Without Access to Fundamental Services:

The Right to Refrigeration

Beko

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A Commitment to Progress

It is simply not acceptable to deny those in the Global South access to a comfortable and healthy living out of fear that emissions will rise as they gain access to what many in the Global North have taken for granted for decades. Our question is this: how can more people gain access to essential home appliances, while we ensure efficient energy consumption?

We decided to investigate an area of Beko expertise – refrigeration. A fridge at home is linked to a variety of important development and human rights indicators. But more refrigerators mean more energy consumption and emissions, and by extension more global warming, the effects of which are being felt around the world, but acutely in the Global South. Therein lies a conflict.

This report exposes the importance of refrigeration with a focus on the Global South, and some of the issues that governments, policymakers, industry and the public will face on the path toward more universal access to refrigeration, which will enable greater quality of life, help meet a basic human right, reduce illness, and increase life expectancy and human potential.

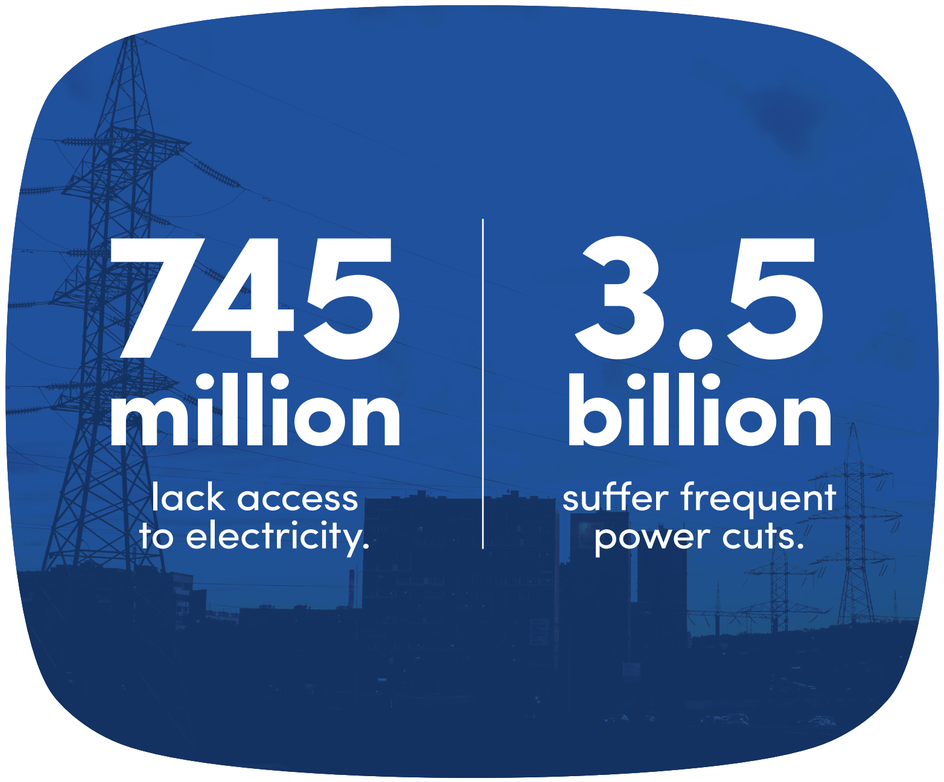
The battles against climate breakdown and the battle for improved quality of life are not mutually exclusive or oppositional. They should be fought together, in tandem.

Our science-based targets including our commitment to reduce Scope 3 emissions stemming from the use of sold products globally is part of our commitment to tackle this challenge. But there is much to do. And our door is open to international policymakers, stakeholder groups and industry peers. Let's tackle this challenge together.

Executive Summary

There are two certainties that together present a frightening dilemma. First, life as we know it cannot survive without a dramatic reduction in our collective emissions. Second, demand from the Global South means hundreds of millions of more domestic refrigerators are set to be in use around the world by 2050. The provision of which, on the current trajectory, would dramatically impact emissions. We must find a way through the quagmire.

Access to refrigeration is far from a luxury. The household refrigerator is inextricably linked to a variety of rights and development indicators, including the United Nations Sustainable Development Goals (SDGs). Specifically, refrigeration is linked to SDG 3, good health and wellbeing, and SDG 12, responsible consumption and production.



Indeed, as highlighted by world-leading cooling expert Professor Toby Peters and Dr Leyla Sayin in their contribution to this report, more than 1.2 billion rural and urban poor globally are categorised as high-risk due to a lack of access to cooling, while lack of effective refrigeration contributes to the loss of 526 million tonnes of food produced annually – enough to feed an estimated one billion people. While not the focus of this report, this food waste generated presents its own massive emissions hazard.

But many challenges stand in the way of universal provision of this essential service.

First, improving access to refrigeration is no easy task when 745 million people lack access to electricity and 3.5 billion of those who have it suffer frequent power cuts. Meanwhile, entrenched poverty and inequality means many cannot afford a fridge whether on-grid or off.

And then there are the emissions problems. Household appliances already account for 8% of global carbon emissions. The global energy consumption by appliances and equipment continues to grow every year, driven largely by expanding ownership and use of energy-consuming devices, particularly in developing countries.

Of the total emissions from household appliances, 15% is caused by domestic refrigerators. And the cooling sector more broadly already consumes nearly a fifth of overall electricity used worldwide and comprises more than 10% of global emissions. What will happen to these figures as the number of domestic refrigerators in use shoots up? The challenge is urgent: millions of people are at income levels near which they will begin buying cheap but polluting fridges.

Yet while estimates suggest that the number of domestic refrigerators used worldwide by 2050 could be more than double the number currently in use (1.87 billion in 2022), Professor Peters and Dr Sayin suggest that these projections are based on low penetration levels of domestic refrigeration. In fact, they write: ‘If everyone who needed a refrigerator had one, there would be 4.2 billion domestic refrigerators in 2050.’

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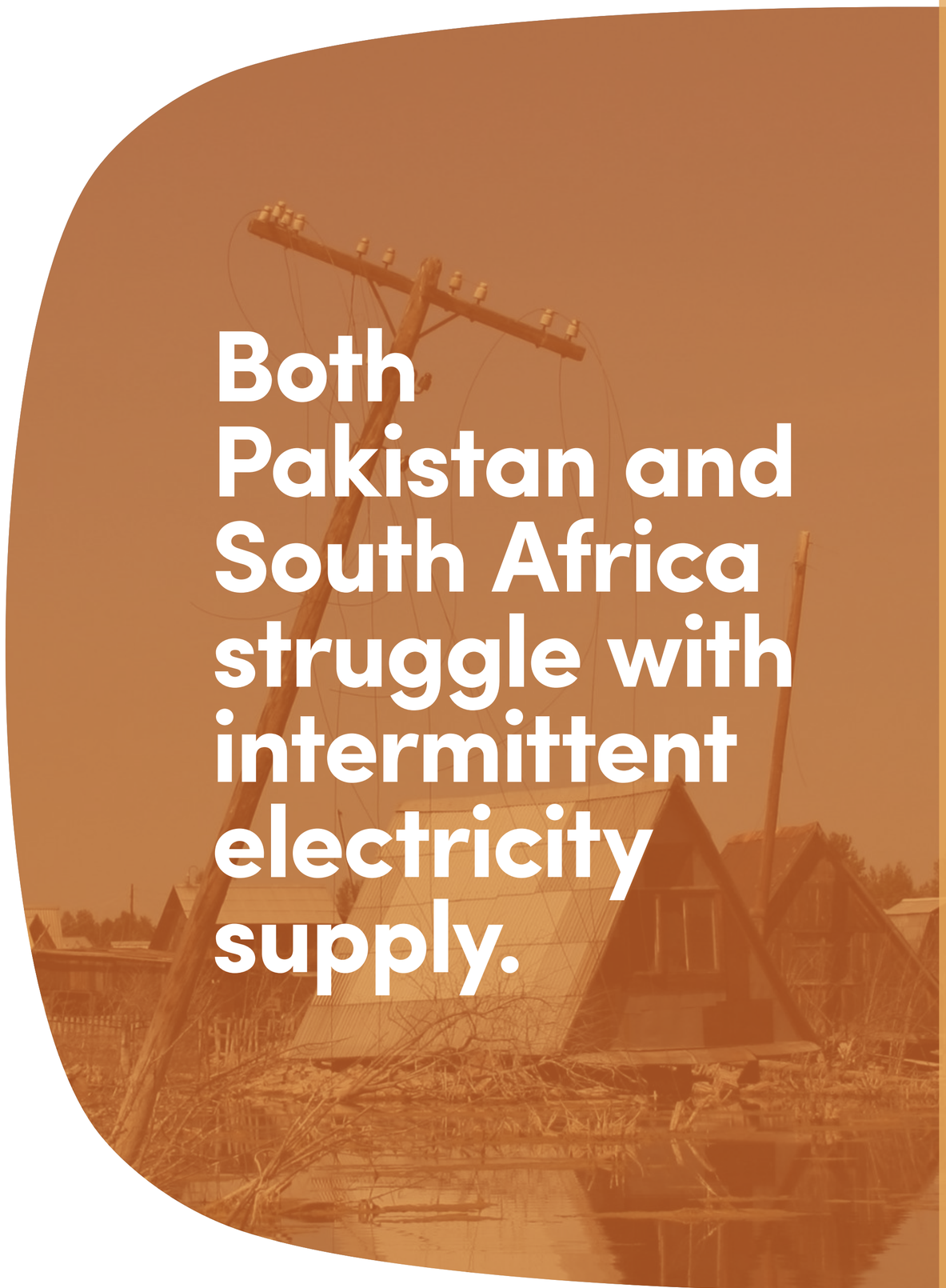
The complexities of the problem are playing out in different ways around the world, which are illuminated by examples in this report. Take Pakistan, for instance, where a huge rural population struggles with access to reliable supply of electricity and low to average incomes. But a large, fast-growing population will nonetheless likely boost the number of refrigerators, with serious implications for global emissions.

South Africa, too, struggles with an intermittent electricity supply, although a larger proportion of the population has access. The key issues facing South Africa are electricity production practices that depend on coal, and the stark inequality that means despite being an upper middle-income country, its poorest citizens may struggle to buy a quality, energy-efficient refrigerator. Both Pakistan and South Africa also have more leakage of harmful chemicals from domestic refrigeration units than is ideal.

Solving the refrigeration problem won't be easy. But there are ways forward. We need the private sector to research and develop pioneering energy-efficient, low leakage and affordable refrigeration solutions; communicate the advantages of energy-efficient products; respect local knowledge and build trust among consumers; lobby for stringent regulation; and contribute to global industry standards.

Policymakers, meanwhile, should pursue and enforce international agreements; create National Cooling Action Plans; run public information campaigns; put processes in place to dispose of older or broken fridges in an environmentally friendly way; and, through advocacy and research, make sure the world's poorest are not excluded from the right to refrigeration.

Finally, to truly address the problems presented in this report, genuine collaboration between the private and public sector will be essential, not optional.



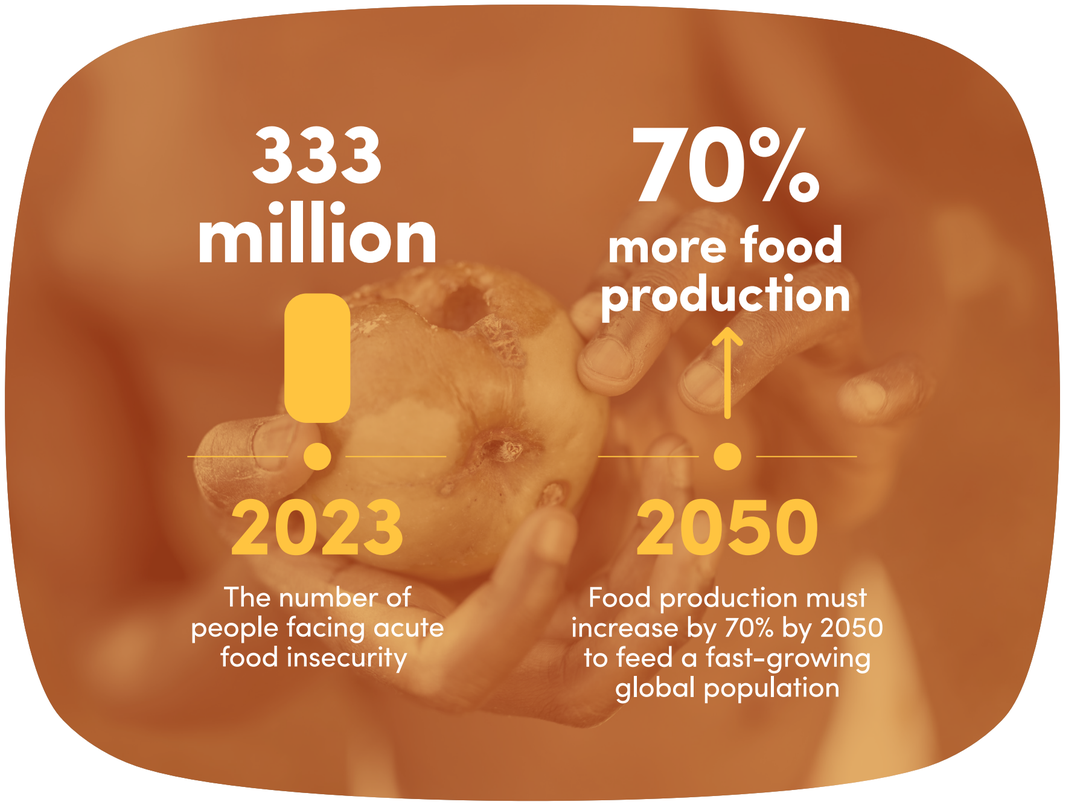
Both Pakistan and South Africa struggle with intermittent electricity supply.

Global Picture

When we fully take stock of the benefits, it is clear that owning a refrigerator is an essential human right and not a luxury.

A fridge can help a household preserve its food at adequately cold temperatures, increasing longevity and maintaining nutritional value. When food is stored at sufficiently cold temperatures there's a reduced risk of spoilage, and therefore food poisoning and food waste.

The advantage of refrigerator ownership felt at the household level will also have global benefits. Cutting food waste by addressing food accessibility, for instance, is critical: in 2023, the number of people facing acute food insecurity was 333 million. That is more than 200,000 above pre-pandemic levels[1]. The long-term outlook is no less worrying. The United Nations' Food and Agriculture Organisation (FAO) says that food production must increase by 70% by 2050 to feed a fast-growing global population[2].



The household refrigerator is therefore an inextricable part of food security, and thus linked to a variety of rights and development indicators and the UN Sustainable Development Goals (SDGs). It is particularly relevant to SDG 3, good health and wellbeing, and SDG 12, responsible consumption and production.

