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

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CLUSTER GREEN H2
RECHERCHE - INNOVATION - INDUSTRIE

GERMAN « NUMOV » DELEGATION
GREEN ENERGY & HYDROGEN

Green Hydrogen in Morocco

Which Opportunities for Germany and Morocco

Rabat, March 6th 2023

Samir Rachidi, IRESEN

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, ...

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

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

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

Green H2A (Hydrogen 2 Ammonia)

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MOHAMMED VI POLYTECHNIC UNIVERSITY

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

INDUSTRIAL
Up-Scalling

MOHAMMED VI POLYTECHNIC UNIVERSITY

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Park green energy

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OCP

other industries

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

Green H2A Hydrogen Ammonia

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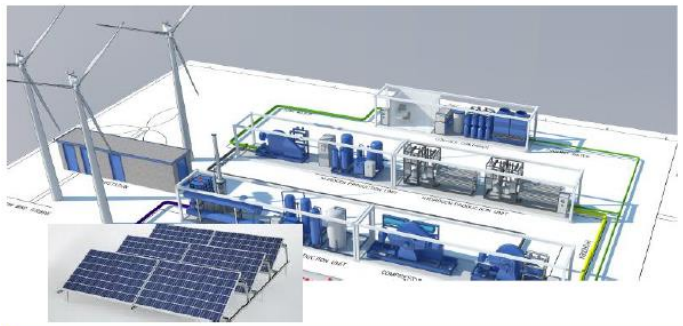
PtX µPilot unit: Research & Capacity Building

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

Capacity Building & Dissemination:

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 Hydrogen Ammonia

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Agora Energiewende

CSIR our future through science

DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.

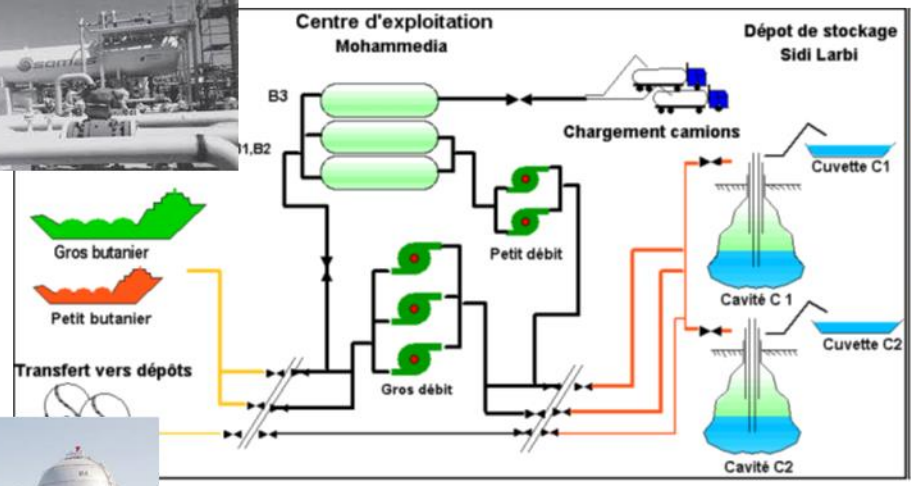
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

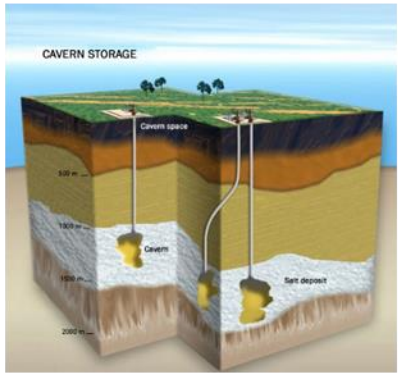
- Project « PtX Pathways » (Power-To-Liquid – PtL)
- Capacity: ~ 1 MWe || ~100kg-1ton/day
- Objectives:
  - Technology Assessment
  - Scale-Up Perspectives
  - Applications: Local Market and Exports

