



Dii

Dii Desert Energy

**‘Logistics of the Energy Revolution’
Energy MEA Regional Conference, DHL**

*Cornelius Matthes
CEO Dii Desert Energy
Dubai, 24th March 2022*

Just to give an impression of the wealth of the Arab Deserts:

About 5% of the vast MENA Deserts alone would in theory be more than sufficient to power the world's 150.000 TWH Energy Consumption!

Our Mission: No Emissions!

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

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 and for MENA to become an exporter to the world energy markets.

13 Years Dii Desert Energy/Desertec Industrial Initiative: *Initiating an unparalleled Energy Transition*



Development phases



Desertec vision

- Studies on the **Desertec vision** a.o. TREC (Trans-Mediterranean renewable energy Cooperation Studies)
- Creation of **awareness and motivation**



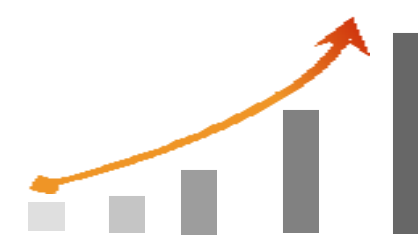
Desertec 1.0

- Power from the deserts for Europe**
- Foundation of **Dii GmbH** (Munich) in 2009
- System, country and technology studies** (Desert Power 2050, Desert Power: Getting Started)
- Local adoption of idea
- Preparation of services** for implementation phase



Desertec 2.0

- Development of the market in the MENA Region first**
- Dii active from Dubai, UAE
- Identifying and solving practical hurdles** of wind/solar/grid projects
- International industry network '**Dii Desert Energy**'
- Renewables become competitive!**



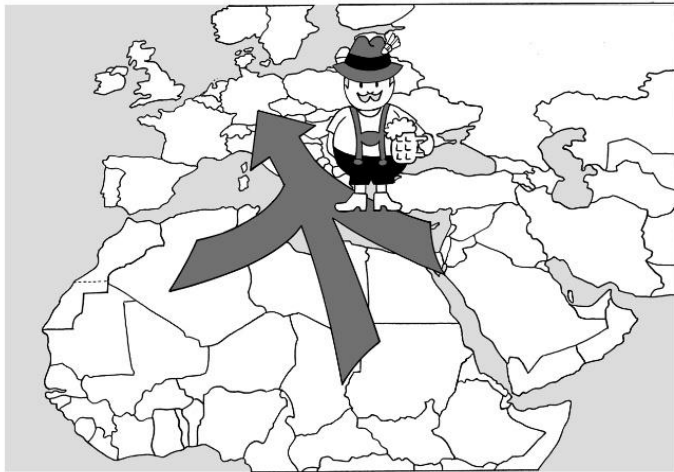
Desertec 3.0

- Market acceleration** towards 100% **green electrons and green molecules**, transportation, storage and flexible demand in MENA
- Full Market integration** throughout MENA and connected markets. MENA to become a 'Powerhouse for green electrons and green molecules for the world energy market'
- Increased focus on **Industry Sector Coupling** through green power, hydrogen, etc.

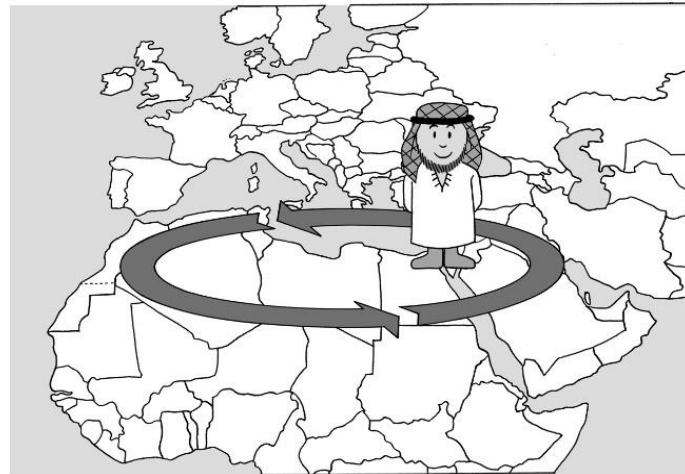
Desertec 1.0, 2.0 and 3.0: the Arab world to become a Powerhouse for itself and a global green exporter



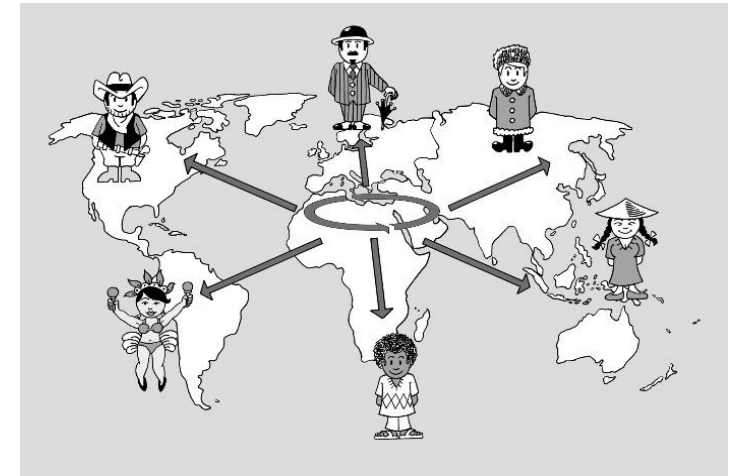
Development phases of Desertec



Desertec 1.0
Export Oriented



Desertec 2.0
Region Oriented



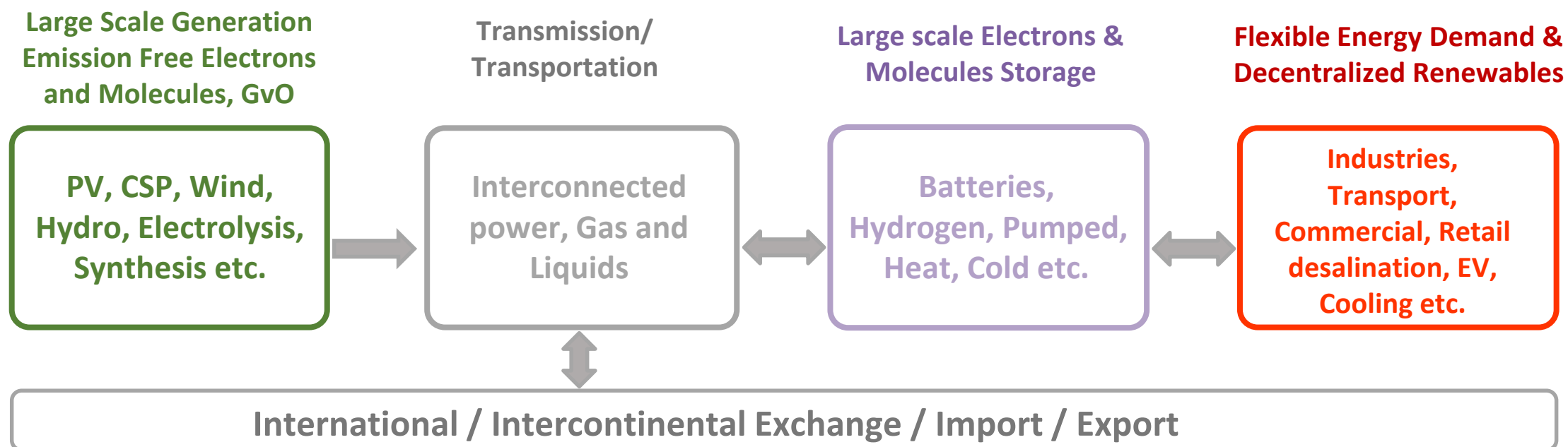
Desertec 3.0
Region and World Oriented

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



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-emission hydrogen economy**

Knowledge partner

Strong presence in leading industry events to help shaping programs by providing **exclusive insights and market updates**

A unique platform for 13 years

Since 2019, **more than doubled** its industrial partners (now 60 from over 25 countries, 4 continents)

