Paul van Son, President & CEO, Dii Desert Energy

'DESERTEC3.0'

VZKC, 5 September 2020

Just to give an impression of the wealth of MENA:

About 8% of the Sahara Desert alone would in theory be sufficient to power the world!

The deserts of Northern Africa and the Middle East (MENA) are a quasi unlimited source of emission-free energy. This shall in the first place benefit the region with its growing population (about 500 mln by 2050). We believe that MENA will eventually also become a major supplier of emission free energy to the world. Regional and international actors are challenged to take this major development jointly in their hands…..

Dii Desert Energy is an Industry Initiative founded in 2009 to connect regional and international players to make the energy transition happen in MENA and to capture synergies among regions and continents.

Dii Desert Energy Vision

Increased **competitiveness of renewables** shall swiftly lead to economic growth and secure 100% energy supply without harmful emissions or waste

Our Mission: No Emissions!

Towards a **fully emission free energy supply** in MENA before 2050 and making MENA a 'power house' for the global energy markets offering benefits to the region

Strategy

Connecting the international industry active in the MENA region with authorities and institutions. Focus on practical conditions for **'green electrons' and 'green molecules'** along the energy value chains leading to tangible and profitable projects and other benefits for local and international stakeholders

10- Years Desertec 1.0 ---> 3.0
Green Energy for North Africa, West Asia and the World

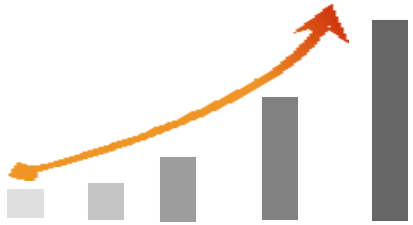
Development phases

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

- 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

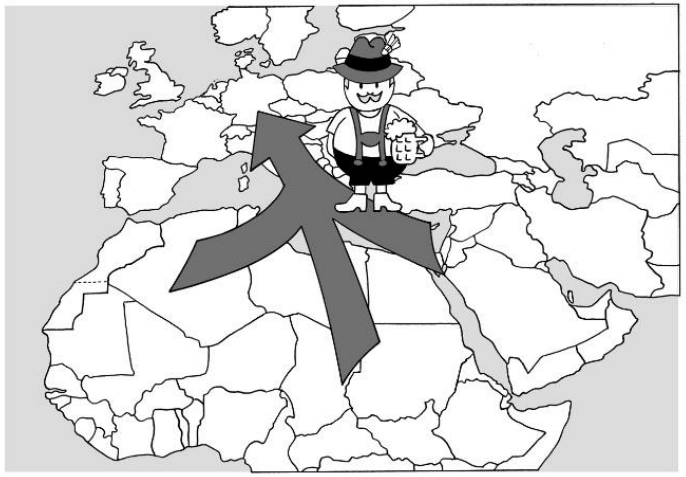
- **Desertec 2.0**
- **Development of the market in the MENA Region first**
- Dii active from Dubai, UAE
- **Identifying and solving practical hurdles** of wind/solar/grid projects
- International industry network **'Dii Desert Energy'**
- **Renewables become competitive!**



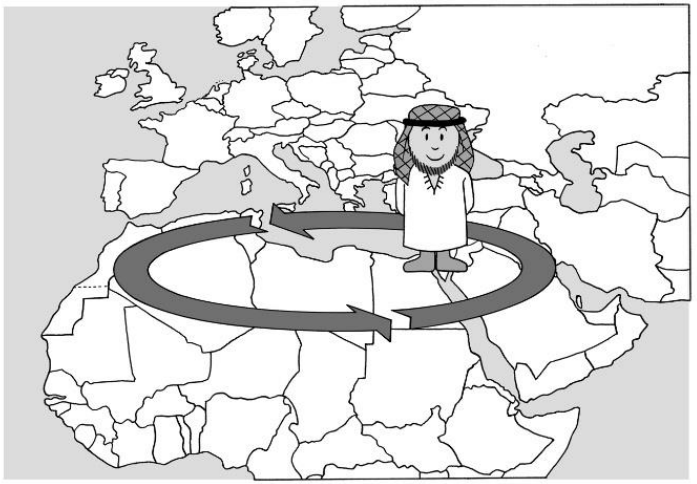
- **Desertec 3.0 Market acceleration** towards full renewable supply of green electrons and green molecules, transportation, storage and flexible demand in MENA
- **Full Market integration** throughout MENA and connected markets. MENA to become a 'Powerhouse for green electrons and green molecules for the world energy market
- **Increased focus on Industry Sector Coupling through** power, hydrogen etc.

Desertec 1.0 --> 3.0: MENA to become a Powerhouse based on *Emission-Free Energy from the deserts*

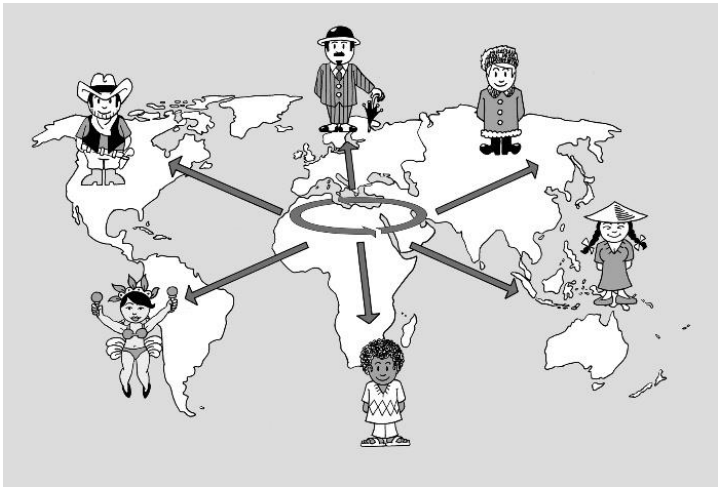
2004	Great Idea!	2009	It works! Concept	2015	First Harvest! Implementation	Acceleration! Green Electrons and green



Desertec 1.0



Desertec 2.0



Desertec 3.0

Development phases (2)

What does “Desertec 3.0” entail?

- Public and Private sector of **MENA Countries in the lead** for a swift energy transition
- MENA to become a highly scalable **‘Green Powerhouse’** for its own people and industry and for exporting green energy to the world energy markets
- Focus on **local benefits and synergies**
- Bankable, integrated and hybrid projects along the **entire energy value chain**:
  - Bottom-up/Top down from rooftop to industry scale solar, wind, hydro, biomass, etc
  - Flexible Demand in harmony with volatile supply
  - Conversion to ‘Green Molecules’ (a.o. Hydrogen, Ammonia)
  - Connecting Markets of ‘Electrons’ and ‘Molecules’
  - Storage of Power, Thermal Energy, Hydro Reservoirs, Gravitation etc.

How to become a 'Powerhouse'?

