H2 development and sustainability concerns in Morocco

29/10/2021
There are promising preconditions to develop a PtX industry in Morocco

1. Morocco has a strong RES-E potential and corresponding low costs prospects for PtX production

   Morocco could cover its domestic demand more than 10 times with its solar sources alone.\(^1\)

   Morocco’s RES-E technical potential\(^2\)


2. Its proximity to Europe and infrastructure partly already in place benefit PtX export prospects from Morocco

   Maghreb-Europe-Gas-Pipeline from the northern part of Morocco to Europe.

   6 harbours with facilities for energy exchange.

3. Morocco has strong international partnerships that lower trade costs and innovation hurdles

   Free trade area between EU and Morocco.

   Technical assistance for a Moroccan PtX industry.

   Financing large-scale RES-E (like Noor I-IV, Ouarzazate).

   H2 alliance DE-MOR.

   OCP engaged in inter-institutional alliances (including Fraunhofer, Germany) for PtA.

4. Involvement of industry and private sector

   Source: Iresen

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\(^1\) Global Solar Atlas (2020)

\(^2\) Iresen
Birth of Power-To-X in Morocco: Preliminary Studies

In 2018, two preliminary studies launched with the support of PAREMA on « Power-To-X » in Morocco.

**Market and Technologies**

With: Fraunhofer IMWS

- Key-Words: Electrolysis, Green Hydrogen & Ammonia
- From: October 2018
- To: December 2018

**Opportunities and Potential for Morocco**

With: Fraunhofer ISI

- Key-Words: PtX Potential, Grid, Infrastructure, Impact, Exports
- From: October 2018
- To: November 2018

Results presented during a workshop chaired by H.E. Mr. A. RABBAH on Feb, 2019.
First Workshop on “Power-To-X” on Feb. 11th 2019

« … Morocco: a Business Case for PtX, given its potential of renewables... »

« Electricity stands for 60 to 75% of the Cost of a Green Molecule … »

« Morocco could capture around 2 to 4% of PtX world market … » (Hydrogen Market~$100Bn, Ammonia Market ~$40 Bn, Methanol Market ~$50Bn)

« Need for R&D demonstration at a pilot scale… »

« Substantial Impacts on Moroccan Economy, Creation of a dedicated Industrial Eco-System… »

- Decision:
  - Creation of a ‘National Commission of PtX
  - 3rd study PtX RoadMap for Morocco
National Commission for Green hydrogen (February 2019)

Composed of the relevant Ministerial Departments (Energy, Finance, Transport, Higher Education, Industry), ONEE, MASEN, IRESEN, CGEM and the Energy Federation...

- In charge of elaborating the H2 strategy

- Participation in the study trip to Germany in November 2019 to learn about the German experience in this field.
Power to X 2050 Roadmap for Morocco

• Launched on October 2019 with support of PAREMA

• Launch during the first meeting of the national commission of Hydrogen Morocco

• A third more in-depth study is launched to:
  • Assess R&D, Innovation and Industrial opportunities for Morocco
  • Evaluation of the socio-economic impact of the PtX economy
  • Focus on the environmental impact of the PtX industry
  • Elaborate a sectorial Roadmap for PtX in Morocco (2030 – 2050)
Ptx Roadmap: Hydrogen opportunities/applications

Short to medium term
2020 - 30
- Input for fertiliser industry, replacing ammonia imports
- Exports

Medium to long term
2030 - 40
- Local grid stability
- Flexibility in electricity exports
- Heavy trucks / mining vehicles
- City buses
- Railway “Hydrail”

Long term
2040 – 50
- Passenger vehicles
- Industrial heat
- Cooking and water heating
- Aviation
- Shipping

*Preconditioned by the plans of Morocco to resume operation of its current refinery “La Samir” or the vision to construct new refinery in the North of Morocco (Nador city) as was announced in 2018
Ptx Roadmap: green ammonia production offers a business case to introduce the PtX industry

Costs of green vs conventional ammonia in Morocco

- PtA (national production)
- Conventional ammonia (imports)
- Ambitious materialisation timing
- Business as usual materialisation timing

Source: Updated Agora/ Frontier Economics (2018) calculator combined with Fraunhofer Haber-Bosch assumptions

Morocco already employs a significant amount of ammonia in its fertiliser industry

- 1.4 Mt imports represented 0.4% of Morocco’s GDP in 2017.
- Between 2012 and 2017, ammonia imports had doubled.
- The OCP group reports 1.8 Mt ammonia procurement in 2018, with expectations of a sharply increasing demand in the future.

Phases to materialise this business opportunity

<table>
<thead>
<tr>
<th>Phase</th>
<th>Until</th>
<th>Description</th>
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<tbody>
<tr>
<td>Short term</td>
<td>2030</td>
<td>Focus on pilot projects, funding support to early projects, electricity from the grid and other cheap electricity sources (for example, industrial waste), can enhance the business case.</td>
</tr>
<tr>
<td>Medium term</td>
<td>2030-2040</td>
<td>Commercial projects could arise, still complementing RES with electricity from the grid and cheap sources would continue fueling the sector.</td>
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<tr>
<td>Long term</td>
<td>2040-2050</td>
<td>Improving commercial cases for ammonia (rising conventional price and expanding fertiliser industry), electricity procurement from RES-E only.</td>
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</tbody>
</table>
Ptx Roadmap: the Maghreb–Europe Gas Pipeline has a potential relevant role to export PtX to Europe

**Exploring this opportunity**

To assess from a technical and cost-perspective
- Hydrogen blending (5%-15%),
- Pipeline reconversion to green hydrogen,
- Injecting green methane.

