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Planets, Pockets, PR: Parables of Energy Storage

i. A Planetary Battery

'Energy is always conserved', it just behaves that way. But whatever is conserved, in words we might half remember like a bedtime prayer 'tends toward absolute entropy'. This means conserved energy likely becomes less useful, it degrades with time and with each conversion until all we are left with is a motionless universe, everything cooled to minus 273.15°C, absolute zero. That, or as a physicist recently explained to me, our expanding universe's many suns will eventually get sucked into black holes. Entropy is in a cosmic death battle with gravity. So, energy isn't a thing we can save forever, it's a process, an ongoing event. If we're lucky or try hard, we can delay entropy in certain places and certain times (We can't do much about black holes). The fundamental problem in storing energy is that it's a Sisyphean task. We're in a constant fight against entropy, against disorder, heat, friction, waste. We are pushing ever-bigger boulders up hills, and this always requires more energy.

The reason that we can keep on pushing is that we keep getting topped up by the Sun. This slowly-dying ball of burning hydrogen constantly beams around 173 terawatts of radiative energy onto our rotisserie planet.[1] This means the most fundamental unit of energy storage is, somewhat strangely, the ground under our

[1] What is a Watt? If energy is a process, then a Watt is a unit that indicates the power or rate of work of a given source or use of energy. Some lightbulbs do 40 watts of work, a horse is conventionally measured as having 746 Watts of working power – hence, horsepower. A terawatt (TW) is a trillion watts (1^{12}), or over a billion horses.

feet. On average, each square meter of Earth's surface receives about 1.366 kilowatts of energy, a figure known as the '*solar constant'*.[2] Lots of energy is lost along the way. A large portion is absorbed by the air sat above each square meter. A proportion of what is left is absorbed into whatever happens to be on that square meter, soil, water, a golf course. This means Earth's average temperature is about 14 degrees centigrade, while the space we float in is just 2.7 degrees above absolute zero. Earth and its atmosphere are a battery. One which, thanks to increasing greenhouse gases, is becoming increasingly good at storing energy.

Leipzig-based physical chemist Wilhelm Ostwald, who later dreamt up an energetic theory of society (to the horror of sociologists), wrote about this planetary battery in his 1901 text *Vorlesungen über Naturphilosophie* (*Lectures on Nature Philosophy*). He described how the Earth 'assimilated' radiating solar energy. In a poetic passage he described how the Sun alone was not good enough to sustain the stable conditions necessary for social progress. The leaves of plants, each a little photosynthetic solar receiver, assimilate energy and mobilise the chemicals contained in soil, grow, and feeding 'higher' forms of life. However, because Earth rotates, at a dizzying 1000 kmph, we get no sunlight at night, and due to the tilt of its axis, we don't get much in winter at higher latitudes. Luckily for those in Northern climes, another source of stored terrestrial energy was available, the leftovers of millennia of insolation and the complex of organisms it granted life: fossil fuels.[3]

[2] This figure fluctuates by about 0.2 percent when Sun spots flare up during 11-year solar cycles, these events are a result of cyclical polarity flips (magnetic reorientations) of the solar axis.
[3] Wilhelm Ostwald, *Vorlesungen über Naturphilosophie* (Leipzig, Veit, 197 [1902]). Thanks to Benjamin Steininger for the reference.

Ironically, there is arguably no better form of energy storage than this residual sunlight. Coal and petroleum are useable for around 500 million years, whereas most biomasses last only a few seasons, without some form of preservation. Or perhaps for a few centuries in the case of wood. Though we might not want to burn antique furniture. However, while fossil fuels are enviable form of energy storage, their formation was wildly inefficient. Of all the land-based photosynthesised stuff on Earth, only 0.09 percent became coal. While only 0.00009 percent of land and sea organismic precursor gunge became oil.[4] The good or perhaps bad thing is that this process occurred for hundreds of millions of years, a time-scale over which concepts like inefficiency don't matter. The result has been the creation of a vast subterranean *stock* of fossilised energy, far more concentrated than sunlight, which we hew, sell, burn, and, as a species, satisfy 80 percent of our collective appetite for power with.