- Let **competitiveness** of emission free energy drive the markets. Make Governments and Investors aware of the practical and economic feasibility

- **Effective Penalties on Emissions & Phasing out Subsidization (unless for starting up innovations)**

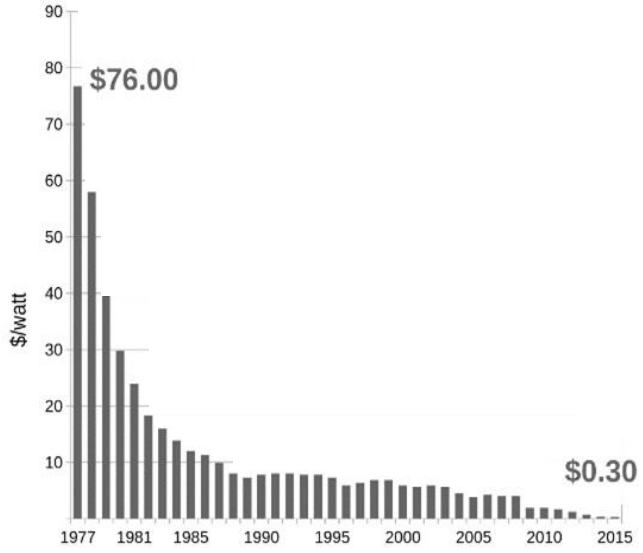
- Cost saving by **energy saving** and more **flexible demand**, e.g. shifting demand:
  - Industrial Demand: e.g. Desalination, Production of Hydrogen
  - Thermal Storage in connection with solar and wind: Cooling / Heating
  - Interaction with EV

- Synergies by using Transport / Transmission Infrastructure (locally, regionally, globally)
  - Through interconnected power grids connecting complementary price zones (HVDC)
  - Shipping hydrogen and synthetic gases/fluids e.a. by existing gas infrastructure, ship, truck

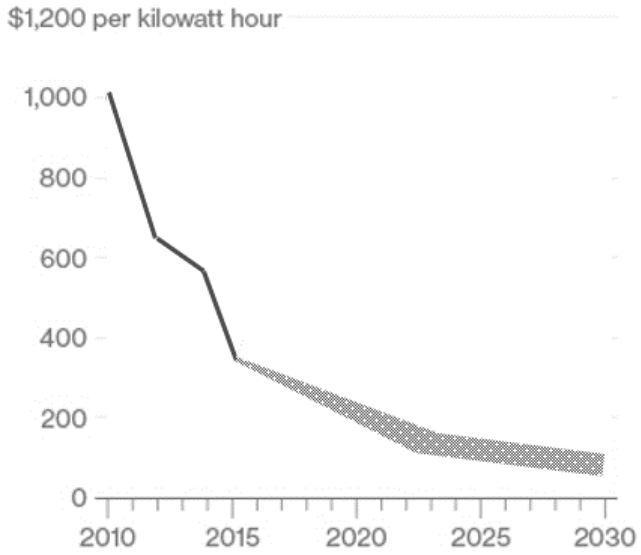
- Minimum requirements of smart local content. Intensify Education and training

Massive cost reductions accelerate deployment of emission-free technologies!

Price history of silicon PV cells
in US$ per watt



Cost for lithium-ion battery packs



'Power to X' (green electrons to become green molecules)

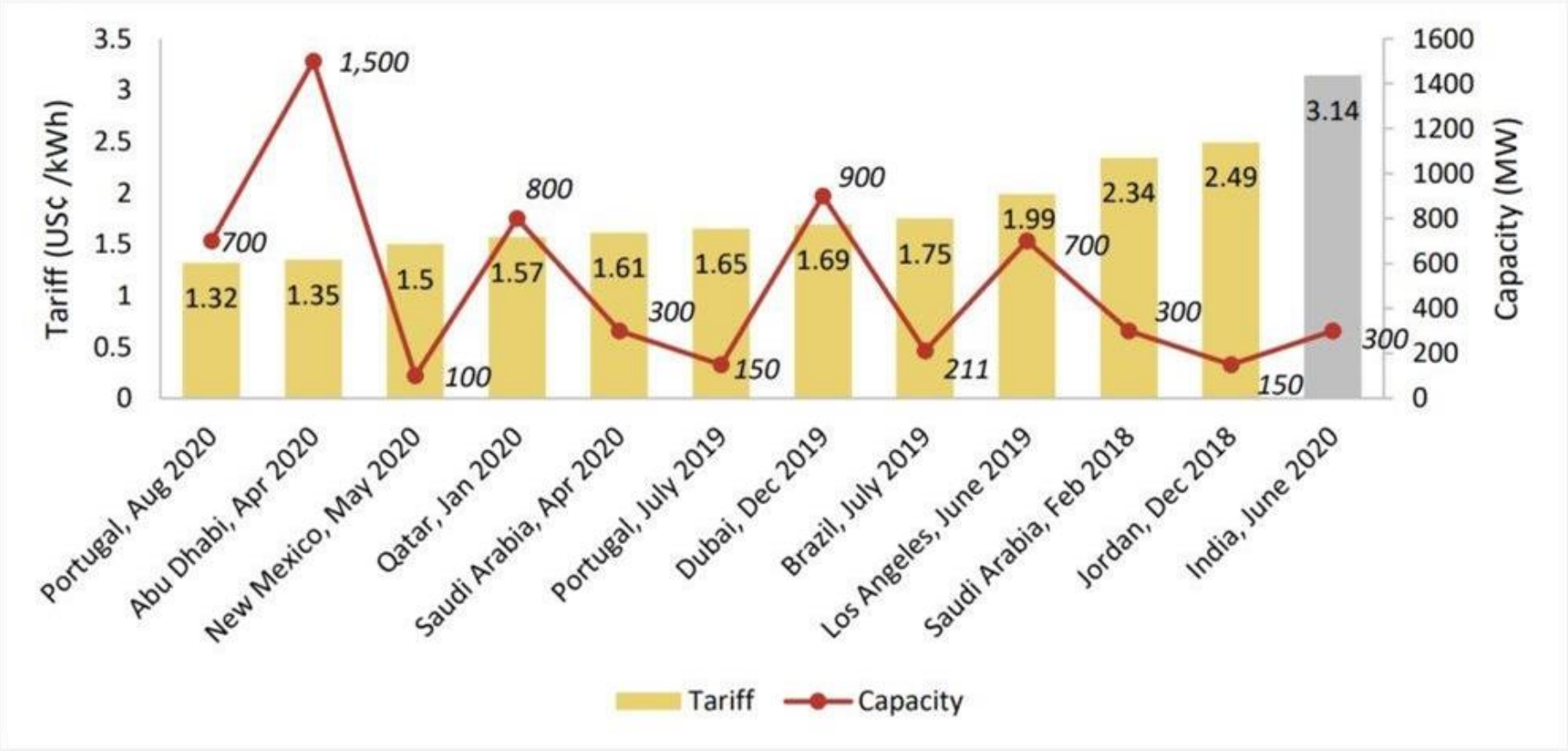
E.g. electrolysis of water on the basis of wind and solar energy from ultra cheap Production sites will lead to 1Ct/Kg!