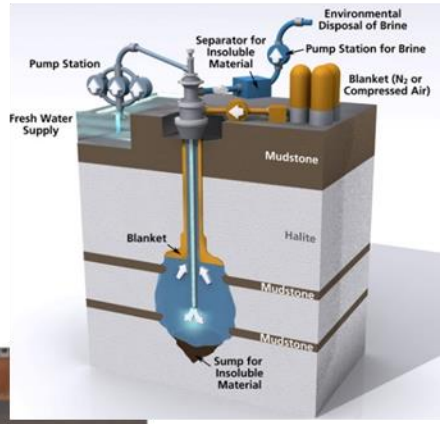
GREEN H2A R&D PLATFORM
INNOVATION TO CO-LOCALIZE PTX INDUSTRY

Green H2A Hydrogen Ammonia

HDF ENERGY | enagas | SOMAS الشركة المغربية للخزن SOCIÉTÉ MAROCAINE DE STOCKAGE | Park green energy | Université Ibn Tofaïl







- Projevt « MELHY »
- Objective: Feasibility Study of Storing Green Hydrogen in Moroccan Salt Caverns

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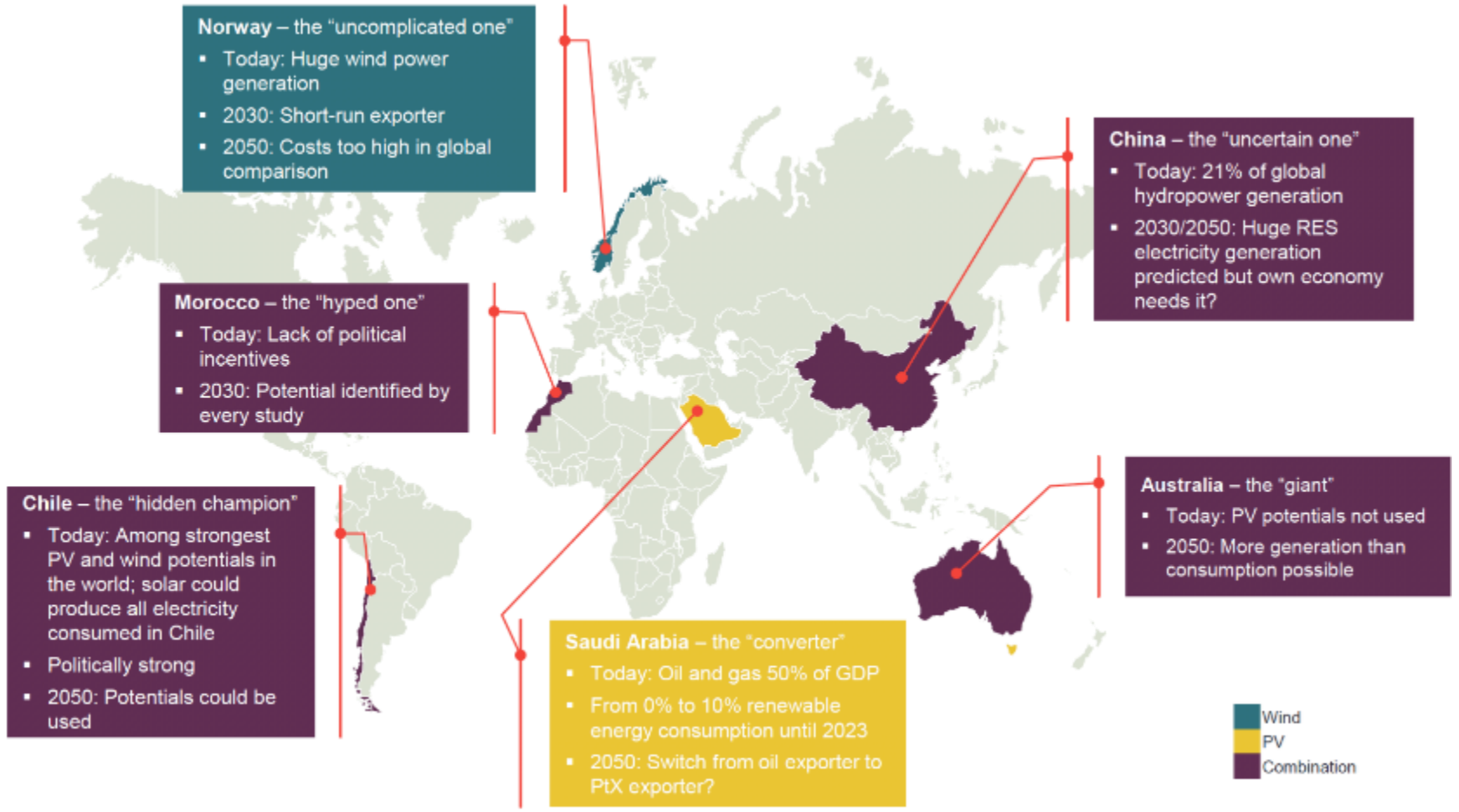
HYDROGÈNE VERT AU MAROC : CHEMIN PARCOURU À CE JOUR

