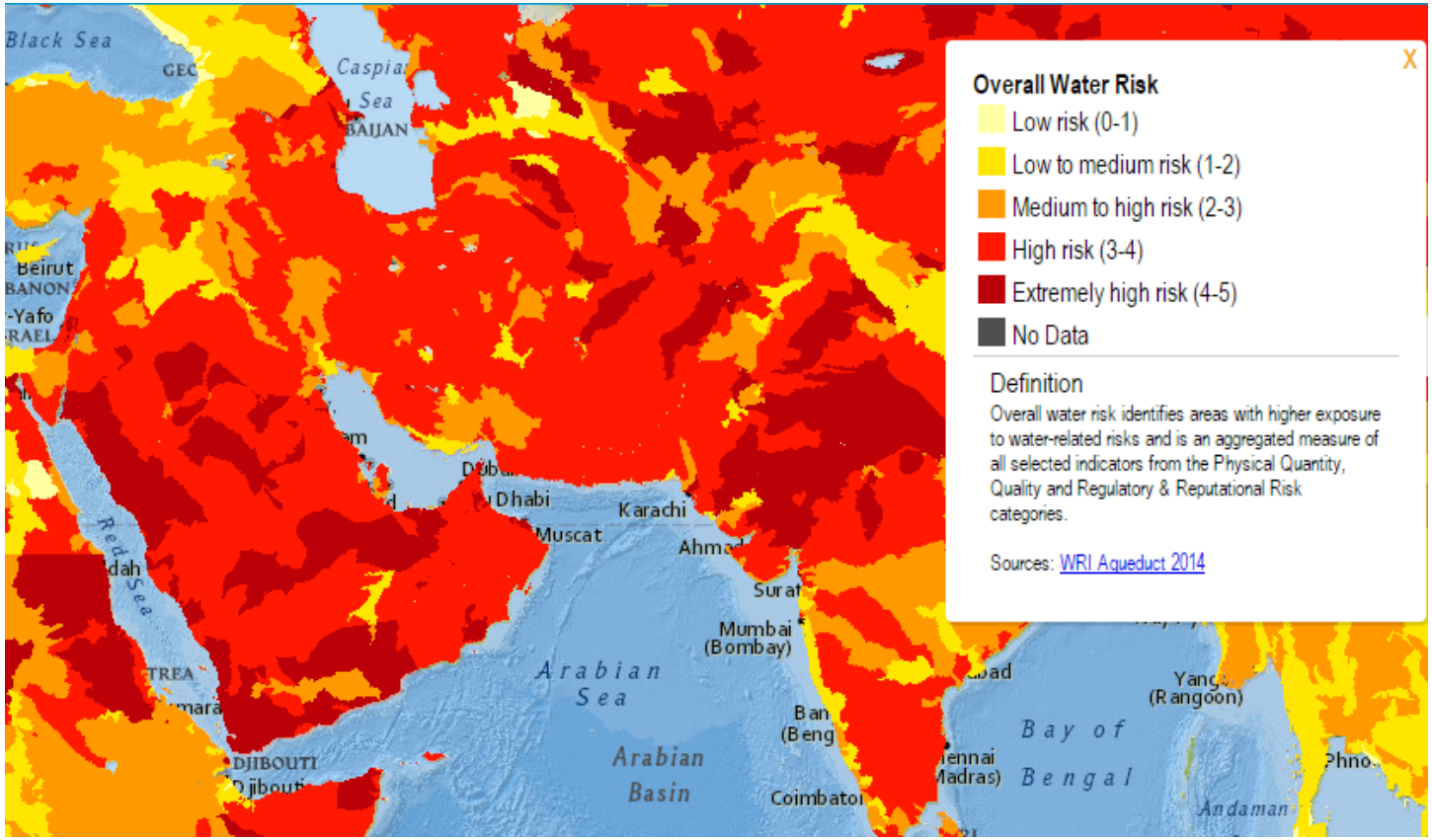
Understand: Water Challenges in the UAE

2040 Projection



“Water is more important than oil”

H.H. Mohammed bin Zayed Al-Nahyan

Crown Prince of Abu Dhabi and Deputy Supreme Commander of the UAE Armed Forces

World Resources Institute
Aqueduct Risk Atlas, 2015

Objectives

Masdar RE Water desalination program objective is to develop and demonstrate advanced and innovative seawater desalination technologies that:

