



# The Water-Renewable Energy Nexus in the GCC Context

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UNITED NATIONS

الاستسقا  
ESCWA

Final Regional Policy Workshop on  
the Water-Energy Nexus

Beirut, Lebanon, 11-12 December 2017

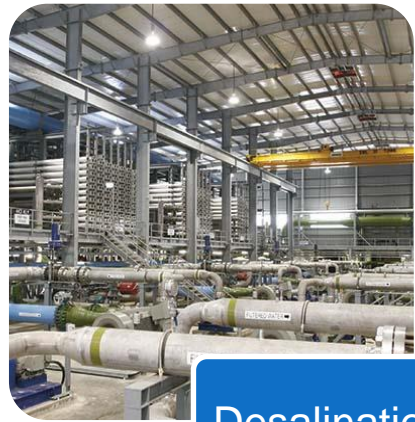
# RE Opportunities in the Water-Energy Nexus:

## Renewable energy can boost water security by:

- Improving affordability and safety of supply
- Reduce water-intensity of power sector
- Improve access to water in off-grid areas
- Enhance reliability of water supply
- Bridge the water gap in arid regions
- Replace traditional water heating



# The Water Use Cycle in the GCC and Energy Intensity



Desalination



Pumping



Usage



Treatment

Desalination

Pumping to  
Reservoir

Usage by  
Consumer

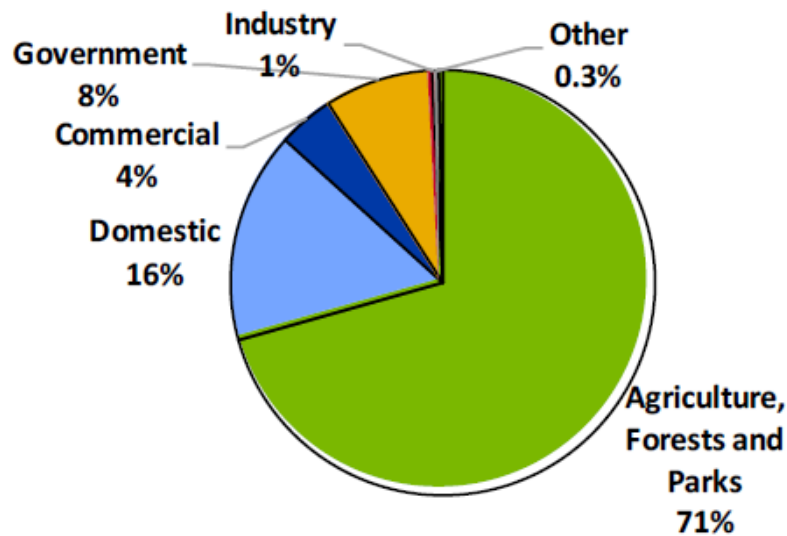
Sewage  
Pumping

Sewage  
Treatment

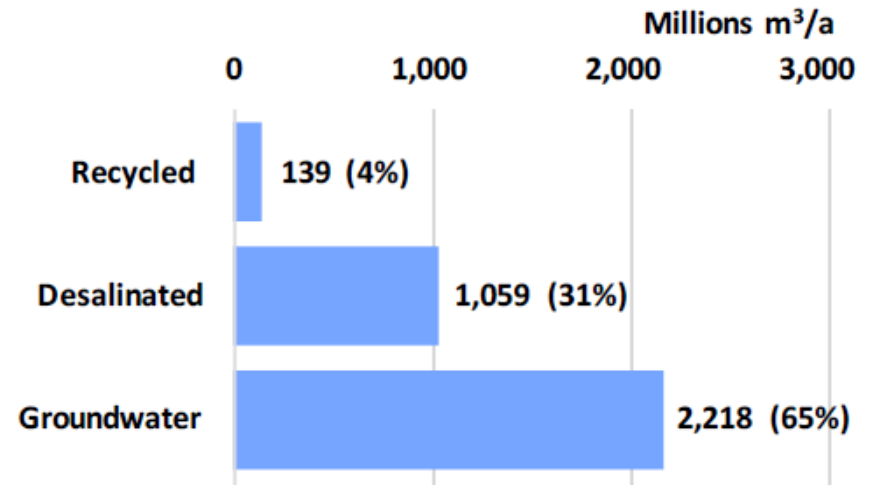
TSE Pumping

# Water Sources and Demand in the Emirate of Abu Dhabi

## Water Demand



## Water Sources

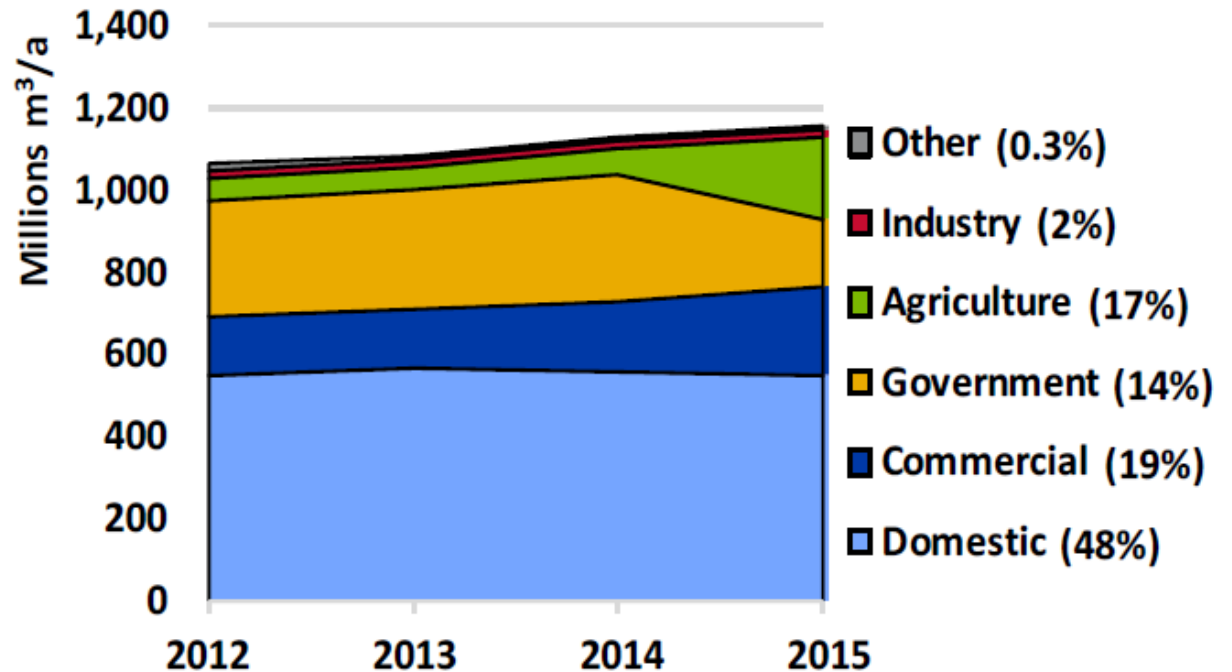




# Water Challenges in the Emirate of Abu Dhabi

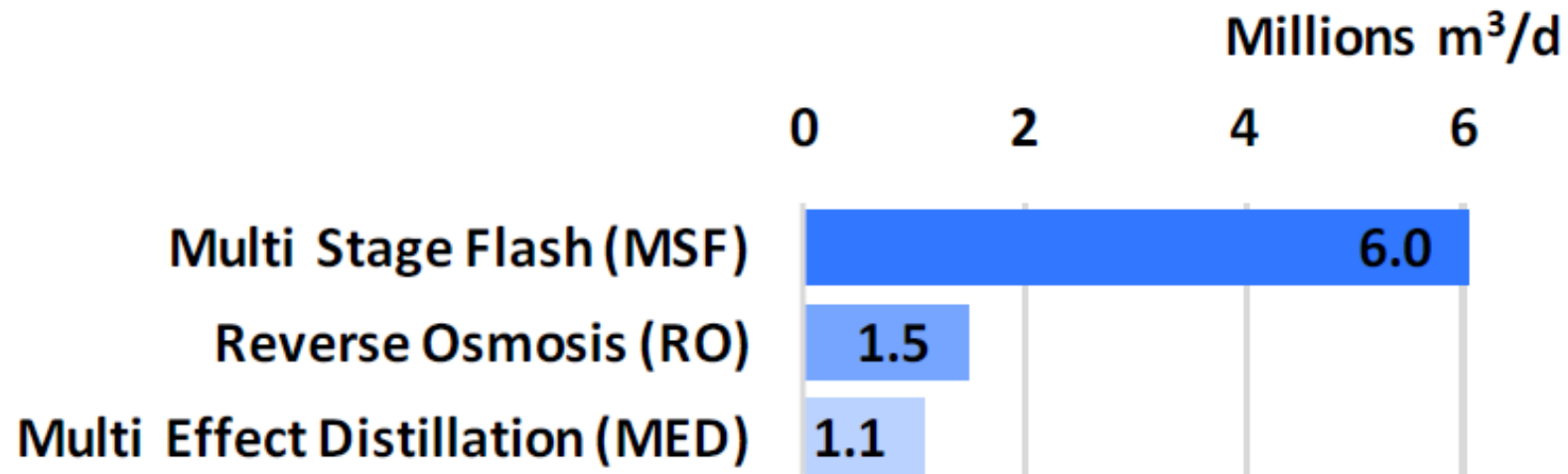
## Desalinated Water Demand is Rising

- Raising demand for desalinated water
- Depleting ground water resources will contribute to higher demand



# Water Challenges in the Emirate of Abu Dhabi

## Desalinated Water Sources



- Reliance on very energy intensive technologies (MSF and MED), consuming about 3.5 times energy compared to RO technology
- Integration of power and water production (co-generation) leads to energetic inefficiencies
- Desalination plants are powered by natural gas: finite source of energy
- Desalination represents roughly 22% of the CO<sub>2</sub> emissions of the Emirate

# MASDAR's Renewable Energy Water Desalination Program

The objective of this program is to **develop and demonstrate** advanced and innovative seawater desalination technologies that:



are more energy efficient than current state-of-the-art systems;



are suitable to be powered by renewable energy sources;



are cost competitive with non-renewable energy powered seawater desalination;



have minimal environmental impact; and



are resilient in challenging seawater and environmental conditions

# MASDAR's Renewable Energy Water Desalination Program

- 5 pilot plants located in Abu Dhabi
- Each pilot plant operated over 18 months
- Masdar implements the program in close collaboration with the Abu Dhabi governmental agencies in the water sector
- The pilot plants demonstrate different advanced and innovative desalination technologies.

