KINGDOM OF MOROCCO
Ministry of EnergyTransition and Sustainable Developmen

IRESEN
Institut de Recherche en Energie Solaire et en Energies Nouvelles

10 ans au service de la recherche et de l'innovation

CLUSTER GREEN H2
RECHERCHE - INNOVATION - INDUSTRIE

IRESEN
Institut de Recherche en Energie Solaire et en Energies Nouvelles

10 ans au service de la recherche et de l'innovation

BETD'24
NUMOV SIDE EVENT

Green Hydrogen in Morocco:
Which Opportunities for Morocco & Germany?

Berlin, March 22nd 2023

Samir Rachidi, DG, IRESEN

BERLIN ENERGY TRANSITION DIALOGUE.24

March 6th 2023!


under the aegis of
KINGDOM OF MOROCCO
Ministry of Energy Transition
and Sustainable Development
hosted by
IRESEN
CLUSTER GREEN H2
UM6P
University Mohammed VI Polytechnic
The World Power-to-X Summit
WorldPtX
SUMMIT
8-10 October 2024, Marrarkesh
SAVE THE DATE
H2
H2 HYDROGEN
ZERO EMISSION
www.worldptxsummit.com

ABOUT THE INSTITUTE

Support and Development of Applied Research and Innovation at the service of National and Continental Energy Transition.

The Research Institute for Solar Energy and New Energies (IRESEN) was created on the sidelines of the "Assises de l'Énergie" in 2011 at the initiative of the Ministry of Energy, Mines and Environment as well as several public and private key stakeholders of the energy sector to support applied research and innovation in the field of green technologies.

IRESEN is now a major player supporting the national energy strategy and is positioned across the entire green innovation value chain, through its two instruments:

1 INFRASTRUCTURES

Network of research and innovation platforms in green technologies

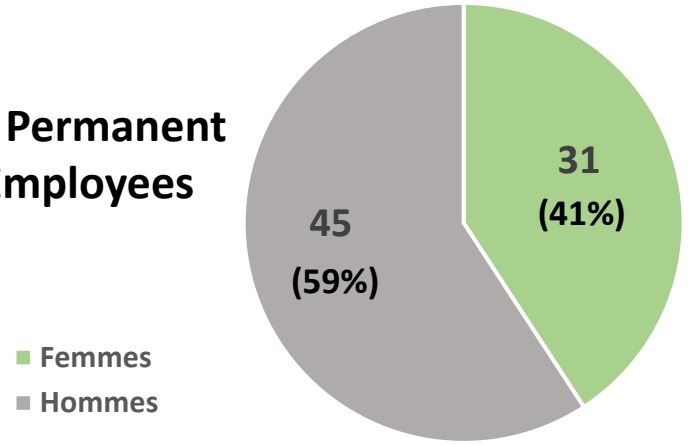
2 FUNDING AGENCY

Funding of applied research and collaborative innovation projects

The Institute also contributes to the development of technological roadmaps in the clean energy sector: Solar Resources, Electric Mobility, Green Hydrogen, ...

IRESEN - Capital Humain

76 Permanent Employees



INFRASTRUCTURES

Le premier réseau de plateformes de recherche et d'innovation en technologies vertes en Afrique

IRESEN assure le développement et l'implémentation d'un réseau de plateformes de recherche, de formation et d'innovation avec des laboratoires entièrement équipés pour mutualiser les infrastructures de recherche et créer des ponts entre les institutions de recherche et le monde socio-économique.

Au niveau national ou continental, la mise en place de ces nouvelles infrastructures de recherche et d'innovation permet de créer des plateformes d'excellence scientifique et technologique complémentaires dans différentes régions et couvrant plusieurs thématiques tout en assurant une mutualisation des moyens et des équipes et en garantissant l'adéquation entre le besoin et la demande

GREEN ENERGY PARK
Énergie solaire photovoltaïque et thermique à concentration

GREEN & SMART BUILDING PARK
Bâtiments verts, réseaux intelligents et mobilité durable

GREEN H2A
Production de molécules vertes à forte valeur ajoutée

AGRO-ENERGY-TIC VALLEY
Biomasse et nexus énergie-agriculture

WATER ENERGY NEXUS
Dessalement et traitement de l'eau

GEP - MAROC CÔTE D'IVOIRE
Énergie solaire en milieu tropical

IRESEN
Institut de Recherche en Energie Solaire et en Energies Nouvelles

GREEN ENERGY PARK

in partnership with

MOHAMMED VI POLYTECHNIC UNIVERSITY

and the support of

KOICA
Korea International Cooperation Agency

IRESEN
Institut de Recherche en Energie Solaire et en Energies Nouvelles

GREEN & SMART BUILDING PARK

en partenariat avec

MOHAMMED VI POLYTECHNIC UNIVERSITY

and the support of

KOICA
Korea International Cooperation Agency

IRESEN
Institut de Recherche en Energie Solaire et en Energies Nouvelles

TOPICS COVERED

SOLAR PHOTOVOLTAIC

CONCENTRATED SOLAR POWERE

SMART GRIDS

ENERGY STORAGE

WIND POWER

BIOMASS

HYDROGEN & POWER-TO-X

ENERGY EFFICIENCY

GREEN BUILDING & SUSTAINABLE CONSTRUCTION

CITY OF THE FUTURE

SUSTAINABLE MOBILITY

WATER-ENERGY-AGRICULTURE NEXUS

RESOURCE MODELING

DIGITIZATION

GREEN H2A R&D PLATFORM
INNOVATION TO CO-LOCALIZE PTX INDUSTRY

Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung

Bundesministerium für Wirtschaft und Klimaschutz

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

KFW

Green H2A

IRESEN Institut de Recherche en Energie Solaire et en Energies Nouvelles

MOHAMMED VI POLYTECHNIC UNIVERSITY

Low Temp. Electrolysis & Cell Lab. ***PEM-ALC***

Temp. Fuel Cell Lab. ***SOEC-SOFC***

PtL

COMB

WATER SPLITTING

Lab. ***E-H_2***

Chemistry & Materials Formulation Lab. ***CHEM***

GREEN H2A R&D PLATFORM
INNOVATION TO CO-LOCALIZE PTX INDUSTRY

RENEWABLE ENERGY HYBRIDIZATION | HYDROGEN PRODUCTION, TRANSPORT & STORAGE | GREEN CHEMISTRY | CARBON CAPTURE STORAGE AND APPLICATIONS | MOBILITY ON HYDROGEN

Green H2A (Hydrogen / Ammonia)

IRESEN Institut de Recherche en Energie Solaire et en Energies Nouvelles

MOHAMMED VI POLYTECHNIC UNIVERSITY

Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung

Bundesministerium für Wirtschaft und Klimaschutz

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

KFW

LOHC Platform

(Oxy-) Combustion Platform: Mobility & Electricity Production (Hydrogen, Ammonia, eFuels, etc.)

