DESALINATION

OUR ESSENTIAL GUIDE TO DESALINATION AND THE GLOBAL WATER CRISIS

Desalination: Quenching growing thirst around the world

With more than 20,000 plants now contracted around the world, desalination is enabling countries to provide water security for future generations amid growing climate concerns. By converting saline water, the process can offer freshwater in areas lacking natural groundwater, or surface water supplies. Together with water reuse, desalination can offer solutions to water scarcity and in some countries, provides over 90 per cent of total water supply. The rapidly growing advance in water reuse, particularly direct and indirect potable reuse of municipal wastewater, uses desalination membrane technology. What are the processes and technologies involved in desalination? What's the difference between MED and MSF thermal treatment? What are the pros and cons of desalination? Our essential guide dives deeper into desalination and the processes it includes.

What is desalination?

Desalination refers to a process that involves taking the salt out of water to make it drinkable. Desalination involves either treating sea or brackish water with the objective to create freshwater. In order to do this, desalination plants involve multiple technologies, from pre-treatment to pumps and membranes.

According to the new International Desalination Association (IDA) Water Security Handbook, the total global installed desalination capacity stands at 97.4 million cubic meters per day (m3/day) while the total global cumulative contracted capacity is 104.7 million m3/d.

As of June 30, 2018, more than 20,000 desalination plants had been contracted around the world. According to the International Water Association (IWA), desalination still only provides one per cent of the world's drinking water, but this is growing "year-on-year".The news in favour of desalination is that the world's oceans contain over 97.2 per cent of the planet's water resources, is "drought-proof and is practically limitless".

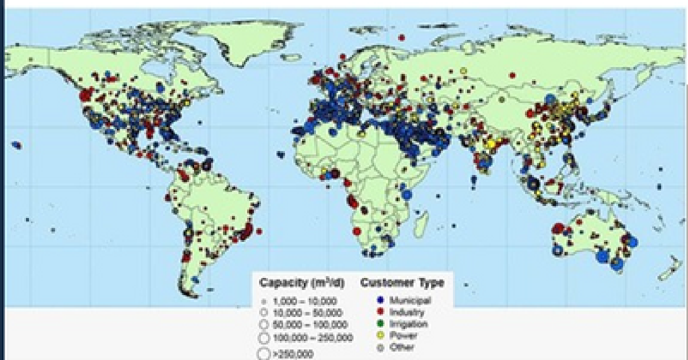
The desalination process can focus on either brackish water or seawater. For brackish water, the water has a salt content less than 10,000 mg/L. Meanwhile, seawater has a higher salinity content, in the range of 30,000 to 44,000 mg/L.

As well as brackish and seawater, other sources may include wells, surface (rivers and streams), wastewater and industrial feed and process waters, according to the American Membrane Technology Association (AMTA).

Around 44 per cent of total global desalination capacity is located in the Middle East and North America, with growth expected in the rate of seven to nine per cent per year. The IWA said expected "hot spots" for accelerated desalination activity include in Asia, the US and Latin America.

The industrial desalination market is also important to reference. Between 2016-2017, this market alone grew by 21 per cent, according to the IDA. Upstream and downstream oil & gas activity also accounted for a substantial amount of the contracted industrial capacity in 2017.

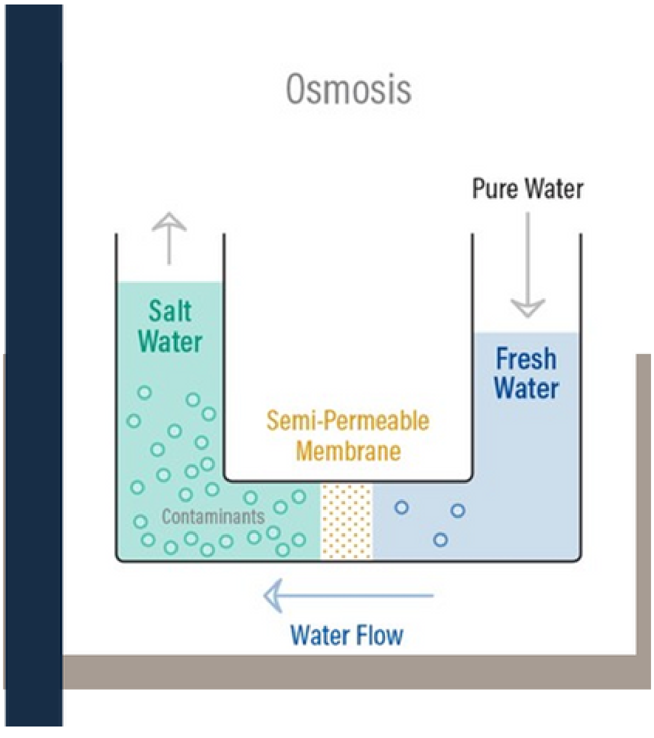
Mining, too, saw over 200,000 m3/day of new capacity contracted in the first half of 2018 alone. Microelectronics is another thirsty industry that is leading to new opportunities for desalination technologies, with contracted capacity more than doubling between 2016-2017.



