THE END OF CAPITLAISM

Why Growth and Climate Protection Are Incompatible – and How We Will Live in the Future

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Synopsis and Sample translation translated by Rose Jones

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Synopsis

Teaser:

Everyone is talking about the climate crisis, but barely anything is actually changing. Greenhouse gas emissions are rising dramatically, and there's nothing to slow them down. This failure is no coincidence, for the climate crisis threatens the very core of capitalism. Growth can only be achieved by using technology and burning fuel. But unfortunately, whereas coal, oil and gas have released enormous amounts of greenhouse gases, the sun and wind will never generate enough green energy to fuel global growth. Developed countries must therefore shift away from capitalism, even though it has brought huge benefits and enabled widespread prosperity. Now, "green shrinkage" is the order of the day, because otherwise there is a risk that a "hot age" will dawn, which will bring about economic collapse by its very nature. But what might this green shrinkage look like? The best model of all is the British war economy from 1940.

The book:

Climate change is extremely dangerous, but the world is still pumping out more and more carbon dioxide. Despairing of their parents, young people have joined forces under "Fridays for Future". They are demanding that scientists finally be heard. "Listen to the science" is their slogan. But climate protection efforts are not failing because politicians and voters are greedy or ignorant. The problem goes deeper than that. The only way to save the climate is to do away with capitalism.

Contrary to what critics of capitalism believe, this is not good news, for capitalism has been extraordinarily beneficial. It was the first social system in human history capable of generating prosperity. Before that, there was no growth to speak of. Prussians and Bavarians in the 18th century were just as poor as the ancient Romans who came two thousand years before. Theirs was a fairly feeble agriculture-based economy, they often suffered from famine and they died, on average, at the age of 35.

But from about 1760 onwards, England began to industrialise – a process that has been generating more and more prosperity ever since. Granted, the distribution of wealth is enormously unequal, but today's workers still live better than 18th-century kings did. Many poor people now have heating, cars, mobile phones, running water and cancer medication, whereas in the past, even rulers keeled over when typhoid struck.

Capitalism is not perfect, but it is politically feasible and perfectly compatible with democracy. This aspect is often overlooked. Examples from across the world show that political participation only becomes viable once prosperity has increased significantly.

Although capitalism was an improvement, it also – unfortunately – has a fundamental weakness. It does not merely generate growth but *relies* on this growth for its own stability. Growth cannot be infinite in a finite world. Industrialised nations are currently acting as if they had more planets at their disposal. But as we all know, there's only one Earth.

Until now, governments have been relying on being able to somehow reconcile economic growth with climate protection. The typical buzzwords are "Green New Deal" or the "decoupling" of growth from energy. The big hope is that the entire

economy – including transport, industry and heating – can be completely converted to run on green power.

But as charming as this notion sounds, it is doomed to fail because green energy will always be meagre. This statement may come as a surprise. After all, the sun sends 10,000 times more energy to Earth than would be required for all of the 7.8 billion people to enjoy a European standard of living. There is no scarcity of physical energy, but the idea that green power can be made available in abundance is a naive miscalculation.

Everyone knows that the sun's energy must first be captured. However, solar panels and wind turbines are more expensive than producing and burning coal, oil or gas. The reason that green power currently appears competitive is because it "only" substitutes power derived from fossil fuels – and only during operation at that. Green power loses ground the moment it is to be stored and used throughout the economy.

Energy return on investment (EROI) – a ratio that describes how many units of energy have to be invested in order to obtain new ones – is an illuminating metric. For it turns out that, at most, green power can supply half of the net energy that can be generated from fossil variants. That’s a bitter pill to swallow, because it makes it plain that green energy is expensive and that efficiency would be cut in half. As soon as productivity falls, there can be no more growth. The economy is bound to shrink if it is to be powered by green energy alone.

But what might this green shrinkage look like? It helps to start at the end and think backwards. If green power remains in short supply, a climate-neutral economy is only feasible if we dispense with all air travel and private cars. Banks and life insurance are also largely superfluous in a shrinking economy, as most

loans can only be repaid when incomes rise and insurance savings are based on receiving more money afterwards than was ever paid in.

No one would starve in a climate-neutral economy, but millions of workers would have to reorient themselves. For example, a much larger workforce would be needed in agriculture, and in forests, too, to alleviate the effects of climate change.

This outlook on the future may seem radical, but there really is no alternative. If we do not reduce our CO_2 emissions to net zero, we will end up in a "hot age", which will cause the economy to shrink by its very nature. In all likelihood, the ensuing unplanned chaos would give rise to a war of each individual against all others that democracy would not survive.

Capitalism must be dismantled in an orderly fashion. Luckily, there is already a historical precedent to use as a guide: the British war economy from 1940. At that time, the British were faced with a monstrous challenge. They hadn't really seen the second world war coming and had to switch their economy completely to war mode almost overnight, without the population starving or suffering severe shortages.

The first step was a statistical revolution: the British invented the system of national accounts, which is still a standard tool for all economists today. This new instrument made it possible to calculate how many factories could be used to produce military equipment without jeopardising civilian supplies.

What emerged was a marketless private economy that functioned remarkably well. The factories remained in private hands, but production targets for weapons and consumer goods were set by the state, and the distribution of food was also organised by the public authorities. There were no shortages, although there was rationing. In this way, the British established a private and democratic planned

economy that bore no resemblance to the dysfunctional socialism seen in the Soviet Union.

Climate change poses a huge social challenge. Once again, the survival of humanity is at stake.

What's new about this book?

There are already a great many books about the climate crisis and climate protection. And yet there is still a gap: nowhere is there a sensible analysis of whether it is at all possible to reconcile capitalism and climate protection.

Broadly speaking, it is possible to distinguish two groups. First of all, there are the many writers who believe in "green growth". Their books usually present lists of technological projects and lay out everything that must happen in order to convert the economy to a climate-neutral one. Their proposals range from electric cars to "green steel". But nowhere is there a model that shows whether enough green energy could conceivably be produced to enable green growth. It is simply taken as read.