**ABENGOA**   
Reverse Osmosis  
+ Membrane Distillation 1,000 m<sup>3</sup>/d  
**ABENGOA**



**SIDEM/VEOLIA**   
Reverse Osmosis  
300 m<sup>3</sup>/d  
**SIDEM VEOLIA**



**SUEZ**   
Reverse Osmosis  
+ Ion Exchange  
100 m<sup>3</sup>/d  
**SUEZ**



**TREVI SYSTEMS**   
Forward Osmosis  
50 m<sup>3</sup>/d  
**TREVI SYSTEMS**



**MASCARA NT**   
Off-grid Solar Powered  
Reverse Osmosis  
30 m<sup>3</sup>/d  
**Mascara**





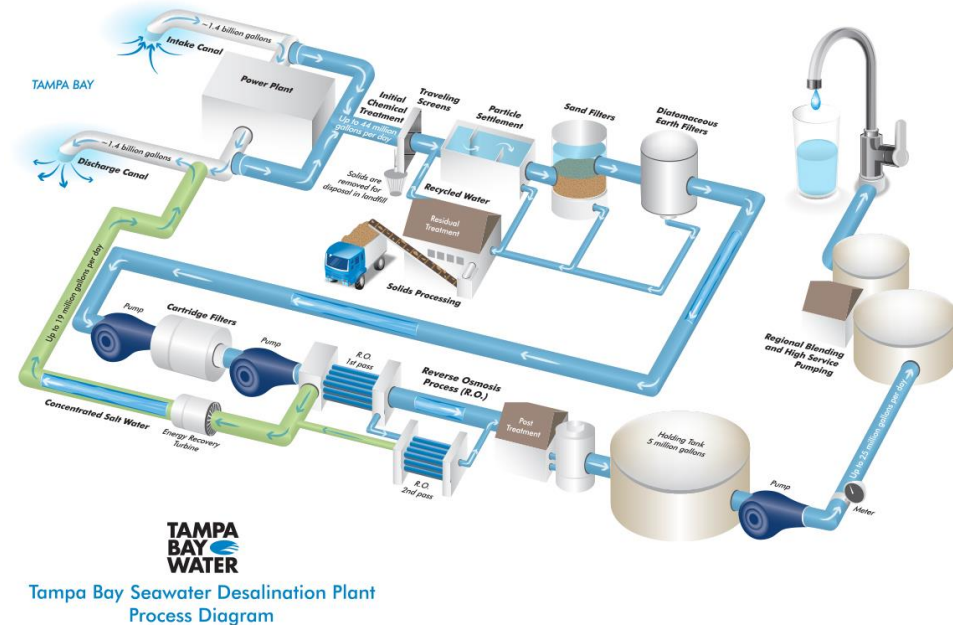
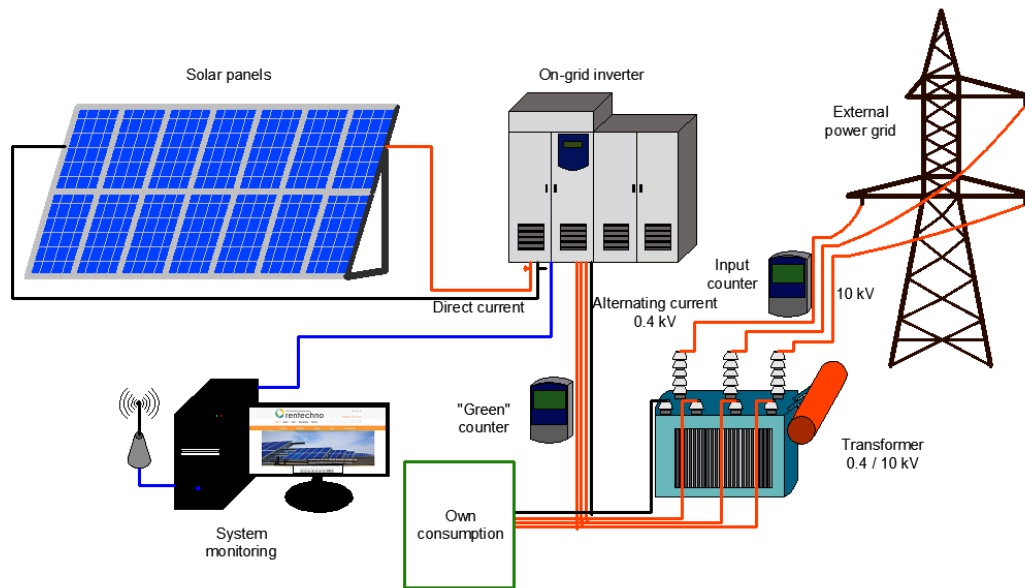
# MASDAR's Renewable Energy Water Desalination Program

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## Key takeaways from the Program:

- All pilot plants met Masdar's performance expectations in terms of energy consumption, reliability and water quality.
- Arabian Gulf seawater has proven to be challenging especially due to the high organic and biological content.
- Reverse Osmosis has proven to be a reliable desalination technology to produce drinking water even with challenging seawaters.
- Dissolved Air Flootation process has proven to be crucial to enhance the performance of the pre-treatment and consequently of the desalination unit.
- The advanced design solutions for Reverse Osmosis piloted in Ghantoot can be easily scaled up to utility size.

# Renewable Energy Powered Desalination for the UAE and the GCC



- Grid-connected PV plant produces 100% of desalination electricity demand.
- The program has demonstrated that producing drinking water with RO plants powered with renewable energy sources is cost-effective, providing Abu Dhabi with the valuable option to reduce the dependence on natural gas for the production of water.
- The calculated cost of drinking water produced by a grid-connected PV-RO plant with the technologies demonstrated in Ghantoot is around 0.90 USD/m<sup>3</sup>.