Hydrogen Refueling Station

Green Ammonia Platform

Green Methanol Platform

PtL Platform: Carbon Capture / Fischer Tropsh / Refining

MAIN BUILDING Indoor Laboratories & Offices

H2 Multi-Technology Electrolysers Platform (Alcalin, PEM, SOEC, etc.)

Low Temp. Electrolysis & Fuel Cell Lab. ***PEM-ALC***

Electrolysis & High Temp. Fuel Cell Lab. ***SOEC-SOFC***

Synthetic Fuels Lab. ***PtL***

Combustion Lab. ***COMB***

Water Splitting Lab. ***WATER SPLITTING***

Hydrogen Mobility Lab. ***E-H_2***

Chemistry & Materials Formulation Lab. ***CHEM***

GREEN H2A R&D PLATFORM
INNOVATION TO CO-LOCALIZE PTX INDUSTRY

Green H2A Hydrogen Ammonia

TRL 1 - 3	TRL 4 - 7	TRL 8 - 9	Med-integration
Test range: *1kW - 50kW* *1g - 1kg*	Test range: *~5MW* *~1 tpd* ***2021***	Test range: *~10MW - 100MW* *~100 tpd - 1000 tpd* ***mid term***	*>1GW* *>1000 tpd* ***long term***

R&D
UM6P / IRESEN
and other universities

R&D pilot projects
GreenH2A

MOHAMMED VI POLYTECHNIC UNIVERSITY

Park green energy

IRESEN Institut de Recherche en Energie Solaire et en Energies Nouvelles

INDUSTRIAL
Up-Scalling

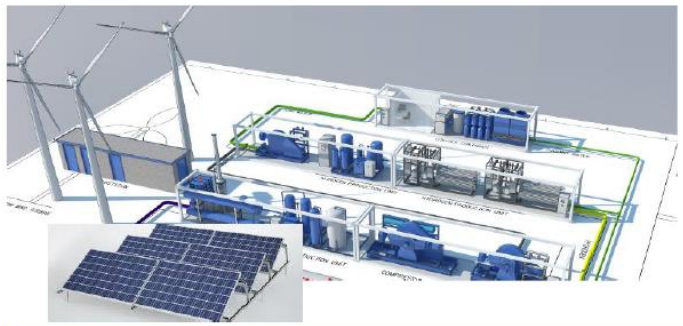
OCP

other industries

MOHAMMED VI POLYTECHNIC UNIVERSITY

IRESEN Institut de Recherche en Energie Solaire et en Energies Nouvelles

GREEN H2A R&D PLATFORM
INNOVATION TO CO-LOCALIZE PTX INDUSTRY



- Project « Green Ammonia Pilot Plant »
- Capacity : ~ 4 MWe || ~4Tonnes/jour
- Objectives:
  - Assessment of technologies
  - Scale-Up feasibility

GREEN H2A R&D PLATFORM
INNOVATION TO CO-LOCALIZE PTX INDUSTRY

Green H2A

Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

Bundesministerium für Wirtschaft und Klimaschutz

IKI INTERNATIONAL CLIMATE INITIATIVE

International PtX Hub

MOHAMMED VI POLYTECHNIC UNIVERSITY

IRESEN Institut de Recherche en Energie Solaire et en Energies Nouvelles

Agora Energiewende

CSIR our future through science

DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

- Project « PtX Pathways » (Power-To-Liquid – PtL)
- Capacity: ~ 1 MWe || ~100kg-1ton/day
- Objectives:
  - Technology Assessment
  - Scale-Up Perspectives
  - Applications: Local Market and Exports

