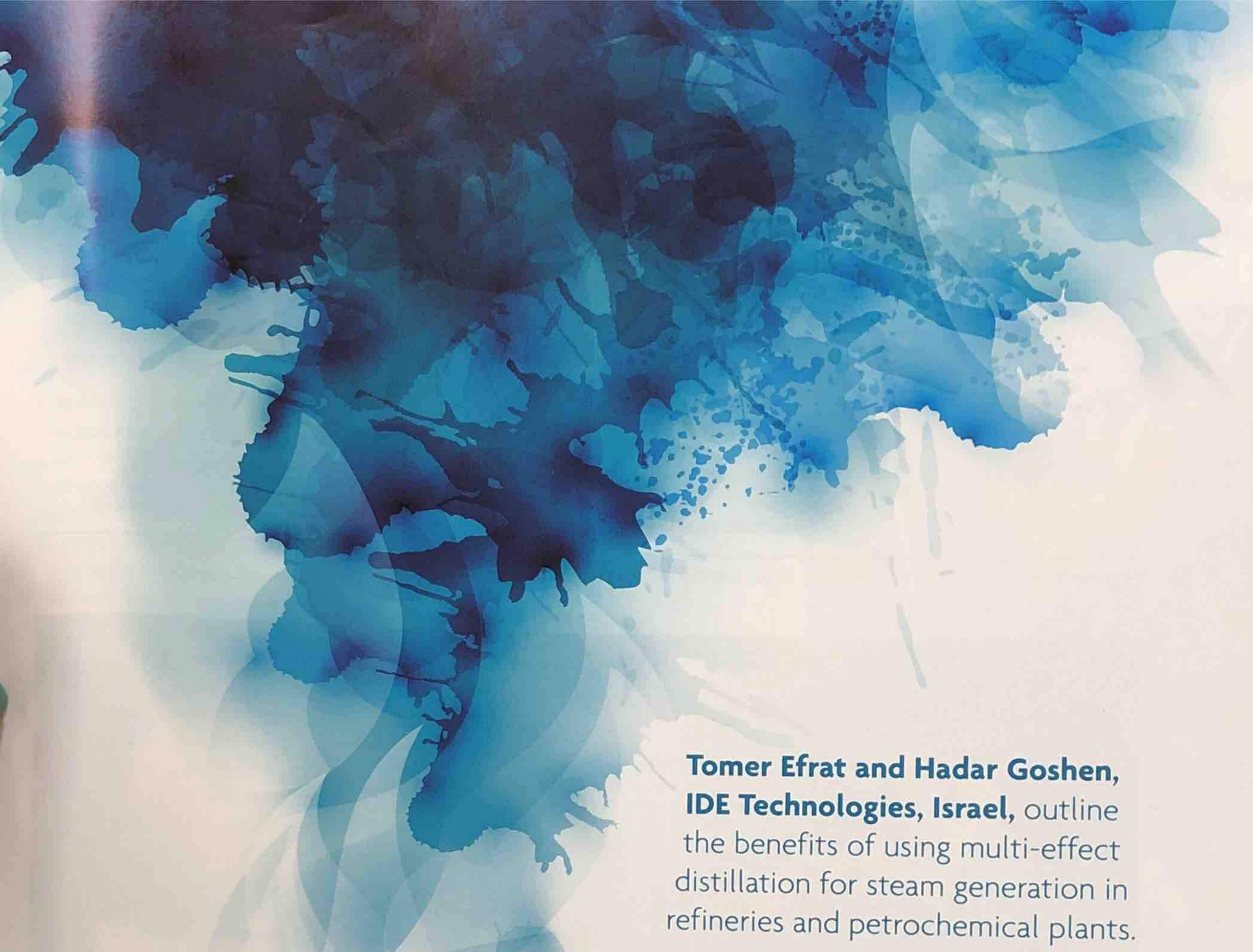

Tomer Efrat and Hadar Goshen, IDE Technologies, Israel, outline the benefits of using multi-effect distillation for steam generation in refineries and petrochemical plants.

TACKLING WATER DEMAND

The growing need for high-quality water for industrial purposes, together with the constant competition and municipal demand for the same water sources in water scarce areas, requires creative approaches to increase water source availability. The analysis presented in this article suggests that most of north-west India (including Gujarat state) is under high or extremely high water stress.

