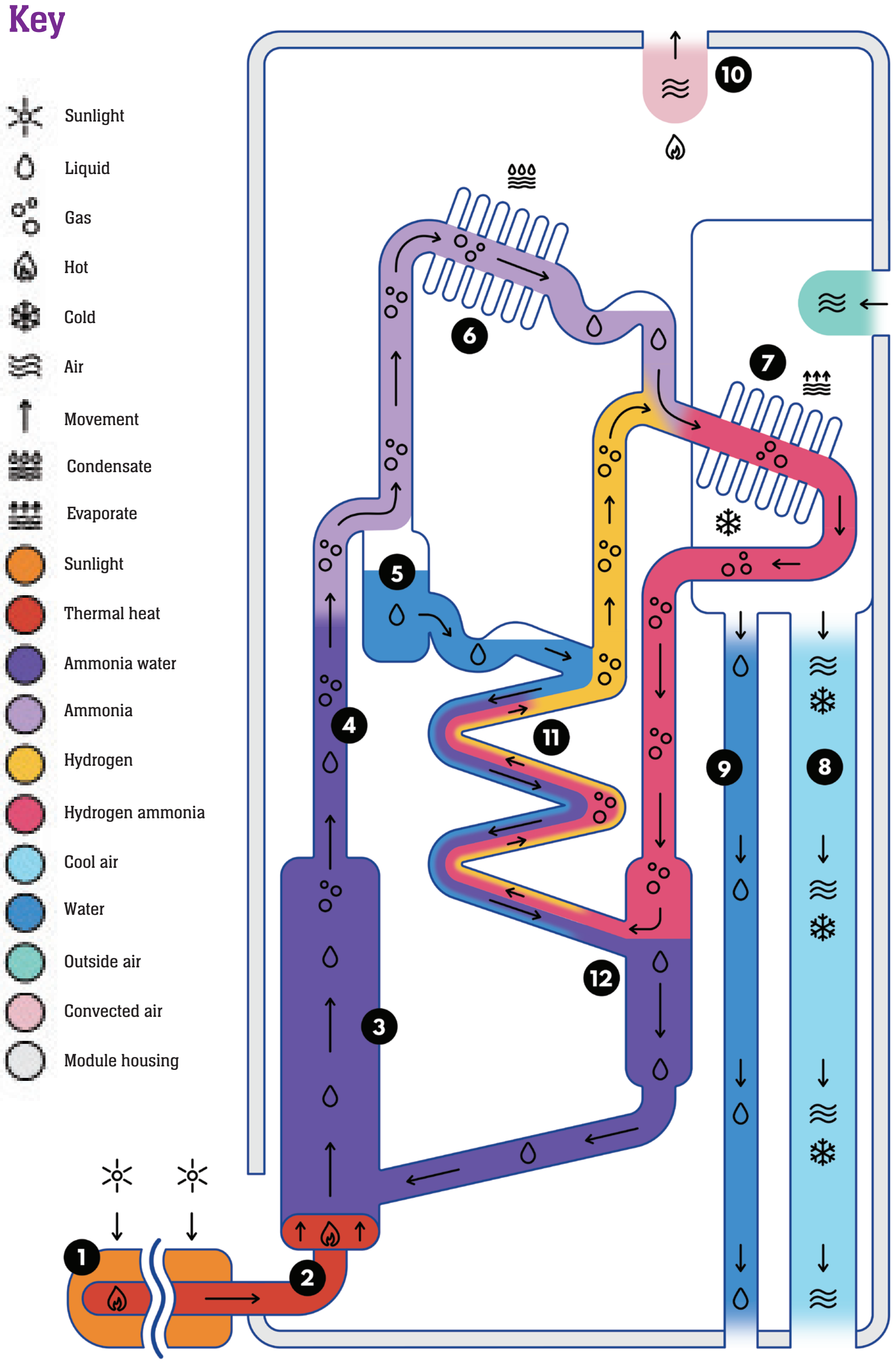
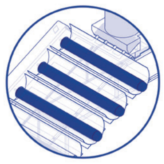
KEEP IT COOL

As the energy demand for air conditioning increases in hotter countries, would a low-cost system that doesn't require any electricity be the coolest solution?