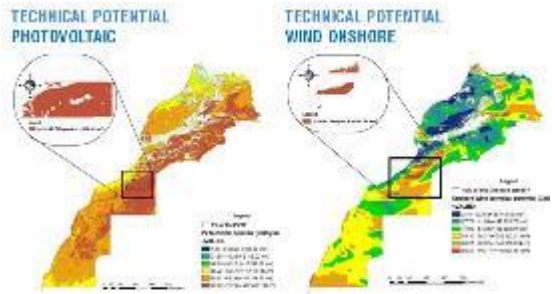
EXPORT POTENTIAL FOR PTX PRODUCTS: FRONTRUNNER POSITION



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

MOROCCAN POSITIVE CONTEXT

HIGH REN. POTENTIAL



	Photovoltaic (PV)	Wind Onshore
Technical Potential (TWh)	49 000	11 500
Technical Potential (GW)	20 000	6 000
5% of the Tech. Pot. (GW)	1 000	300

STRONG POLITICAL SUPPORT & INTERNATIONAL PARTNERSHIP

SUCCESSFUL DEPLOY. OF REN.

GROWING R&D INFRASTRUCTURE AND CAPACITY BUILDING

INVOLVMENT OF THE INDUSTRY AND THE PRIVATE SECTOR

STRONG PROXIMITY + MARITIME & GAS CONNECTIVITY WITH EU

GREEN HYDROGEN IN MOROCCO: FIRST STEPS, INITIATIVES & DRIVERS

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