What are the desalination processes?

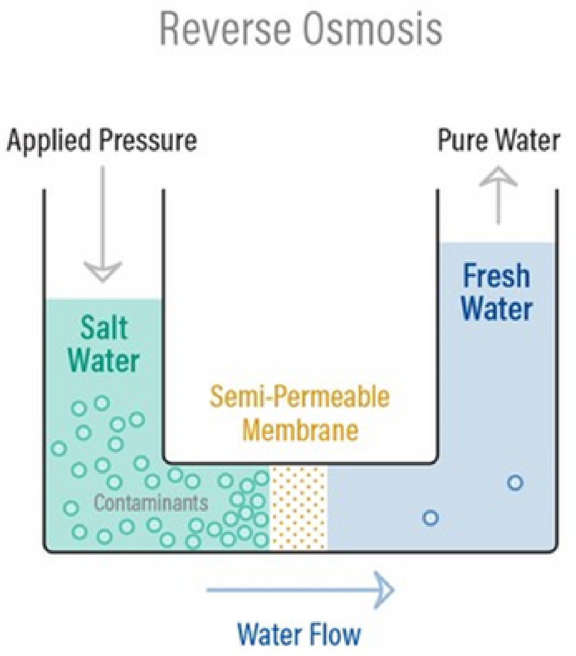
WiThere are two main types of desalination processes: membrane (reverse osmosis (RO) and nanofiltration (NF) and thermal, which includes multi-effect distillation (MED), multi-stage flash distillation (MSF) and mechanical vapour compression (MVC). Other technologies and processes include electrodialysis (ED), forward osmosis (FO) and membrane distillation (MD).

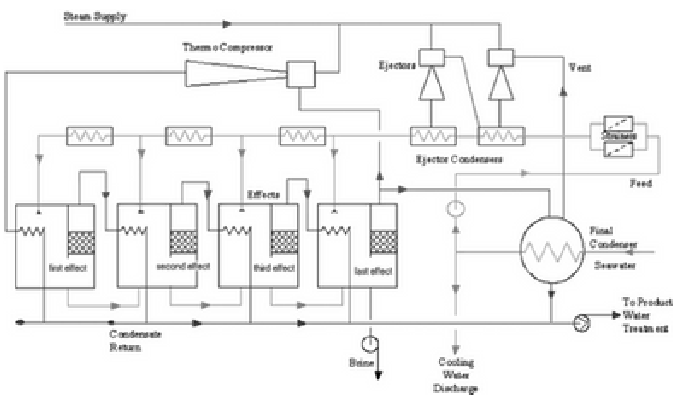
Membrane-based desalination continues to provide the vast majority of installed desalination capacity. To put this into perspective, in 2017, membrane technology accounted for 95.6 per cent of annual contracted capacity while thermal processes account for a mere 4.4 per cent.



Membrane desalination

According to AMTA: Reverse osmosis (RO) and Nanofiltration (NF) are the leading pressure-driven membrane processes. Membrane configurations include spiral wound, hollow fibre, and sheet with spiral being the most widely used. Contemporary membranes include primarily polymeric materials with cellulose acetate still used to a much lesser degree. One notable example is the thin-film composite (TFC) membrane, which includes polyamide as an active layer. Depending on feed water salinity, operating pressures for RO and NF are in the range of 50 to 1,000 PSIG (3.4 to 68 bar, 345 to 6896 kPa). The seawater RO requires electric power of 3.0 to 3.5 kWhr/m3.