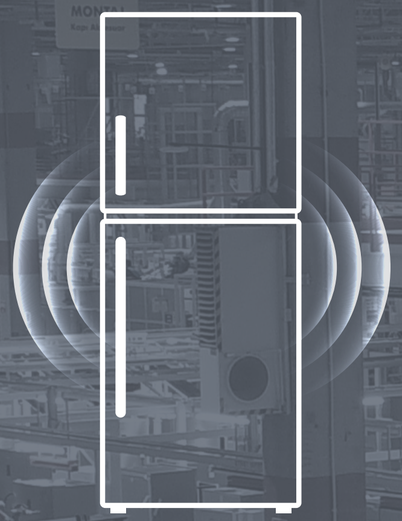
The multitude of benefits of refrigerator ownership are clear to consumers across the world. Research shows that as people escape poverty and reach a certain income threshold, they start buying durable goods like fridges and freezers. A fridge is often the first electrical appliance that a household buys[3]. According to the German Agency for International Cooperation (GIZ), a household is likely to buy a fridge once its income reaches 10,000 USD per year[4].

Access to electricity is another key driver of domestic refrigeration demand. While access to electricity has begun to grow again after shrinking during the pandemic, 745 million may still live without[5]. It looks unlikely that the SDG of universal access by 2030 will be met, with an estimated 660 million likely to be left without by that point[6].

Moreover, among those with access to electricity, many in fact have only intermittent or unreliable access. There is no universally accepted definition of reliable electricity but when defined as no more than one hour of outage per month, the number of people without or with inconsistent access stands at 3.5 billion[7]. That's particularly worrying in the context of refrigeration: inconsistent refrigeration is of little use when it comes to keeping food fresh and safe to eat.

Still, demand for domestic refrigeration continues to grow, and the number of appliances in use in 2022 approached 1.9 billion[8], with 165 million units sold[9]. By 2030 there are projected to be 2.5 billion units in use and 209 million units sold annually; and by 2050, 3.8 billion units in use and 256 million units sold annually[10].

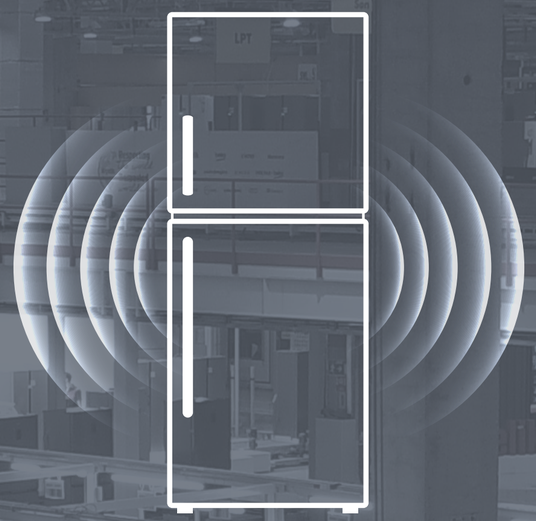
2022



1.9 billion
units in use

165 million
units sold annually

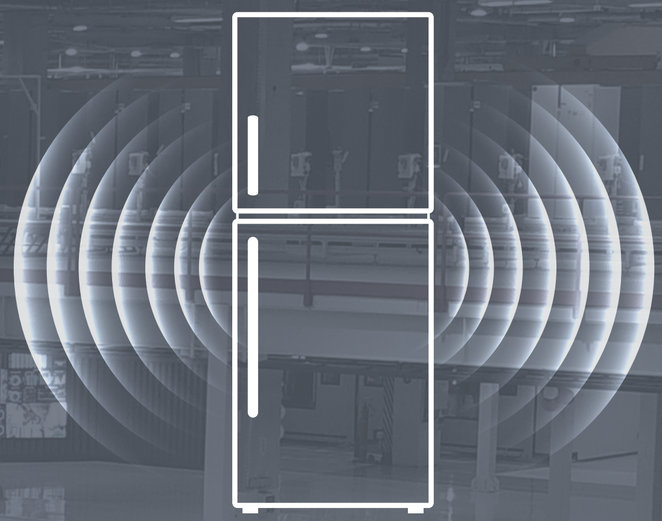
2030
(projected)



2.5 billion
units in use

209 million
units sold annually

2050
(projected)



3.8 billion
units in use

256 million
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Domestic Refrigeration and Climate Change

Given the many benefits to both society and households, this fast-rising demand for household refrigeration, in some ways, is cause for celebration. But it also comes with a challenge: the potential for emissions to skyrocket as refrigerator access increases.

Household appliances already cause 2,859 megatonnes (Mt) of carbon emissions, which is 7% of all global emissions[11]. And energy consumption by appliances and equipment continues to grow, driven largely by expanding ownership and the use of energy-consuming devices, especially in developing countries. In 2022, energy consumption by appliances grew by 2%[12].

In many countries, fridges and freezers are often responsible for a large proportion of a household's overall energy consumption. In Brazil, for instance, the figure is 30%[13]. This high energy consumption leads to high levels of indirect emissions. Indirect emissions from cooling devices come from electricity usage, which remains, globally, mostly produced using fossil fuels. The cooling sector consumes more than 17% of the overall electricity used worldwide[14]. In turn, the cooling sector, which includes domestic refrigeration, is estimated to cause 10% of global CO_2 emissions[15].

On top of this, they also cause direct emissions that come from chemical compounds called hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs). HFCs and HCFCs are transitional substitutes for chlorofluorocarbons (CFCs), which were phased out in 2010. These compounds are emitted from cooling devices during manufacturing, operations and disposal. Both HFCs and HCFCs have high Global Warming Potential (GWP), a metric that quantifies how much a greenhouse gas contributes to global warming compared to the impact of the same quantity of carbon dioxide (CO_2) in the atmosphere.

The cooling sector consumes more than 17% of the overall electricity used worldwide.

2.3 billion people

worldwide are reaching income levels where they are likely to purchase inexpensive, inefficient, and polluting refrigerators.

Only 6% of emissions from domestic refrigeration are direct[16]. This fits with a general pattern in developed countries, which tend to have high indirect emissions but minimal leakage of harmful refrigerants. But elsewhere, the data tells a different story. The German Development Agency (GIZ) **estimates that the leakage rate over the life of an appliance may be 27% in developing countries. That's partly because poor quality roads cause broken pipes, and end-of-life appliance disposal is inadequately regulated[17].**

Whether we look at direct or indirect emissions, the future is full of questions. As incomes and standards of living rise, the Economist Intelligence Unit estimates that 2.3 billion people around the world are approaching income levels at which they are likely to buy cheap, inefficient, polluting fridges[18], meaning both types of emissions could skyrocket.

And the projected rise in electricity consumption related to domestic refrigeration in developing countries from 2005 to 2030 equates to the entire energy generating capacity of Belgium and Bulgaria combined[19].

But there is a way forward. It is possible to harness the development and human rights potential of access to refrigeration without excessively increasing emissions. This will require large-scale take up of well-designed, energy-efficient fridges, as well as improvements in the energy mix. Indeed, to get on track with net-zero emissions targets by 2050, nearly all appliances and equipment need to match today's best available technology, says the IEA[20].

by 2030

Under a business-as-usual scenario, domestic fridges will create 540 Mt of CO_2e per year[21]. But under a mitigation scenario, involving an improved energy mix and highly efficient appliances, the Green Cooling Initiative forecasts emissions would be reduced by 41 Mt CO_2e. That difference is the equivalent to reducing the number of cars on the road by nearly 9 million[22].

by 2050

That gap between a business-as-usual scenario and a mitigation scenario becomes even more pronounced. By 2050, the former will mean 697 Mt CO_2e every year. But under a mitigation scenario, emissions would be cut by 131 Mt CO_2e. That is more than the current total carbon emissions of the Philippines[23]. But these dramatic emissions savings cannot be made without the full inclusion of the developing world.

International Politics and Agreements

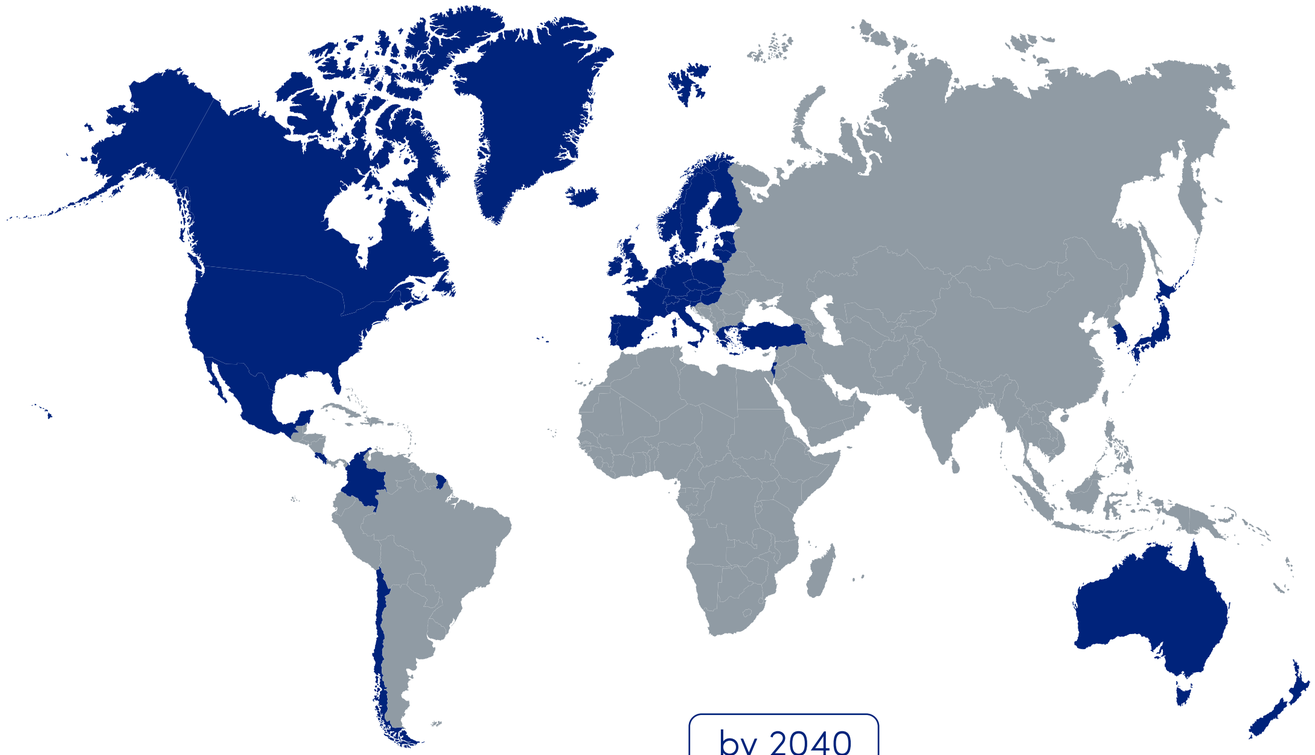
In many ways, the challenges outlined illustrate a conflict inherent to the pursuit of net zero. On the one hand, we must acknowledge the pursuit of higher living standards, particularly in the Global South; on the other, we must reduce emissions, acknowledging the emissions stemming from home appliances.

The responsibility for cutting carbon emissions and compensation for loss and damage in the developing world is already a point of contention amongst nations. Relevant frameworks here include the 2015 Paris Agreement on Climate Change and the UN SDGs – including reductions in poverty, hunger and inequality, as well as responsible consumption and production, and sustainable cities and communities.

The Global North has been responsible for around half of all emissions since the industrial revolution, reflecting higher consumption levels despite a far smaller population[25]. Yet while the effects have been and will continue to be felt globally, they are disproportionately felt in the Global South.

We know that as the economies of the Global South grow, they will require more energy. **Indeed, by 2040 the energy demand from non-OECD countries is set to increase by 40%, while that of OECD countries will grow no more than 10%[26].** The impact of evolving energy needs will depend on from where that energy is derived.

But as we have highlighted, refrigeration is not simply a carbon issue. In 2016, the Kigali Amendment to the Montreal Protocol was passed, with a stated goal to reduce HFC use by 80% by 2050[27]. To date, the Amendment has been ratified by 155[28] nations and the European Union, and could help avoid 0.5C° of global warming by the end of the century[29]. Time will tell if that can be delivered.



by 2040

Energy Demand of Non-OECD Countries

40%

Energy Demand of OECD Countries

10%

‘We must urgently transform the cooling sector’: Clean cooling for all must be a global commitment

Toby Peters

is Professor of Cold Economy at the University of Birmingham and Heriot-Watt University, Director of the Centre for Sustainable Cooling, and the academic lead for the Centre of Excellence for Sustainable Cooling and Cold-chain program in Africa and India.

Toby is an award-winning technology developer (Liquid Air Energy Storage, Highview Power, Dearman Engine) and has extensive industry and academic experience in energy systems, energy storage and sustainable cooling and cold chains for food and health. Toby researches whole-system solutions to transition to sustainable, equitable and resilient cooling and cold-chain practices in both developed and developing economies.

Dr. Leyla Sayın

is a Senior Research Fellow at the Centre for Sustainable Cooling at the University of Birmingham. Leyla holds a PhD in Environmental Economics from the University of Bath, an MSc in Quantitative Economics from Université Paris 1 Panthéon-Sorbonne, and a BSc in Chemical Engineering from Bogazici University.

Leyla sits on the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC) of the Montreal Protocol and is seconded part-time to the UK Government’s Department for Energy Security and Net Zero (DESNZ) to provide cooling technical evidence and advice to the Government’s policies and strategies, and innovation teams responsible for decarbonising the UK’s energy system. Leyla has produced several papers and reports on cooling and cold-chain needs, and whole system approaches to sustainable and resilient cooling and cold-chain provision as well as data gathering frameworks and assessment methodologies.

Demand for cooling is nothing new. Before the days of refrigerators, ice harvesting was a major industry. At the start of the 20th century, there were 2,000 commercial ice plants in the US[30], harvesting ice from frozen lakes, ponds, and rivers, to be shipped around the world. Since the advent of electric refrigerators demand for these products has been growing fast. And with good reason: the benefits from refrigeration are enormous and indisputable.

Cooling is vital to our ability to function in the modern world. Without it, we would not have access to safe and nutritious food, the efficacy of medicines and vaccines would be compromised, workplaces and homes would be less comfortable for work, study, and relaxing.

Even the electric systems that underpin every aspect of contemporary life would be unable to operate, as wires and cables can be damaged, mobile telephones can overheat and laptop computers can stop operating properly – to name but a few.

