected to be a risk faced by green hydrogen production projects in Tunisia. A key means of mitigating this risk is further development of desalination capacity in the country.
- Tunisia and Germany signed "The German-Tunisian Energy Partnership" in 2020, agreeing to collaborate on innovation and development activities to establish international hydrogen value chains.



Source: IRENA Planning Prospects for North Africa, 2023.

Sources: IRENA 'Planning Prospects for North Africa', 2023; Deloitte 'Green hydrogen: Energizing the path to net zero', 2023, GIZ 'Study on the Opportunities of "Power-to-X" in Tunisia', 2021.

Infrastructure availability and readiness

- Tunisia has an extensive natural gas pipeline network, which has been growing year-on-year. There are already engineering efforts underway to determine whether or not these pipelines could be converted to transport hydrogen cost effectively in the future.

- There are also natural gas pipelines in operation for the conveyance of gas between Tunisia and Italy. These pipelines could perhaps be converted for the international transport of hydrogen.

- Existing production of hydrogen derivative commodities, including ammonia and methanol, may assist in the storage (or transport) of green hydrogen in the country.

- Further analysis is required to ascertain whether Tunisian ports may also serve as logistics hubs for the transport (and refuelling) of green hydrogen and derivatives in the future.

Source: GIZ ‘Study on the Opportunities of “Power-to-X” in Tunisia’, 2021. Original figure adapted from Société Tunisienne de l'électricité et du gaz.

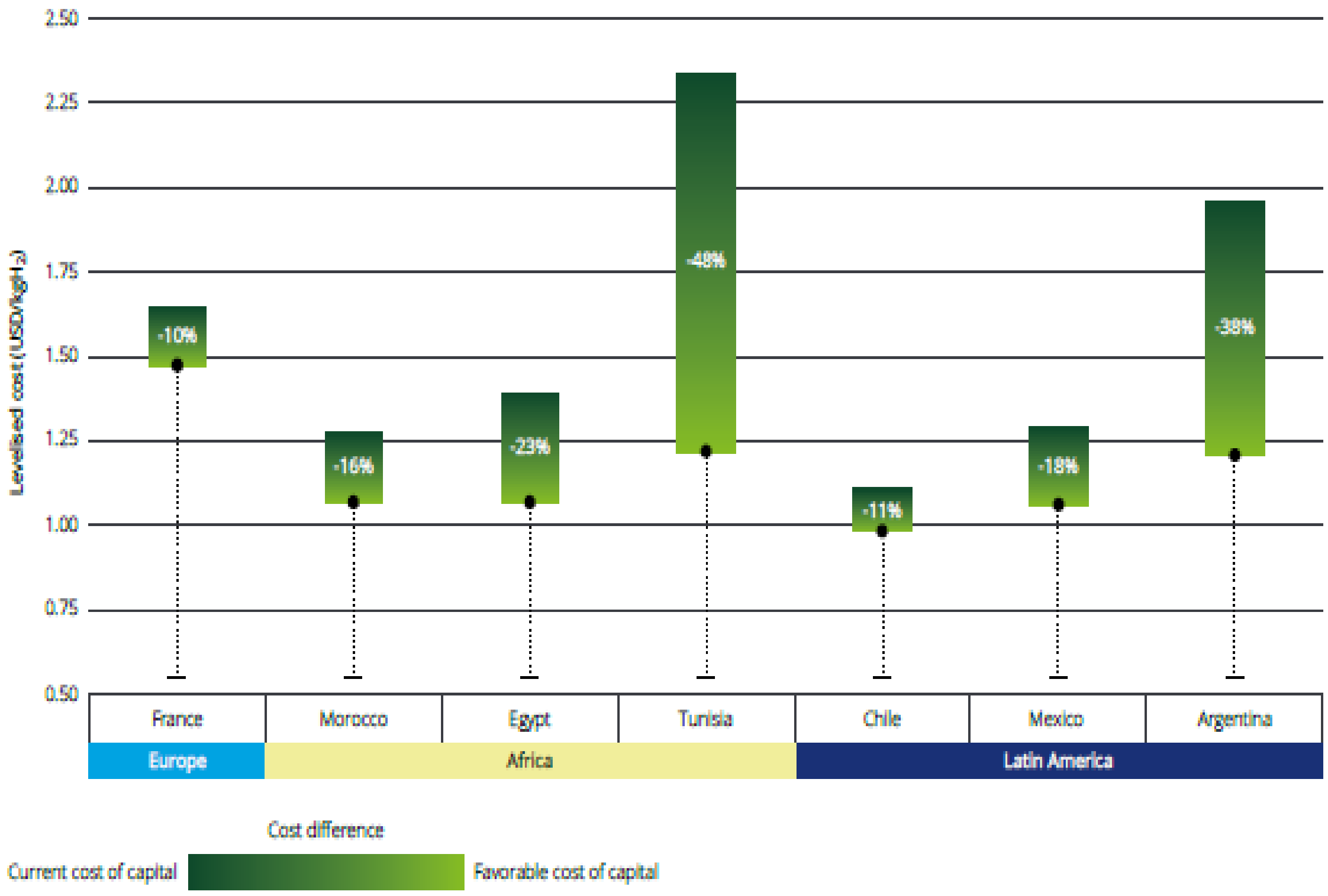
Sources: IRENA ‘Planning Prospects for North Africa’, 2023; Deloitte ‘Green hydrogen: Energizing the path to net zero’, 2023, GIZ ‘Study on the Opportunities of “Power-to-X” in Tunisia’, 2021.

Potential efficiency of hydrogen production and export opportunities

- Much analysis has been devoted to the potential for green hydrogen and green hydrogen derivatives to be exported and imported as net zero compliant commodities. It may be cheaper in the future to produce green hydrogen in countries with abundant renewable potential, for export to countries with high demand for these commodities.

- IRENA analysis has suggested that Tunisia could begin green hydrogen production for export as early as 2025. International collaboration efforts are also dedicated to developing the relevant value chains to support this emerging international market.

- The cost of capital will be a key parameter requiring attention, to support Tunisia's export potential. This is shown in Deloitte analysis from 2023.



Source: Deloitte 'Green hydrogen: Energizing the path to net zero', 2023

Sources: IRENA 'Planning Prospects for North Africa', 2023; Deloitte 'Green hydrogen: Energizing the path to net zero', 2023, GIZ 'Study on the Opportunities of "Power-to-X" in Tunisia', 2021.

Local market opportunities for decarbonisation with green hydrogen

IRENA
International Renewable Energy Agency

- Fossil-derived hydrogen is currently utilised in Tunisia in sectors such as refining, steel and chemicals. Fertiliser production may provide an offtake for local green hydrogen, via the production of ammonia, but this value chain has not been developed yet.
- Displacing these fossil-derived volumes of hydrogen with locally produced green hydrogen in the future may contribute to developing a local market, in addition to targeting export to Europe.
- Opportunities also exist to consider adopting green hydrogen for fuel production in Tunisia's transport sectors, including in aviation and maritime end uses.
- Prior studies have suggested that green hydrogen could be used to displace natural gas in Tunisia's dispatchable power generation sector.

	Utilisations actuelles de l'hydrogène	Pertinence pour la Tunisie aujourd'hui	Potentiel de développement à long terme Tunisie
Raffinage	Désulfurer et valoriser le pétrole brut lourd via • Hydrocraquage • Hydrotraitement	Le pays a une seule raffinerie sans aucune unité de traitement donc actuellement nous n'avons pas de demande pour l'hydrogène vert pour le raffinage en Tunisie.	Nouvelle raffinerie ou ajout d'unités de traitement pourrait créer une demande limitée dans l'avenir. Mais ces options comportent des risques comme les effets de verrouillage technologique ou des investissements échoués.
Fer & Acier	Réduction directe du fer (DRI) dans la production d'acier primaire	La Tunisie possède une seule aciérie avec une production d'acier secondaire à partir des ferrailles à l'aide d'un four à arc électrique. Ce procédé ne nécessite pas d'hydrogène.	Création d'une nouvelle industrie sidérurgique avec le DRI et ainsi la demande en hydrogène associée est peu probable. En plus, la Tunisie n'a que des réserves limitées de minerai de fer.
Produits chimiques	• Production d'ammoniac • Production de méthanol • Autres procédés chimiques	Actuellement, nous n'avons pas une production d'ammoniac ou de méthanol en Tunisie, les deux produits sont importé. Il y a uniquement une demande indirecte d'hydrogène aujourd'hui.	L'ammoniac vert et le méthanol pourraient être produit en Tunisie à partir d'hydrogène générés avec des énergies renouvelables pour couvrir une demande intérieure et pour l'exportation.
Chaleur à Haute température	Aucune utilisation actuelle, mais demande potentielle dans le avenir	Aucune demande d'hydrogène pour le chauffage des procédés industriels en Tunisie.	Pas de demandes potentielles en Tunisie à court et moyen terme. Une demande sur le long terme est possible mais l'utilisation directe de la chaleur solaire concentrée pourrait être une option plus réalisable.

Source: GIZ 'Study on the Opportunities of "Power-to-X' in Tunisia', 2021

Source: ien.com, accessed 28/02/24

Sources: GIZ 'Study on the Opportunities of "Power-to-X" in Tunisia', 2021.

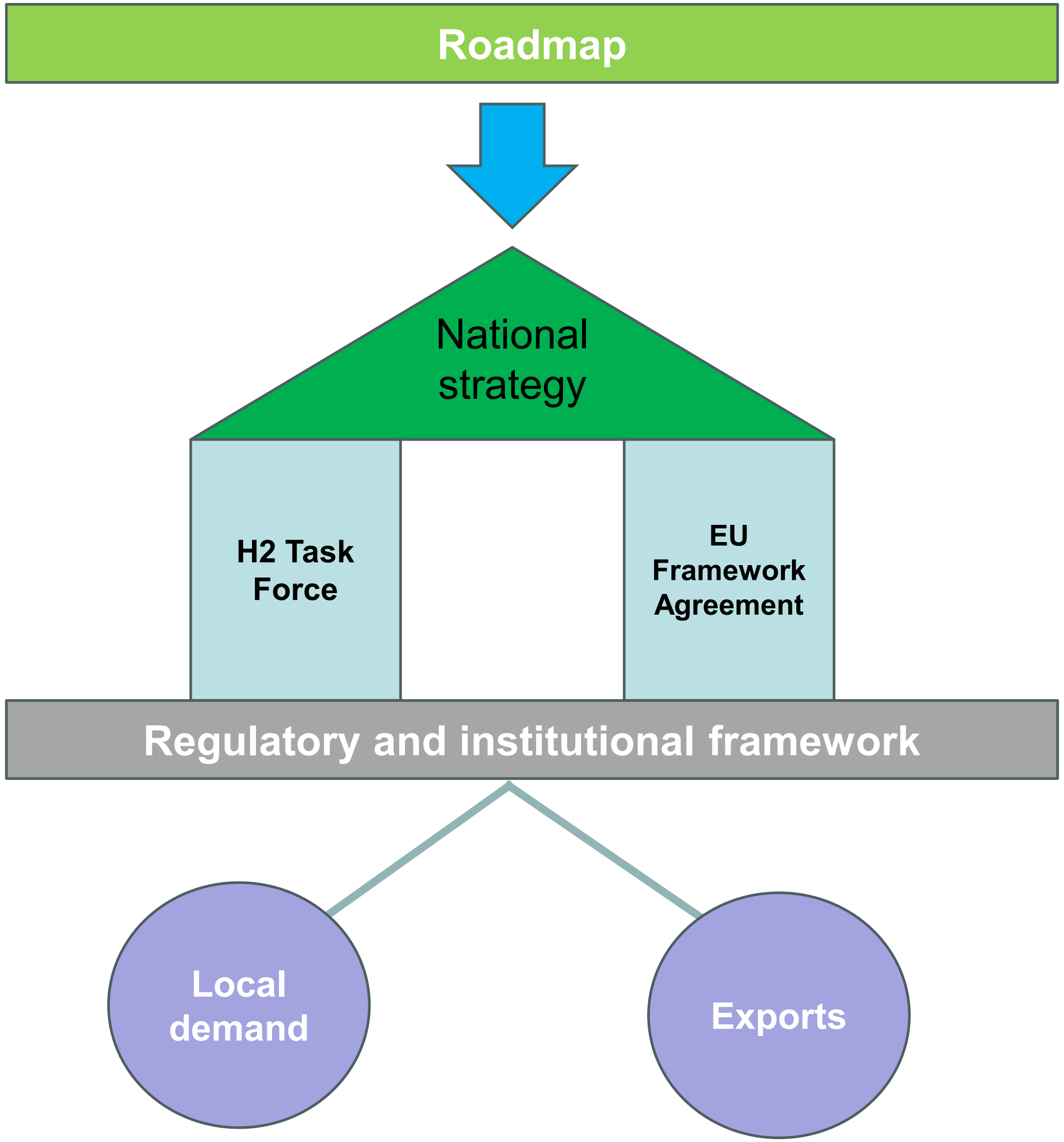
5

Tunisia Green Hydrogen Strategy

Roadmap step 2

Key messages from Tunisia H2 Strategy

Pillars for implementing strategic vision



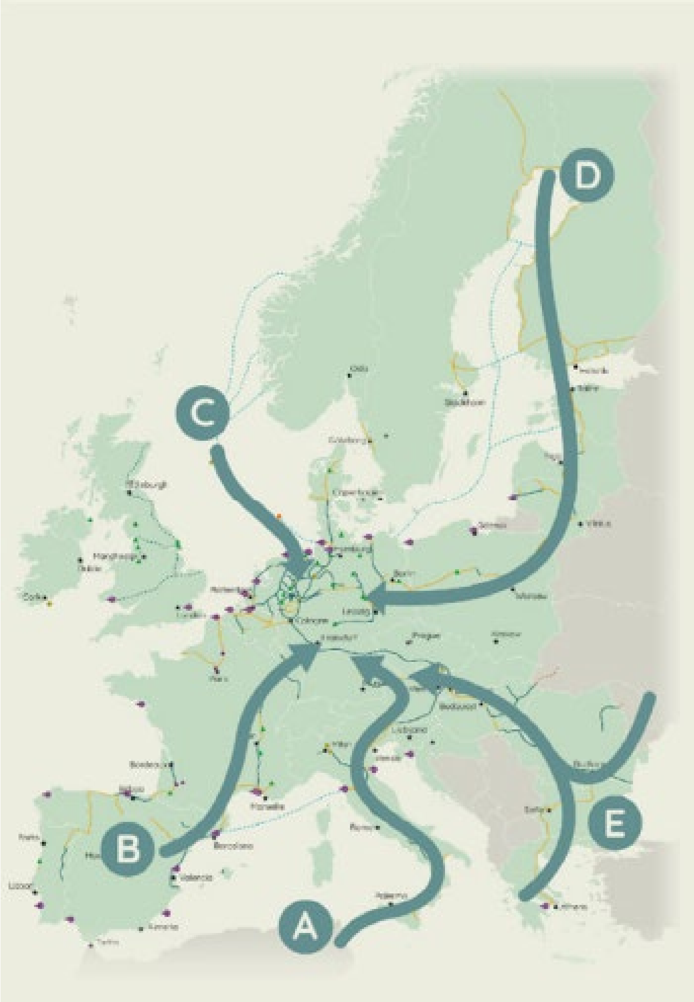
Key points from the Tunisia Green Hydrogen Strategy