Independent Think Tank

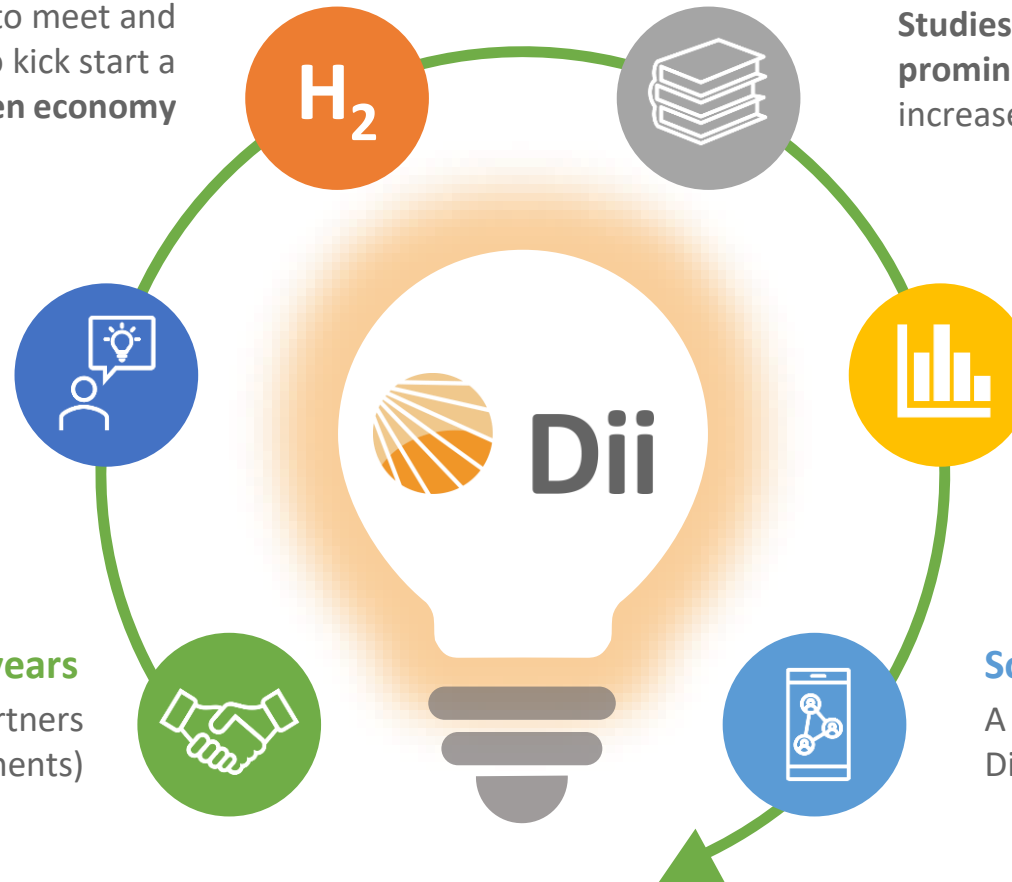
Studies and papers, technology agnostic, with prominent partners and available freely to increase knowledge for a greater impact

RE Toolkit and financial models

Best in class and neutral financial models for Levelized Cost of Electricity (LCoE), Storage (LCoS), Hydrogen (LCoH) and Ammonia (LCoA)

Social Media

A powerful communication platform to amplify Dii's **activities and partners' achievements**



Over 60 industry partners from 25 countries



OUR STRATEGIC PARTNERS



OUR LEAD PARTNERS



All Partners of Dii Desert Energy
are members of the MENA
Hydrogen Alliance

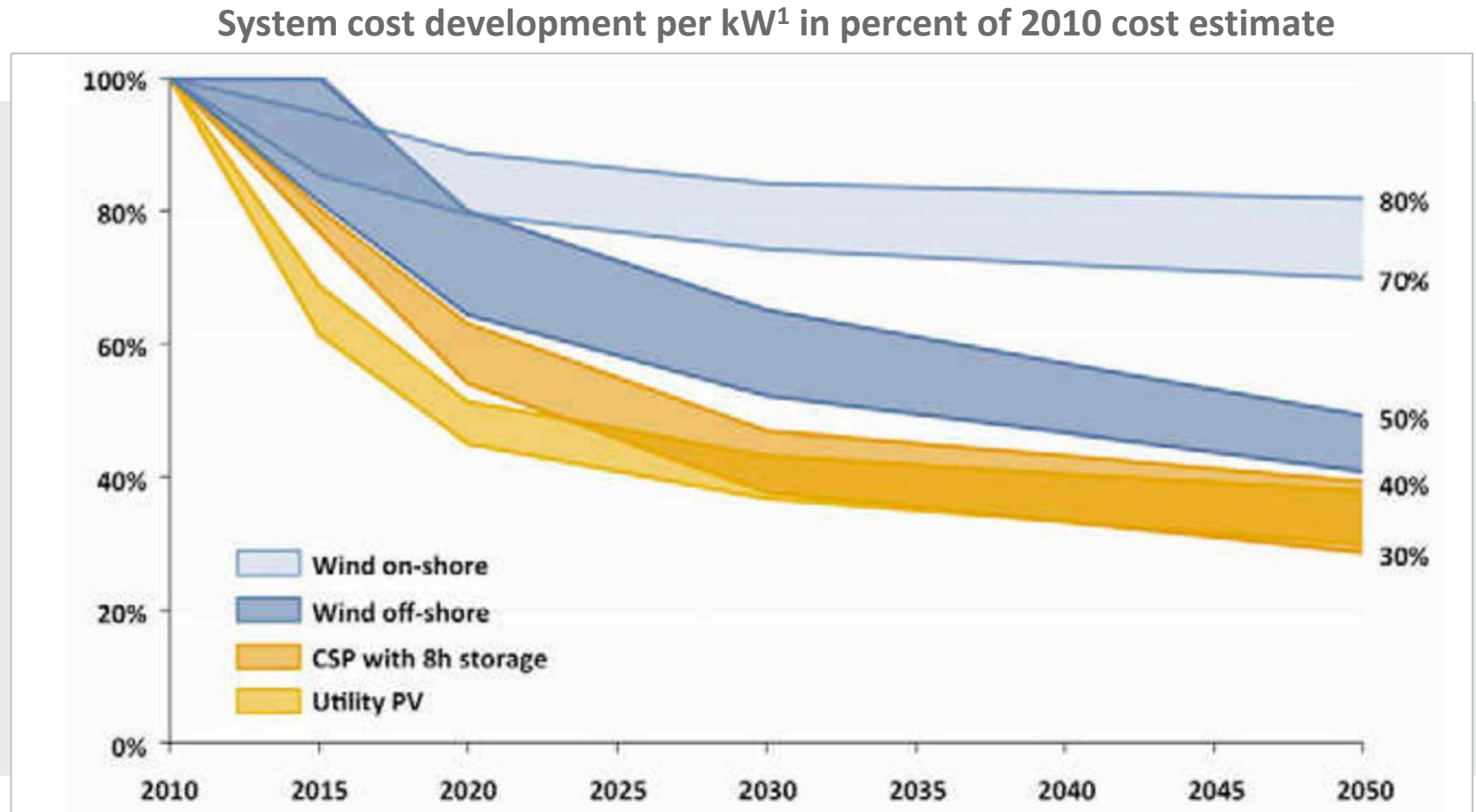
OUR ASSOCIATED PARTNERS



Long term estimates for Desert Power 2050

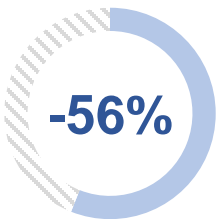


- **Emission-free technologies** in the MENA region have become competitive **much quicker** than even the greatest optimist would have ever expected
- Dii's optimistic predictions in Desert Power 2050, published in 2012, have been by far overachieved in 2020!



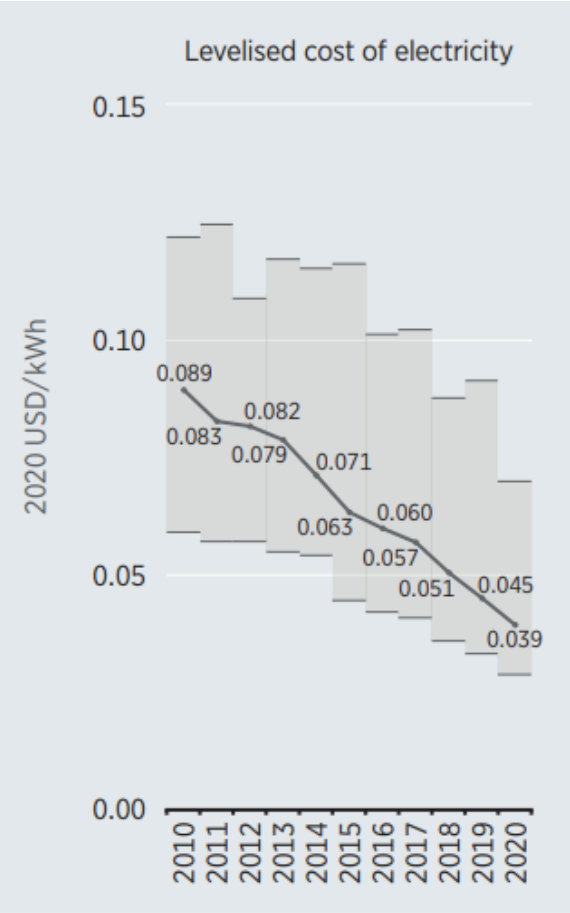
Source: Dii 1. Refers to nameplate capacity, i.e. kW_p (kW peak) for Utility PV and Wind and kW_E (kW Electric) for CSP

Stunning decline in LCoE for solar and wind in 2010's prove even the greatest optimist wrong!