But more than 1.2 billion rural and urban poor globally are categorised at high risk due to lack of access to cooling[31]. The lack of effective refrigeration is the single largest contributor to the loss of 526 million tonnes of food production annually (or 12% of the total food produced) – enough to feed an estimated one billion people[32].

More than 1.2 billion rural and urban poor globally are categorised at high risk due to lack of access to cooling.

The current demand projections typically underestimate the scale of the challenge ahead. **For example, according to the Green Cooling Initiative, there could be 3.8 billion domestic refrigerators worldwide by 2050[33]. That is more than double the 1.8 billion total in 2022, according to the Green Cooling Initiative[34]. However, these projections are based on low penetration levels of domestic refrigeration.**

If everyone who needed a refrigerator had one, there would be 4.2 billion domestic refrigerators in 2050. In other words, 435 million more than the baseline forecast. Including other active cooling appliances, providing cooling for all who need it by 2050 would require 14 billion active cooling appliances worldwide, or 3.8 times as many as are in use today[35] (see Figure 1).

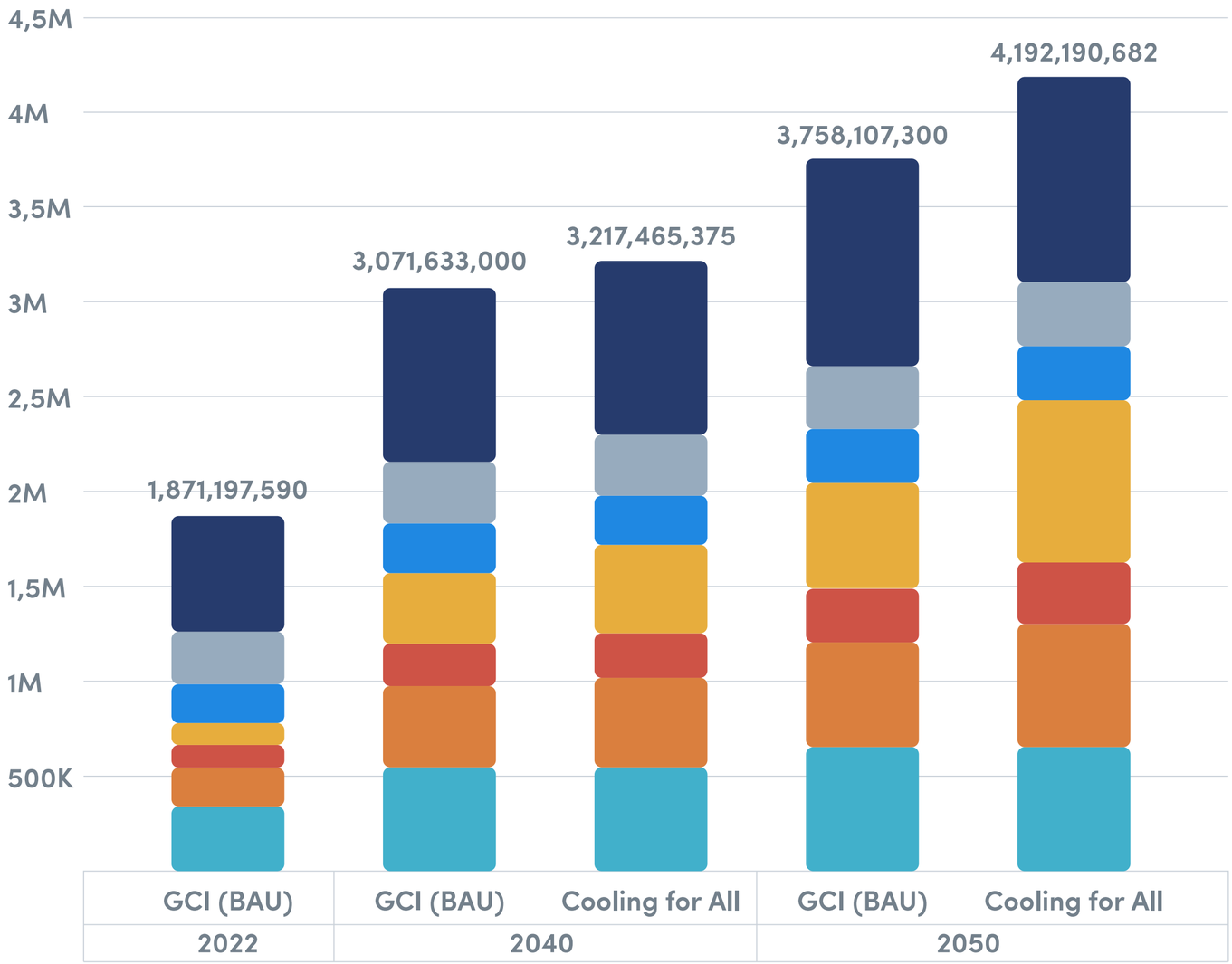
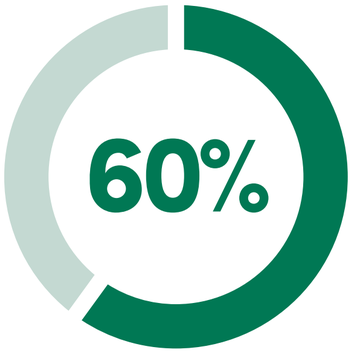


Figure 1. Under the Green Cooling Initiative (Business as Usual), GCI(BAU) and Cooling for All scenarios, the total number of domestic refrigerators is expected to increase significantly between 2022-2050 across China, India, ASEAN, Sub-Saharan Africa, USA, EU & UK markets. From Toby Peters, 'A Cool World: Defining the Energy Conundrum For All.' Reproduced with permission.

Moving Forward

We must urgently transform the cooling sector. One challenge is how to deliver cooling to everyone who needs it, not just those who can afford it, and to do this with minimal environmental impact in a fast-warming world. Another is that ensuring the 2.3 billion around the world on the brink of becoming middle class and able to afford a refrigerator do not buy cheap but inefficient devices[36].



less electricity than comparable products with outdated technology

There are better options. **The best available domestic fridge-freezers consume 60% less electricity than comparable products with outdated technology,** according to United for Efficiency, a UNEP agency[37]. Without policies to increase the uptake of such devices, electricity consumption for domestic refrigerators could rise by more than 53% by 2040. Even modest policies could cut this increase to 11%; more stringent policies could decrease consumption to significantly below current levels[38]. There is value in going further, faster.

Consumers are likely to make long-run savings with more energy-efficient refrigerators – transitioning to energy-efficient solutions could annually save consumers $26 billion on their electricity bills[39]. But the high up-front costs could be a significant deterrent, especially in developing countries where many who need the cooling the most have the least means.

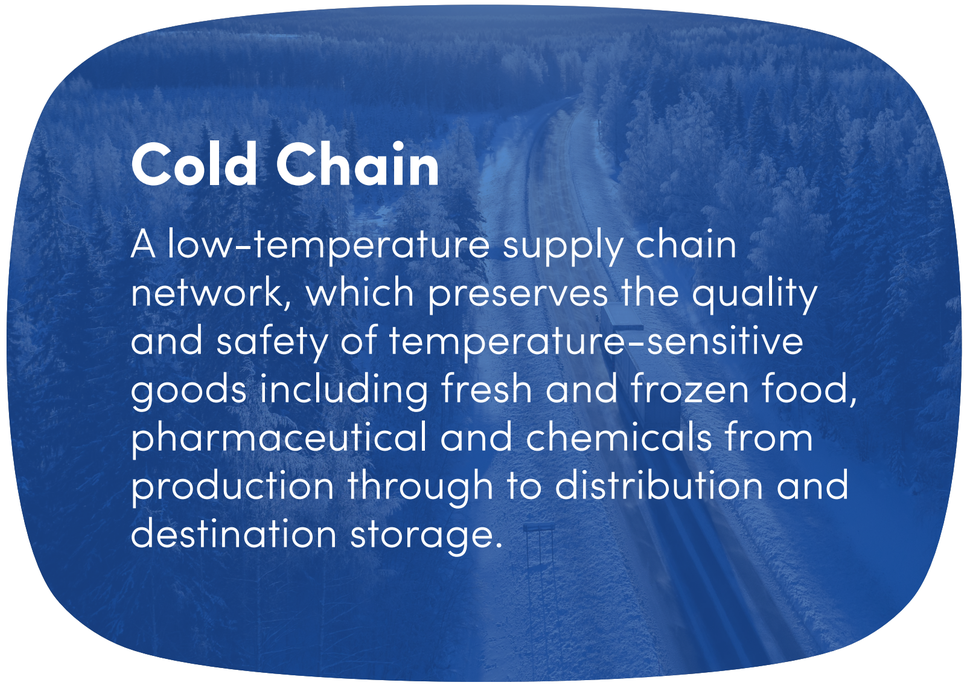
Transitioning to energy-efficient solutions could annually save consumers $26 billion on their electricity bills.

Policies to address the potentially high costs of such sustainable cooling technologies are vital. One option is offering subsidies and other financial incentives for sustainable cooling technologies. Microfinance institutions could help the financially vulnerable buy better cooling devices by offering loans that tie repayment to income. Innovative business models too can help lower financial barriers and investment risks. One example is pay-per-service models, where consumers pay no upfront costs and instead pay a fee per ton hour of refrigeration consumed, or pay-as-you-go models.

Governments must adopt minimum energy performance standards to ensure that ever-better performing technologies are designed, produced, and taken up at scale. Current efforts are not ambitious enough. Lack of standards is also contributing to the dumping of substandard equipment to developing countries, which could lock these countries into obsolete and substandard technologies for the next 15 to 20 years.

The development and uptake of constantly improving cold-chain technology also requires far more research funding. For example, the EU spent only 0.22% of its total engineering research budget on cooling research in 2018[40]. Investment in research and development is not only critical to accelerate technological innovation, but also to make solutions more affordable and accessible to all.

And we have to build a workforce able to maintain these new technologies. In many countries there are insufficient numbers of trained technicians and engineers to deploy, operate, and maintain new technologies nor safely decommission old systems. Accreditation bodies and curriculum developers should be more responsive to trends in new cooling technologies and modify and expand the curriculum accordingly.



Cold Chain

A low-temperature supply chain network, which preserves the quality and safety of temperature-sensitive goods including fresh and frozen food, pharmaceutical and chemicals from production through to distribution and destination storage.

Ultimately, all approaches must be underpinned by detailed analyses that seek to uncover the specific social and environmental benefits of access to sustainable cooling, that are typically challenging to quantify. Research so far has tended to focus too narrowly on measuring energy efficiency, quantifying savings on energy bills, using these as the basis for the return-on-investment calculation. The broader societal benefits of access to cooling are typically treated as a “soft win” rather than the core driver for provision. Social and environmental benefits do have financial value—which often translate into reductions in other costs or lower economic losses. These must be investigated. For example, what is the real cost to society of food poisoning or food loss? Can you meet reduction in malnutrition or improvements in mortality rates without a cold-chain and a fridge to protect the quality of food? (Figure 2). Realising a truly sustainable and resilient cooling system demands understanding, quantifying, and valuing the broader and potentially strategic impacts of cooling with their linkages to developmental goals, targets, and commitments.

Figure 2. Benefits to sustainable, equitable, resilient cooling are not limited to energy savings. The social, economic and environmental benefits demonstrate the value of sustainable cooling in contributing to the Sustainable Development Goals (SDGs), as well as international climate and emission reduction agreements. Toby Peters, 'A Cool World: Defining the Energy Conundrum For All.' Reproduced with permission.

Sustainable, Equitable, Resilient Cooling

Social Benefits
- Decreased poverty
- Reduced food loss
- Improved access to vaccines, blood, medicines
- Improved health & safety
- Lower mortality rates
- Improved inclusivity & gender equality
- New businesses and jobs
- Reliable energy access
- Community resilience

Economic Benefits
- Reduced energy cost
- Increased disposable income
- Increased productivity
- Increased market connectivity
- Increased job & investment oppportunities

Environmental Benefits
- Reduced emissions
- Less pollutants
- Reduced waste
- Improved air quality
- Reduced resource consumption

- SDG 2: Zero hunger
- SDG 5: Gender equality
- SDG 10: Reduced inequalities
- SDG 3: Good health & well-being
- SDG 11: Sustainable cities & communities
- SDG 12: Responsible consumption & production
- SDG 1: No poverty
- SDG 8: Decent work & economic growth
- SDG 7: Affordable & clean energy
- SDG 13: Climate action
- Kigali Amendment to Montreal Protocol
- Paris Agreement

As the Earth warms at a dangerous pace and we are at risk of surpassing the Paris goal of 1.5 ˚C, the lack of cooling and cold-chain access is an increasingly critical development challenge that has significant implications for people's livelihoods, productivity, health, and food and nutritional security. The global demand for cooling is already putting pressure on the energy system and the environment. There is now an absolute urgency for governments to drive the development and deployment of sustainable, affordable, and resilient cooling solutions, and thereby contribute to three internationally agreed goals simultaneously: the Paris Agreement; the SDGs; and the Kigali Amendment to Montreal Protocol. Access to sustainable cooling for all who need it must become a key global commitment.

PARIS AGREEMENT

SUSTAINABLE DEVELOPMENT GOALS

MONTREAL PROTOCOL 1989

There is now an absolute urgency for governments to drive the development and deployment of sustainable, affordable, and resilient cooling solutions.

International Examples

Those without access to fundamental services like domestic refrigeration cannot be left behind in the ongoing pursuit of global prosperity and improved quality of life. But it will require collective will and innovation to ensure that improving living standards does not come at an irreversible cost to the planet in the longer term. We can see these issues at play when we look at representative case study countries, South Africa and Pakistan.

1. Spotlight on: Pakistan

Pakistan is a large, populous country in Asia, bordering Iran, Afghanistan, China, and India. The following analysis shows the implications of its large, fast growing and mostly rural population, limited and intermittent electricity supply, and entrenched poverty on the refrigeration conundrum.

ECONOMY

Pakistan is categorised by the World Bank as a lower middle-income country, with a GDP per capita of 1597 USD[41]. While these incomes are not evenly distributed, Pakistan is not as unequal as many other countries. This is evidenced by its relatively low Gini coefficient (a measure of income distribution) which currently stands at 29.6[42].

Yet human development measures remain poor. For example, 12% of the population is undernourished; 38% of under-fives are stunted from malnourishment; and 41% of pregnant women are anaemic[43].