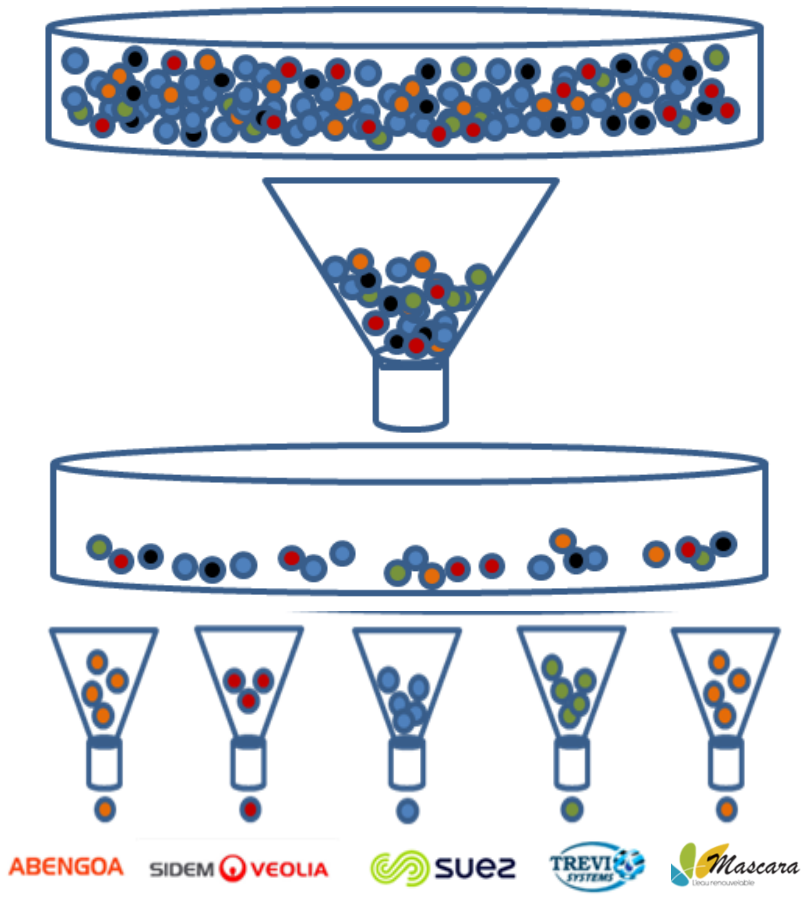
- are more energy efficient than current state-of-the-art systems;
- are suitable to be powered by renewable energy sources;
- are cost competitive with non-renewable energy powered seawater desalination;
- have minimal environmental impact; and
- are resilient in challenging seawater and environmental conditions

The selection process

RFQ

RFP

Pilots



Invited bidders

Received SOQs

Qualified bidders

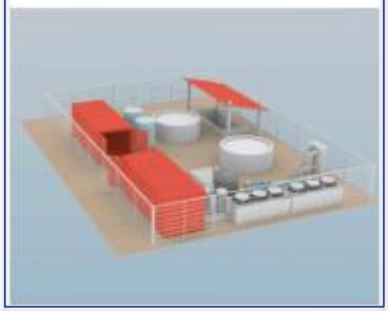
Selected Partners

Project Implementation

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

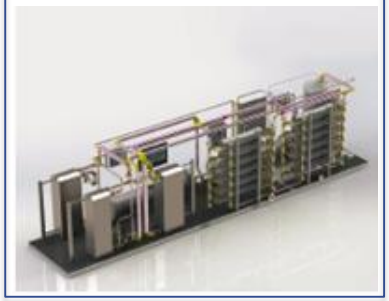
ABENGOA
Reverse Osmosis
+ Membrane Distillation
1,000 m^3/d