Batteries, photovoltaic, PtX

- Dramatic cost reduction – to be continued
- Scalability of technologies
- Consumer investment across market segments accelerating developments

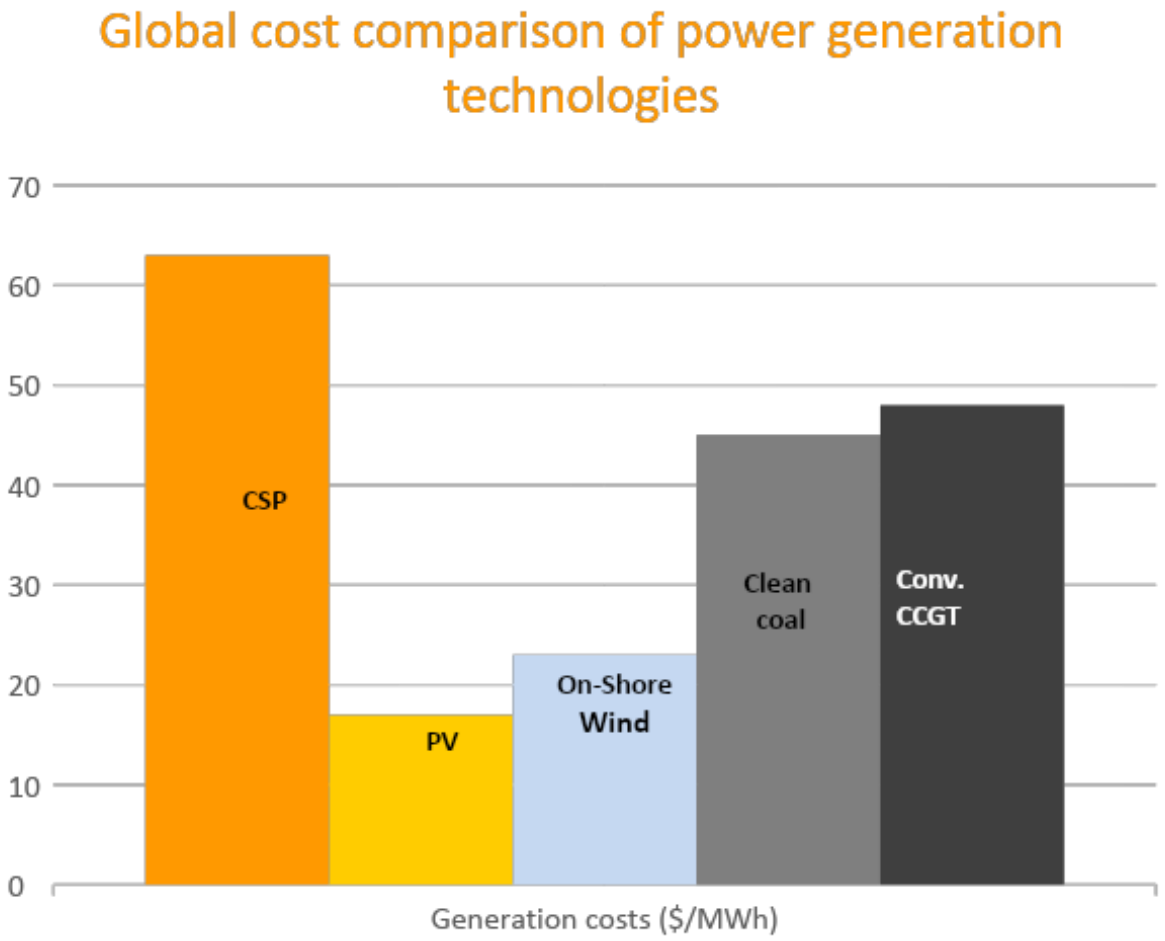
Source: Bloomberg New Energy Finance, ABB

Lowest Solar Tariff Trends Across the World



Source: JMK Research

Solar and wind energy have become widely competitive without subsidies



PV / Wind have become competitive/CSP is staying behind:

- Aggressive price drops PV and Wind (e.g. PV from 28 ct/kWh in 2009, to 5.85$ct/kWh in 2015 to close to 1$ct/kWh in 2020!)
- Gradual reduction of fossil AND renewables subsidies
- Flexibility is getting a higher value
- Ambitious Renewable Energy Targets in most countries in MENAT
- Chinese manufacturers diving into the RE industry have further led to lower costs
- Competitive bidding procedures

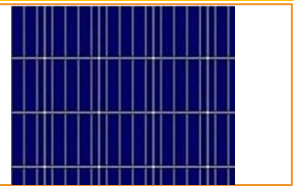
*Based on recently awarded power plant contracts, not considering emission effects

‘Green Electrons’ and ‘Molecules’ along the energy value chain

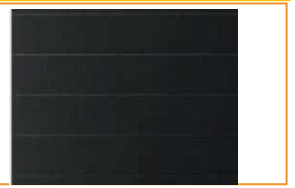
PV

Monocrystalline

Polycrystalline



Thin-Film



CSP

Parabolic Trough

Power Tower

Fresnel

Innovation Lens

Wind

On-shore

Off-shore

Hydro

Other RE

Conversion

H2 Electrolysis

Transmission/Transportation

Interconnection/Local Infrastructure

Energy Storage

Power, Heat, Cooling & Pumped Hydro-storage

Market (Spot) Price Driven Interaction of Wind, Solar, Hydro etc. and Conventional Generation with Storage, Transport/Exchange and flexible demand!

