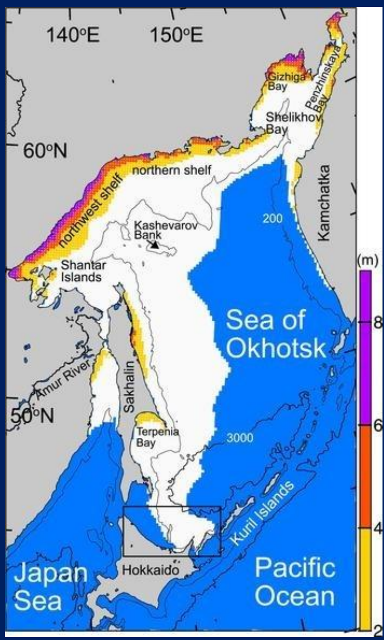
Refreeze the Arctic

A Short Story

A bold plan to refreeze the Arctic

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After the meeting, we went to the little bar downstairs, an old-fashioned Japanese place, like Midnight Diner.

We had been watching and discussing a presentation from the Cambridge Centre for Climate Repair about the melting of the arctic and a sense of doom filled the air.

After the first beer, a short, older man with glasses approached me and asked for a word.

'What would YOU do about this, if you could?'

Emboldened by Sapporo, I ran our dream scheme past him.
He asked a few questions. We pulled up a map. Sat at the bar & ordered more beer.

Coming up to midnight, I'd missed the last train & was wondering where to crash for the night.

Ito San, for that was his name, had gone for a leak, and had urged me to wait.

There were 4 of us sat at the corner of the bar, waiting and finishing off the wasabi nuts.

When he returned, slightly unsteady on his feet, he sat down and considered each of us in turn, in silence.

After a long moment, he said, 'I will pay'

We started to thank him for the beer & his hospitality, and he said,
'no, no, no', 'I will pay for your magnificent plan.'
'It is November.'
'Can we have everything in place for February?'

So here we are, in northern Hokkaido.

We'd been worrying about the weather forecast, but of course, climate change can bring cold weather forward as well as back.

It has been freezing here for 2 weeks already. It's minus 20 today. The Okhotsk sea ice is due to arrive tomorrow.

All the equipment is set, and we are beyond excitement to start the work.

Ito San is here, with his entourage and a camera crew to record the start of the work. The camera crew will remain with us for the 2 months of planned work.

Ito industries have arranged all of the equipment and we have developed a series of scientific experiments which will explore our hypothesis.

The idea is simple.

The Arctic ice is melting.

In order to help manage climate change, we need to manage the melting of the ice.

We will do that by simply making lots more ice – and we will do that by spraying huge volumes of sea water into freezing air and making new sea ice.

Ito San has hired us an ice breaking tug, a crew and a series of water cannon, snow machines and other high power pumps with which to do the experiments.

Ito San has been remarkably helpful, popping up at unexpected times while we made the arrangements.
He said last week 'This is the most fun I have ever had spending a million dollars – and I can get most of it back as a tax rebate! – I'm almost embarrassed to reclaim it from the government!'
We have found that most people have bent over backwards to help us – pleased at the prospect of being involved in something that can actually make a difference to the climate crisis.

We are in Hokkaido because, for 2 months every year, there is a huge area of sea ice that comes down from the Sea of Okhotsk in Russia – though there is nothing hot about it! The sea ice is not persistent, it melts away completely as the weather warms, which makes it ideal for our trial work – no lasting harm can be done. We will make some areas of thickened ice – marked with food dye, and compare them with the naturally formed ice. This will allow us to calculate the longevity of the thickened ice, and to work out if it really could help in the Arctic.

This is stage 1 of the plan.

Stage 2. We're going to need a bigger boat. Up in Arctic waters, working the whole winter, thickening as much ice as possible & monitoring the new ice with satellites and drones.

The third stage would be a lot more boats and a series of new technologies we have been dreaming up to make thousands of km2 of thickened ice.

This will help with albedo as well so many other things – see foot note for a detailed explanation.

Stage 4, insanely bold as it is, is to refreeze the high Arctic so that there is as much ice as there was at the end of the last ice age. This is a big man-made cooling block to balance the centuries of man-made heating.

This huge reflective shield will be less damaging than the SRM mini-Pinatubos that have been considered – the earth has had ice shields before, after all, and it will buy time.

Time.
A resource we thought we had run out of.

