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The energy transition: A marathon, not a sprint

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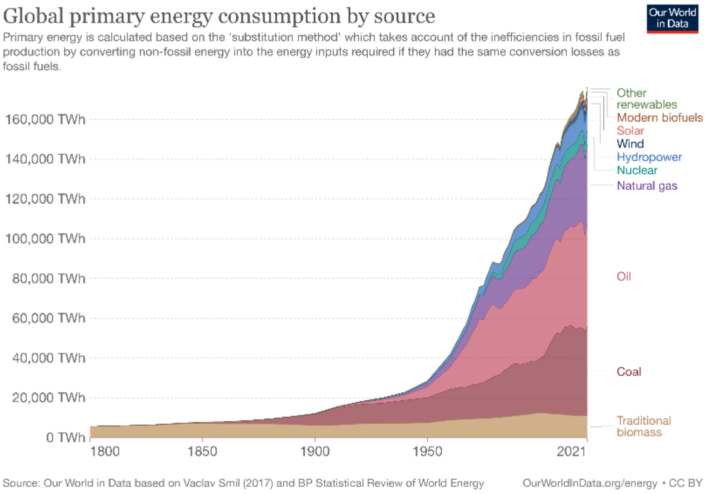
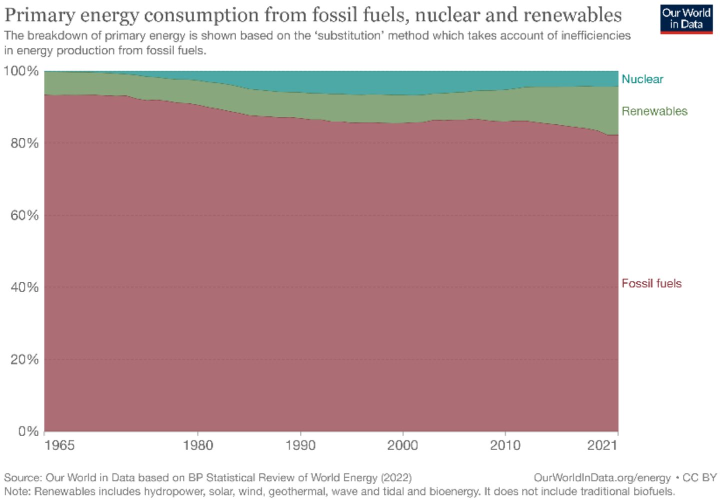
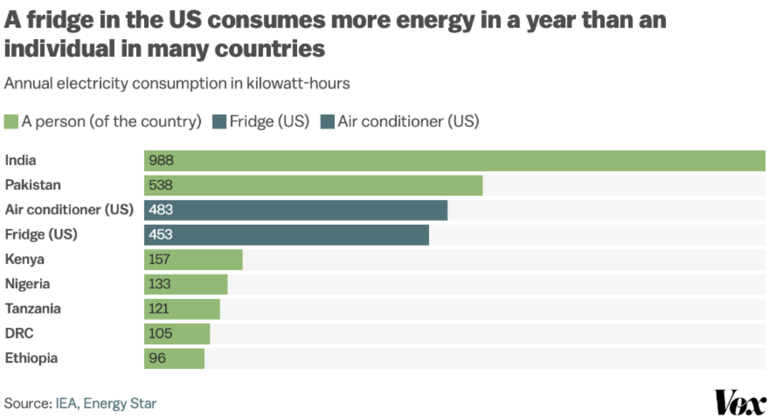
South Africans possess a peculiar depth of understanding about energy, born of our sporadic access to it. In many other nations, the affordability of power may occasionally be a worry, but its constant availability is a given. Energy is a broad subject, and beyond our local challenges, a colossal shift towards low-emission energy sources is unfolding worldwide to curb global warming. We predict that this transition will be more difficult and time-consuming than most anticipate.

Our ancestors' primary source of power was food, fuelling both humans and their domesticated animals to accomplish necessary tasks. The discovery and exploitation of fossil fuels propelled us forward, enabling us to perform tasks unimaginable before and to progress beyond a predominantly agricultural society. This showcases a fundamental truth: an enhanced quality of life requires increased energy input. Our progression to the present state is largely due to our intellectual capacity and our aptitude to harness energy beyond that which our own bodies can produce. As illustrated below, a significant proportion of this energy still comes from fossil fuels today.