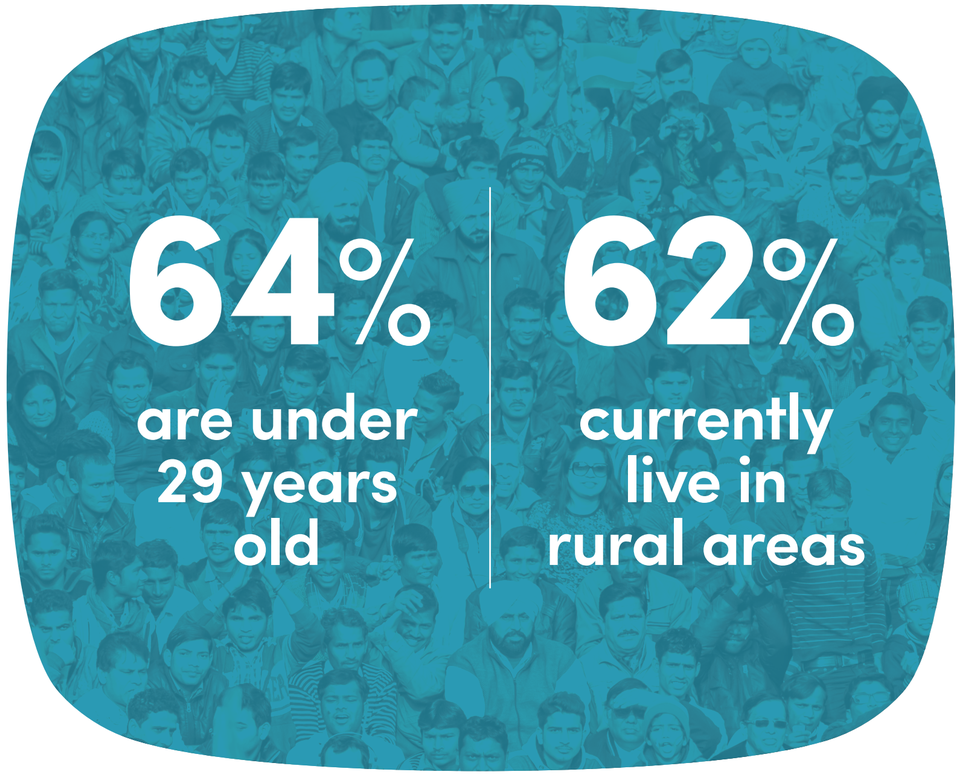
The situation has not been helped by various global crises. All Pakistan's development indicators were badly hit by COVID-19. It is also on the sharp end of climate change.

In 2022, it experienced disastrous and unprecedented flooding, impacting 33 million people[44], and leaving a third of the country under water[45]. The World Bank says up to 9 million more people may have been pushed into poverty as a result of the floods[46].

DEMOGRAPHY

Pakistan is the world's fifth-most populous country, with 210 million people. Most (64%) are under 29 years old, making it a particularly youthful population[47]. Analysts believe the proportion of young people will continue to increase until 2050, at least[48]. It's also a largely rural population. Although more people move to towns and cities every year, 62% currently live in rural areas[49].

Every year, too, the number of households in Pakistan grows. In 2020 there were 37.5 million households, up 1.9% from the previous year[50]. Yet the number of households is not increasing as fast as in many other developing countries. Analysts say this in line with the trends across Asia and could be down to cultural factors[51].



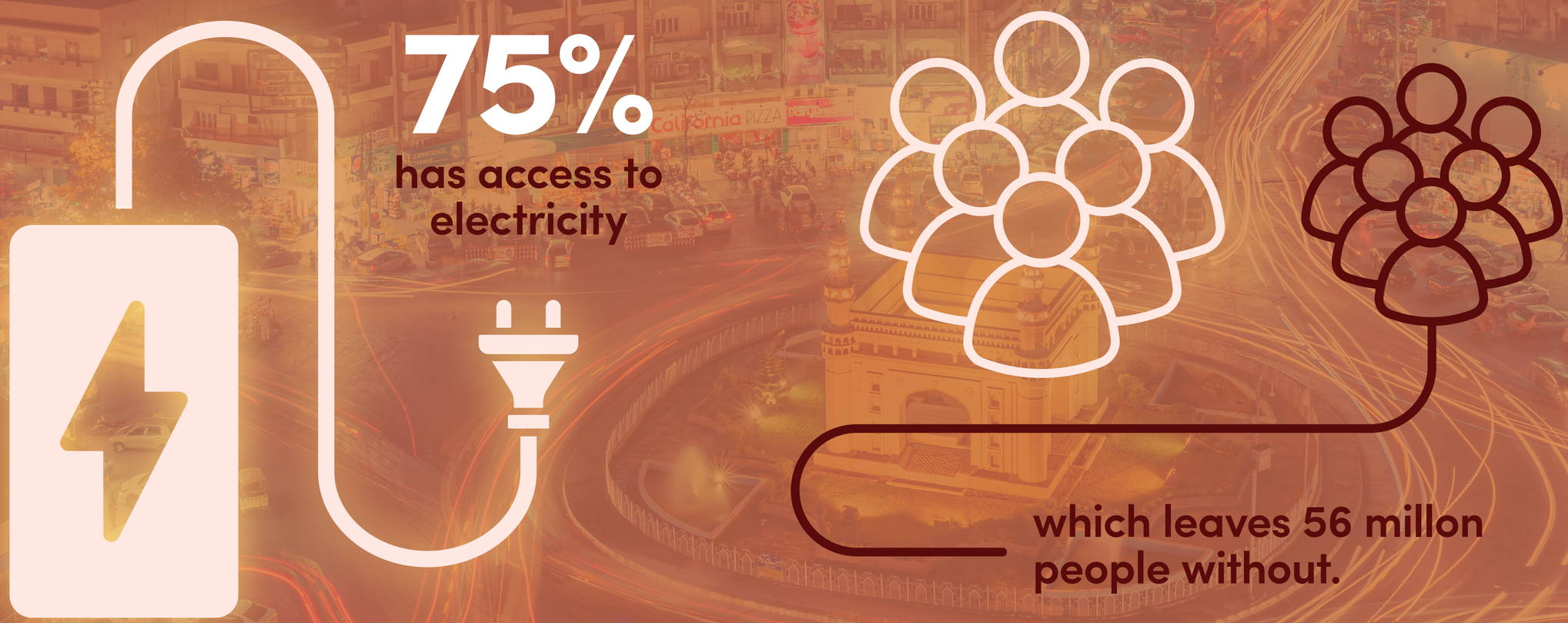
ELECTRICITY

Just over 75% of Pakistan's population has access to electricity[52], which leaves 56 million people without[53]. There is a rural/urban divide here: 100% of the urban population has access to electricity[54], but only 91.9% of the rural population[55].

However, fluctuating power supplies and load shedding – where electricity supply to some areas is temporarily reduced to prevent the entire system from failing – mean even those who are connected to the grid suffer from frequent blackouts[56]. It should also be noted that, although all areas are impacted, rural areas tend to experience blackouts for longer periods than urban ones[57].

Pakistan generates nearly all the electricity it uses. (In 2016 it imported 1% of its total usage.) The majority of this is from non-renewable fossil fuels, with 34% from renewable sources and 5% from nuclear power[58].

In 2020, the Prime Minister at the time promised that Pakistan would produce 60% of its electricity from renewable sources by 2030. But some question the commitment following large-scale construction of new coal-fired power plants[59].



DOMESTIC REFRIGERATION

There are 17.2 million refrigeration units in Pakistan[60]. So, in a country with 37.5 million total households there are clearly many who go without. Some, particularly in rural areas, instead use clay pots or buy ice to keep food and water cool[61]. Nevertheless, more people buy a refrigerator every year. This is in line with the trend in the cooling industry in Pakistan more broadly, which has seen steep growth over the past decade, driven by a growing population, rising temperatures, and increased economic activity[62].

EMISSIONS IN GLOBAL AND REGIONAL CONTEXT

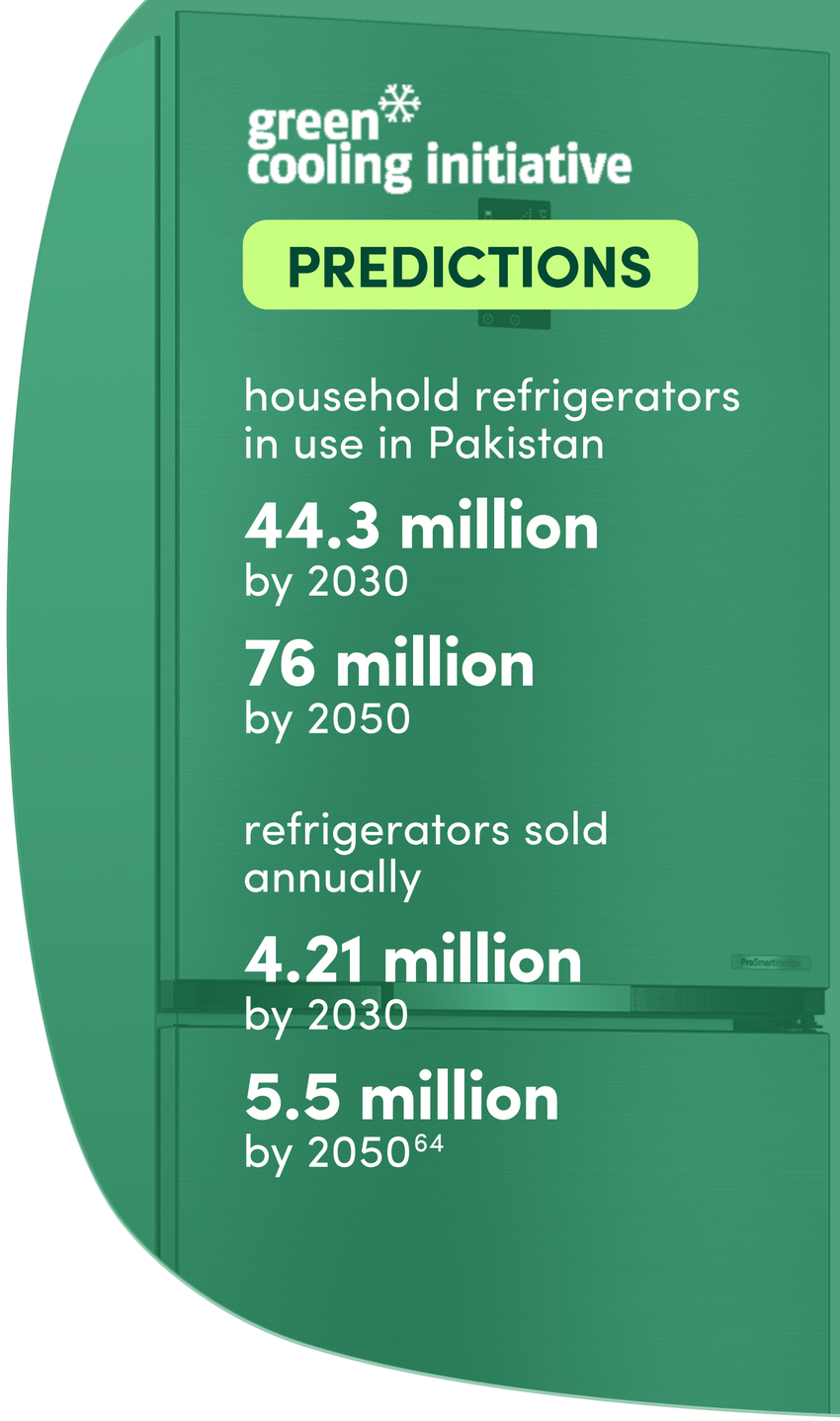
Total emissions from domestic refrigeration in Pakistan are 3.1 Mt, working out as 16.2 kg per capita (rather below the global average of 53 kg per capita). Direct emissions make up 6.5% of this total, while 93% are indirect. That means direct emissions make up only slightly (0.5%) more of total emissions than the global average.

It should be noted that there are countries in the region where direct emissions make up a far higher proportion of the total: in Nepal, for instance, the figure is 92%[63]. In other words, Pakistan's domestic refrigeration sector has a relatively low direct emission impact compared to some neighbouring countries.

THE FUTURE: 2030 AND 2050

Identified drivers of demand for domestic refrigeration – incomes, number of households and access to electricity - are set to grow over the coming years. But there are a few caveats to consider. For one, although incomes are rising, they are rising from a low starting point of 1,597 USD per capita. As noted earlier, although a fridge is often the first electrical appliance a household buys, purchase is more likely once a household earns 10,000 USD or more. Second, incomes are not growing as quickly as they are in other countries and regions.

Despite these caveats, it is safe to assume that the number of domestic refrigerators in Pakistan will grow rapidly over the coming years. A relatively low Gini coefficient means income growth could pull more people into the income bracket in which they buy a refrigerator.



The development implications of this should be celebrated. **It would be particularly beneficial for the development of the country if these fridges were of the type that can stay cool despite power cuts. This capability is vital to keep food fresh and thus reduce food poisoning and waste risk, when the grid fails, as it so often does.**

But we must also consider the problem of energy consumption and carbon emissions. **Under a business-as-usual scenario, the Green Cooling Initiative predicts that indirect emissions in 2030 will be 5.24 Mt, while direct will rise only slightly to 0.476 Mt; by 2050 the prediction is for indirect emissions to rise to 8.13 Mt and direct emissions to rise to 0.555 Mt.** But under a mitigation scenario, total emissions can be cut by 0.49 Mt by 2030 and 1.9 Mt by 2050, the equivalent to taking more than 410,000 cars off the road[65].

One factor that will determine the impact that the growth in refrigerator demand will have on emissions is how the required electricity will be produced – the so-called electricity mix. As things stand, most electricity is derived from non-renewable fossil fuels.

If Pakistan manages to reach its goal of producing 60% of its electricity from renewable sources[60], that will make a major difference to indirect emissions of domestic fridges. But, as discussed, some question this commitment, considering the large-scale construction of new coal-fired power plants, funded by China[67].

Yet whether or not this aim is achieved, it is clear a broad provision of clean, low-energy domestic refrigeration units is required. This would not only help reduce emissions but also cut fridge running costs, an important consideration in a low-income country.

Good News from Pakistan

While Pakistan has many challenges ahead, there are some positive signs that it can rise to them. For example, in October 2021, it announced it will adopt a National Cooling Action Plan by 2026[68]. The plan will likely include Minimum Energy Performance Standards (MEPs) for electrical appliances, including refrigerators. The action plan will aim to increase access to cooling for more than 3 million people residing in off-grid and weak-grid areas across Pakistan[69].

1. Spotlight on: South Africa

South Africa, located at the southern tip of Africa, highlights specific risks and challenges related to its domestic refrigeration question. In contrast to Pakistan, it is a largely urban, upper-middle income country. Yet stark inequality means incomes are not distributed equally and poverty remains widespread. And, although a reasonably large portion of the population has access to electricity, it is both intermittent and highly polluting in its production.