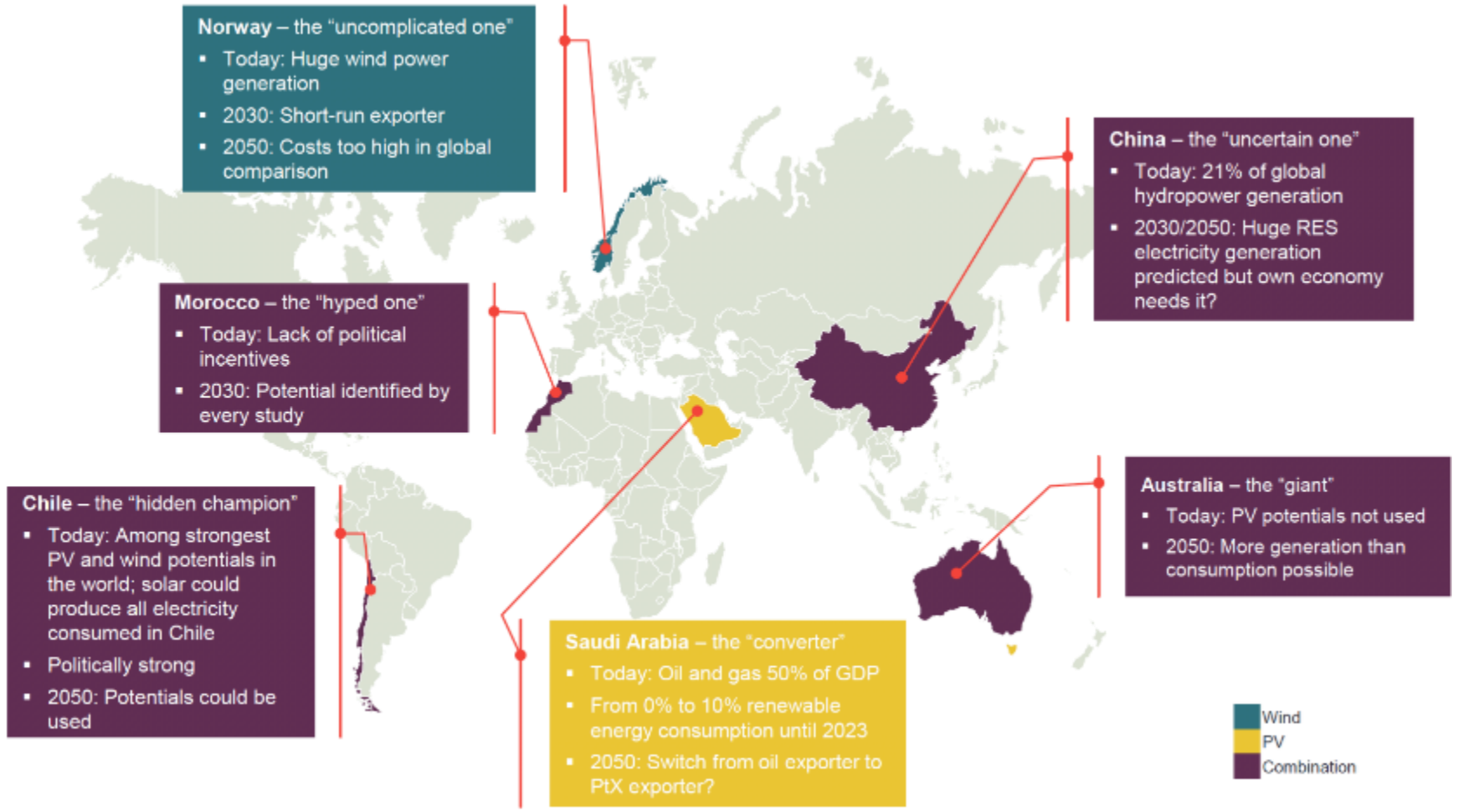
IRESEN Institut de Recherche en Energie Solaire et en Energies Nouvelles

GREEN H2A R&D PLATFORM
INNOVATION TO CO-LOCALIZE PTX INDUSTRY

Capacity Building & Dissemination:

GREEN HYDROGEN IN MOROCCO: FIRST STEPS

EXPORT POTENTIAL FOR PTX PRODUCTS: FRONTRUNNER POSITION



Source : World Energy Council Germany, Frontier Economics 2018 Study Fraunhofer ISI, Etude Opportunités PtX pour le Maroc, 2019

GREEN HYDROGEN IN MOROCCO: FIRST STEPS, INITIATIVES & DRIVERS

3 important studies conducted since 2018 on « H2 - Power to X in Morocco »

Bundesministerium für Wirtschaft und Energie

PAREMA
Partenariat énergétique Maroco-Allemand
Deutsch-Marokkanische Energiepartnerschaft

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

MARKET & TECHNOLOGIES

with Fraunhofer IMWS

Keywords: Electrolysis, Green Hydrogen & Ammonia

OPPORTUNITIES & POTENTIAL FOR MOROCCO

with Fraunhofer ISI

Keywords: H2 / PtX Potential, Grid, Infrastructure, Impact, Exports

MOROCCO'S PTX 2050 ROADMAP

with frontier economics

Keywords: R&D, Innovation & Industrial opportunities

MOROCCO-EU Partnership
Morocco signed an agreement with Germany in June 2020 ,to develop a regional market of PtX

COMMISSION NATIONALE HYDROGENE

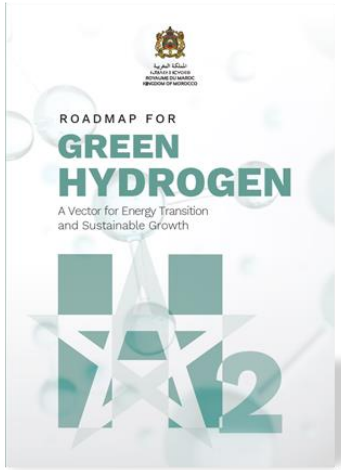
Creation of a National Commission for Power-to-X by the Moroccan Energy Ministry on Feb. 11th, 2019

CLUSTER GREEN H2

Creation of an industrial Green Hydrogen Cluster

NATIONAL GREEN H2 STRATEGY

Published in August 2021



GREEN HYDROGEN IN MOROCCO: FIRST STEPS, INITIATIVES & DRIVERS

3 important studies conducted since 2018 on « H2 - Power to X in Morocco »

Bundesministerium für Wirtschaft und Energie

PAREMA
Partenariat énergétique Maroco-Allemand
Deutsch-Marokkanische Energiepartnerschaft

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

MARKET & TECHNOLOGIES

with Fraunhofer IMWS

Keywords: Electrolysis, Green Hydrogen & Ammonia

OPPORTUNITIES & POTENTIAL FOR MOROCCO

with Fraunhofer ISI

Keywords: H2 / PtX Potential, Grid, Infrastructure, Impact, Exports

MOROCCO'S PTX 2050 ROADMAP

with frontier economics

Keywords: R&D, Innovation & Industrial opportunities

MOROCCO-EU Partnership
Morocco signed an agreement with Germany in June 2020 ,to develop a regional market of PtX

COMMISSION NATIONALE HYDROGENE

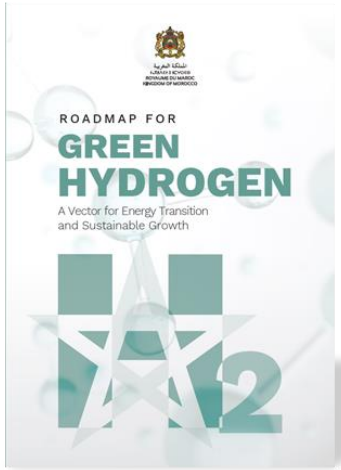
Creation of a National Commission for Power-to-X by the Moroccan Energy Ministry on Feb. 11th, 2019