I can't wait to get on that boat.

Refreeze the Arctic
10 Years On
A Short Story

A bold plan to refreeze the Arctic
A gigatonne scale negative emission operation

Refreeze the Arctic – 10 Years on – A Short Story

Murmansk Zeppelin Yard

Good morning. Andrei here. Ready for the interview.

Da, I can hear you. But my hearing is not so good. I will repeat your questions, so I am sure I answer the question you are asking. Your accent is also a bit difficult for me. Please speak clearly and slowly.

Da, where do I work?
I am an engineer working on the Murmansk Zeppelin yard.
Not so many of us speak good English here, so I have been volunteered.
I am 65 years old and have been working on this yard since it opened nearly 10 years ago
We repair the zeppelins that work in this region on the ice restoration and the firefighting. They work hard, so there are lots of repairs to do.
We also receive and launch the zeppelins from the Singapore Equatorial zeppelin yards. There is a similar location in Tiksi, at the other end of Russia. It sounds crazy to build zeppelins so far away and send them to the north, but when the wind blows here and there is no more room in the hangars for the broken zeppelins, we are glad that there is somewhere in the world where it is possible to work without high winds. And that place is around the equator, in the doldrum belt.

How many zeppelins are there in Murmansk?
The numbers vary a lot. Today we have 407 in our wider control area. There are about 2,000 in the arctic merry-go-round all together. It very much depends on the weather. The wind blows mostly from west to east in these northern latitudes. It takes a lot of energy to work back into the wind when it is strong, so the zeppelins move over to the next control station following the wind.

How are the zeppelins powered?
The zeppelins are all electric. There are now numerous charging stations all along the arctic circle, fed by grid electricity where possible, and in the most remote locations there are nuclear powered ships, buoys, platforms and other structures that supply power. The high arctic is the most difficult area. Each zeppelin has a range of about 1,000 miles, 1,600 km, but we try to stretch that as much as possible by anchoring over work sites. Once anchored, the propellors serve as wind turbines and top up the batteries. A zeppelin might be out for weeks before heading back to a control centre for repairs. Occasionally, a zeppelin has a failure and runs out of power, so one of the long-range tug drones goes out to rescue it and return the straggler to the nearest yard for repair

What is the oldest zeppelin?
We have one old bird, 401 that has been around the arctic circle 5 times over the course of 9 years. It is now dedicated as a parts lifter, so a fairly easy duty, but still pretty impressive. It has the Volvo compressor and trim control system which has been very reliable.

How many types of zeppelin are there?
Quite a few now. They come in 3 different sizes, which are quite similar in design. They need to be as interchangeable as possible. The small ones like 401 do scouting, hose lifting, parts recovery and sometimes water shuttling. The medium sized ones do anchor handling, medium weightlifting, front line firefighting and the main ice work. These two sizes are all remote controlled.
The largest zeppelins are manned and take crews out into the field for ice and fire work. We also use them to get to crash sites to recover parts from zeppelins that have failed to return to the fold.

How many are lost each year?
That’s tricky. 20 or more. We pick up most of the damaged ones and get them back into service, so they don’t count. When a zeppelin is on a risky job firefighting, or in heavy weather, a planned crash site is chosen and programmed into the onboard control system. This is a tree-free space with firm enough ground to work and for the heavy parts not to sink into the peat. There are hundreds of these planned crash sites around the arctic circle

and most have been used several times.
When a zeppelin goes down over the ice, we try to get to it before the melt, although we do lose more up there.

Do you go out?

Yes, during the spring and summer we are out regularly. There is a winters' worth of parts to collect. It is always a bit sad arriving at a crash site, with the ribs poking in the air and the fabric flapping in the wind. We try to view ourselves as repairers of broken toys, rather than vultures picking over the carcases of mighty steeds, but it is tricky sometimes, especially when there has been a fire on impact.
We recover the engines, batteries, the compressor and trim control, the lifting gear, hoses and any of the water bags that are still usable. All of the main parts are waterproof and impact resistant, and have a marker buoy on them which helps us find sunken pieces and lift them out of the mud and soft permafrost. It is surprising how often we have to call in a small zeppelin to lift and slurp the pieces our of the deep mud before re-strapping and sending the parts back to base. We gather together the loose fabric, ribs and any other parts to keep the sites tidy and store the material for a later pickup.

What is it like out there?