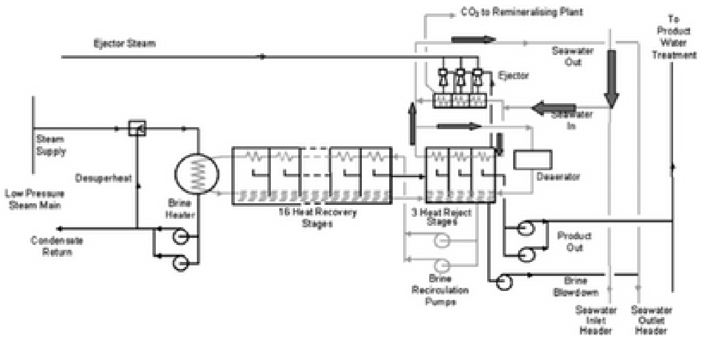


Multi-effect distillation (MED)

A low-temperature thermal process, MED obtains freshwater by recovering the vapour of boiling seawater in a sequence of vessels, known as the multiple ‘effects’. Vapour boiled off in one vessel can then be used to heat the next one, as the boiling point of water decreases at the same time as the pressure decreases. As a result, according to Sidem, only the first vessel requires an external source of heat. In short: from the first to the last vessel, both pressure and temperature decrease from hot to cold. The MED process requires heat input and electric power of 0.9 to 1.5 kWhr/m3.

Multi-stage flash distillation (MSF)

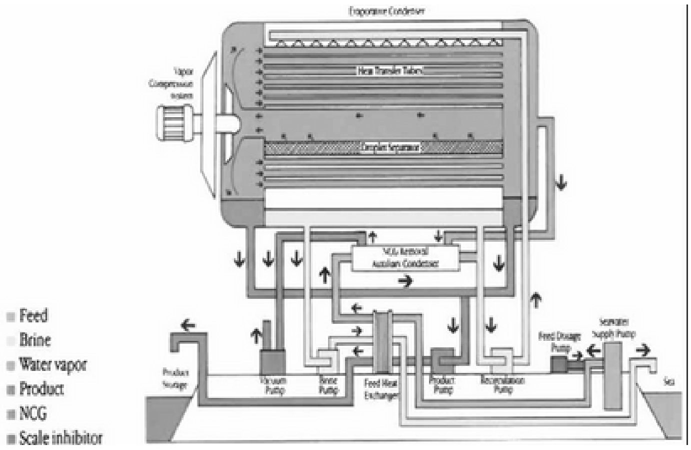
In commercial use since the 1950s, like MED, multi -stage flash (MSF) involves a number of stages. Seawater or recycled brine flowing inside the tubes is heated by steam exhausted from turbines in heat exchanger, called Brine Heater. This heated seawater flows through the brine heater to the evaporator stages, each operating at a lower temperature and pressure. As a result, the brine is flashing generating water vapour, which condenses on the tubes and is collected in each stage as distill product. The condensing water vapour pre-heats the seawater brine flowing in the tubes and recovers the heat. In the heat recovery stages, the last few stages of MSF, the brine blowdown and distillate are cooled, and the remaining heat is rejected in heat rejection section of MSF. The MSF process requires heat input and electric power of 3.5 to 4 5 kWhr/m3.

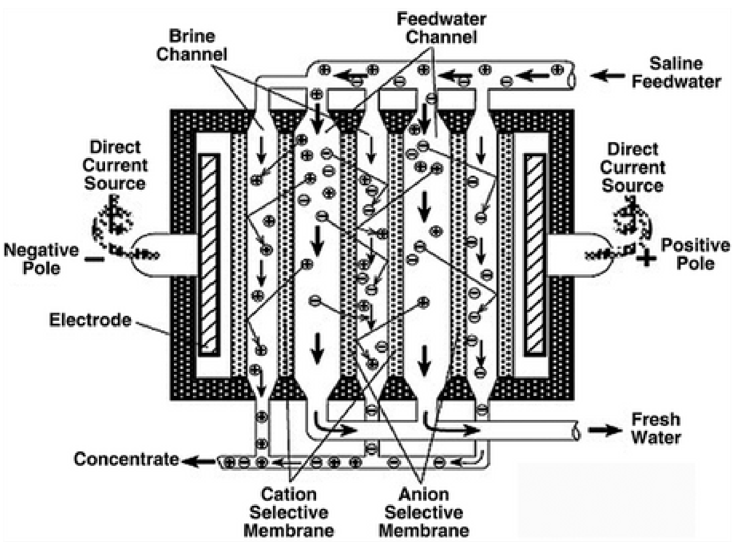


AQUA TECH

Mechanical vapour compression (MVC)