CLUSTER GREEN H2

Creation of an industrial Green Hydrogen Cluster

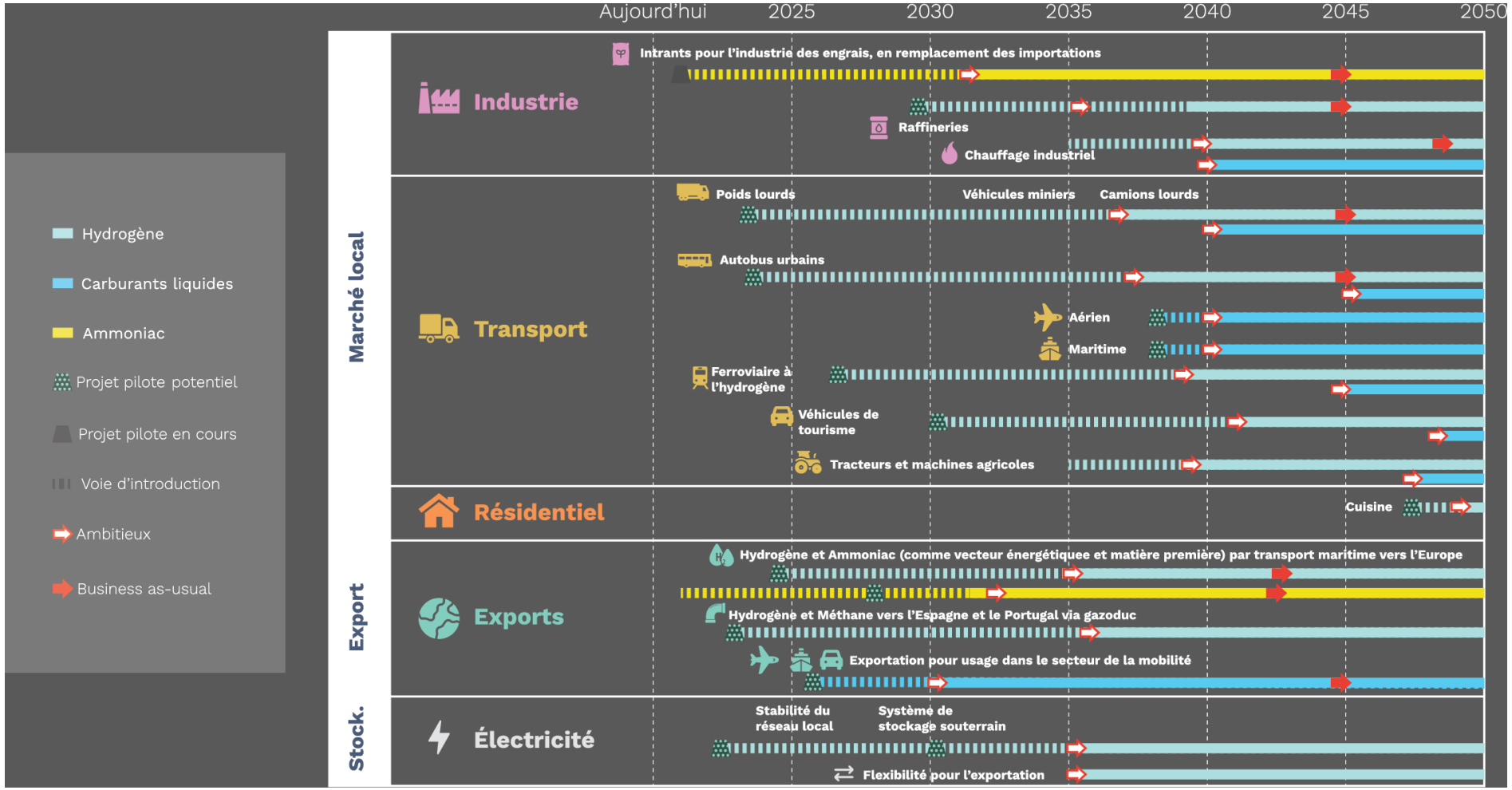
NATIONAL GREEN H2 STRATEGY

Published in August 2021



GREEN HYDROGEN IN MOROCCO: ROADMAP (1/4)

Market Opportunities & Applications



GREEN HYDROGEN IN MOROCCO: ROADMAP (4/4)

CLUSTER GREEN H2

RECHERCHE - INNOVATION - INDUSTRIE

The main object of the GreenH2 Cluster is to promote the hydrogen sector in Morocco through the initiation, support and coordination of innovative collaborative projects in the field of green hydrogen in the Kingdom of Morocco and abroad, in order to encourage innovation and contributing to the emergence of a competitive hydrogen sector.

- Strengthen the technical and technological capacities of national players to produce, use and enhance hydrogen
- Develop innovation in the hydrogen sector
- Supporting national industries
- Support the National Hydrogen Commission in creating a regulatory and incentive framework for the development of the hydrogen industry
- Encourage and develop the production of hydrogen in Morocco
- Contribute to the promotion of Moroccan hydrogen on a regional and international scale

Kingdom of Morocco – Ministry of Energy, Mines and Environment

Kingdom of Morocco – Ministry of Industry, Commerce and Green and Digital Economy

Kingdom of Morocco – Ministry of National Education, Vocational Training, Higher Education and Scientific Research

Kingdom of Morocco – Ministry of Equipment, Transport

IRESEN – Institut de Recherche en Energie Solaire et en Energies Nouvelles

GREEN HYDROGEN IN MOROCCO: FIRST STEPS, INITIATIVES & DRIVERS

3 important studies conducted since 2018 on « H2 - Power to X in Morocco »