Fossilized energy was once seen as a promethean gift to humankind (or at least to some humans), a source of fire stolen from the gods that freed many of us from the limited gift of the solar constant. Wealth was no longer dictated by how much land – the former fundament of energy storage - you owned. In a solar-land system many societies involved an armed elite creaming off a good proportion of the wealth from a fairly limited and seasonally-fluctuating productive economy. For most of human history we were in a situation that has been termed a 'Malthusian deadlock'.[5] Wealth and population growth were constrained by the productive limits of the Sun's energy,

[4] Jeffrey S. Dukes, "Burning Buried Sunshine: Human Consumption of Ancient Solar Energy", *Climatic Change* 61 (2003): 31-44.
[5] On Malthus see Edward Wrigley, "The Limits to Growth: Malthus and the Classical Economists." *Population and Development Review,* 14, (1988): 30–48.

directly or in processed forms. Worse still, a proportion of what was derived the Sun was forcefully “donated” to an armed aristocracy and its supporting spiritual authority. For good or ill, change came when Western Europeans started burning coal in engines. The concentrated accumulation of capital this allowed for, though it also went to the few not the many, was a precondition for calls for the redistribution of wealth and creation of a distinct hydrocarbon-dependent form of democracy.

Historical anthropologist James C Scott argues that the storage of energy was a precondition for the formation of the earliest political states. The rich alluvial soils deposited by the Tigris and Euphrates rivers provided the nutritional substrate for Mesopotamian society, home of some of the earliest city-states. In fecund river valleys, grains were grown and harvested, leading to some of the earliest forms of agriculture in the so-called ‘Fertile Crescent’. From sediment came grain, tiny nuggets of solar-powered protein and carbohydrates. Grain was not only a food, calories, but also a medium of conversion, something to be traded for objects or services believed of equivalent value. It could be transported, and if kept dry, free from rats, weevils, and thieves, stored for years. Grains were accumulations of surplus energy, and a unit of currency for those able to enforce equivalencies. Grain became a basis for accumulating wealth and building states via taxation. The historical formation of states governments, armies, and bean-counting bureaucrats then partly depended on a simple means of storing solar energy: the granary.[6]

[6] James C Scott, *Against the Grain: A Deep History of the Earliest States* (New Haven, Yale: 2018), 175.

These simple raised structures helped to free fledgling states from uncertainty: floods, bad harvests, war, drought, and other disruptions to calorific flow. Grain could also be used to generate other forms of energy, ambulant stocks of fat and protein which some call chickens, cows, sheep, and pigs. Domesticated animals are vessels of energy storage, fed on excess grain or food otherwise destined for the bin. They are charged up during periods of abundance and eaten in scarcer times, such as the long winters of Northern latitudes. Other techniques to escape the limits of seasonality include salting, pickling, fermenting, drying, and smoking. By immersing a gurken in an electrolytic brine, energy flows become energy stocks. The difference between this storage technique and simply foraging for food in the wild is the extra labour involved. Tribes of hunter gatherers, as we've probably all read somewhere, supposedly had shorter working days than both the medieval peasant and today's software engineer.[7] So why did we relent to working harder and longer? The lure of enrichment, the inhumanity of enslavement, the threat of state-sanctioned violence all played a role, as did the promise we could escape the tyranny of the seasons.