Flying out over the permafrost? It is incredible. So empty. So peaceful.
When we land, it is a bit more challenging. After June the mosquitoes are unbelievable. Breath-taking! We wear mesh hoods to work.
I keep thinking https://getyarn.io/yarn-clip/7ddbbc9e-5c4d-468a-98ed-fe39e3824806 'what to they eat when they can't get Hobbit!'
Flying out over the ice is truly amazing. We pick our way up to the crash sites, and it is like crossing the planet Hoth. We go in the spring, so the weather can be pretty twitchy. We've had to retreat to other control stations many times, and we've even ended up in Alaska after one angry storm chased us north over the pole.

Who flies the zeppelins?

The zeppelins are large drones, flown by remote control. We have some pilots here – they work from those buildings next to the hangers, but there are pilots all around the world. This drone control technology was developed for the military, of course, but is ideal for this work. There is some automated control for transit flights, but for the actual firefighting, the zeppelins are under direct control by a real pilot. It reduces the loses.
When the zeppelins are working with ground teams, there is very close control and communication along with several backups to ensure that the operations are as safe as possible.

What is the lift gas?

We would love to use helium for the fleet, but there just isn't enough in the world, and it is far too useful for other things to be used for a rough duty like this. The manned zeppelins are filled with helium, but everything else is hydrogen. To be honest, the hydrogen doesn't give us too much trouble – even the original zeppelins in the 1900's didn't have many problems and travelled huge distances quite safely. We've only had a few isolated Hindenburg incidents through millions of hours of operation.
We've recently started experimenting with steam as a lift gas – although it sounds crazy, I think we might be able to get it to work. It could be a very useful supplement to the existing systems.

How is this operation paid for?

The work this arctic circle operation does putting out peat fires alone prevents around 100 million tonnes of GHG release each year, and a lot of the money that funds this work comes from the carbon credits created by putting out peat fires. It is monitored closely by satellite and calculation done to determine the amount of GHG that would have been released with no control vs the release with intervention.

How is a fire fought?

There are several types of fire. The most impactful is actually the one that looks least like a fire. Peat fires generate huge amounts of GHG – methane as well as CO_2 – and can burn for months.
A medium airship with a few small ones in support approach the fire from downwind. The main zeppelin anchors by lowering a large bag to the ground and filling it with water. If possible, the zeppelin arrives with a full load of 20 tonnes of water, and as it is used, it is topped up by shuttle flights from the smaller ships. The water is drawn from nearby local lakes, of which there are an enormous number in the north.

A peat fire is fought from the air with a drone which has a long vertical lance attached underneath. The drone is on a hose which supplies power and water. It flies over the fire, activates the lance, which is like a jetwasher, and lowers itself towards the surface. The lance cuts deep into the burning peat, injecting water sideways and down. The hot peat turns the water to steam which expands, pushes out the air and snuffs out the fire. Other techniques are used around the edge of the fire to reduce the rate of spread. It can take days to cover a whole area and gradually put out the whole underground fire. There are rarely ground crews involved, as this is pretty hazardous work. The airships allow us to access areas which are very remote, hundreds of miles from any humans.

In other areas such as Indonesia, the drone lance rigs are often run from the roadside and reach out nearly a kilometre with hoses. For more remote areas, airships are also used. In Indonesia the fire crews also work with locals to turn waste biomass into biochar. With the biochar added in, these tropical crews generate a fantastic number of negative emission carbon credits.

Tree fires?

Tree fires are a bit more difficult, as the flames can reach much higher and the associated wind and updrafts are much stronger. We've lost quite a few airships to sparks and burning debris. We try to steer the fire into a narrow front and direct it to a lake edge. This is done by spraying fire retardant on the trees a kilometre or so ahead of the flame front, and in some cases dumping water from above.

Controlled burns?

When the conditions permit, we do a programme of controlled burns. This involves making three down wind lines of flame retardant and then launching flares. This reduces the available fuel in overloaded areas and helps guide the fires when a big fire comes through.

We've improved this technique over time. With a careful burn and a quench at the right time, it is possible to make a crude form of biochar. We get a lot more black carbon into the ground now than we did a few years ago.

Ground crews with a proper biochar rig are still far more effective, converting 25% of the carbon to char, we only manage 6% with a careful burn. We've been airlifting a lot more gear out into suitable areas and shuttling crews to work them. It's very physical work, pays well, and is popular with the ex-oil workers. The same camaraderie. They work through the winter when the ground is harder and there are no mosquitoes.
The crews work with simple gear, a big winch and a biochar unit. They cut and drag trees across the snow to the central work site, making a radial star about 1km across. This breaks up the forest a bit, without stripping it bare. When a fire passes through these star-spangled areas, it is much easier to steer and control.