- Commercial assessment
  - MEG connects with the Iberian Peninsula. PtX aspirations of Portugal and Spain shape the economic viability of this option.

Source: Sémhur (2009)
PtX Roadmap: three pillars defining a sustainable framework to develop the PtX industry in Morocco and eight areas of action

3 pillars:
- **Technologies** encompassing technological developments and cost savings,
- **Investment and supply** comprising the conditions for investment in the PtX industry,
- **Markets and demand** referring to the realisation of demand opportunities, giving place to new markets.

### 8 Actions Plans

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 H2 Cluster (launched on March 2021)

Vision => creation of the first national and regional (international) collaborative platform fully dedicated to the development of hydrogen/PTX industry, notably through collaborative innovation, industrial integration, capacity building, knowledge transfer and market development

Objectives:
- Create, develop and animate an efficient H2 ecosystem
- Strengthen the exchange and collaboration between actors
- Conduct business intelligence studies for collaborative purposes
- Contribute to the capacity building of the members of the H2 ecosystem
Green H2 Cluster – Structure

Working Groups

1. R&D&I
2. Industry-ENR
3. Industry-Chemical
4. Project development
5. International Partnership
6. Transport of Energy

Website: www.greenh2.ma
National H2 Commission vs Green H2 Cluster vs
Summary of Important milestones

MARKET & TECHNOLOGIES

- Creation of a National Commission for Green hydrogen on February 2019

MOROCCO’S PTX 2050 ROADMAP

- MOROCCO-GERMANY ALLIANCE
  - Signature d’accords bilatéraux pour lancer des projets d’hydrogène vert et de ses applications sur le court terme (Filière “Power-To-X”)

OPPORTUNITIES & POTENTIAL FOR MOROCCO

- National Hydrogen Strategy published in July 2021
Sustainability Concerns of H2 in Morocco

The additionality of renewable electricity generation:

The production of green hydrogen presupposes additionality of the expansion of renewable energy sources.

- We assume that - at least for the foreseeable future - there will be a dedicated investments in wind and solar farms exclusively earmarked for PtX, as.
  - (i) this will make it easy to prove 100% RE,
  - (ii) off-grid regions are particularly suitable (land availability, RE yield) and
  - (iii) regulatory uncertainties and costs can be avoided (grid fees, connection procedures, etc.).
- We assume that the energy transition in the electricity sector and the PtX strategy will mutually benefit each other (synergy effects, economies of scale, learning curves) and will not lead to a slackening of momentum in the "electricity transition"
Sustainable use of space:

relates to competition between various land uses. Competition with the use of land for food production and with forested areas are of particular importance in this regard.

Renewable power facilities, synthetic fuel production plants and, as necessary, plants for obtaining water and CO2 all require space.

=> In Morocco, 12.25% of the land is dedicated to agriculture and 12.8% is forested.

=> This suggests that nearly 75% of the territory could be used for PtX or other purposes.

=> We estimate that land needed for additional RES dedicated to the PtX industry would be between 990 and 1,660 km². This is at most 0.36% of non-agricultural nor forested land in Morocco.
Sustainability Concerns of H2 in Morocco

Existing potable water supply must not be used in dry climate zones:

Even though Morocco has limited availability of sweet water in the country, the access to the sea provides the option to gain sweet water from desalination.

⇒ it can be expected that water availability is likely not a limiting constraint in Morocco since desalination plants can be built along the coastline, where RES-E potentials are promising.

⇒ Morocco has started to build small-scale desalination plants since 1995 and has reached a capacity of 132 Mm3/year by 2016. In the 2015 National Water Plan, the country planned to increase this capacity to over 500 Mm3/year out to 2030.
Sustainability Concerns of H2 in Morocco

Sustainable economic development in production countries:

CO2 reduction measures in foreign countries are implemented in a manner that encourages sustainable economic development.

=> Criteria for sustainable development could include the requirement to make additional investment, reduce poverty levels, increase employment, local content and/or transfer new technologies/

=> It can be expected that successful economic development depends heavily on political and regulatory factors with along a strong industrial development policy.
Sustainability Concerns of H2 in Morocco

Closed carbon loop:

the origin of carbon in case of synthetic energy carriers such as methane, syn-fuels, methanol.

• The production of 1TWh of synthetic methane requires 198 kt CO2 (Agora/Frontier Economics, 2018).
• The CO2 supply is limited in the long-term. Using CO2 from fossil processes is not sustainable. A true CO2 recycling process is required.
• The origin of the carbon will be the more an issue if Morocco becomes an exporter of PtX to countries with 95% reduction targets. It is difficult to envisage that those countries would import PtX based on non-sustainable CO2 sources.
• Direct Air Capture (DAC) appears as the main approach.
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