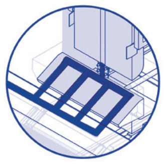
By **Siobhan Doyle**



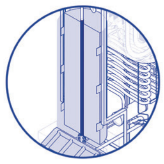
How it works



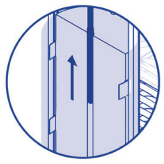
1. Solar collectors
The solar collectors are filled with water and have large parabolic mirrors beneath them which reflect the sunlight into the collector throughout the day.



2. Heat pipe
The heat pipe moves the heat generated from the solar collectors. It does this by shifting the energy through the water in a vacuum where the heat is then transferred to the generator.

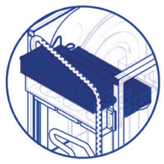


3. Generator
The heat energy from the heat pipe is transferred into the generator where it boils the ammonia water solution, turning the ammonia into a gas. The temperatures will reach upwards of 200°C so it is heavily insulated with thick insulation around the system.



4. Bubble pump
As the generator boils the solution, the bubble pump located inside it raises the ammonia gas up to the rectifier from the bottom of the generator.

5. Rectifier
The rectifier separates any remaining water from the ammonia mixture and, using the gravity-fed system, funnels it back to the reservoir via the absorber. The ammonia gas continues up to the condenser.



6. Condenser
The ammonia gas condenses into ammonia liquid as it travels down the sloped system, pooling in the trap, which stops hydrogen from back-flowing into the condenser.

The system has no mechanical parts in it and doesn't rely on electricity

SOLAR POLAR

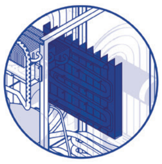
COUNTRIES LIKE INDIA are known for their scorching hot weather. Many parts of North India reeled under heatwave-like conditions this June alone, with the temperature in many cities hovering above 42°C. Delhi sweltered under the stifling heat with the thermometer crossing the 46°C mark on 19 June.

With such conditions, you can't blame the city's residents for wanting access to technologies that will keep them cool, particularly air conditioning. But high demand and use of these systems, which rely on electricity, can put a large strain on the grid. "A lot of [developing] countries can't cope with the load from air-conditioning (A/C) units," says Dr Robert Edwards, chief executive of UK renewable energy design company Solar Polar. "So what you get is a brownout [voltage drop], which is where demand for electricity is higher than the grid can provide."

In India, air conditioning was once seen as a luxury item, but the Indian government changed the law in 2017 to ensure that all new houses in its cities had A/C. "They've [the government] now realised that with these temperatures, it is unrelentingly hot, that actually it is a basic necessity. So governments are recognising that it's a needed thing," Edwards explains. This change, of course, increased demand further.

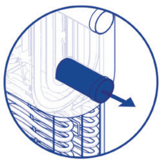
In fact, the global heating, ventilation and air-conditioning market is projected to reach $367.5bn (£290bn) by 2030, according to a report published in Statista in April, based on a compound annual growth rate of 3.9 per cent between 2020 and 2030. Such growth will likely be due to a continued rise in construction sector revenues, from both publicly and privately funded projects, the report highlights.

Solar Polar uses a solar-thermal-powered absorption refrigeration system to make cooling modules, which may be mounted on a roof or the wall of a building



7. Evaporator

The evaporator is where the magic happens. In the upper section, the condensed ammonia gas meets pure hydrogen and, by the law of partial pressures, it causes the ammonia to evaporate, cooling the air within the system. The heavier mixed solution then moves further down the system to the reservoir.



8. Cool air

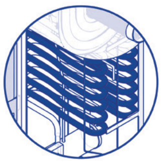
The cool air generated from the evaporator is funnelled out of the unit and pushed into your home or refrigeration unit.

9. Condensed water

Condensed water from dehumidifying your air is fed out of a condensate pipe at the base of the unit. In areas where water is scarce, this water can be used, for example, to water plants or boiled to make tea.

10. Convected air

Hot convected air, which is rejected heat generated from around the condenser and evaporator, rises out of the top of the unit, back into the atmosphere.



11. Absorber

When the hydrogen gas saturated with ammonia reaches the reservoir it starts to travel back up the absorber where it meets the water from the rectifier. As the gas and the water pass each other the water reabsorbs the ammonia, creating the ammonia water solution, while leaving behind pure hydrogen, which travels up to the evaporator.

