Utilities Middle East

ESSENTIAL INSIGHTS FOR MIDDLE EAST WATER, GAS AND ELECTRICITY PROFESSIONALS

November 2011 • Vol 5. Issue 11

WATER FROM WASTE

Could water recycling solve scarcity and save money?

SCADA SYSTEMS

Smart data management is revolutionising utilities

SHOW PREVIEW
SWPF
MEET THE EXHIBITORS

LEADING THE CHARGE

SETE CEO George Antonopoulos reveals the firm's power, water and renewable expansion plans

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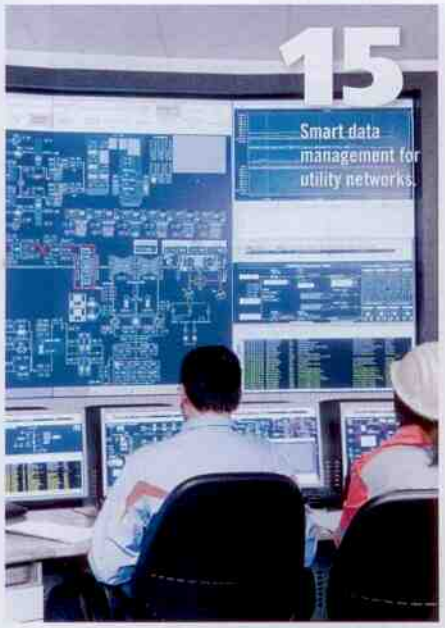
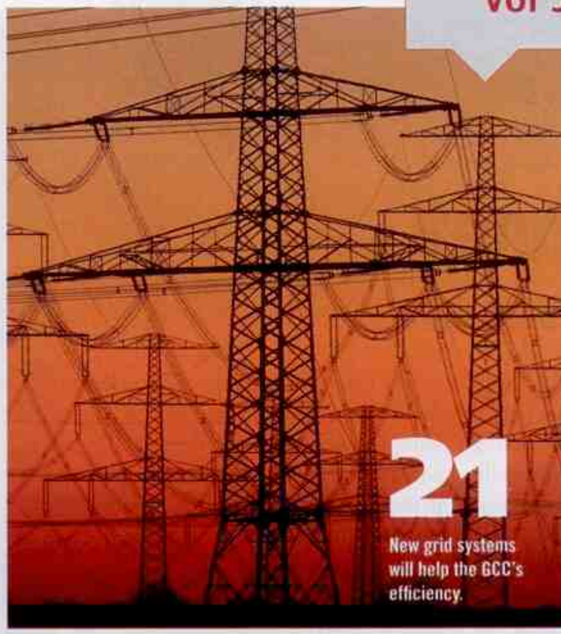
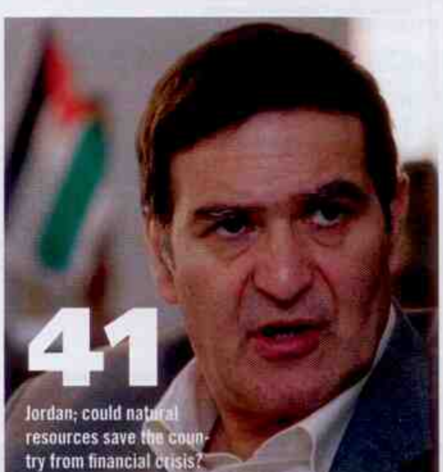


