GLOBAL COOLING

What price cooling for all?

Thermal energy is not just for heating – cooling is an important, sometimes vital, service for both the developed and developing worlds and a major and growing user of energy. Here, *Toby Peters* take a look at the current status of cold technology and the viability of accommodating its projected growth.

In 2015, the United Nation's Sustainable Development Goals laid down a new challenge – economic and social development and the environment must live together; you can no longer have one at the expense of the other. Rather, our aim has to be a world where everyone can live well and within the sustainable limits of our planet.

Cold sits at the nexus of this challenge but it has been almost ignored so far. And as Sustainable Energy for All points out: 'given that millions of people die every year from lack of cooling access, whether from food losses, damaged vaccines or severe heat impacts, this is a glaring omission.'

The need for cooling is universal but cooling means very different things to different groups of people.

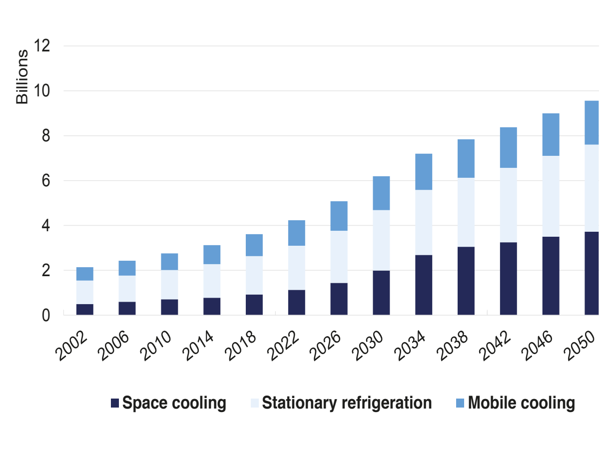
For those of us in the developed world it is about air-conditioned offices, hotel rooms, apartments, a fridge full of fresh food and convenience meals from all over the world, ice in our drinks. In Dubai, most of electricity use is for air conditioning; in Europe the majority of our food goes through the cold chain at some point.

But subsistence farmers to the urban poor equally have a need for cooling but in very diverse and perhaps more life threatening ways – extending the life of crops while trying to move them to market; ensuring access to basic vaccines; and bearable or even just safe working and living environments. In its report: *Chilling Prospects* SEforAll calculates that more than one billion people among the rural and urban poor people remain at high risk from a lack of access to cooling.

Food losses

Up to 40% of food is lost post-harvest in developing countries, primarily because of lack of cold chain. At the same time, more than 1bn people continue to live in extreme poverty – more than 75% of them reside in rural areas, primarily dependent on agricultural production.

Figure 1. Number of cooling appliances in-use globally (number of units)
Source: A Cool World – Defining the Energy Conundrum of Cooling for All, University of Birmingham, 2018



Equally 800mn people globally are malnourished. Malnutrition is the largest single contributor to disease in the world, according to the UN's Standing Committee on Nutrition. More children die each year from malnutrition than from AIDS, malaria and tuberculosis combined. And a 2015 World Health Organization (WHO) report concluded that 600mn people – almost one in ten worldwide – fall ill after eating contaminated food, and 420,000 die every year. Cold chain is vital.

And the consequences of food loss are far beyond hunger, farmer poverty and inflated food prices. Food wastage accounts for 4.4bn tonnes of carbon dioxide equivalent – if food waste was a country, it would be the third biggest emitter of carbon after the US and China.

The WHO also estimates that nearly 50% of freeze-dried and 25% of liquid vaccines are wasted each year primarily because of broken cold chains. It reports that 19mn infants were not reached with routine immunisations, including the temperature sensitive DPT vaccine. It estimates that 1.5mn deaths could be avoided each year if global immunisation coverage improved.

Meanwhile, even though mortality from heat is episodic, already, 30% of the global population is exposed to life threatening temperatures for nearly 20 days a year. The WHO forecasts that, by 2050, deaths from heat waves could reach 260,000 annually unless governments adapt to the threat.

With populations growing, rapid change in demographics, continued urbanisation and climate change, we will need far more cooling. Forecasts suggest that the Asia-Pacific middle class will nearly triple by 2030 to more than 3bn people. Their increased affluence, changing lifestyles and aspirations will require ever more cooling – air conditioning for comfort; cold chains to support food preference changes and better medical care; and datacentre cooling for the digital economy.

Energy intensive

By 2050, there could be more than 9.5bn cooling appliances worldwide – more than 2.5 times today's 3.6bn – see **Figure 1**. Cooling, however, is energy intensive. In 2018, the global cooling equipment stock (for air conditioning, refrigeration, and transport) was estimated to consume around 3,900 TWh/year globally of electricity, approximately 17% of the world's total demand for electricity. Air conditioning accounts for the largest share and currently consumes approximately 2,000 TWh/year, a number that is projected to triple by 2050.

