Imagination is everything. It is the preview of life’s coming attractions.

Albert Einstein
Desertec idea: Solar and wind from the deserts (and oceans)

Just a few % of the vast MENA Deserts alone would in theory (!) be more than sufficient to power the world’s 160.000 TWH Energy Consumption!

A failed idea? (common opinion in Germany)

The deserts of Northern Africa and the Middle East (MENA) are still almost fully ‘fossil’ based, but they a emerging supplier of lowest cost green energy for their 500 mln inhabitants and for the world markets

Dii Desert Energy (Desertec3.0) is an international industry initiative, founded in 2009 in Germany as an international industry Market Enabler for ‘Green Electrons and Molecules’ (e.g. Hydrogen, PtX), connecting people and countries for accelerating the energy transition in MENA.
Desertec 1.0, 2.0 and 3.0: the Arab world to become a Powerhouse for itself and a global green exporter

Development phases of Desertec

2004 Great Idea! Pre-phase
2009 It works! Concept phase
2015 First Harvest! Implementation phases
2019 Acceleration! Green Electrons and green molecules

Desertec 1.0
Export Oriented

Desertec 2.0
Region Oriented

Desertec 3.0
Region and World Oriented
Dii Desert Energy and Desertec 3.0: creating good momentum and positive vibes in the market

MENA Hydrogen Alliance
A platform for members to meet and discuss pathways forward to kick start a low-carbon hydrogen economy

Think Tank
Studies and papers well received by the market and available freely to increase knowledge for a greater impact

Knowledge partner
Strong presence in leading industry event to help shape programs by providing exclusive insights and market updates

A reinforced and unique platform
Since 2019, more than tripled its industrial partners (now almost 100 from 30 countries, 5 continents)

RE Initiative Toolkit
Levelized Cost of Energy (LCoE), Storage (LCoS), Hydrogen (LCoH) and Ammonia (LCoA) financial models integrate the toolkit.

Social Media
Maximize social media platform to amplify our activities and partners achievements
To date: Over 100 industry partners from 35 countries

**Our Strategic Partners**

TCWA Power

ENOWA

NEOM

State Grid Corporation of China

 thyssenkrupp

**Our Lead Partners**

AIR PRODUCTS

OUDRA

Al Gihaz Holding

AMEA Power

Envision

**Our Associated Partners**

All Partners of Dii Desert Energy are members of the MENA Hydrogen Alliance
Integration of Green ‘Electrons’ and ‘Molecules’ along the Emission-Free Energy Value Chain

Objectives: Lowest cost, secure, emission free and local benefits

Chain Optimization: Virtual (Guarantees of Origin) and Physical Trading
Egypt is currently leading installed RE capacity in MENA, but other countries move faster!

### Installed Capacity

- **Egypt**: 3,320 MW
- **Morocco**: 2,323 MW
- **Tunisia**: 363 MW
- **Algeria**: 458 MW
- **UAE**: 3,338 MW
- **Morocco**: 2,323 MW
- **Sudan**: 136 MW
- **Oman**: 807 MW

### Historical Trend

- **2022**: 17.2 GW

Source: IRENA database 2022, Dii Database

Other countries: Bahrain, Iraq, Israel, Kuwait, Lybia, Mali, Palestine, Qatar, Syrian AR, Yemen
The MENA Hydrogen Alliance focuses on connecting MENA to Europe by fostering a regional partnership between Europe, North Africa and the Middle East to kick-start green hydrogen economies, to accelerate the deployment of green hydrogen projects and local value chains.

- First two physical meetings at WFES, January 2020 hosted by Masdar and March 2020 at InterSolar
- Presentation of 2x40 GW initiative to EVP Timmermanns
- Numerous bilateral talks with Minister of Energy in Morocco, Masen, Nareva, IRESEN, AMEE, CEO of Sonelgaz, STEG Tunisia, League of Arab States
Dii’s MENA Hydrogen Alliance: first ideas for connecting MENA with Europe
Dii’s MENA Hydrogen Alliance: connecting MENA with Europe
Green Hydrogen Study on Jobs! Dii Desert Energy & Roland Berger!

- Joint study with Roland Berger on ‘The Potential of Green Hydrogen in GCC Region’
- Focus on localization of hydrogen value chain and job creation
- Launched in April at the World MENA Hydrogen (virtual) Congress
Anticipating the emerging importance of international trade of net emission free energy carriers bilateral trade concepts (e.g. connecting production in MENA with Off-takers in Europe) have been initiated in early 2022.

On March 29th Paul van Son (Dii) and Jan Haizmann (formerly EFET) have founded the foundation ZETA (Zero Emission Traders Alliance) in Amsterdam with support by Dii.

ZETA will closely cooperate with Dii and draw Dii partners and other qualified companies with an energy trading interest together to discuss, propose and advocate concepts, certification, standards and mechanisms for bilateral and multilateral zero / low emission energy trade.