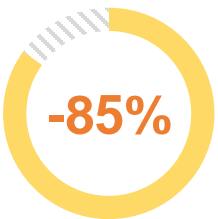


Onshore Wind

Between 2010 and 2020, the global weighted-average LCOE for offshore wind fell 56%, from USD 0.089/kWh to USD 0.039/kWh.

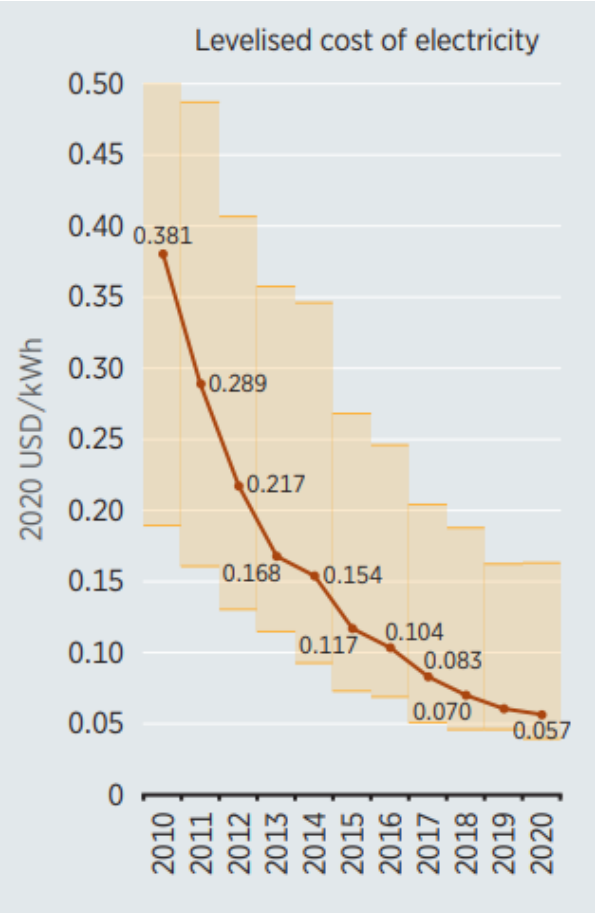


Global weighted-average LCOE for onshore wind, 2010-2020
Source: IRENA Renewable Cost Database



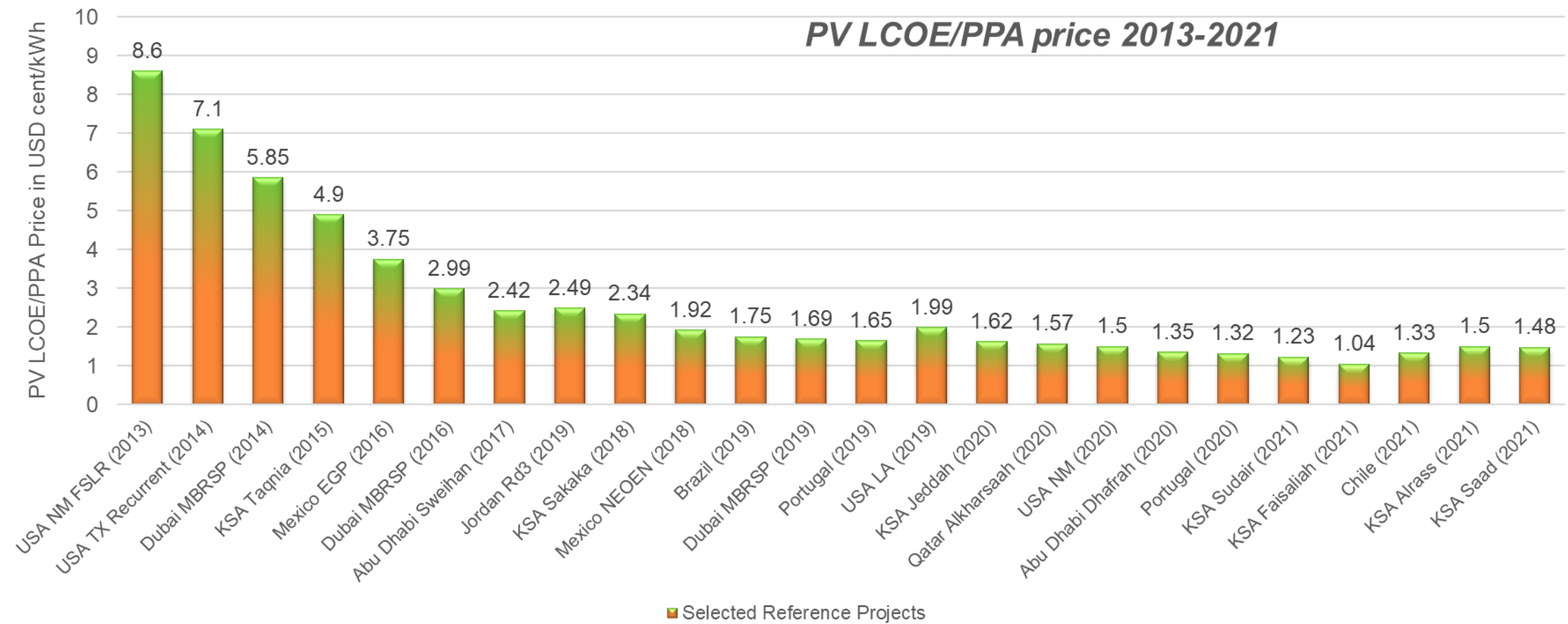
PV

Between 2010 and 2020, the global weighted-average LCOE for PV fell 85%, from USD 0.381/kWh to USD 0.057/kWh.



Global weighted-average LCOE for PV, 2010-2020
Source: IRENA Renewable Cost Database

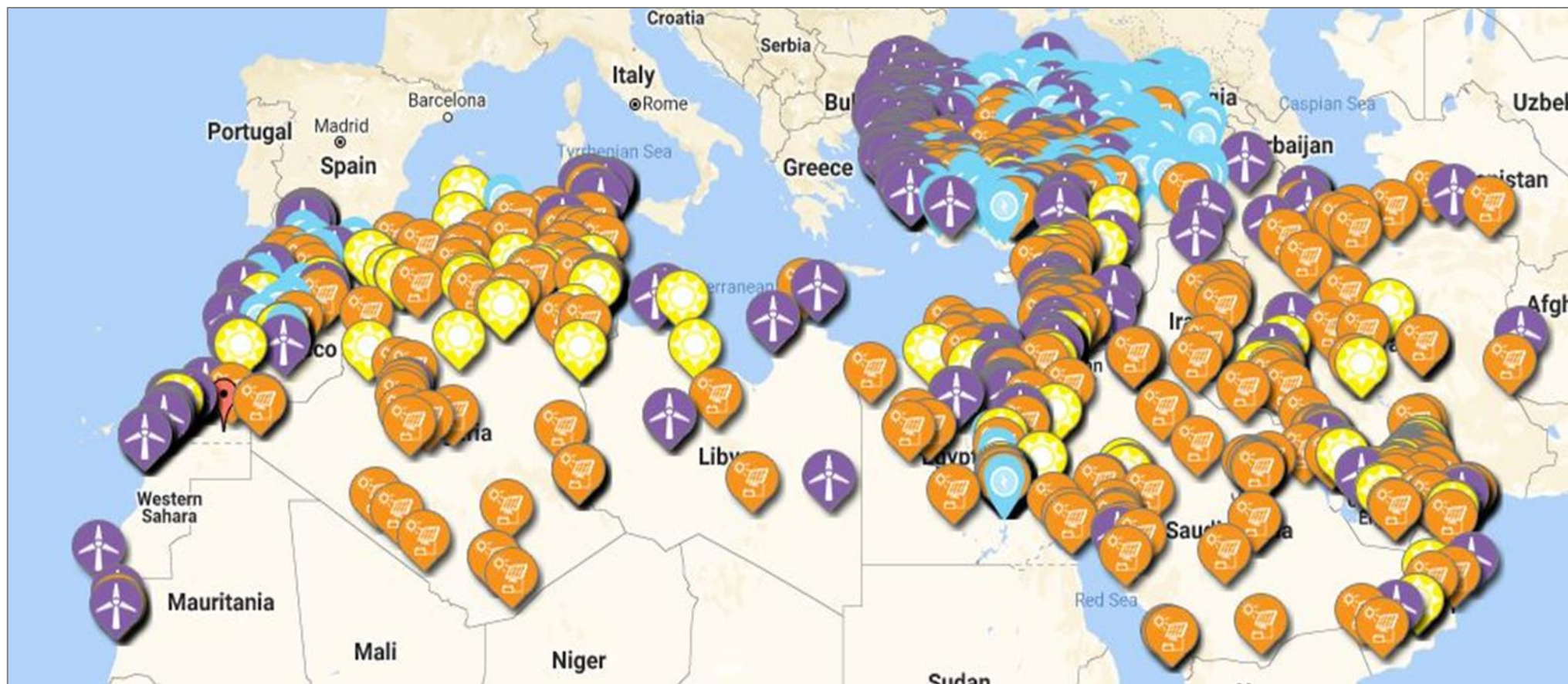
The MENA region has been leading the race to the bottom with continous new low world records for solar (and wind)



Renewables are swiftly taking off in MENA



Dii's project database indicates **over 20GW** to be operational in **2022**



Opportunities for Green H2 in the MENA Region



The MENA region is blessed with some of the **world's best solar and wind resources**, allowing a high combined capacity factor for solar photovoltaic and wind, which is crucial to achieving very **low prices to produce green hydrogen**.