This cheerful confidence is expressly not shared by the second group: the "post-growth" movement. Their books depart from the idea that raw materials and environmental resources are limited. From this standpoint, they are constantly developing new versions of what an ecological circular economy might look like, in which only as much is consumed as can be recycled. They use buzzwords like barter economy, monetary reform, economy for the common good, consumption renunciation, reduction of working hours and unconditional basic income. To put it uncharitably, they are designing some kind of green Scandi paradise.

Post-growth books are often notable for confusing the vision with the way there. The question of how to actually get off the train of ever-growing capitalism without provoking a severe economic crisis and making millions unemployed is seldom asked. The bridge from the dynamic present to a static future is missing.
My book seeks to fill these gaps and to show that "green shrinkage" cannot be left either to the "market" or to initiatives by private individuals. Comprehensive government planning is required, of a kind that resembles the British war economy from 1940 as closely as possible.

The planned structure:

I recognise that this approach seems very strange in a world where most people mistakenly believe that they are living in a "free market economy". The first part of my book is therefore intended to show how capitalism was born and how it functions today. Experience has shown that readers find it easiest to follow ideas when historical developments are described clearly and when real individuals feature. The arc of the story therefore extends from the first textile manufacturers in England to the first people who discovered CO_2.

The idea behind the second part of the book is to explain how many climate protection proposals are fundamentally flawed because they are based on false assumptions about capitalism.
The third part then deals with the British war economy, what can be learned from it – and what cannot. Our future will, of course, be completely different, but some features of that time will resurface. To give just one example: the possibility that rainfall in Germany will be so scarce at times that water has to be allocated is already on the horizon. Rationing will return.

Sample translation

translated by Rose Jones

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I. THE RISE OF CAPITAL

1. A boon: Growth creates prosperity

Capitalism has a bad rap. When asked about it in surveys, people all across the world say that it is in urgent need of reform. In Germany, only 12% of people believe that the current economic system serves them well and that they benefit sufficiently from growth. In contrast, 55% believe that capitalism in its current form does more harm than good.[1]

This resentment is understandable, and yet capitalism is better than its image. Before industrialisation set in, famine was a widespread problem. In Germany, too, people often died because there was not enough food to go around. The last Europe-wide famine was in 1846-47, when bad weather destroyed a large part of the grain harvest just as potato blight was rife.[2]

Since then, there has never been a shortage of food in western Europe, other than when world wars were being waged. Only in Finland did a final hunger crisis break out in 1867; 100,000 of the 1.6 million inhabitants died following crop failure.[3] Capitalism conquered hunger and instead produced excess, causing “butter mountains” to form and “milk lakes” to rise.

Everyone in the developed world now lives a healthier and more comfortable life than their kings once did. Nobles may have resided in castles and always had plenty to eat, but they also often died young, carried off by some rampaging disease, be it plague, typhoid, scarlet fever, diphtheria, tuberculosis or smallpox. The same was clearly true of the

monks: even though monasteries were often very well provisioned, the well-fed clerics lived no longer on average than the laypeople.[4]

Even fairly harmless illnesses could end in death: the eminent economist David Ricardo died in 1823 of a mild infection of the middle ear, and the banker Nathan Mayer Rothschild—then the world's richest man—succumbed in 1836 to a boil on his bottom.

Today, in contrast, baby girls born in Germany can expect to live to more than 83 years of age on average, and boys to almost 79. In rich developed nations at least, the maximum possible human lifespan has already largely been stretched as far as it can go: even if we succeeded in defeating all forms of cancer, we would only live four or five years longer on average.[5]

But it's not just that pure lifespan has more than doubled; quality of life is significantly better too. Worn-down knees and hips are now routinely replaced, freeing patients from excruciating pain, whereas a simple fracture could in the past have rendered someone severely disabled for the rest of their lifetime.[6]

Everyday life got a lot more pleasant as well. Even the poor now live more comfortably than 18th-century kings did. To name just a few conveniences that would once have been unthinkable, almost all households nowadays have cars, mobile phones, computers, running water, heating, washing machines, fridges, televisions, bicycles and artificial lighting.[7]

Moreover, it takes less and less work to afford these amenities. In 1919 an employee in the US had to work about 1,800 hours to be able to buy a fridge. A century later, the same feat takes less than 24 hours.[8]

At the same time, the devices themselves are becoming more and more powerful: a normal smartphone currently starts at about 200 euros, but for that you don't just get a telephone, but also a computer, a camera, a calculator, a sat nav, an alarm clock, a torch, a TV and a VCR. The computational power of a smartphone today is 160,000 times greater than that of Apollo 11, which in 1969 pulled off the first moon landing.[9]

The triumph of consumer goods has benefited women in particular, as housework now swallows up significantly less time. A hundred years ago, looking after a family was far more than a full-time job, involving about 58 hours' work per week. Now, it only occupies an average of 11.5 hours. Even just doing the laundry used to take almost 12 hours per week and now takes a mere 1.5.[10] The South Korean economist Ha-Joon Chang is hardly exaggerating when he remarks pointedly: "The washing machine changed the world more than the internet."[11]

Despite this, housework and childcare are still very unequally distributed between the sexes: in 2016, men in heterosexual couples did about 37% of the housework.[12] But precisely because looking after the family falls predominantly to women, women would not have had the chance to participate in working life if household appliances had not come to their aid.

The realisation that capitalism is a blessing is nothing new. The most beautiful hymn to it comes from Karl Marx, of all people. In his *Communist Manifesto*, he describes eloquently how the new bourgeoisie had changed the world: "It has been the first to show what man’s activity can bring about. It has accomplished wonders far surpassing Egyptian pyramids, Roman aqueducts, and Gothic cathedrals."

Marx and Engels had a lifelong fascination with the technical inventions of their time and meticulously enumerated these "wonders": "Subjection of Nature’s forces to man, machinery, application of chemistry to industry and agriculture, steam-navigation, railways, electric telegraphs, clearing of whole continents for cultivation, canalisation of rivers, whole populations conjured out of the ground—what earlier century had even a presentiment that such productive forces slumbered in the lap of social labour?"

