International Energy Agency
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The Future of Cooling

Opportunities for energy-efficient air conditioning

The Future of Cooling
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Corrigendum

Please note that despite our best efforts to ensure quality control, errors have slipped into *The Future of Cooling*.

The text in pages 11 and 27 has changed. It should be replaced by the following pages.

Executive summary

The world is facing a looming "cold crunch"

The use of energy for space cooling is growing faster than for any other end use in buildings, more than tripling between 1990 and 2016. Space cooling – typically by means of an electric-powered fan or air conditioning (AC) system – is contributing increasingly to global energy demand. Global sales of ACs have been growing steadily and significantly: since 1990, annual sales of ACs nearly quadrupled to 135 million units. There are now about 1.6 billion in use, with over half in just two countries – the People's Republic of China (hereafter "China") and the United States. Those ACs vary enormously in energy efficiency, and keeping them running consumes over 2 000 terawatt hours (TWh) of electricity every year, which is two and a half times the total electricity use of Africa. Almost a fifth of all the electricity used in buildings is for cooling.

Rising demand for space cooling is already putting enormous strain on electricity systems in many countries, as well as driving up emissions. Increased AC loads push up not only overall power needs, but also the need for generation and distribution capacity to meet demand at peak times, placing further stress on the power system. In some countries, such as in the Middle East and also parts of the United States, space cooling can represent more than 70% of peak residential electrical demand on extremely hot days. Averaged across all countries, space cooling accounted for around 14% of peak demand in 2016. Building, maintaining and operating electricity capacity to meet that peak demand is very expensive because it is used only for limited periods, and this drives up overall costs. Meanwhile, carbon dioxide (CO_2) emissions from cooling have tripled since 1990 to 1 130 million tonnes (Mt), equivalent to the total emissions of Japan. Local air pollutants caused by cooling energy demand have similarly grown.

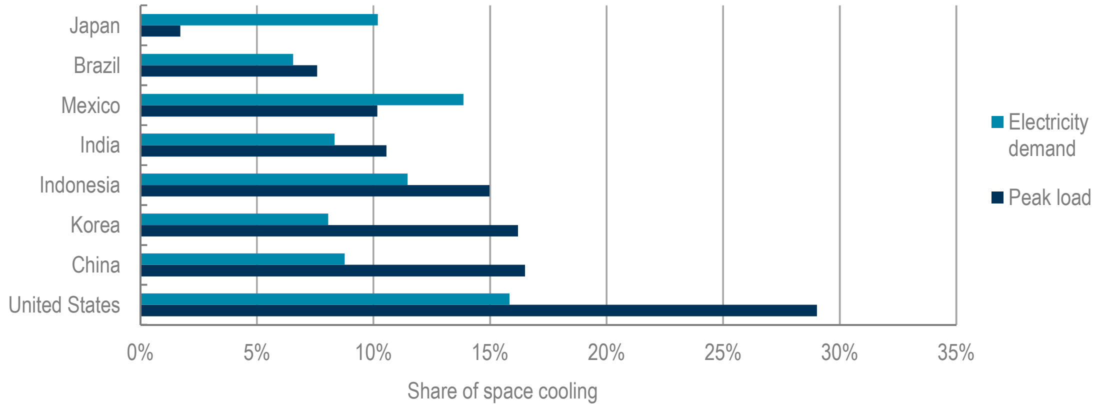
Growing demand for cooling is driven by economic and population growth in the hottest parts of the world. Global growth is shifting south, to countries that experience high temperatures that drive the demand for cooling, which is becoming affordable for more people as income levels rise. The lion's share of the projected growth in energy use for space cooling by 2050 comes from the emerging economies, with just three countries – India, China and Indonesia – contributing half of global cooling energy demand growth. And the efficiency of ACs varies widely - in all major markets today, people are typically buying air conditioners whose average efficiencies are less than half of what is available.

Absent firm policy interventions, cooling-related energy demand will soar

There is no doubt that global demand for space cooling and the energy needed to provide it will continue to grow for decades to come. Access to cooling is a major social issue. Of the 2.8 billion people living in the hottest parts of the world, only 8% currently possess ACs, compared to 90% ownership in the United States and Japan. But just how fast cooling-related energy demand grows hinges critically on government policy action. The analysis presented in this report shows that policies currently in place or planned would have only a very limited effect in slowing that growth.

In our Baseline Scenario, which takes account of the likely effect of current policies and targets, energy needs for space cooling will triple by 2050. Soaring AC ownership drives overall electricity demand to unprecedented levels. Global energy use for space cooling in 2050 reaches 6 200 TWh, with nearly 70% of the increase coming from the residential sector, and much of it taking place in a handful of emerging economies. The share of space cooling in total electricity use in buildings grows to 30%. Cooling becomes the strongest driver of growth in buildings electricity demand, responsible for 40% of the total growth, and the second strongest driver of all conditioning demand in Madrid in Spain accounted for one-third of total peak consumption in June 2008 (Izquierdo et al., 2011). Where there is demand for cooling throughout the entire year, such as Singapore or many countries in the Middle East, the share of air conditioning in peak load can be as high as 50% or more. In Saudi Arabia, air conditioning accounts for a staggering 51% of total electricity demand, with summertime demand twice as high as during the cooler "winter" months (Demirbas, Hashem and Bakhsh, 2017). Obviously, the efficiency of AC equipment has a huge impact on this effect, with one analysis suggesting that a 30% improvement in global AC performance by 2030 would reduce peak load by the equivalent of as much as 710 mid-sized coal power plants (Shah et al., 2015).

Figure 1.12 • Share of cooling in peak load and total electricity demand by country/region, 2016



Notes: The share of cooling in national peak load has been calculated for the moment in the year at which the overall peak in total electricity demand occurs; the contribution of cooling to local peak load in towns and cities can be much higher.

Key message • Space cooling is a significant contributor to electricity demand, especially at peak.

Building, maintaining and operating electricity capacity to meet peak demand is particularly costly – often between two and four times the cost per kWh of baseload electricity supply and sometimes higher – because the generation and network capacity dedicated to meeting peak load is used only for limited periods. The capital cost associated with this capacity normally represents a large portion of the total cost of supplying electricity at peak (Box 1.2). This is reflected in consumer electricity prices either directly through time-of-day or seasonal tariffs, or through average annual tariffs that are based on the cost of supply throughout the year.

Box 1.2 • Meeting electricity peak load

Peak load or demand is used in the electricity sector to describe the highest level of electricity demand measured over a period of half an hour or an hour that occurs within a given time period, such as a day, season or year. For most electricity systems, daily peak occurs early in the morning, when people wake up, and in the evening, when people return from work and make use of household appliances and lighting. In hot and humid countries with high levels of electricity demand for cooling, the daily peak may occur in the afternoon or evening, when ambient temperatures are highest. Countries with hot summers and cold winters may see peaks in both seasons depending on the extent to which electricity is used for heating purposes. California is an example of the former, with air conditioning being the main driver of peak load in the summer, while daily peak loads and electricity demand are much lower during the winter (Figure 1.13).

Power system operators are responsible for ensuring that generating, transmission and local distribution capacities are sufficient to meet expected peak load at all times – even if the peak period lasts for just one hour each year. Generally, a safety margin, known as reserve capacity, is built into the system in the event of an unexpected surge in peak load or loss of capacity due to an accident or unscheduled maintenance. If peak demand exceeds the maximum supply that the system can provide, unplanned power outages, deliberate shedding or brownouts (a deliberate or unplanned drop in