ECONOMY

South Africa has one of the continent's biggest and most developed economies. However, growth has slowed over the last decade, with GDP growing by only 0.1% in 2019, before Covid-19 forced it into negative growth in 2020. While the country saw a post-pandemic recovery, with 1.9% growth in 2022, growth prospects for South Africa remain uncertain[70].

Its GNI per capita is 6,780 USD[71], and it is currently classed as an upper-middle income country[72]. However, analysts say its political and economic outlook means it is at risk of becoming a lower-middle-income nation by 2028[73].

Moreover, incomes are not evenly distributed. South Africa has the highest Gini coefficient in the world. It is afflicted with chronic poverty, home to a few high-income earners and a relatively small middle class. Around one-fifth of the population live below the international poverty line[74].

This economic situation translates into a poor nutritional profile. Around one-fifth of children under five suffer from stunting; 14.2% of infants have a low birth weight; and 3.4% suffer from wasting. Nearly a third (30.5%) of women aged 15 to 49 suffer from iron-deficiency anaemia[75].

DEMOGRAPHY

South Africa has a youthful population, like the rest of the continent. Of its 60 million people, 44% are under the age of 25[76]. Unlike the rest of Africa, however, South Africa is highly urban, with 68% living in urban areas[77]. This growing figure is expected to hit 80% by 2050[78].

Another fast-rising figure is the number of households. There were 18 million households in South Africa in 2021, a number which is likely to rise exponentially as more people choosing to live alone: nearly a quarter (23%) of the total are one person households[79].

ELECTRICITY

The World Bank says 89% of the population has access to electricity[80], leaving 9 million without, a figure which has remained relatively constant over the past decade[81]. But the proportion who have access to reliable electricity is far less. South Africa experiences disruptive bouts of load shedding, a type of scheduled electricity shutdown to relieve pressure and avoid system-wide collapse[82].

The vast share of South Africa's electricity is generated through fossil fuels (87%), mostly coal (86%). Only 13% was produced with low-carbon sources, of which 7.6% is derived from renewables[83]. South Africa is Africa's biggest polluter, and the world's 15th biggest emitter of climate warming gases[84].

DOMESTIC REFRIGERATION

There are 10.1 million domestic fridges in South Africa, up from 7.8 million in 2010[85]. In total, 77% own a fridge, though this figure higher in urban areas (82%) than in rural areas (68%)[86]. Nevertheless, the percentage of the population that owns a fridge is well above sub-Saharan Africa's regional average of 17%, with only 4% for off-grid African households[87].

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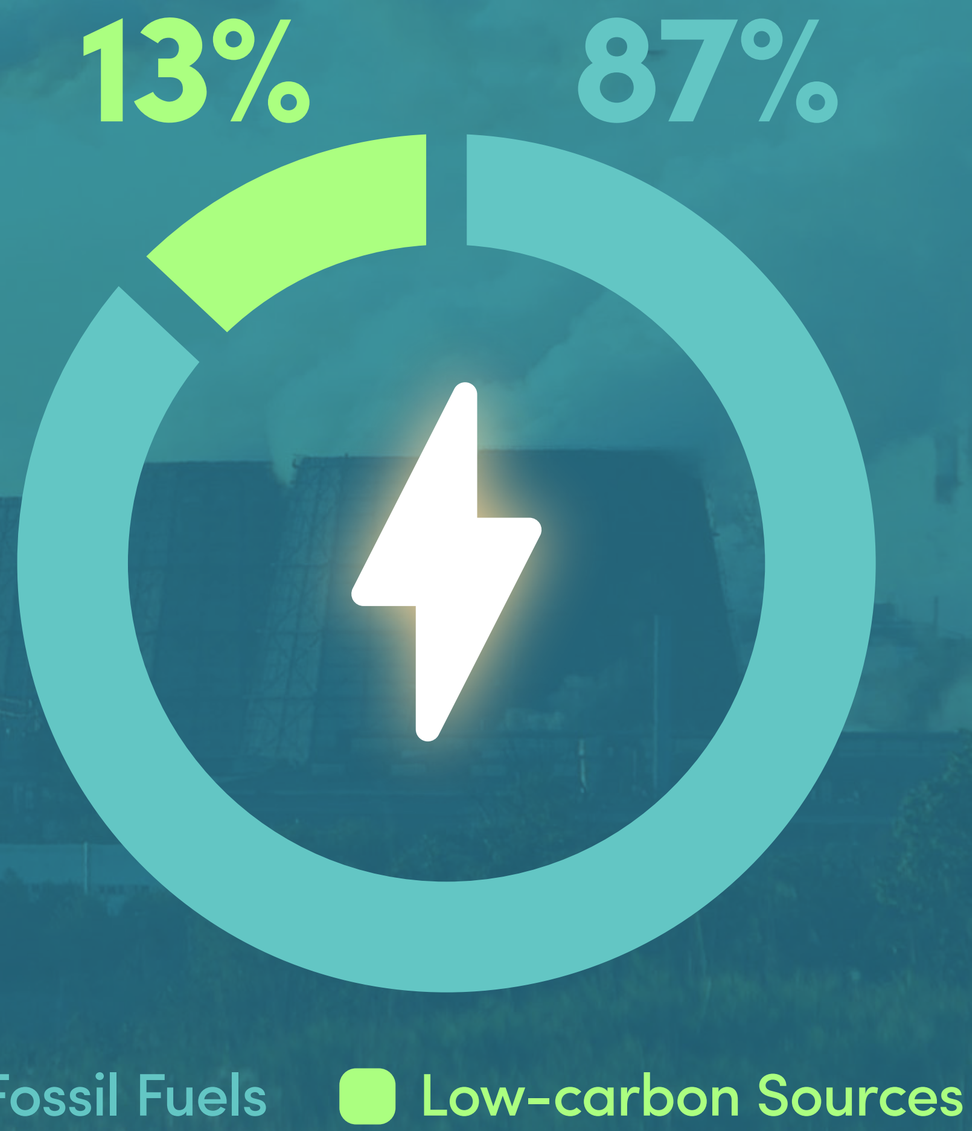


EMISSIONS IN GLOBAL AND REGIONAL CONTEXT

Domestic fridges in South Africa emit 4.7 Mt CO2e in total, or 86.8 kg per capita, of which 97.5% are direct and 2.5% are indirect[88]. A complete regional breakdown of the domestic refrigeration sector in sub-Saharan Africa is not available. However, according to the available data, the direct emissions from refrigerators are likely to be lower than the average of the continent. In Zambia, for example, direct emissions make up nearly 90%[89].

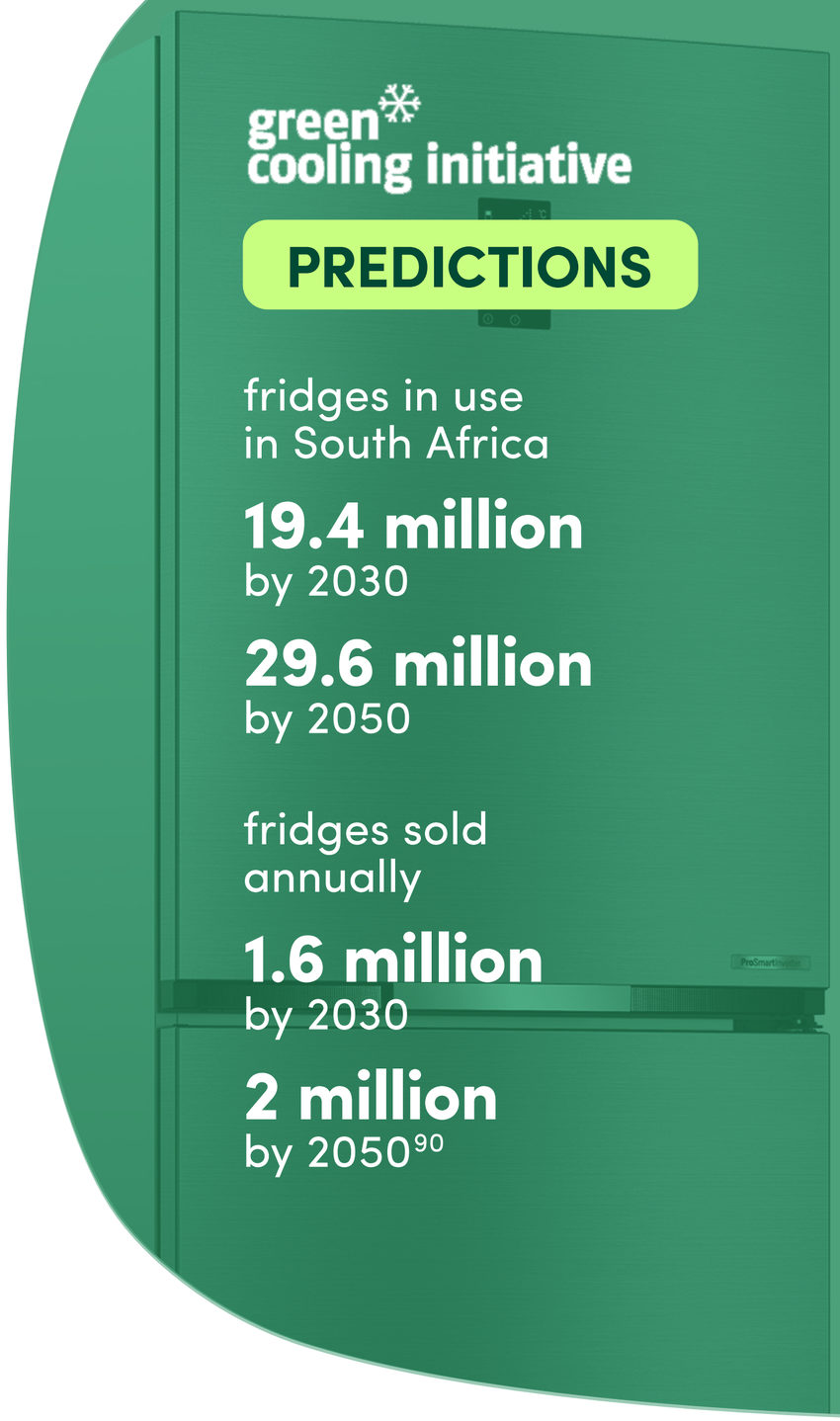
THE FUTURE: 2030 AND 2050

Over the coming years, most of the key indicators that drive refrigerator demand are expected to increase. The number of households, in particular, will likely rise quickly given the youthful and fast-growing population, combined with the prevalence of single-person households. Access to electricity, already reasonably high, especially when considered in regional context, will have to increase if the government is serious about meeting SDG 7 (affordable and clean energy).

Incomes represent a bit more of a question mark. Although GDP is growing, stark inequality means it's unclear how many people will be pulled over the income threshold at which they will choose to buy a fridge. There is also the risk that people are pulled just over this threshold and choose to buy a cheap, inefficient, and polluting fridge.

Yet the many benefits of having a refrigerator, especially for boosting nutrition and reducing the risk of food poisoning, will likely mean the number of fridges will increase dramatically over the coming years. Indeed, by 2030, 19.4 million fridges are estimated to be in use in South Africa, and 29.6 million by 2050, with 1.6 million bought a year by 2030 and 2 million per year by 2050[90].

Currently, South Africa's direct emissions comprise a relatively small proportion of total domestic refrigeration emissions when compared with the region. Yet this could and should still be cut further. According to the Green Cooling Initiative, by 2030 direct emissions could be cut by 0.039 Mt and by 0.209 Mt by 2050.



Indirect emissions from refrigeration are clearly a problem in South Africa, where such a large proportion of its electricity is generated through coal. South Africa's population clearly needs access to affordable, environmentally sound, and energy-efficient fridges that can continue to work with frequent power cuts. Affordable off-grid options also must be available.

If South Africa can pursue a mitigation scenario, it can cut indirect emissions by 0.390 Mt by 2030, and by 1.30 Mt by 2050, compared to a business-as-usual-scenario[91]. In other words, to take the 2050 figure, that is the equivalent of taking more than 282,000 cars off the roads[92].

Good News from South Africa

Following the latest review of MEPs, all refrigerators sold in South Africa will have to meet a minimum energy requirement of A from 2023. Moreover, South Africa published a National Cooling Plan in 2023, which states the requirement will increase to A+ from 2026. It also intends to update energy labelling to include a refrigerant gas indicator icon (good; average; poor). And the government says it will develop a Monitoring, Verification and Enforcement plan to increase compliance with all regulations[93].

Conclusions

Urgent action is required. We face a stark reality: the lives of millions of households, particularly in the Global South, will be improved by access to refrigeration. Without that access, the social and development potential of millions will be stunted. Yet business-as-usual cooling solutions, without innovation and application, will result in significant additional contributions to global emissions.

So how do we achieve sustainable cooling for all?

There are challenges and opportunities for the private sector, policymakers, and public-private collaboration.

Challenging the private sector

The private sector has unique power to harness its efficiency, creativity, nimbleness, and flexibility, and its ability to understand, respond to and influence consumer demand to help solve the refrigeration double-bind. Corporations must also remember that they often have considerable political clout, which they can use for good.

The private sector's unique powers to help solve the refrigeration double-bind.

- **Efficiency**
- **Creativity**
- **Nimbleness**
- **Flexibility**
- **Ability to understand, respond to and influence consumer demand**

Actions that could be taken by corporations include:

1. Committing to R&D to pioneer cost-effective, energy-efficient refrigeration solutions

Many manufacturers are researching and developing low-carbon refrigeration to great success. Some examples are discussed in further detail in the Innovation in Action section.

As companies come up with technologically advanced solutions it is important that they are responsive to local needs and affordability. Partnerships and collaborations with NGOs, research institutions and governments will help manufacturers understand and meet real needs more effectively.

With growing incomes meaning many are on the brink of buying refrigerators, it is imperative that manufacturers ensure that energy-efficient alternatives are no more expensive than regular models. If possible, they should be even less expensive to spur uptake.

As Ray Gluckman, a consultant with over 30 years of experience in refrigeration, energy efficiency and climate change told the Economist Intelligence Unit: "In the US, over the last 30 years, energy used by new domestic refrigerators has more or less halved, but the equipment cost, in real terms, has come down, not gone up. Over time, energy efficiency improvements to devices often get absorbed into the price and the consumer doesn't pay that much for it up front, and saves a lot on electricity costs.[94]" Manufacturers must double-down on ensuring that households in emerging markets have easy, affordable access to these options.

2. Drive behavioural change and build trust with local population

Where models need to be more expensive, a company must be prepared to run a thoughtful campaign that helps people who may well be sceptical understand that an energy efficient fridge will save money in the long term.