Bitcoin mines?

There is also a bitcoin mine in a 40' container on each site. There are a lot of these units now, after individual bitcoins included a tag which declared where and when they were mined and what electricity is used.
It is no longer acceptable to use any form of fossil fuel and even grid electricity for most bitcoins and the associated transactions. Almost all bitcoins are now produced from fully stranded energy sources, such as the biochar units we lift out into the forest. These generate a decent amount of electricity from the off-gas, which would otherwise be flared. This electricity runs the biochar operation, but there is a big excess which is used to run the bitcoin mines. They are often hundreds of miles from the grid, so there is no way to export the electricity. The ongoing demand for these isolated sources of energy has funded many of the biochar rigs, and it is astonishing to read that the bitcoin industry is now carbon negative, because it has funded so much of the biochar industry – who would have thought it just a few years ago. The only other thing the bitcoin mines require is an internet link, which is easily provided by the new global broadband satellite network.

Carbon stores?

Da. This is a really interesting development, and came from an experiment from a team in Tomsk.
They were interested in recovering some of the timber from the remote biochar sites, so developed the zeppelin log handling equipment that we use today.

The trees are dragged back to the central area, the brash trimmed off and the logs tidied up for transportation. The brash is the main feed for the biochar unit as it is easy to chip and is in any case, it is the main fire hazard. The logs are lifted out by the zeppelin, by a single grab clamped onto the base. The mature pine trees can be pretty heavy, several tonnes https://extension.tennessee.edu/publications/documents/sp748.pdf

Naturally, a few logs get dropped. This became a game for one crew, who spent a quiet week picking up logs, and dropping them from a height to see if they could bury the whole length in the ground. As you can imagine, this involved many hours of mostly harmless, boyish fun. They found that up to 15m of log could be buried, and 20m if the log was dropped from 100m height into a marshy pond. They collected the data as part of the betting pool that they were running – who could get the log furthest into the ground.

But their game was not all frivolous. The team realised that this could be a really simple means of sequestering a lot of carbon at very low cost – all of the work was being done anyway, and the equipment was on site. This was a way of burying wood deep into the peat and permafrost where it would be preserved for millennia.

The system has now been widely deployed on the most remote sites. It is used in combination with the bitcoin mines, as the direct storage of carbon by log burial is even more effective than the conversion to biochar, which still releases some CO_2 while capturing and storing large amounts of carbon in the soil.

Each site has a dedicated zeppelin which lifts the logs to 120m and drops them, narrow end first into a nearby permafrost lake. There is a marking tag on each end to allow the exact location in the mud of each log to be determined, so that the next logs can be dropped accurately into the available gaps. We try to pack in as many as possible into each lake so the sites can be monitored. As the permafrost does get disturbed, we freeze the lake in the winter with a dedicated on-site buoy powered from the nearby biochar site or a small, dedicated windmill. This allows the ice to become really thick over the lake, cooling down the permafrost, stabilising the trapped methane and preserving the buried logs.

So far we have buried many millions of logs this way, each worth at least 1 tonne of carbon, and these provide some of the highest value carbon credits on the market. In combination with the biochar, the big-fire prevention and the carbon negative bitcoin mining, this is a high impact operation, hundreds of millions of tonnes of negative emission per year and still increasing

The fate of the biochar is interesting. A lot of it is produced in very isolated locations which can only be reached by zeppelin. While the best quality char is also shipped out by zeppelin, there is a lot that is not worth moving. We have started adding trace minerals to this char and spreading it by air over the forests. Many of the areas lack trace minerals, so this is a means of significantly increasing the primary productivity of the landscape. This draws even more CO_2 out of the atmosphere, hundreds of millions of tonnes, which is of course great. But it is a bit of a double-edged sword, as it ultimately adds more fuel to the fires. We will need to stay up here for ever to manage this big new garden we are building. That is one of the responsibilities of undertaking to manage the climate at the necessary scale to avoid calamity.

Ice?

In the winter there are no fires to fight – although it is easier to find and fight the zombie peat fires – so most of the zeppelin fleet switches to ice making in the Arctic Ocean. This is a much more hazardous occupation for the airships, as the conditions are really tough. We lose quite a few as the season progresses.