# Decentralized and Off-grid Desalination

## Grid-Independent Operation Possible at Smaller Scale

- Ramp water production according to availability of solar power (PV plant)
- Switch-off at night
- No batteries required, simplifying operations and maintenance
- Membranes protected from fluctuating production rates by hydraulic energy storage
- Suitable for micro-grid integration, providing electricity or saving diesel fuel

## Potential Applications

- Islands
- Remote locations, offsetting costly water and electricity transmission infrastructure
- Dispersed in-land locations (groundwater desalination), avoiding water tanker supply



# Renewable Energy Powered Desalination for the UAE and the GCC

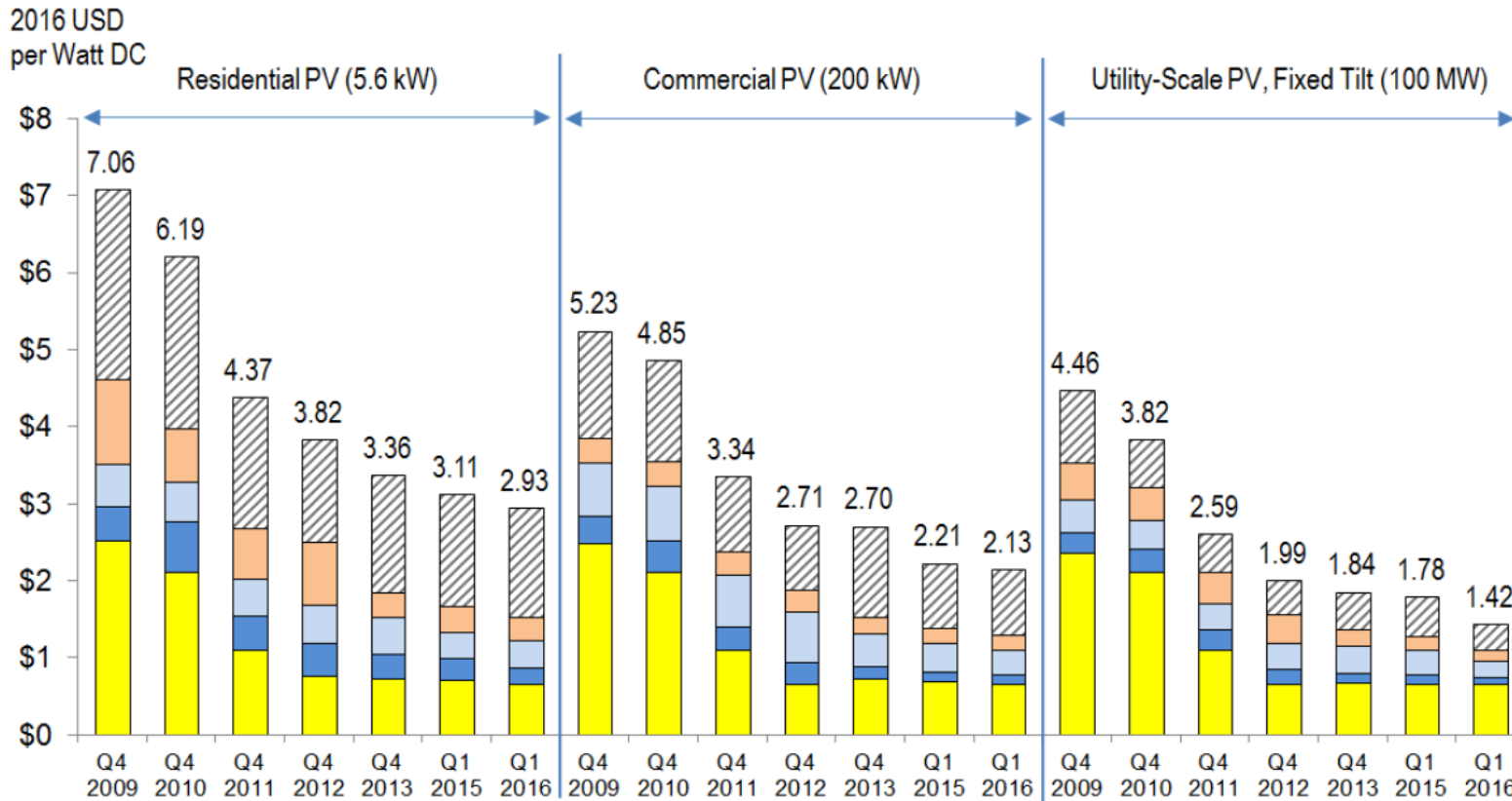
## Reverse Osmosis Desalination

- Large electrical load for every plant
- Modular setup
- Product (water) can be easily stored and dispatched



- Desalination plants can **optimize water production** according to availability of electricity.
- **Offer valuable service** to grid operators
- Avoid or **minimize inefficient operation** of conventional gas turbines