One of the most reliable ways of increasing water availability over the last few decades has been through seawater desalination, which provides the ability to utilise an infinite water source for industrial and municipal needs.

When considering the use of seawater desalination as high-quality boiler feed water for steam generation in refineries and petrochemical plants, thermal

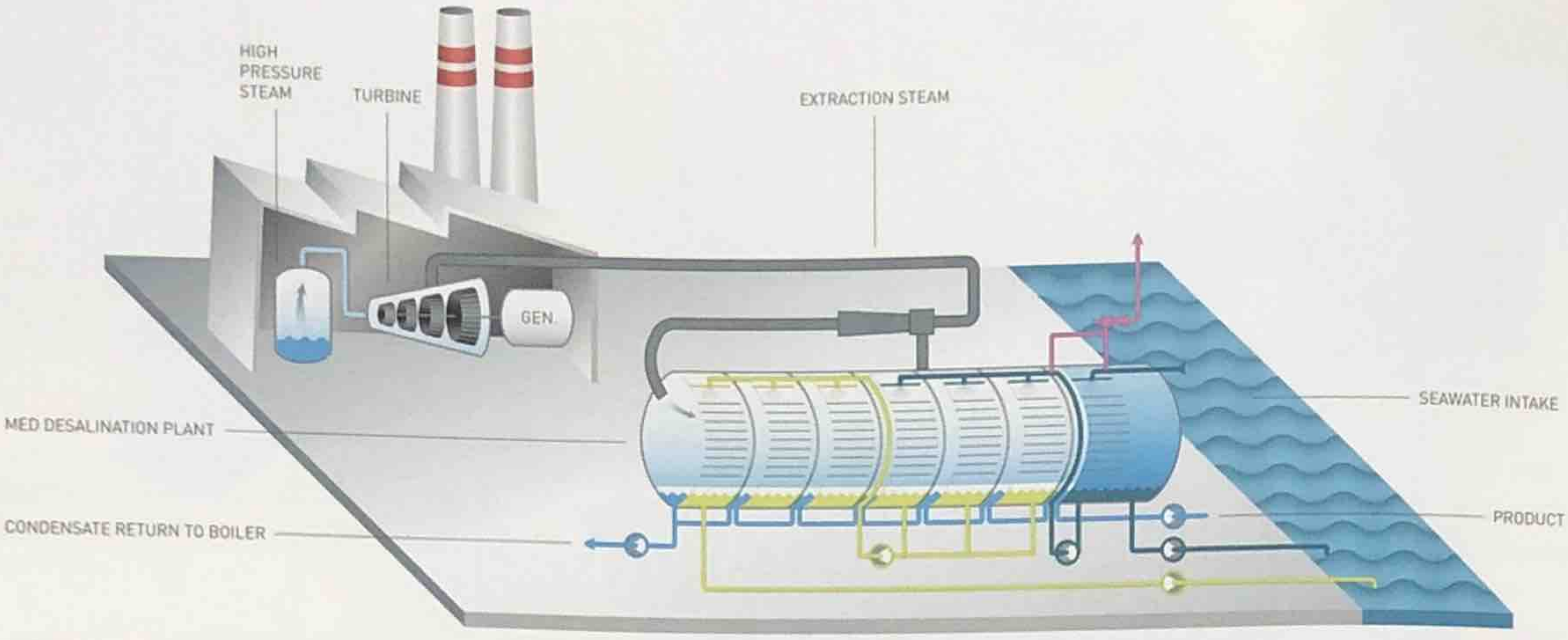

Figure 1. Integration of a MED unit in an industrial plant.