Electrical Power/Hydrogen/Ammonia etc. as transport and storage medium

Demand Management

Improved Responsiveness of Demand

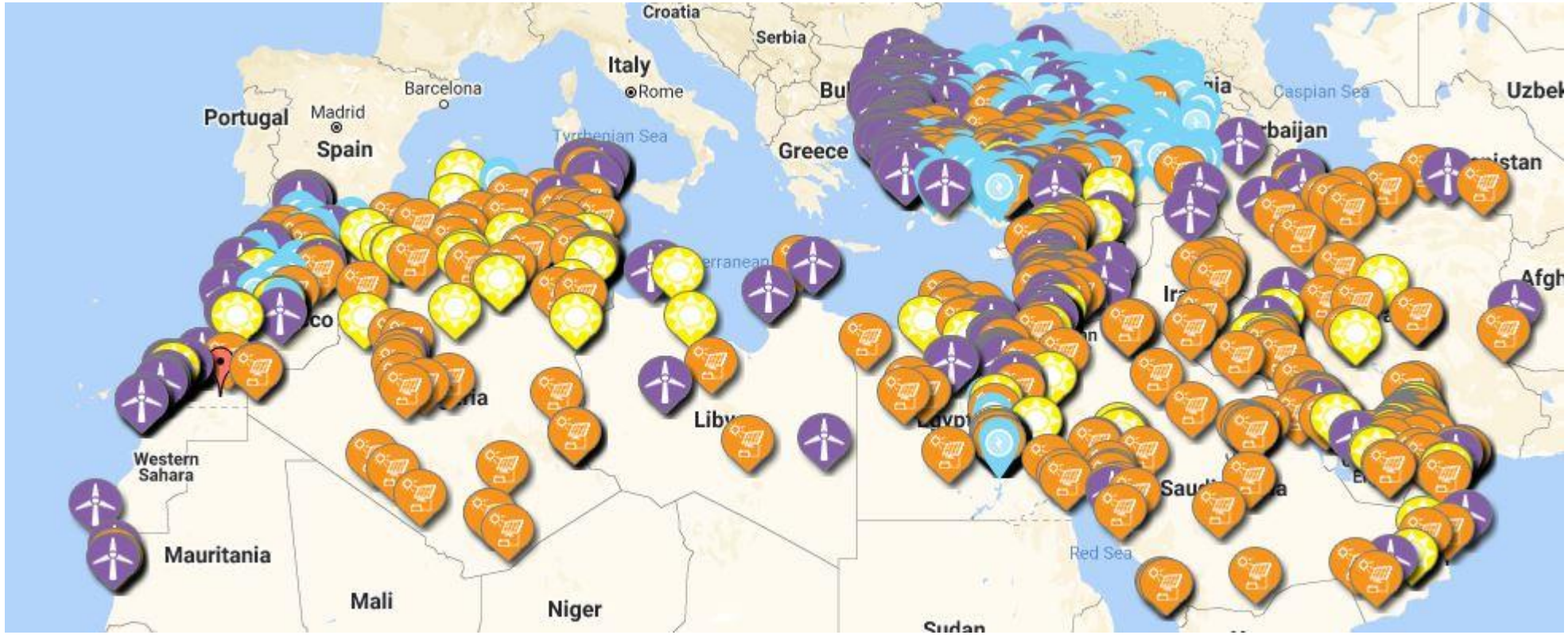
Desalination

Sea Water

Transport/E-mobility

in 2020 Dii identified in MENA

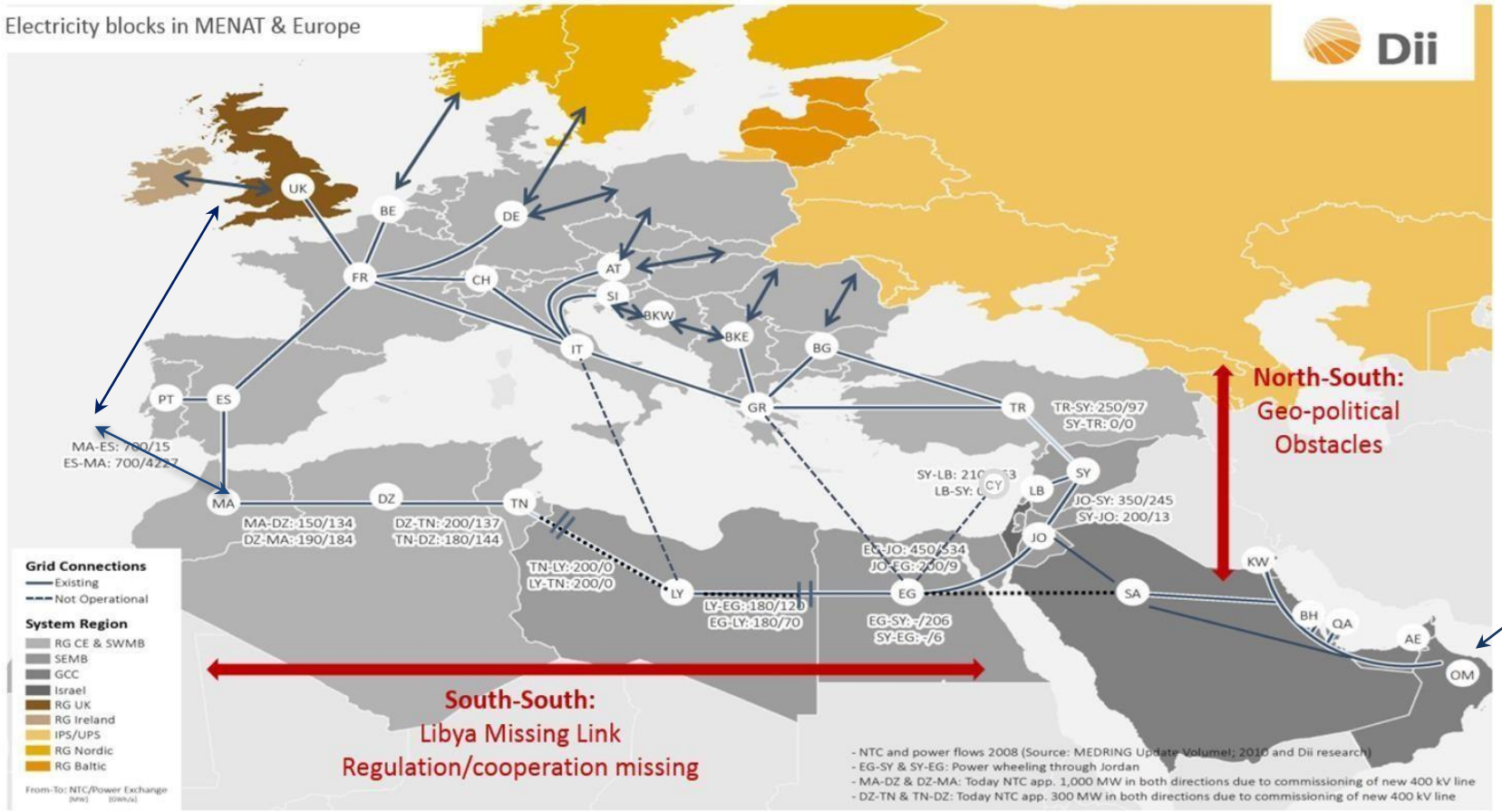
over 1,250 RE Projects (Dii Project Database >5 MW)



Power Grid Interconnections MENA and Europe are gradually expanding

Potential Connection Morocco - UK

Potential Connections to Sub-Saharan Africa



Potential Connections to India

Zooming in on CSP MENA

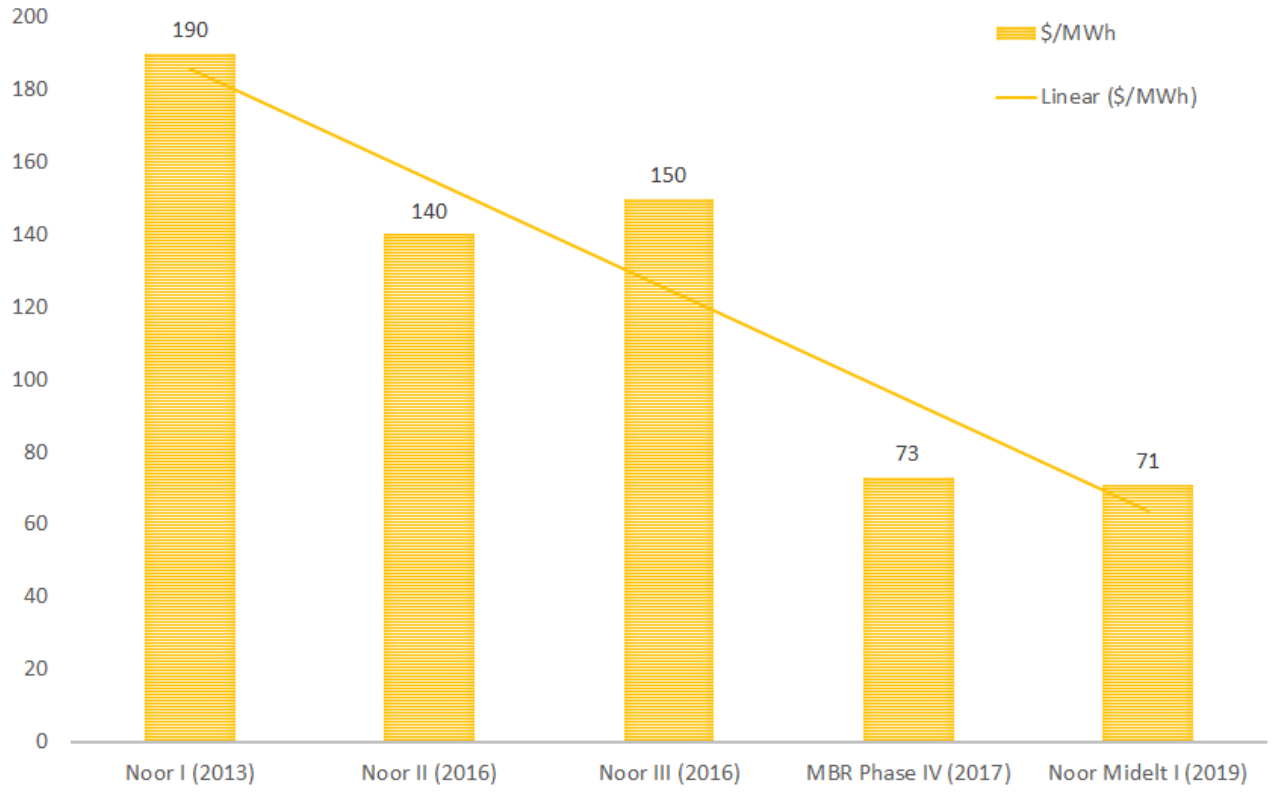
Current Situation

- Operational Capacity: 877MW
- Under construction or Awarded: 2.02 GW
- Total number of projects: 40+ live projects (positive/realistic announcements)