- Tunisia aims to produce **8 million tonnes** of green hydrogen in 2050.
- Exporting hydrogen to Europe is the main driver for developing the hydrogen economy in Tunisia, with a target of **6 million tonnes** to be exported by 2050
- Green hydrogen is the preferred production route, with a goal of reaching **100 GW renewable energy capacity by 2050**. Desalinisation of seawater is the envisioned water source for electrolysis.
- The strategy has three main implementation tools:
    1. **Establishment of a hydrogen task force** to oversee the overall development of the national hydrogen economy.
    2. **Creation of an EU co operation framework** that will allow market alignment and attract investors to develop the infrastructure needed for hydrogen production.
    3. **Development of a national hydrogen framework** that will provide a regulatory framework to ensure a conducive environment for hydrogen economy development.
- The aim is to transport hydrogen locally as well as exporting it by **pipeline**. There is also potential to leverage ammonia as an alternative hydrogen carrier.
- Local demand for hydrogen market starts with the development of an **ammonia industry** and expands to methanol, steel and synthetic fuels.
- **QI is sparsely mentioned** in the strategy, focusing on general categories of standards required.

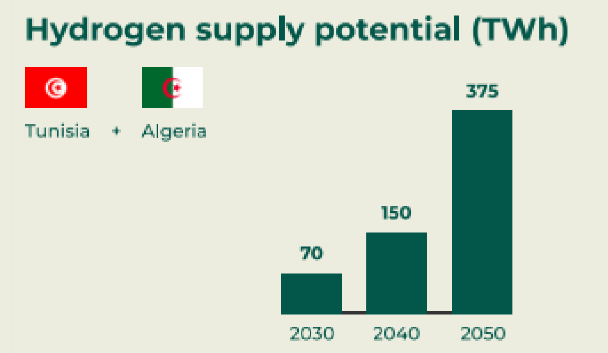
H2 development context

Main driver for hydrogen development: EU market

- Green hydrogen is increasingly being viewed as a vector to support global decarbonisation efforts.
- The European Union is placing a strong emphasis on this energy carrier to support its compliance with the 1.5° C Scenario as stipulated in the Paris Agreement.
- According to the REPowerEU initiative, the European Union aims to reach hydrogen demand of 20 million tonnes by 2030, of which **10 million tonnes will be imported**.
- This EU import demand and the export potential offered by Tunisia **due to geographical proximity** are key tenets for promoting the development of hydrogen trade between these two markets.
- The European Hydrogen Backbone forecasts that the EU hydrogen import potential from Tunisia and Algeria is 11 million tonnes by 2050.
- Tunisia and Algeria have a combined hydrogen supply potential of 375 TWh by 2050.



European Hydrogen Backbone – Corridor A is envisioned for Tunisia and Algeria



Tunisia + Algeria Hydrogen Supply Potential Projection 2030-2050

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Tunisia hydrogen development – end use application context

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International Renewable Energy Agency

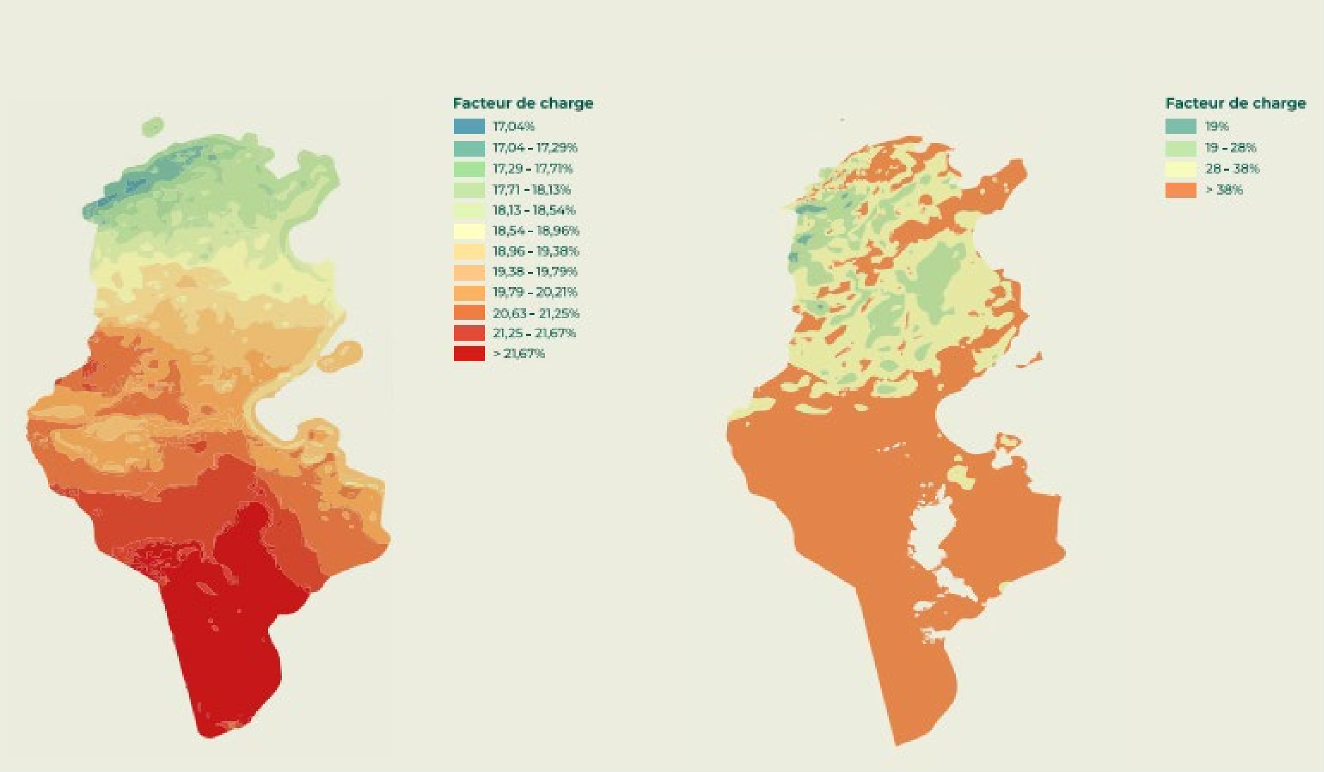
According to the Tunisia's national strategy some of the key end use applications of hydrogen are as follows:

Sector	Description	Priority
Ammonia production	Ammonia is a crucial component for agricultural fertilisers. Green hydrogen can be used to make this derivative.	High
Transport	There is a focus on refuelling ships while docked at port. Discussion on looking at hydrogen applications for road, train and aviation transport, but not a priority.	High (for shipping applications)
Methanol and steel production	Two other hydrogen derivatives are being considered, but currently there are limited existing facilities in the country.	Low
Electricity generation and storage	For hydrogen-based electrification and electricity storage to become a viable option in Tunisia, the share of renewable energy needs to increase significantly in the future.	Low

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Advantages of clean hydrogen production in Tunisia

- Tunisia is blessed with tremendous potential from solar and wind resources:
  - ❖ **250 GW** of **solar PV** with a 21% average load factor
  - ❖ **92 GW** of **onshore wind** with a 41% average load factor
  - ❖ **280 GW** of **offshore wind** with a 46% average load factor
- Tunisia can use this large renewable energy potential to generate electrical power for green hydrogen production (through water electrolysis).
- The potential for the co-existence of solar PV and onshore wind within the same geographical area is an attribute that can attract investors to Tunisia.
- By combining the utilisation factors of these renewable technologies, the cost of electricity (levelised cost of electricity [LCOE]) can be optimised, which directly influences the cost of green hydrogen (levelised cost of hydrogen [LCOH]).



Solar PV (left) and onshore wind (right) potential in Tunisia – in the southern part of the country the load factors for these technologies exceed 20% and 40% respectively

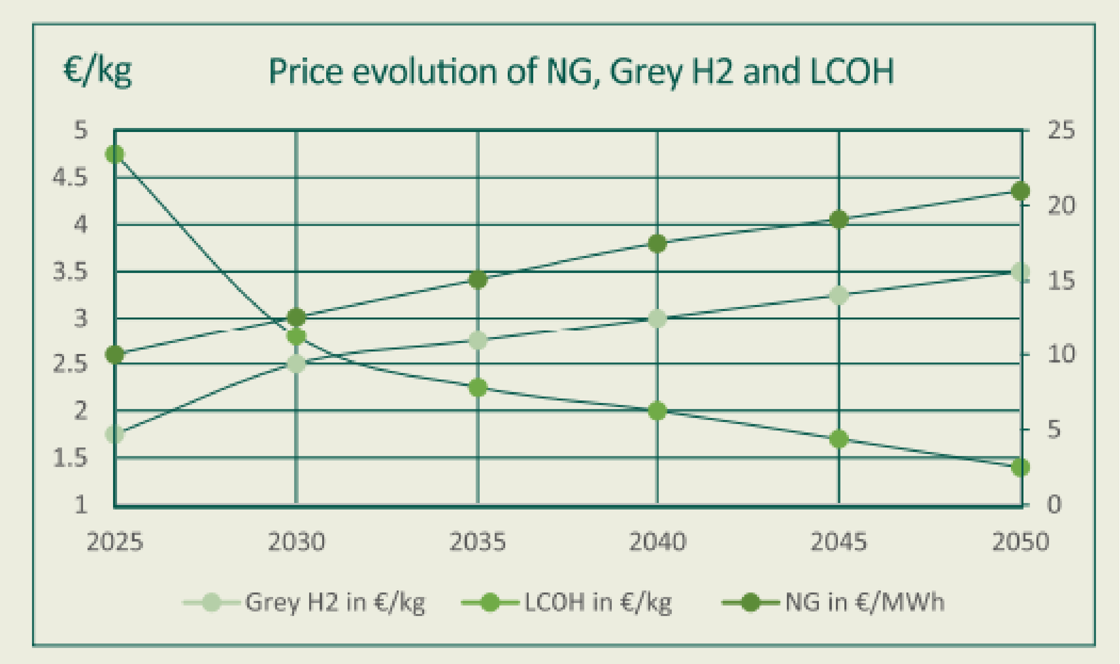
Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Cost competitiveness of hydrogen produced in Tunisia

- Tunisia is aiming for its energy supply and demand to be fully met by renewables from 2050. The envisioned renewable energy mix in an optimistic scenario for GH2 production can be seen in the table below:

	2025	2030	2035	2040	2045	2050
Solar PV (% mix)	100	40	30	30	30	30
Onshore Wind (% mix)	0	60	70	60	50	40
Offshore Wind (% mix)	0	0	0	10	20	30
Productivity (MWh/MW)	1 857	2 898	3 071	3 150	3 229	3 308
RE Capacity (GW)		5	16.4	28.4	54	100

- As seen the table above, in the scenario proposed by Tunisia, PV and onshore wind are key enablers of green hydrogen production, with offshore wind joining the mix in 2040.
- The LCOH in this optimised scenario would decrease from **EUR 4.7/kg H2 in 2025 to around EUR 1.4/kg H2 in 2050**. The modelling for this cost prediction also suggests that green hydrogen would become more competitive than grey hydrogen from between 2030-2035.



Green Hydrogen cost evolution when compared to natural gas and grey hydrogen between 2025-2050

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

H2 roadmap (or vision)

Tunisia Hydrogen Roadmap 2050

- Tunisia aims to become a **sustainable, carbon-neutral and green hydrogen-inclusive economy** by 2050.
- Target production of **8 million tonnes of green hydrogen** in 2050 – with 6 million tonnes to be exported.
- **100 GW** installed renewable energy capacity and priority on **water electrolysis** production path.
- Tunisia's water stress coefficient is **96%**, hence **desalination of seawater** will be the source for electrolysis.
- The investment required for the roadmap implementation is **EUR 117.2 billion**, covering PtX products, gas infrastructure, renewable power plants and electrolysers.
- The export of GH2 and its derivatives, as well as the substitution of imports by domestic production, can result in positive trade balance of **USD 2.3 billion in 2035 and USD 9.4 billion in 2050**.