In the MVC process, seawater enters the pre-heater unit where it exchanges thermal energy with concentrate and product water effluents. Pre-heated seawater is sprayed over bundles of heat exchange tubing, which are at a higher temperature then seawater. Here, the seawater partially evaporates. Water vapors are compressed using a mechanical compressor, and they are pumped inside the tubing of heat exchange bundles. The compressed vapor condenses inside the tubing, releasing energy that is transferred to seawater sprayed over the tubing and causes its evaporation.



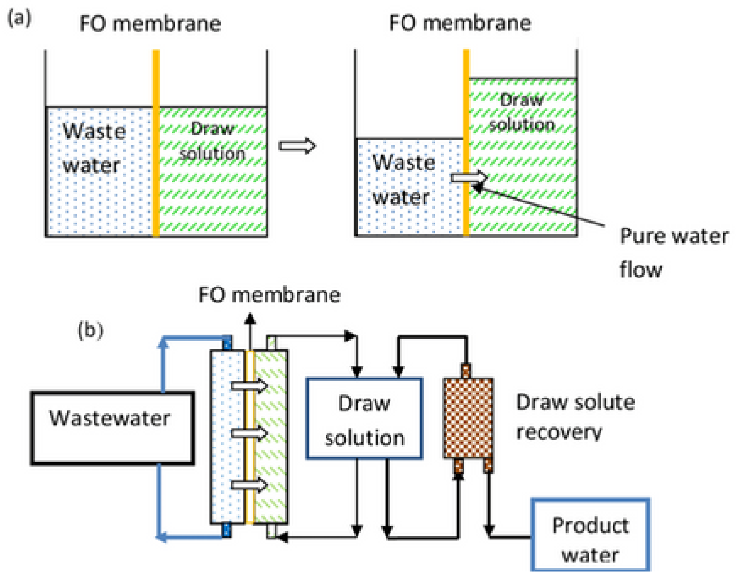


Electrodialysis (ED)

Electrodialysis (ED) and Electrodialysis Reversal (EDR) processes are driven by direct current (DC) in which ions flow through ion-selective membranes to electrodes of opposite charge, according to AMTA. This is the opposite compared to water in pressuredriven processes as outlined above. In EDR systems, the polarity of the electrodes is reversed periodically. Ion-transfer (perm-selective) anion and cation membranes separate the ions in the feed water. These systems are used primarily in waters with low total dissolved solids (TDS).

Forward Osmosis (FO)

Compared to RO, where saline water is pushed through a membrane, instead, forward osmosis (FO) uses osmotic pressure generated from a natural salt concentration gradient as the driving force through a membrane. For this work, there is the feedwater – often seawater – on one side and membrane and then a draw solution on the other side. AMTA said this means without applying any external pressure, the water from the feed solution will naturally migrate through the membrane to the draw solution. The diluted solution is then processed to separate the product from the reusable draw solution.



Desalination costs

The cost of desalination can be broken down in the following elements: fixed cost (37 per cent), labour (4 per cent), membrane replacement (5 per cent), maintenance and parts (7 per cent), consumables (3 per cent) and electrical energy (44 per cent).

Desalination has historically been perceived as a more expensive option compared with traditional treatment of surface or groundwater, with prices approximately US$1 per cubic metre ($/m3). However, one of the latest breakthroughs in desalination has been an improvement in the overall cost, including operational expenditure (OPEX), as well as the initial capital expenditure (CAPEX). Over the last 20 years this has been reduced by 80 per cent as a result of advances in technology and equipment.

Very recently, project tenders in Abu Dhabi, Saudi Arabia and Israel have seen the price fall below $0.50/m3 for the first time. “After a decade in which price drifted upwards as a result of high materials costs and higher energy costs, this is very good news. Indeed, we expect 2019 to be the best year ever in the desalination market,” said Christopher Gasson, publisher of GWI.