SIDEM/VEOLIA
Reverse Osmosis
300 m^3/d



SUEZ
Reverse Osmosis
+ Ion Exchange
100 m^3/d

TREVI SYSTEMS
Forward Osmosis
50 m^3/d



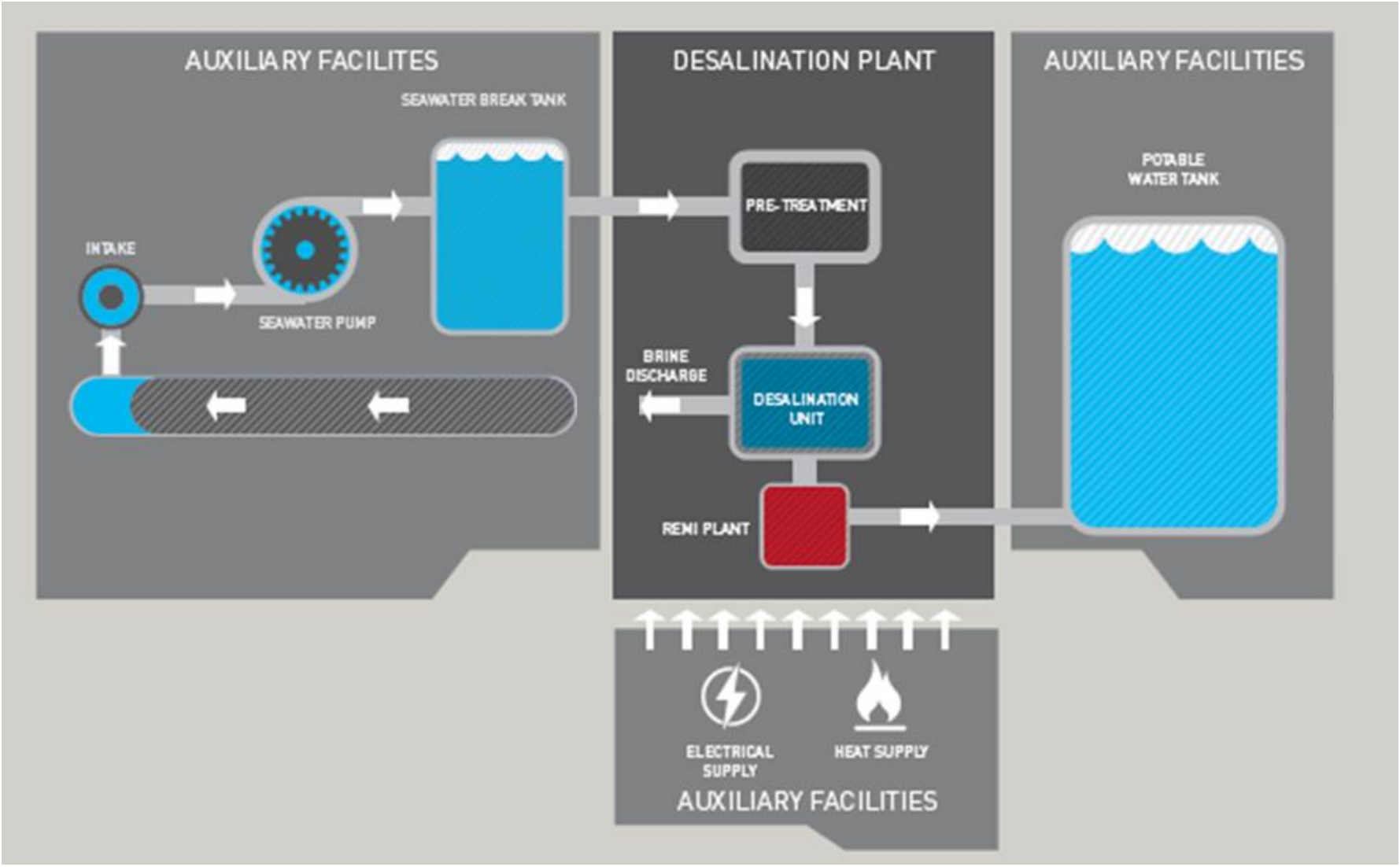
MASCARA NT
Off-grid Solar Powered
Reverse Osmosis
30 m^3/d

Project Site

- The Project is located in Ghantoot, in the Emirate of Abu Dhabi, which is a coastal place around 65 km northeast of the city of Abu Dhabi and around 60 km southwest of Dubai.