It would therefore be a mistake to think that Marx and Engels rejected capitalism. They welcomed unbridled growth. It was good for prosperity to grow, so that there would be as much as possible to distribute when the communist revolution came around.[13]

But capitalism is far more than just an economic system that fosters growth and prosperity. It shapes our lives from cradle to grave and has long encroached on the most intimate aspects of our private lives. Whom we marry, how we raise our children and what we do with our free time—we live completely differently now to how our forebears who did not grow up under capitalism lived 250 years ago.

Human beings have always loved, but they were generally not able to live out this love. In the past, marriage served primarily to preserve and increase the assets of one’s own extended family. For farmers, tradesmen and nobles alike, marriage was a kind of life insurance policy and was often arranged. Fathers carefully picked out whom their sons and daughters had to choose. Love matches could only become the norm when increasing prosperity meant that young families were no longer materially dependent on their parents but rather earned their own money.

Capitalism is therefore a total system. It does not only permeate the economy, but life in its entirety. That is also what makes it so difficult to develop thinkable alternatives. This dilemma was summed up in the legendary line: "It is easier to imagine the end of the world than the end of capitalism."[14]

Moreover, many of capitalism's achievements are so beneficial that no one would want to give them up. Material prosperity has immaterial consequences. It’s not just life expectancy that has doubled; general education, equal rights and democracy only become possible when a society becomes richer.

Let's return to Marx. When he finished his *Abitur* in Trier in 1835, before heading off to university, only about 1% of boys in Prussia went to secondary school.[15] The only ones to get an education were—like Marx himself—the sons of the upper class. His father was a prominent lawyer of high social standing in the city. If they even attended primary school, other

boys just went for a few years to learn a bit of reading, writing and arithmetic in over-crowded classrooms. Girls often received no education at all. Children were needed to work in fields or in trades, which meant that parents couldn't afford for their sons and daughters to go to school.

But although academics were so rare at the time, there were still too many of them. Theologians and lawyers often had to wait for 12 years before they finally got a post as a pastor or judge—and they weren't allowed to marry or start a family before then. Poor agrarian states have barely any need for academics—and barely anything to feed them either.

Education is a human right, but it is only capitalism that has created countless jobs that require well-trained staff. Today more than half of each year group in Germany leaves secondary school with an *Abitur* (the proportion is slightly higher among girls).[16] But it is not only high-achieving secondary school students who have been affected by the education revolution: all children receive a better, longer education than would have been imaginable a hundred years ago.

However, it is also a fact that not all children have the same opportunities; the path they take depends largely on their background. It is still very uncommon for working-class children to go to university, whereas the offspring of academics almost always undertake further study.[17]

Capitalism is no paradise and has by no means eliminated all inequalities. What *is* new, however, is that it is at least possible to protest against discrimination. The issue of equal opportunities only arises when societies

become wealthier. Whether it's equality for working-class children, women, homosexuals, people with disabilities or immigrants, calls for equality only have a chance if prosperity reigns.

While a society remains poor, its rulers can only make themselves rich by exploiting their subjects. And so it boils down to a brutal zero-sum game: the powerful take the scarce goods for themselves, such that the vast majority are left almost completely empty-handed. But when the economy grows, this brutal struggle stops being necessary. The gains are substantial enough to reach everyone. There may still be inequality, and the rich may still get richer, but ordinary citizens benefit too. The elites no longer feel the need to forcibly subjugate the common people.[18]

That is why democracy could only prevail once industrialisation had already made significant progress. Universal suffrage was introduced in Germany and Austria in 1918. The same was true for men in Britain, but it took until 1928 for all British women to be allowed to vote[19]. Switzerland is an outlier here: men have enjoyed universal suffrage since 1848, but that right was not formally introduced for women until 1971.[20]

However, that does not make the opposite conclusion true. Although democracies flourish only when they are prosperous, it does not follow that an industrialised country is necessarily a democratic one. China is a fascinating case: per capita income there is almost as high as it was in Australia in 1990[21], and yet there are still no signs of the Communist Party losing power.

The Chinese example also shows that capitalism has reached the global south and is no longer restricted to countries traditionally considered developed. Even in poor countries, life expectancy is rising significantly: newborn babies in southern Africa now have a better chance of reaching their fifth birthday than children born in England in 1918. Indians now live longer on average than Scots did in 1945, even though they are a long way from being as wealthy as the British were back then.[22]

The scale of global progress is impressive: in the past 20 years, extreme poverty has halved worldwide, 80% of children are now vaccinated, and 80% of families have access to electricity. "These are great achievements," concedes even Luisa Neubauer, a climate activist with *Fridays for Future*.[23]

But these success stories cannot conceal the fact that inequality in the world is still extremely high, and that not all people benefit equally from capitalism. Let's start with Germany, where the richest hundredth of the population (i.e. the top 1%) owns as much as 33% of the national wealth. The richest tenth accounts for a remarkable 64% in total. This leaves precious little for the less-well-off classes; the poorer half owns a grand total of 2.3% of the national wealth.[24] Germany is a class society, even though many citizens believe that they live in a "levelled middle-class society".

The differences between countries are even bigger. Life expectancy is rising significantly all over the world, but some places are being left behind. There are still countries where more than 10% of newborn babies die before their fifth birthday. Among them are Nigeria, Chad and Sierra Leone. Young

children there do not generally fall victim to exotic pathogens, but rather to mundane diseases such as diarrhoea or malaria, for which there actually is effective treatment.[25]

At first glance, it seems strange that the global south finds it so hard to catch up with traditional developed nations. An obvious approach would be to simply copy their technique: as we all know, Germany's luxury cars earn it a huge amount of money, so why doesn't Bangladesh just set up its own production lines and export high-end vehicles too?

But modern capitalism is complex. The best way to understand it is to start from the beginning and go back to the place where it first emerged: England, from about 1760.