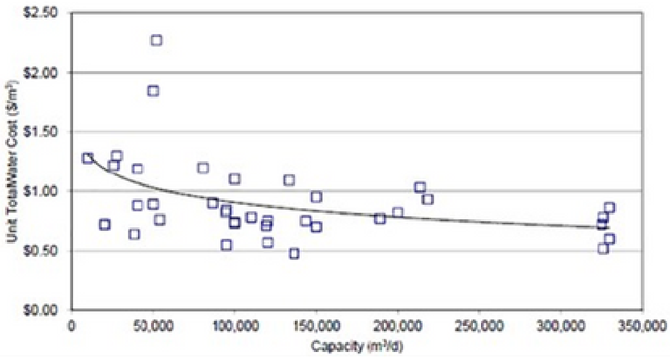
With seawater desalination at $0.40/m3, the cost is approaching the indirect potable reuse, with prices in the $0.30-$0.40 range.

In the IDA Water Security Handbook, there are multiple factors at play why the cost of desalination reached a historically low recently.

This includes “cost-efficient optimisation of the construction process”, following contractors’ experience after years of building large-scale projects. This, coupled with new contractual and financial models, together with lower interest rates in the financial sector, help to “push tariff downs”.

Furthermore, the reduced cost of desalination plant components due to lower petroleum prices is also helping to push the price down.

“Additionally, energy savings has been realized through advances in membranes that require less inlet pressure, energy-efficient recovery devices, and larger reverse osmosis trains with larger pumps and motors capable of higher efficiencies,” added Carlos Cosín, IDA and CEO of Almar Water Solutions.



What are the world’s largest desalination plants?

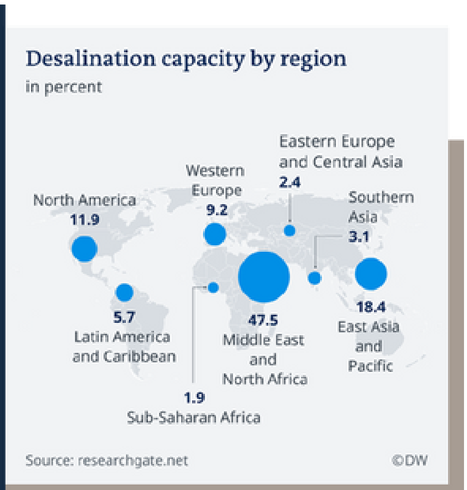
As reported by Aquatech Global Events, the Rabigh 3 project recently awarded in Saudi Arabia was considered one of the world’s largest plants, with a capacity of 600,000 m3/day. However, there are much larger desalination plants in operation around the world. Below is a list of five of the world’s largest projects.

1 | Ras Al Khair, Saudi Arabia: 1,036,000 m3/day

Commonly regarded as the desalination heavyweight of the world, the massive Ras Al-Khair is a hybrid project that uses both thermal multistage flash (MSF) and reverse osmosis (RO) technologies. Located 75km north-west of Jubail and serving Riyadh, the site also has a substantial power generation component, with a capacity of 2,400MW. The main contractor for plant construction was Doosan and its consortium partner Saudi Archirodon, with Poyry acting as the consultant for the project.

2 | Taweelah, UAE – 909,200 m3/day

The Emirates Water and Electricity Company and ACWA Power, have signed the water purchase agreement, for the world’s largest sea water reverse osmosis desalination plant to be constructed at Taweelah Power and Water Complex, 50 km north of Abu Dhabi. ACWA Power, with the lead developer of the project and a 40 per cent shareholder, confirmed the successful financial closing of the world's largest SWRO plant, at a cost US$847m, has the tariff of desalinated water 49.05 cents/m3. Construction of the project commenced in May 2019 with completion expected in October 2022. The plant is expected to deliver 909,200 cubic meter of water a day. Once complete, the Taweelah power and water development is expected to raise the emirate's proportion of desalinated produced water by RO from 13 per cent today to 30 per cent by 2022.



3 | Shuaiba 3, Saudi Arabia – 880,000 m3/day

A consortium involving Siemens of Germany for the power plant and Doosan for the thermal desalination plant were selected by ACWA Power to provide project engineering, procurement and construction of the plant. One expansion to the plant has been completed and one expansion is in the final construction stage with a total additional 400,000 m3/day of RO capacity added, according to ACWA Power. When complete, Shuaiba will eventually overtake Ras Al Khair as the largest operating desalination plant with total capacity of 1,282,000 m3/day.