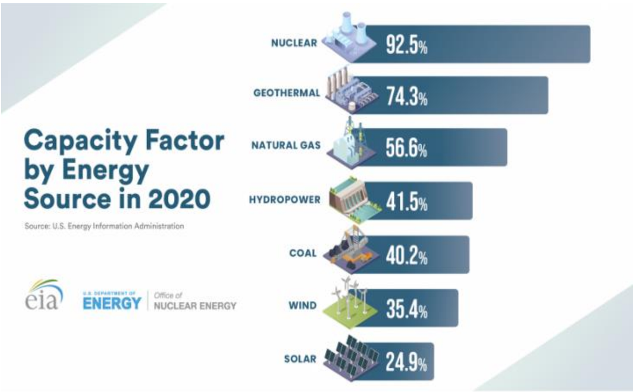
The current shift towards renewable[1] energy marks a historic first, as we attempt to both replace certain forms of energy while still growing total energy consumption. This increase is mainly driven by population growth in the developing world and aspirations for improved living standards which are escalating the demand for energy. China and India alone constitute 35% of the global population and their per capita energy usage is considerably less than that of developed nations. The US and Western Europe make up just 7% of the global population. Though the developed world is making progress in enhancing energy efficiency, we see a phenomenon known as Jevon's Paradox coming into play: the rise in efficiency leads to an increase in resource consumption instead of the decrease one might expect. No affluent, developed nation is a low-energy consumer. Energy = quality of life! Conversely, numerous poor, developing nations are low-energy users, as the accompanying image illustrates. These populations surely aspire to more than basic amenities.

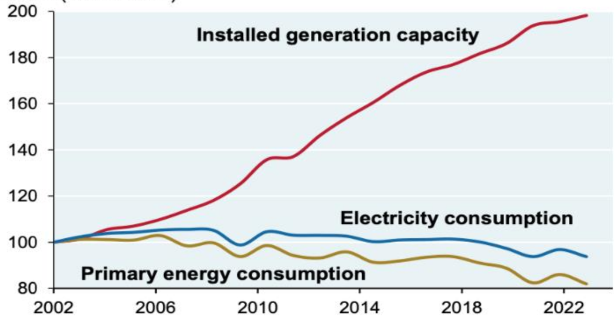


Renewable energy sources like solar and wind are intermittent—the sun doesn't always shine, and the wind doesn't always blow. South Africans with solar panels at home are acutely aware of this. This intermittent nature of renewable power is measured by capacity factors, with renewables scoring the lowest. This necessitates an overcapacity in renewable power generation compared to other energy sources. Energy storage solutions like batteries can partially address this issue, but they are costly and

[1] In this discussion, when we refer to renewables, we mean solar and wind energy. While hydropower is also renewable, it is well-established in most regions that can support it so its potential for growth is limited.

provide only short-term storage. Lower capacity factors ultimately mean that more renewable capacity must be built to meet the same energy demands, and other baseload power must be kept in reserve to counter the intermittency. This overcapacity requirement is evident in Germany's substantial rollout of renewable power as part of their Energiewende (energy turnaround) policy, as shown by the disparity between their installed capacity and actual electricity consumption.

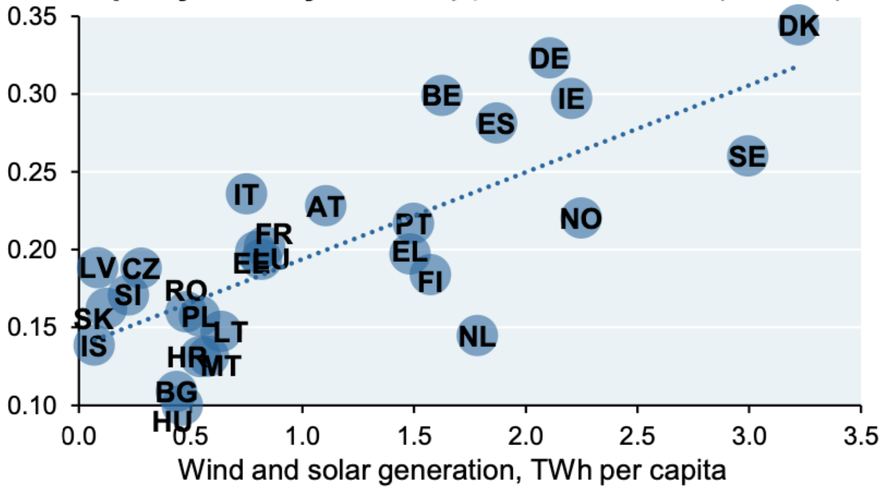




Source: Bundesverband BDEW, Fraunhofer Institute, JPMAM. 2023.