[…]

II. NO SUCH THING AS "GREEN GROWTH"

9. CO_2 is not going to disappear

"Green growth" is slightly reminiscent of the fantasy that you can gorge yourself on cake all day long and never get fat. Life should know no limits. When it comes to people's bodies, a downright brutal way of getting rid of those dangerous pounds has already been found: the fat gets sucked away. Similarly, when it comes to tackling climate change, the idea is to simply remove greenhouse gas from the atmosphere.

The technical term for this is “sequestration”, and it means that CO_2 is captured and stored permanently in underground reservoirs. This approach supposedly has the incontrovertible advantage of providing humanity with a kind of reinsurance policy. If it gets too onerous or too expensive to avoid producing CO_2, the gas can just be sucked out of the air. Unfortunately, this solution is too good to be true. Carbon sequestration will only be possible on a small scale, if at all. This is because filtration requires enormous amounts of energy and the technology is far from being mature.

Carbon dioxide is a devious gas. Even though it causes tremendous damage to the climate, it is present in the atmosphere in only the tiniest of quantities. Right now, there are about 420 CO_2 molecules in a million air particles.[1] This means that a huge amount of air has to be filtered before a single CO_2 molecule finally gets caught, and this effort requires energy.

Despite this, various ways of recapturing CO_2 are still being explored. Naturally, the idea of continuing to operate fossil fuel power plants,

collecting the carbon dioxide in the chimneys and then putting it into storage is a hugely attractive one. In coal-fired power plants, greenhouse gas accounts for 14% of the exhaust air—a high concentration.[2] But even under these very favourable conditions, the energy required would be exorbitant: the power plant's coal consumption would need to increase by about 30% to separate out the greenhouse gas. The carbon dioxide would then have to be transported in pipelines to its final storage destination and pumped underground, which would increase the energy consumed by another 10%.[3] In addition, the filters are not yet particularly effective, meaning that only about 60-70% of the carbon dioxide would actually be captured.[4]

Sequestration is therefore not an option that would allow fossil fuel power plants to carry on operating. All it would create is an expensive zero-sum game whereby almost as much carbon dioxide would be produced as is simultaneously filtered out of the exhaust air.[5] This realisation is a bitter one, for there has been no lack of billions in research spending.[6] Governments and oil firms have pumped huge amounts of money into the hope that CO_2 can be treated like normal waste that can be filtered out and disposed of safely. However, as even the German government was forced to concede in 2018, this hope has been dashed: the development of sequestration had "recently progressed much more slowly than was envisaged in the 2000s"[7].

Germany can only become carbon neutral if it renounces coal, oil and gas and switches over to green energy. Nevertheless, the subject of sequestration will remain salient in the long term, given that humankind will most likely fail in its aim of limiting global warming to an increase of

1.5 degrees. But dangerous tipping points lie in wait on the other side of that threshold, which means it would be useful if sequestration one day succeeded in reducing levels of CO_2 again. The Intergovernmental Panel on Climate Change (IPCC) is firmly convinced that, at some point, filtration technologies that allow carbon dioxide to be fished directly out of the atmosphere will become profitable.[8]

This method is known as "direct air capture" (DAC) and works by filtering the ambient air. So off we go in search of those 420 CO_2 molecules that can be found in every million air particles. The technology uses the same principle as a vacuum cleaner: huge fans are used to draw the air through membranes or solvents. The Swiss company *Climeworks* already offers plants of this kind, having established its first pilot project in 2017 in Hinwil, near Zürich. However, this decentralised filtration technology is extremely energy-intensive, precisely because greenhouse gas particles are so rarely found in the ambient air.[9]

But it is not only the filtration technology that has its shortcomings; it is still unclear where the captured CO_2 can be kept. An obvious proposal would be to channel the liquefied greenhouse gas into emptied oil reservoirs, gas deposits or coal mines. The carbon would therefore end up back where it had been mined from. The circle would be perfect. But as charming as this approach is, it would promptly fail, because CO_2 takes up much more space than oil, gas or coal. When bituminous coal (black coal) is burned, its volume as CO_2 is up to 5.4 times greater. For lignite (brown coal), it is 1.9 times and for crude oil, it is 4.6 times greater.

The old deposit sites would therefore be nowhere near big enough to accommodate the greenhouse gas. On top of that, many of the tunnels are so far from being leak-proof that there's no way they could be used to stash away CO_2. In any case, brown coal comes mostly from open-cast mines. Many black coal mines, too, have more holes than Swiss cheese, because the rocks got completely riddled with entrances so that the deposits could be exploited as fully as possible.

According to a calculation by the IPCC, the former oil, gas and coal deposit sites could store a maximum of 1,100 gigatonnes of CO_2[11] (where one gigatonne is equivalent to one billion tonnes). Humankind currently emits about 50 gigatonnes of CO_2 per year, of which only about half gets bound up again in oceans, plants, soils and moorlands.[12] On this basis, the underground storage facilities would be used up for good in just 44 years—and that's without taking into account the fact that worldwide energy demand keeps on rising.

That is why there is a frantic search for other rock formations that could be suitable CO_2 repositories. "Saline aquifers" in particular have got geologists' pulses racing. These dome-shaped salt formations lie deep[13] underground and are filled with water. Pumping out the water could make room for greenhouse gas. But this solution would not be as easy to implement either as it might first sound. The water in the salt domes is obviously very salty—so where should it go after it has been pumped out? It can hardly be channelled into the rivers.[14]

Moreover, it is not easy to stop the CO_2 from ever escaping again. The safest thing would be to dissolve the carbon dioxide in water before pumping it into the aquifers as something resembling sparkling water, because then the greenhouse gas would be bound up. The downside of this reliable method, though, is that the water would take up too much space. This prompted the German government to declare that "given the storage capacity available, only relatively small amounts of CO_2 could be stored".