This is however only half the picture.

Despite the significant growth in cooling equipment stock, under these projections, much of the world would still only have low penetration levels of cooling. Without cooling for all, food and medicine loss in the supply chain will be high; food poisoning from lack of domestic temperature management will be significant; farmers will lack market connectivity; hundreds of millions of people will not have safe, let alone comfortable, living or working environments; medical centres will not have temperature-controlled services for post-natal care, etc.

As an indication of the impact of widespread global access to cooling, at the University of Birmingham we have looked at scenarios where the world has 'Cooling for All'. The number of cooling appliances rises to more than 14bn. Even assuming accelerated technology progress, projections delivering aggressive energy performance improvements, the energy requirement could still equate to 15,500 TWh, which is approximately 2.5 times the 6,300 TWh maximum sector allocation envisaged by the IEA 2°C scenario.

To achieve the required amount of cooling within the energy budget available would require us to double the efficiency of our cooling devices, on average, in addition to the technology progress proposed currently. Alternatively, to 'green' this volume of electricity would require more than 60% of the total projected renewables capacity for all demands from transport to industry to our cities under the IEA's 2°C scenario.

Although ultimately the actual detail of the numbers in a Cooling for All scenario will necessarily be different to some degree, given the size of the gap between current demand projections and those including cooling for all, the conclusion is, however, highly likely to be correct.

As one example of the size of the challenge – 2017 was a record year for global deployment of solar renewables at 94 GW of capacity added. In the same year, the full load power draw from all new refrigeration and air conditioning (RAC) units sold added to the global grid was around 106 GW. Again, 2018 was a record year for global deployment of solar renewables at 104 GW of capacity added, while global RAC sales grew by around 9% year-on-year.

Put simply, we have a problem.

Direct and indirect emissions

The 2016 Kigali Amendment to the Montreal Protocol on eliminating the use of hydrofluorocarbons for cooling is crucial to reduce the sector's environmental footprint through the use of high global warming potential (GWP) refrigerants (direct emissions). And, given the projected growth in demand across all sectors, countries need to ensure that there is a

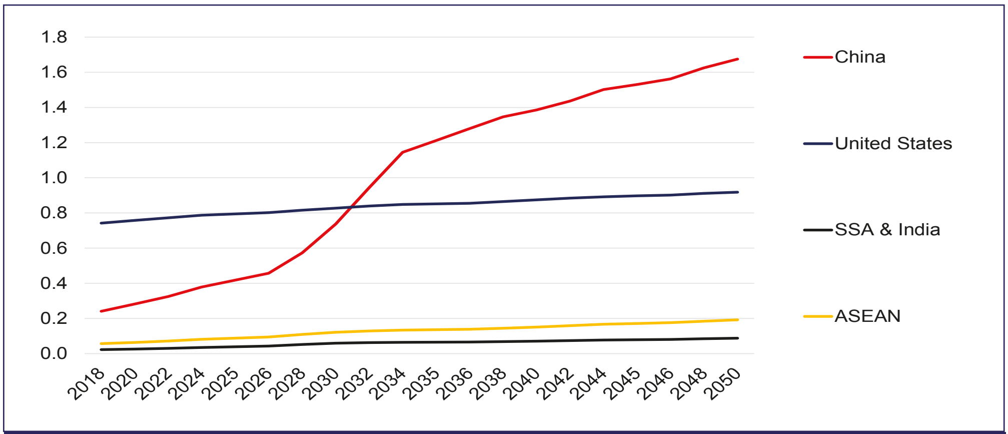


Figure 2. Number of air conditioning units per capita per region

Source: A Cool World – Defining the Energy Conundrum of Cooling for All, University of Birmingham, 2018

rapid transition to very low GWP refrigerants if we are not to create a legacy problem.

But the United Nations Environment Programme (UNEP) Technology and Assessment Panel also reminds us that: 'more than 80% of the global impact of RAC systems is associated with the indirect emissions generated during the production of the electricity used to operate the equipment (indirect), with a lower proportion coming from the use/release (direct emissions) of GHG refrigerants where used.'

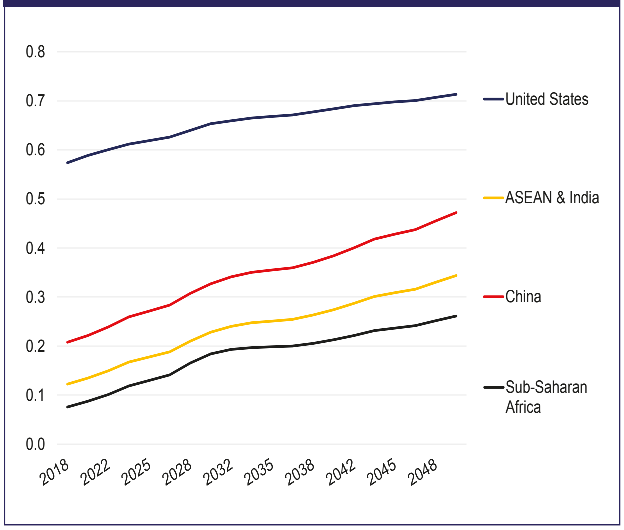
We are seeing the development of more efficient cooling technologies. These are absolutely essential, but they alone, even together with greening electricity, will not be enough to achieve sustainable cooling for all, let alone at costs fit for market.