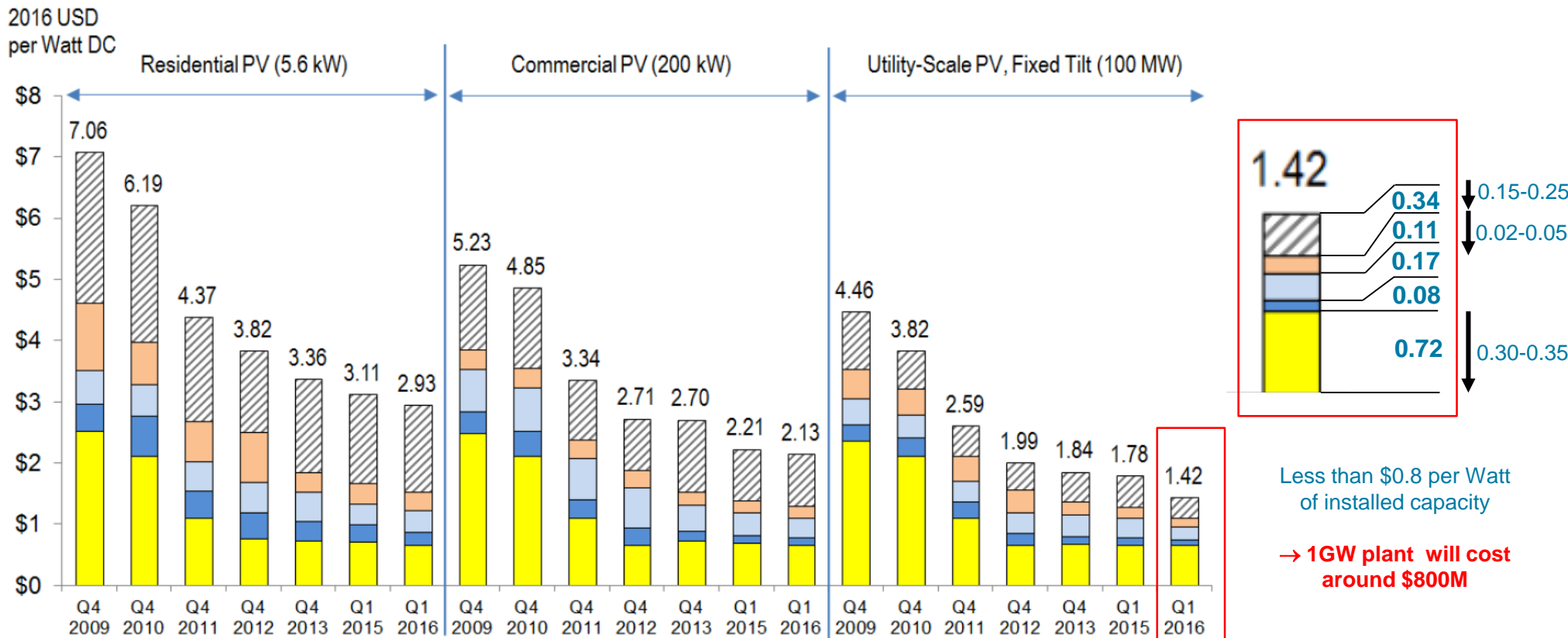
# Cost Benchmark of Solar Photovoltaic Systems (NREL Model)



- ▨ Soft Costs - Others (PII, Land Acquisition, Sales Tax, Overhead, and Net Profit)
- Soft Costs - Install Labor
- Hardware BOS - Structural and Electrical Components
- Inverter
- Module



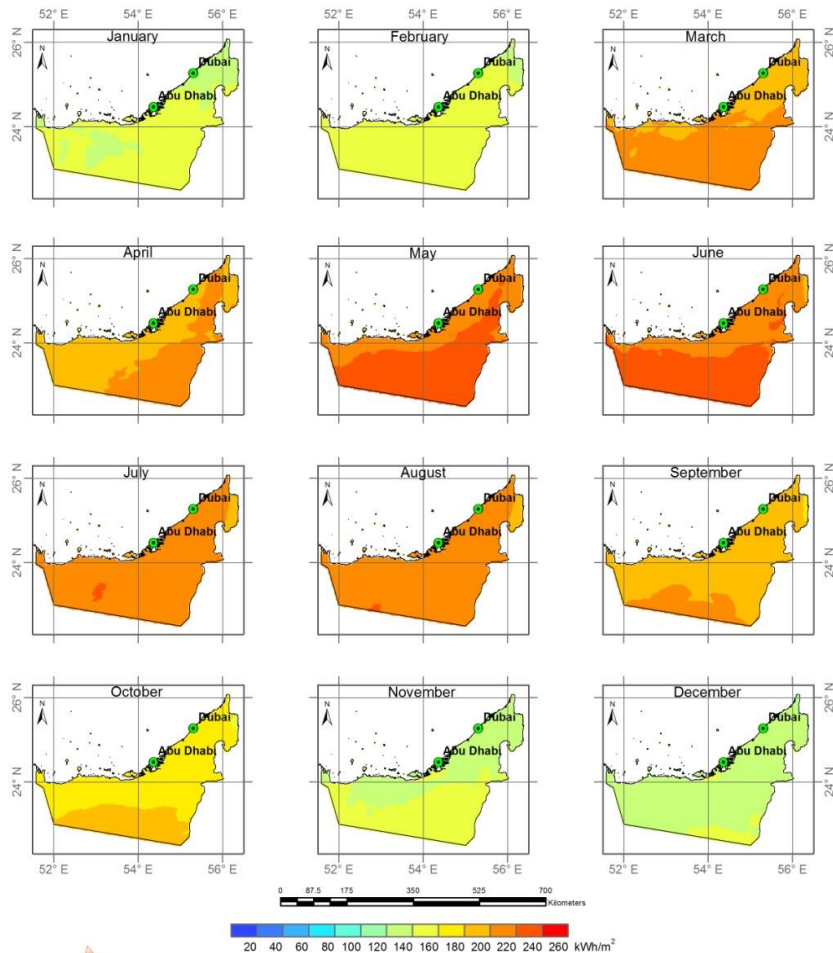
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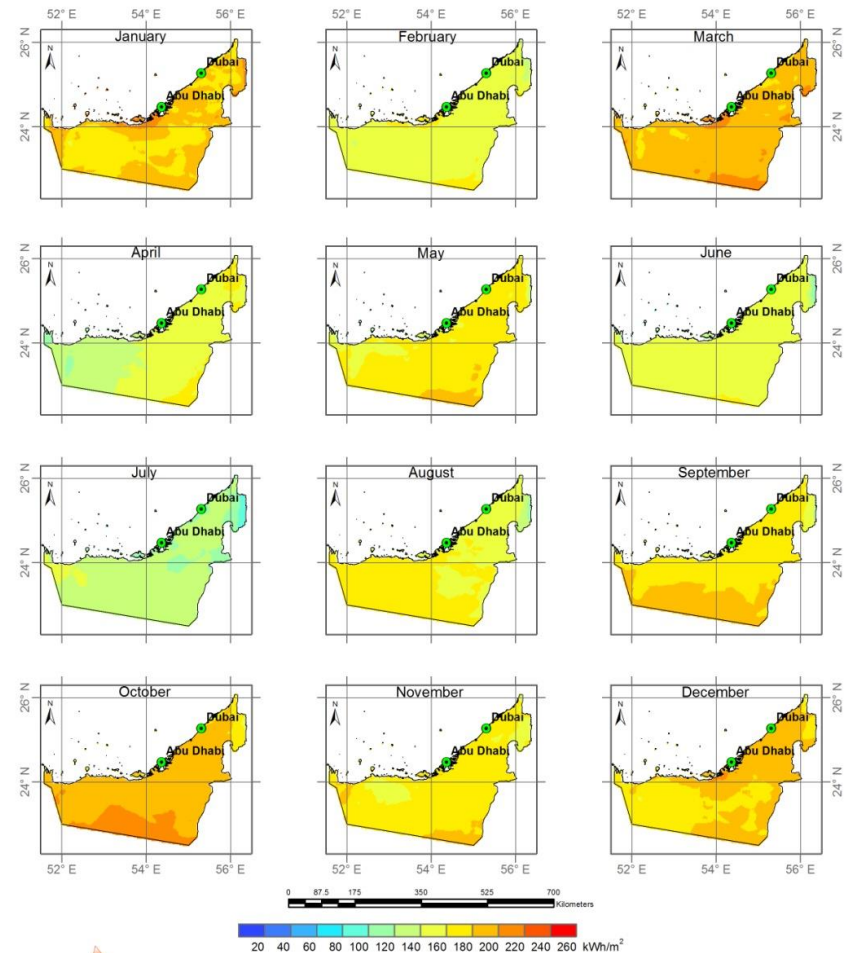
# Spatial and Temporal Variability of Solar Resources