With a **zero emissions goal by 2050**, **Europe** is expected to import large quantities of green hydrogen, mainly due to geographical limitations (limited size and high population density) and limited renewable energy resource (other regions will be able to produce hydrogen at lower cost)



The production of green hydrogen in MENA will foster **socio-economic development, boost export, create new green and future-oriented jobs** in a high-tech sector and **support social stability**.

Potential **off-takers in Europe** are already lined up: **steel or heavy transport industries** are evaluating where to source in the mid-and long term the big amounts of green molecules through market mechanisms. Europe as both off-taker and financial supporter (financially and technically).



2020/2021 a turning point in the global energy industry: historic crisis in oil & gas, **shift in mind towards climate friendly solutions**.

The **MENA region** is positioning itself as a potentially dominant player to lead the energy transition. '**Green molecules**' have been included in the strategy of leading organizations like ACWA Power, NEOM, Siemens or Masen, alongside '**green electrons**' to accelerate the transition towards a low carbon economy in the Arab World.



Emerging Local and Global Markets Supply and Demand for Green Hydrogen



Besides Local Use, **Europe and East Asia** could be very attractive markets for MENA since they will not be able to meet their growing H₂ demand.

Hydrogen strategies and imports

Many regions and countries are defining their hydrogen strategy...



Hydrogen Europe aims for **2x40 GW green hydrogen by 2030** (2x5 Mton H₂) with 40 GW in Europe and 40 GW in Europe's neighborhood with export to EU

- > Primary focus on **green hydrogen** with a potential role for blue hydrogen (grey H₂ and CCS) in the transition period
- > EU to develop partnerships for **hydrogen import from MENA region**



5-10 Mton of hydrogen consumption mainly for power generation & mobility and **85 Mton of CO₂-free ammonia** for power generation by 2050, with target of 3 USD/ kg H₂ by 2030 and 2 USD/kg H₂ by 2050



17 Mton of hydrogen consumption by 2050 mainly driven by mobility applications (32%), building heating and power (21%) and power generation (15%)

... with large emphasis on H₂ imports as essential part of its energy supply



Belgium could be importing **c.24 Mton** p.a. of H₂ in 2050



Port of Rotterdam announced aim to import **c.20 Mton** p.a. of H₂ in 2050



Germany estimated imports of **c.24 Mton** p.a. of H₂ in 2050 & **EUR 2 bn** to build **international partnerships** for H₂ imports



Total need for H₂ imports in Europe can be **up to 100 Mton** p.a. as Europe will not have sufficient renewable electricity to produce own H₂ demand



Japan is setting up import supply chains H₂ and ammonia needs, with **3.5 Mton of CO₂-free ammonia import by 2030** and 85 Mton by 2050

Prominent government and private sector initiatives want to bring down cost of green H2 at par with grey in this decade!



UN launches Green Hydrogen Catapult to halve production costs

By Matthew Farmer | 08 Dec 2020

Some of the world's largest energy companies have signed up to the UN Green Hydrogen Catapult to bring down the cost of hydrogen production.

The project aims to drive down the cost of hydrogen to \$2/kg by 2026, approximately half its current price. The partner companies aim to do this with 25GW of green hydrogen production by 2026, approximately 50 times more than is currently produced.

The Hydrogen Stream: US government wants to reduce green hydrogen cost by 80% to \$1 per kilogram in one decade

The US Department of Energy (DOE) launched the Energy Earthshots Initiative to accelerate energy breakthroughs within the decade. The first Energy Earthshot — Hydrogen Shot — seeks to reduce the cost of clean hydrogen by 80% to \$1 per kilogram in one decade, the DOE said in a statement released on Monday. At the

Australia's pathway to \$2 per kg hydrogen

Prosperity, emissions reductions and opportunities for Australia to lead on a global stage — all underpinned by the most common element in the universe.

India has potential to meet global green hydrogen demand: Jitendra Singh

Explaining India's 'aspirational' goal of 'Hydrogen 2-1-2', the minister said, "2 means green hydrogen that nation costs for less than \$2 per kg; 1 means hydrogen storage plus distribution plus refuelling that cost less than \$1 per kg and the last 2 is for replacement of incumbent end-use technology with green hydrogen technology of less than 2 millions."

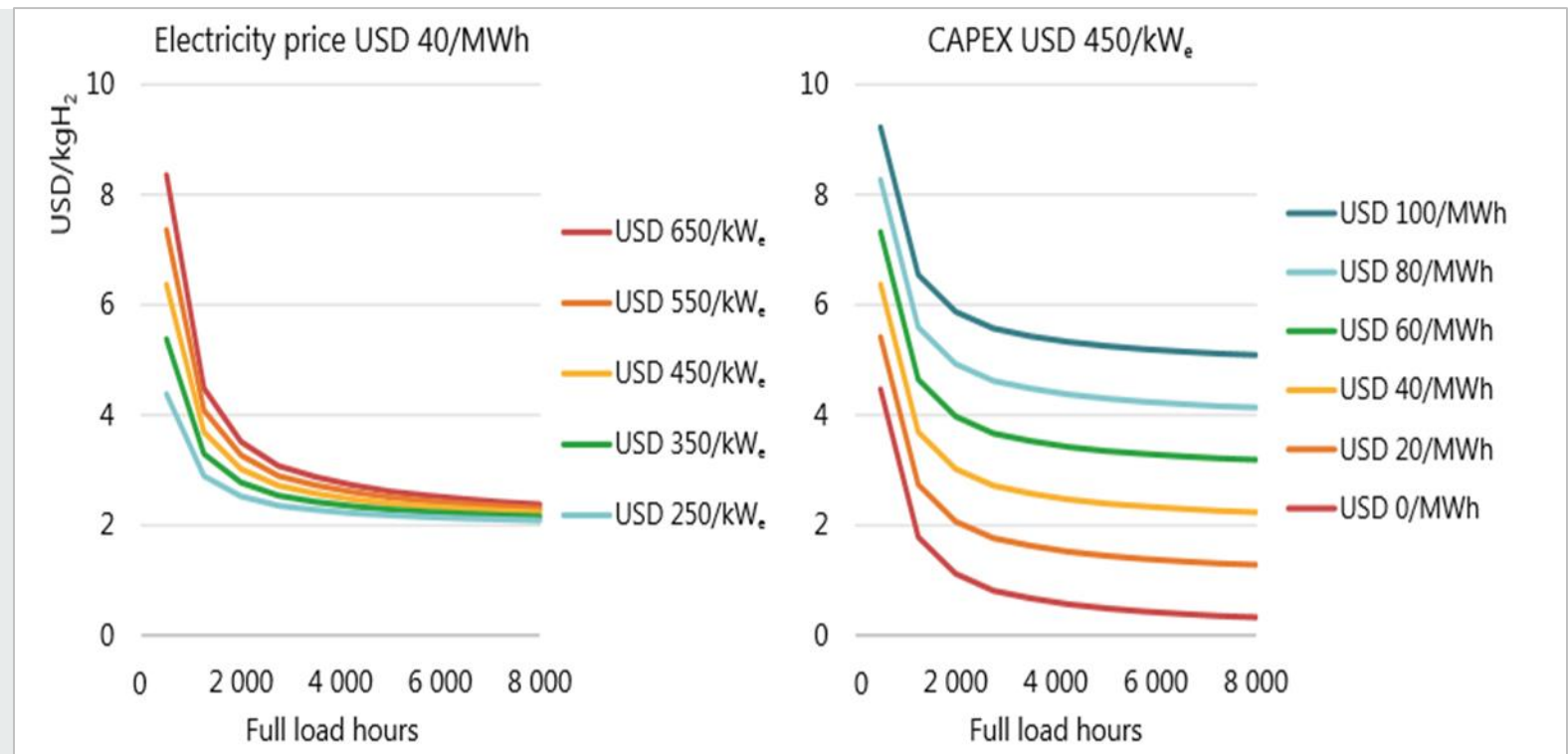
A total of 30 major companies from across Europe are laying the foundations to create HyDeal Ambition, a value chain promising to provide 100% green hydrogen for €1.5/kg by 2030, matching the current price of fossil-fuel produced 'grey' hydrogen.