The ice is made in several different ways.

- There are a number of large fixed circular platforms in high current areas which act like large static icebreakers. They are anchored to the seabed on large suction piles and are stripped down versions of the oil platforms that were designed for the arctic. The ice flows past the circular hulls and a wide clear channel of open water is formed, along with two high ridges of ice. An ice hardened tug sails up and down this little channel spraying water far out onto the open ice beyond the ridges. The are also water cannon on the main platform. The aim is to spray as much water as possible through the freezing air and thicken the ice. Usually a zeppelin works with the platform to spray even more water, out beyond the reach of the water cannon. The platforms are either nuclear powered, or have an OTEC unit. They serve as recharging stations for the zeppelins and any other craft operating in the area, as well as safe refuges and science centres.

- There are ice hardened tugs which plough their own path through thin ice, spraying water to the sides, They recharge from the platforms and maintained in Murmansk shipyard.
- There is an inshore fleet of mudmasters which do a similar role and recharge on shore.
- And there are the zeppelins. They fly further out with a large submersible pump on a hose which is also a cable and a powerline. Once on site, the pump is dropped through the thin ice to act as a weighed but buoyant anchor and the hose reeled out. The zeppelin switches the propellers over so that they serve as power generators, and this provides the electrical energy for the pump. The pump drives a large volume of water ~100m back up the pipe and this sprays through the freezing air onto the ice below, thickening the ice.
  The ice gets pretty thick, sometimes 10 metres or more, so it can be difficult to get the pump back out. To help this, the line and the top of the pump can be electrically heated so that they melt their way out, but as you can imagine, we've lost a lot of pumps and several zeppelins doing this. If a pump is lost, it fully inflates its buoy which stops it sinking to the bottom of the sea, and most of the pumps are picked up in the summer as the ice breaks up and they float back to the surface. These zeppelins and pumps make clusters of large thick, manmade icebergs which last all the way through the summer. The icebergs are much more resilient than natural, thin sea ice. We've been steadily increasing the amount of multi-year sea ice.
  This pump-zeppelin-windmill arrangement has been evolving. Initially, it was limited by the power that the tethered zeppelins could generate. This fixed the size of the pump. We have since increased the generating power of the zeppelins with extra motors and then dedicated large counter-rotating generators on each end of the zeppelin. A neat Russian design. These are able to generate 1MW of power or more, which allows a really big pump to be deployed. We've had to develop new ways of supporting these pumps, in a 40' container with submarine ballast tanks – another Russian design. The tethering system has had to be changed and it now takes 3 zeppelins to deploy one of these new, more complex arrangements. One stays on station as the flying wind turbine and the others return for more deployments. These big units stay on station, frozen into the ice in the very highest arctic, all year round.

https://www.motralec.com/public/fichiers/docs/Abs-AFP-.pdf https://www.andritz.com/products-en/marine-offshore/pumps/submersible-motor

- We have recently started freezing the onshore lakes, either with a static pumping buoy on the smaller lakes, or with a small zeppelin on the bigger lakes. It is important that we find ways to reduce the melting of the permafrost and the associated methane release – we are in really serious trouble if that happens.

How many negative emissions and does it work?

We are now approaching one gigatonne per year of negative emissions. A remarkable achievement.
But we must remember, every single thing we do has a carbon footprint. If we have a beer each, that is one kilo of CO_2. There is a huge industry making, delivering and serving that product to us. There needs to be a matching industry somewhere that does a negative 1kg emission to match every single 1kg emission we make.
Can you imagine how vast that industry needs to be? No. Neither can I.

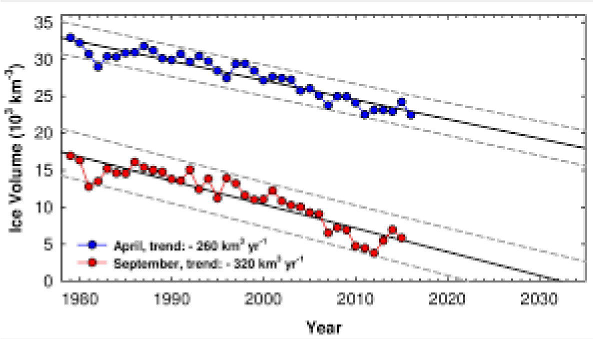
We are using two main mechanisms to refreeze the Arctic.
This explanation is a considerable simplification, but it gives the general idea.