First focus will be on green H2 and Ammonia in MENA.
The MENA Gas infrastructure is ideally positioned for a fast exchange and export of green hydrogen!

An existing gas infrastructure from Algeria and Morocco could be converted to a hydrogen infrastructure (grey-orange lines). A “new” hydrogen transport pipeline must be realized from Italy to Greece, crossing the Mediterranean Sea to Egypt, which could eventually be extended to the Middle East (orange line).

Source: The North Africa-Europe Hydrogen Manifesto, Prof. Dr. Wijk A. v., Frank Wouters F., Ikken, B., Samir, R.
An Eastern Mediterranean hydrogen pipeline could be easily filled by up to 100 GW zero emission energy from three or more countries.

- NEOM will be powered by **100% low-cost renewable energy** (40 – 60 GW)
- One of three strategic projects of **Saudi Agenda 2030**
- Given the availability of competitive and low-cost renewable energy, NEOM will produce **green hydrogen at scale** for local and world markets
- **Largest green hydrogen project globally** currently under construction (1.5 GW wind, 2.5 GW solar PV), 2,200 MW electrolyzer capacity
- 24 hydrogen projects already announced in Egypt
- Jordan has become a leader in solar and wind
- Excellent available infrastructure in the region, including local offtakers
• Produced in cooperation with Roland Berger

• A collection of hydrogen projects recently announced in the MENA region with the majority focusing on green hydrogen

• Includes – among others - project partners, estimated investment, renewable energy capacity and technology, off-take, and import-export component
Various hydrogen projects have recently been announced in the MENA region – with the majority focusing on green hydrogen.

Non-exhaustive

Hydrogen project announcements in MENA

Total of 76 projects across the MENA region – with >85% projects geared towards production of green hydrogen.

1) includes some yellow H2 projects

Source: Desk research, Dii, Roland Berger
Majority of projects in the region target international off-takers with Europe being one of the largest markets.
Largest green hydrogen projects to be built in Oman, Mauritania and Egypt

Non-exhaustive

Largest known green H₂ projects by electrolyzer capacity [GW]

17 projects are powered by a combined ~67 GW of electrolyzer capacity

Source: Desk research, Dii, Roland Berger

cornelius.matthes@gmail.com
Building the world’s largest green hydrogen plant

3 equal joint venture partners with more than 80 years experience across ACWA Power, Air Products and NEOM

A total investment value of $8.4 billion with $6.1 billion non-recourse financing from 23 local, regional and international banks

Exclusive 30-year offtake agreement with Air Products

Up to 600 tonnes per day of carbon free green hydrogen produced by the end of 2026 to be transported in the form of green ammonia

Saving the planet up to 5 million tonnes of CO2 annually

Around 4GW of integrated onshore wind and solar energy

Supporting Saudi Arabia’s Vision 2030 and Saudi Green Initiative

Over 300 km2 of land in NEOM
Hydrogen potential for Omani Ports

Oman is one of the top countries for renewable resources

- **Solar PV potential**
  - kWh/m²
  - >2400 kWh/m²

- **Wind speed**
  - m/s
  - Up to 11 m/s

50,000 km² allocated for green H₂ projects

3 areas selected with a total area of ~50'000 km² for green H₂

1. Global Horizontal Irradiation (GHI)
2. Source: Global solar atlas, global wind atlas (July '23)
Hydrogen potential for Omani Ports

Oman has ambitious production targets until 2050, with already >1 Mtpa by 2030

Green H₂ production ambition for Oman in 2030–2050 (Mtpa)

- 2030: 1.0 - 1.5 Mtpa
- 2040: 3.25 - 3.75 Mtpa
- 2050: 7.5 - 8.5 Mtpa

- Electrolyzer capacity (GW):
  - 2030: 8-15 GW
  - 2040: 35-40 GW
  - 2050: 95-100 GW

- Renewables capacity² (GW):
  - 2030: 16-30 GW
  - 2040: 65-75 GW
  - 2050: 175-185 GW

1. Approximate values for Duqm, Oman. 2. Includes 25% buffer over Renewables needed for electrolyzers to account for Balance of plant load (which includes N₂ synthesis loop, storage tanks for H₂/N₂, another auxiliary facilities load). Assumption: Sustainable Development Scenario (2°C), Source: Yenom analysis; IEA
Hydrogen potential for Omani Ports

5 projects in the Duqm region awarded in June 2023, positioning Oman as one of the world’s leading gH₂ hubs.
Hydrogen potential for Omani Ports

Oman’s integrated hydrogen ecosystem

- Key economic and industrial zones of Oman to be connected via an infrastructure network.
- Approximately 2000 km of low carbon Hydrogen pipelines spread across Oman.
- Spurring localization of key industries and forward connected industries in existing and new industrial zones.