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

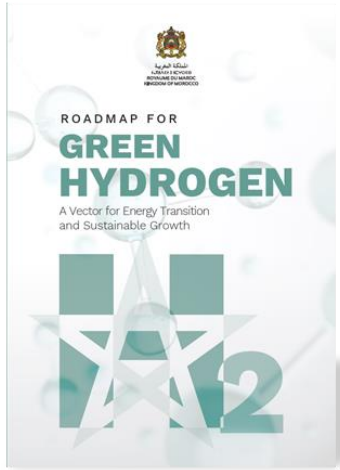
MOROCCO'S PTX 2050 ROADMAP

with frontier economics

Keywords: R&D, Innovation & Industrial opportunities

NATIONAL GREEN H2 STRATEGY

Published in August 2021



MOROCCO-EU Partnership

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

COMMISSION NATIONALE HYDROGENE

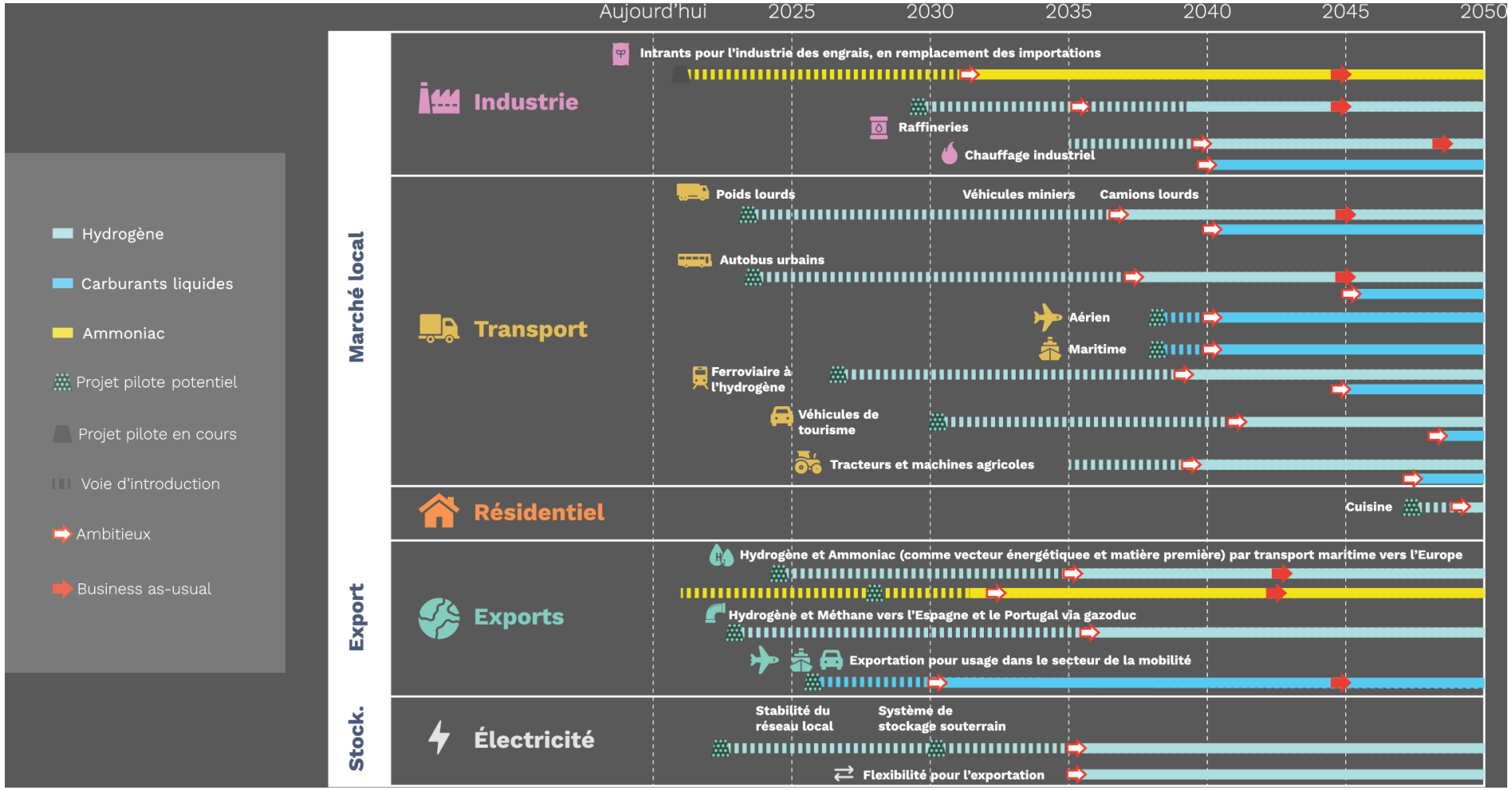
Creation of a National Commission for Power-to-X by the Moroccan Energy Ministry on Feb. 11th, 2019

CLUSTER GREEN H2

Creation of an industrial Green Hydrogen Cluster

GREEN HYDROGEN IN MOROCCO: ROADMAP (1/4)

Market Opportunities & Applications



GREEN HYDROGEN IN MOROCCO: ROADMAP (2/4)