Finding suitable salt domes would also be difficult, no matter how promising these deposit sites might look on paper. Germany offers a good example of this. Theoretically, it would be conceivable to store 9.3 billion tonnes of CO_2 in salt domes.[16] That would provide more than 12 years of cover, given that Germany emitted 762 million tonnes of CO_2 in 2021.[17] These salt domes are found predominantly in northern Germany, under the North Sea, in Upper Bavaria and in southeastern Württemberg. The locals, however, are not particularly enthusiastic about their own subsoil being pumped full of carbon dioxide. The CO_2 injected would increase the pressure in the aquifers, meaning that the pressure in the layers of rock above it would also rise. However, these have often already been "disturbed" and are therefore potentially full of holes.[18] If the CO_2 could just escape back into the atmosphere, it would be pointless to spend energy separating out greenhouse gas and pumping it into salt domes. Even small holes could render the sequestration efforts completely futile in the long run.

Added to that, leakages could prove fatal. CO_2 is not toxic per se. After all, it is created inside our own bodies when food is burned—and we breathe it

out all the time. But the gas becomes dangerous when it occurs in high concentrations and displaces oxygen. Because CO_2 is heavier than oxygen, it accumulates directly above the earth's surface where there are depressions and when wind is low. It could therefore prove catastrophic if a CO_2 salt dome were to leak: a metre-high layer of greenhouse gas could build up and destroy all forms of life.[19] That is why German environmental associations fought hard for a law that has imposed extremely strict limits on sequestration since 2012. Sequestration is only permitted at research facilities, such as the one in the town of Ketzin in Brandenburg; large-scale storage has so far been prohibited.[20]

However, there are deposit sites elsewhere in Europe. Norway in particular is staking a lot on a new business model of sinking neighbouring countries' CO_2 emissions into the water off its own shores. If the world goes carbon neutral, the Norwegians will no longer be able to sell their oil and gas, and so they are now looking for alternative sources of income.

Since 1996, Norway has been pumping just over a million tonnes of carbon dioxide every year into a saline aquifer called Sleipner, which is about 800-1,000 metres below the sea floor.[21] However, it has not yet been conclusively determined whether this deposit site is in any way leak-proof. In fact, seismic studies have detected less CO_2 than has already been injected.[22]

However, the Norwegians are not allowing themselves to be swayed and are developing further deposit sites. Construction is currently under way

north of Bergen on the "Northern Lights" project, and the storage capacity along the Norwegian coastline is enormous, at least in theory: it has been estimated at 80 billion tonnes of CO_2 —as much as the whole EU emits in over 20 years.[23]

Aquifers are not the only option either. The Icelanders are pursuing the concept of turning CO_2 into stone. In September 2021, the first pilot plant, Orca, went into operation.[24] The approach is fascinating: 90% of the volcanic island is made of basalt, which in turn contains a lot of magnesium, calcium and iron. When the CO_2 is dissolved in water and pumped deep underground, it comes into contact with these minerals, forming carbonates—a kind of chalk. This chemical process takes about two years, after which the greenhouse gas has been turned to stone and bound up forever.

In Iceland alone, 80-200 times as much CO_2 could be stored as the whole world emits every year. Moreover, basalt is the most commonly occurring rock on earth. However, it is mostly found at the bottom of the ocean, and Germany has only one major source of it—the Vogelsberg mountain range. But because it is this very area that supplies the greater Frankfurt region with drinking water, it is not suitable as a CO_2 storage facility.[25]

Around the world, however, there would be enough opportunities for turning CO_2 into stone. But unfortunately, the technology is not ready yet. It is extremely expensive, and only small pilot plants currently exist. Iceland's

Orca project has swallowed up an estimated 15 million euros but can only filter 4,000 tonnes of CO_2 out of the air each year.[26]

Humankind currently emits 50 billion tonnes of carbon dioxide annually. Which means that 12.5 million Orca facilities would be needed to remove all of this greenhouse gas from the air. If the machines remained as expensive as the ones being used in Iceland, the filters alone would cost 187.5 trillion euros. This astronomical sum simply cannot be raised.

The industry is therefore hoping that the history of capitalism will repeat itself—and that the more the technology is used, the cheaper it will become. But the parallel doesn't quite hold up. The steam engine paid for itself immediately, which is why people were keen to order one and why the machines became more and more efficient. CO_2 filters, on the other hand, are so expensive that they just aren't worth it from a commercial point of view. Which means that, without enormous state subsidies, nothing will change. Moreover, it is questionable how quickly technical progress is being made. Researchers at the University of Oxford are not particularly optimistic that capturing CO_2 will become cheaper any time soon: "it has exhibited no promising cost improvements so far in its 50 year history."[27]

And so the "put it away" method fails. CO_2 cannot simply be gathered up and disposed of. Humanity will therefore be forced to relinquish fossil fuels and turn to green energy. However, there is controversy about what should count as carbon neutral. Quite a few countries believe that nuclear power is ecological too, and that it offers a worry-free future.

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15. Why technical innovation and digitalisation cannot save the climate

Predicting the end of capitalism is by no means original. Its dynamics seemed uncanny from the start. The new economic order was still young, and yet its death had already been prophesied. Even in 1776, Adam Smith was making fun of the fact that economic collapse was constantly being invoked: "The annual produce of the land and labour of England, for example, is certainly much greater than it was a little more than a century ago, at the restoration of Charles II. Though at present few people, I believe, doubt of this, yet during this period five years have seldom passed away, in which some book or pamphlet has not been published, […] pretending to demonstrate that the wealth of the nation was fast declining; that the country was depopulated, agriculture neglected, manufactures decaying, and trade undone."[1]

The English economist John Stuart Mill was also perturbed by his contemporaries' persistent pessimism and accused them of only wanting to raise their own status. As Mill said in 1828: "I have observed that it is not the man who hopes when others despair, but the man who despairs when others hope [who] is admired by a large clan of persons as a sage."[2]

Marx then became the first economist to devise a whole system to justify the inevitable end of capitalism.[3] But even socialists soon began to doubt that a revolution was necessary. As early as 1899, the German social

democratic theorist Eduard Bernstein coolly stated that the situation of the workers was by no means hopeless. On the contrary, some proletarians would even rise in society, as figures from the tax authorities indicate: "The fact that the propertied class is expanding rather than diminishing is not an invention of bourgeois harmony economists, but a fact that the tax authorities generally know well, much to the dismay of those concerned."[4] Bernstein's "revision" carried weight with his comrades, for not only had he been a close friend of Friedrich Engels, but he was also the executor of his estate.