Lowest Bids so far

- Noor Midelt (Morocco) - $71/MWh in May 2019 (by EDF Consortium)
- Noor Energy I (UAE) - $73/MWh in 2017

Falling CSP Costs!!



Dubai takes leadership with the world's largest solar park and record low prices

- Largest single-site solar park in the world based on IPP
- Once it will be complete in 2030, the total area of the solar park will be 214 square kilometers
- The solar park has a total planned capacity of 1,000 MW by 2020, and 5,000 MW by 2030
- The solar park is a total investment of AED 50 billion
- The solar park will reduce 6.5 million tons of carbon/year
- Oct 2013: 13 MW PV by First Solar (operating)
- Nov 2014: 200 MW PV by ACWA Power & TSK (operating)
- June 2016: 800 MW PV by Masdar/EDF (partly operating)
- Sep 2017: 700 MW CSP by ACWA Power (under constr.)

UAE and Morocco – The CSP forerunners!

Shams 1 Abu Dhabi

- Capacity: 100MW
- COD: March 2013
- Technology: Parabolic trough
- Owners: Masdar, Total & Abu Dhabi Retirement Pensions and Benefits Fund (ADRPBF)

MBR Solar Park Phase IV, Dubai

- Capacity: 700MW, part of 3000MW (1000 operational / planned 2000MW)
- Under construction
- COD: 2022*
- Technology: Parabolic trough (600MW) & Solar Tower (100MW)
- 15 hours storage
- **$73/MWh**
- Owners: ACWA Power & China Silk Road Fund

Noor I (ACWA Power)

- 160MW (3 hours of storage)
- COD: Feb 2016
- Parabolic trough
- $190/MWh

Noor II (ACWA Power)

- 200MW (7 hours of storage)
- COD: Feb 2016
- Parabolic trough
- $140/MWh

Noor I (ACWA Power)

- Noor III (ACWA Power)
- 150MW (7 hours of storage)
- COD: Sep 2018
- Parabolic trough
- $150/MWh

Noor Midelt I (EDF/Masdar)

- 200MW (5 hours of storage)
- COD: 2022*
- Parabolic trough
- **$71/MWh**

CSP Pipeline for the next years!

- Morocco (Noor Midelt II – 200MW)
- Algeria (2GW by 2030 is dormant for long!) ~450MW in planning stages
- Egypt (700MW of CSP by 2022! With only 20MW installed capacity and 250MW projects on positive pipeline)
- Saudi Arabia (2.7GW of CSP by 2030? Only 90MW under construction)
- Kuwait (1.15GW of CSP announced/ expected – phase III Shagaya)
- UAE – 4th phase of MBR Solar park – world's tallest solar tower under construction
- Oman (2GW of EOR announced by Occidental & Miraah project 1GW under development

CSP – Operational

Operational Projects: 877MW (15 projects)

CSP – Construction & Awarded

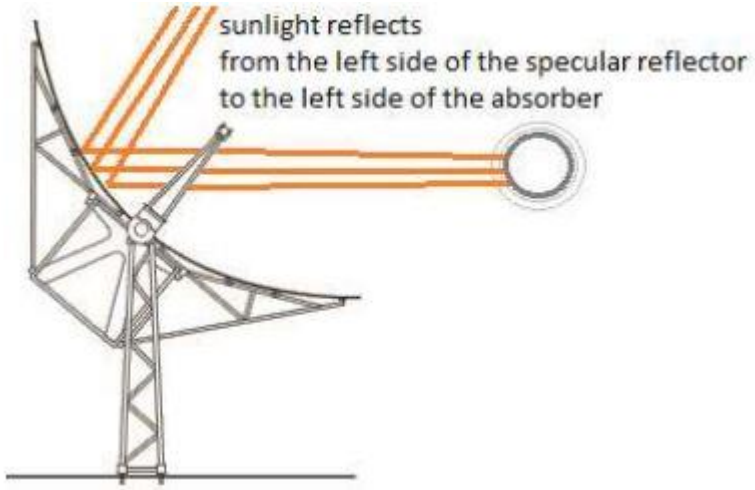
Projects under planning stages: 2.4GW (23 projects)

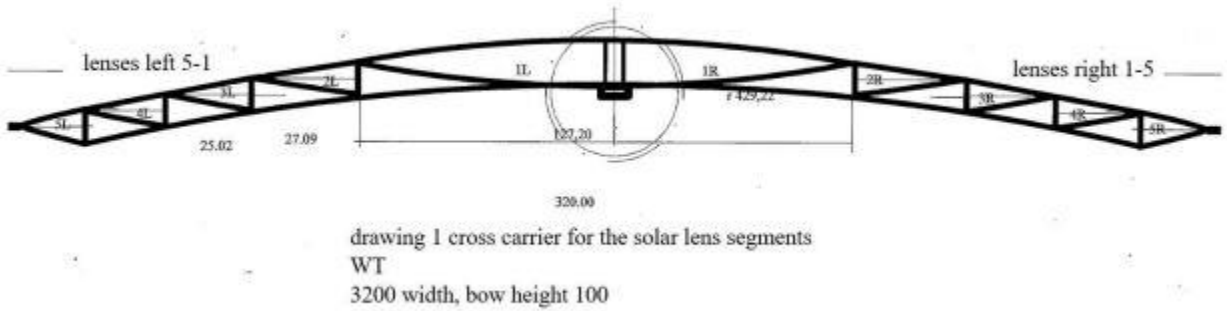
CSP – Dormant & Cancelled

Dormant / Cancelled:12.45GW (38 Projects)

On the Edge of CSP Innovation: ‘Smart Lenses’ instead of Mirrors !?

Focusing sunlight onto a focal line with glass lenses would produce more concentrated energy at lower costs.





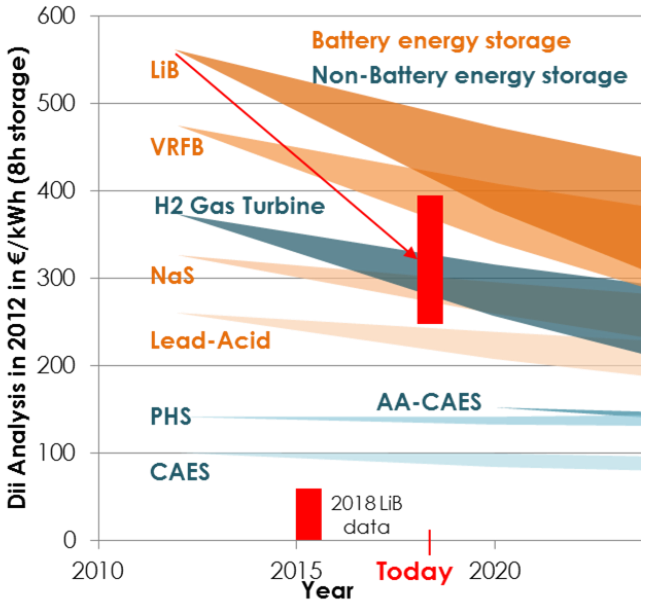
Technical drawing cross carrier for the solar lens segments

Revival of Dii Desert Energy (Desertec Industry Initiative) Leadership by ACWA Power and State Grid of China

Battery Storage, emerging competitor to CSP?