This doesn't mean non-domesticated humans didn't store energy. David Graeber and David Wengrow, in their recent book *The Dawn of Everything* reimagine human history. They argue that our expanding, ever-more-precise, and technologically-sophisticated archaeological record rubbishes any broad-brush theories about human societies having inevitably moved from being hunter gathers to farmers,

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[7] Anthropologist Marshall Sahlins popularised the idea that hunter-gathering was a 4-hour-a-day doddle. Sahlins, "Notes on the Origins of the Affluent Society", Richard B Lee and Irven DeVore, *Man the Hunter* (Aldine de Gruyter: New York, 1968), 85-89. More recent research suggests this leisurely life wasn't the case for all 'prehistorical' people. David Graeber and David Wengrow, *The Dawn of Everything*, 139-140.

increasing in the sophistication of their energy storage techniques. In doing so, they have unsettled the idea that grain-energy rich states were bound to rule over others. Not even the invention of steam engines had to inevitably lead to the rise of a hegemonic empire. The first steam engines, as they point out, were invented in Ancient Greece, but rather than using them to conquer 4/5 of the World, as Britain later did, they used them to create theatrical illusions: such as temple doors that seemed to open of their own accord. The Davids argue that human history is far stranger than we assumed. In part because *Homo Sapiens* have existed for around 200,000 years, for which we only have about 5,000 years of written records (early Sumerian cuneiform tablets). We know little about the remaining 97.5 percent of history, and what we do know is based on remains and rubbish. This archaeologically-vital trash shows energy storage has an extremely long history.

Take an example from the western-edge of France, specifically Cap Sizun in Brittany. There, in 1985 a geographer called Bernard Hallégouët discovered a cave called Menez Dragan that had been sealed over by a rockfall. In it were shards of flint and cut pebbles, traces of human occupation. Eight stones had been arranged neatly in a circle, and within this, there were traces of charcoal and fire-reddened flint. All of this would have been pretty unremarkable were it not for the fact that since someone had lit this fire, the cave appeared to have been periodically inundated with seawater. This suggested the hearth had undergone dramatic sea level rises, fluctuations in environmental conditions which suggested the fire belonged to a period of Earth history long before the last Ice Age. Hallégouët and colleagues subjected a hearth stone to electron spin resonance, a dating method that measures how much of Earth's trace radiation has been absorbed by something, in this case a lump of burnt quartz. It gave a fairly precise indication of how old it was.[8] The results suggested the Menez Dragan cave fire was lit around 465,000 years earlier. It had illuminated this dark recess, and its radiating heat would have been absorbed into the walls enclosing it, while the air circulating in the cave would have warmed a little. Though inefficient without a door, it appeared someone had been trying to save energy. Pyroarchaeologists considered this one of the oldest examples of the controlled use of fire. We've been trying to store energy imperfectly and in specific places and specific times, for at least a 1/4 of our species' existence.

As Earth has become a dangerously efficient battery, some humans have realised that we need to move away from our super-persistent forms of energy storage, coal and oil. This will require us to return to the irregularities of a solar energy system. A return to intermittencies, to seasons, and diurnal fluxes, dark and early nights, feasts and fasting. This is the nightmare situation that critics of de-fossilization often fall back on. How can server farms or life-support machines run on intermittent solar panels? Some claim they know the answer. If once we had Watt's rotating steam engine or Thomas Edison's electrical grid as energy 'solutions', today we have heir to an apartheid-era emerald empire, online transaction vampire, and persistent twitter-irritant Elon Musk, who claims he can overcome the intermittencies of a solar economy with batteries. In 2016 he purchased SolarCity, a large solar firm run by his

[8] Jean-Laurent Monnier, Bernard Hallégouët, Stéphan Hingaunt, et al. "A new regional group of the Lower Palaeolithic in Brittany (France), recently dated by Electron Spin Resonance", *Compte rendus de l'Académie des Sciences de Paris*, 319, 1 (1994), 155-160.

cousins. This was the first step in a widely publicised 'Secret Tesla Motors Master Plan", Musk's long-term plan to move from a 'mine-and-burn hydrocarbon economy towards a solar electric economy'.[9] If allied with cutting edge photovoltaics, he claims his lithium-ion 'powerwall' batteries will not 'suck' like others. Instead, they will become an obligatory passage point, a commercial product that can tame the Sun.[10]

So, we appear to be stuck between a rock and a hard place. Do we have to supplicate to the world's richest man to allow us to effectively store low-carbon energy or do we want to live free from the burdens imposed this energy-storage autocrat? Wouldn't it be nice if we could find alternative ways of using energy that don't involve lining the pockets of arguably the world's most self-important man? In doing so, do we need to go back into the cave, or are less austere approaches possible? What about slowing down and learning to live with intermittencies, with fluctuations, cycles, and seasonality? We might enjoy shorter working days, longer nights.[11] Rather than attempting to tame the Sun, maybe we should be tamed by it?

