



Q&A: We need to think differently about how we cool things down

The ability to keep food, medicines, vaccines and our buildings cool underpins much of our modern way of life, but it is also a major source of greenhouse gas emissions. If the world is to meet its development goals and climate change targets over the coming decades, we need to rethink how we keep things cold, says Professor Toby Peters, an expert in the cold economy at the University of Birmingham in the UK.

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What is the 'cold chain' and why is it important?

Vaccines and medicines in hospitals, along with much of the food we buy from supermarkets, get to these places through a long logistics chain that is temperature controlled. It is not just cold storage, but all of the elements – from a farm, for example, right through to the refrigerator in our homes – and how they work together seamlessly to keep food fresh. As soon as food is harvested, it is essentially dying, so keeping it cool helps to slow down that process. I found it very concerning when everyone was talking about developing vaccines against Covid-19 in February and March 2020, but no one was talking about how to deliver it and keep

it cold.

What are the consequences of an inadequate cold chain?

In Africa and India about 25% of vaccines are lost due to broken cold chains. There is no point having expensive temperature-controlled processes to deliver a vaccine when for the final couple of miles to a clinic, it is put in a bag on the back of a bike and it spoils. All that effort and energy earlier in the chain is wasted. When we are talking about the kind of volumes needed for the Covid-19 vaccinations, 25% is pretty important. Likewise, in Africa, they can lose 40% of food due to inadequate cold chains.

What are the problems that you think need to be fixed?

The real challenge is how do we ensure cold chains are resilient while also meeting the [net-zero targets](#) on carbon emissions needed to tackle climate change? The cold chain today is very dependent on diesel and fossil fuels to drive the cooling demand of a warehouse and in the vehicles moving everything around. And while the diesel engines that drive refrigerated trucks have to meet stringent emissions standards in Europe, the refrigeration unit on the back also runs on diesel and is relatively unregulated by comparison. Yet it accounts for about [12%-20% of the energy consumption](#) of that vehicle, and [six times more nitrogen oxide emissions and 29 times more particulate matter](#) than the engine pulling it around.

There is actually little really good data about what the direct emissions of the cold chain are, and that is part of what my colleagues and I are trying to understand through our research. But (emissions) exist on a number of levels. Food wastage is a huge source of unnecessary emissions. About [1.3 billion tonnes](#) of edible food is lost or wasted each year – think of all the resources that went into producing and transporting that. It is responsible for about [4.4 gigatonnes](#) of carbon dioxide each year, and around [1 gigatonne](#) of that is due to a lack of cold chain. In the developing world, this is a particular cause of food loss.



In Africa and India about 25% of vaccines are lost due to broken cold chains, says cold economy expert Prof. Toby Peters. Image credit - Toby Peters

How is the demand for cooling likely to rise in the future?

Cooling currently accounts for about [7% of global greenhouse gas emissions](#). As many parts of the world become wealthier, that is being accompanied by [a massive, rapid growth in demand for air conditioning and refrigeration](#). At the same time, as global temperatures increase due to climate change, there is going to be more and more need for cooling. And it is not something we can do without, as without it we lose food, we lose productivity when it is too hot. Even cows produce less milk when they overheat, so need to be kept in air-conditioned facilities in some parts of the world.

What's the solution?

It is going to need a different way of thinking. Generally, when we talk about green energy, we mean electricity. But cooling is really a thermal energy issue – we don't necessarily need to convert energy to electricity to cool things down. What is the point of charging up a battery with solar energy to run a fridge through the night, when you can just freeze a block of ice and use that to keep your fridge cool?

There are large amounts of low-grade waste heat from industry, for example, that could be used to enhance cooling with the help of [absorption chillers](#) (which refrigerate through a sudden change of pressure, driven by heat).