Stabilizing the power grid and balance power supply with batteries

Current Situation



- Business cases with growth potential are becoming economic
- Cost decrease due to scaled production and technology improvements
- First large scale projects deployed

Outlook

- High market potential
- Current trends of wind and PV will trigger further market growth
- Further cost decline expected, less regulation for positive business cases required.
- Dependent on trends of de-carbonization and sustainability

Dii work in 2019

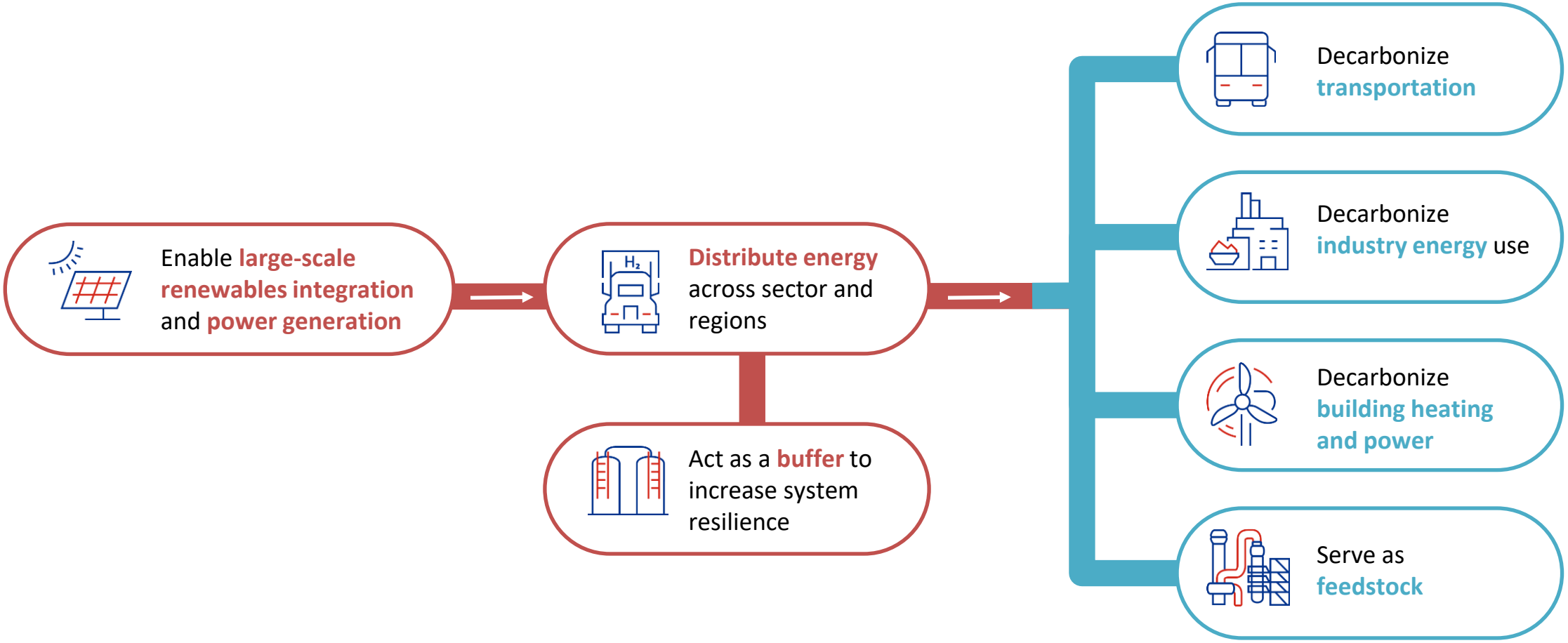
- Meta study on cost and performance of storage technologies development – status and outlook (group 1)
- Overview of use cases, estimate added value for the region (group 2)

LiB: Lithium-ion battery, VRFB: Vanadium redox flow battery, NaS: Sodium sulfur battery, PHS: Pumped hydro storage, (AA)-CAES: Advanced adiabatic compressed air energy storage

30 MW LiB in California [1)]

1) Photo(s) courtesy of San Diego Gas & Electric. https://sdgenews.com/article/sdge-escondido-battery-energy-storage-facility-and-press-conference-photos

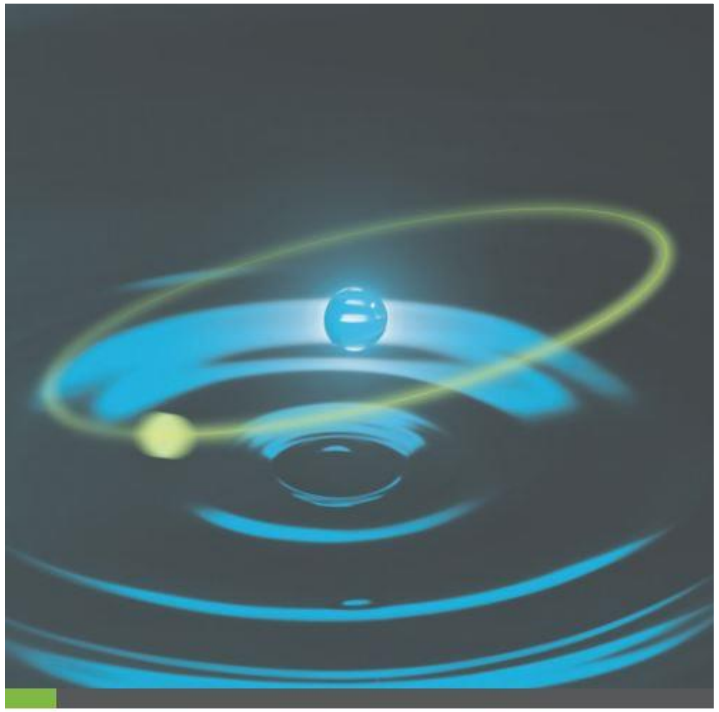
What role does hydrogen and 'Green Molecules' play in the energy transition?