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[9] Elon Musk, "The Secret Tesla Motors Master Plan (just between you and me). August 2 2006. Available: https://www.tesla.com/blog/secret-tesla-motors-master-plan-just-between-you-and-me

[10] One estimate is that meeting the US's energy storage needs alone would require 37.8 billion Tesla Powerwall 2.0 home energy storage systems. Varun Sivaram, *Taming the Sun: Innovations to Harness Solar Energy and Power the Planet* (Cambridge Mass., MIT: 2018), 225.

[11] Kyle Powys Whyte and Holly Jean Buck, "Geoengineering and Indigenous Climate Justice: a conversation with Kyle Powys Whyte", in J.P. Sapinski, Holly Jean Buck, and Andreas Malm, *Has it Come to This? The Promises and Perils of Geoengineering on the Brink* (New Brunswick: Rutgers, 2021), 79.

‘A mobile phone in a cave’, DALL-E-Mini with assistance from the author, 13 June 2022

ii. Pocket-sized entropy delayers

Most humans walk around with a battery rubbing against their upper thigh or one of their bum cheeks, or perhaps in a handy belt-fastened holster. Around 91.54 percent of the world own a mobile phone, that is 7.26-billion of us. Each of us are carrying a little box of conserved energy, a pocket-sized demonstration of the energetic principles which simultaneously enables and constrains every process in the universe. Each battery is a device for converting electrical energy into a charged chemical solution, which we then transform into information, be it emoticons, likes, or a transgressively old-fashioned phone call. Like almost all technologies, batteries are a means to allow us to briefly and advantageously delay entropy for some time.

When our battery runs out, we might pull out a battery pack to charge it or plug it into two or three small holes in the wall. When we do this, we are realising a process of electrochemical polarisation. In effect we channel current, a flow of charged particles, into the battery, until it can't take any more – it becomes resistant. This limit occurs because there is a finite solution of electrons in the battery's constituent electrolytic solution which can become charged when they encounter current.

US Vietnam war veteran Richard Shallenberg wrote a very beautiful history of the battery in the late eighties called *Bottled Energy*.[12] Like most things, batteries have a strange history, particularly in Germany. There, Munich-based chemist and philosopher Johann Ritter thought of batteries as a demonstration of the principles of

[12] Richard H Schallenberg, *Bottled Energy: Electrical Engineering and the Evolution of Chemical Energy Storage* (Philadelphia: APS, 1982).

Naturphilosophie, a philosophical blend of science and romantic ideas about nature.[13] Its central belief was *Weltseele*, a spiritual force believed to pervade the universe and animate all human and non-human entities. This force, and so all of nature, was composed of opposing forces, life-death, north-south, up-down, positive-negative. Everything was polarised. The World was a gigantic pile of substances with either positive or negative relations to one and other, which constantly underwent countless processes of attraction and repulsion. Batteries were far more than an technology, they demonstrated the vital *elan* dynamizing all things in the universe.

Today we understand electricity is not a *source* of energy so much as a means for transferring its power over space and time, it's a kind of currency. We've replaced our enchantment with batteries with terrestrial accountancy. The Sun drives Earth's hydrological and atmospheric cycles. In doing so, the formation of lakes, glaciers, and snowfall above sea-level are natural forms of energy storage. The potential energy of frozen or dammed water is stored by the planet's topography. Reservoirs, for example, store the energy of raised water. Just how much depends on the mass of the water, its gravity, and the height at which it is stored. This liquid battery could later flow, driving a water wheel, or spinning electricity-generating magnets. All that was once sacred has arguably been profaned, and we get to charge our phones.