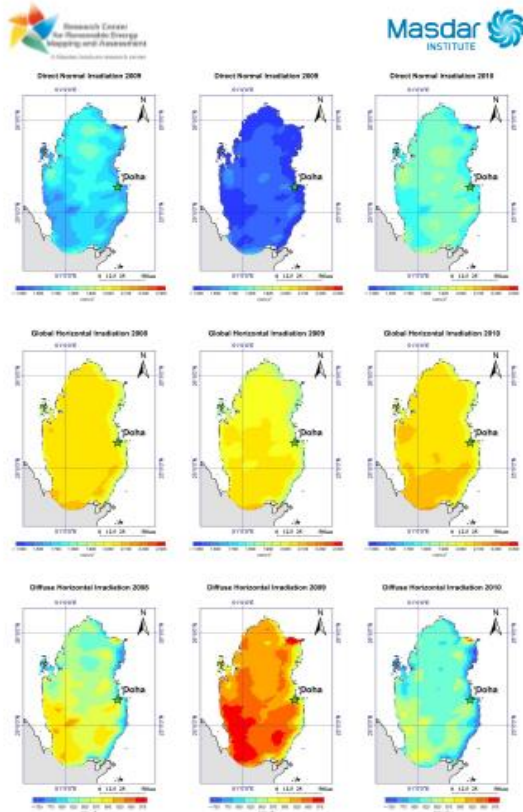
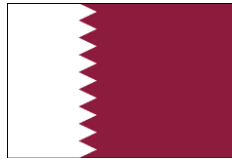
## Global Horizontal Irradiation 2010



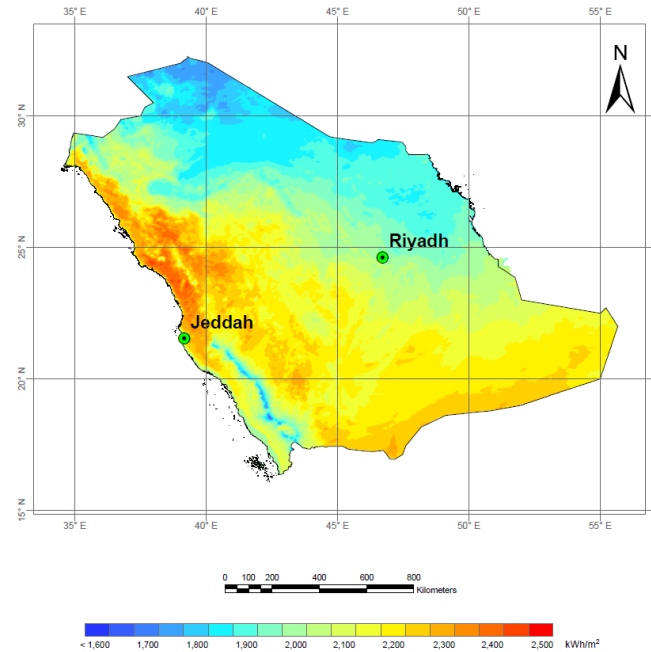
## Direct Normal Irradiation 2010



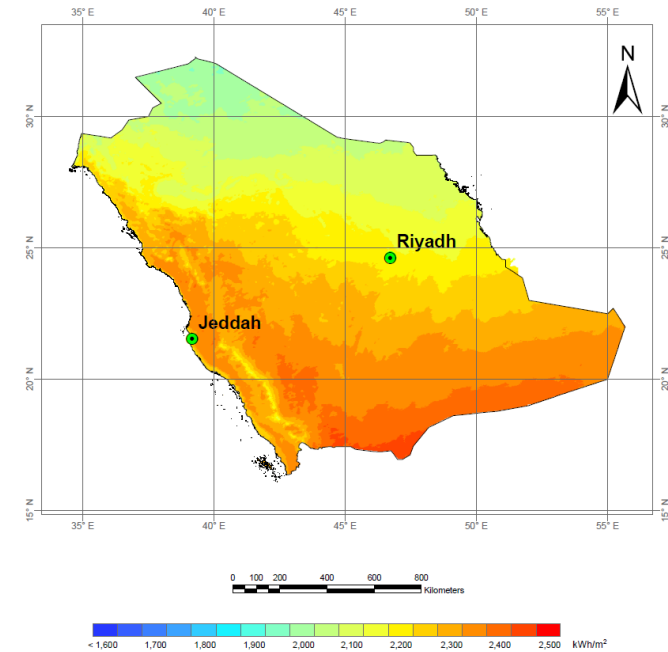
# Spatial and Temporal Variability of Solar Resources