2030 | 2040 | 2050

- Green Hydrogen Hub
- Wind and Solar plants

Disclaimer: This map is for illustrative purpose only and does not necessarily accurately reflect international borders. The data provided in this schematic are provided for illustration purposes only. Hydrom is not responsible for the misuse or misinterpretation of the data.
A report in cooperation with the Oman Hydrogen Center for ASYAD, Oman’s new integrated logistics provider that aims to be one of the world’s top ten logistics hubs by 2040.

Established in 2016, ASYAD Group is comprised of three deep ports and three free zones supported by Oman’s five airports, a new rail network and a world class road network.

Exploring the hydrogen potential for the three main ports of Oman and their role in the energy transition: Port of Sohar, Port of Duqm and Port of Salalah.
Highlights and recommendations

- **ASYAD** has a huge opportunity to develop an **integrated strategy** to make Oman one of the key global hubs for hydrogen;

- A **hydrogen economy** should be developed aiming at both export and meeting local demand;

- Ports should develop as **fully integrated clean industrial hubs** to decarbonize or reaching net zero emissions in their own operations in the first instance;

- As repurposing the existing gas network is not likely to be achievable due to the substantial costs involved, there is the opportunity to **develop a new separate hydrogen infrastructure system**;

- Oman could play a **strategic role in the evolving ammonia and methanol market**, attracting new business and should aspire at becoming a global production and bunkering hub;

- Oman has the chance to **contribute setting global standards** and create a competitive advantage as **early mover** in an emerging market for low emission molecules;

- Emerging **hydrogen valleys** around the three ports will be the key enabler for a hydrogen economy in Oman, creating significant **job opportunities** for the country; and

- **Collaboration** among the three ports, and with international ports and associations, will be a key factor to provide a common strategy to position Oman as the export leader in hydrogen.
ASYAD Ports

2 Weeks
Sailing range to all major ports globally

200 weekly services
To 86 commercial ports across more than 40 countries

2 Billion Consumers
Market covered by direct trade & feeder’s operations to Middle-East, Africa, East-Asia.

- Port of Sohar - 20.6 sq km
- Port of Salalah - 6.3 sq km
- Port of Duqm - 44.3 sq km

Capacity
- General Cargo: 100+ Million MT
- Container: 8+ Million TEUs
- Liquid Cargo: 10 Million + MT

Volumes handled (in 2021)
- Containers: 5.2m TEUs
- Dry & Break Bulk: 57.7m Tons
- Liquid Cargo: 19.7m MT
It will be important for Oman moving forward to develop projects that can **cover the value chain, leverage local assets and address local needs**

All three Omani ports have the **potential to emerge as hydrogen valleys**, with an integrated approach, including the free and Industrial zones around each port.

**Building production facilities close to the coastal areas** i.e. at the ports or in their vicinity would minimize transport costs that remain a key challenge in developing hydrogen economies.

**Using and processing hydrogen directly at the ports**, and thus making them gateway hubs and fully integrated clean industrial hubs, would represent a great opportunity for establishing a hydrogen-driven industry.

In a recent study, the MENA Hydrogen Alliance and Roland Berger looked at the potential to localize the hydrogen value chain and learning from hydrogen valleys in Europe.
Hydrogen valleys and the potential for new jobs

The Ministry of Energy and Minerals during the presentation of Oman’s green hydrogen strategy envisaged the creation of cumulative till 2050 - **70,000 jobs** that would be directly related to hydrogen developments.

A recent study from the MENA Hydrogen Alliance and Roland Berger indicates that the localization of the hydrogen value chain activities in the Gulf region could result in 400,000-900,000 new indirect jobs.

Oman expected to account for 20% of the job demand i.e. 80,000-180,000 jobs. Almost half of the new jobs created would be in the renewable generation space, followed by electrolysis, storage and distribution.

Across the value chain, **multiple skills will be required**, creating diversified opportunities for high-skilled workers, technicians and unskilled workers.

*Forecast job creation in the GCC region by value chain activity.*

*Source: MENA Hydrogen Alliance, Roland Berger*
Potential applications of hydrogen in ports

**Ship refueling (Sohar, Duqm, Salalah)**

Ports could offer the possibility of refueling ships with low-emission ammonia or e-methanol during unloading or loading. An important development is anticipated in the fuel market for ocean-going vessels. Ammonia will be traded as a possible fuel, together with e-methanol, and used for co-firing gas turbines to reduce emissions in electricity generation.

**Heavy industry (Sohar)**

Various types of heavy industry, such as the production of ammonia or methanol, already require large quantities of hydrogen. This hydrogen produced by fossil fuel sources could be gradually replaced by low-emission hydrogen in the short to medium term. Steel and Cement are the earlier adapter of such production technologies.