15
Smart data management for utility networks.



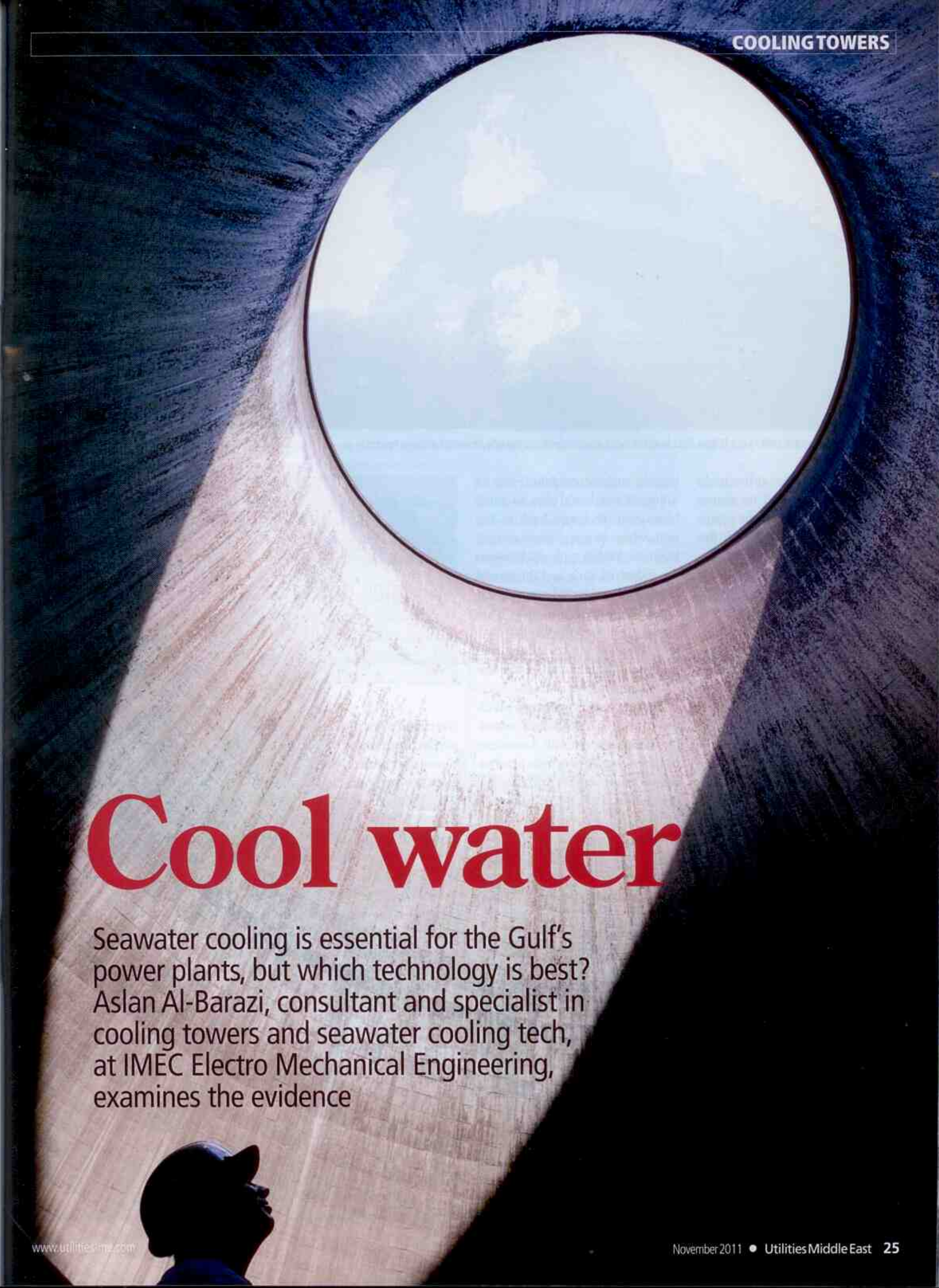
21
New grid systems will help the GCC's efficiency.

32
George Antonopoulos, SETE's CEO on power, water and a move into renewables.



41
Jordan; could natural resources save the country from financial crisis?

47
Reusing our water - are we doing enough to recycle resources?



Cool water

Seawater cooling is essential for the Gulf's power plants, but which technology is best? Aslan Al-Barazi, consultant and specialist in cooling towers and seawater cooling tech, at IMEC Electro Mechanical Engineering, examines the evidence

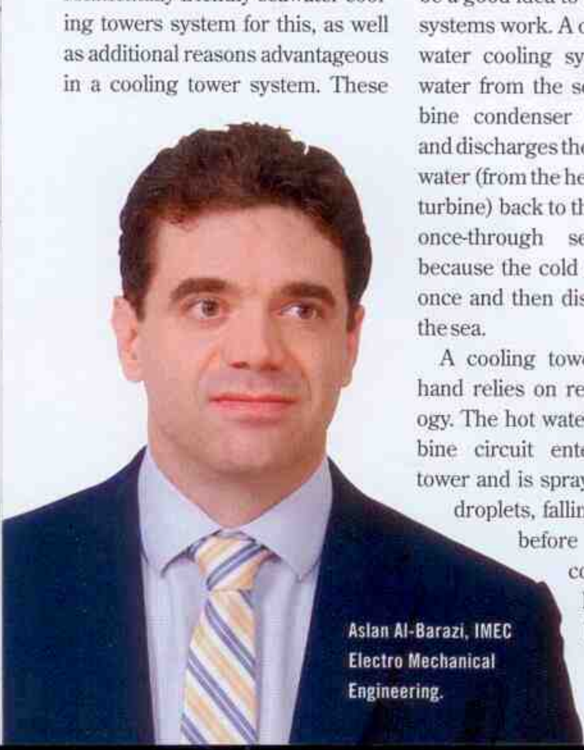
There has been a recent shift in the Middle East towards more environmentally friendly seawater cooling towers.