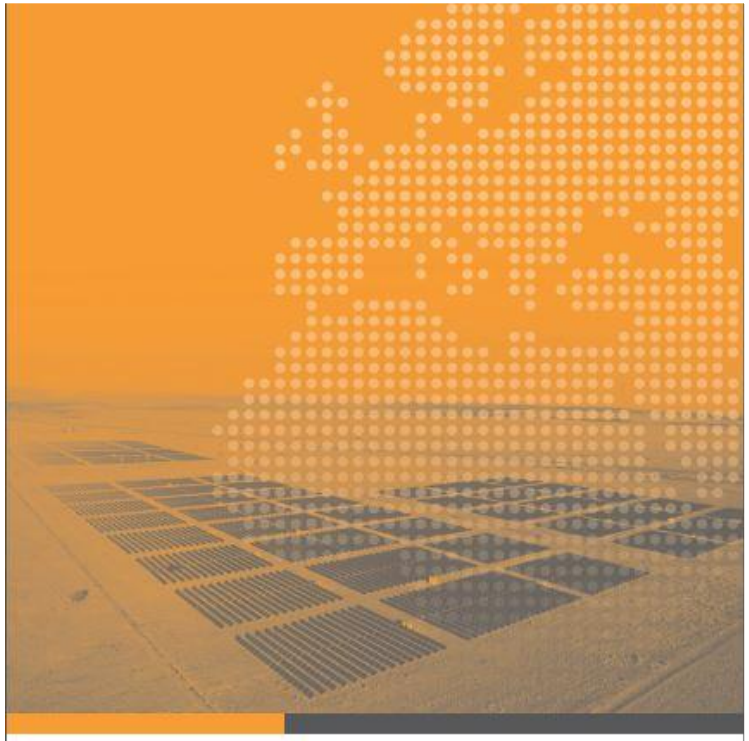
Enable the renewable energy system → **Decarbonize end uses**

Source: Hydrogen Council

Desertec 3.0 H2 studies appreciated by market with new momentum …

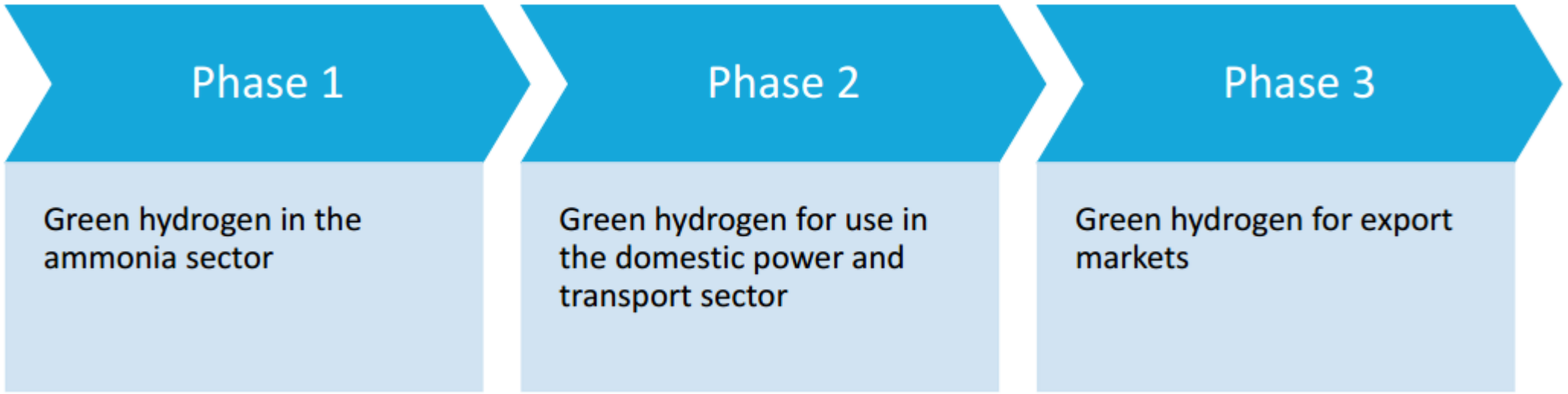


- Published **April 2020**, in cooperation with Hydrogen Europe
- **Presented to FransTimmermans**, EVP EU Commission in charge of Green Deal and 14CEOs of utilities and companies active in hydrogen value chain
- Discussed and partnered with **Energy Minister of Morocco**

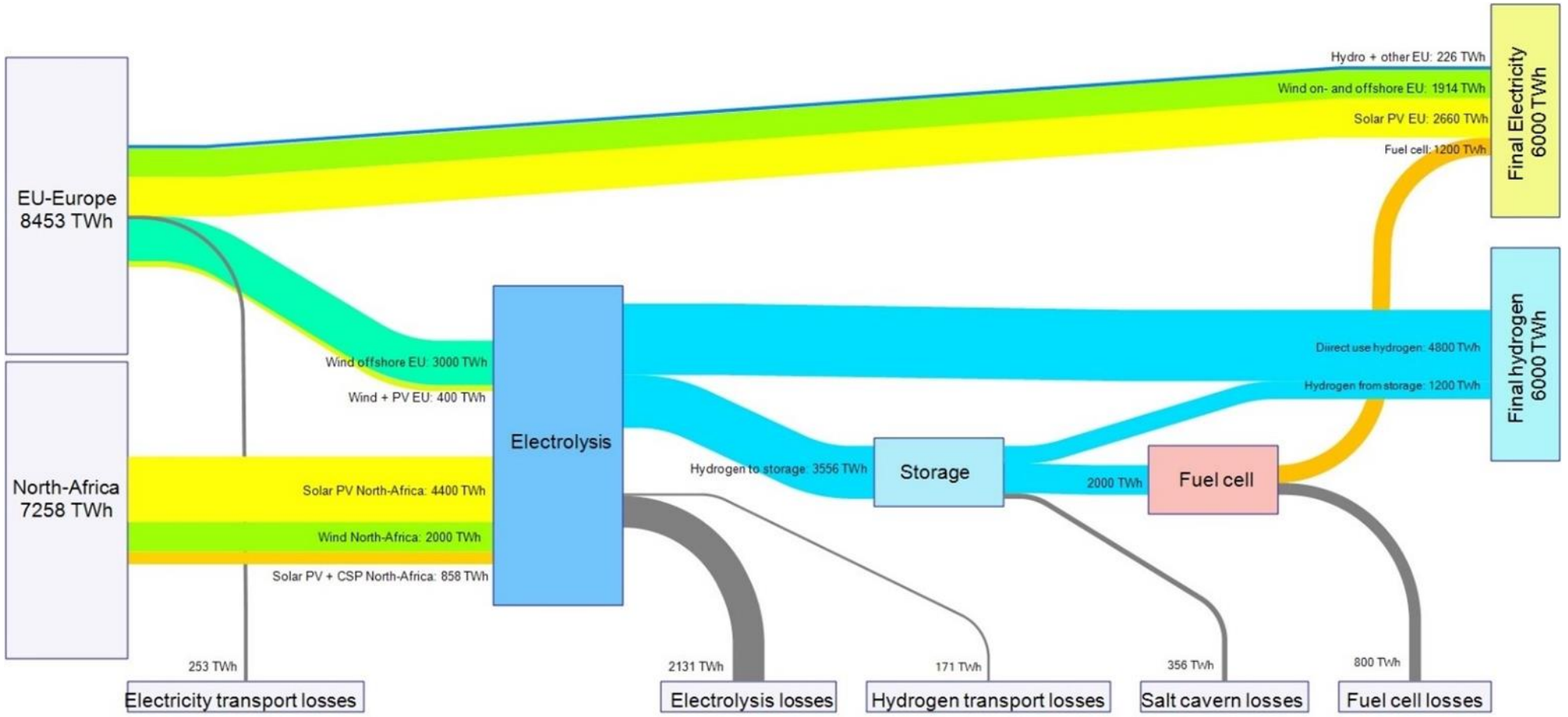


- Published **November 2019** in cooperation with IRESEN (Morocco)
- Presented to **Frans Timmermans,** EVP EU Commission in charge of Green Deal
- Discussed with key **stakeholders for hydrogen in Europe and MENA**