**Refineries (Sohar, Duqm)**

Hydrogen-based fuels (e-fuels) can be blended with conventional fuels. E-fuels will have a premium price and help towards reaching quotas e.g. in aviation, a minimum quota of sustainable fuels is expected to spread globally. In the long term, many refineries are already thinking about applying a circular carbon approach.

**Mining (Sohar, Duqm, Salalah)**

Traditional mining activities require the consumption of substantial water and diesel. The first projects for alternative propulsion of mining vehicles, which are usually in mobile operation 24/7, are being tested on a hydrogen basis e.g. by Anglo-American in South Africa.
Developing a dedicated infrastructure for hydrogen

As repurposing the existing gas network is not likely to be achievable due to the substantial costs involved, there is the opportunity to develop a new separate hydrogen infrastructure system.

In addition to transport, storage will also be an important component of the hydrogen value chain and must be considered early on in the planning.

Underground storage will be one of the best ways, with numerous advantages in terms of environment protection, safety, and above all, CAPEX and OPEX.

Distance of the three deep-sea ports from salt cavern locations range from 35 to 80 km, therefore storage in lined rock caverns could also be considered as viable option.

Schematics of underground hydrogen storage in salt formations (left) and rock caverns (right). (Courtesy of Geostack)
Oman might be to take a **leading role in boosting the global market for ammonia**. Ammonia production could globally increase three-to-six-fold (from 185 Mt in 2020 to 540-1,140 Mt by 2050).

While a race between green ammonia and methanol is expected for the decarbonization of global shipping, **ammonia has a clear edge as the transport vector of choice** for most projects announced through 2030.

**E-methanol could play an important role in the industrial development of the country**, leveraging on a current total production capacity of 2 million tonnes.
A bunkering spot between Singapore and Rotterdam

- Oman is ideally located **midway on the Rotterdam-Singapore route**
- Oman should aim at becoming a **low carbon bunkering spot** for hydrogen and derivatives, adopting a flexible approach for the three ports
  - Sohar recently launched bunkering services by leveraging on being the **main export center** for petroleum products in Oman
  - Salalah, which has the highest container traffic in the country, has also ambitions to become a **bunkering hub by focusing on methanol**
  - Duqm could focus on becoming a **bunkering hub for ammonia**

*Source: Getting to Zero Coalition*
# Opportunities and challenges for Omani ports

<table>
<thead>
<tr>
<th>OPPORTUNITIES</th>
<th>PORT OF SOHAR</th>
<th>PORT OF DUQM</th>
<th>PORT OF SALALAH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>▪ Well-developed <em>infrastructure and industrial zone</em></td>
<td>▪ Abundance of <em>solar and wind resources</em></td>
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<tr>
<td></td>
<td>▪ Diversified group of <em>off-takers</em></td>
<td>▪ Availability of <em>land for renewable energy and hydrogen production</em></td>
<td>▪ Availability of space within the FZ for <em>further expansion</em></td>
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<td></td>
<td>▪ Proximity to <em>industrial and residential centers</em></td>
<td>▪ <em>Mining sector</em> active in the region</td>
<td>▪ <em>Largest trans-shipment port and biggest container hub</em></td>
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<td></td>
<td>▪ Higher <em>job demand</em> in the area</td>
<td>▪ <em>Largest distance from potential conflict zones</em></td>
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<table>
<thead>
<tr>
<th>CHALLENGES</th>
<th>PORT OF SOHAR</th>
<th>PORT OF DUQM</th>
<th>PORT OF SALALAH</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Lack of <em>renewable energy sources and land</em> for further expansion</td>
<td>▪ Distance from <em>residential and industrial centers</em></td>
<td>▪ Difficulty of <em>transport logistics</em> outside the ports area</td>
<td></td>
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<tr>
<td>▪ <em>Proximity to Fujairah</em> as leading bunkering hub in the region</td>
<td>▪ Workers will be required to <em>work on rotations</em>, at least initially</td>
<td>▪ Furthest from big <em>residential and industrial centers</em></td>
<td></td>
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<tr>
<td>▪ Proximity to <em>potential conflict zones</em></td>
<td>▪ Lack of <em>existing infrastructure</em></td>
<td>▪ Limited <em>job demand</em>, with Port of Salalah already being the first employer in the area</td>
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SAVE THE DATE –
11/2023 13TH Dii Desert Energy Leadership Summit

13th Dii Desert Energy Leadership Summit

COP28 for IMPACT: TIME FOR ACTION
From Announcements to Tangible Projects

28 November 2023
The W Dubai – The Palm

- 28th -29th November 2023 in Dubai
- Ahead of COP28, with prominent pre-COP reception
- Showcasing MENA’s leading role in the global energy transition
- W Palm Dubai hotel – well established special location for last major Dii events
- Potential site visit for the new phase of the MBR solar park
Thank You For
Your Attention!