[13] Ritter's 'pile' consisted of 600 layers of saltwater soaked cardboard and copper. The battery was assembled in his flat, 'a vile and dismal room in which everything possible: books, instruments, wine bottles – lay indiscriminately about', where he used it in a series of brutal self-experiments, eventually dying aged 33. Stuart Walker Strickland, "The Ideology of Self-knowledge and the Practice of Self-experimentation", *Eighteenth-Century Studies*, 31, 4 (1998): 453-471.

Most people are vaguely aware and mildly guilty about the geological make-up of the battery in their pocket. In most there's a lithium-ion cell, a little bottle or bottles of lithium (perhaps from Chile, or Saxony), cobalt (perhaps from the Congo), and oxygen (from the atmosphere), a mixture called lithium cobalt oxide. This cell or a set of cells can be plugged into the electrical grid. In doing so, we connect it to a far larger network of current that has been generated elsewhere, perhaps with Lusatian lignite in Jänschwalde, or maybe, if the sun is shining, a solar farm in Werneuchen.

Current flows through this electrolytic cocktail, triggering a reversible reaction during which lithium ions become negatively charged. As we charge a battery, the current potentiates the energy which is latent in this chemical solution. It can help to imagine the ions as if they were dominos. In charging, it is as if we stand each domino on its end, upright. If we actually did this, we would use our bodies' physiological energy to raise and line up each domino. We would be the current. Some of the energy we would expend in standing the dominos up is now stored in the potential of their position. When we use a battery, it is as if we tip the dominos over, and use the energy generated over the time in which they sequentially fall. Unfortunately, it always takes more energy to pile up the dominos than we get from knocking them down. This differential is a manifestation of the universe's tendency toward absolute entropy. In a closed system, every energy conversion always results in a net loss.

We get less energy from a battery than we would have had we been able to directly make use of the chemical energy stored in a lump of Lusatian lignite. Were climate change not an issue, this would be a great thing, because as we earlier heard, coal is a wildly effective means for storing energy. However, it's not clear how we could use coal's energy directly, a change in state is necessary. Of course, it's also easier to carry around a lithium-ion battery than a lump of coal and a pocket-sized furnace and steam turbine. In using electricity to charge a lithium-ion battery, we trade a fossil fuel's capacity for long-term storage for far greater practicality and ease of use.

Great losses occur as we harness the energies of our terrestrial battery, and as we do so, It is clear we contribute to accelerating climate change. Around thirty percent of Germany's electrical energy still comes from burnt coal.[14] Under the rubric of the *Energiewende*, the plan is to find ways of generating energy that reduce the carbon emissions of Europe's largest economy, while also finding means to harvest low-carbon energy in a manner that can be stored and that assures *security* of supply. Security hasn't always been such a concern, but since Russia declared war on Ukraine, we learnt that Germany's strategic gas reserve is part owned by Gazprom.

A problem with vision of low-carbon transition, is that the energy density of the lithium-ion batteries upon which it depends is pretty low. Compared to their mass, they store far less energy than fossil fuels.[15] Moreover, making them requires a lot of water and can heavily pollute it. The ecology community largely agree that battery fabrication is not a good idea in a water-scarce region like Brandenburg. But perhaps a more important reason for not letting this situation go unchallenged is, that, ,

[14] Germany's energy mix in percentages: lignite 18.7, hard coal 9.4, nuclear 11.9, natural gas, 15.4, mineral oil 0.8 percent respectively, as of 2021, data from Destatis.de.
[15] Lithium-ion batteries store around 265 Wh/kg which equals <1 megajoule (MJ) per kg, whereas the density of bituminous coal has 29 MJ/kg, and crude oil can be as high 43 MJ/kg.

batteries, like many forms of energy storage, allow the accumulation of not just energy but also capital. History has shown us that controlling the means of energy storage become hyper-capitalised individuals with a political authority that can exceed that of states and certainly their citizens. As Musk says ‘batteries suck’.[16]