While the costs of renewables have decreased significantly and are competitive, the assertion that they are cheaper than other energy sources is not universally valid. One must factor in storage costs, variable pricing throughout the day, and the need for overcapacity. The levelised cost of electricity is often cited to argue that renewables are cheaper, but this measure overlooks the cost of the entire system, focusing instead on the cost of producing an additional unit of power. This is acceptable when renewables contribute minimally to the grid, causing little disruption, but it can be misleading as their proportion grows. This is evident in Europe's real-world outcomes. If renewables were indeed cheaper than existing power options, increased adoption should lead to reduced consumer costs. Yet, data from 2021 (pre-invasion) contradicts this, showing that grids with a higher share of intermittent power sources tend to be more expensive.

Household electricity prices vs wind and solar penetration in Europe by country, Electricity prices, EUR / kWh (H2 2021)

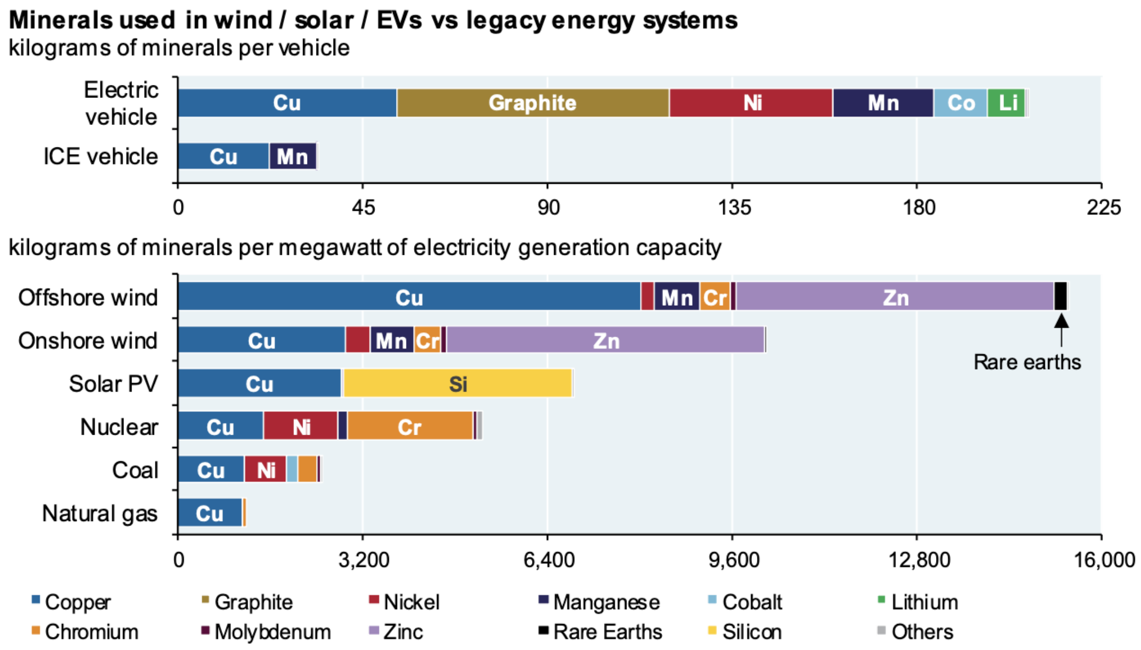


Source: Eurostat, JPMAM. 2022.

Another perspective to consider when discussing real costs involves the energy returned on energy invested (EROI) ratio, which is calculated by dividing energy output by energy input. An EROI ratio of 1 signifies no return on the energy invested. For comparison, nuclear power has an EROI of approximately 75, a natural gas plant stands at about 30, well-placed onshore wind energy at around 12, and solar at about 8. However, including the backup requirements for wind and solar power drops their EROI to about 6 and 2, respectively. The economic breakeven EROI is projected to be around 7 for developed nations. This underlines an essential point: typically, all new energy sources adopted by humans have been more efficient or cost-effective than their predecessors. For instance, oil, as a liquid, is better suited to transportation needs than coal, and hence, it replaced coal in these applications. This transition occurred with minimal policy requirements or external influence; the physical properties and economic advantages were sufficient. Switching to renewables, which have lower capacity and EROI, contradicts this trend and poses greater challenges.