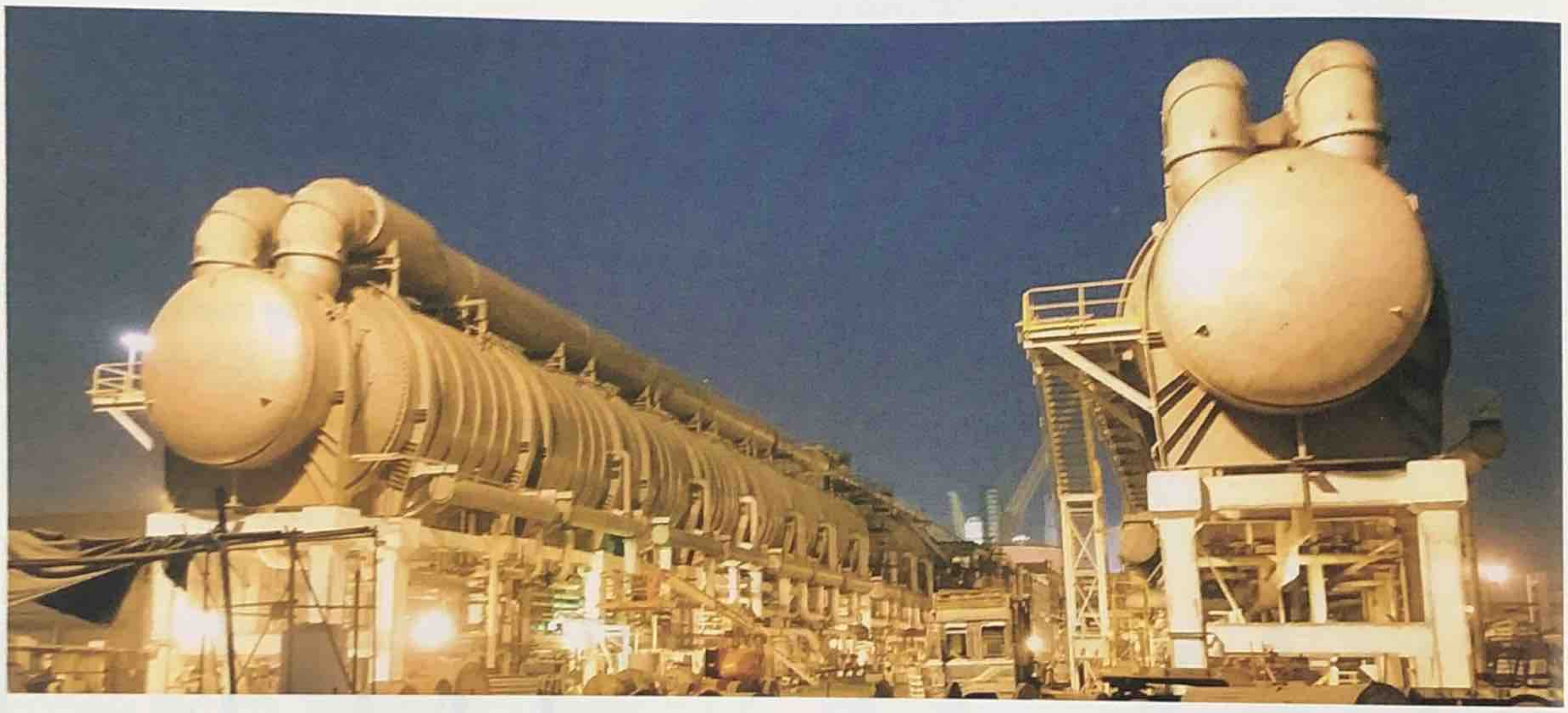

Figure 2. Two 24 000 m^3/d MED units in India.

desalination, such as multi-effect distillation (MED), can be the most effective solution. The ability of MED to utilise a wide variety of waste heat sources for high-quality water production, together with its robustness and ability to use existing infrastructure, makes this method suitable for downstream oil and gas applications. While being a 'veteran' technology in the water treatment market, among many new and innovative water desalination technologies, such as reverse osmosis (RO), many mission-critical facilities continue to use MED to benefit from its proven advantages.

When comparing MED with other water treatment technologies, the most important factor to consider is the availability of waste heat. Since MED utilises heat for water production, high quantities of heat, in the form of low-pressure (LP) steam or hot water, must be available. Cases where MED technology may not be the most economical solution are where the heat is specially-generated for the MED or when the LP steam has an alternative cost due to potentially profitable power generation.

However, in industries where high quantities of low-grade waste heat is available, MED can be economical, in terms of both CAPEX and OPEX. Together with utilising waste heat from plants, MED could be operated using some existing infrastructure, which contributes to its economics and implementation time. For example, in most cases, MED plants can utilise an existing intake and outfall that are available for providing the industrial facility with the required cooling water demand – and even use the actual cooling water as feed water to the desalination plant after it is utilised for cooling. As a result, the time and money required for obtaining the necessary permits and constructing these facilities can be significantly reduced or eliminated.