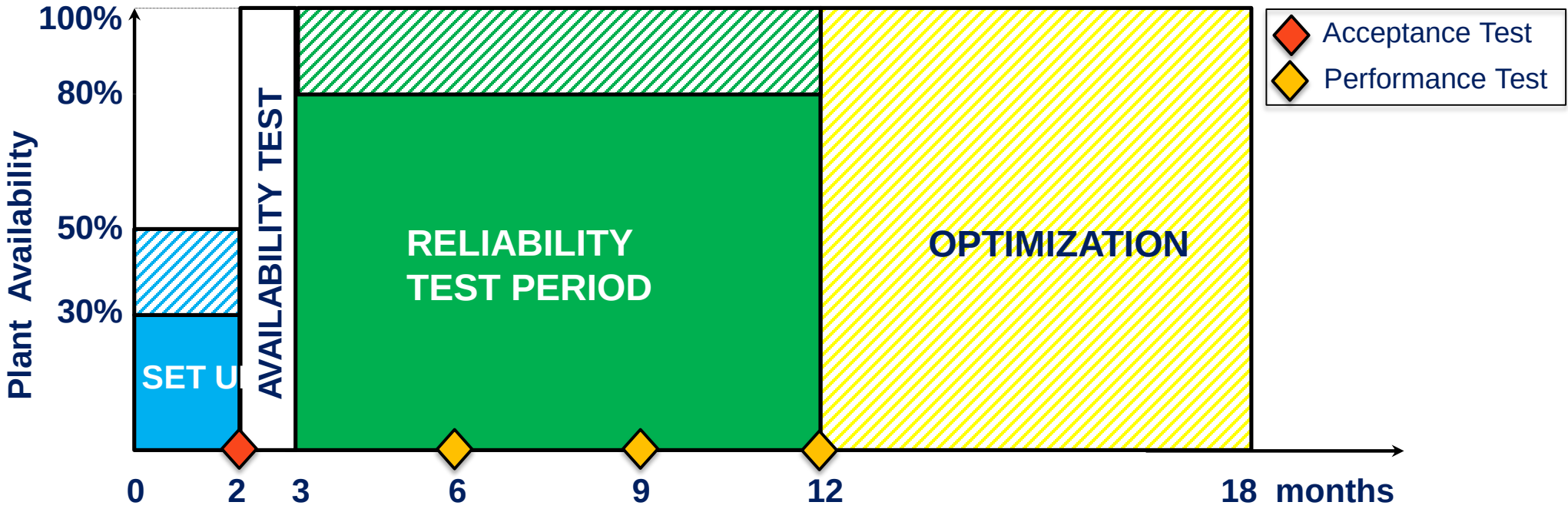
Ghantoot

Pilot Plant Setup



Test Regime

Pilot plant operation time	Months 1 – 2	Month 3	Months 3 - 12	Months 12 – 18
Operational mode	Initial setup	Availability test	Reliability test period	Optimization
Plant availability	30 – 50 %	100%	Min 80%	Up to 100%



Site Photos

ABENGOA

Abengoa desalination pilot plant

suez

Suez desalination pilot plant

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TREVI SYSTEMS

Trevi Systems desalination pilot plant

SIDEM VEOLIA

Veolia desalination pilot plant

Mascara L'eau renouvelable

Mascara desalination pilot plant

Veolia

SIDEM VEOLIA

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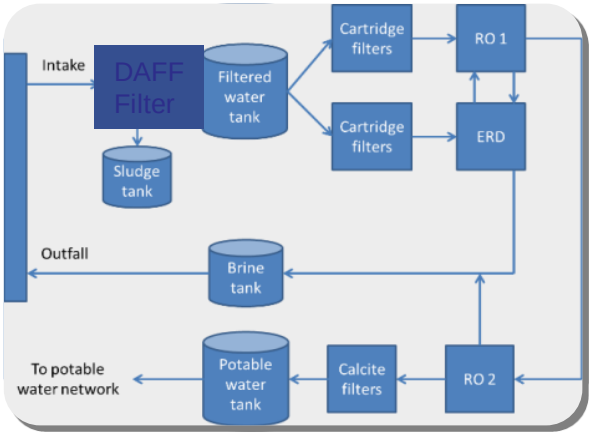
Description of Technology