Building trust with local populations through effective and honest communication combined with exemplary and honourable behaviour is the best way to achieve this.

3. Advocating for more stringent regulation, contributing to global industry standards

It is no longer acceptable for business to lobby for solely their own interests. As laid out in the UN Guiding Principles on Human Rights: "Just as States should work towards policy coherence, so business enterprises need to strive for coherence between their responsibility to respect human rights and policies and procedures that govern their wider business activities and relationships. This should include, for example, policies and procedures that set financial and other performance incentives for personnel and procurement practices; and lobbying activities where human rights are at stake[95]."

Corporations could advocate for the improvement and enforcement of regulations governing the disposal of refrigerators around the world. They could also push for more ambitious Minimum Energy Performance Standards (MEPS) and mandatory labelling.

Challenging policymakers

International and national governments should make the most of their control over law-making. This responsibility can be influenced by NGOs, who can play an important advocacy role, as well as research institutions, who can provide both detailed technical knowledge as well as broader philosophical questions to provoke change.

1. Enhance and enforce agreements and link funding

The Kigali Amendment to the Montreal Protocol, which sought to phase out HFC use, entered into force in January 2019. Along with the phasing-out of HFCs, parties are also expected to ensure global industry standards to enable the safe introduction of low-GWP alternatives and agree a path to maximise energy efficiency in the transition out of HFCs[96].

Multilateral agencies could link financial assistance to adherence to these policies. And more financial assistance is needed for cooling projects: currently less than 0.1% of international development support goes to cooling[97].

2. National Cooling Action Plans

One positive development is that, since 2018, several countries have developed National Cooling Action Plans (NCAPs), intended to address the cross-cutting nature of cooling. Right now, over 30 NCAPs are at various stages of development around the world[98].

These efforts should be accelerated. Countries that do not currently have NCAPs in place could consider using the Cool Coalition guiding framework, which draws on global best practice. Plans should include ambitious MEPs and labels; research into the costs and benefits of cooling; and solid market assessments. NCAPs can be advanced with governments who can utilise their communications networks to influence choices, drawing on the latest research in behaviour change and behavioural economics, as well as positive examples from other countries further along in the process.

And as governments themselves are major buyers in goods and services, they should commit to purchasing energy-efficient cooling systems with low refrigerant leakage. By doing this they will make a tangible difference and lead by example.

3. Stopping the flow and disposing of wasteful fridges

As outlined, there are significant negative effects of poorly disposed of, or poorly recycled, refrigeration units. But going further, progressive policy options and proactive community engagement in this area could seek to incentivise the transition towards more efficient, more environmentally friendly units through trade-in incentives.

4. Advocacy, research and targeting the poorest

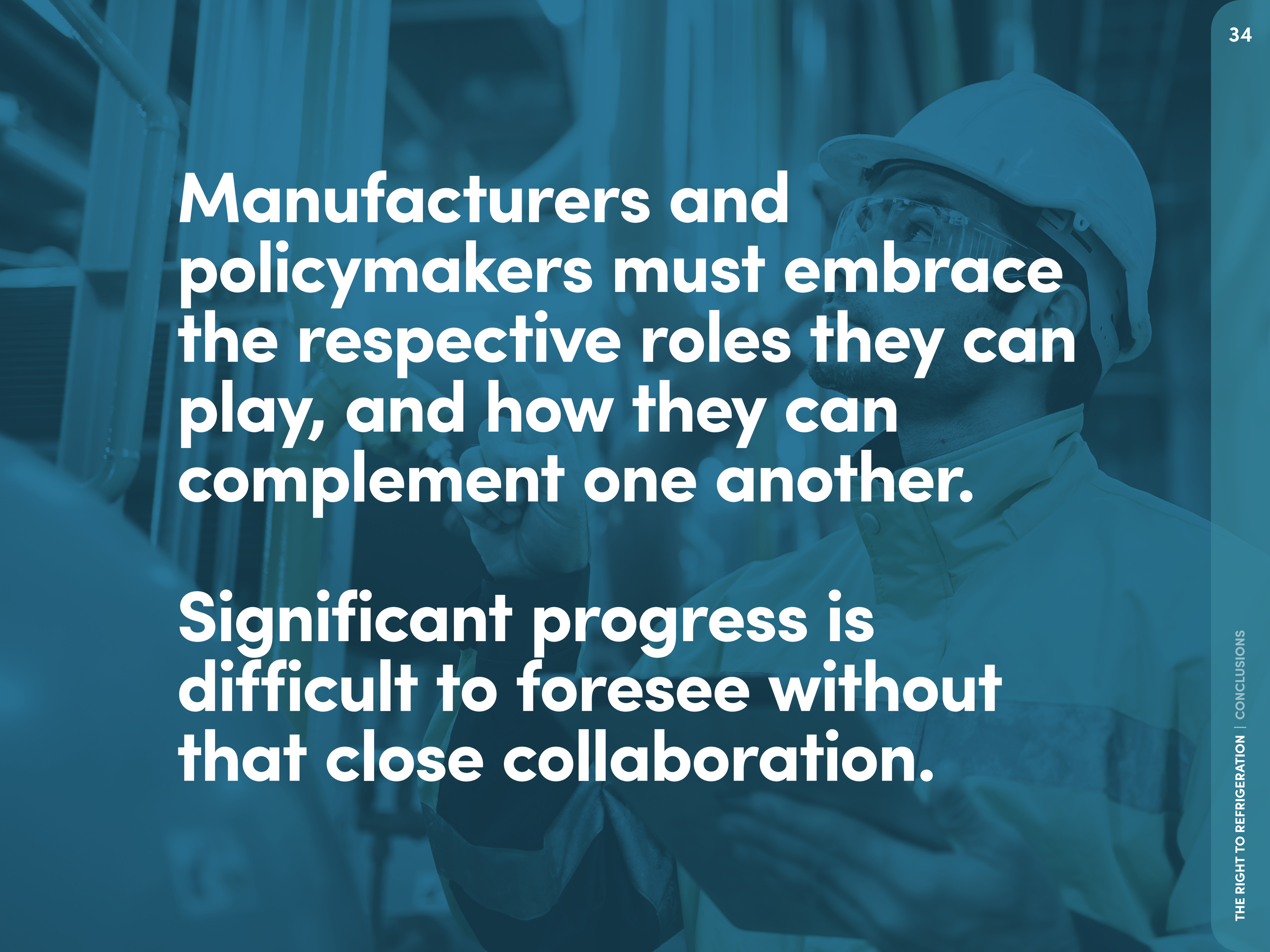
NGOs, with their expertise and grassroots connections, are well placed to work with the poorest and most excluded from cooling. This might be as a partner with corporations and governments, or putting pressure on governments where they are less engaged on these issues.

NGOs are primed for advocacy and to hold governments, the private sector and multilateral organisations to account. They could campaign for greater legislation and enforcement of laws governing HFCs and carbon.

Private and public collaboration

It is imperative that relevant public and private sector actors collaborate to tackle these issues constructively. Manufacturers and policymakers must embrace the respective roles they can play, and how they can complement one another. Significant progress is difficult to foresee without that close collaboration.

One example of such action is:
Working together on maintenance and end-of-life care for domestic refrigeration | Leakages of harmful refrigerants are low in developed countries, but could be as high as 27% in developing countries. This is partly due to poor disposal practices and regulation[99]. The private and public sector should work together to find a way through this difficult problem. To find a way forward, manufacturers and sellers could contribute to national and local government efforts in advisory roles, exploring recycling and circular-economy business models, and advocating for improved regulation that addresses poor disposal practices.



Manufacturers and policymakers must embrace the respective roles they can play, and how they can complement one another.

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Innovation in Action

While we face a difficult road ahead, we can draw encouragement from innovations that are providing solutions. Here, we look at some examples from markets analysed that show cause for optimism.

1. How to collaborate: The Africa Centre for Sustainable Cooling and Cold Chain

! CHALLENGE

The complexities of the global refrigeration challenge cannot be solved by any one player alone. Genuine collaboration is needed.

✔ SOLUTION

The Africa Centre of Excellence for Sustainable Cooling and Cold Chain (ACES) was established in 2020 by the Governments of Rwanda and the United Kingdom, the United Nations Environment Programme's United for Efficiency (U4E) and the Centre for Sustainable Cooling. A consortium of universities is involved, including several British institutions and the University of Rwanda. The centre aims to develop and accelerate the uptake of sustainable cold chain solutions in agriculture and health sectors throughout Africa[100].

The organisation's plan is to connect local and international experts, investors, private companies, farmers' organisations and energy and logistics providers, with a view to collaboratively tackling cold chain issues.

So-called 'Living Laboratories' are being set up to conduct and test research and innovations in real-life settings. Going forward, these laboratories will be rolled out across Africa, both transferring knowledge to local communities and lessons back to ACES in Kigali, Rwanda[101].

2. Help to upgrade appliances: The Rwanda Cooling Finance Initiative

! CHALLENGE

Thousands of refrigerators remain on the market in developing countries that are likely to be energy inefficient and have high leakage rates of damaging chemicals. But replacing them remains financially difficult for many people.

✔ SOLUTION

The Rwanda Cooling Finance Initiative (R-COOL FI) is a financial mechanism where eligible, salaried employees from the public and private sectors can request loans from participating banks to purchase new cooling appliances that adhere to certain strict criteria.

The project aims to provide 4 million USD of credit so that 12,500 energy-efficient and climate-friendly cooling products in Rwanda can be purchased. From that initial phase, if successful, its plan would be to then scale up the project to help more households.

The project is funded by the Clean Cooling Collaborative and the Government of Rwanda. It is also supported by U4E and the Basel Agency for Sustainable Energy[102].

3. Manufacturing innovation: Defy Appliances' Solar Hybrid products

CHALLENGE

Low levels of access to reliable electricity are hampering refrigeration access.

SOLUTION

In 2021, Beko Group company Defy Appliances launched a Solar Hybrid range of products designed for Africa, believing that sustainability and energy efficiency will be critical in supporting the continents development. The products have been created in response to the challenges facing many parts of Africa.

Lack of access to reliable electricity is a particularly intractable problem, with the continent suffering frequent power cuts. Without reliable power, fridges can struggle to maintain constant cooling. Even a short refrigeration outage can mean perishable food is wasted entirely or spoil and cause food poisoning.

Furthermore, the cost of electricity in many countries in Africa continues to increase. In South Africa, for example, the cost has increased by more than 4 times since 2008, far above inflation[103].

Defy appliances have designed a dual-power cooling solution. It can operate on solar power alone when there is sun, cutting electricity bills by up to 44%. The fridge-freezer can operate without solar power too: Defy's unique endura-chill technology keeps the food cool for up to 40 hours in the freezer and 21 hours in the fridge freezer, with no electricity.

With these two unique features, Defy offers a solution for more efficient and reliable cooling, helping consumers to preserve their food for much longer periods, while also cutting their electricity bills, energy consumption and carbon footprint.

Defy's objective is to power homes with the most affordable, versatile, and renewable technology that exists today.

References & Bibliography

REFERENCES

[1] 'World Food Programme', WFP at a Glance (blog), accessed 15 November 2023, https://www.wfp.org/stories/wfp-glance.

[2] FAO, 'Global Agriculture Towards 2050' (Food and Agriculture Organization, 2009), https://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf.

[3] 'Country Data - Green Cooling Initiative', accessed 16 November 2023, https://www.green-cooling-initiative.org/country-data#!country-data-sheet/76/commercial-refrigeration.

[4] Oppelt Dietram, 'Namas in the Refrigeration, Air Conditioning and Foam Sectors. A Technical Handbook.' (Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, October 2013), https://transparency-partnership.net/sites/default/files/u1300/modul2-20131025-web.pdf.

[5] IEA, 'Access to electricity improves slightly in 2023, but still far from the pace needed to meet SDG7' https://www.iea.org/commentaries/access-to-electricity-improves-slightly-in-2023-but-still-far-from-the-pace-needed-to-meet-sdg7

[6] 'Access to Electricity: Data and Projections', International Energy Agency, accessed 21 March 2023, https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity.

[7] John Ayaburi et al., '3.5 Billion People Lack Reliable Power', Energy For Growth, accessed 25 March 2023, https://www.energyforgrowth.org/memo/3-5-billion-people-lack-reliable-power/.

[8] 'Global Greenhouse Gas Emissions from the RAC Sector', Green Cooling Initiative, accessed 21 March 2023, https://www.green-cooling-initiative.org/country-data#!total-emissions/all-sectors/absolute.

[9] 'Global Greenhouse Gas Emissions from the RAC Sector'.

[10] Green Cooling Initiative, 'Global Greenhouse Gas Emissions from the RAC Sector'.

[11] 'Appliances and Equipment Analysis', International Energy Agency, accessed 3 April 2023, https://www.iea.org/reports/appliances-and-equipment.

[12] 'Calculations Based on International Energy Agency Data', 15 December 2023, Source data: https://www.iea.org/reports/appliances-and-equipment.

[13] 'Appliances and Equipment Analysis'.

[14] 'Country Data - Green Cooling Initiative'.

[15] Toby Peters, 'A Cool World: Defining the Energy Conundrum For All', University of Birmingham, 2018, https://www.birmingham.ac.uk/Documents/college-eps/energy/Publications/2018-clean-cold-report.pdf.

[16] Yabin Dong, Marney Coleman, and Shelie Miller, 'Greenhouse Gas Emissions from Air Conditioning and Refrigeration in Developing Countries', Annual Review of Environment and Resources 46, accessed 16 October 2023, https://www.annualreviews.org/doi/10.1146/annurev-environ-012220-034103#:~:text=The%20total%20GHG%20emissions%20associated,1%2C%2049%2C%2050).

[17] Green Cooling Initiative, 'Global Greenhouse Gas Emissions from the RAC Sector'.

[18] Judith Evans, 'Cold Chain Technology Brief: Commercial, Professional and Domestic Refrigeration' (United Nations Environment Programme, Institut International du Froid, 2018), http://www.foodcoldchain.org/wp-content/uploads/2019/03/Commercial-Professional-and-Domestic-Refrigeration.pdf.

[19] Conor Griffin et al., 'The Cooling Imperative: Forecasting the Size and Source of Future Cooling Demand' (The Economist Intelligence Unit, 2019), http://www.eiu.com/graphics/marketing/pdf/TheCoolingImperative2019.pdf.

[20] Birmingham Energy Institute, 'Clean Cold and the Global Goals' (University of Birmingham, n.d.), https://www.birmingham.ac.uk/documents/college-eps/energy/publications/clean-cold-and-the-global-goals.pdf.