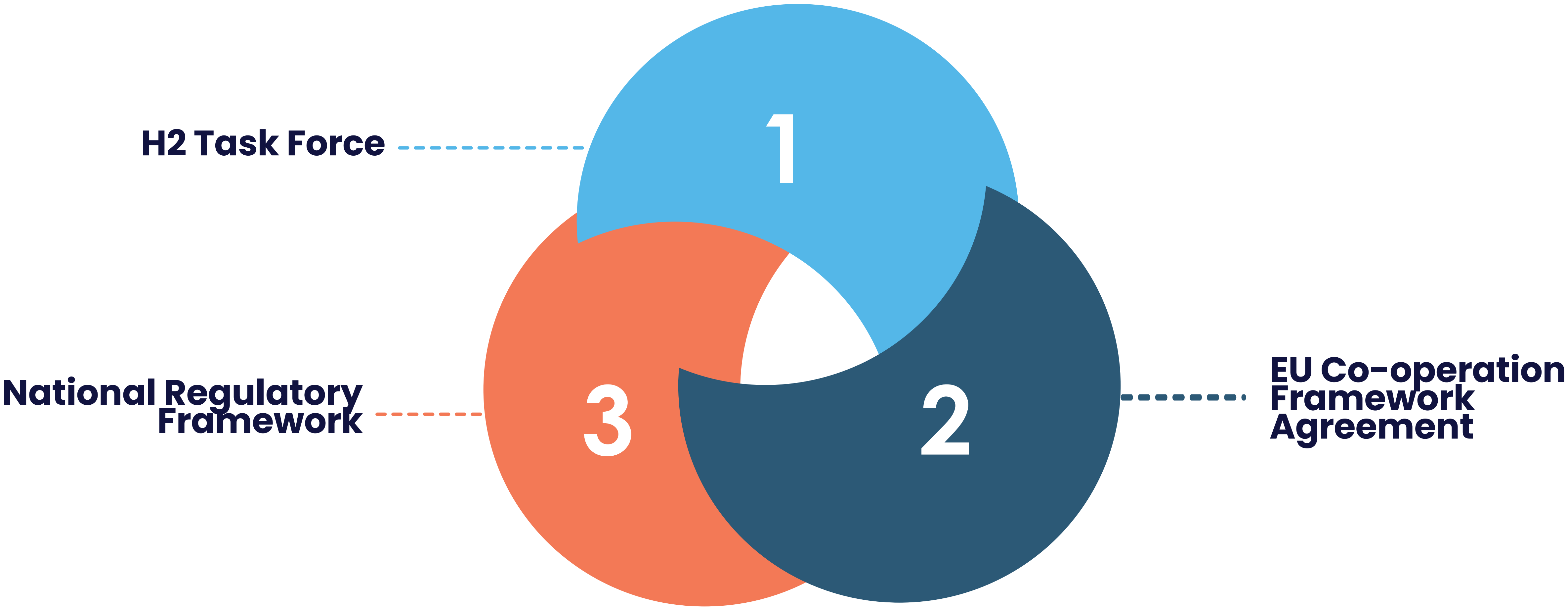
	2025	2030	2035	2040	2050
GH_2 production* (kt)	-	~ 320	~ 1100	~ 2100	~ 8300 (6000 export via pipeline)
Electrolysers capacity (GW)	-	3,85	12,9	23,3	86,8
RE capacity (GW)	-	~5	16,4	28,4	~ 100
Jobs (n)	-	19000	64000	116000	434000
Avoided emissions (kt CO_2eq)	-	217	1400	4800	19000

** Total production: local market + export*

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

H2 strategy

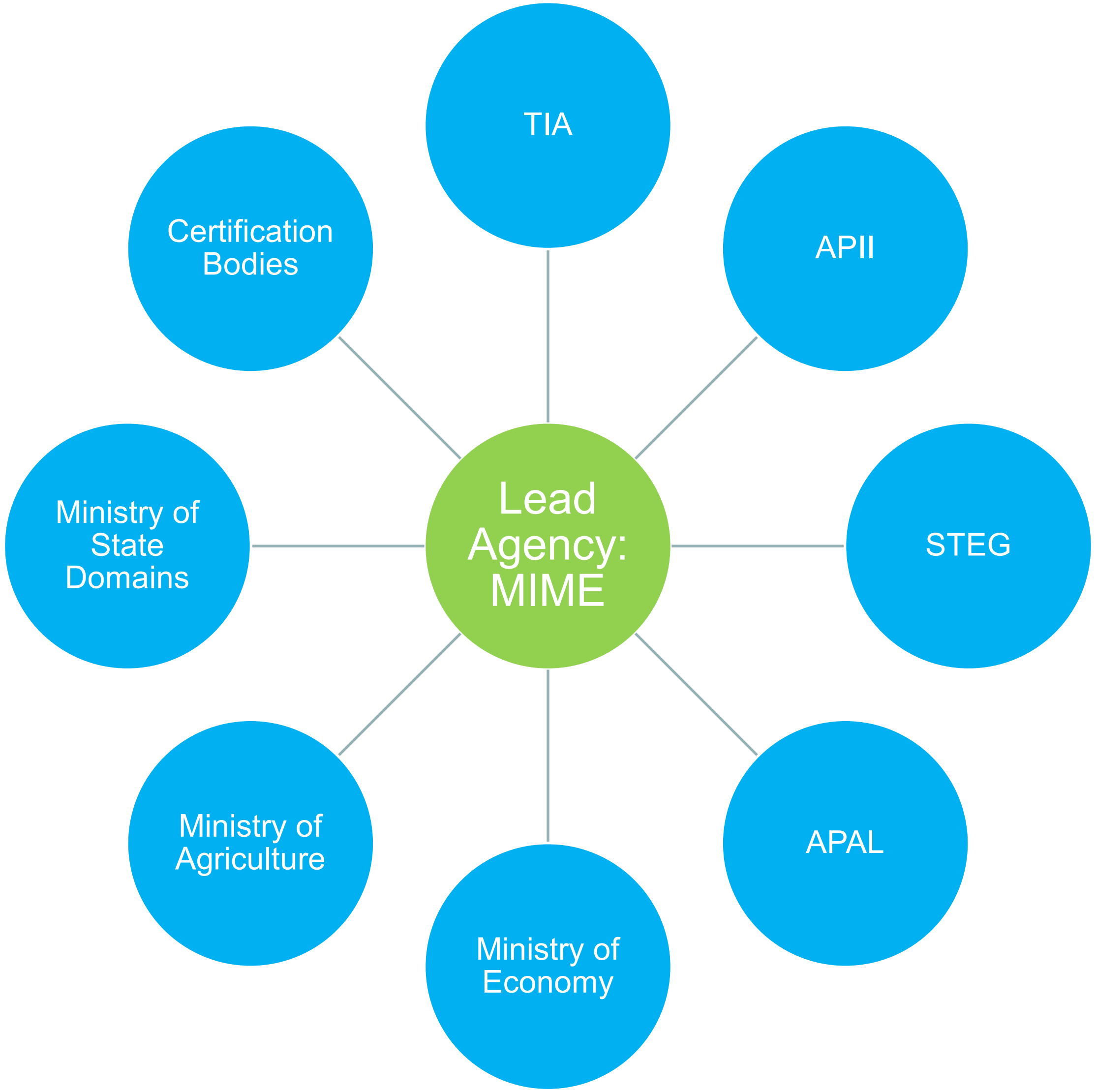
Tunisia strategic pillars to realise 2050 vision



Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Tunisia H2 Task Force

- The proposed task force is envisioned to have a mandate to support the government in developing its GH2 and derivatives sector.
- The task force will have **two subcommittees focusing on local demand and export** to the European Union respectively.
- The task force will act as the interlocutor between local demand and exports of hydrogen by managing matters relating to **infrastructure provision, setting regulatory framework guidelines and making connections with international donors**.
- With regard to exporting to the European Union, it is expected that this task force will engage the **Tunisian Branch of the Trans Tunisian Pipeline Company and the Trans-Mediterranean Pipeline Company** to explore how hydrogen can be transported.



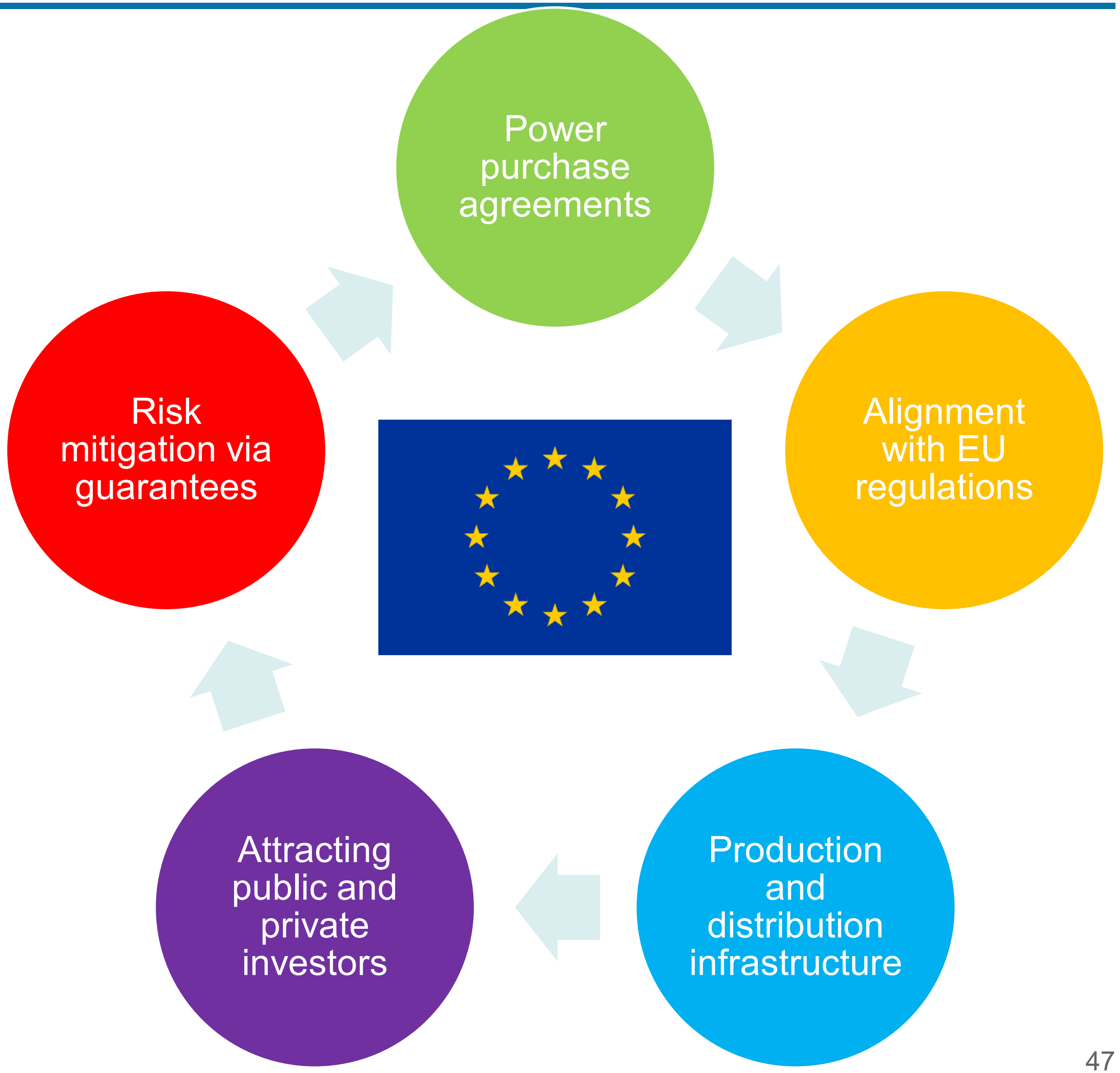
National entities that will be represented in the H2 Task Force

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Exporting to the EU – key actions planned

Tunisia is expected to play a key role in the EU Hydrogen Backbone initiative, and the following areas of co operation within a co operation agreement are envisioned:

- Mobilise EU member states for the conclusion of **purchase agreements for GH2/PtX**.
- Support for the **compliance of the Tunisian regulatory framework** with that of the European Union.
- Support for the construction of GH2 **production and distribution infrastructure**.
- Open market for **public and private investors**.
- Reducing the financial risks of projects through **guarantee mechanisms**.



Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

National regulatory framework

- For a hydrogen economy to be established in Tunisia, a robust regulatory framework needs to be established so that there is clear guidance for national and international stakeholders on how they can contribute to the development of this economy.
- Key legal and policy matters that will be considered in the development of this framework are as follows:

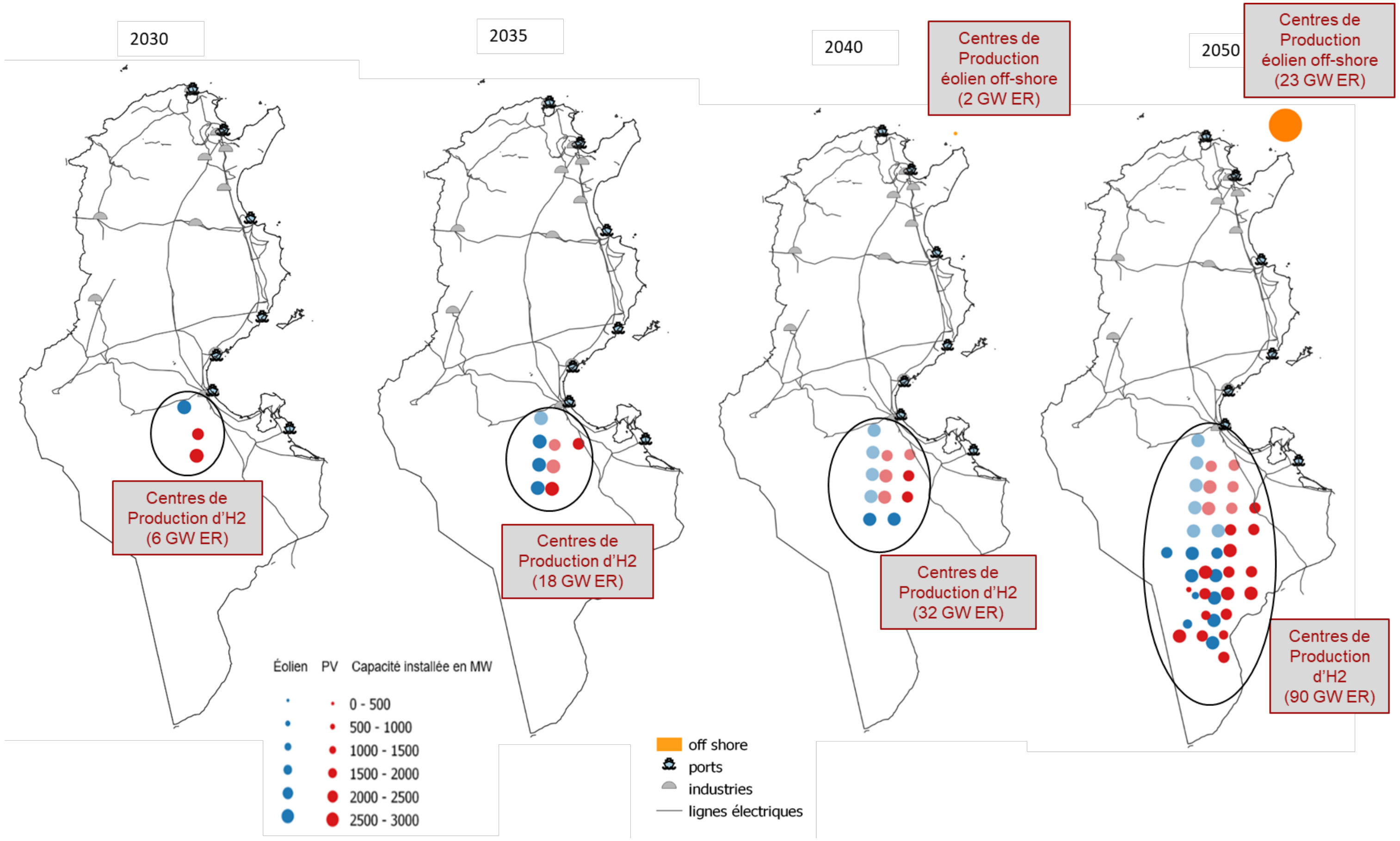
The definition of “green” hydrogen	Authorisation and permitting protocols for GH2 projects	Site selection criteria for electrolysers
Creation of a land agency for renewable projects	Hydrogen safety standards for production/storage and transport	Desalination protocols for seawater
Development of special economic zones for hydrogen industrial clusters	Access to the electricity network and incentive mechanisms (feed-in tariffs and guarantees of origin)	Creation of a decree to establish the H2 Task Force

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Local demand for H2

Vision to create a GH2 hub by 2050 – hydrogen valleys

- By 2030 the main objective is to develop 6 GW of renewable energy capacity in Gabes Governate, 25 km from Nabes pipeline (75% free capacity). Temporarily blend hydrogen into the pipeline.
- Between 2030 and 2035 to establish five new production centres in Gabes and Kebali. A water supply pipeline from Gabes will need to be extended to Kebali.
- Between 2035 and 2040 to establish four new production centres in Medenine and Tataouine.
- During the final decade, 2040-2050, establish 17 PV and 10 onshore wind farms in Tataouine. Also explore potential for offshore wind–hydrogen coupling.



Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Spur ammonia production in Tunisia

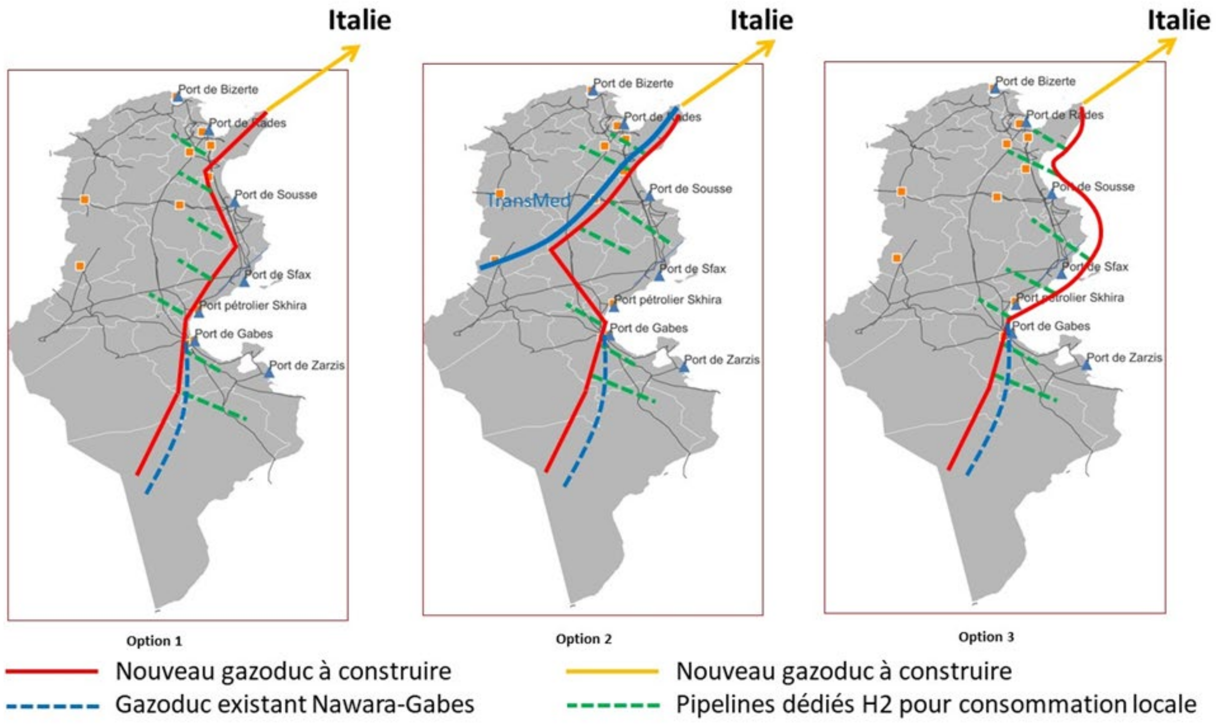
- Tunisia aims to develop its first green ammonia production plant between 2025 and 2030 as a **kick-start for local hydrogen demand.**
- The project will be developed in Akarit within the governate of Gabes. This site was chosen for the following attributes:
  - Close to major road transport routes (GP1 national route and A1 motorway)
  - Near key port infrastructure (30 km from port of Gabes and 25 km from port of Skhira)
  - Close to HP 20" gas pipeline as well as power lines (150 kV-225 kV)
  - Potential to install a solar PV plant with a capacity of 200 MW, allowing annual electricity production of 350 GWh
  - Annual production capacity for green hydrogen of 7 000 tonnes, which can translate into **32 000 tonnes/year of green ammonia**

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Export strategy for H2

Deliver hydrogen to Europe via natural gas pipeline

- Tunisia plans to export an annual quantity equivalent to 300 kt of hydrogen from 2030, and expand to 1 000 kt in 2035, with a final goal of **6 000 kt in 2050**.
- Conversion of existing Transmed gas pipeline (TTPC and TMPC) to a dedicated green hydrogen pipeline does not seem to be an option due to Algeria–Italy agreements; therefore **new pipelines will need to be built.**
  - **Option 1**: Construct a new onshore gas pipeline from Gabes to the Transmed sea entry point.
  - **Option 2:** Build a new pipeline from Gabes to Haouaria within the right-of-way of Transmed's existing gas pipeline.
  - **Option 3:** Build an offshore gas pipeline with near-shore routing from Gabes to Haouaria, to join Transmed at the point of entry into the sea.
- The investment range for the three options is **between EUR 9.6 billion and EUR 13.4 billion.**
- From a technical standpoint, international standard **ASME B31.12** defines the compatibility criteria for new and existing steel pipelines for the transport of hydrogen.



	2030	2035	2040	2045	2050
Ammonia	22	72.5	127	232	347
Methanol	-	25.5	64	108	197
Hydrogen	300	1 045	1 802	3 716	7 327
Synthetic fuels	-	-	119	240	403
Quantities of green hydrogen in kt	322	1 143	2 112	4 296	8 274

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

Overarching hydrogen export considerations

International Renewable Energy Agency

Export pillars

Hydrogen derivatives

- Ammonia is a prime candidate due to the know-how of Tunisian Chemical Group, which stores and uses this commodity for local and export purposes

- Port of Zarzis has been identified as a potential candidate for the production and export of ammonia. It has 134 hectares of space available and aims to reach **134 kt production capacity by 2035**.

- Port of Gabes can focus on local demand requirements

Bunkering international vessels

- Tunisia wishes to cater for bunkering of ships powered by ammonia and methanol.

- Port of Bizerte has adequate bunkering facilities and aims to provide **183 kt and 62 kt of ammonia and methanol by 2035** respectively.

- Source of ammonia and methanol are from trucks or sea-going vessels that head towards Port of Bizerte

Synthetic fuels

- Not expected to take place until 2040, with a target set of reaching **125 kt in 2050**.

- Ports of Skhira and Zarsis are expected to play a role in the export of these fuels.

- CO_2 sequestration from non-biogenic and biogenic sources is expected to drive synthetic fuel production.

Future European import regulations

EU Renewable Energy Directive (RED II & III)

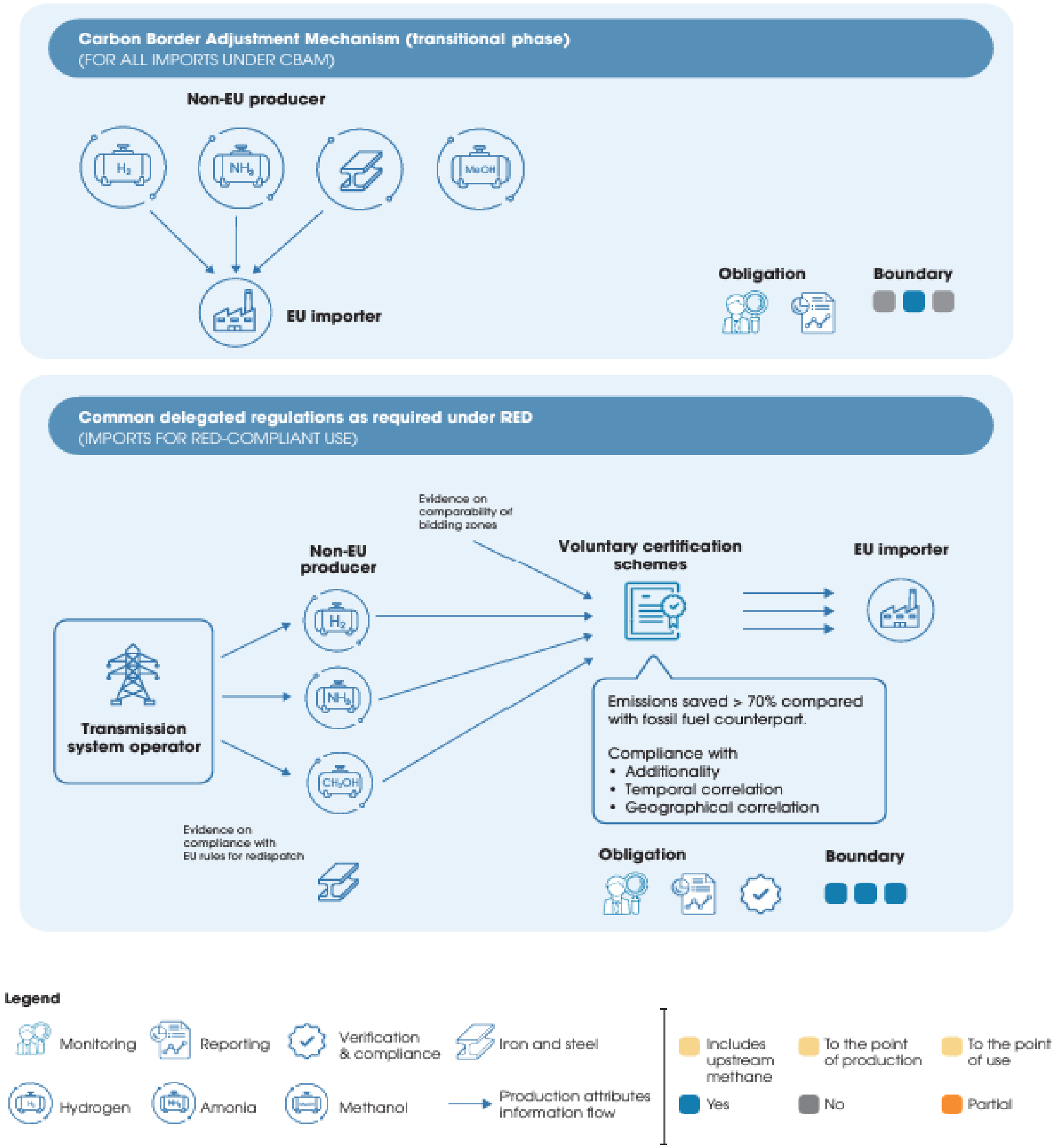
- Sets ambitious targets for the consumption of renewable fuels of non-biological origin (RFBNOs), which are hydrogen derivatives.
- Comes with strict sustainability requirements.

EU Emissions Trading System

- From 2025, shipping companies must surrender emission allowances (for the previous year) that cover an increasing share of emissions (from 40% of 2024 emissions to 100% of 2026 emission by 2027).

Carbon Border Adjustment Mechanism (CBAM)

- This regulation is aimed at preventing the relocation of emissions-intensive companies to countries outside the European Union with or without a lower carbon price.
- From 2027 onwards, EU importers will need to pay a “carbon tax” for hydrogen and ammonia, as well as key commodities such as iron and steel, basic organic chemicals and fertilisers.



Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ) and Global trade in green hydrogen derivatives: Trends in regulation, standardisation and certification (IRENA 2024)

Alignment of H_2 roadmap and strategy

Tunisia Green Hydrogen Strategy and roadmap alignment

- To implement the strategic vision and achieve the strategic targets the following steps have been identified by the government:

2025

Hydrogen Task Force Operational

Preparatory activities for GH2 regulation framework development

GH2 reflected across all national policy visions

Development of hydrogen industrial cluster in south of the country

2030

Green ammonia project in Gabes operational (80-100 kt/year)

Construction of pipeline to transport 300 kt/year GH2 to the European Union

2040

Export pipeline to the European Union reaches 1 million tonnes/year GH2 capacity

Production of synthetic fuels commences with an objective to have a single methanol-powered vessel

Hydrogen industrial cluster in the south of country is operational

2050

Export pipeline reaches intended capacity of 6 million tonnes/year GH2 capacity

Market for hydrogen derivatives is established

GH2 is a key contributor to net zero economy in Tunisia

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

6 Assessment of the national quality infrastructure system in Tunisia

Roadmap step 3

Assessment of the national QI system: Methodology

With the aim of identifying strengths and areas for improvement in the national QI system, independently from the specific services required, the following methodology was applied:

- **Desk research** of public information on the status of the national QI system
- Interviews with **35 representatives of the national QI system**
- Analysis of the status of the national QI system based on **predefined criteria**

The results of the analysis are presented in the following slides.

Assessment of the national QI system: Summary of key results

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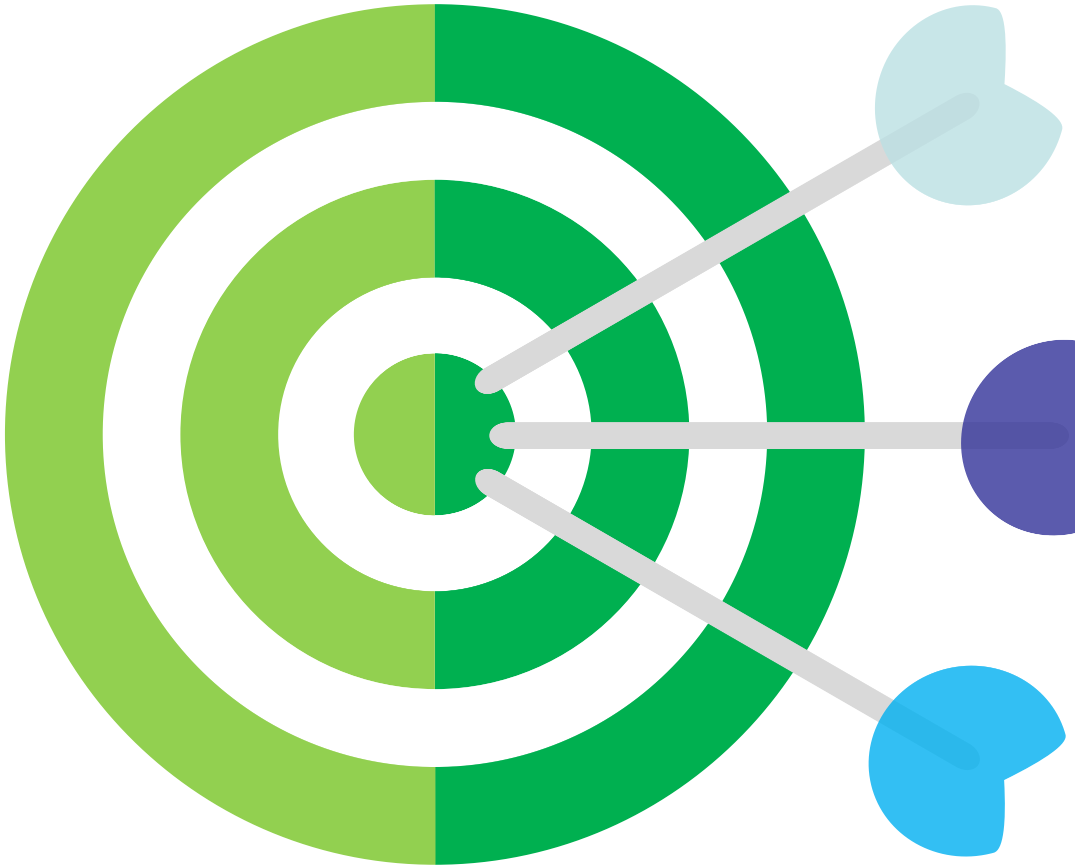
- QI has a long history in Tunisia, contributing to a general awareness on the importance of quality assurance.
- All relevant QI organisations exist. Several are well established and have a long history.
- Legal and institutional framework: The existing framework covers several parts of QI. Recommendations: Develop a national quality policy and quality law, ensuring a clear separation of functions and the required financial resources. Define aligned development plans for the QI organisations.
- Co ordination and HR: Key QI organisations are co ordinated by MIME. Recommendations: Strengthen co-operation and co-ordination amongst QI organisations and between QI and the private sector. Foster HR capacities based on the development plans.
- Standardisation: INNORPI is well established. Recommendations: Expand participation in international technical committees (TCs) and strengthen national mirror committees. Train management and staff according to the organisation's strategy.
- Metrology: ANM is established as a national metrology institute (NMI) with several calibration and measurement capabilities (CMCs) (by the designated institute DEF-NAT). Recommendations: Develop an updated metrology law and related strategy, assuring the fulfilment of the core functions and the national recognition of the NMI.
- Testing: A large number of testing laboratories offer the most demanded accredited services. Recommendations: Develop a recognised testing strategy for green hydrogen aligned with the public priorities. Further develop the capacities and services of public testing laboratories according to the strategy. Support the accreditation of public laboratories and co operation between laboratories.

Assessment of the national QI system: Summary of key results

- Certification/inspection: Several certification bodies are accredited for the most demanded services. Recommendations: Update the legislation for certification and inspection, permitting other certification bodies besides INNORPI to certify based on Tunisian product standards. Develop a national strategy for certification and inspection, expand the accreditation of public organisations and establish a notification system for inspection bodies and foreign certificates.
- Accreditation: TUNAC is well established and internationally recognised for most relevant scopes. Recommendations: Include proficiency test providers in accreditation scope and define an updated accreditation strategy.
- Technical regulation and market surveillance: The functions of technical regulation and market surveillance are defined in an updated law on the safety of industrial products. Recommendations: Update technical regulations according to national priorities. Assure notification according to WTO-TBT and improve co ordination of related activities amongst the organisations involved.

QI system: General overview



QI organisations

All relevant QI organisations exist. Several are well established and have a long history.

QI awareness

Based on this long history, there is a general awareness on the relevance of quality assurance and QI. This includes the private sector.

QI status

Several QI organisations are operating according to international standards/good practices and have good relations with the relevant international organisations (e.g. TUNAC, INNORPI).

QI system: Legal and institutional framework

Strengths
• Existing legal framework covers several parts of QI.

Potential for further development
• Definition of a national **quality policy and quality law**, clearly describing mandates, organisational responsibilities and competences. • Update of **specific legislation** based on the quality policy and quality law. • Implementation of structures for QI organisations that ensure **independence** of decisions and financing. • Definition of **aligned development plans** for QI organisations. • Ensure a **clear separation of the functions** of public QI organisations (in specific cases, for example standardisation and certification, the separation is not sufficiently clear). • Ensure **sufficient financial resources** for the development and maintenance of public QI organisations, guaranteeing at the same time **independent decisions on the use of budgets**.

QI system: Co-ordination and HR

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Strengths

- Key organisations in the QI system are co-ordinated by MIME.
- Several QI organisations are well known and nationally recognised.

Potential for further development

- Development of QI services focused on current and future **demand** for their services.
- Improvement in the **co-ordination and co-operation** amongst QI organisations and with the private sector, e.g. supported by a “National Quality Commission”, with representation from the relevant organisations and including the related ministries.
- Strengthening of **HR capacities** and improvement in **staff retention**.

Standardisation

Strengths

- INNORPI is a **well-established** standardisation body with financial autonomy.
- INNORPI is **full/participating member** of ISO, IEC and regional standardisation organisations. It is represented in several relevant international **TCs** and has related mirror committees.
- A **standardisation strategy** and **standardisation programme** exists.
- The department for **information on standards** is working effectively.
- A relatively **large number of national standards** in relevant areas exist.

Potential for further development

- Expansion of **representation on international TCs** and the discussion of international standards in **national mirror committees**.
- Implementation of **training programmes** for INNORPI management staff and key stakeholders.

Metrology

Strengths

- ANM is **established as an NMI** according to Law No. 2008-12, Article 15, 11.02.2008 under Ministère du Commerce et de l'Artisanat.
- ANM as signatory to the **CIPM Mutual Recognition Arrangement** with BIPM, with two **designated institutes**: DEF-NAT (electricity and magnetism, and time and frequency) and INRAP (metrology in chemistry).
- DEF-NAT with several **CMCs** in time, frequency and electricity.
- Large number of **accredited secondary metrology laboratories** covering the basic services.

Metrology – continued

Potential for further development
• Develop an up-to-date and commonly recognised **national metrology law and related aligned national metrology strategy**, ensuring **independent** development of the national metrology system. • Ensure the NMI is recognised both internationally **and by relevant national organisations**. • Ensure the NMI covers its **core national functions**, i.e. establishment and maintenance of national measurement standards, establishment of traceability and distribution of units to all relevant organisations, maintenance and development of the national metrological system. • **Develop the existing services** of the NMI and designated institutes, including the required training, introduction of management systems, intercomparisons and accreditation/CMCs. • **Evaluate the designation of other institutes** with advanced metrological competences.

Testing

Strengths

- A large number of private testing laboratories offer the **most demanded accredited services**.
- Several public organisations, i.e. “technical centres”, offer specialised testing services.

Potential for further development

- Develop and implement a **recognised national testing strategy for GH2**, defining clear roles and responsibilities for public organisations, as well as **areas of development** aligned with national priorities.
- Further develop the capacities and services of public testing laboratories according to the strategy, including training, business planning, organisational development, quality management and equipment.
- Foster the **accreditation of public testing laboratories** and establish a system of recognition by the relevant ministries.
- Support **co-operation amongst laboratories**, e.g. by creating laboratory networks.
- Ensure access to the most required services at the testing laboratories, including **calibrations, reference material** and **round robin/proficiency tests**.

Certification and inspection

Strengths
• Several inspection bodies and certification bodies for systems certification are accredited, as well as one for personnel certification. • INNORPI is recognised as the product certification body and organisation issuing the quality mark based on Tunisian Standards "NT".

Potential for further development
• Create an updated legal basis for certification and inspection according to international good practice, ensuring **other certification bodies besides INNORPI may certify products** based on Tunisian Standards. • Develop an updated and **recognised national strategy** for the development of certification and inspection. • Ensure public certification bodies are **accredited** for their services and base their decisions on **accredited tests**. • Implement a system of **notification and recognition** of inspection bodies and foreign certificates.

Accreditation

Strengths

- TUNAC as the national accreditation body is **nationally recognised and holds international mutual recognition agreements with ILAC, IAF and EA**.
- TUNAC offers the **most demanded accreditation services**.
- The organisational structure guarantees the **independence** of the organisation and its decisions.
- A **large number of organisations accredited** by TUNAC exist, contributing to the financial stability of the organisation.
- The organisation has active relations with **foreign accreditation bodies** as well as with the relevant **regional and international organisations**.

Potential for further development

- Develop the accreditation service for **proficiency test providers**.
- Define an up-to date and recognised **accreditation strategy**, based on current and future demand.

Technical regulation and market surveillance

Strengths

- Technical regulation and market surveillance are carried out by several ministries in Tunisia.
- The related functions are defined in a draft law on the safety of industrial products.

Potential for further development

- Define priorities for market surveillance, considering national priorities.
- Ensure notification according to the WTO-TBT requirements.
- Review and update technical regulations according to their priority.
- Improve co-ordination of regulation and market surveillance activities amongst the organisations involved.

7 Assessment of the quality infrastructure services and their demand in Tunisia

Roadmap step 4

QI service offering and demand assessment: Methodology

With the aim of comparing the QI services required and offered along the green hydrogen value chain, the following methodology was applied:

- Desk research on the services offered by the national QI system, considering the following:
    - ❖ Interviews with 35 representatives of the national QI system.
    - ❖ Email exchange on detailed questions with 12 representatives of the national QI system.
    - ❖ Analysis of conformity assessment services accredited in Tunisia, including the specific annexes to the accreditation certificates.
    - ❖ Interviews with three experts on selected services to clarify specific questions.
    - ❖ Analysis on information available online of 33 conformity assessment organisations in Tunisia.
- Consideration of green hydrogen potential and National Green Hydrogen Strategy.
- Analysis of the information obtained based on the predefined checklist of QI services required.

The results of the analysis are presented in the following slides.