[16] Suzanne Jacobs, “Elon Musk unveils fancy new tesla battery – ‘cause existing batteries “suck”’, *Grist,* May 1 2015. Available at: https://grist.org/business-technology/elon-musk-unveils-fancy-new-tesla-battery-cause-existing-batteries-suck/

‘Tesla Gigafactory, Brandenburg in a sandstorm’, DALL-E-Mini with assistance from the author, 13 June 2022

iii. Energy and Information

North American mathematician Norbert Wiener is infamous for popularising cybernetics, the science of information and control. In doing so, he thought deeply about the relationship between energy and information. At a certain level of abstraction, he argued, information was, in a sense, the same thing as energy. A lump of coal was like a dense chunk of information, a book, an orderly cluster of bits. Entropy on the other hand, is as if someone put a book through a shredder and then let the resulting ribbons blow around like autumnal leaves. Weiner believed the relation between energy and information was not a mere analogy, they had a causal relation to one and other. Computers, recently invented, could be used to organise information, and information could be used to work against entropy. His example was the thermostat, a feedback mechanism that allowed humans to control the temperature of their home and, thereby, minimise unnecessary energy use. In his second book *The Human Use of Human Beings,* Wiener set out the idea that, thanks to our ability to use information to control our environment, the very possibility of progress had depended on unceasing maintenance of ‘local and temporary islands of decreasing entropy in a world in which the entropy as a whole tends to increase’.[17]

[17] Norbert Wiener, *The Human Use of Human Beings* (Boston: Houghton Miffin Co., 1950), 36.

That said, not all information is created equally. From the perspective of information theory, it doesn't matter if something is right or wrong, it's all just bits. Information can be used to *increase* as well as decrease the entropy in a given system. One way those who want to profit from the sale of energy do this, is to persuade us that it is not them who is the problem but us, the consumer. In a sense, they are right. Many of us have evolved, culturally, into a species whose who require a continuous input of high levels of energy to maintain our ecological niche. One estimate is that the richest 0.54 percent of our species consume a third more fossil fuels than the poorest *half* of humankind; another is that the richest 1 percent have a *carbon footprint* 175 times larger than the poorest 10 percent.[18] In the Congo, the DRC, the country where Tesla intends to source much of its lithium from, the average human's carbon footprint is just 0.08 tons per year. Berliners emit over 5,000 times more than Congolese people; and the average German, double again.[19] These vast differences have been the necessary precondition establishing the ecologically unequal relations on which wealth is built. We get battery-powered 'living rooms on wheels', while a few people in Manono, DRC, get temporary jobs as security guards.[20]

Tesla's Berlin-made 'Model Y' electric car is part of a growing suite of products that promise customers all the pleasures of a high-energy 'lifestyle' with none of the

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[18] Andreas Malm, *How to Blow Up A Pipeline: Learning to Fight in A World on Fire* (London: Verso, 2020), 127.
[19] Hanna Ritchie and Max Rose, "Democratic Republic of Congo: CO_2 Country Profile. Available at https://ourworldindata.org/co2/country/democratic-republic-of-congo; Jess Smee, "Energy use in the city of Berlin", 16 Jan 2019. Available at: https://cleanenergywire.org/factsheets/energy-use-city-berlin
[20] Jasper Jolly, "A living room on a skateboard: how electric vehicles are redefining the car", Guardian Sat 11 Jun 2022. Available at: https://www.theguardian.com/business/2022/jun/11/living-room-on-a-skateboard-how-electric-vehicles-are-redefining-the-car; on the maintenance of underdevelopment via relations of ecologically unequal exchange see Stephen G Bunker, *Underdeveloping the Amazon: Extraction, Unequal Exchange, and the Failure of the Modern State* (Chicago: University of Chicago Press, 1985).