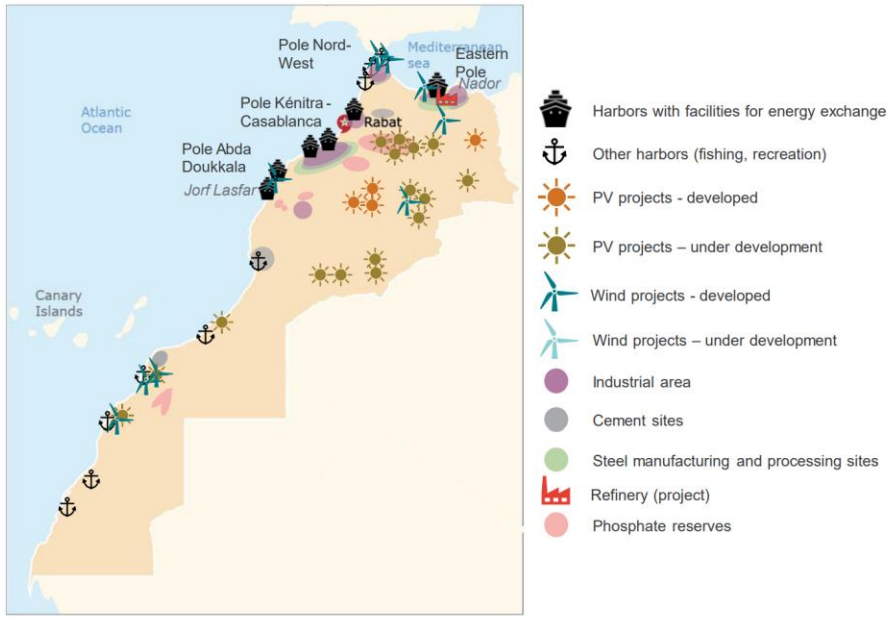
Sustainable framework to develop the **PtX industry** in Morocco & **Action Plan**

1. **Facilitating costs reduction** along the PtX value chain.
2. **R&D:** Setting-up a **Moroccan** and **international research cluster**.
3. Defining the relevant measures for **local content**.
4. Setting-up an industry cluster and develop related **infrastructure masterplan**.
5. **Securing financing** to developing the PtX industry.
6. Creating the **conditions for exporting PtX** products from Morocco.
7. **Assessing** in detail a **storage** plan for the electricity sector.
8. Developing **domestic markets.**

GREEN HYDROGEN IN MOROCCO: ROADMAP (3/4)

Set up an **Industry Cluster** & develop related **infrastructure masterplan**

Location of renewable energy sources, industry and ports



Source: Frontier Economics based on Masen (2020) for RES deployment, the Ministry of Industry (2020) for industry location, Ministry of Transport (2011) for harbours , Ayad, A. et al. (2019) for phosphate reserves and CemNet (n.d.) for cement sites.

- The locational array of the PtX industry strongly determines infrastructure requirements and associated costs.
- Developing the industry in clusters may enable synergies in the use of infrastructure and lead to cost savings.
- Four options appear possible for Morocco:

Cluster	*Drivers of cost differences*				
	RES-E generation	RES-E transport	Carbon procurement	H2 pipeline	Harbor adaption
South-South					
South-North (via H2)					
South-North (via electricity)					
North-North					

Recommended actions (short term)

- Conducting technical and cost studies to choose the cluster (or clusters) and its **related infrastructure**.
- Including **PtX in "Special Economic Zones" (SEZ)**, define its legal framework and market design
- **Assessing grid needs** and lead the dialogue on PtX grid access terms

Source : Frontier Economics

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

ONHYM · Fédération de l'Energie · OCP · masen · IRESEN · amee · UEMF · Université Ibn Tofail · MASCIR · green energy · NAREVA

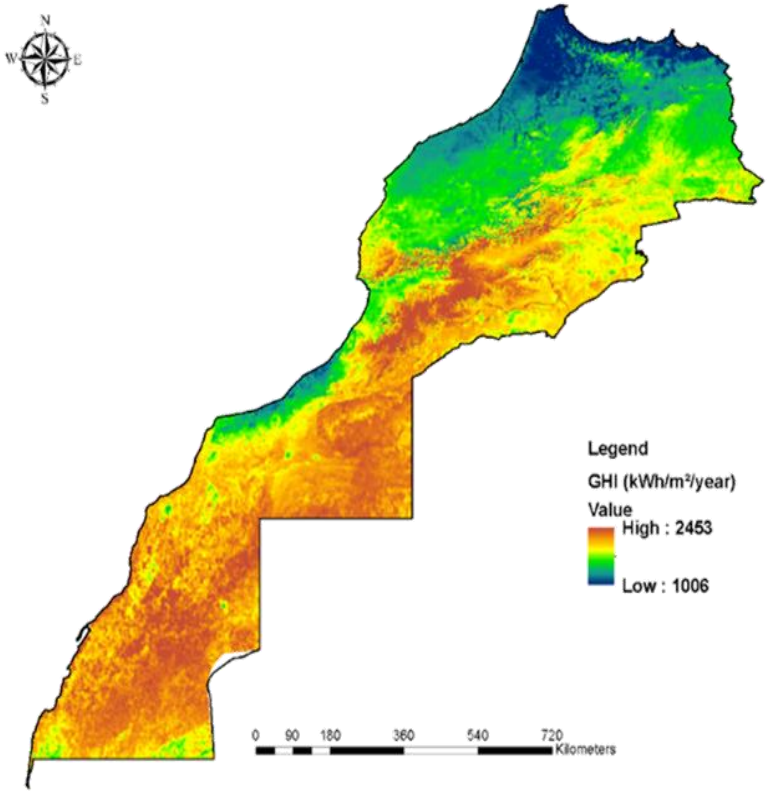
MAGHREB STEEL · AFRIQUIA · AKWA · Air Liquide · SNEP · enel · Sumitomo Corporation · ACWA POWER · Vestas · ENGIE · John Cockerill · BASF · thyssenkrupp · EDF · AAQIUS · SIEMENS energy