[21] IEA, 'Appliances and Equipment Analysis'.

[22] Green Cooling Initiative, 'Global Greenhouse Gas Emissions from the RAC Sector'.

[23] 'Calculations Based on United States Environmental Protection Agency Data', n.d., Source data: https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#:~:text=2%20per%20mile.-,What%20is%20the%20average%20annual%20carbon%20dioxide%20(CO2)%20emissions,of%20CO2%20per%20year.

[24] World Population Review, 'Carbon Footprint by Country 2023', World Population Review, accessed 29 March 2023, https://worldpopulationreview.com/country-rankings/carbon-footprint-by-country.

[25] Chancel, L., 'Climate Change and Global Inequality of Carbon Emissions', World Inequality Lab, October 2021, https://wid.world/document/summary-of-climate-change-the-global-inequality-of-carbon-emissions-1990-2020-study-world-inequality-lab-working-paper-2021-21/

[26] Baker Institute, 'Energy Over the Next 20 Years: It's Not All About the US', Baker Institute, accessed 29 March 2023, https://www.bakerinstitute.org/research/energy-over-next-20-years-its-not-all-about-us.

[27] United States Environmental Protection Agency, 'Recent International Developments Under the Montreal Protocol', Other Policies and Guidance, United States Environmental Protection Agency, 15 July 2015, https://www.epa.gov/ozone-layer-protection/recent-international-developments-under-montreal-protocol.

[28] 'United Nations Treaty Collection', accessed 25 March 2023, https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-2-f&chapter=27&clang=_en.

[29] United Nations Treaty Collection. 'Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer', 'United Nations Treaty Collection'.

[30] IFCO, 'The Ice Revolution and Today's Cold Chain', IFCO Systems, 23 March 2017, https://www.ifco.com/the-ice-revolution-and-todays-cold-chain/.

[31] SEforALL, 'Chilling Prospects: Tracking Sustainable Cooling for All 2022', 2022, https://www.seforall.org/chilling-prospects-2022.

[32] IIF/IIR, 'Annex- The Carbon Footprint of the Cold Chain', 7th Informatory Note on Refrigeration and Food', April 2021, https://iifiir.org/en/fridoc/the-carbon-footprint-of-the-cold-chain-7-lt-sup-gt-th-lt-sup-gt-informatory-143457.

[33] Green Cooling Initiative, 'Global Greenhouse Gas Emissions from the RAC Sector'.

[34] Green Cooling Initiative, IEA, 'Appliances and Equipment – Analysis', IEA, 2022, https://www.iea.org/reports/appliances-and-equipment; 'Global Greenhouse Gas Emissions from the RAC Sector'.

[35] Peters, T., 'A Cooling World: Defining the Energy Conundrum of Cooling for All'

[36] Griffin et al., 'The Cooling Imperative: Forecasting the Size and Source of Future Cooling Demand'.

[37] UNEP, 'Cooling Emissions and Policy Synthesis Report', 2020, accessed 29 March 2023, https://wedocs.unep.org/bitstream/handle/20.500.11822/33094/CoolRep.pdf?sequence=1&isAllowed=y

[38] 'Refrigeration', United for Efficiency, accessed 7 December 2023, https://united4efficiency.org/products/refrigerators/.

[39] UNEP, 'Cooling Emissions and Policy Synthesis Report'.

[40] Peters, T., 'Clean Cooling Landscape Assessment', Heriot-Watt University and University of Birmingham, accessed 12 April 2023, https://www.clean-cooling.ac.uk/resources/CleanCoolingLandscapeAssessment%2012-18.pdf

[41] The World Bank, 'GDP Per Capita: Pakistan', accessed 29 March 2023, https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=PK.

[42] Wisevoter, 'Gini Coefficient by Country 2023', Wisevoter, accessed 27 March 2023, https://wisevoter.com/country-rankings/gini-coefficient-by-country/.

[43] Global Nutrition Report, 'Country Nutrition Profiles: Pakistan', Global Nutrition Report, accessed 27 March 2023, https://globalnutritionreport.org/resources/nutrition-profiles/asia/southern-asia/pakistan/.

[44] 'The World Bank in Pakistan', Text/HTML, World Bank, accessed 27 March 2023, https://www.worldbank.org/en/country/pakistan/overview.

[45] 'Pakistan Floods: One Third of Country Is under Water - Minister', BBC News, 29 August 2022, sec. Asia, https://www.bbc.com/news/world-europe-62712301.

[46] 'Quantifying the Poverty Impact of the 2022 Floods in Pakistan', 18 May 2023, https://blogs.worldbank.org/developmenttalk/quantifying-poverty-impact-2022-floods-pakistan.

[47] UNDOC, 'UNODC: Pakistan Country Profile', accessed 27 March 2023, https://www.unodc.org/pakistan/en/country-profile-pakistan.html.

[48] Shakeel Ahmad, 'Unleashing the Potential of a Young Pakistan', UN Development Program, 24 July 2018, https://hdr.undp.org/content/unleashing-potential-young-pakistan.

[49] The World Bank, 'Rural Population: Pakistan', The World Bank, accessed 27 March 2023, https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=PK.

[50] 'Number of Households in Pakistan', Helgi Library, accessed 27 March 2023, https://www.helgilibrary.com/indicators/number-of-households/pakistan.

[51] Our World in Data, 'The Rise of Living Alone: How One-Person Households Are Becoming Increasingly Common Around the World', Our World in Data, accessed 27 March 2023, https://ourworldindata.org/living-alone.

[52] Hannah Ritchie, Max Roser, and Pablo Rosado, 'Energy', Our World in Data, 27 October 2022, https://ourworldindata.org/energy/country/pakistan.

[53] 'Number of People Without Access to Electricity', Our World in Data, accessed 27 March 2023, https://ourworldindata.org/grapher/people-without-electricity-country.

[54] The World Bank, 'Access to Electricity, Urban: Pakistan', The World Bank, accessed 27 March 2023, https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?locations=PK.

[55] The World Bank, 'Access to Electricity, Rural: Pakistan', The World Bank, accessed 27 March 2023, https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=PK.

[56] Caroline Davies and Tom Spender, 'Pakistan Power Cut: Major Cities Without Electricity After Grid Breakdown', BBC News, 23 January 2023, sec. Asia, https://www.bbc.com/news/world-asia-64369144.

[57] Sudarshan Varadhan, 'Factbox: Why Were Millions of Pakistanis Without Electricity?', Reuters, 23 January 2023, sec. Energy, https://www.reuters.com/business/energy/why-were-millions-pakistanis-without-electricity-2023-01-23/.

[58] Worldometer, 'Pakistan Electricity Statistics', Worldometer, accessed 27 March 2023, https://www.worldometers.info/electricity/pakistan-electricity/.

[59] The Express Tribune, 'Pakistan Aims for 60% Clean Energy by 2030', The Express Tribune, 16 July 2022, https://tribune.com.pk/story/2366224/pakistan-aims-for-60-clean-energy-by-2030.

[60] Green Cooling Initiative, 'Country Data: Pakistan', Green Cooling Initiative, accessed 27 March 2023, https://www.green-cooling-initiative.org/country-data#!country-data-sheet/586/commercial-refrigeration.

[61] Kiran Batool et al., 'Nexus Between Energy Poverty and Technological Innovations: A Pathway for Addressing Energy Sustainability', Frontiers in Environmental Science 10 (2022), https://www.frontiersin.org/articles/10.3389/fenvs.2022.888080.

[62] UNDP, 'GHG Emissions in Pakistan's Refrigeration & Air Conditioning Sector | United Nations Development Programme', UNDP, accessed 27 March 2023, https://www.undp.org/pakistan/publications/ghg-emissions-pakistan%E2%80%99s-refrigeration-air-conditioning-sector.

[63] 'Global Greenhouse Gas Emissions from the RAC Sector'.

[64] Green Cooling Initiative, 'Pakistan: Domestic Refrigeration', Green Cooling Initiative, accessed 25 March 2023, https://www.green-cooling-initiative.org/country-data#!country-data-sheet/586/commercial-refrigeration.

[65] 'Calculations Based on United States Environmental Protection Agency Data'.

[66] Ebrahim, Z. T., 'Pakistan Faces an Unexpected Dilemma: Too Much Electricity', Reuters, 24 February 2021, sec. APAC, https://www.reuters.com/article/us-pakistan-energy-climate-change-featur-idUSKBN2AO27C.

[67] Ebrahim, Z. T., 'Pakistan Faces an Unexpected Dilemma'.

[68] Zofeen Ebrahim, 'How Will Pakistan Stay Cool While Keeping Emissions in Check?', The Third Pole (blog), accessed 26 October 2023, https://www.thethirdpole.net/en/climate/pakistan-cooling-action-plan/#:~:text=In%20October%202021%2C%20in%20its,possible%20impact%20on%20the%20environment".

[69] Lina Kelpsaite and Karishma Joseph, 'Paving Pakistan's Pathway to Efficient Cooling', Clasp: Efficient Appliances for People and Planet (blog), 12 October 2023, https://www.clasp.ngo/updates/paving-pakistans-pathway-to-efficient-cooling/.

[70] The World Bank, 'The World Bank in South Africa', Text/HTML, The World Bank, accessed 27 March 2023, https://www.worldbank.org/en/country/southafrica/overview.

[71] The World Bank, 'GNI Per Capita, USD', The World Bank, accessed 30 March 2023, https://data.worldbank.org/indicator/NY.GNP.PCAP.CD?locations=ZA.

[72] The World Bank, 'GNI Per Capita, PPP: South Africa', The World Bank, accessed 27 March 2023, https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD?locations=ZA.

[73] Antony Sguazzin, 'South Africa Heading for Lower-Middle-Income Status, Model Shows', Bloomberg.Com, 19 November 2021, https://www.bloomberg.com/news/articles/2021-11-19/south-africa-heading-for-lower-middle-income-status-model-shows.

[74] The World Bank, 'Poverty & Equity Brief: South Africa' (The World Bank, 2020), https://databankfiles.worldbank.org/public/ddpext_download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Global_POVEQ_ZAF.pdf.

[75] Global Nutrition Report, 'Country Nutrition Profiles: South Africa', accessed 27 March 2023, https://globalnutritionreport.org/resources/nutrition-profiles/africa/southern-africa/south-africa/.

[76] Statista, 'South Africa: Population, by Age Group 2022', Statista, accessed 27 March 2023, https://www.statista.com/statistics/1116077/total-population-of-south-africa-by-age-group/.

[77] The World Bank, 'Urban Population: South Africa', accessed 27 March 2023, https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=ZA.

[78] UN Habitat, 'Urbanization in South Africa: Building Inclusive & Sustainable Cities', UN Habitat, accessed 27 March 2023, https://unhabitat.org/south-africa.

[79] Statistics South Africa, 'What Do South African Households Look Like?', 23 June 2022, https://www.statssa.gov.za/?p=15473.

[80] The World Bank, 'Access to Electricity: South Africa', The World Bank, accessed 27 March 2023, https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZA.

[81] Our World in Data. 'Number of People Without Access to Electricity'.

[82] Pumza Fihlani, 'South Africa's Minister of Electricity: Can Ramokgopa End Load-Shedding?', BBC News, 7 March 2023, sec. Africa, https://www.bbc.com/news/world-africa-64874059

[83] Hannah Ritchie, Max Roser, and Pablo Rosado, 'Energy Country Profile: South Africa', Our World in Data, 27 October 2022, https://ourworldindata.org/energy/country/south-africa.

[84] Global Carbon Atlas, 'Global Carbon Atlas', accessed 27 March 2023, http://www.globalcarbonatlas.org/en/content/welcome-carbon-atlas.

[85] Green Cooling Initiative, 'Global Greenhouse Gas Emissions from the RAC Sector'.

[86] James de Villiers, 'Almost a Third of South African Households Now Own Their Own Cars', News24, accessed 27 March 2023, https://www.news24.com/news24/bi-archive/general-household-survey-2018-south-african-households-third-own-cars-electrical-stoves-2019-5.

[87] Efficiency for Access, 'Advancing Access to Cooling in a Warming World', Efficiency for Access, accessed 27 March 2023, https://impact.efficiencyforaccess.org/.

[88] Green Cooling Initiative, 'Global Greenhouse Gas Emissions from the RAC Sector'.

[89] 'Global Greenhouse Gas Emissions from the RAC Sector'.

[90] Green Cooling Initiative, 'Global Greenhouse Gas Emissions from the RAC Sector'.

[91] 'Global Greenhouse Gas Emissions from the RAC Sector'.

[92] 'Calculations Based on United States Environmental Protection Agency Data'.

[93] 'South Africa National Cooling Plan' (The Government of South Africa, 2023), https://eta-publications.lbl.gov/sites/default/files/sa_ncp_full_report_2023.pdf.

[94] Griffin et al., 'The Cooling Imperative: Forecasting the Size and Source of Future Cooling Demand'.

[95] United Nations Human Rights Office of the High Commissioner, 'Guiding Principles on Business and Human Rights' (New York and Geneva: United Nations Human Rights Office of the High Commissioner, 2011), https://www.ohchr.org/sites/default/files/documents/publications/guidingprinciplesbusinesshr_en.pdf.

[96] Fluorocarbons, 'Regulations Affecting HFCs', Fluorocarbons, accessed 3 April 2023, https://www.fluorocarbons.org/regulation/regulations-affecting-hfcs/.

[97] 'Cooling for All – the 18th Sustainable Development Goal | Climate & Clean Air Coalition', accessed 20 November 2023, https://www.ccacoalition.org/news/cooling-all-18th-sustainable-development-goal.

[98] SEforAll, 'Chilling Prospects 2022: The Role of National Cooling Action Plans in Delivering the Global Environment Agenda', Sustainable Energy for All, 22 June 2022, https://www.seforall.org/data-stories/role-of-national-cooling-action-plans.

[99] Evans, 'Cold Chain Technology Brief: Commercial, Professional and Domestic Refrigeration'.

[100] Africa Centre of Excellence for Sustainable Cooling and Cold Chain, 'Cooling Africa', accessed 4 April 2023, https://coolingafrica.org/.

[101] Africa Centre of Excellence for Sustainable Cooling and Cold Chain, 'Summit on ACES and Living Laboratories' (Africa Centre for Sustainable Cooling, n.d.).

[102] United for Efficiency, 'United for Efficiency: Rwanda', United for Efficiency, accessed 4 April 2023, https://united4efficiency.org/country-regional-activities/rwanda/.

[103] Sean Moolman, '2022 Update: Eskom Tariff Increases vs Inflation since 1988 (with Projections to 2024) - PowerOptimal - the Future of Energy', 1 August 2021, https://poweroptimal.com/2021-update-eskom-tariff-increases-vs-inflation-since-1988/.