Bundesministerium für Wirtschaft und Energie

MAR
TECH

with Fra

March 2024: Moroccan Offer for Green Hydrogen

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

COM
NATI
HYDR

EEN

ned in 2021

بسم الله الرحمن الرحيم

ⵜⴰⴳⵍⴷⵉⵜ ⵏ ⵍⵎⵖⵔⵉⴱ

المملكة المغربية
رئيس الحكومة

03 / 2024

Royaume du Maroc
Le Chef du Gouvernement

11 Mars 2024

Mesdames et Messieurs les Ministres, les Ministres Délégués et les responsables des Etablissements et Entreprises Publics

Objet : Mise en œuvre de l'Offre Maroc pour le développement de la (des) filière(s) de l'hydrogène vert

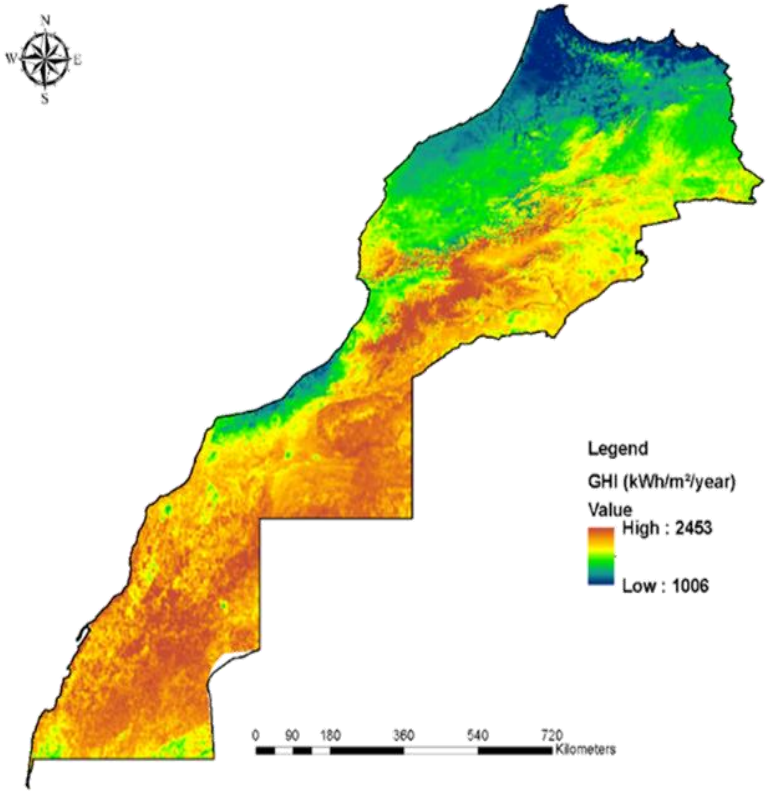
La Vision éclairée de Sa Majesté le Roi que Dieu L'assiste permet au Maroc d'occuper aujourd'hui une place de choix, aux échelles continentale et mondiale, **en termes de développement d'énergies renouvelables et d'avoir pour ambition** d'aller au-delà.

Face aux défis environnementaux, économiques et politiques actuels, accentués par des