12. Reservoir

The new ammonia water solution flows into the reservoir and then down to the generator to start the cooling cycle over again. The closed-loop system continually repeats the process throughout the daylight hours, providing an excellent source of refrigeration or cooling.

Reducing food wastage

The rise in demand on the grid isn't the only challenge for developing countries. The sweltering heat also has an impact on the livelihoods of farmers growing produce. Edwards explains that in India, more than half of the food that is grown rots before it can be consumed because they don't have an established cold chain. Many of the rural areas don't have any electricity at all and there is a lack of domestic refrigeration, he adds.

So how can companies take the pressure off the grid, meet the high demand and cater for those off-grid simultaneously and at a low cost? Peterborough-based Solar Polar has designed a low-cost-per-watt solar cooling system that operates without the need for electricity and was developed for off-grid, remote communities.

Chief executive Edwards and co-founder Michael Reid started looking into solar cooling solutions around a decade ago after meeting in India. "I was designing solar panels and he was designing refrigerators," Edwards explains, "and we found there were patterns going back more than 100 years into solar cooling technologies."

Edwards and Reid found that such solutions were a "no brainer" for solar cooling. "Because the time when you have maximum sunshine and maximum heat is when you need the maximum cooling, you need to make a system that is highly efficient – and with efficiency comes expense." The duo returned to India and designed the system to produce the cheapest watt of cooling.

"We found that an ammonia-water absorption system, although not very efficient, is actually very cheap to manufacture," Edwards explains. With this knowledge, they found a cooling module and designed it to be as big as it could be with no moving parts. "Then we joined the modules together to match the cooling loads," he adds. "So this is around 1kW of cooling joined together to produce very cheap cooling."

Edwards and Reid's first demonstration was in India where they aimed to use the sun to power the system, but monsoons and the environment in the country remained a challenge in getting it to work efficiently. "We found the solar collectors really struggled in the times leading up to a monsoon, when the heavy rains came, because there's very little sunshine," Edwards explains, adding that instead of producing 1,000W/m^2, the dust and pollution in the air enabled them to produce only 500-600W/m^2. To overcome this issue, the team turned to a concentrated solar thermal system instead.

A cooler world

One of the main benefits of the system they have developed, Edwards says, is that it emits no greenhouse gases. "The liquids and gases you put inside [the system] are all-natural refrigerants: ammonia, water, hydrogen," he explains.

It also doesn't have any moving parts, therefore is largely maintenance-free. But Edwards stresses that users will need to clean the solar collectors regularly because they often get covered in dust and this disrupts the performance of the system.

He adds that the system is ideal for crops and produce applications, "but it will also provide zero-carbon air-conditioning with no utility bills in the developed and developing world". As the system is modular, Edwards says they could use one module to run a refrigerator, half a dozen or so modules to cool a shipping container, and then 15-20 modules to cool a house.

Giving farmers the power

The team at Solar Polar believe another market for these systems is dairy farmers. "In India, dairy farmers milk their cows then they wait for somebody to pick the milk up and take it to an aggregated centre where it will be refrigerated – this collection happens twice a day. If the truck is late, the milk is spoiled and few people will accept it," Edwards explains. "If we can give the dairy farmers a method of storing their milk on the farm, they would only need one collection a day and it would be better quality milk because it's been refrigerated straight away."

This would also give the dairy farmers a bit more freedom as to who they sell their milk to. "It shifts the power back into the hands of the farmer." Furthermore, Edwards says aggregators could invest into supplying cooling systems for these farmers as it could cut half their time travelling. The equipment would last for 30 years or more.

As the systems are made of mild steel, Edwards says that they plan to manufacture them locally rather than in the UK. They also intend to teach local people how to maintain the systems. "If you manufacture in the country it is being based, you then have the skillset there to be able to repair the system if there are any problems."

Earlier this year, Solar Polar landed an Innovate UK energy catalyst grant to provide demonstrator solar fridges to Kenya. In June, the company – in collaboration with Imperial College London – received a grant from the Engineers Without Borders USA 'Chill Challenge' to develop a solar-driven diffusion absorption refrigeration icemaker based on new working-fluid pairs and innovative designs aimed at increasing system performance, affordability and lifetime. •