The Gulf region has traditionally relied on seawater cooling for the power plant process, and the location of a power plant would determine the type of cooling process used. For areas requiring power located further away from the sea, air coolers, air cooled condensers, or air cooled heat exchangers would typically be used. The region however has typically relied on direct seawater cooling, also known as 'once through cooling' which can damage the marine ecosystem with thermal pollution.

Recently there has been a noticeable shift to move to the more environmentally friendly seawater cooling towers system for this, as well as additional reasons advantageous in a cooling tower system. These include making minimum use of a limited sea bank (due to small bleed rate discharge back to the sea), where in many cases competition for land is typically between the industrial zone and the tourist hotels and residential resorts, and the ability with the seawater cooling towers to meet the thermal challenge of delivering cold water even during the summer when the seawater temperatures are high.

The aim here is to compare both the direct once-through seawater cooling system with a seawater cooling tower system from a technical, commercial and environmental perspective. To begin with it would be a good idea to explain how both systems work. A once-through seawater cooling system takes cold water from the sea, cools the turbine condenser heat exchanger, and discharges the hot or warm seawater (from the heat rejection of the turbine) back to the sea. It is called once-through seawater cooling because the cold seawater is used once and then discharged back to the sea.

A cooling tower on the other hand relies on re-cooling technology. The hot water leaving the turbine circuit enters the cooling tower and is sprayed as fine water droplets, falling to the PVC fill before going into the cold water basin. It is then directed back through the circuit towards the turbine condenser, from where the loop is continuously repeated.



Aslan Al-Barazi, IMEC Electro Mechanical Engineering.

> "From our regional ecosystem perspective, the thermal damage in our region due to once through seawater cooling is substantial"
>
> Aslan Al-Barazi

As the water droplets are falling into the cooling tower, ambient air is entering the cooling tower and going upwards thereby removing heat from the water droplets. This will account for the heat transfer evaporation process, whereby one per cent of the water is evaporated, cooling the remaining 99 per cent of the water in the system in approximate proportionate measures.

HEAT TRANSFER

Another important heat transfer mechanism occurs when the water droplets fall onto the PVC fill (or splash bar fill in the case of industrial or high-concentration particulate water). The PVC fill impedes the water's fall, allowing more time for the heat transfer process to occur while stretching the cross sectional area of the water droplet surface against the PVC fill wall layer, allowing forced convection to occur on the water droplets, further removing heat from the water. It can be said that from the total heat transfer mechanism in the cooling tower, around 70 to 90 per cent is related to the evaporation process while 10 to 30 per cent is due to the forced convection heat transfer process.

There are several different ways cooling towers can be designed to achieve this.

Typical towers used in our region include induced draught counterflow, induced draught crossflow and

1km

The Gulf only achieves sufficient depth for intakes 1km offshore.

forced draught cooling towers. Natural draught cooling towers would not work in this region because outside ambient temperatures are not cool enough, air density variance is minimal between certain heights and there is not enough natural draught in the air (particularly in hot weather) for this type of tower to efficiently work in the GCC.

Induced draught simply means that the fan is positioned on top of the tower, and induces the air from the top where the fan is located thereby allowing the air to enter from the sides or from the bottom part of the tower, and flow upwards to the tower fan discharge area. A forced draught cooling tower simply means that the fan of the cooling tower is situated on the lower bottom end of the cooling tower and forces the air upwards against static pressure in the way, such as the PVC (heat transfer) fill, drift eliminators and fan stack external static pressure.

An induced draught counter flow simply means that when the hot water enters into the cooling tower it is sprayed through the water distribution pipes or nozzles. As it falls downwards towards the PVC fill, it continues to the cold water basin. Meanwhile the ambient air is entering the cooling tower, at a 180 degree angle to the falling water.

This is the most efficient mode of heat transfer as the force per unit area between the water droplets falling and the air countering it is at the maximum 180 degree angle. Consequently, the minimum fan power is consumed and for industrial range towers this is the optimum design selection.