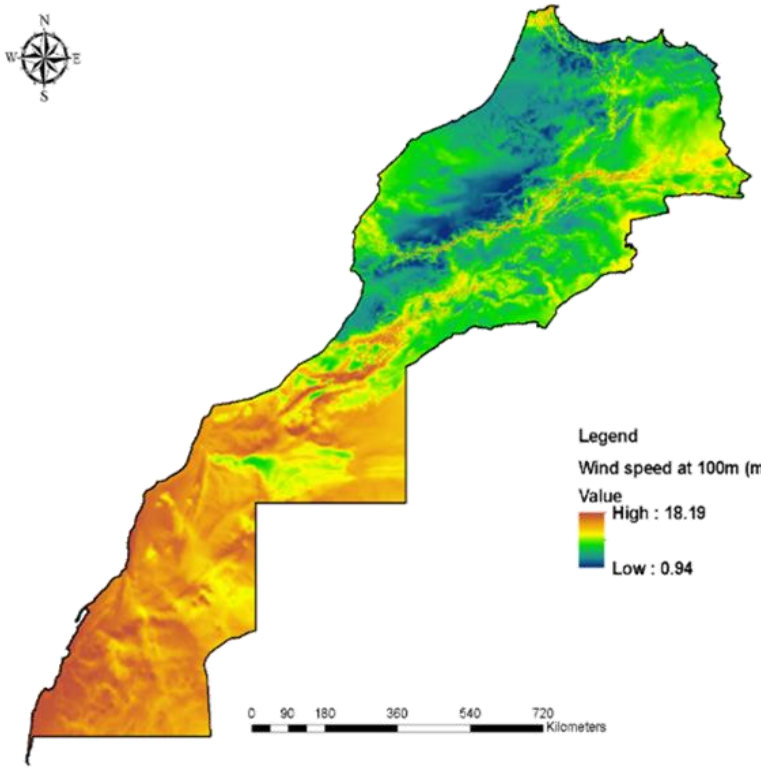
GREEN HYDROGEN IN MOROCCO : POTENTIAL, OPPORTUNITIES & PERSPECTIVES

POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

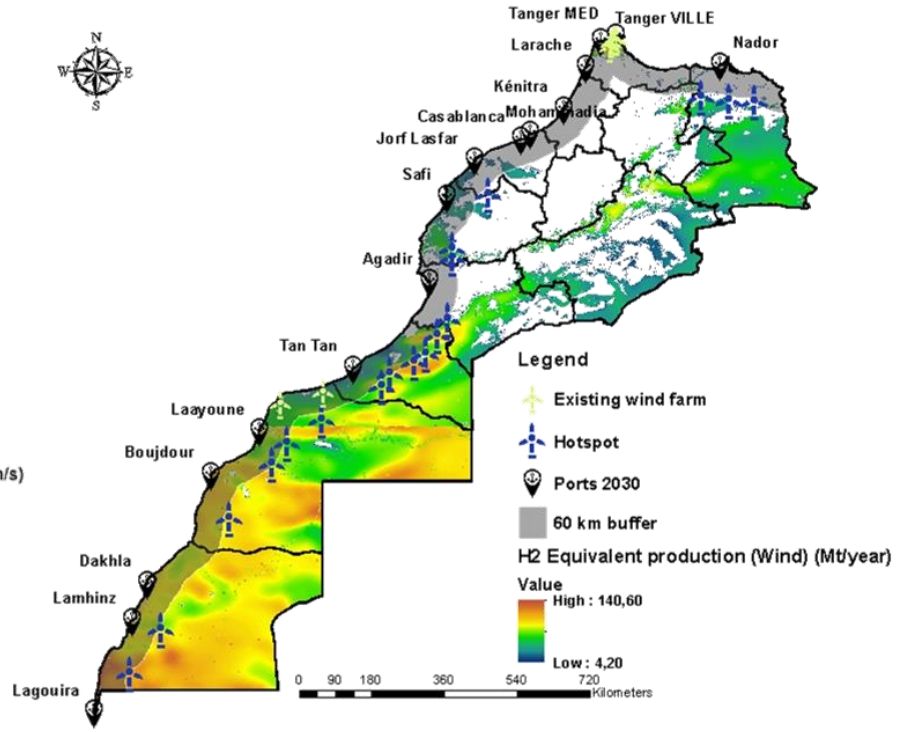
CRITERES DE SELECTION ÉNERGIE SOLAIRE PV