carbon footprint, or at least far less of it. But what is this informational metric and why is it significant? The carbon footprint, as a method for divvying up responsibility for climate change, was an idea dreamt up, not on the frontlines of climate change activism but by public relations company Ogilvy & Mather at the turn of the millennium. Their client? British Petroleum. They took an existing ecological idea, that of 'ecological footprint', and applied it to the energy consumer.[21] The primary driver of climate change was not the oil industry but its customers. It became *our* responsibility to use less fossil fuels, not that of the company who ensures their ready supply. The responsibility to deconstruct the largest extractive and combustive infrastructure in human history, has been placed on the shoulders of us shoppers.[22] In our planet-spanning market-driven economy, our survival strategy has become to 'carry on as before' but emit less CO_2. The solution, we are told, is to buy differently: electric cars, solar panels, oat milk. The energy revolution has been commodified.[23]

If the solution to excessive consumerism is more consumerism, then who is keeping an eye on how much energy is used to make the things we buy? Rest easy, industrial ecologists and sustainability gurus tell us. Given the atmospheric constraints we face, modern manufacturers use a cutting-edge form of accounting called 'Life Cycle Analysis' or LCA, to ensure that the consumption of energy and

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[21] Julie Doyle, "Where has all the oil gone? BP branding and the elimination of climate change risk", in Nick Hefferman and David Wragg eds. *Culture, Environment and Eco-Politics* (Cambridge Scholars Press, 2011), 200-225; Mark Kaufman, "The Carbon Footprint Sham". Available at: https://mashable.com/feature/carbon-footprint-pr-campaign-sham
[22] On this infrastructure see Karen Seto, Steven Davis, Ronald Mitchell et al. "Carbon Lock-in: Types, Causes, and Policy Implications", *Annual Review of Environment and Resources* 41 (2016) 425-452.
[23] James Meek, "Who holds the welding rod?", *London Review of Books*, 43, 14 (2021): 1-19.

resources is minimised just as sales are maximised. For instance, Tesla have made sure to publicise the fact that their products impose a less severe ‘lifetime environmental impact’ than that of their rivals.[24] From extraction, to fabrication, and disposal, information about the impact of the company’s production processes for a subset of Earth parameters are carefully recorded and strategically publicised.

This is surely a good thing? Possibly not. It wasn’t big oil that came up with the idea this time, but the Coca Cola Company. In the late 1960s, coke-exec Harry Teasley Jr., commissioned a ‘lab for hire’ called the Midwest Research Institute (MRI) to develop a method for measuring the energy and resources consumed and emissions and waste created if the company adopted various different kind of bottles. The method was picked up by the United States’ Environmental Protection Agency.[25] ‘Resource and Environmental Profile Analysis’, or REPA, offered a convenient means for large corporations to demonstrate their concern for the environmental regulations that had begun to appear, while also finding ways to cut costs at different stages of production. Coke’s research remained secret, but one publicised outcome was that it persuaded the company to shift from glass bottles to lighter, more easily transported, and thus ‘energy efficient’, plastic bottles. The rest is history. Today, coke sells 200,000 plastic bottles of sugar water every minute and has been voted ‘world’s biggest polluter’ for the last four consecutive years.[26] Beware the REPA!

[24] Tesla 2020 Impact report. Available at: https://www.tesla.com/ns_videos/2020-tesla-impact-report.pdf
[25] Robert G Hunt and William E Franklin, “LCA - How it Came About – personal reflections on the origin and development of LCA in the USA”, *The International Journal of Life Cycle Assessment*, 1 (1996): 4-7.
[26] Break Free from Plastic, Brand Audit Report 20121 Vol IV. Available at: https://www.breakfreefromplastic.org/wp-content/uploads/2021/10/BRAND-AUDIT-REPORT-2021.pdf