4 | Sorek, Israel – 624,000 m3/day

Sorek could be considered the heavyweight membrane plant of the world in operation with an enormous 624,000 m3/day capacity. Located 15km south of Tel Aviv in Israel and developed by IDE Technologies, the project was and continues to be unique in the use of 16-inch seawater reverse osmosis membranes but in a vertical formation. A further development - Sorek 2 - IDE Technologies and Bank Leumi have won the Israeli government's PPP tender to build and operate the Sorek 2 water desalination plant. IDE has now won four of the five tenders to operate desalination plants in Israel. The bid, with an unprecedented price of USD 0.41 per cubic meter of water, calls for the annual production of 200 million cubic meters of water (nominal capacity of 548,000 m3/day). Once complete, Sorek 2 will be the sixth desalination plant to operate in Israel alongside Hadera, Ashkelon, the first Sorek, Palmachim and Ashdod.

5 | JUBAIL 3A IWP - 600,000 m3/day

SThis year in April 2020 The 25-year water purchase agreement was signed with the Saudi Water Partnership Company (SWPC) by a consortium led by ACWA Power including Gulf Investment Corporation (GIC) and Al Bawani Water & Power Company (AWP). Under the terms of the partnership, the consortium led by ACWA Power will design, construct, commission, operate and maintain the desalination plant as well as associated potable water storage and electrical special facilities. The ACWA consortium submitted the lowest levelised water cost of USD 0.41 per m3. With an investment value of USD $650 million, the Jubail 3A Independent Water Plant (IWP) will generate 600,000 m3 of potable water/day. The greenfield seawater reverse osmosis desalination project will be in Jubail, Kingdom of Saudi Arabia. The Engineering Procurement Construction contract has been awarded to a consortium consisting of Power China, SEPCO-III and Abengoa.

Pros and cons of desalination

Cons of desalination

One of the wider environmental challenges associated with desalination is managing the by-product of brine – a high salinity waste produced during the process.

In 2019 the United Nations (UN) backed a paper entitled ‘The state of desalination and brine production: A global outlook’.

The paper referred to brine as a ‘salty dilemma’, with desalination plants around the world collectively discharging 142 million cubic metres of hypersaline brine per day.

Four Middle Eastern nations – Saudi Arabia, Kuwait, UAE and Qatar – were found to be responsible for over half of the global brine output, with report authors stating Middle Eastern plants produced “four times as much brine per cubic metre of clean water as plants where river water membrane processes dominate”.However, it should be noted that river water doesn’t contain the levels of salt as seawater, so the comparison here is not equal.

Another concern is the potential impingement and entrainment (I&E) impacts associated with the operation of open ocean intakes for seawater desalination plants.

Impingement can occur when organisms sufficiently large enough to avoid going through the screens are trapped against them by the force of the flowing source water, according to the EPA.

Meanwhile, entrainment occurs when marine organisms enter the desalination plant intake, are drawn into the intake system and pass through the treatment facilities.

However, the level of environmental impacts on marine organisms caused directly by impingement and entrainment of seawater intakes is site-specific, according to the Water Reuse Association. It can vary significantly from one project to another and more modern plants upholding environmental standards experience extremely low levels of I&E.

Pros of desalination

Globally, more than 300 million people rely on desalinated water for some or all of their daily needs. In total, desalination is practised in 150 countries around the world with a total of 20,516 desalination plants now contracted.

In the future, the demand for fresh water will increase in tandem with the world's expanding populations. However, available freshwater supplies are in limited supply and poorly distributed.

With climate change intensifying droughts and floods, desalination can provide a guaranteed source of potable water from seawater to ensure water supply sufficiently meets water demand.

Together with water reuse, desalination provides a reliable solution for countries to augment their existing water supplies and have additional capacity acting as an 'insurance policy', should they need it.

"Desalination and water reuse are non-conventional, environmentally sound water supply solutions in keeping with circular water economy and offer solutions to water scarcity," according to the IDA.

Developments are also accelerating on the coupling of desalination processes with renewable energy, such as solar photovoltaic. Renewable and desalination technologies can be combined to reduce desalination's carbon footprint in the near term. Furthermore, the evolution of battery technology is being seen as pivotal to achieve a heralded 24/7 independently powered, desalination plant. A 2020-2025 goal has been set for 20 per cent of new plants to be powered by renewables by the Global Clean Water Desalination Alliance.