: Carte du rayonnement solaire global

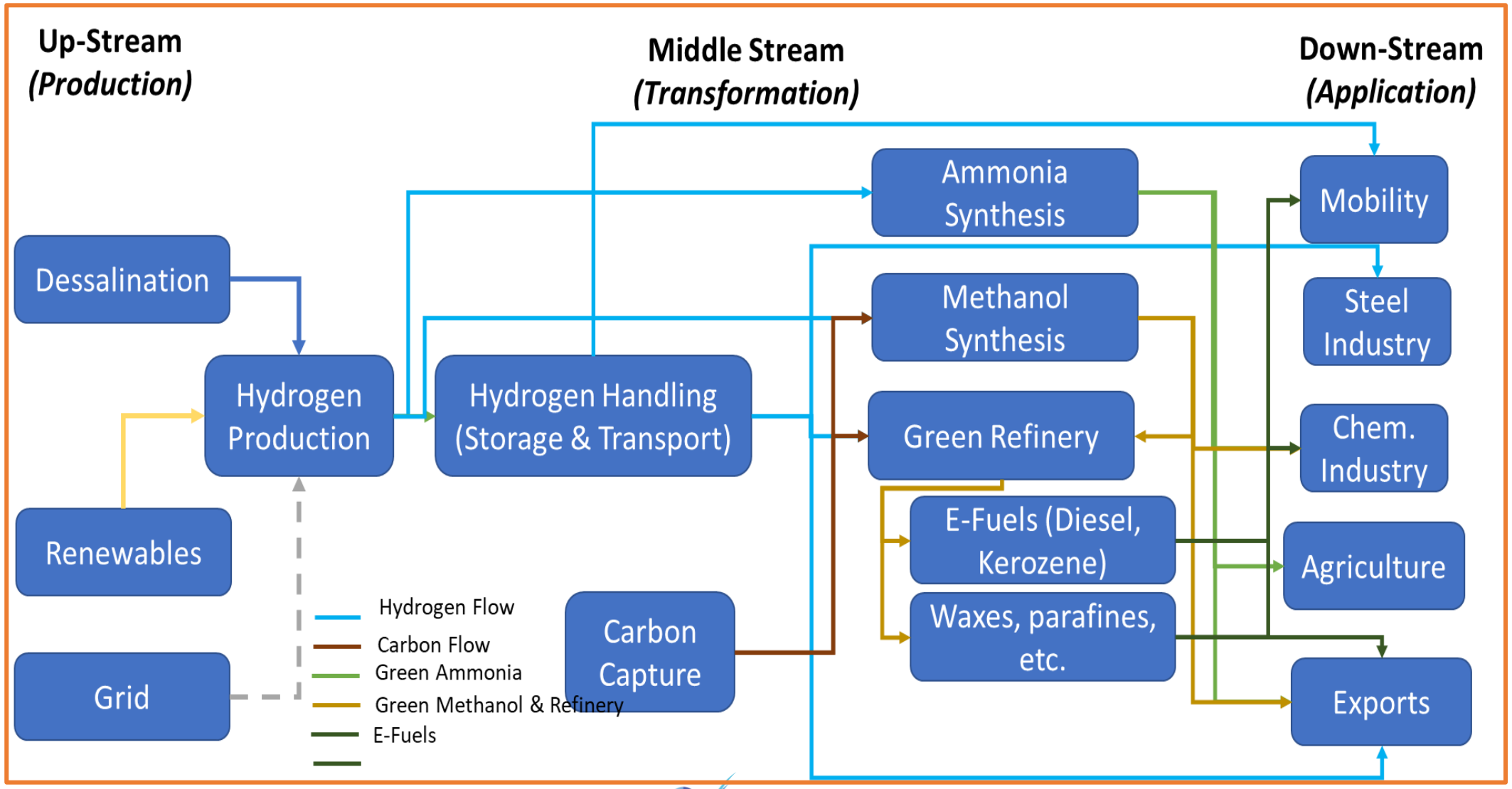


Carte de la vitesse du vent



Superposition + Infrastructure portuaire

HYDROGÈNE VERT: UNE CHAINE DE VALEUR INDUSTRIELLE



POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

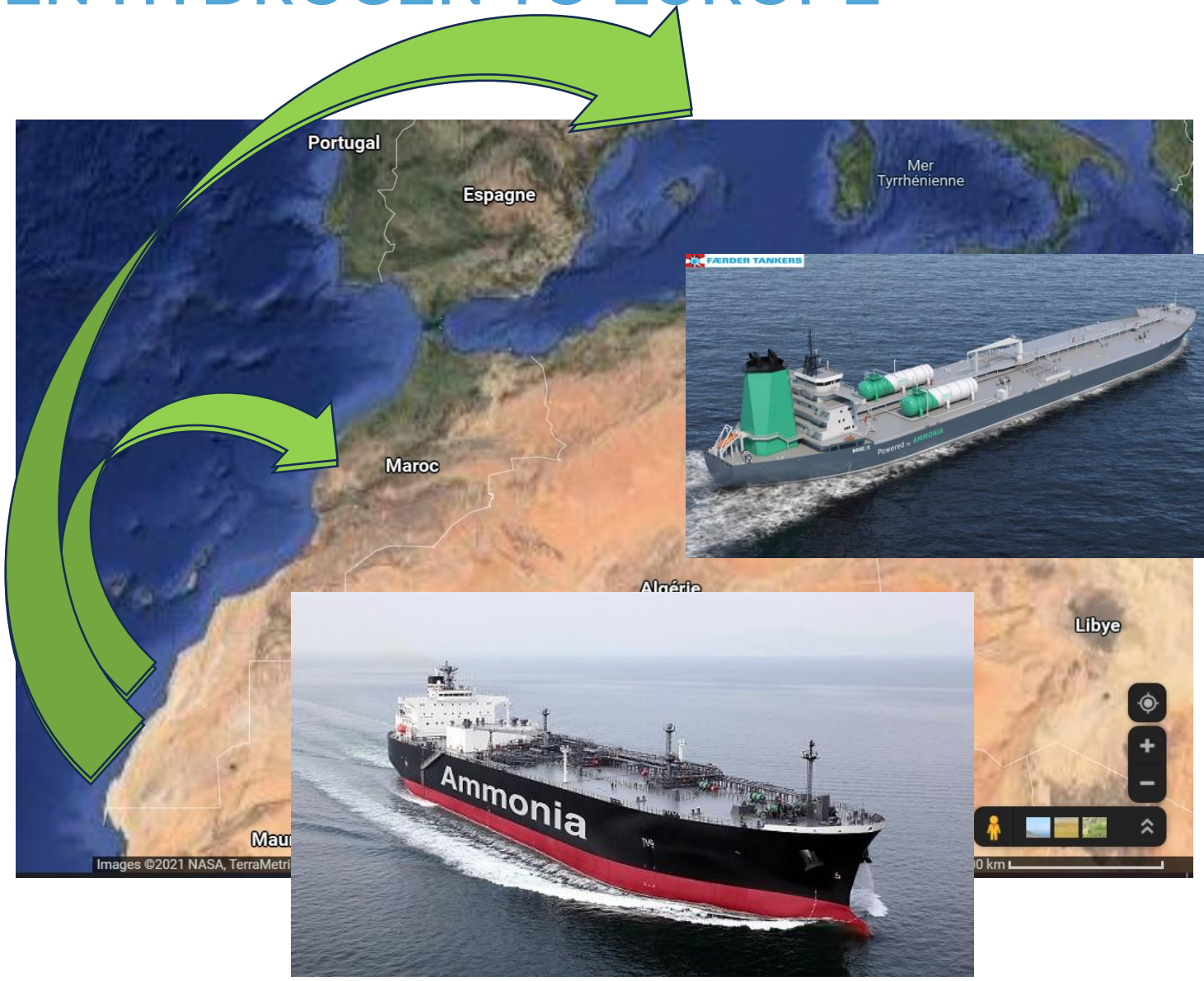
POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