Direct Normal Irradiation 2013



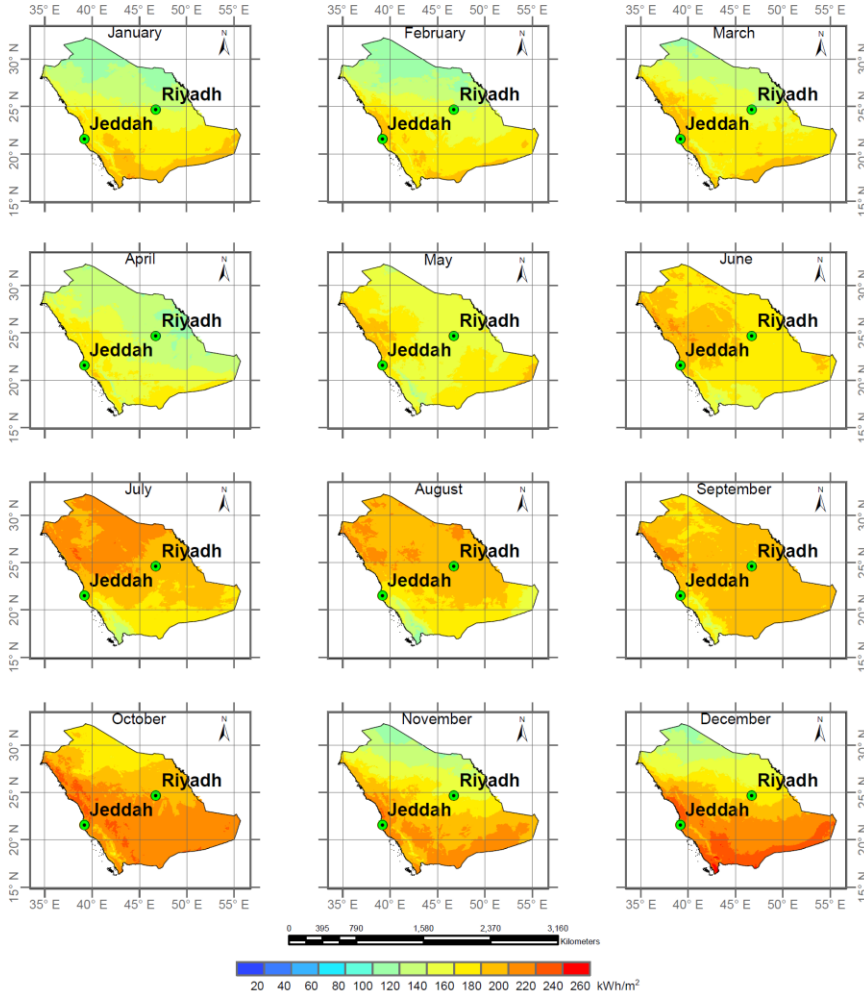
Global Horizontal Irradiation 2013



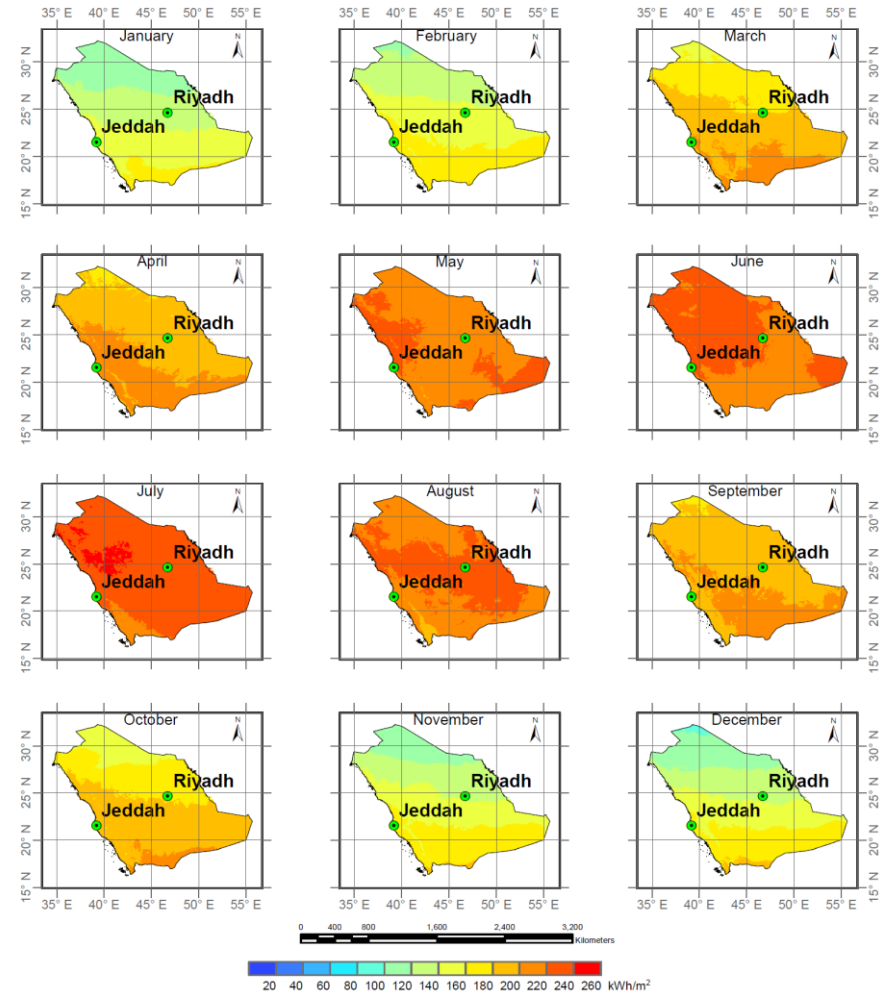
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## Direct Normal Irradiation 2013