An induced draught cross flow cooling tower varies from a counterflow in that while the water droplets in the tower are falling, the air crosses the water from the side. This tower is typically used when height is a problem, and for smaller commercial range tower capacities when maintenance accessibility becomes a problem in counterflow towers. The disadvantage on the crossflow tower is the higher energy consumption in comparison with a counter flow design.

Finally, the forced draught cooling tower is typically used for low-noise applications and length and width space savings. The

Due to high ambient temperatures, natural draught cooling isn't an option in the GCC.

disadvantages include high initial cost, and high energy consumption.

For the seawater intake station of the cooling system, this may be classified into three different types depending on the capacity usage and whether a once through seawater cooling or a sea water cooling tower system is required in the design.

Small capacities belong to the passive screen, medium capacities to the travelling band screen while larger capacities to the drum screen. The passive screen goes up in capacities to 15,000 gallons per minute (GPM) per unit. The travelling band screen is typically available up to 230,000 GPM, while the drum screen goes up in capacity up to 630,000 GPM. The passive screen is typically a fish protection system as well, as fish cannot enter due to low velocity suction and small clearance intake protective slits at the entry.

Travelling band screens as well as the drum screens typically have variations in design including fish protection systems, stop gates (for seawater intake station building process and maintenance shutdown), bar screens (to clear any major obstacles in the way such as tree logs, obstructive trash, seaweeds) and raking systems if needed, to remove obstructive obstacles. Smaller-size filtration systems can also be included downstream into the intake system before reaching the seawater condenser, allowing the removal of particles from 1mm in size down to 30 microns.

It is worth noting that a seawater cooling tower system, due to its low water requirements, would typically require a seawater intake station a fraction of the cost and size of the once through direct seawater cooling system, varying with the former between a small passive screen to a medium capacity travelling band screen at its maximum flow rate capacity.

Some once-through cooling systems in the region have reached a flow rate six times that of the River Thames in London.

HIGH-FLOW

A direct once through seawater cooling system, due to its high-capacity usage of seawater flow rate for cooling purposes, would go from a small passive screen capacity up to a very large drum screen in capacity usage. To give a typical example on some projects used in this region with the once through seawater cooling systems, drum screens have reached a seawater flow rate usage up to six times the water flow rate capacities of London's River Thames.

The reason for the capacity difference between the seawater cooling tower intake system and the direct once through seawater cooling intake system, is that in the former only five per cent make-up water is required to feed into the seawater intake system and two and a half per cent typically discharged due to the cooling tower bleed rate. The once through system has a 100 per cent seawater flow rate both in and out of the system.

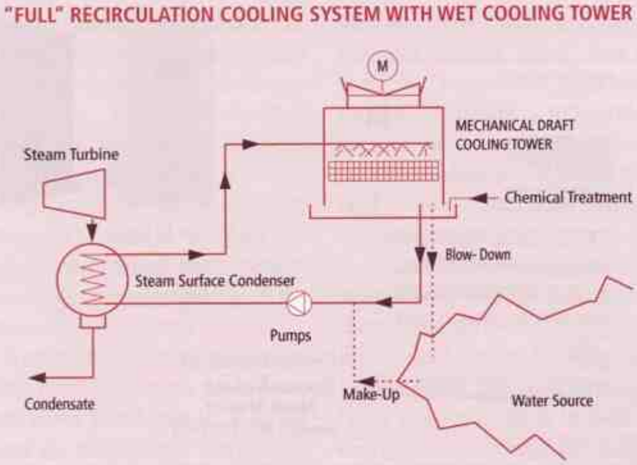
The total heat rejection and circulating system seawater flow rate into the turbine condenser remains the same for both systems, as the cooling tower has the same amount of seawater circulating between the cooling tower and the turbine condenser as in the direct once through seawater cooling system.

The high cost of the seawater intake station and related equipment in the direct once through system is hugely decreased in the cooling tower case. This also makes a fish protection system affordable when used with a cooling tower, given the small size and related cost of the related seawater intake system being a twentieth of the size of the seawater intake capacity of a once through system.

A fish protection system not only protects the fish, but also eliminates or reduces the possibility of a plant shut down due to the potential of large amounts of fish being sucked through at the intake. Fish protection systems vary in design, as different systems are effective for different types of fish.