MENA has three strong trump cards: lowest cost, 'unlimited' potential and access to capital



Future levelized cost of Hydrogen production by operating hour for different electrolyzers electricity costs (left) and investment costs (right)

- With increasing full load hours, the impact of **CAPEX** on hydrogen costs **declines** and the **electricity becomes the main cost** component for water electrolysis.
- Solar and Wind** cost-range from USD 10 -40/MWh!



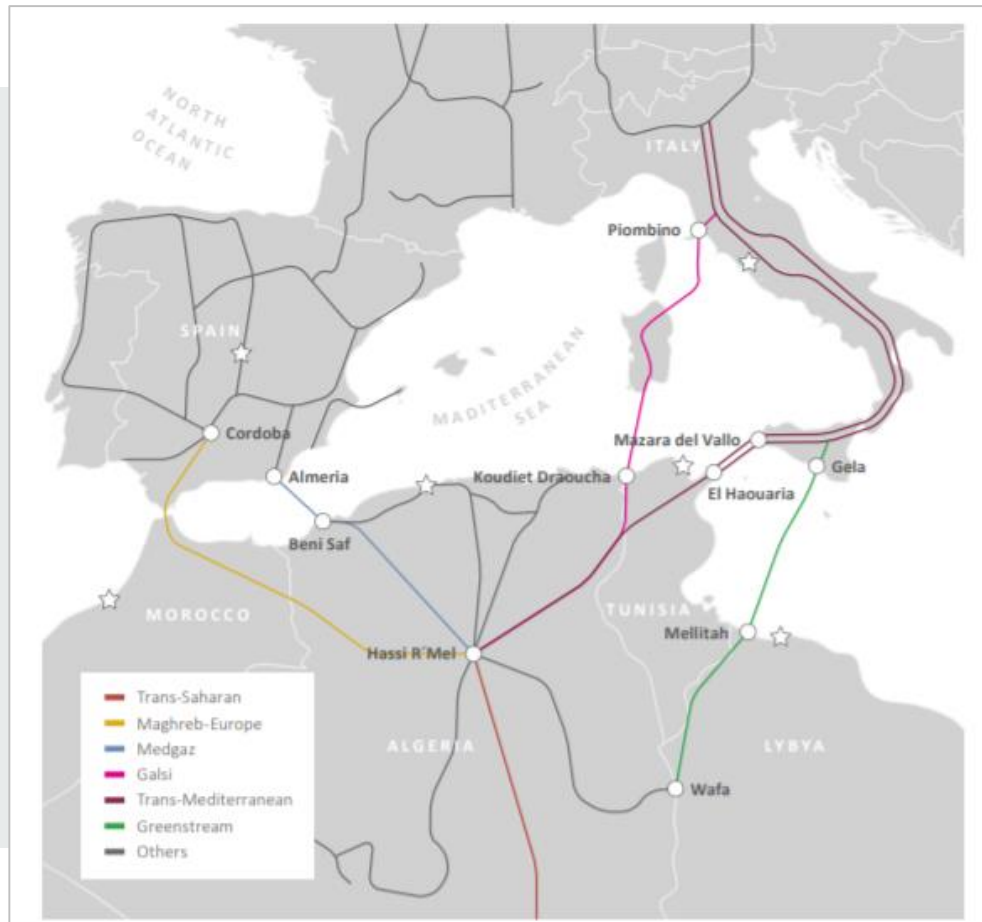
Notes: MWh = megawatt hour. Based on an electrolyzer efficiency of 69% (LHV) and a discount rate of 8%.

Source: IEA 2019. All rights reserved.

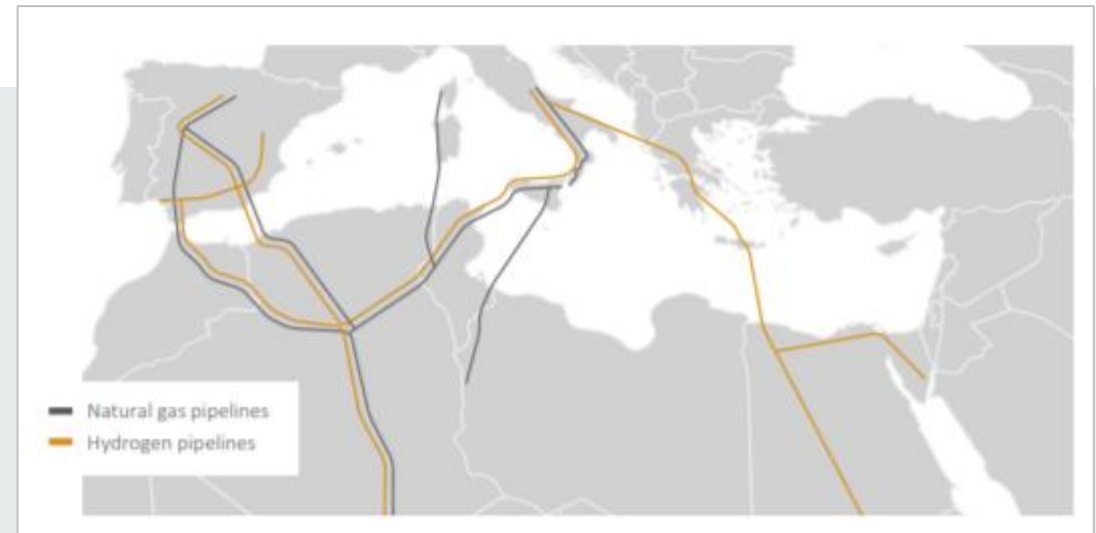
The MENA Gas infrastructure is ideally positioned for a fast exchange and export of green hydrogen!



Natural gas infrastructure Europe - North Africa



First outline for a hydrogen backbone infrastructure Europe-North Africa



- 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.

NEOM (Saudi Arabia), an emerging world leader in green ammonia export (initially by vessels)



- New 'city', the **size of Belgium** (26,000 km²)
- One of three strategic projects of **Saudi Agenda 2030**
- **Saudi's Public Investment Fund** and others have committed \$500 billion
- NEOM will be powered by **100% low-cost renewable energy** (40 – 60 GW)
- Given the availability of competitive and low-cost renewable energy, NEOM will produce **green hydrogen at scale** for local and world markets
- **NEOM, ACWA Power and Air Products** signed in July 2020 an Agreement for 6.5 Billion\$ Solar-based Green Hydrogen for producing **1.2 mln tons of Green Ammonia per year**



A wave of projects and initiatives in record time ...



United Arab Emirates

- **Dubai:** Small scale **1.25 MWe electrolyzer pilot plant** at **DEWA MBR Solar Park**, in collaboration with **Siemens**.
- **Abu Dhabi:** Planned **small scale electrolyzer pilot plant** to produce H₂ and other e-fuels (aviation, etc.). This is in collaboration with **Siemens, Masdar** and others.
- **Abu Dhabi:** MOU between **Siemens** and **Mubadala** to create a **strategic partnership** for H₂ and synthetic fuels.
- **ADONC, ADQ** and **Mubadala** formed **Abu Dhabi Hydrogen Alliance** to explore clean hydrogen. Blue is of interest for the desire to re-purpose fossil gas industry.
- **Ministry of Energy & Infra** issued its first publication on **H₂ potential in UAE**.
- UAE government approved **technical regulations for hydrogen-powered vehicles** (developed by ESMA).
- UAE government **AED 300B industrial plan by 2030** includes H₂ economy as key target sector.
- **Mubadala** and **Snam** (Italy) signed an agreement to collaborate **on joint investment & development of H₂**, incl. technical-economic feasibility studies to develop H₂ economy for the UAE.
- **Helios Industry** announced intentions to set up **0.2 million ton/yr green NH₃ plant at KIZAD**. To be powered by 800 MW solar plant. **ThyssenKrupp** has been appointed to conduct feasibilities studies consulting service.
- **Ta'ziz** announced intentions to set up **1 million ton/yr blue NH₃ plant** at Ta'ziz industrial cluster. Will possibly use blue hydrogen feedstock from **ADNOC**.
- **Fertiglobe**, a JV between ADNOC and OCI, will join the development of a large blue **ammonia plant** in the UAE's downstream center in Ruwais. Fertiglobe will join the development in the Ta'ziz Industrial Chemicals Zone within Ruwais, which is being developed by ADNOC and holding company ADQ to manufacture downstream products.
- **DEWA** invited consulting companies to submit **bids to develop strategy to produce green hydrogen**. The objectives are to develop the green mobility sector, reduce carbon emissions from various industries, generate electrical and thermal energy and produce water and other applications.