A common counterargument regarding the costs involves the claim that fossil fuel generation doesn't adequately incorporate externalities (although carbon pricing is beginning to address this issue). Therefore, a direct comparison with renewables might not be entirely fair. However, historical evidence suggests that people resist paying more or making do with less, a fact that politicians are keenly aware of. Germany offers a useful case study: when Russia cut off most of their gas, it quickly reverted to coal power generation. In 2022, coal accounted for roughly a third of their power generation. As soon as the possibility of power shortages loomed, even a nation at the forefront of the energy transition and generally supportive of the goal ramped up its coal plants. To assist with affordability, they also implemented subsidies nationwide for consumers and industries.

Physical limitations are another concern, as constructing renewable infrastructure is very resource intensive. As illustrated below, renewables demand considerably more metals. Furthermore, they require substantial amounts of concrete and steel, both of which are energy-intensive to produce. Plotting the demand for these metals against future renewable growth plans reveals potential supply shortages. There are also escalating geopolitical concerns about the locations where these metals are mined and processed.

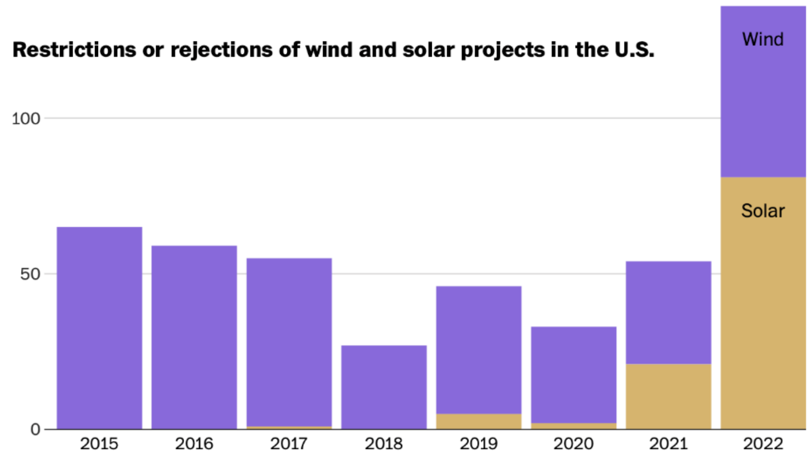


Source: IEA. JPMAM. 2022.

Copper is a prime example of a metal crucial to the renewable revolution due to its role in electrification and its unparalleled versatility. Current annual copper mining stands at about 22 million tonnes, a figure we estimate needs to double by 2050 to meet decarbonisation goals. Doubling copper supply that fast is not going to be easy: Chile and Peru account for two-fifths of global copper mining and a third of reserves. Both countries are experiencing significant political unrest. Despite the need for more mines, S&P Global Intelligence forecasts a decline in capital spending for copper production in real terms between 2022 and 2024. This would place spending at about half the previous supercycle peak, hardly enough to meet future growth requirements. Anglo American recently opened a copper mine in Peru called Quellaveco. According to their estimates, we would need 60 similar-sized mines with an estimated expenditure of $1 trillion to reach decarbonisation targets. However, they also project that it takes 15-20 years to develop a new mine. It's evident that, particularly with copper, we lack sufficient supply to meet our targets, investment in supply growth is lacking, and the lead times to establish a new mine are extensive.

Considering China's silent yet significant role in the global processing of numerous transition metals, as well as the manufacturing of batteries and solar panels, is essential too. The nation is responsible for producing 60% of the world's rare earth metals, which are indispensable for electric motors and wind turbines and processes nearly 90% of these metals. Furthermore, it processes 65% of the world's cobalt, 40% of its copper, and 58% of its lithium. China manufactures 77% of the world's lithium-ion batteries, crucial for electric cars and backup storage. The production of polysilicon of sufficient purity for use in solar panels is an incredibly energy-intensive process, and China accounts for 80% of global production. They also manufacture nearly all the wafers necessary for solar panels. With growing global political fragmentation, any interruptions to the current production processes could significantly impede our progress towards achieving decarbonisation goals.