Fish protection systems include the sound acoustic screen system (most popular given its effectiveness against 50 per cent of the marine population), the air bubble system which is suitable for guiding fish to a point downstream of the seawater intake, and the

"FULL" RECIRCULATION COOLING SYSTEM WITH WET COOLING TOWER



100%

Once-through system has total seawater flow rate in and out.

> "Seawater in the Gulf is typically poor in circulation, with studies showing that water typically takes three to five years to renew itself."
>
> **Aslan Al-Barazi**

strobe-light system, used in conjunction with other behavioral systems and suitable for deflecting fish less sensitive to sound, such as eels.

Other fish protection design systems include increasing in the design of the seawater intake area thereby reducing the suction velocity, as well as the fish recovery and return system where fish entering the travelling band screen or drum screen area, are safely returned to the sea through a return channel.

In addition to being environmentally friendly, such systems also keep the intake more efficient in operation, reducing handling costs, ensuring disposal of fish kills and maintaining the mechanical plant and process.

From our regional ecosystem perspective, the thermal damage in our region due to once through seawater cooling is substantial. To begin with, you are normally discharging back to the sea a temperature of five to 10 degrees centigrade higher than the seawater intake temperature.

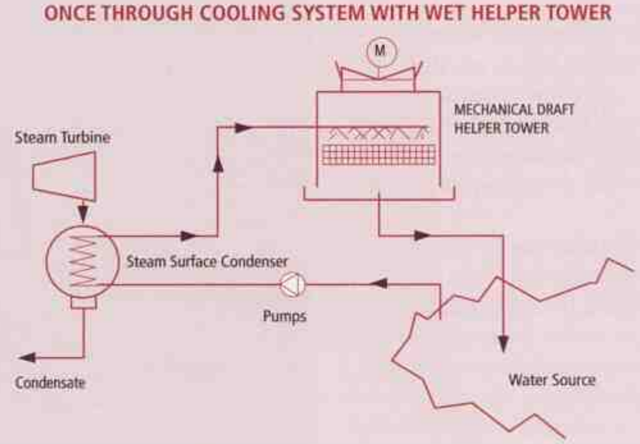
That is not normally a major problem in the winter when the seawater temperatures are already cool, and able to withstand and absorb this thermal pollution much better. Typically most marine life cannot survive above 41 degrees water temperatures.

Add to that the chemical water treatment, (which adds chlorides to the water during treatment, designed to eliminate marine creatures entering the seawater intake), is then discharged back into the sea.

This problem is multiplied by the fact that the Gulf region has a shallow-ended coastal region and a relatively low seawater basin, normally taking more than one kilometre before any substantial water depth is achieved from the coast.

Add to that the fact that seawater in the Gulf is typically poor in circulation, with studies showing that water typically takes three to five years to renew itself. This means that additional problems accrue from multiplication of the environmental damage due to shallow and relatively poor fresh seawater recirculation.

ONCE THROUGH COOLING SYSTEM WITH WET HELPER TOWER



Seawater cooling systems discharge water five to 10 degrees higher than the intake.

41 degrees

Most marine life cannot survive above 41 degrees.

COLD SHOCK

Another problem with direct once through seawater cooling is what is termed the 'cold shock effect'. Some marine life is able to survive, adapt and acclimatise to the warm thermal discharge water temperatures at the seawater discharge channel. Marine life living near the channel will be exposed to thermal shock during plant shutdown, leading to further destruction given ultra sensitivity to temperature gradients.

This includes microscopic sea creatures to small or medium size fish, some of which are critical to the overall ecological balance of the regional sea ecosystem.

A seawater cooling tower on the other hand discharges the two per cent tower bleed rate back to the sea at the same temperature as the sea. What's more, the five per cent make-up water for the cooling tower at the seawater intake can be taken directly from coastal waters, even if the shallow waters are typically high in temperatures.

In comparison, a direct seawater cooling system would need to go approximately one kilometre into the sea to obtain cold seawater at greater depth, which would substantially add to the cost of the piping and pumping and energy related costs, making a seawater cooling tower more feasible.

As for the many existing once through seawater cooling systems in the region, whether for the oil, gas or power sectors, a 'helper' seawater cooling tower may be used to re-cool the discharge thermal effluent temperature back to the sea and even to go so far as doubling the availability of cold water for the process application itself.

A seawater cooling tower system is not only a sound environmental solution for the power sector in the Gulf region, but it is also a better option from a performance, initial cost in addition to both an energy and operational perspective as well. Utilities