The Cold Economy

The 'Cold Economy' is the development of cohesive and integrated system-level strategies to mitigate and meet cooling needs sustainably within our climate change, natural resource and clean air targets, while supporting economic growth. This involves thinking about how to mitigate demand through behavioural change and urban and building design. But also to then understanding the multiple cooling needs and the size and location of the thermal, waste, free and wrong-time energy resources to define the step-change novel energy vectors, thermal stores and clean and energy efficient cooling technologies.

Figure 3. Domestic refrigeration equipment per capita per region

Source: A Cool World – Defining the Energy Conundrum of Cooling for All, University of Birmingham, 2018



Key to this is using surplus and free cold and heat. For example, we should be far more efficient in how we harness the cold energy of liquefied natural gas (LNG), the free cold of lakes and rivers and the sea, along with harnessing industrial waste heat and low-grade geothermal energy for cooling.

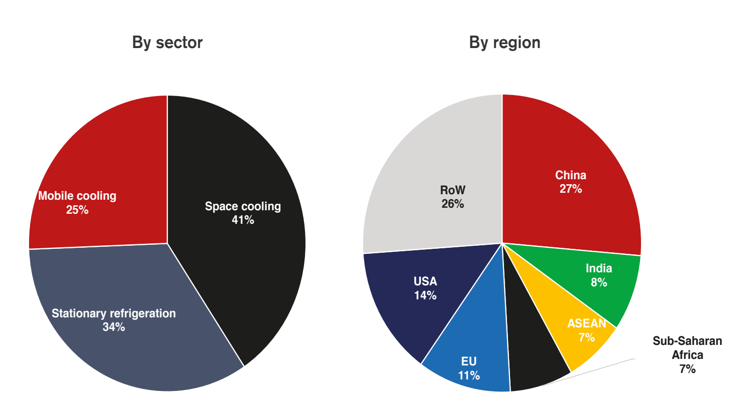
But meeting the challenge also needs the societal, business and financial models, policies and skills that will allow new, fit-for-market approaches to be adopted and optimally integrated in a commercially sensible and technologically practical way with the different and dynamic cooling services and cooling loads.

In short, we have to transition from technology to system, asking a new question – no longer 'how much green electricity do we need to generate?' but rather: 'what is the service we require, and how can we provide it in the least damaging way?' The challenge now is to embed this approach quickly enough to avoid locking-in both direct (and indirect) cooling emissions for years or decades.

Overheating the planet

In order, though, for a government or community to ensure that the cooling needs of their population are met sustainably – and track progress – they first need to

Figure 4. Global cooling energy consumption in 2018
Source: A Cool World – Defining the Energy Conundrum of Cooling for All, University of Birmingham, 2018



understand what these needs are and what does Cooling for All mean? To date, much analysis and projection of cooling demand have been based on models of GDP and population growth. These do not deliver access to cooling for the benefit of all who need it; rather, they are projections of those who will be able to afford it.

The implications this demand has for the energy systems, new-build generation requirements and the environment (climate change and pollution) or workforce are therefore poorly understood. An underestimation of the scale of the cooling demand and its impact on energy demand risks a lack of ambition in policy, infrastructure and technology development that could have far-reaching social, economic and environmental consequences.

Universal access to clean cooling is a multi-faceted challenge. In short – how do we meet the urgent global need for cooling for the benefit of all, without overheating the planet?

Clean and energy efficient cooling has the rare potential to advance three internationally agreed goals simultaneously – the Paris Climate Agreement; the UN Sustainable Development Goals; and the Montreal Protocol's Kigali Amendment. In other words, it could address poverty, reduce food loss, improve health, raise energy efficiency, manage our natural resources, support sustainable cities and communities and combat climate change... concurrently.

We need comprehensive cooling strategies at community, regional and national level to:

- deliver overall system efficiency and operational energy resilience;
- reduce lifecycle carbon emissions and pollution; and
- minimise total costs of cooling while meeting economic and social aspirations.

If we are going to deliver access to cooling for the benefit of all sustainably, we have to work bottom-up, understanding the needs of a community – nutrition, health, economic and social prosperity – to define how we can aggregate and meet them in the most affordable and least damaging way. ●

We should be far more efficient in how we harness the cold energy of liquefied natural gas, the free cold of lakes and rivers, along with harnessing industrial waste heat and low-grade geothermal energy for cooling

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