Levels of QI development to support the national green hydrogen strategy

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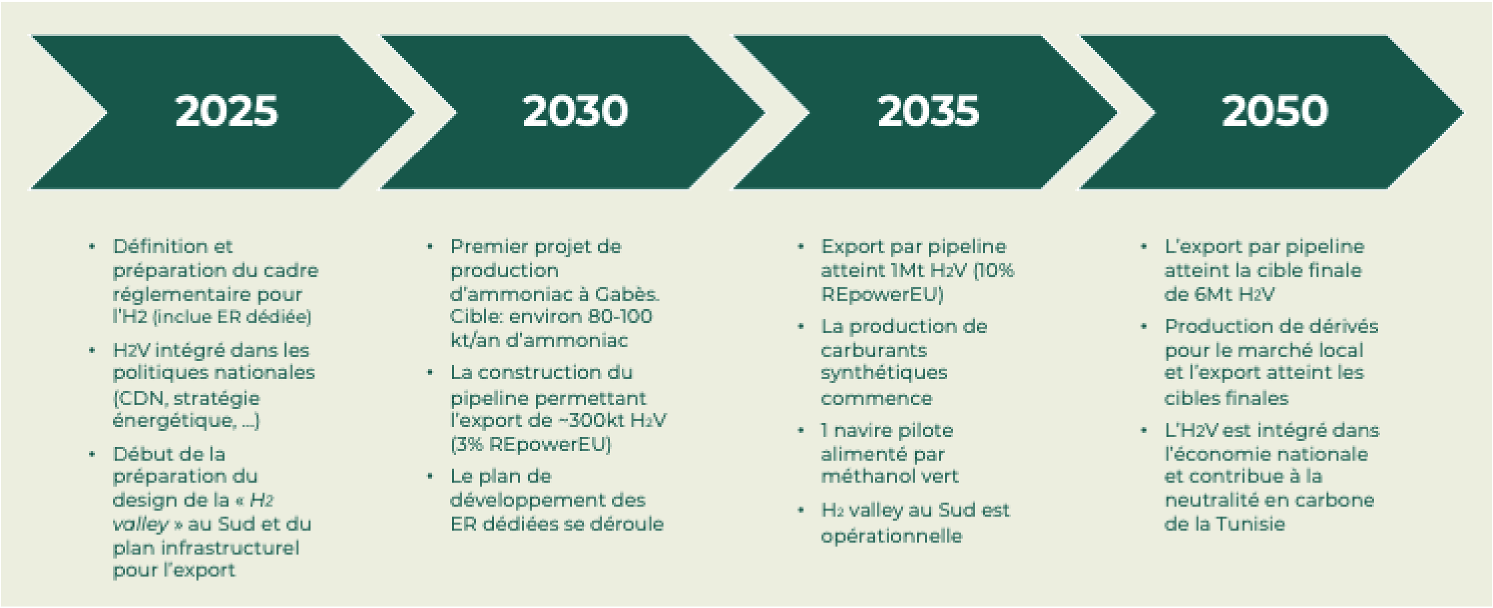
Stages in implementing the National Green Hydrogen strategy.

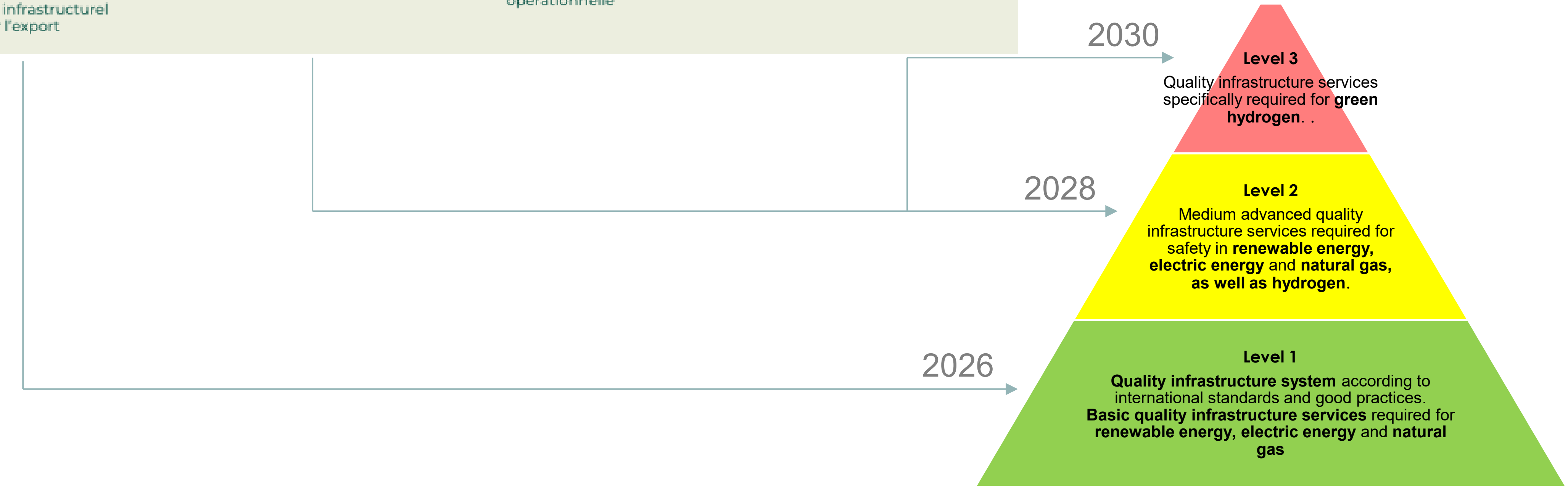


↓

Consideration in the planning of the QI service development.

(Note: The timeline for the QI development is very ambitious!)

Levels of QI development defined in the QI for green H2 roadmap



QI service development: Strategic focus

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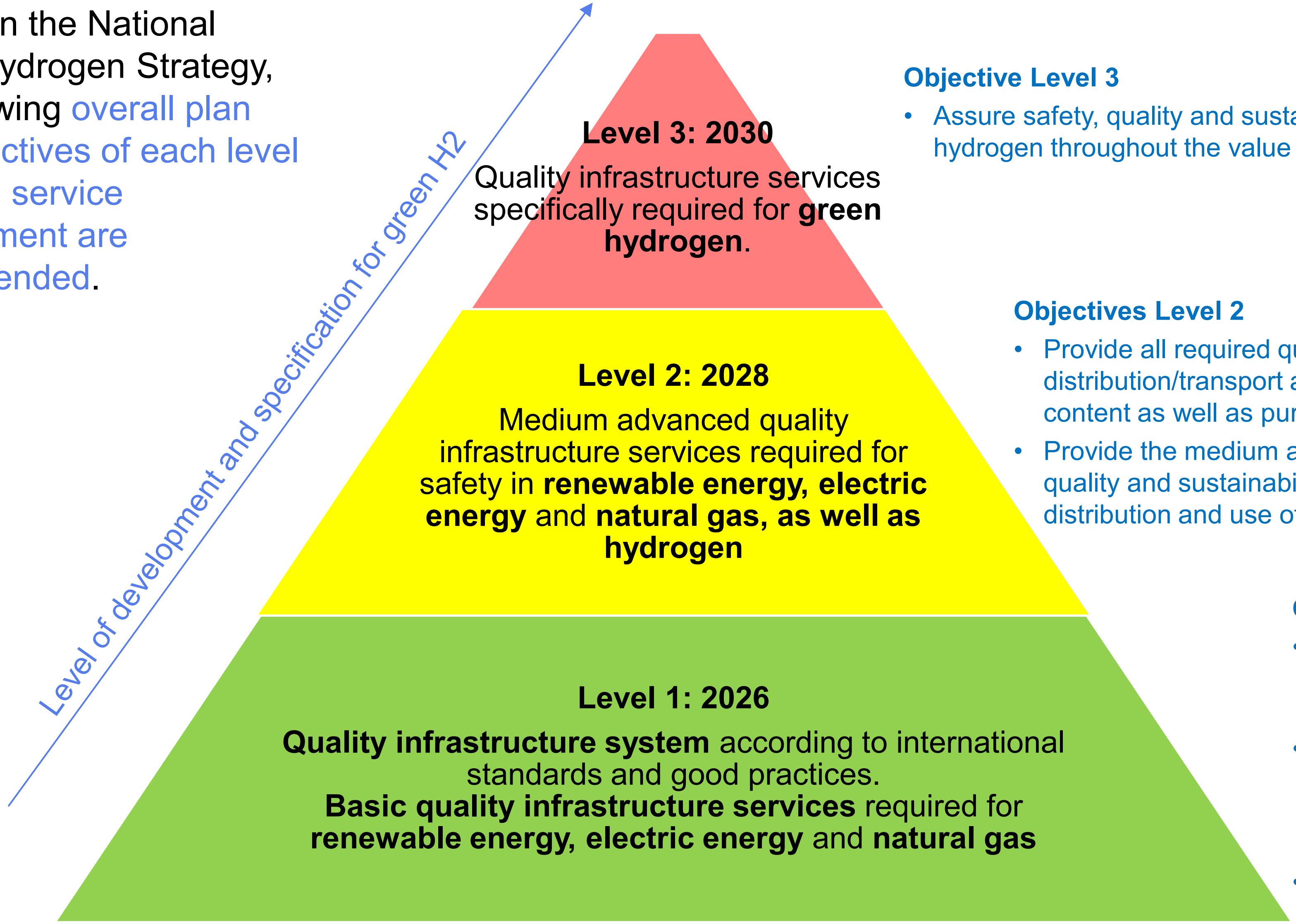
In line with the timeline defined in the National Green Hydrogen Strategy, the following overall plan and objectives of each level of the QI service development are recommended.



Objective Level 3

- Assure safety, quality and sustainability of green hydrogen throughout the value chain

Objectives Level 2

- Provide all required quality infrastructure services to assure safe production, distribution/transport and use of gas mixtures with more than 20% hydrogen content as well as pure hydrogen
- Provide the medium advanced quality infrastructure services for assuring quality and sustainability in renewable energy generation as well as the distribution and use of electric energy and gas (especially natural gas)

Objectives Level 1

- Establish a quality infrastructure system in accordance with international standards and good practices
- Provide all required quality infrastructure services to assure safety in renewable energy generation as well as the distribution and use of electric energy and gas (especially natural gas)
- Provide the basic quality infrastructure services required to assure quality and sustainability in the previously mentioned sectors

QI service development: Strategic focus

Scenario B and C are relevant for Tunisia: QI services required for green hydrogen production for export as well as for national use should be developed. The import of green hydrogen is not relevant.

Renewable Energy Generation	Production			Distribution and transport	Utilization
	Electro-lysis	Conversion into derivates	Storage		

Scenario C: National production, use and export of green hydrogen

- Quality infrastructure (QI) services considering the results of the QI analysis for: renewable energy generation, electric safety, gas (especially natural gas) as well as production, distribution/transport and utilisation of green hydrogen and its derivatives.
- Technical regulation on safety, human health and environmental aspects along the entire value chain.

Scenario 2: National green hydrogen production for export

- QI services considering the results of the QI analysis for: Renewable energy generation, electric safety, gas (especially natural gas) as well as production and distribution/transport of green hydrogen and its derivatives.
- Technical regulation on safety, human health and environmental aspects along the value chain, excepting use of green hydrogen.

Scenario 1: Import of green hydrogen for national use **(not relevant for Tunisia)**

- QI services considering the results of the QI analysis for: electric safety, gas (especially natural gas) as well as distribution/transport and utilisation of green hydrogen and its derivatives.
- Technical regulation on safety, human health and environmental aspects with focus on import/market surveillance, distribution/transport and utilisation of green hydrogen and its derivatives.

Standardisation: Status of existing services

	Renewable Energy Generation	Production			Distribution and transport	Utilization
		Electro-lysis	Conversion into derivates	Storage		

Level 1	• Adopt international standards in the national standard system as defined in the database for Level 1. • At least "observer" status in international TCs and establishment of the related national mirror committees in the following areas: IEC TC 31 – Explosive atmospheres and related subcommittees (i.e. SC 31J, SC 31M), IECEx (acceptance of international certificates of conformity), ISO/TC 180 – Solar energy, IEC TC 82 – Solar photovoltaic energy systems, IEC TC 88 – Wind energy generation systems, ISO/TC 161 – Controls and protective devices for gaseous and liquid fuels, ISO/TC 22/SC 32 – Electrical and electronic components and general system aspects, ISO/TC 301 – Energy management and energy savings, ISO/TC 58 – Gas cylinders. • Adopt relevant ISO CASCO – Standards related to the national quality infrastructure system.
Level 2	• Adopt international standards into the national standard system as defined in the database for Level 2. • Full participating member in international TCs and establishment of national mirror committees in the following areas: TCs mentioned for Level 1 with "observer status" previously, IECEx and IECEE (Member Body), ISO/TC 197 – Hydrogen technologies. • At least "observer" status in international TCs and national mirror committees in the following areas: ISO/TC 207 – Environmental management (i.e. SC 7 Greenhouse gas and climate change management and related activities), ISO/TC 158 – Analysis of gases, ISO/TC 161/WG 5 – High-pressure controls, ISO/TC 193 – Natural gas.
Level 3	• Adopt international standards into the national standard system as defined in the database for Level 3. • Full participating member in international TCs and national mirror committees in the following areas: TCs mentioned for Level 2 with "observer status" previously, IEC/TC 105 – Fuel cells, IECRE (Member Body).

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Metrology: Status of existing services

	Renewable Energy Generation	Production: Electro-lysis	Production: Conversion into derivates	Production: Storage	Distribution and transport	Utilization
Level 1	• Electrical characteristics: Current and voltage • Temperature • Humidity • Conductivity • Force and torque • Verification of electricity meters	• Reduced temperature range (-40ºC to 100ºC) • Pressure (up to 200 bar) • Calibration of gas detectors				
Level 2	• Irradiance level and spectral irradiance of the light source • Wind speed • Calibration of photovoltaic reference cells and modules • Verification of smart/digital electricity meters • Frequency • Harmonic distortion	• Expanded temperature range (-260ºC to 100ºC) • Pressure (up to 800 bar) • Gas flow rate • Mass (e.g. for the production of reference gas) • Density (liquid) • Chemical composition and purity of gases • Calorific value • Gas standards and certified reference gas mixtures				

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Metrology: Status of existing services

	Renewable Energy Generation	Production			Distribution and transport	Utilization
		Electro-lysis	Conversion into derivates	Storage		
Level 3	• Acoustics	• Efficiency of hydrogen generators • Water purity				• Efficiency of hydrogen utilisation
		• Chemical composition of hydrogen derivatives • Very high pressure (up to 1 000 bar) • Volume				
	Modelling of green H2 systems					

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Testing: Status of existing services

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	Renewable Energy Generation	Production			Distribution and transport	Utilization
		Electro-lysis	Conversion into derivates	Storage		
Level 1	Environmental conditions: • Humidity • Temperature • Air salinity	• Explosion protection and safety of gas pipelines, valves and storage devices (e.g. durability, mechanical/hydraulic, chemical, insulation) devices • Electrical safety • Detection of gas leakages				
Level 2	Environmental conditions: • Irradiance • Wind speed Plant performance and safety (field testing): • Power (IV curves, current, voltage) • Sound power • Structural analysis • Electroluminescence imaging • Insulation testing • Infrared imaging • Cables/connector boxes	• • Component resistance to corrosion (including in ammoniacal atmosphere) and hydrogen embrittlement • Hydrogen permeation in metals • Gas composition, purity (sulphur compounds can be tested by STEG) • Calorific value (i.e. of gas mixtures) (no lab tests offered, online tests are performed by STEG) • IECEx and IECEE approved testing of equipment for use in explosive atmospheres and electrotechnical components				

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Testing: Status of existing services

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	Renewable Energy Generation	Production			Distribution and transport	Utilization
		Electro-lysis	Conversion into derivates	Storage		
Level 3	Testing of renewable energy components according to ISO/IEC standards, i.e. • Photovoltaic modules • Inverters • Wind turbines	• Water purity • Efficiency of hydrogen generators				• Efficiency of utilization
		• Component quality according to applicable standards for hydrogen generators, as well as components for H2 distribution and transport.				