While the workers were reconciling with capitalism, their employers had other concerns. They raised a question early on that is still relevant today: would there be enough raw materials to feed voracious capitalism in the long run? The Ruhr barons were already worrying about running out of fuel in the 19th century. The steel manufacturer Leopold Hoesch, for instance, reported discussions about "whether there is enough coal and coke to make all the pig iron that the world needs"[5].

These commodity concerns never eased completely but grew increasingly focused on oil. In 1970, the US ecologist Kenneth Watt prophesied: "By the year 2000, if present trends continue, [...] there won’t be any more crude oil"[6]. As we all know, this prognosis was wrong too.

The destruction of nature seemed to be another ever-growing threat: US researchers at that time expected that "between 75 and 80 percent of all animal species would be extinct" before the turn of the millennium. *Life*

Magazine reported that "scientists have solid experimental and theoretical evidence […] that in a decade urban dwellers will have to wear gas masks to survive air pollution, […] by 1985 air pollution will have reduced the amount of sunlight reaching earth by one half"[7].

Feeding everyone no longer seemed possible either. In 1968, the US biologist Paul Ehrlich published his bestseller *The Population Bomb*, in which he predicted mass extinction in the global south. "In the 1970s and 1980s, hundreds of millions of people are going to starve to death." He considered India particularly overstretched in terms of feeding its constantly growing population: "I don't see how India could possibly feed two hundred million more people by 1980."[8] The opposite happened yet again. Food did not become more scarce; harvests just became more bounteous. Since then, India’s grain and rice yields have tripled, while the Indian population is only slightly more than twice as big. India's economic output has actually increased fiftyfold.[9]

The reason why the "population bomb" has not exploded is because new, high-yielding varieties with shorter stems and larger kernels have been bred. Or to put it another way, if humankind were still cultivating the old varieties from 1960, additional fields the size of the US, Canada and China would be needed to feed the growing population. These expanses do not exist, but nor were they needed, because biological breeding successes were so spectacular.[10]

Ehrlich had underestimated scientific progress—a criticism also levelled at the 1972 bestseller *Limits to Growth*. This study, commissioned by the Club of Rome[11], was the first to use computer simulations to model the future. Its forecasts were bleak: "If the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity."[12]

This hundred-year forecast period is not yet over, but around mid-2022, many newspaper articles appeared, cheerfully proclaiming that the classic study "no longer had anything to contribute to the social debate". The work was better off being put "back on the shelf": "The authors' derivations have proven to be false."[13]

In actual fact, there are several predictions that have not come true. As mentioned earlier, gold was only supposed to last for another 29 years at most. It was meant to take 42 years for all the silver reserves to be exhausted, 48 for copper, 50 for oil and 55 for aluminium.[14] But the end of these raw materials is not in sight. The authors certainly never denied that they might be wrong about the specifics: "We shall emphasise just one more time that none of these computer outputs is a prediction. We would not expect the real world to behave like the world model."[15]

Moreover, some forecasts were astonishingly accurate. For example, the projected increase in greenhouse gas was right on target[16], even though it was still not possible in 1972 to assess in detail how dangerous these emissions would become: "It is unknown how much carbon dioxide […] can be released without irreversibly changing the Earth's climate."[17]

But even as early as 1972, the authors were certain that relying solely on scientific progress would not be enough, for the model's calculations revealed that "even the most optimistic estimates of the benefits of technology […] did not in any case postpone the collapse beyond the year 2100".[18]

Techno-optimists cannot comprehend this fatalism. Their main counter-argument is that scientific progress has always been underestimated because people tend to mistake the present for the future. They can come up with reams of funny anecdotes of times when people completely misjudged the potential of technology.

Let's pick out a couple of examples. By 1870, many German engineers were already convinced that electricity had little innovation potential left to exploit.[19] There wasn't much faith in the telephone either. It had "too many shortcomings to be seriously considered as a means of communication", pronounced William Orten, president of the US telegraph company Western Union, in 1876.[20] Agricultural economists, meanwhile, could not imagine that farmers would ever use technology at all. The Agricultural Academy of Hohenheim found in 1893 that "construction of the most commonly used

machines was almost complete". Tractors and huge harvesters were unthinkable at the time.[21] The British politician Scott-Montagu had the following to say of the car in 1903: "I do not believe the introduction of motor-cars will ever affect the riding of horses."[22] Also famous is the error of IBM chief Thomas Watson, who in 1943 believed that "there's a world market for maybe five computers"[23]. Almost nobody saw small PCs coming either; Siemens and AEG were still planning to co-operate on a mainframe computer in the 1970s.[24] The container revolution came as another surprise. Initially, the only expectation for the steel boxes is that they would relieve the railroads on the American East Coast.[25] Bill Gates is supposed to have said in 1993 that the internet was "a hype". For its part, the consulting firm McKinsey projected in 1985 that there would be a maximum of one million mobile phones by the year 2000. In fact, there were 106 million, and today there are more than six billion.[26]

The list of false prophecies is therefore long. But that does not mean that the reverse argument—that everything is technically possible—is true. Many problems still do not have a particularly good solution, even though the search for one goes back decades, or even millennia. Some 13,000 years ago, people came up with the idea of filling in dental cavities. Back then, they took a mixture of natural bitumen, hair and plant fibres. Beeswax, tree resin, rock flour and plant seeds also played a role. Today, we mainly use ceramics, but the optimal filling has still not been found.[27] Nor do we have perfect sleeping pills, painkillers or sedatives, even though there has been research into them for more than a century. Likewise, there

is no antidepressant that works reliably, has no unpleasant side effects and is not addictive.[28] Many types of cancer remain undefeated, despite the billions of euros that are funnelled into this fight every year.