...all across MENA



Saudi Arabia

- **NEOM** is the **first real and credible H₂ project** with 2.2 GWe electrolyzer capacity, 4 GW PV+Wind. COD in 2025. Green NH₃ production at 1.2 million tons p.a.. Est. CAPEX is USD 6.5B.
- KSA aims to be **global leader in H₂** as announced by Ministry of Energy. Also, KSA is interested in **Blue H₂** and **NH₃**.
- KSA aims to be **global leader in Blue Hydrogen**. KSA announced that it will use one of the world's biggest natural-gas projects "**Jafurah**" to produce Blue Hydrogen. A large portion of gas from the \$110 billion gas plant development will be used for producing Blue Hydrogen. The Jafurah gas plant is expected to begin production in 2024.
- Partnership between **Saudi Aramco** and **Intercontinental energy** on green hydrogen



Oman

- The **ports of Duqum & DEME** (Belgium) are studying establishing green H₂ hub. The HYPOR Duqum project electrolyzer capacities range from 250 to 500 MWe.
- **Port of Sohar**, a 50% JV with Port of Rotterdam, plans to host a large-scale green hydrogen generation hub. Cooperation with German energy specialist **Hydrogen Rise**.
- **OQ, Intercontinental Energy & Enertech** announced intentions to set up **giga green NH₃ plant with 14 GWe electrolyzer capacity**, commissioned in phases from 2032 till 2038. To be powered by 25 GW renewables (PV+Wind). At completion, it will produce around 9.9 million tons p.a. of green NH₃.
- Ministry of Energy & Minerals is setting up "**Oman Green Hydrogen Alliance**". The **Hy-Fly PPP platform** includes 13 public and private entities.
- **ACME Group** (India) plans to develop **\$3.5B Green Ammonia plant in Duqum**. Capacity is 2400 ton/day and 900 kton/yr, powered by 3 GW solar and 0,5 GW wind park. **KBR** was appointed to provide technology, engineering and commissioning services.
- **Marubeni** signed joint development agreement w/ **OQ/Linde/Dutco** for green hydrogen & green ammonia production infrastructure in Salalah free zone in Oman. The project '**SalalahH2**', targets the production of up to 1,000 ton/day of green ammonia, utilizing OQ's existing ammonia plant in Salalah. A 400 MW electrolyzer plant will be constructed to produce green hydrogen. It is estimated that 1 GW of solar and wind energy capacity is needed and be procured by either existing or new energy parks.

...all across MENA



Egypt

- Egypt signed an agreement with **Siemens** to conduct **feasibility study on H₂**. Project first phase is for 1 GWe. It will double to 2 GWe in 5 years.
- Egypt is exploring signing MOU with **ThyssenKrupp** to set up green H₂, NH₃ & Other derivatives **production facilities**.
- Egypt received 3 direct proposals from green H₂/NH₃ project developers to set up **production plants**. Additional details were not disclosed.
- A **Belgian Alliance** (DEME, Fluxys, Port of Antwerp, Advisory Office, Roland Berger) submitted feasibility report to Ministry of Electricity & RE. The project is for **Green H₂ production & export to Europe**.
- Egypt signed agreement with **Siemens** to develop **pilot plant for H₂ production**. The plant electrolyzer capacity is 400 MWe.
- First concrete project by Scatec/Fertiglobe and other partners for a 100 MW green H₂ project to produce green ammonia



Morocco

- **Masen** signed MOU with **Germany** to develop the first green H₂ project (Est. 100 MWe electrolyzer). Production will be exported to Germany.
- Ministry of Energy, Mines & Sustainable Dev. signed declaration of cooperation with **Portugal** to establish necessary bases to develop partnership in green H₂ sector.
- **IRESN** aims to set up a **green hydrogen application platform** for applied research on Power to X, and knowledge transfer.
- **Fusion Fuel** (Ireland) & **CCC** (Greece) plan to develop \$850M green hydrogen powered ammonia project. The NH₃ capacity is 183,000 ton/yr by 2026.

Toolkit initiatives for green electrons and molecules

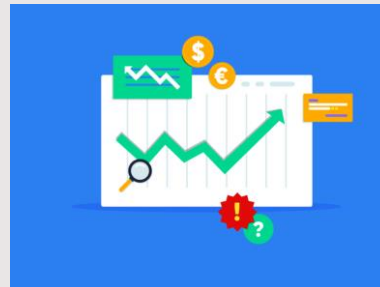


- The Dii Toolkit Initiative “**Establishes RE Knowledge Base**” thus enabling talent connection, opportunity creation, & therefore renewable energy implementation acceleration
- The objective is to provide RE industry stakeholders, both private and public, with access to **state-of-the-art measures & techniques** (tools) which enable accelerated and smooth energy transition
- In the ever-evolving energy markets, the **power of information** and in particular know-how, innovation, & collaboration, are key success factors

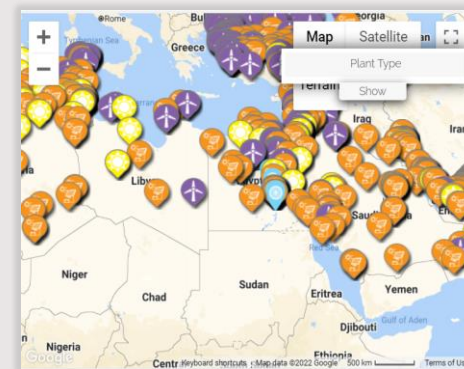
Toolkit for Project Developers



Financial Models



Project Databases



MENA Hydrogen Alliance

Industry Forces bundled by Dii Desert Energy



- 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



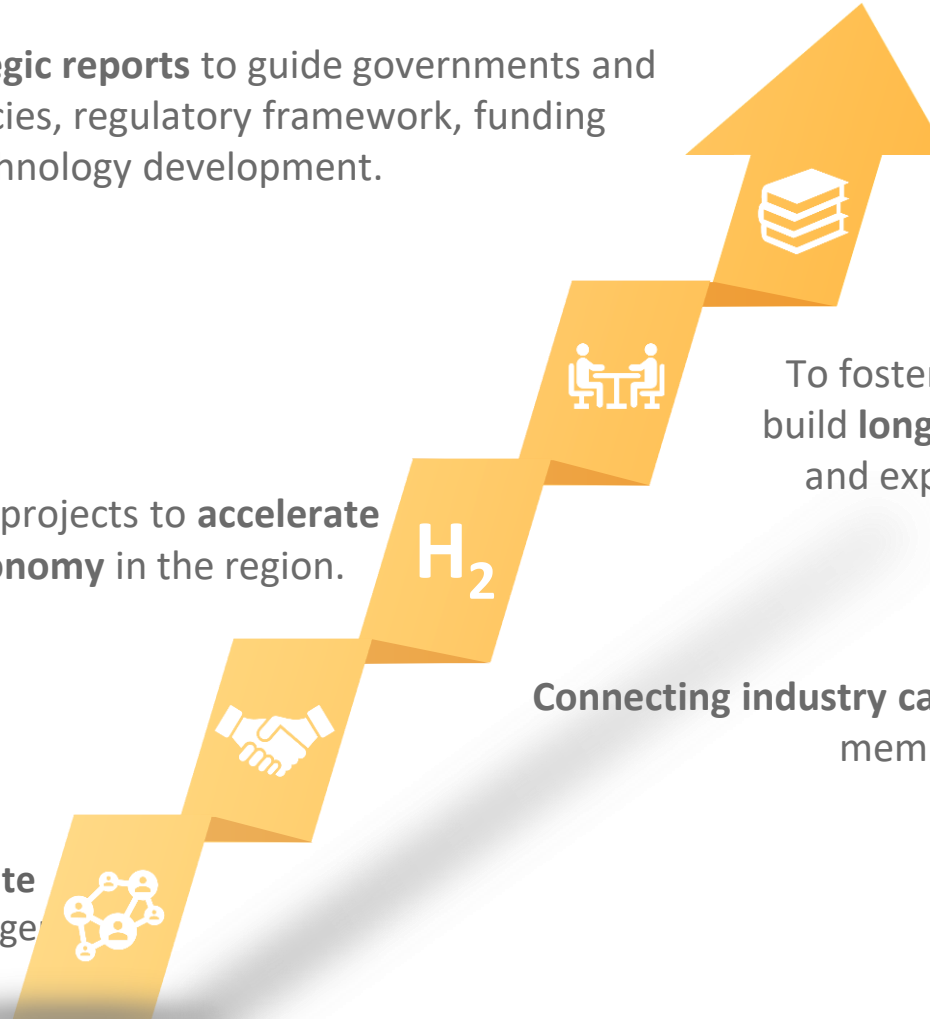
Strategy of the MENA Hydrogen Alliance



To elaborate **joint studies** and **strategic reports** to guide governments and other stakeholders on global policies, regulatory framework, funding mechanisms and technology development.