Green Hydrogen Roadmap e.g. Morocco, KSA/Neom



A Study Scenario Outlook: Energy Balance European Union – North Africa 2050

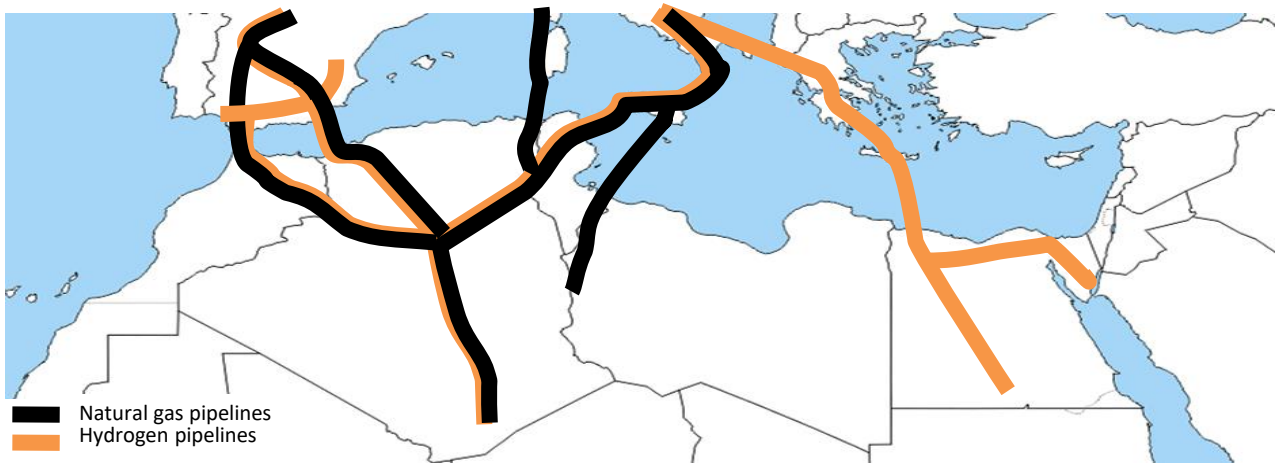


European Hydrogen Strategy – 8th July 2020

- Priority focus on green hydrogen
- At least 6 GW of electrolyzers by 2024 and at least 40 GW installed by 2030
- Role for import from neighboring regions
- **Dii's 2x40GW adopted!**
- By 2030, the Commission estimates that €13-15bn could be invested in electrolyzers across the EU, in addition to €50-150bn for a dedicated wind and solar capacity of 50-75 GW.

Export: Existing and new Gas Infrastructure

Eventually to be used for hydrogen



- Natural gas infrastructure Europe - North Africa (left figure) and first outline for a hydrogen backbone infrastructure Europe-North Africa (figure above)
- 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).

Current green hydrogen activities in Morocco

GREEN ENERGY PARK:
Solar Photovoltaic and Thermal energy

GREEN & SMART BUILDING PARK
Green building, energy efficiency, smart grid and electric vehicles

NEXUS WATER-ENERGY:
Marine energy, water treatment

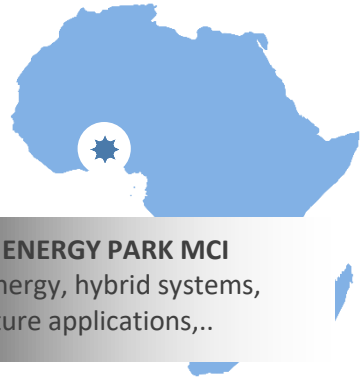
BIOENERGY & STORAGE PARK:
Bio energy, biomass and energy storage

GREEN H2A:
Green molecules

Green H2A RESEARCH PLATFORM

masen

Masen is starting a 'reference project', which is an industrial size project to produce green hydrogen and ammonia with around 100 MW of electrolyzer capacity.



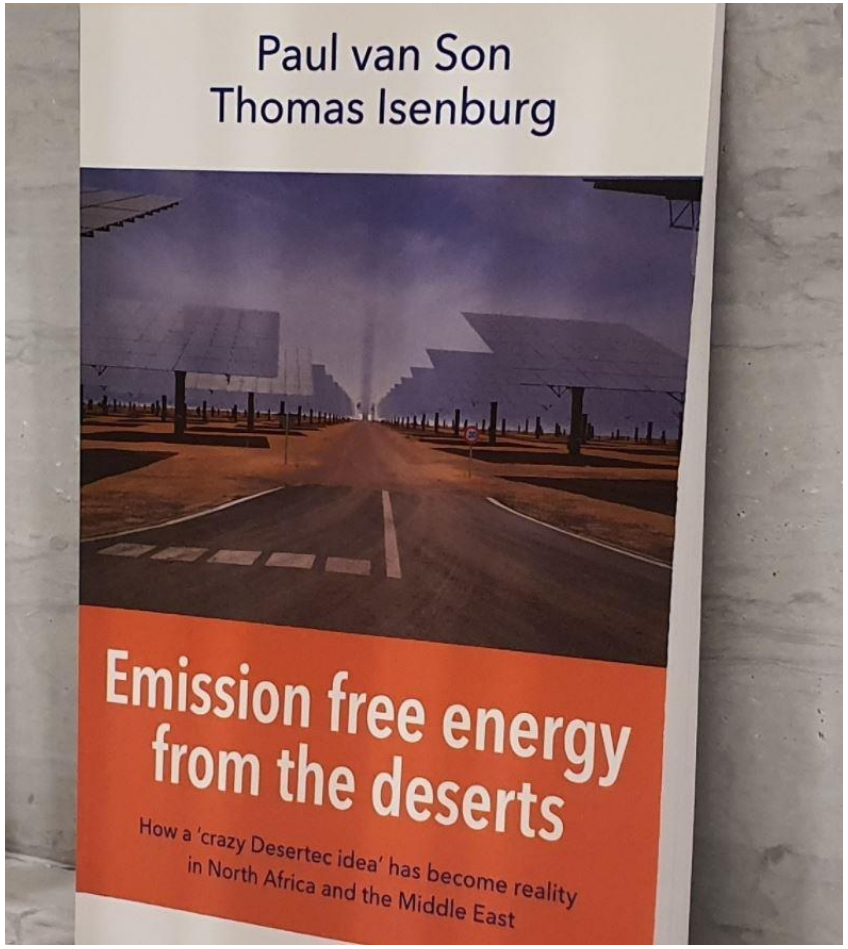
GREEN ENERGY PARK MCI
Solar energy, hybrid systems, agriculture applications,..

NEOM (KSA) has strong interest in green hydrogen

- New city, the size of Belgium (26,000km^2)
- One of three strategic projects of Saudi Agenda 2030
- Saudi's Public Investment Fund and others have committed $500 billion
- NEOM will be powered by 100% low-cost renewable energy (40 – 60 GW)
- Given the availability of competitive and low-cost renewable energy, NEOM will produce **green hydrogen** at scale for local and world markets
- NEOM, ACWA Power and Air Products signed in July an Agreement for **5 Billion$ Solar based Green Hydrogen for producing 1.2 mln tons of Green Ammonia per year**

Dii's Book on Emission Free Energy from MENA

- Published in 2019, German and English
- 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 expeort of green electrons and molecules
- **Update and translation into French to 'zoom' into the perspective of 'green electrons and molecules' in Maghreb (2020)**



Thank You!

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