- 2-pass RO desalination system with a special center-port configuration;
- Combination of dissolved air flotation + gravity dual media filter in a single unit reduces pressure loss and required civil works;
- OSMOREC's energy recovery device: uses energy from the brine to pressurize the feed, lowering the required energy for feed pressurization



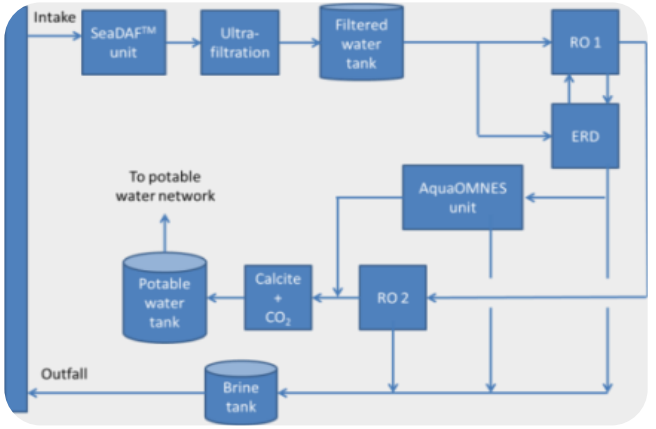
Key results

- Plant has successfully completed the acceptance test, availability test, and the reliability tests and is currently in the last phase of the pilot program, the optimization phase.

Suez

Description of Technology

- 2-pass RO system using dissolved air floatation and ultrafiltration as pre-treatment.
- The RO system is integrated with an innovative brine management unit (AquaOmnes™) based on a liquid-liquid ion exchange. This enables an increased recovery ratio.



Key results

- Plant has successfully completed the acceptance test, availability test, and the reliability tests and is currently in the last phase of the pilot program, the optimization phase.

Abengoa

ABENGOA

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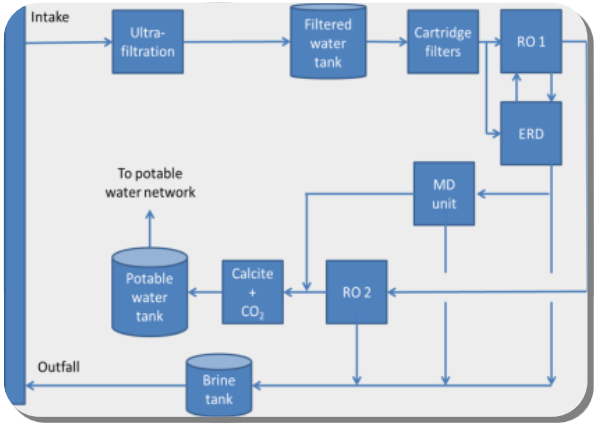
Description of Technology

- Integrated RO and MD plant, where the brine from the 1st pass RO plant is treated using the downstream MD system
- Innovative combination, which has the potential to increase the total recovery ratio and to reduce the energy consumption compared to the state-of-the-art
- The increased recovery ratio lowers the environmental impact of the desalination plant



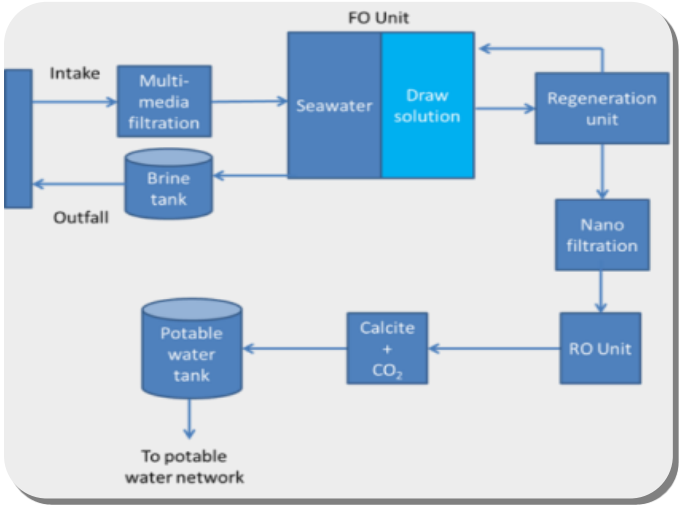
Key results

- Plant has successfully completed the acceptance and availability test. The plant is currently being tested for reliability.