BIBLIOGRAPHY

Africa Centre of Excellence for Sustainable Cooling and Cold-Chain . 'Cooling Africa'. Accessed 4 April 2023. https://coolingafrica.org/.

Africa Centre of Excellence for Sustainable Cooling and Cold-Chain. 'Summit on ACES and Living Laboratories'. Africa Centre for Sustainable Cooling, n.d.Africa, Statistics South. 'What Do South African Households Look Like?', 23 June 2022. https://www.statssa.gov.za/?p=15473.

Ahmad, Shakeel. 'Unleashing the Potential of a Young Pakistan'. UN Development Program, 24 July 2018. https://hdr.undp.org/content/unleashing-potential-young-pakistan.

Ayaburi, John, Morgan Bazilian, Jacob Kincer, and Todd Moss. '3.5 Billion People Lack Reliable Power'. Energy For Growth. Accessed 25 March 2023. https://www.energyforgrowth.org/memo/3-5-billion-people-lack-reliable-power/.

Baker Institute. 'Energy Over the Next 20 Years: It's Not All About the US'. Accessed 29 March 2023. https://www.bakerinstitute.org/research/energy-over-next-20-years-its-not-all-about-us.

Batool, Kiran, Zhen-Yu Zhao, Faraz Atif, and Azer Dilanchiev. 'Nexus Between Energy Poverty and Technological Innovations: A Pathway for Addressing Energy Sustainability'. Frontiers in Environmental Science 10 (2022). https://www.frontiersin.org/articles/10.3389/fenvs.2022.888080.

BBC News. 'Pakistan Floods: One Third of Country Is under Water - Minister'. 29 August 2022, sec. Asia. https://www.bbc.com/news/world-europe-62712301.

'Calculations Based on International Energy Agency Data', 15 December 2023. Source data: https://www.iea.org/reports/appliances-and-equipment.

'Calculations Based on United States Environmental Protection Agency Data', n.d. Source data: https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#:~:text=2%20per%20mile.-,What%20is%20the%20average%20annual%20carbon%20dioxide%20(CO2)%20emissions,of%20CO2%20per%20year.

'Clean Cold and the Global Goals'. University of Birmingham, n.d. https://www.birmingham.ac.uk/documents/college-eps/energy/publications/clean-cold-and-the-global-goals.pdf.

'Cooling Africa'. Accessed 4 April 2023. https://coolingafrica.org/.

'Cooling for All – the 18th Sustainable Development Goal | Climate & Clean Air Coalition'. Accessed 20 November 2023. https://www.ccacoalition.org/news/cooling-all-18th-sustainable-development-goal.

'Country Data - Green Cooling Initiative'. Accessed 16 November 2023. https://www.green-cooling-initiative.org/country-data#!country-data-sheet/76/commercial-refrigeration.

'Country Nutrition Profiles: South Africa'. Accessed 27 March 2023. https://globalnutritionreport.org/resources/nutrition-profiles/africa/southern-africa/south-africa/.

Davies, Caroline, and Tom Spender. 'Pakistan Power Cut: Major Cities Without Electricity After Grid Breakdown'. BBC News, 23 January 2023, sec. Asia. https://www.bbc.com/news/world-asia-64369144.

Dietram, Oppelt. 'Namas in the Refrigeration, Air Conditioning and Foam Sectors. A Technical Handbook.' Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, October 2013. https://transparency-partnership.net/sites/default/files/u1300/modul2-20131025-web.pdf.

Dong, Yabin, Marney Coleman, and Shelie Miller. 'Greenhouse Gas Emissions from Air Conditioning and Refrigeration in Developing Countries'. Annual Review of Environment and Resources 46. Accessed 16 October 2023. https://www.annualreviews.org/doi/10.1146/annurev-environ-012220-034103#:~:text=The%20total%20GHG%20emissions%20associated,1%2C%2049%2C%2050).

Ebrahim, Zofeen. 'How Will Pakistan Stay Cool While Keeping Emissions in Check?' The Third Pole (blog). Accessed 26 October 2023. https://www.thethirdpole.net/en/climate/pakistan-cooling-action-plan/#:~:text=In%20October%202021%2C%20in%20its,possible%20impact%20on%20the%20environment".

Efficiency for Access. 'Advancing Access to Cooling in a Warming World'. Accessed 27 March 2023. https://impact.efficiencyforaccess.org/.
Evans, Judith. 'Cold Chain Technology Brief: Commercial, Professional and Domestic Refrigeration'. United Nations Environment Programme, Institut International du Froid, 2018. http://www.foodcoldchain.org/wp-content/uploads/2019/03/Commercial-Professional-and-Domestic-Refrigeration.pdf.
Fihlani, Pumza. 'South Africa's Minister of Electricity: Can Ramokgopa End Load-Shedding?' BBC News, 7 March 2023, sec. Africa. https://www.bbc.com/news/world-africa-64874059.
Fluorocarbons. 'Regulations Affecting HFCs'. Accessed 3 April 2023. https://www.fluorocarbons.org/regulation/regulations-affecting-hfcs/.
'GDP Per Capita: Pakistan'. Accessed 29 March 2023. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=PK.
'Global Agriculture Towards 2050'. Food and Agriculture Organization, 2009. https://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf.
'Global Carbon Atlas'. Accessed 27 March 2023. http://www.globalcarbonatlas.org/en/content/welcome-carbon-atlas.
Global Nutrition Report. 'Country Nutrition Profiles: Pakistan'. Accessed 27 March 2023. https://globalnutritionreport.org/resources/nutrition-profiles/asia/southern-asia/pakistan/.
Green Cooling Initiative. 'Country Data: Pakistan'. Accessed 27 March 2023. https://www.green-cooling-initiative.org/country-data#!country-data-sheet/586/commercial-refrigeration.
Green Cooling Initiative. 'Global Greenhouse Gas Emissions from the RAC Sector'. Accessed 21 March 2023. https://www.green-cooling-initiative.org/country-data#!total-emissions/all-sectors/absolute.
Green Cooling Initiative. 'Pakistan: Domestic Refrigeration'. Accessed 25 March 2023. https://www.green-cooling-initiative.org/country-data#!country-data-sheet/586/commercial-refrigeration.
Griffin, Conor, Diana Fisher, Haider Syedah, Eve Labalme, Devika Saini, Sara Constantino, Vidhi Garg, et al. 'The Cooling Imperative: Forecasting the Size and Source of Future Cooling Demand'. The Economist Intelligence Unit, 2019. http://www.eiu.com/graphics/marketing/pdf/TheCoolingImperative2019.pdf.
'Guiding Principles on Business and Human Rights'. New York and Geneva: United Nations Human Rights Office of the High Commissioner, 2011. https://www.ohchr.org/sites/default/files/documents/publications/guidingprinciplesbusinesshr_en.pdf.
Helgi Library. 'Number of Households in Pakistan'. Accessed 27 March 2023. https://www.helgilibrary.com/indicators/number-of-households/pakistan.
IEA. 'Appliances and Equipment – Analysis'. IEA, 2022. https://www.iea.org/reports/appliances-and-equipment.
IFCO. 'The Ice Revolution and Today's Cold Chain'. IFCO Systems, 23 March 2017. https://www.ifco.com/the-ice-revolution-and-todays-cold-chain/.
IIF/IIR. 'Annex- The Carbon Footprint of the Cold Chain', 7th Informatory Note on Refrigeration and Food', April 2021. https://iifiir.org/en/fridoc/the-carbon-footprint-of-the-cold-chain-7-lt-sup-gt-th-lt-sup-gt-informatory-143457.
International Energy Agency. 'Access to Electricity: Data and Projections'. Accessed 21 March 2023. https://www.iea.org/reports/sdg7-data-and-projections/access-to-electricity.
International Energy Agency. 'Appliances and Equipment Analysis'. Accessed 3 April 2023. https://www.iea.org/reports/appliances-and-equipment.
Kelpsaite, Lina, and Karishma Joseph. 'Paving Pakistan's Pathway to Efficient Cooling'. Clasp: Efficient Appliances for People and Planet (blog), 12 October 2023. https://www.clasp.ngo/updates/paving-pakistans-pathway-to-efficient-cooling/.
Moolman, Sean. '2022 Update: Eskom Tariff Increases vs Inflation since 1988 (with Projections to 2024) - PowerOptimal - the Future of Energy', 1 August 2021. https://poweroptimal.com/2021-update-eskom-tariff-increases-vs-inflation-since-1988/.
Our World in Data. 'Number of People Without Access to Electricity'. Accessed 27 March 2023. https://ourworldindata.org/grapher/people-without-electricity-country.
Our World in Data. 'The Rise of Living Alone: How One-Person Households Are Becoming Increasingly Common Around the World'. Accessed 27 March 2023. https://ourworldindata.org/living-alone.
Peters, Toby. 'A Cool World: Defining the Energy Conundrum For All'. University of Birmingham, 2018. https://www.birmingham.ac.uk/Documents/college-eps/energy/Publications/2018-clean-cold-report.pdf.

'Poverty & Equity Brief: South Africa'. The World Bank, 2020. https://databankfiles.worldbank.org/public/ddpext_download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Global_POVEQ_ZAF.pdf.
'Quantifying the Poverty Impact of the 2022 Floods in Pakistan', 18 May 2023. https://blogs.worldbank.org/developmenttalk/quantifying-poverty-impact-2022-floods-pakistan.
Reuters. 'Pakistan Faces an Unexpected Dilemma: Too Much Electricity'. 24 February 2021, sec. APAC. https://www.reuters.com/article/us-pakistan-energy-climate-change-featur-idUSKBN2AO27C.
Ritchie, Hannah, Max Roser, and Pablo Rosado. 'Energy'. Our World in Data, 27 October 2022. https://ourworldindata.org/energy/country/pakistan.
———. 'Energy Country Profile: South Africa'. Our World in Data, 27 October 2022. https://ourworldindata.org/energy/country/south-africa.
SEforALL. 'Chilling Prospects: Tracking Sustainable Cooling for All 2022', 2022. https://www.seforall.org/chilling-prospects-2022.
Sguazzin, Antony. 'South Africa Heading for Lower-Middle-Income Status, Model Shows'. Bloomberg.Com, 19 November 2021. https://www.bloomberg.com/news/articles/2021-11-19/south-africa-heading-for-lower-middle-income-status-model-shows.
'South Africa National Cooling Plan'. The Government of South Africa, 2023. https://eta-publications.lbl.gov/sites/default/files/sa_ncp_full_report_2023.pdf.
Statista. 'South Africa: Population, by Age Group 2022'. Accessed 27 March 2023. https://www.statista.com/statistics/1116077/total-population-of-south-africa-by-age-group/.
'Summit on ACES and Living Laboratories'. Africa Centre for Sustainable Cooling, n.d.
Sustainable Energy for All. 'Chilling Prospects 2022: The Role of National Cooling Action Plans in Delivering the Global Environment Agenda', 22 June 2022. https://www.seforall.org/data-stories/role-of-national-cooling-action-plans.
The Express Tribune. 'Pakistan Aims for 60% Clean Energy by 2030', 16 July 2022. https://tribune.com.pk/story/2366224/pakistan-aims-for-60-clean-energy-by-2030.
The World Bank. 'Access to Electricity, Rural: Pakistan'. Accessed 27 March 2023. https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=PK.
The World Bank. 'Access to Electricity: South Africa'. Accessed 27 March 2023. https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZA.
The World Bank. 'Access to Electricity, Urban: Pakistan'. Accessed 27 March 2023. https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?locations=PK.
The World Bank. 'GNI Per Capita, PPP: South Africa'. Accessed 27 March 2023. https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD?locations=ZA.
The World Bank. 'GNI Per Capita, USD'. Accessed 30 March 2023. https://data.worldbank.org/indicator/NY.GNP.PCAP.CD?locations=ZA.
The World Bank. 'Rural Population: Pakistan'. Accessed 27 March 2023. https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS?locations=PK.
The World Bank. 'The World Bank in South Africa'. Text/HTML. Accessed 27 March 2023. https://www.worldbank.org/en/country/southafrica/overview.
UN Habitat. 'Urbanization in South Africa: Building Inclusive & Sustainable Cities'. Accessed 27 March 2023. https://unhabitat.org/south-africa.
UNDP. 'GHG Emissions in Pakistan's Refrigeration & Air Conditioning Sector | United Nations Development Programme'. Accessed 27 March 2023. https://www.undp.org/pakistan/publications/ghg-emissions-pakistan%E2%80%99s-refrigeration-air-conditioning-sector.
United for Efficiency. 'Refrigeration'. Accessed 7 December 2023. https://united4efficiency.org/products/refrigerators/.
United for Efficiency. 'United for Efficiency: Rwanda'. Accessed 4 April 2023. https://united4efficiency.org/country-regional-activities/rwanda/.
'United Nations Treaty Collection'. Accessed 25 March 2023. https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-2-f&chapter=27&clang=_en.
United States Environmental Protection Agency. 'Recent International Developments Under the Montreal Protocol'. Other Policies and Guidance, 15 July 2015. https://www.epa.gov/ozone-layer-protection/recent-international-developments-under-montreal-protocol.
'UNODC: Pakistan Country Profile'. Accessed 27 March 2023. https://www.unodc.org/pakistan/en/country-profile-pakistan.html.
'Urban Population: South Africa'. Accessed 27 March 2023. https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=ZA.
Varadhan, Sudarshan. 'Factbox: Why Were Millions of Pakistanis Without Electricity?' Reuters, 23 January 2023, sec. Energy. https://www.reuters.com/business/energy/why-were-millions-pakistanis-without-electricity-2023-01-23/.
Villiers, James de. 'Almost a Third of South African Households Now Own Their Own Cars'. News24. Accessed 27 March 2023. https://www.news24.com/news24/bi-archive/general-household-survey-2018-south-african-households-third-own-cars-electrical-stoves-2019-5.

WFP at a Glance. 'World Food Programme'. Accessed 15 November 2023. https://www.wfp.org/stories/wfp-glance.
Wisevoter. 'Gini Coefficient by Country 2023'. Accessed 27 March 2023. https://wisevoter.com/country-rankings/gini-coefficient-by-country/.
World Bank. 'The World Bank in Pakistan'. Text/HTML. Accessed 27 March 2023. https://www.worldbank.org/en/country/pakistan/overview.
World Population Review. 'Carbon Footprint by Country 2023'. Accessed 29 March 2023. https://worldpopulationreview.com/country-rankings/carbon-footprint-by-country.
Worldometer. 'Pakistan Electricity Statistics'. Accessed 27 March 2023. https://www.worldometers.info/electricity/pakistan-electricity/.

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