MED process

The MED process utilises the efficient horizontal tube, falling film type evaporator-condensers. A train of

Table 1. IDE MED units in the Jamnagar Area

	Refinery 1				Refinery 2		Total
MED unit	1 – 4	5	6 – 9	10 – 12	1 – 2	3 – 4	16
MED capacity (m^3/d)	12 000	14 400	24 000	24 000	8450	24 000	295 300
Year of commissioning	1998	2005	2008	2016	2006	2012	n/a

vaporator-condenser effects forms the heat recovery section of the rocess. Multiple quantities of distillate are then derived from a given uantity of input steam by recycling the latent heat given off by the notive steam supplied by the client, in repeated steps of evaporation nd condensation. Each successive step is carried out in a separate vessel r effect at a slightly lower temperature liquid-vapour equilibrium point.

A horizontal tube falling film designed condenser unit functions as ne heat rejection section at the end of the line. The latent heat is ejected at the lowest possible temperature by heating the incoming ater, which serves as the heat-sink coolant.

The seawater supplied to the plant is fed into the heat rejection ondenser, where it absorbs the heat that is rejected from the process nd it is de-aerated at the same time. This stream becomes the feed to ne unit. It is treated with a polyelectrolyte liquid additive to inhibit caling and is fed into the lower temperature group of effects. There, a stem of spray nozzles distributes it evenly over the top rows of tubes f each effect. The stream then flows in thin films down each bank of bes, where the part is evaporated as it absorbs the latent heat released the vapour condensing inside the tubes.

The remaining feed from this group of effects, which is now slightly ncentrated, is collected and pumped to the next higher temperature oup of effects where it is similarly sprayed over the horizontal heat ansfer tubes, and so on. Motive steam is condensed in the tubes of the st effect, sending latent heat to the liquid flowing over the outer rface of the tubes.

The evaporation condensation process is repeated through to the last fect. Each effect contributes almost a full amount of additional oduct. The vapour that is generated in the last effect flows into the al condenser, giving up its latent heat to the feed water stream.

The condensate that was collected from the first effect flows back to e main condensate heater.

The distillate is collected in a series of interconnected product shing tanks, which cool the distillate stream while flashing some of it increase the unit's efficiency. The cooled product is finally discharged the product pump to the product distribution system. The brine, ich flows from the hottest group of effects, is similarly cascaded and sh cooled in stages to recuperate heat until it is rejected by the brine charge pump.

Non-condensable gases (NCGs) flow collectively from one effect to next until they are finally concentrated at the coldest end of the heat ection condenser. The NCG is then evacuated by a set of ejectors. An stration of this process can be seen in Figure 1.

upling MED to a refinery

D units are well-integrated in a refinery (or in any other industrial nt). Coupling the refinery with a MED desalination plant can benefit h facilities for the following reasons:

MED acts as a heat sink for the steam, thus eliminating the need for condensers.