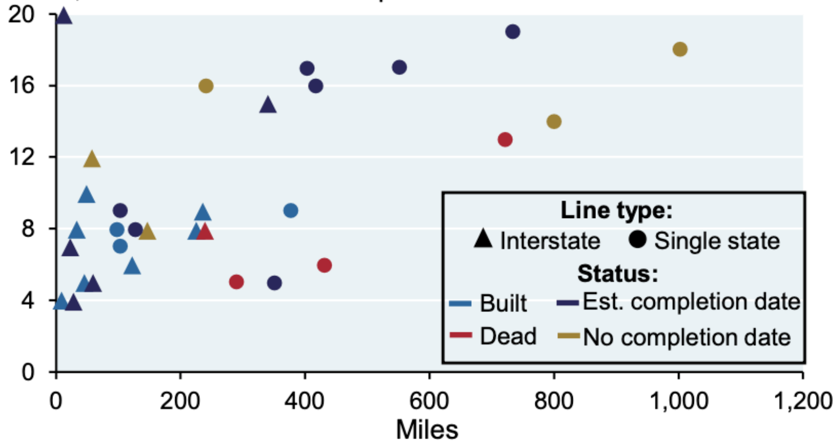
It's evident that the production and processing capacity of current clean energy materials is far more concentrated than our current energy mix. Coal is widely used still for power generation; it is a globally widespread resource and coal plants are generally easy to operate (with perhaps the exception of those in South Africa). The concentration of clean energy materials and production represents a significant geopolitical issue that hasn't gone unnoticed. However, addressing this issue and developing local processing and manufacturing capabilities will take time and may not even be possible. The developed world has been offshoring metal processing and energy-intensive manufacturing to the developing world for years, making it doubtful that there's the will or public support to re-shore these industries. While people tend to support the idea of constructing copper mines or wind farms, they often oppose these projects in their local areas. Such opposition can significantly slow down or even halt progress, as we're currently observing in developed countries where people are opposing solar and wind farms (see below analysis from The Washington Post), never mind actual mines.



Additionally, grid capacity and transmission infrastructure pose challenges. Renewable energy facilities are often located far from populated areas due to their dispersed nature or because certain regions are more suited for these facilities (such as solar farms in the Northern Cape). Consequently, additional transmission infrastructure needs to be developed concurrently with the renewable infrastructure. As pointed out by Investec, it can take up to 10 years to establish certain transmission infrastructures in South Africa due to the need to secure land servitudes. This isn't only a South African issue. The US requires annual growth of over 5% in transmission mileage until 2050 to meet stringent decarbonisation goals. While this might not sound like much, the growth rate from 1978 to 2020 was only 1.5% and it slowed down to 1% in the last five years. Expanding renewable energy generation significantly is impossible without the requisite transmission capacity. No matter how much wind and solar energy is installed, it's useless if it can't be connected to the grid. Supporting this point, the American Clean Power Association reported an 18% drop in US clean power installations last year, marking the worst year for onshore wind installations since 2018.

US transmission lines: length vs time to completion

Years, estimated or actual completion time



Source: "*The Challenges of Decarbonizing the U.S. Electric Grid by 2035*", Moch & Lee (Harvard). February 2022.

It's crucial to underscore that our discussion thus far has focused solely on electricity generation, which accounts for just around 20% of the world's energy demand. Even if we successfully navigate the challenges previously mentioned, we will only address the emissions from power generation. We still need to account for other forms of energy, with oil being a prime example. Power generation contributes to only 25% of total emissions, while agriculture accounts for 24%, manufacturing 21%, and transportation 14%. Decarbonising these sectors is a daunting task, likely to be even more difficult and time-consuming. We also need to contemplate second-order effects. For instance, if replacing current capacity and growing new capacity leads to resource shortages, might that not result in prolonged inflation?

The global energy transition necessitates a complete re-visioning of our entire energy system while maintaining the current system's operation. Essentially, it's akin to swapping out the engine of an aeroplane mid-flight. We should also deliberate whether concentrating solely on renewables is the most effective strategy to reach our objectives. Nuclear technology, which is emission-free, highly productive, and safe, offers a promising alternative. We are heartened by recent indications that nuclear energy is beginning to receive the recognition we believe it merits. Carbon capture, a process involving the removal of carbon dioxide from the air or industrial processes and its permanent storage underground, is also attracting increased investment. Given the enormity of the task, a variety of solutions are necessary. Despite the extensive global investment in terms of money and effort, we believe the constraints and timeline for achieving this transition are too often misunderstood.

This misunderstanding has already resulted in investment opportunities, whether through the required clean metal resources or the sustained demand for commodities like oil. We also foresee the emergence of additional investment opportunities in the future as entirely new kinds of businesses are established and others are disrupted.

Glacier Research thanks Ryann Dean for his contribution to this week's *Funds on Friday*

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Ryann obtained his Postgraduate Diploma in Accounting at UCT and went on to complete his articles and qualify as a chartered accountant at KPMG in Cape Town, specialising in financial services and the valuation of financial instruments. After qualifying he worked at Coronation Fund Managers for more than five years on the Global Equity team as an investment analyst. Ryann joined the Aylett & Co. Investment team in 2020 as a global equity analyst.