GREEN HYDROGEN IN MOROCCO : IDEAS ON HYDROGEN TRANSPORT

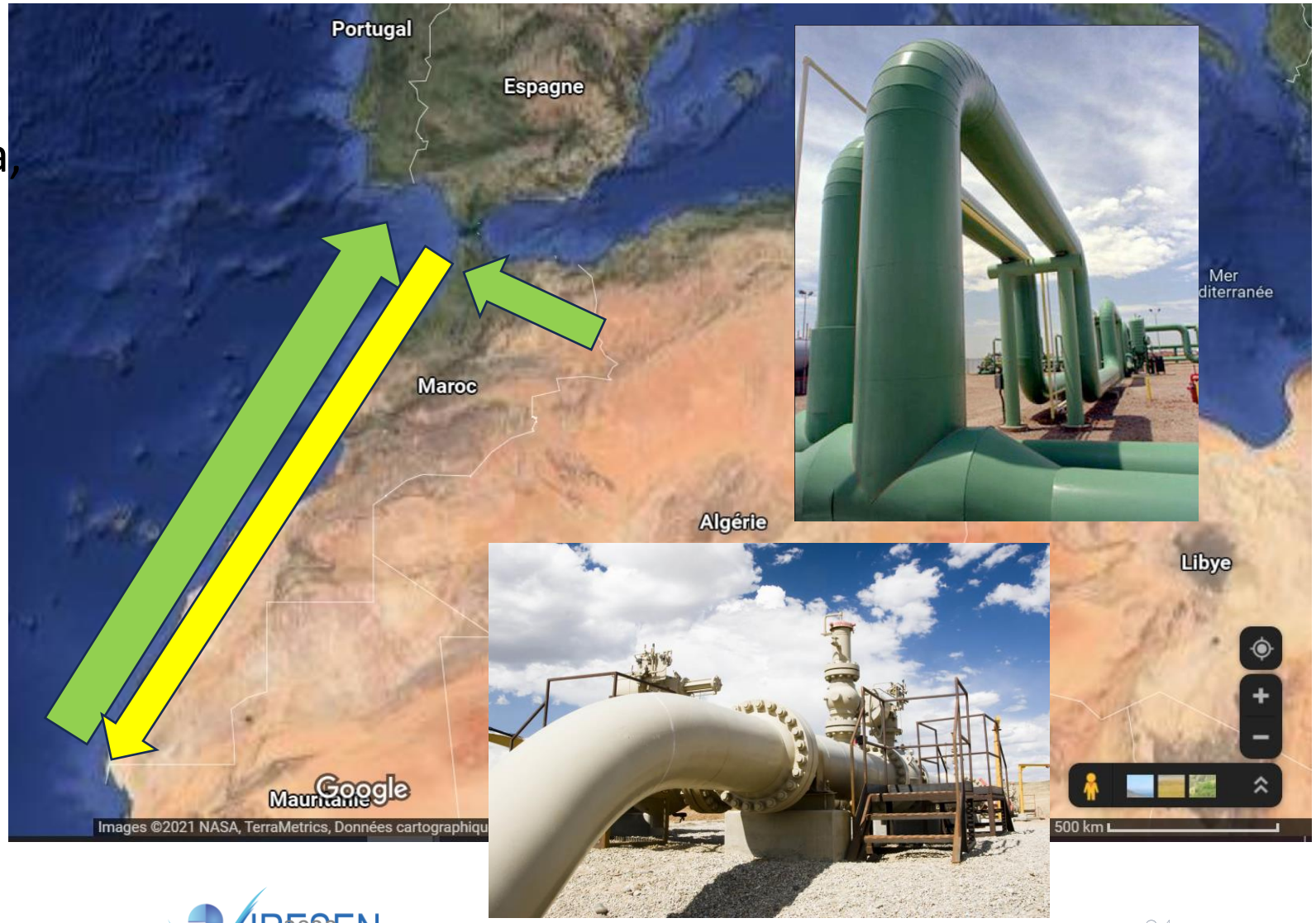
HOW TO DELIVER GREEN HYDROGEN TO EUROPE

- **<u>Short Term:</u> Ammonia**
  - Ammonia via Shipping
  - Techno-economic optimal
  - Exiting corridors and infrastructure (Ammonia imports, for the fertilizer business)
  - No need for CO2
  - All ongoing projects under development are on Ammonia



HOW TO DELIVER GREEN HYDROGEN TO EUROPE

- **Longer Term, Option 1:**
  - Piplines (Hydrogen, Ammonia, eNatural Gas?)
  - ~2000km to build
  - Existing 500km MGE pipeline
  - Ongoing Nigeria Morocco Corridor



HOW TO DELIVER GREEN HYDROGEN TO EUROPE

- **Longer Term, Option 2**:
  - eFuels
  - Shipping
  - Colocalization of vertical integration → Green Refinery industry
  - Existing sources of CO2: cement and fossil power plant

HOW TO DELIVER GREEN HYDROGEN TO EUROPE

- **Longer Term, Option 3**:
  - Green Steel
  - Colocalization of a heavy industry
  - The most dense way to transport Hydrogen

HOW TO DELIVER GREEN HYDRO[illegible]TO EUROPE

- **Longer Term, other Options**
  - LOHC
  - Still under demonstration technology
  - Energy symetry challenge

GREEN HYDROGEN IN MOROCCO : CONCLUSIONS

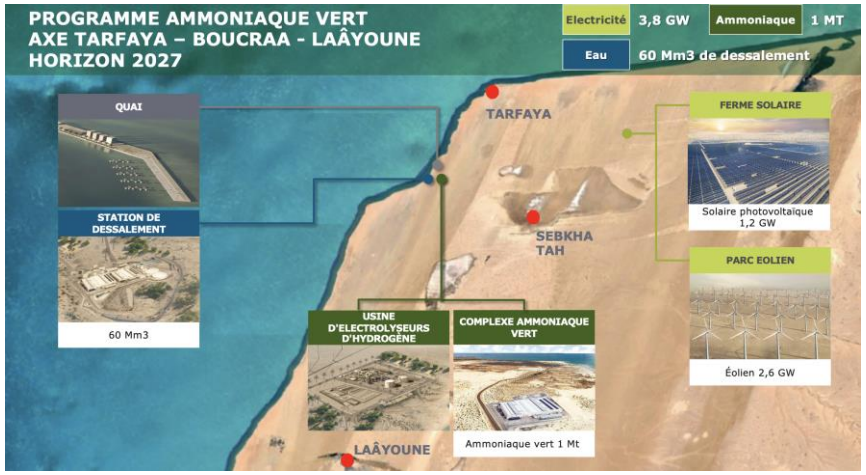
- Morocco has a **massive potential** to produce competitive **green molecules**

- Morocco has been pionneering and proactive in the whole MEA Region in exploring its potential and preparing the deployment of this highly added value future economy

- The « **Moroccan Offer for Green Hydrogen** » has been validated by His Majesty the King and the **Moroccan Govenment** is working on **its deployment**

GREEN HYDROGEN IN MOROCCO : PERSPECTIVES

- Export of highly added value industrial Green Molecules (Market size by 2050 ~ €1000Bn)
- Decarbonization of the Moroccan Local Economy :
  - OCP Group's GW scale Project to produce 1 MT of Green Ammonia by 2027
    - → ~ 0.2 MT of Green Hydrogen
    - → ~ 2 GW of Electrolysis Capacity → ~ 4 GW of Renewable Power
- Co-Localization of an impactful green industrial value chain:
  - Electrolyzers' Gigafactory announced by John Cockerill (04/01/2023)
  - Perspectives: PV, Wind, Desalination, Steel, Methanol & Heavy Chemical Industry




lecho.be

L'Echo

ACTU > ENTREPRISES > ENERGIE

John Cockerill investit dans la filière hydrogène au Maroc

Après un investissement annoncé sur ses terres liégeoises, John Cockerill conclut un accord stratégique pour développer la filière hydrogène au Maroc. ©Valentin Bianchi / Hans Lucas

LOUISE RENSON | 04 janvier 2023 18:24

John Cockerill a conclu un accord stratégique avec une entreprise marocaine pour développer


under the aegis of
KINGDOM OF MOROCCO
Ministry of Energy Transition
and Sustainable Development
hosted by
IRESEN
CLUSTER GREEN H2
UM6P
University Mohammed VI Polytechnic
The World Power-to-X Summit
WorldPtX
SUMMIT
8-10 October 2024, Marrarkesh
SAVE THE DATE
H2
H2 HYDROGEN
ZERO EMISSION
www.worldptxsummit.com

IRESEN
Institut de Recherche en Energie Solaire et en Energies Nouvelles

10 ans au service de la recherche et de l'innovation

Thank you for your attention

contact@iresen.org

16, rue Amir Sidi Mohammed - Rabat

www.iresen.org

+212 (0) 5 37 68 22 36