Trevi Systems

Description of Technology

- This pilot plant is demonstrating forward osmosis desalination technology
- It applies the natural process of osmosis to extract water from seawater due to a difference in osmotic pressure
- The process uses a thermally regenerated draw solution (patented by Trevi Systems) to carry out the separation.



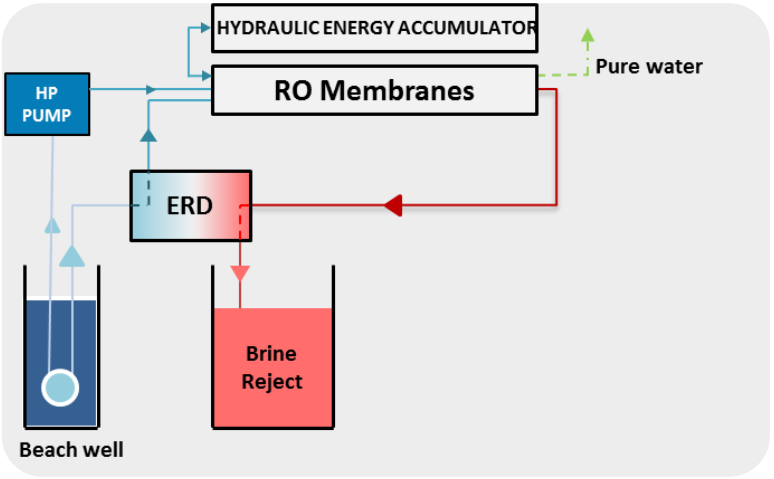
Key results

- Plant has successfully completed the commissioning and first testing phase.

Mascara NT

Description of Technology

- This pilot plant demonstrates fully solar powered off-grid reverse osmosis technology without use of batteries
- The desalination unit is operated only during sunlight hours
- Proprietary technology allows operation under varying power supply
- Seawater supply via beach well



Key results

- Plant has successfully completed the acceptance test. The plant is currently being tested for reliability.

Accompanying Research at Masdar Institute

- **MI supports all 5 partners with accompanying R&D**

ABENGOA	VEOLIA WATER	SUEZ	TREVI SYSTEMS	Mascara L'eau renouvelable
Scope	**Scope**	**Scope**	**Scope**	**Scope**
Evaluate scaling and fouling processes in membrane distillation modules.	Develop capacitive de-ionization of RO product water to avoid double-pass RO systems.	Develop optimized design of solar energy powered RO plant using most practical and economical.	Develop and test high temperature FO membranes and manufacturing techniques.	Evaluate feasibility of PV system active cooling in terms of productivity for solar powered desalination.
Results	**Anticipated results**	**Anticipated results**	**Results**	**Anticipated results**
- Strategies to reduce scaling and fouling - Evaluation and troubleshooting report for commercial plants.	- Demonstration of 100l/h unit in lab envir - Identified improvements on electrode materials - Evaluation of bio-fouling propensity; - Basic design for 20,000 m^3/d RO+CapDI plant.	- Optimized processes and configurations for solar RO plants - Cost of water by solar RO plants.	- Developed a recipe for composition and structure of advanced FO membranes - Experimental verification of prototype membranes - Developed novel manufacturing techniques.	- Quantification of active cooling impact on photovoltaic system used for desalination. - Experimental prototype of the active cooling system.
Completion	**Expected completion**	**Expected Completion**	**Completion**	**Expected completion**
Q1 / 2016	Q2 / 2017	Q1 / 2017	Q1 / 2016	Q1 / 2018

Expected Results

- Energy and cost savings: Estimated annual cost savings of 94 million USD is expected from 2020 onwards, if 15% of Abu Dhabi's newly built desalination capacity is met by the implementation of the demonstrated energy efficient technologies.

- Reduced dependence on natural gas: The program will enable Abu Dhabi to cost-effectively power desalination plants with renewable energy sources, providing Abu Dhabi with the valuable option to reduce dependence on natural gas for the production of water.

Key Takeaways

- 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 Floatation 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 RO piloted in Ghantoot can be easily scaled up to utility size.
- 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 0.87 – 0.92 USD/m^3.

The ILF Group

Thank you for your attention!

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