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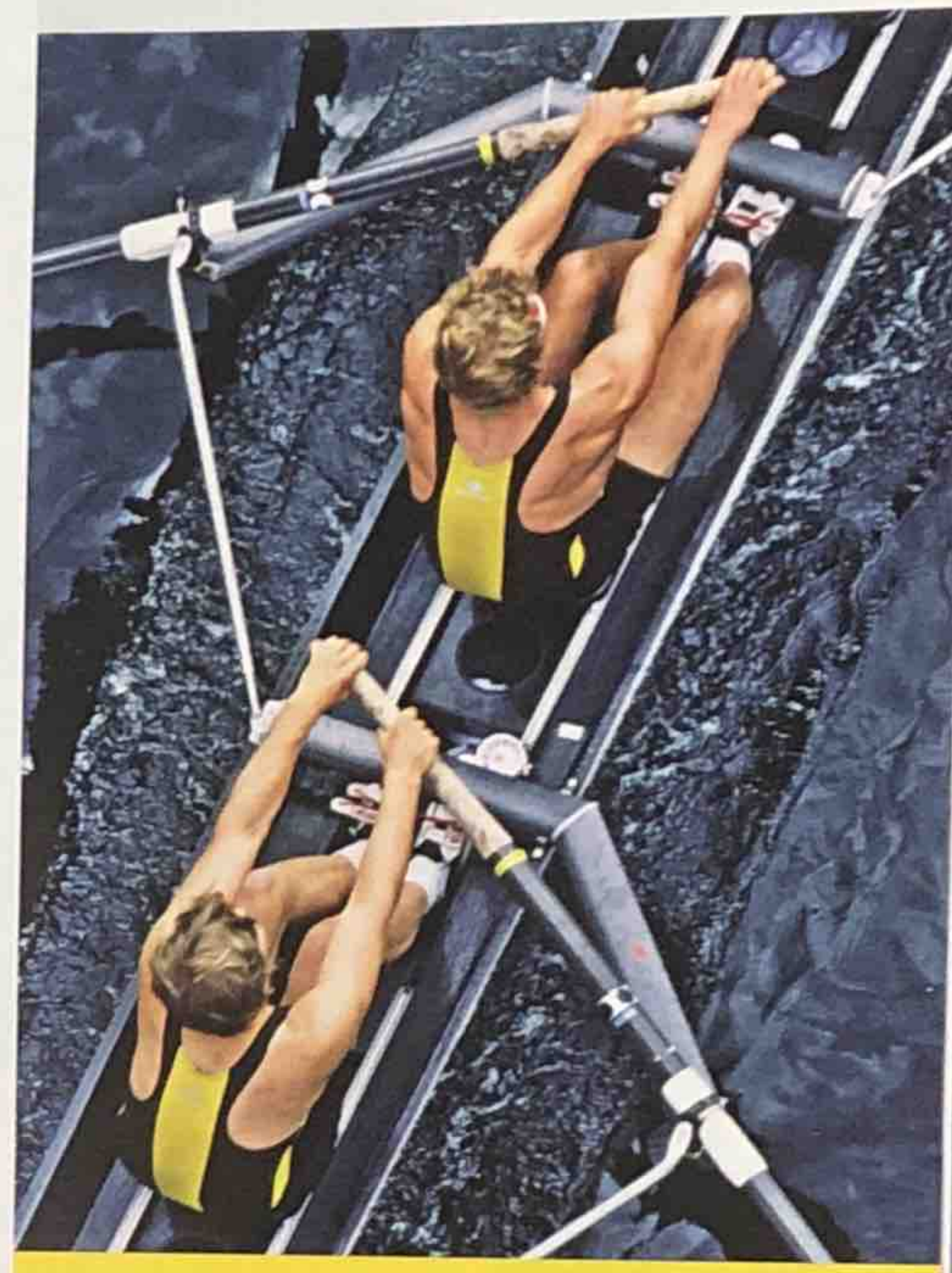