Sometimes, the issue is that technology is too expensive, which can affect even the most basic things. The first toilet that used water was invented 2,800 years ago in Mesopotamia, but 2.5 billion people still have no access to sanitary facilities.[29] The poorest often have mobile phones but no toilets. Making a phone call barely costs anything anymore, but unfortunately these revolutions in communication technology have not made it cheap to lay sewage pipes.

We cannot rely completely on technology. Sometimes finding good solutions is impossible, and sometimes inventions remain expensive, even though they have been in use for thousands of years. It would therefore be a bold move to blindly trust technological developments to guarantee that the climate catastrophe is averted.

A bigger issue, though, is that people mix the time frames up. The funny anecdotes given above are supposed to suggest that the technological future has always turned out better than expected. That may be true. But now there is not enough time to wait for possible breakthroughs. We must act now if we want to prevent climate collapse.

It also usually takes a long time for technologies to gain broad acceptance. Even if groundbreaking inventions were to emerge soon, it would probably be decades before these sensational eco-ideas were market-ready.

Progress moves at snail's pace: the first computers were invented towards the end of the second world war, but it then took another 55 years for a systematic "digitalisation" of the economy to begin. Even today, digital interconnectedness is still not the norm everywhere, as became evident during the coronavirus pandemic, when many health authorities had to send their data by fax.

The climate crisis must be managed with the technology that is already available. But the current options cannot generate enough cheap, eco-friendly energy to fuel green growth. And so all that’s left is green shrinking: fewer new buildings, fewer cars, fewer chemical products.

This purely quantitative analysis only considers the amount of products, which often raises the question of whether there might not also be such a thing as "qualitative growth". After all, it can be observed that many goods use less material but are simultaneously becoming more efficient.

Digitalisation in particular is awakening high hopes that the virtual worlds of computers could open up completely new opportunities for expansion that do not bring with them any environmental consequences. As the Harvard psychologist Steven Pinker writes enthusiastically: "Whereas the First Machine Age that emerged out of the Industrial Revolution was driven by energy, the second era is driven by the other anti-entropic resource, information."[30]

In this way, the knowledge revolution is supposed to liberate humankind from almost all earthly needs. This concept was deemed absurd by the

renowned environmental economist Herman E. Daly almost 30 years ago: "The notion [... of] substituting information for resources, is fantasy. We can surely eat lower on the food chain, but we cannot eat recipes![31] The growth critic Niko Paech expressed a similar opinion: "There is not yet a car or plane that can be refuelled with liquid knowledge instead of petrol or kerosene."[32] Moreover, as Daly noted, knowledge does not spread in a vacuum but requires a material foundation: "information does not exist apart from physical brains, books, and computers, and, further, brains require the support of bodies, books require library buildings, computers run on electricity, etc."[33]

Pinker should be just as well aware that computers without electricity are just dead matter. Nevertheless, he sees immense potential for liberation from the curse of raw materials, drawing on the experiences of every consumer: "The digital revolution, by replacing atoms with bits, is dematerialising the world in front of our eyes." The cubic yards of vinyl that used to be my music collection gave way to cubic inches of compact disks and then to the nothingness of MP3s. The river of newsprint flowing through my apartment has been stanched by an iPad." Most importantly, however, the smartphone gives wings to the fantasy that a kind of consumption that does not use raw materials is a conceivable prospect. Pinker again: "Just think of all the plastic, metal, and paper that no longer go into the forty-odd consumer products that can be replaced by a single smartphone, including a telephone, answering machine, phone book, camera, camcorder, tape recorder, radio, alarm clock, calculator, dictionary, Rolodex, calendar, street

maps, flashlight, fax, and compass—even a metronome, outdoor thermometer, and spirit level."[34]

But as neat as these examples may be, they do not actually solve the problem. The shift away from vinyl hasn't reduced greenhouse gas emissions at all. On the contrary, streaming music digitally consumes far more energy than listening to a good old record. In 1977, when vinyl still dominated, US music fans were responsible for 140,000 tonnes of CO_2 per year. By 2016, that figure was around 300,000 tonnes.[35]

Worse still are the films that are watched online via smartphones. Mobiles are indeed replacing telephone directories and city maps, but they have also become handheld cinemas, consuming enormous amounts of electricity. Video conferencing and cloud computing, Google searches and social media are not harmless either: digital technologies could well be emitting more CO_2 than all global car traffic put together as soon as 2025. [36]

The first mobile phones came onto the market in 1983, weighing just under 800 grams, and were so expensive that they were only common among police officers and millionaires—and in Hollywood films. In the blockbuster *Wall Street*, the unscrupulous speculator Gordon Gekko puts one of these "bricks" to his ear, signalling his status as one of the super-rich.

Today, almost everyone can afford a smartphone because they are now about 50 times cheaper than they were in Gekko's day. Technical progress has meant that far less energy and fewer raw materials are required to produce one. But ultimately, no resources have been saved, because

billions of mobile phones were manufactured instead. It is precisely because they became cheaper and cheaper that they multiplied exponentially.

The "rebound effect", which had been observed in the 19th century with steam power, strikes again. When machines or goods are manufactured more efficiently, what happens is not that fewer raw materials are consumed, but rather that more goods are produced instead. New growth is generated that would otherwise have been impossible.