“GREENH2 MAROC” CLUSTER

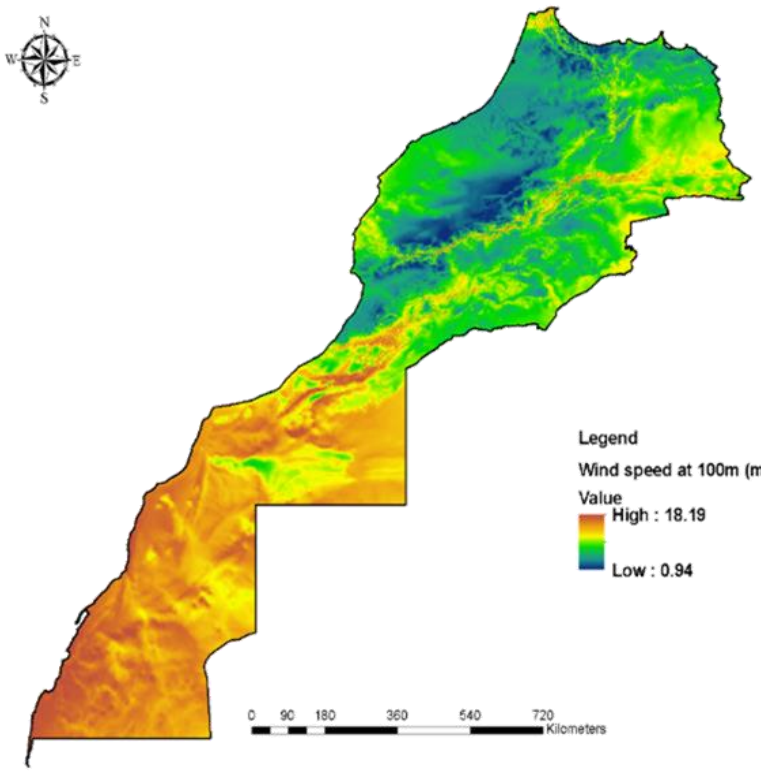
HYDROGÈNE VERT AU MAROC : LE POTENTIEL ET LES OPPORTUNITÉS

POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

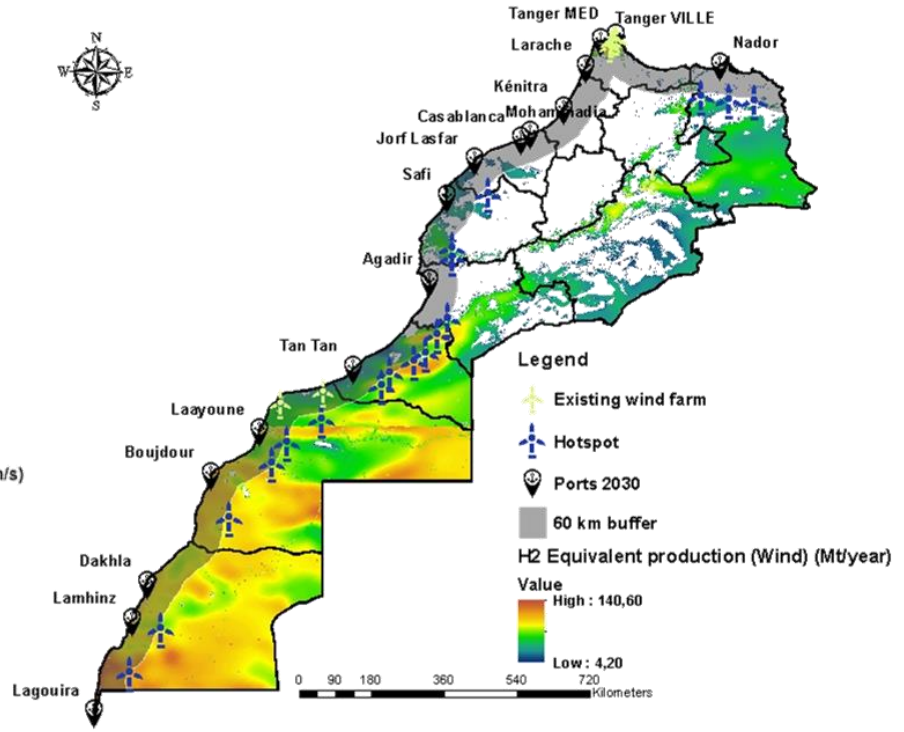
CRITERES DE SELECTION ÉNERGIE SOLAIRE PV