Not all information is created equally. Environmental metrics that emerge as an aspect of corporate strategy, like carbon footprints or the LCAs, are a means to 'cook the books', to engage in some sketchy accounting practices. A given process can be shown to be significantly less energy-intensive than another depending on how you define the boundaries of measurement. Do you factor in the energy needed to fly Tesla execs from the US to Brandenburg, or to educate their kids at Berlin's best international schools? Maybe not, but why not? In making such measurements, the choice of system boundaries can have a decisive effect on whether a given process can be show to be more or less environmentally impactful than that of others.[27] The supposed certainties of measurement can also have a kind-of anti-political effect, allowing companies to conspicuously demonstrate regulatory compliance, and to publicly relate these indicators of altruism, all while avoiding the more important question of whether their continued growth, or even existence, is a good idea.[28]

Other forms of information are available. Musk's recent bid to buy Twitter was unfortunately unavoidable news. The 140-character medium might be somewhat new, but the strategy is old. In 1878, when the newspapers began asking difficult questions about the business practices of oil magnate JD Rockefeller, he initially fled to his holiday home in New Jersey, where he reportedly chewed celery to ease his nerves. He regrouped, hiring the *New York Herald's* editor to create a new narrative

[27] Gustav Cederlöf and Alf Hornborg, "System boundaries as epistemological and ethnographic problems: assessing energy technology and socio-environmental impact", *Journal of Political Ecology,* 28, 1 (2021): 2-21.
[28] Andrew Barry, "The anti-political economy", *Economy and Society,* 31, 1 (2002), 268-284.

about him. The paper soon ran a story titled ‘the human side of JD Rockefeller’, and this increasingly monopolistic petroleum industry magnate gained a vocal public defender.[29] Today, if as newspapers tell us, print is dead, Musk’s purchase of Twitter is just the latest iteration of a foundational PR strategy: create the news.[30]

Clearly Musk refuses to entertain some forms of information. For instance, does he know Brandenburg contains Germany’s largest desert? Lieberrose Wüste, or ‘sweet rose desert’, lies 90 kilometres southeast of Berlin. It was created in 1942 as a result of a forest fire and the soil-churning tracks of the tanks and incendiary weapons of the occupying Soviet army. The removal of foliage and topsoil revealed glacier-ground sand underneath. This *Panzerwüste* or ‘tank desert’ is a distinctly anthropogenic environment that has since adopted the succession dynamics of a natural desert. Within its five-square-kilometres, wind has formed dunes and reforms them, migrating birds land in confusion, mistaking this place for Africa, and desert lichens have grown between the footpaths and discarded unexploded munitions.[31]

Brandenburg’s Desert experiences temperature extremes unlike that of the temperate forests surrounding it. Its idiosyncrasies have led to the site being designated a nature protection area of special interest. However, as average global temperatures rise, most of Brandenburg is becoming more arid. The region may

[29] Ron Chernow, *Titan: the life of JD Rockefeller* (London: Random House, 1999), 218.
[30] Edward Bernays, *Crystallizing Public Opinion* (New York: Boni and Liveright, 1927), 170
[31] Ingo Brunk, Christoph Saure, Kenneth Anders, Gerhard Wiegleb “Der ehemalige Truppenübungsplatz Lieberose”, in Anders Wallschläger and Mrzljak Wiegleb eds. *Offenland-Management* (Springer, 2004), 227-242.

become more like Lieberrose Wüste than the swampy, lake-filled *Fichte* forests we are used to. It is also predicted that drinking water will become an increasingly scarce commodity. Tesla's factory will use as much water as a town of 40,000, and will do so by tapping into Berlin's primary water source, Müggelsee. Water contaminated with sulphates will be discharged back into the lake.[32] When asked about the implications of his plant (which is set to double in size) for the water supply of the city and region, Musk's reply was 'We're not in the desert'! Well, not yet.

[32] Leibniz Institute of Freshwater Ecology, "The Berlin-Brandenburg region and the Tesla Gigafactory", 2021. Available at: https://www.igb-berlin.de/en/news/berlin-brandenburg-region-and-tesla-gigafactory

‘Elon Musk in Lieberrose Wüste, Brandenburg’, DALL-E-Mini with assistance from the author, 13 June 2022