The rebound effect can be seen everywhere.[37] Anyone who uses a computer will be familiar with the paradox whereby a new storage device is too big at first but soon becomes too small, because more memory allows more data to accumulate, which in turn requires more storage capacity.[38] TVs have become cheaper and cheaper, but their screens are often almost big enough to be cinema-sized. Fridges consume less energy but are getting larger and come with secondary appliances such as wine coolers, freezers and ice machines. The energy needed to heat every square metre of living space fell by 15% between 2000 and 2015, but living space per head grew by 14% over the same period.[39]

As regards traffic, too, the rebound effect nixes all austerity measures: although car engines are becoming more and more efficient, demand for diesel and petrol has not decreased because the horsepower of new cars has increased by 29% over the past 15 years instead.[40] A similar trend can be observed for aircraft: the amount of kerosene required per passenger is

falling all the time,[41] but unfortunately, the number of flights just keeps on rising. Estimates indicate that global air traffic will have tripled by 2050.[42]

Even ecological means of transport, such as rail, have to contend with the rebound effect. A good example is the ICE, a high-speed train line from Berlin to Munich, which was inaugurated in 2017, cost 17 billion euros and reduced the journey time from six hours to four. In its first year alone, 2.2 million new passengers were recorded on the route. Admittedly, half of those would previously have driven or flown. But the other half—about 3,000 people a day—had started travelling between Berlin and Munich, precisely because it was so nice and quick.[43]

Moreover, it is by no means certain that any flights will actually be saved now that some former passengers take the train between Munich and Berlin. Flight connections to the capital may have been cancelled, but this has just freed up slots for other destinations. In any case, there is no indication that the opening of the new railway line to Berlin in 2017 has meant that Bavarians fly any less. On the contrary, the growth of Munich Airport has continued unabated. In 2016, the airport handled 42.3 million passengers; by 2018, the total was 46.3 million.[44]

In the political arena, it is popular to make voters attractive propositions so that they opt to protect the climate for themselves. Trains are supposed to run fast and frequently to tempt citizens to climb aboard. But this approach fails because overall mobility is increasing. New trains mean more transits, not more climate protection.

Since the coronavirus pandemic, there has been a growing hope that at least the shift towards home working might calm things down. Unfortunately, however, there is no reason to expect traffic to decrease even if employees do communicate primarily through video conferencing. They will indeed commute to the office less frequently, but they will make extra trips—to go shopping, for example, which often used to be combined with the journey to and from work. At the same time, people's motivation to move further away from their employer increases when they only need to make occasional forays into the office. The number of work-related journeys may be falling, but the distances travelled are getting longer.[45]

The rebound effect can even be observed with bicycles, even though they are supposed to liberate our inner cities from the noise and stench of traffic. Amsterdam and Copenhagen are admired all over Europe because it is widely assumed that these self-proclaimed "bike-friendly cities" have hardly any cars.[46] But this beautiful image is deceptive. In fact, both cities have even more cars per inhabitant than Berlin, for example.

Only 26% of all journeys in Berlin are made by car, but that share is 31% in Amsterdam and 32% in Copenhagen. In neither city has the bicycle ousted the car; people there simply walk less than they do in Berlin. Moreover, fixating on inner-city traffic distorts our perception, as the number of car journeys is rising strongly across the country. The Dutch covered about 127 billion kilometres by car in 1994, compared with 139 billion in 2017. At the same time, however, the number of bicycle kilometres only increased from 14.1 to 14.5 billion. Cycling in Denmark has actually declined over the

past 30 years—from 680 to 487 kilometres per citizen per year—whereas car traffic has increased significantly there too.[47]

It is unrealistic to rely solely on technical efficiency. It cannot solve the climate problem, because the raw materials saved are promptly used to produce even more goods and to generate fresh growth. A look back to the 20th century can help us to precisely quantify this rebound effect: between 1900 and 2005, global economic output increased 23 times over. In the same period, the consumption of raw materials increased eightfold.[48] Which meant that there was a kind of "decoupling", because economic growth was three times faster than resource consumption. But that's little consolation. The environment would only benefit if far fewer raw materials were used. And then growth would be impossible.

Rebound effects crush any hope that there might be such a thing as "green growth". That's why they are simply ignored in most studies, as the Wuppertal Institute notes: "Rebound effects are implicitly assumed to be either weakly demonstrated or avoided by external conditions."[49] Yet again, it becomes apparent that economics-focused climate research does not meet scientific standards. Although new studies are emerging all the time, the crucial problems are being excluded.

Purely "qualitative growth" does not exist. Capitalism cannot be transformed into a knowledge-based social system that flourishes in the virtual worlds of the internet. Digitalisation itself gobbles up huge amounts of energy, and old consumption patterns do not disappear simply because people now have

smartphones. They still drive places, just with a mobile phone glued to their ear.

However, the term "qualitative growth" is sometimes understood in a completely different way: the idea would be to expand specific activities that are important for society, but that at the same time do not generate huge amounts of emissions.[50] Care work, education and art would be particularly relevant here. There is no doubt that Germany needs more staff in its hospitals and retirement homes, and there is also a shortage of teachers in schools. But as sensible as it would be to invest in care and education, doing so would not give rise to "qualitative growth".

Instead, there would be some kind of "consumption exchange". If the German government were to decide to employ more nursing staff or to pay them better, contributions for nursing care insurance would have to rise in order to cover these additional costs. Citizens would be left with less money overall and could not take as many flights to Mallorca, for example. However, the nurses *would* have more money for travelling to the Balearics. In the end, there would be just as many Germans in Mallorca as there were before—only different ones.

Or in other words, there is no "qualitative growth", because nurses want to be able to build houses and buy cars too. Even if a certain occupation generated hardly any greenhouse gas emissions, wages would be spent on goods that are mostly harmful to the climate. "Qualitative growth" would require that the additional teachers only consume educational products and

nothing else. A ludicrous notion.[51] The growth critic Niko Paech summed it up pointedly when he said: "A CO_2-neutral euro, dollar or yen is impossible, simply because they embody the demand for material values."[52]

Moreover, it is not true that care work, education or art would be purely immaterial and would not produce any greenhouse gas. The Berlin *Schaubühne* recently had its carbon footprint assessed, and the results were staggering: the theatre emits huge amounts of CO_2 because it flies to all continents to give about one hundred guest performances every year.

Which means that growth cannot be "qualitative" any more than it can be "green". These terms serve only to cloud the realities. There is no miracle technology that would suddenly "dematerialise" capitalism. So the problem remains that there will not be enough green energy to fuel the whole economy. It is time to think about "degrowth". There has been little research into this difficult topic because it touches on the unthinkable: capitalism collapses as soon as there is no growth. However, as we have already heard, "it is easier to imagine the end of the world than the end of capitalism."

[END OF SAMPLE]