Refrigeration units also produce a lot of heat out of the back end, and that could be used to provide hot water and heating for nearby buildings. Buildings and systems can also be designed better to mitigate the need for cooling. A good example of this is a project in Africa set up by a drone company called Zipline to deliver blood to rural clinics. They have a central warehouse where they store the blood, it is taken out of the chiller, put into an insulated pack and flown to the location in 20 minutes and parachuted down. It has negated the need for refrigerated transport vehicles to be driving along the uneven roads for hours.

It is about changing the way our systems work and this is what is known as the [cold economy](#) – making the cooling systems and business models we use as efficient as possible.

So how might the cold economy work?

What is important to remember here is that there isn't going to be a single panacea solution. We are going to need a portfolio of solutions that have strengths and weaknesses depending on their use. Running refrigerated transport on batteries, for example, isn't necessarily the optimum solution.

One alternative is to use liquid air. I am one of the co-inventors of [liquid air energy storage](#), which means renewable energy can be used to cool air to the point where it turns into a liquid and is currently used as large scale energy storage. When you expose the liquid air to ambient temperatures again, you get a rapid expansion, producing a high-pressure gas that can drive a turbine or a piston in an engine. The cold can also be cycled back to the liquidation end to increase efficiency.

If you were to put this into something like a transport refrigeration unit (as a [Dearman engine](#) that uses the expanding gas to move a piston), you can use the liquid air to drive the vehicle, harnessing the cold and power to keep the stuff in the back cool. This is something we have been exploring as part of the [CryoHub project](#), which is led by Professor Judith Evans at London South Bank University.

What are you hoping to do with CryoHub?

The aim is to put liquid air energy storage to work in a supermarket refrigerated warehouse, so CryoHub was investigating the potential to do this on a large scale. It installed a demonstrator at a cold storage warehouse in Lommel, Belgium, and that is now being tested to see how it performs. But if it is successful, there are [more than 1,000 sites across the EU](#) and UK that could have a system like this integrated into their cold storage warehouses.

Are there things that could be done more immediately?

We could take the example of liquid natural gas – the gas is taken out of the ground, cooled to -162°C to make it easier to transport and then shipped around the world. When it reaches its destination it is heated again (to

turn it back into gas), and all that cold is discarded into the sea. We are theoretically throwing away billions of Euros (worth) of cooling, as well as burning fossil fuels to create electricity to drive cooling systems. We could use that cold by transferring it to other cooling systems (in warehouses or data centres) or use it to create district cooling systems (where cold is piped into homes in a nearby community) and so reduce the demand for electricity to run air conditioners.

What's stopping us?

It's not all about the technology. A lot of it is about behaviour and the way cooling is approached. One of the biggest problems is getting all parts of the system working together so that temperature management is seamless. For food, it has to work from the field, to the packhouse, to the retailer and into our homes.

But we are also facing a lack of skills and training in many parts of the world. By simply cleaning and maintaining existing refrigeration systems, we could often deliver a 25% increase in energy efficiency (compared to unmaintained equipment). And as we move towards more cooling to meet demand and new types of systems, we are going to need more skilled people able to manage the new technologies.

Governments are also going to need to start thinking about how they can build more integrated and resilient cold chains. At the moment it is mainly left up to industry and most people are largely blind to the cold chain despite how important it is for a resilient society.

What impact could a better cold economy have?

For me, the reason why this is really important is when you think about the three big goals the world has set itself. There are the [UN Sustainable Development Goals](#), the [Paris Agreement](#) on climate change and the [Montreal Protocol](#), along with the [Kigali Amendment](#), on refrigerant use. The cold chain underpins all of them. If you want to feed the world, you need more resilient food supplies that can deliver food and reduce waste. Less waste means less water is being used and fewer resources, while farmers' incomes increase. Equally, if you can keep medicines and vaccines at the right temperature up to the moment they are delivered, you can improve health. Then there is the impact of the cold chain on the climate – all the energy used and emissions that come from burning fossil fuels to keep them running. And finally, the refrigerants themselves are also potent greenhouse gases. If we want to meet these goals, then solving the problems of the cold chain is going to be essential.

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