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Certification and inspection: Status of existing services

	Renewable Energy Generation	Production			Distribution and transport	Utilization
		Electro-lysis	Conversion into derivates	Storage		
Level 1	• Acceptance of international certificates of conformity based on the IECEE and the IECEx					
	• Market surveillance of the most relevant renewable energy components, including sample testing, certification and inspection, i.e. PV modules and inverters • Personnel certification: Certification of renewable energy plant installers (including, e.g. welding personnel)	• System certification: Quality management, environmental management, energy efficiency management, occupational health and safety • Inspection and certification of safety aspects based on national technical regulations aligned, i.e. with EU Directives Pressure Equipment Directive (PED), and equipment for potentially explosive atmospheres (ATEX)				

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Certification and inspection: Status of existing services

	Renewable Energy Generation	Production			Distribution and transport	Utilization
		Electro-lysis	Conversion into derivates	Storage		
Level 2	• Membership in IECEx and IECEE with the related certification and approval systems (i.e. approved certification bodies and testing laboratories according to the schemes), including IECEx Certified Equipment Scheme, IECEx Certified Service Facilities Scheme and IECEx Certification of Personnel Competencies					
Level 2	• Renewable energy plant inspection during construction and commissioning • Product certification: renewable energy plant components related to safety, i.e. cables/connector boxes, mounting structures, wind turbines	• Product certification: Components for hydrogen production, distribution and transport according to international standards • System certification: Hydrogen production systems • Renewable gas guarantee of origin, e.g. based on European Renewable Gas Registry (ERGaR)				

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Certification and inspection: Status of existing services

	Renewable Energy Generation	Production			Distribution and transport	Utilization
		Electro-lysis	Conversion into derivates	Storage		
Level 3	• Certification according to the IECEE and IECRE certification schemes (by accepted national certification bodies)					
	• Product certification: Certification of the most relevant renewable energy plant components, i.e. PV modules, inverters • System certification of renewable energy component manufacturing • Guarantee of origin and carbon dioxide emissions certification for renewable energy	• Product certification: Equipment for hydrogen utilisation, hydrogen and derivate quality • Certification, validation and verification of green hydrogen according to international standards, including carbon footprint, renewable content, use of land/water, social impacts				

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Accreditation: Status of existing services

Renewable Energy Generation	Production			Distribution and transport	Utilization
	Electro-lysis	Conversion into derivates	Storage		

Level 1

- Testing and calibration laboratories (services according to the checklists for metrology and testing, Level 1)
- Certification, inspection, validation and verification bodies (services according to checklist, Level 1)
- Evaluators and experts with technical expertise in the conformity assessment services required, especially related to safety

Level 2

- Proficiency test providers
- Testing and calibration laboratories (services according to the checklists for metrology and testing, Level 2)
- Certification, inspection, validation and verification bodies (services according to checklist, Level 2)
- Evaluators and experts with technical expertise in proficiency tests and conformity assessment, especially related to hydrogen

Level 3

- Testing and calibration laboratories (services according to the checklists for metrology and testing, Level 3)
- Certification, inspection, validation and verification bodies (services according to checklist, Level 3)
- Evaluators and experts with technical expertise in proficiency tests and conformity assessment, especially related to green hydrogen

Note: All services must be offered by an internationally recognised accreditation body

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Technical regulation: Status of existing services

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	Renewable Energy Generation	Production			Distribution and transport	Utilization
		Electro-lysis	Conversion into derivates	Storage		
Level 1	• **Grid codes** covering renewable energy connection • Regulation of **renewable energy power plant** safety and environmental aspects	**Regulation on occupational safety** • For example, safety and health protection of workers potentially at risk from explosive atmosphere, 1999/92/EC **Regulation on environmental aspects** in gas production, distribution, transport and utilization **Regulation on product safety,** for example, • Equipment for potentially explosive atmospheres (e.g. ATEX Directive 2014/34/EU, Pressure Equipment Directive (e.g. PED Directive 2014/68/EU) • Machinery Directive 2006/42/EU and Regulation (EU) 2023/1230				

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

Technical regulation: Status of existing services

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<table>
<tr><th></th><th>Renewable Energy Generation</th><th colspan="3">Production</th><th>Distribution and transport</th><th>Utilization</th></tr>
<tr><th></th><th></th><th>Electro-lysis</th><th>Conversion into derivates</th><th>Storage</th><th></th><th></th></tr>
<tr><td rowspan="2">Level 2 and 3</td><td></td><td colspan="3">Regulation on safe production of hydrogen, for example,
• Control of major accident hazards (e.g. Directive 2012/18/EU SEVESO III)

Regulation on sustainable production of hydrogen
• For example, EU RED II and delegated acts
• US Inflation Reduction Act (Section 45V and Guidance from the Internal Revenue Service)</td><td colspan="2">Regulation of distribution and transport of hydrogen, for example,
• Control of major accident hazards (e.g. Directive 2012/18/EU SEVESO III)
• Control of transport of hydrogen in liquified or gaseous cylinders or pipelines (e.g. EU 2021/535)
• Control of transportation of hazardous materials (e.g. 49 CFR Part 192)

Regulation on end uses in new sectors, for example,
• Hydrogen refuelling stations (e.g. OIML R139, PED or TPED, AFIR)
• Fuel cell vehicles (e.g. UN Regulations No. 134,146, 153)</td></tr>
<tr><td></td><td colspan="5">Regulation on product safety, for example,
• Pressure equipment (e.g. Directive 2014/68/EU)
• Measuring instruments (e.g. Directive 2014/32/EU)</td></tr>
</table>

Existing services marked in green, Not existing services marked in orange, Missing information marked in grey

8

Tunisia Quality Infrastructure Action Plan

Roadmap step 5

Action plan: Overview and summary

- Based on the previous analysis, an action plan is recommended to develop the QI system and its specific services to support the green hydrogen sector.
- The action plan follows the general timeline and levels of QI development defined in the previous chapter.
- Suggestions for organisations leading the activities and to be involved are included in the plan.
- The action plan should be reviewed with the main stakeholders of the activities and adapted according to the comments received.
- Activities recommended as first priority are marked in yellow, considering their relevance to the development of the green hydrogen sector.
- The meaning of the following symbols are as follows:
    - ↑ Political support required
    - Knowledge capacity to be developed
    - $ Financial support required

Note: The National Green Hydrogen Strategy sets extremely ambitious targets and milestones. Consequently, the activities suggested to develop the required QI services are also extremely ambitious and can only be realised with the clear support and commitment of all parties involved.

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Action plans

General QI, regulations, standardisation

Activities recommended: Short term (to 2026)

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Activity	Leading organisation	Organisations to be involved	Main resources required
Quality Infrastructure System: Legal and institutional framework			
• Based on the conclusions of this study and previous assessments conducted as part of the DGIIT-PTB co operation, review and discussion of the findings of the analysis of the general QI system and the required improvements with the relevant stakeholders.	• MIME (DGIIT)	• QI organisations	↑
• Considering the results of the general analysis of the QI system, definition of a national **quality policy and quality law**, clearly describing mandates, organisational responsibilities and competences. Update of **specific legislation** based on the quality policy and quality law.	• MIME (DGIIT)	• QI organisations	↑ 💡
• Review and approval of a national action plan for the development of the QI for the green hydrogen sector, as an annex to the National Green Hydrogen Strategy (based on the action plan developed as result of the IRENA/PTB process presented in the following slides).	• MIME (DGITT & DGETE)	• QI organisations	↑
• Based on the national action plan: Analysis of the status of the QI services defined as priority. Specification of requirements for the development of the related organisational structures, systems, infrastructure and personnel resources. Definition and implementation of **specific development plans of** QI organisations for the green hydrogen sector.	• DGIIT	• QI organisations and related ministries	$ ↑ 💡
• Definition of business plans for QI organisations for all services to be newly built up nationally.	• QI organisations	• DGIIT	↑ 💡
• Assessment of the QI for water quality and quantity (i.e. for desalination and water use for electrolysis).	• MIME (DGIIT)	• QI organizations	↑ 💡
Quality Infrastructure System: Coordination and HR			
• Information and awareness raising on the relevance of QI for the development of the GH2 sector.	• MIME (DGIIT and DGETE	• QI organisations, business associations, international co-operation	↑
• Improvement in **co-ordination and co-operation** amongst QI organisations and with the private sector, e.g. supported by a "National Quality Commission" with representation of the relevant organisations.	• MIME	• Relevant ministries and business associations	↑
• Development of **HR and training plans** for QI organisations for the green hydrogen sector, considering the required services defined for the green hydrogen sector.	• QI organisations	• Relevant ministries	💡 $

Activities recommended: Short term (to 2026)

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Activity	Leading organisation	Organisations to be involved	Material resources required
Standardisation			
Expansion of **representation on international TCs** and the discussion of international standards in **national mirror committees**, based on an updated strategic plan for INNORPI. Participating member in international TCs and national mirror committees in the following areas: **International**: ISO/TC 161 Controls and protective devices for gaseous and liquid fuels (to be upgraded to participating member). **National**: Mirror committee to be created for: ISO/TC 301 Energy management and energy savings, ISO/TC 22/SC 32 Electrical and electronic components and general system aspects, ISO/TC 301 Energy management and energy savings, ISO/TC 180 Solar energy. **International and national**: IEC/TC 31 – Explosive atmospheres, IECEx (Member Country), IEC TC 88 Wind energy generation systems, IEC TC 82 Solar photovoltaic energy systems, ISO/TC 28 Petroleum and related products, fuels and lubricants (to be upgraded to ISO participating member and creation of national mirror committee).	• INNORPI	• MIME	↑ $
• **Updated training programme** for INNORPI management staff and key stakeholders for the standardisation areas as defined in this action plan.	• INNORPI	• MIME (DGIIT) • International cooperation	$
• Adoption of international standards to the national standard system as defined in the checklist for **Level 1**.	• INNORPI	• Relevant stakeholders in TCs • International cooperation	↑

Activities recommended: Short term (to 2026)

Activity	Leading organisation	Organisations to be involved	Material resources required
Technical regulation			
Ensure technical regulations in the following areas are in place, updated and effectively implemented: • **Grid codes** covering renewable energy connection. • Regulation on **renewable energy power plant** safety and environmental aspects. • **Regulation on occupational safety** e.g. Safety and health protection of workers potentially at risk from explosive atmospheres, 1999/92/EC. • **Regulation on product safety**, e.g. Equipment for potentially explosive atmospheres (e.g. ATEX Directive 2014/34/EU, Pressure Equipment Directive 2014/68/EU). • **Regulation on environmental aspects** in gas production, distribution, transport and utilisation. • Regulation on civil protection, i.e. related to environmental aspects and explosion protection. • Update Renewables Law to also consider quality infrastructure requirements.	• DGETE • MIME (Safety Department) • Ministry of Interior	• International co operation • Ministry of Labour • Ministry of Social Affairs • Ministry of Interior • STEG	↑ 💡

$: Financial resources; 💡 : Knowledge; ↑ : Political support

Activities recommended: Medium term (to 2028)

Activity	Leading organisation	Organisations to be involved	Material resources required
QI System: Legal and institutional framework			
• Definition of a national **quality policy and quality law**, clearly describing mandates, organisational responsibilities and competences. Ensure a **clear separation of the functions** of public QI organisations.	• MIME (DGIIT)	• QI organisations and related ministries	↑
• Update of **specific legislation** based on the quality policy and quality law.	• MIME (DGIIT)	• Relevant ministries	↑
• Implementation of structures for QI organisations that ensure **independence** of decisions and financing.	• MIME (DGIIT)	• Relevant ministries	↑

$: Financial resources; 💡: Knowledge; ↑: Political support

Activities recommended: Medium term (to 2028)

Activity	Leading organisation	Organisations to be involved	Material resources required
Standardisation			
• Adopt international standards to the national standard system as defined in the checklist for Level 2.	• INNORPI	• Relevant stakeholders in TCs • International cooperation	💡 ↑
• Expansion of **representation on international TCs** and the discussion of international standards in **national mirror committees**, based on an updated strategic plan for INNORPI. Participating member in international TCs and national mirror committees in the following areas: • **National**: Create a national mirror committee for: ISO/TC 207, Environmental management (i.e. SC 7 Greenhouse gas and climate change management and related activities). • **International and national:** IECEE (Membership), ISO/TC 197 – Hydrogen technologies. Upgrade to participating member and create a national mirror committee for the following: ISO/TC 193 Natural gas, ISO/TC 158 Analysis of gases, ISO/TC 161/WG 5 High pressure controls.	• INNORPI	• MIME	💡 $