: Carte du rayonnement solaire global

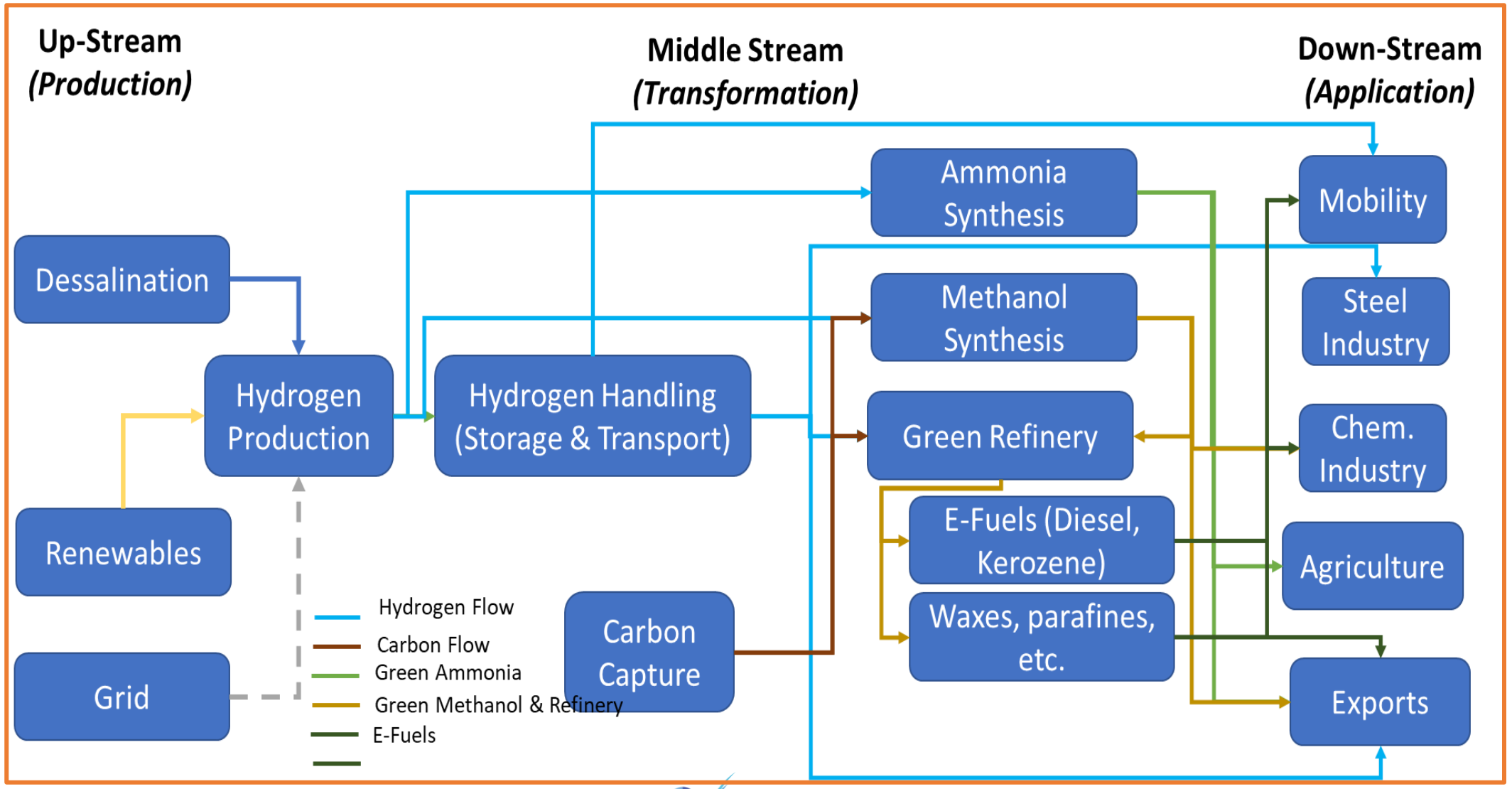


Carte de la vitesse du vent



Superposition + Infrastructure portuaire

HYDROGÈNE VERT: UNE CHAINE DE VALEUR INDUSTRIELLE



POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

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POTENTIAL GREEN HYDROGEN VALLEYS IN MOROCCO

HYDROGÈNE VERT AU MAROC: CONCLUSIONS

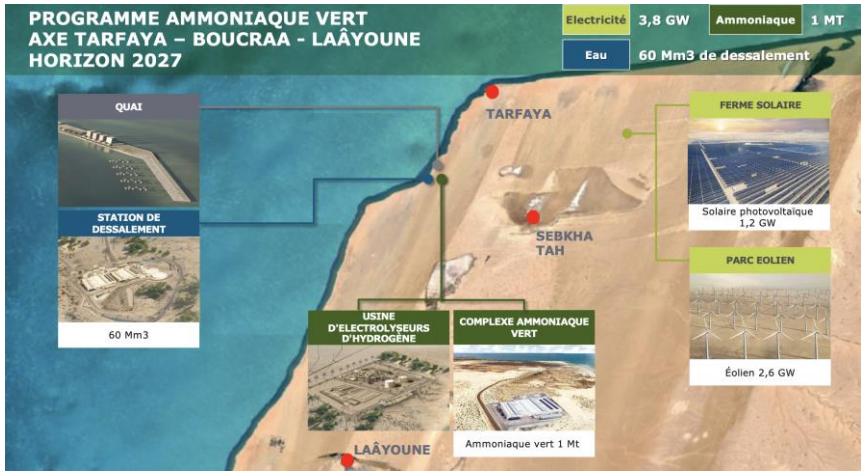
- Le Maroc possède un grand potentiel pour produire des molécules vertes à un coût compétitif

- Le Maroc a été pionnier et proactif dans la région pour l'exploration de son potentiel et de préparer les étapes nécessaires pour le déploiement de cette économie à forte valeur ajoutée

- Suite à la réunion du 22/11/2022, SM Le Roi que Dieu l'Assiste a donné Ses Hautes Instructions pour préparer l'Offre Maroc de l'Hydrogène Vert sur l'ensemble de la chaine de valeur

HYDROGÈNE VERT AU MAROC: PERSPECTIVES

- Exporter des molécules industrielle à haute valeur ajoutée (Marché à terme ~$1000 Mds)
- Décarboner l'économie locale:
  - Exemple → Annonce du dernier plan d'investissement du Groupe OCP:
  - 1MT d'Ammoniac Vert d'ici 2027, ~ 4GW de Puissance Renouvelables, ~ 2GW de Capacité d'Electrolyse
- Co-Localisation d'une chaine de valeur industrielle : pointue, propre et à fort Impact!
  - Annonce de la 'Gigafactory' d'Electrolyseurs de John Cockerill (04/01/2023)
  - Perspectives: Industrie EnR, Dessalement, Acier, Methanol et Chimie Lourde, etc.

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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 la filière hydrogène au Maroc. Point majeur de

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Thank you for your attention

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