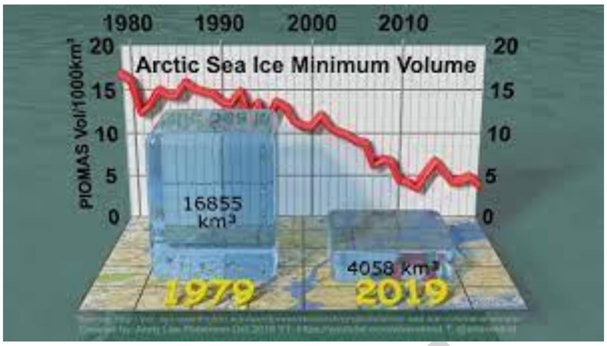
Latent heat of fusion

https://link.springer.com/referenceworkentry/10.1007/1-4020-3266-8_124#:~:text=A%20total%20of%20334%20J,the%20latent%20heat%20of%20fusion.

It takes heat to melt ice. We are all familiar with this. What is less appreciated, is that this heat is released when ice freezes. This heat is known as 'The Latent Heat of Fusion'.
We make ice by spraying water into the freezing air of the winter night. The freezing of the ice releases the heat of fusion, which transfers to the atmosphere. A significant proportion of this heat then escapes directly into space, taking heat away from the earth.
In the winter night in the arctic, there is plenty of weather, but there is also plenty of clear sky. This clear sky allows the heat, in the form of several specific lengths of infrared radiation, to escape into the deep cold of space. This is the same effect as produces black ice on a clear night, and was used in pre-industrial Iran to make ice at night when conditions were above freezing.
https://www.fieldstudyoftheworld.com/persian-ice-house-how-make-ice-desert/
https://www.maxfordham.com/research-innovation/the-physics-of-freezing-at-the-iranian-yakhchal/

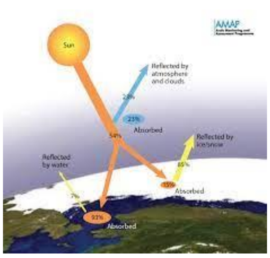
The manufacturing of the thick ice dumps heat into the atmosphere when it is connected directly to the cold of space for months on end.
We just need to make a lot of ice. Thousands of cubic kilometres per year in fact, to reverse the ongoing trend. This may seem like a lot, but with thousands of big pumping units in place and working through the winter, it can in principle be done, and we are well on the way to achieving that goal.

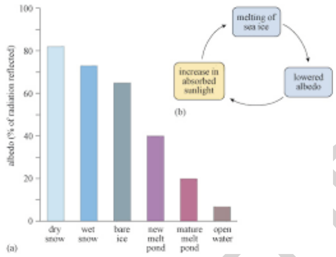


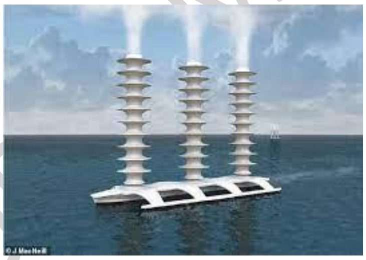


Albedo

The growing areas of thick ice last several years and help rebuild the dwindling stock of multi-year ice. This bright white surface reflects heat back into space during the long summer months. This is direct return of energy is a good thing in its own right. Ice has a high albedo, or ability to reflect light.
Ice cover also prevents the heating of open, dark water which has a very low albedo







The refreezing of the arctic increases the albedo, returns more energy to space, reduces ice melt and slows the warming of the arctic ocean.
In the summer we also generate reflective clouds over open water to reflect more incoming energy.

The way forward

So now countries working more together. Not enough together, but better than before. And not before time. The west is finally rolling out renewables at the proper rate. Hydrocarbon usage is finally falling.

The eights countries of the Arctic circle work closely together to fight the fires and freeze the ice – we have to cooperate, because the prevailing wind from west to east makes it impossible to work in isolation. The zeppelins are blown into the neighbouring territory, it is better to just let that happen and let them circle all around the top of the world doing their essential work.

This ice rebuilding and firefighting operation is just coming up to speed, approaching a gigatonne a year of negative or prevented emissions as well as restored albedo, and needs to be at least four times bigger. Remarkably, the peat fire prevention, biochar and ice albedo carbon credits cover much of the cost of the operation.
Who would have thought that restoring the planet might be self-funding?