$: Financial resources; 💡: Knowledge; ↑: Political support

Activities recommended: Medium term (to 2028)

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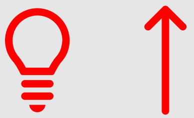
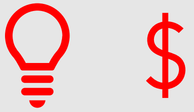
Activity	Leading organisation	Organisations to be involved	Material resources required
Technical regulation			
Ensure technical regulations in the following areas are in place, updated and effectively implemented: • **Grid codes** covering renewable energy connection. • **Regulation on renewable energy power plant safety** and environmental aspects. Regulation on occupational safety e.g. Safety and health protection of workers potentially at risk from explosive atmospheres, 1999/92/EC. • **Regulation on product safety**, e.g. Equipment for potentially explosive atmospheres (e.g. ATEX Directive 2014/34/EU). • Regulation on environmental aspects in gas production, distribution, transport and utilisation. • Regulation on gas equipment safety for hydrogen (update of existing regulation, e.g. NT109.01 on Safety of pipeline transport of combustible gas, or creation of new specific regulation). Cover integrity of pipelines and equipment against the impacts of hydrogen. • Regulations on water desalination requirements. • Regulations on land use.	• Related ministries.	• International cooperation	↑ 💡

$: Financial resources; 💡 : Knowledge; ↑ : Political support

Activities recommended: Long term (to 2030)

Activity	Leading organisation	Organisations to be involved	Material resources required
Standardisation			
• Adopt international standards to the national standard system as defined in the checklist for Level 3.	• INNORPI	• Relevant stakeholders in TCs • International cooperation	
• Expansion of **representation on international TCs** and the discussion of international standards in **national mirror committees**, based on an updated strategic plan for INNORPI, participating member in international TCs and national mirror committees in the following areas: IEC/TC 105 – Fuel Cells, IECRE (member body).	• INNORPI	• MIME	

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Action plans

Metrology and testing

Activities recommended: Short term (to 2026)

Activity	Leading organisation	Organisations to be involved	Main resources required
Metrology			
• Develop an up-to-date **national metrology law and related aligned national metrology strategy, including scientific, legal and industrial metrology,** ensuring **independent** development of the national metrology system and the recognition of the **NMI** by all relevant ministries and stakeholders.	• Ministry of Trade • MIME	• ANM, INRAP, DEFNAT, LCAE, other metrology laboratories (CTMCCV, CETIME, CNCC, CRTEN, etc.)	
• Review the current capacities and define specific activities to develop the metrological services relevant to gas pipelines and equipment for natural gas and hydrogen mixtures.	• Ministry of Trade • MIME	• ANM, INRAP, DEFNAT, LCAE, other metrology laboratories (CTMCCV, CETIME, CNCC, CRTEN, etc.)	$
• Develop the **existing services of the NMI and designated institutes** based on the analysis of current status, including the required training, introduction of management systems, intercomparisons and accreditation/CMCs: electrical characteristics: current and voltage; temperature; humidity; conductivity; force and torque; verification of electricity meters; medium temperature range (-40°C-100°C).	• ANM, INRAP, DEFNAT, LCAE, other metrology laboratories.	• Ministère du Commerce • Ministère de l'Industrie, des Mines et de l'Energie (MIME) • International cooperation	
• Development of **new national metrology services** or access to foreign services, based on assessment of specific current/future demand and business planning: calibration of gas detectors.	• ANM, INRAP, DEFNAT, LCAE, other metrology laboratories.	• Relevant ministries, Int. cooperation	

Activities recommended: Short term (to 2026)

Activity	Leading organisation	Organisations to be involved	Main resources required
Testing			
• Develop and implement a **recognised national testing strategy for GH2**, defining clear roles and responsibilities of public organisations, as well as the **areas of development** aligned with national priorities. Specify which testing and metrology services for green hydrogen should be nationally established as a priority.	• DGIIT	• DGETE • ANME • Testing laboratories, ACTIT	↑
• Identify and facilitate the access of relevant testing laboratories to the most required services in the areas of **calibration, reference material (metrology demand to be considered in the proposed metrology strategy, see above)** and **round robin/proficiency tests**.	• NMI	• International co-operation	$ 💡
• Develop **existing services of relevant testing laboratories** based on the analysis of current status: completion of the required training, introduction of management systems including laboratory safety, intercomparisons and accreditation: explosion protection and safety of gas pipelines, valves and storage devices; electrical safety; detection of gas leakages.	• DGIIT	• Testing laboratories, ACTIT, international cooperation, Ministry of Labour	$ 💡

$: Financial resources; 💡 : Knowledge; ↑ : Political support

Activities recommended: Medium term (to 2028)

Activity	Leading organisation	Organisations to be involved	Main resources required
Metrology			
• Develop the existing services of the NMI and designated institutes based on the analysis of current status, including the required training, introduction of management systems, intercomparisons and accreditation/CMCs: irradiance level and spectral irradiance of the light source; wind speed; calibration of PV reference cells and modules; verification of smart/digital electricity meters; mass (for example for the production of reference gas); gas flowrate/calibration of gas meters; chemical composition and purity of gases; calorific value.	• ANM, INRAP, DEFNAT, LCAE, other metrology laboratories.	• Relevant ministries, international co-operation	Knowledge
• Development of new national metrology services or access to foreign services, based on assessment of specific current/future demand and business planning: large temperature range (260°C-100°C), reference gases, density.	• ANM, INRAP, DEFNAT, LCAE, other metrology laboratories	• Relevant ministries, international co-operation	$ Knowledge
• Development of measurement procedures and review of adequate technologies for flow measurement for higher hydrogen content in natural gas.	• DGETE	• STEG, LCAE, CRTEN, ANM	Knowledge
• Recognition of measurement/calibration services for higher hydrogen content in natural gas by the legal metrology authorities.	• ANM	• All metrology service providers in Tunisia	Political support

$: Financial resources; Knowledge; Political support

Activities recommended: Medium term (to 2028)

Activity	Leading organisation	Organisations to be involved	Main resources required
Testing			
Develop the **existing services of relevant testing laboratories** based on the analysis of current status: completion of the required training, introduction of management systems, intercomparisons and accreditation: Environmental conditions: • Irradiance • Wind speed Renewable energy plant performance and safety (field testing): • Power (IV curves, current, voltage) • Acoustic • Structural analysis • Electroluminescence (EL) imaging • Insulation testing • Infrared (IR) imaging	• DGIIT	• Testing laboratories, ACTIT, International co-operation • STEG	💡
• Development of **new testing services at public laboratories or access to** foreign services, depending on the assessment of specific current/future demand and business planning: Component resistance to corrosion (including in ammoniacal atmosphere) and hydrogen embrittlement; hydrogen permeation in metals, gas composition/purity, gas calorific value.	• DGIIT	• Testing laboratories, ACTIT, International co-operation	$ 💡

$: Financial resources; 💡 : Knowledge; ↑ : Political support

Activities recommended: Medium term (to 2028)

IRENA
International Renewable Energy Agency

Activity	Leading organisation	Organisations to be involved	Main resources required
Testing			
• Foster the **accreditation of public testing laboratories offering the services defined in Levels 1 and 2** and ensure their recognition based on accreditation by the relevant ministries.	• DGIIT	• TUNAC • Public testing laboratories	$ ↑
• Establish a network of metrology and testing laboratories relevant to the green hydrogen sector. Organise activities of common interest, including training, round robin tests and public relations .	• ACTIT	• Testing and metrology laboratories	↑

$: Financial resources; 💡: Knowledge; ↑ : Political support

Activities recommended: Long term (to 2030)

Activity	Leading organisation	Organisations to be involved	Main resources required
Metrology			
• Develop the existing services of the NMI and designated institutes based on the analysis of current status, including the required training, introduction of management systems, intercomparisons and accreditation/CMCs: very high pressure; volume.	• ANM, INRAP, DEFNAT, LCAE, other metrology laboratories.	• Relevant ministries, international co-operation	💡
• Development of new national metrology services or access to foreign services, based on assessment of current/future demand and business planning: efficiency of hydrogen generators and utilisation; chemical composition of hydrogen derivatives; modelling of GH2 systems.	• ANM, INRAP, DEFNAT, LCAE, other metrology laboratories.	• Relevant ministries, international co-operation	$ 💡
Testing			
• Develop the **existing services of relevant testing laboratories** based on the analysis of current status: **PV modules; inverters; water purity**.	• DGIIT	• Testing laboratories, ACTIT, international co-operation, • STEG	$ 💡
• Development of **new testing services at public laboratories or access to** foreign services, based on assessment of specific current/future demand and business planning: **efficiency of hydrogen generators and utilisation; component quality according to applicable standards for hydrogen generators, as well as components for hydrogen distribution and transport.**	• DGIIT	• Testing laboratories, ACTIT, international co-operation	$ 💡

$: Financial resources; 💡: Knowledge; ↑: Political support

Action plans

Accreditation and certification

Activities recommended: Short term (to 2026)

IRENA
International Renewable Energy Agency

Activity	Leading organisation	Organisations to be involved	Material Resources Required
Certification and inspection			
Ensure the following certification and inspection services are offered by accredited national certification/inspection bodies with appropriate personnel capacities or are available through foreign certification bodies: • Recognition of IECEE Certificates of Conformity. • Personnel certification: certification of renewable energy plant installers. • Recognition of IEC Ex and IECEE Certificates of Conformity. Certification according to the IECEx schemes for: certified equipment, personnel and service facilities. • Market surveillance of the most relevant renewable energy components, including sample testing and certification, e.g. PV modules and inverters.	• DGIIT	• International co-operation • Private sector stakeholders • Control offices • Ministry of Trade/DQPC • Private certification bodies • MIME, Security Department • TUNAC • INNORP • ANME • STEG	↑ $
Review of the current import control and surveillance systems of IEC Ex and IECEE equipment. Update the systems where required and ensure appropriate personnel capacities.	Ministry of Trade	MIME International co-operation	$ ↑

Activities recommended: Medium term (to 2028)

IRENA
International Renewable Energy Agency

Activity	Leading organisation	Organisations to be involved	Material Resources Required
Certification and inspection			
• Create an updated legal basis for certification and inspection according to international good practice, permitting other certification **bodies besides INNORPI to certify products** based on Tunisian Standards.	• MIME	• International co-operation	↑
• Develop an updated and **recognised national strategy** for the development of certification and inspection relevant to the GH2 value chain.	• MIME	• International co-operation	↑
• Foster the accreditation of relevant public certification bodies and of related testing services.	• DGIIT	• International co-operation	↑
• Implement a system of **notification and recognition** of inspection bodies and foreign certificates.	• MIME	• Multilateral organisations, countries in the region with existing systems	↑
Ensure the following certification and inspection services are offered by accredited national certification/inspection bodies or available through foreign certification bodies: • Product certification: components for hydrogen production, distribution and transport according to international standards. • System certification: hydrogen production systems. • Renewable gas guarantee of origin. • Renewable energy plant inspection during construction and commissioning.	• DGIIT	• International co-operation	↑

Activities recommended: Medium term (to 2028)

Activity	Leading organisation	Organisations to be involved	Material Resources Required
Accreditation			
• Foster the inclusion of the following service into TUNAC's accreditation scope: proficiency test providers. • Constructeurs de Matériaux de référence 17034, 17029. • Formation des évaluateurs de schéma de certification privée.	• TUNAC	• International co-operation, accreditation body with existing accreditation scope	
• Train evaluators with technical expertise in proficiency tests and conformity assessment as specified for Level 2, i.e. related to hydrogen.	• TUNAC	• International co-operation, accreditation body with existing accreditation scope • Ministry of Transport • Private sector stakeholders	

Activities recommended: Long term (to 2030)

Activity	Leading organisation	Organisations to be involved	Material Resources Required
Accreditation			
• Foster the **accreditation of public testing laboratories offering the services defined in Level 3** and establish a system of recognition by the relevant ministries.	• DGIIT	• TUNAC • Public testing laboratories	
• Train evaluators with technical expertise in metrology services, proficiency tests and conformity assessment as specified in Level 3, i.e. related to hydrogen.	• TUNAC	• International co operation, accreditation body with existing accreditation scope	$
Certification and inspection			
Ensure the following certification and inspection services are offered by accredited national certification/inspection bodies or available through foreign certification bodies: • Product certification: certification of the most relevant renewable energy plant components, e.g. PV modules, inverters, cables/connector boxes, mounting structures; components for hydrogen utilisation, hydrogen and derivative quality. • System certification of renewable energy component manufacturing. • Certification according to the IECEE and IECRE certification schemes (by approved national certification bodies). • Certification of green hydrogen according to international standards, including carbon footprint, renewable content, use of land/water, social impacts.	• DGIIT	• International co-operation	

9 Concluding thoughts and next steps

Follow-up studies as listed in National H2 Strategy – to be undertaken before implementation in 2025

Desalination and water supply for green production projects

- Objective of this study is to define the approach and configuration to supply this desalinated water to the various GH2 production projects by 2050

Upgrade of ports for the export of GH2 derivatives

- Undertake hydrogen integration readiness of Tunisian port system in general as well as a focus on the candidate ports (Gabes, Zarzis, Skhira, Rades and Bizerte)

Hydrogen transport infrastructures by gas pipeline

- Objective of this study is to define the development scheme for the hydrogen network and the conditions of its use by GH2 production project leaders as well as local consumers and international buyers

Use of hydrogen and its derivatives in transport

- Objective of this study is to define the technical, regulatory, normative and economic conditions for the use of GH2 and its derivatives in the different types of transport.

IRENA Tunisia QI case study

- This case study, can be used by Tunisia to start setting up the QI services that will be required for the safe and sustainable production of GH2

Value added from this case study for Tunisia H2 Strategy Action Plan development

Source: National strategy for the development of green hydrogen and its derivatives in Tunisia (MIME, GiZ)

THANK YOU!