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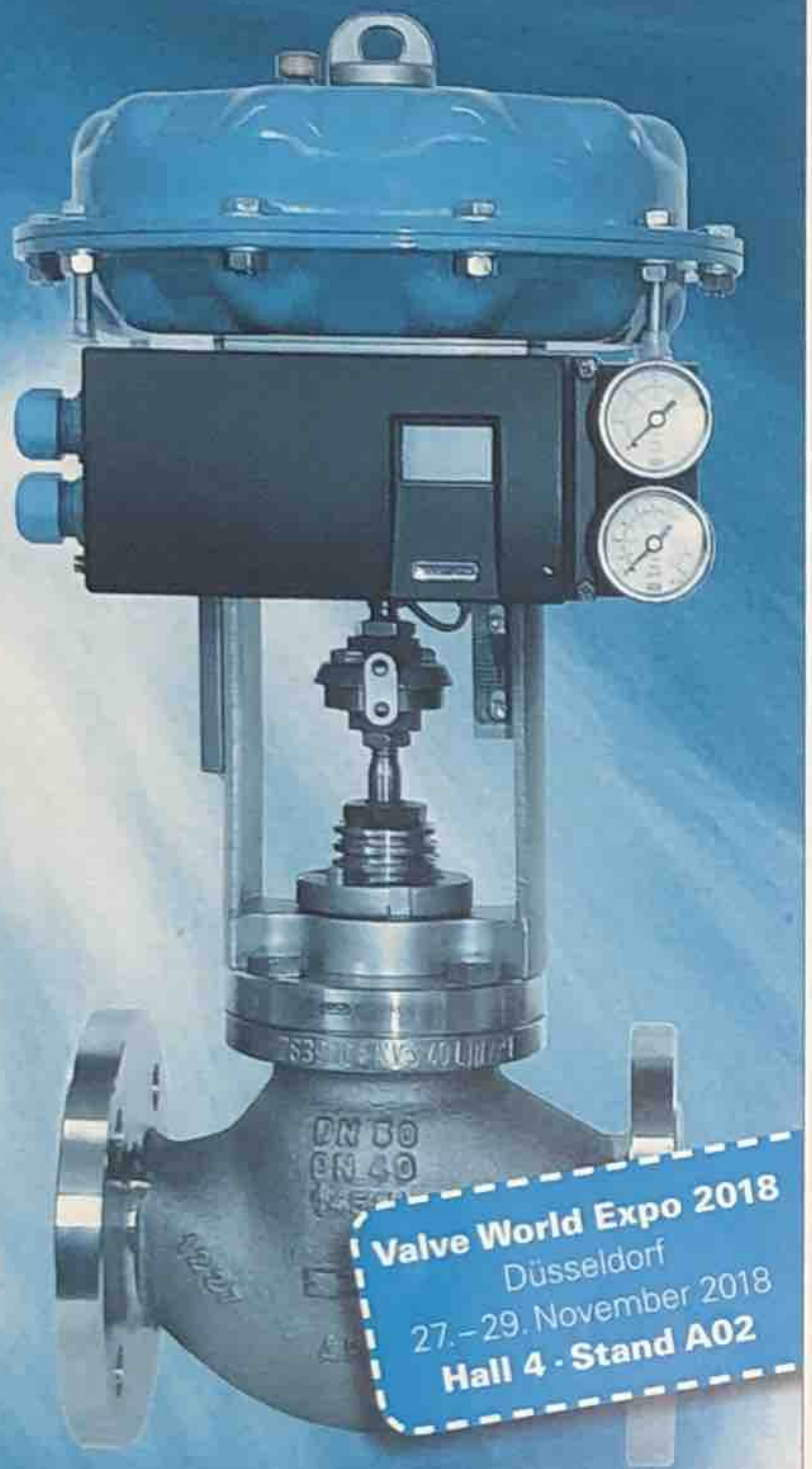

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- MED utilises the waste steam (whether it is LP steam or back-pressure steam) to produce a valuable product (high-quality distillate).
- MED distillate water serves several purposes in the industrial plant, including: cooling tower make-up; process water (for refining process units); boiler feed water (BFW); demineralised water; fire water make-up; and domestic (tap) water.
- MED is a robust, high-availability and low-maintenance unit that goes together with the requirement for high availability of the refinery. For example, the operation of a 100 000 m³/d MED complex would usually be performed by a team of two or three operators and technicians per shift. Furthermore, the required skillset of these operators is similar to that required for the operation of the other facilities (e.g. demineralisation, fire-fighting, cooling towers, nitrogen and air supply, etc.), so manpower resources can be shared.
- MED can share the refinery's infrastructure, such as seawater intake and brine outfall, thus eliminating the need for constructing additional infrastructure.

MED units in India

Over the years, numerous MED units have been installed in refineries across India, and specifically in the Jamnagar area. IDE Technologies has installed many of these units, which were designed as TVC-MED, meaning that they utilise LP steam to motivate a steam thermo-compressor. Some of the units are dual-purpose, meaning that they can be operated either as TVC-MED or as BP-MED with back-pressure steam. The steam pressures used are in the range of 2 – 5 bara.

Recently, the company commissioned a 168 000 m³/d seawater reverse osmosis (SWRO) plant in a refinery, which raised the total installed water capacity to 463 000 m³/d.

Today, there are refineries in India that are utilising MED units that were installed in the last 20 years. These reliable sources are providing almost 300 000 m³/d (or >100 million m³/yr) of distillate capacity, alleviating at least some of the water stress in the region.

Conclusion

Global water scarcity and the local situation in India call for advanced desalination technologies for industrial plants. The natural coupling between a refinery and a MED desalination is a win-win solution, with the MED acting as the heat sink for many refinery facilities and providing a high-quality distillate source for the plant's process needs. Furthermore, the infrastructure of the MED can be shared with that of the refinery, as well as the manpower for the operation of the facilities.

All in all, even though RO accounts for most desalination plants globally, MED can be considered as a viable solution when high-availability, low-maintenance and waste heat utilisation are required.