To create practical conditions and pilot projects to **accelerate the creation of a green hydrogen economy** in the region.

Creating a truly collaborative **public-private 'platform'** for discussion and for the Hydrogen MENA Alliance to be the '**convener**'.



To foster **international cooperation** and to build **long-term partnerships** to develop local and export markets for green molecules.

Connecting industry captains to provide meaningful information to members and a wider audience.

Planning 2022: MENA Hydrogen Alliance: some of the topics



Partnerships

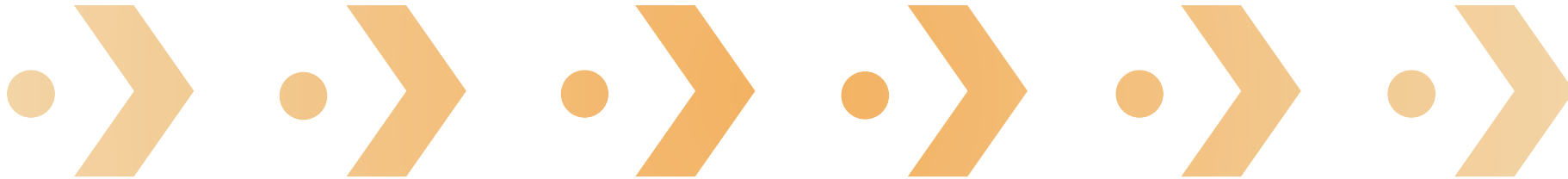
Consolidate the new partnerships with public sector & research partners:
e.g. IRESEN, KAUST, KAPSARC, GIZ, BMWi, BMZ

Startup database

Set up and maintain database on innovative start ups and growth companies in green molecules

Global Policies

Monitor global policies, regulations and funding facilities: national H2 strategies, H2 Global



Connecting production and demand

Analysis of demand side and identification of green molecules off-takers

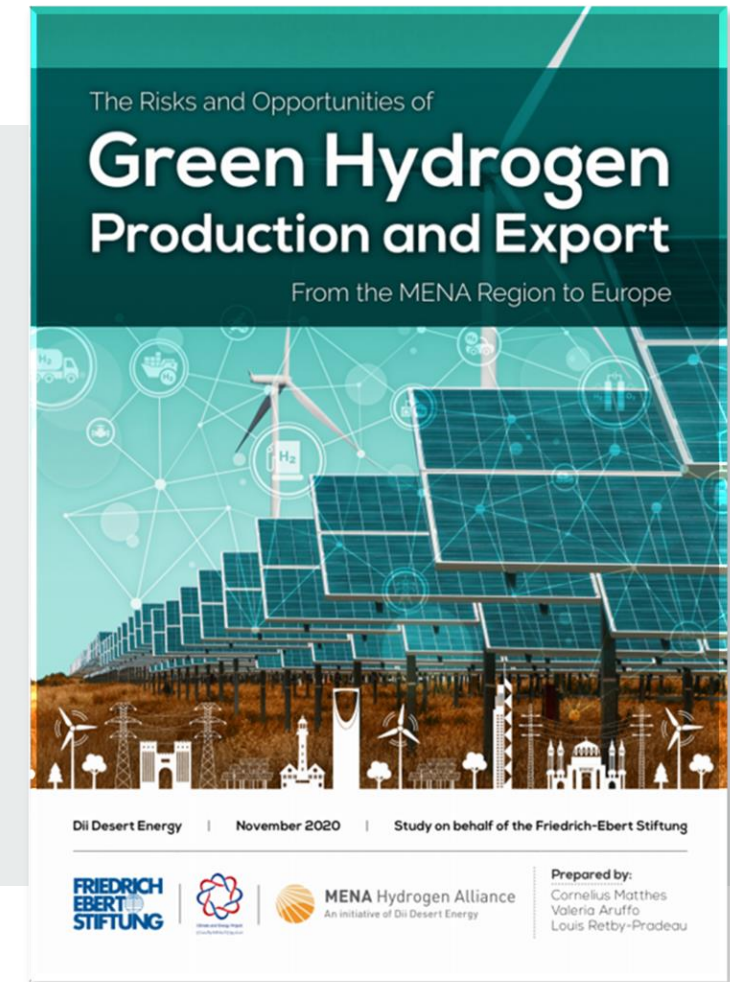
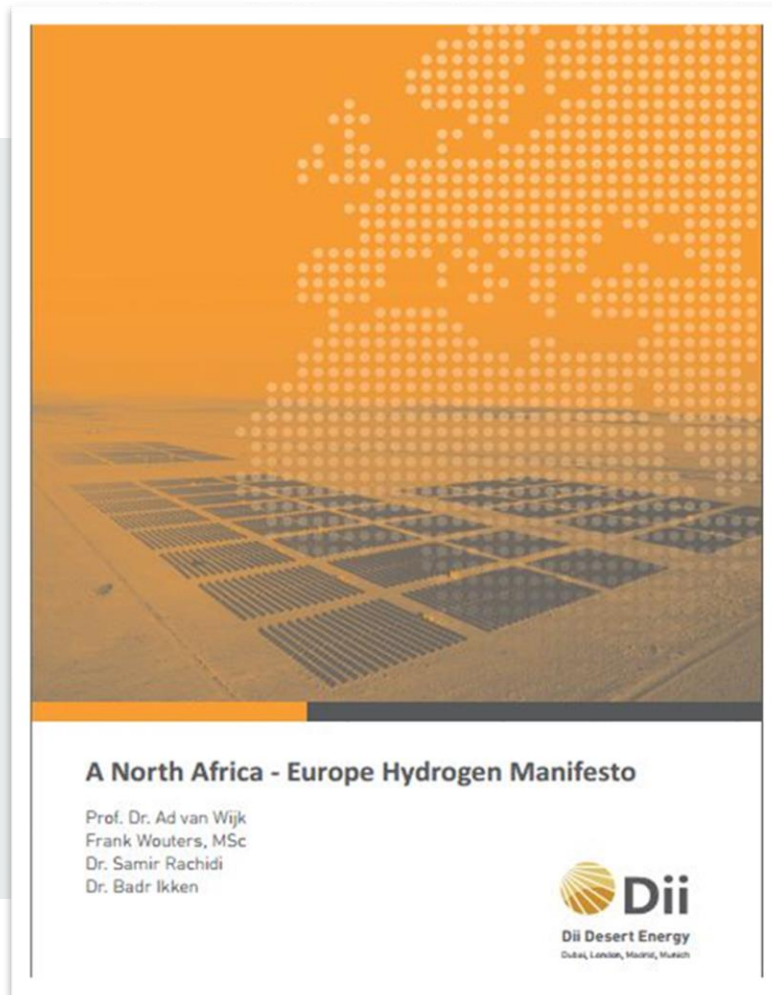
H2 Project Tracker