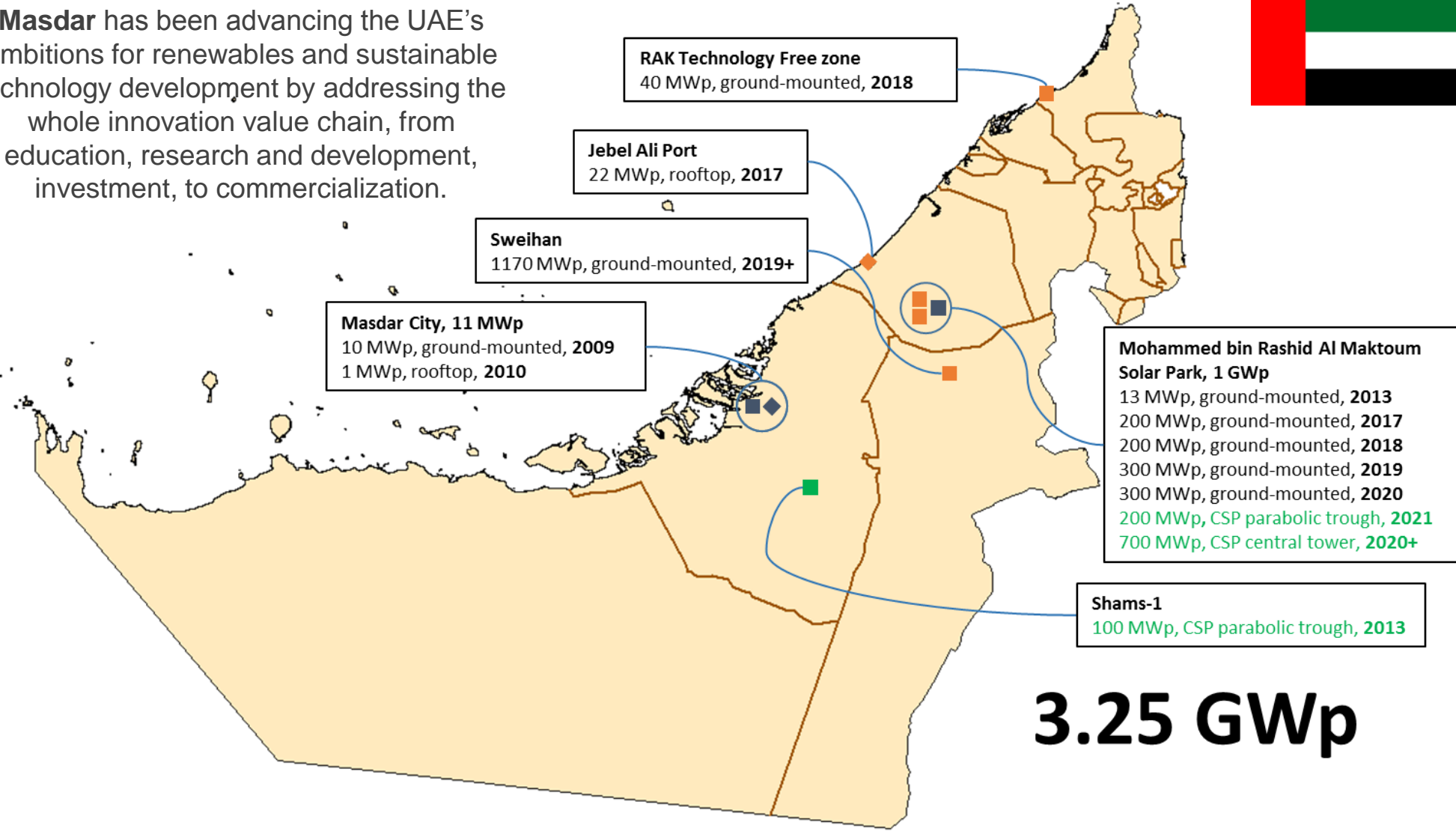


## Global Horizontal Irradiation 2013



# Solar Energy in the UAE: Current Status and Future Prospects

Masdar has been advancing the UAE's ambitions for renewables and sustainable technology development by addressing the whole innovation value chain, from education, research and development, investment, to commercialization.



**3.25 GWp**



# Solar Energy in the UAE: Current Status and Future Prospects

The UAE is being steered towards a future beyond oil → *The UAE set the region's first renewable energy targets, at a time when there was widespread doubt about its viability and value.*



- The UAE has raised its ambitious Clean Energy Target to 27% by 2021
- In **2016**, the UAE broke two world records for **PV** prices:
  - **May 2016**: DEWA received a bid of **2.99 US cents per kW/h**
  - **September 2016**: ADWEA received a bid of **2.42 US cents per kW/h**
- In **2017**, the UAE broke two new world records for **CSP** prices:
  - **June 2017**: DEWA received a bid of **9.45 US cents per kW/h**
  - **September 2017**: DEWA received a bid of **7.3 US cents per kW/h**

**Dubai Solar Park** will be the largest single-site solar project in the world with a planned capacity of 5,000 MW by 2030: **25% of output**  
→ **Enough to power 800,000 homes.** (75% by 2050)



# Thank You

For more information: [hghedira@masdar.ac.ae](mailto:hghedira@masdar.ac.ae)