Creating and maintaining a project tracker for the entire H2 value chain

Standards

Start working on H2 standards and codes for the region: define key partners

Dii's MENA Hydrogen Alliance: first ideas for connecting MENA with Europe

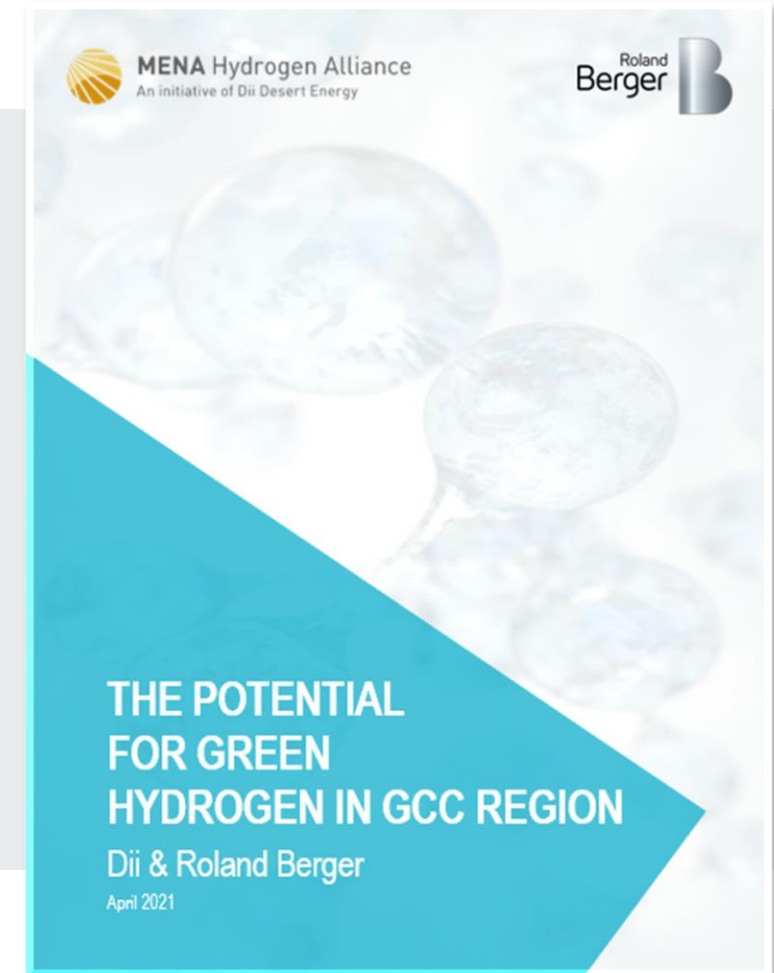


Green Hydrogen Study on Jobs!

Dii Desert Energy, Roland Berger, Masdar!



- Joint study with Roland Berger on **‘The Potential of Green Hydrogen in GCC Region’**
- Focus on **localization** of hydrogen value chain **and job creation**
- Launch in April at the **World MENA Hydrogen** (virtual) Congress
- Joint Press Release with **Masdar** for a greater impact



Key findings

Deployment and production

Long term renewable energy deployment of up to 1,000 GW, with up to 500 GW electrolyzer capacity, leading to the production of approximately 100m MT of green hydrogen.

Revenues

Annual revenues from green hydrogen in GCC could grow up to USD 200 bn by 2050.

Job Creation

High job creation potential across different parts of the value chain: Up to 1 million jobs by 2050.

Big movement

Different projects under development mark the start of a big movement with countries like Saudi Arabia e.g. planning to become the world's largest exporter of green hydrogen.

Hydrogen economies

International experiences from hydrogen valleys show that this concept could be a key enabler in creating local hydrogen economies.



Benefits for MENA when developing a green energy ecosystem



- Immense **socio-economical benefits** can be harnessed from green power and a clean hydrogen economy for the region

Economic development & diversification



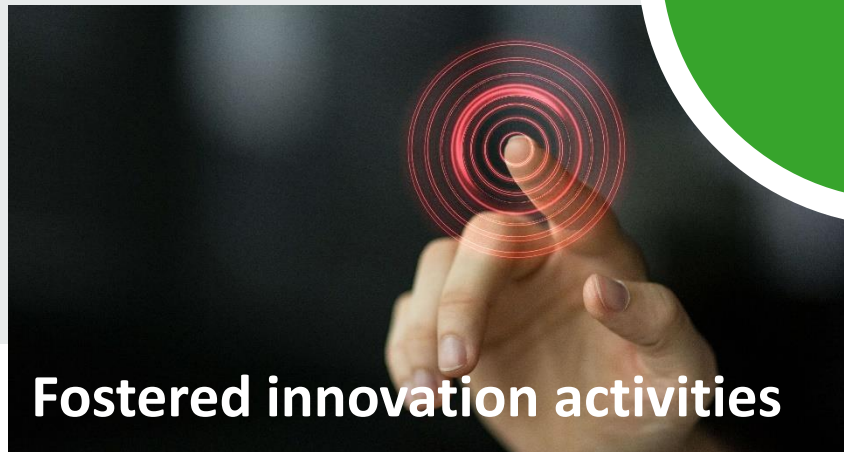
Job creation with increased qualification



Green Energy



Fostered innovation activities



Zero emissions



What to expect in the 2020's: A Decade of Disruption



Net zero in MENA

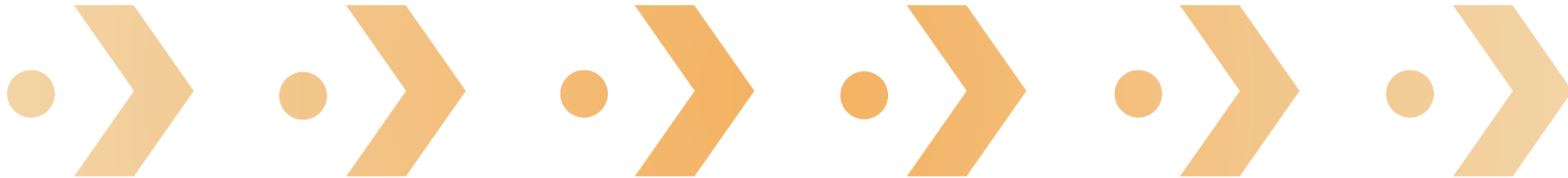
Final phase out of fossil fuel subsidies!
And carbon (+ emissions) will need to have a price, also in MENA.

Liabilities & premium

Externalities finally priced (with an increasing tag) and made transparent, increased value of 'green products'

Hydrogen

'Sexy' green hydrogen as accelerator of the energy transition (more need for green power, storage, large scale transport, de-fossilize ALL sectors)



Technology cost

Technology cost learning curves (PV, CSP, Wind, Batteries, Electrolysers, Grids etc.) will continue with exponentially growing capacity

Interconnections

Towards creation of markets, power and gas grid interconnections in MENA with Europe, Sub-Sahara Africa and West Asia

Global cost leadership

With increased capacity, MENA will remain the lowest cost producer, in a central location to connect markets

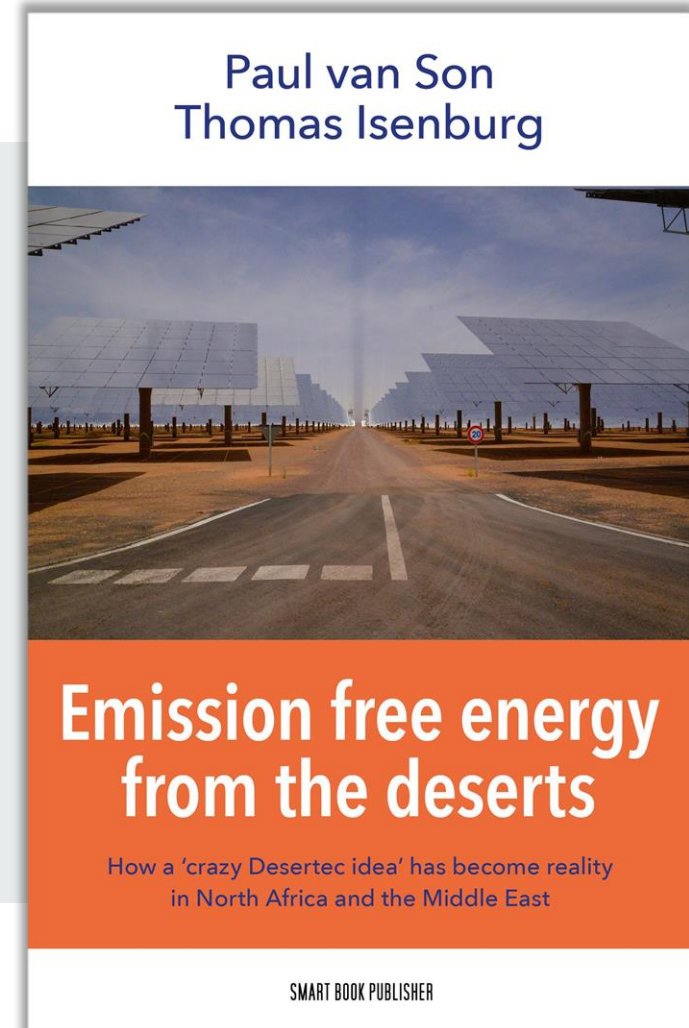
Tipping points

Market shares of new technologies, combined with record low prices and other factors make things converge

Dii's book on emission-free energy from MENA



- Published in 2019 in **German, English** and **French** (possibly also in Arabic and Spanish)
- How a '**Crazy Desertec**' idea has become reality in the sense of expanding renewable energy in North Africa and the Middle East and **potential for massive export** of green electrons and molecules
- Updated and translated into French to 'zoom' into the perspective of '**green electrons and molecules**' in **Maghreb** (2021)



Thank You For
Your Attention!

