Atmos CAPITAL

"ENERGY WILL DO ANYTHING THAT CAN BE DONE IN THE WORLD; AND NO TALENTS, NO CIRCUMSTANCES, NO OPPORTUNITIES WILL MAKE A TWO-LEGGED ANIMAL A MAN WITHOUT IT"[1]

The first source of energy was the sun. The Eternal Flame. It played the lead role for a semi-eternity, providing heat and light to everything that existed on the surface of the earth. From a bolt of lightning, fire was born. It took millions of years to be tamed by *Homo Erectus*. Our ancestors were able to warm themselves in winter, defend themselves from predators, and enhance the nutritional value of food. This new diet turbocharged the evolution of the species. The fabric of history unfolds. Time passes, and wind debuts as a maritime propeller for primitive boats. Continents are populated. The Persians erect the first mills, grinding grain and irrigating crops. *Voilá*. A new agricultural revolution. Fast forward to 18th century England. New machines convert thermal energy into mechanical energy. The Industrial Revolution emerges and, with it, the capitalist mode of production. Efficiency multiplies. The wicked coal replaces human labor and biomass. Candles, lanterns, and fire are replaced by electric light. Whales escape from extinction. The rhythm of life begins to be controlled by man, and the atoms start dancing to his music. Oil is discovered! A new leap in productivity fuels the spread of energy following the rhythm of economic reasoning. Barbaric wars are replaced by geopolitical chess. The eternal conflict between the privileged and the unfortunate. Growth and wealth cease to be the only targets. Access to energy becomes a supranational defense strategy. Diversification of the energy matrix turns into a new obsession. New fossil fuels are explored. Suddenly, a rich and mature world, illuminated by environmental awareness, brings carbon into the equation.

Energy has always been a profound force in history. Our society has been shaped by man's struggle to master its environment and overcome the forces of nature and entropy. Energy is the ability to perform work, it is never created, always transformed. The most familiar energy-transforming machine lies behind the eyes reading these words. Our bodies convert the chemical energy from food into heat and mechanical energy. This chemical energy we ingest originated from the sun, as plants harness sunlight through photosynthesis to produce the glucose.

The power of the human body to produce energy is remarkably limited when compared to the machines we rely on. To toast a single slice of bread, we would need to completely exhaust an Olympic cycling champion[2]. The energy in a single disposable cup of gasoline is equivalent to the energy required to climb Mount Everest while carrying 5 gallons of water. On average[3], each human consumes as much energy as produced by 200 manual laborers. This is why the history of human productivity is closely tied to breakthroughs in energy conversion - the driving force behind the progress of civilization.

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[1] Goethe.

[2] https://www.youtube.com/watch?v=S4O5voOCqAQ.

[3] The concept of average consumption is naturally deceptive. While in the U.S. per capita consumption is 4 times the global average, in Bangladesh it is 15%.

For centuries, this pursuit was somewhat wild and unrestrained, driven by an insatiable ambition for efficiency gains. It was marked by a seemingly rational disregard for the resources consumed to achieve these goals. After all, these resources appeared infinite in the context of a world with low population density and vast untapped potential. Today, as climate discussions take center stage, it has become commonplace to label different energy sources as inherently good or bad. Heroes and villains in a Hollywood script. However, this Manichean reductionism is misleading and often treacherous. Context is everything. Electricity is ideal for keeping a refrigerator running but unsuitable for powering a blast furnace at 2,000 °C. Aviation fuel is exceptional for flying airplanes, but disastrous for feeding your dog. The relevance of an energy source depends on its availability, cost of use, and the ease with which it can be transported through space and time.

In medieval Europe, wood provided heat for both industries and domestic use. By the 16th century, as the population grew and cities expanded rapidly, the demand for energy increased significantly, leading to a shift towards a coal-based economy. Starting in 1530, wood prices began to soar. In 1555, the English Parliament imposed restrictions on wood exports when prices exceeded certain levels[4]. Concerned about potential shortages - especially since wood was essential for shipbuilding - the British government moved to curb deforestation in the early 17th century. Coal, which had been known for at least a few centuries[5], emerged to fill this vacuum. Manufacturing processes originally developed to operate with wood had to be redesigned, as coal smoke often damaged the products. From this adaptive optimization process, knowledge on how to handle coal emerged, and along with it the First Industrial Revolution[6]. Despite its grime, soot, and stench, coal provided a new wave of comfort to the damp and cold climate of the UK, accelerating its economic development and securing Britain a dominant position on the global geopolitical stage for centuries to come.

The shift from wood to coal is often regarded as the first major energy transition. Coal's abundance, low cost, and ease of storage were major advantages. However, its solid form and low density made transportation difficult. The discovery of oil solved the issue of energy for mobility. Being a liquid at room temperature with exceptional energy density, it became the quintessential mobile energy source. Its availability allowed the automobile to become a mass phenomenon, shaping the spatial and political organization dynamics of various societies throughout the 20th century. It also played a decisive role in the Allies' victory during World War II, serving both as a fuel for military vehicles and as a raw material critical for wartime production[7]. Following oil came natural gas, hydropower, nuclear energy, and, more recently, renewables. However, classifying these phenomena as transitions may be misleading. After all, wood was the only source with a

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[4] The Great Wave - Price Revolutions and the Rhythm of History.

[5] Coal was consumed on a small scale in areas where it outcropped near the surface in England since the 12th century, but given that wood was widely available, there were no incentives for more intensive exploitation.

[6] The reverberatory furnace, for example, was developed to allow for the burning of coal without contaminating the products with combustion gases. Additionally, processes such as cementation for the conversion of iron to steel, the use of coal in malt drying, and the introduction of the coke furnace for iron smelting, replacing charcoal, emerged. These adaptations enabled the expansion of various industries and were essential for the development of the First Industrial Revolution.

[7] The U.S. faced a severe rubber shortage due to the Japanese occupation of producing regions in Southeast Asia. Rubber was essential for the war effort, used in tires, aircraft, and other military materials. To overcome this limitation, the U.S. invested heavily in the development of synthetic rubber, which relies on oil as its main ingredient.

nominal decline in consumption[8]. Coal, for instance, continues to break consumption records despite centuries of use. Today, global coal consumption is nearly three times higher than it was 50 years ago. China, which represented about 10% of global consumption in 1970, now accounts for over 55%. In the past two decades alone, China's annual coal consumption has increased by more than 11 times the reductions achieved by the eco-conscious European Union. Reductions that, in turn, were quickly reversed following the gas supply crisis triggered by Russia's invasion of Ukraine. Necessity does not allow for choice.

"IF PEOPLE DO NOT BELIEVE THAT MATHEMATICS IS SIMPLE, IT IS ONLY BECAUSE THEY DON'T REALIZE HOW COMPLICATED LIFE IS"[9]

Recent public discourse highlights decarbonization as a new and pressing goal to be pursued. To bring greater clarity and structure to the debate surrounding greenhouse gas (GHG) emissions, Japanese economist Yoichi Kaya developed the following mathematical identity:

$$GHG = GHG / E \text{ [A]} * E/GDP \text{ [B]} * GDP/POP \text{ [C]} * POP \text{ [D]}$$

The formula shows that global greenhouse gas emissions (GHG) are determined by four factors: emission intensity per unit of energy [A], energy required to produce goods and services [B], GDP per capita [C], and population size [D]. To reduce emissions we must reduce the balance of these four elements. Excluding the extreme scenarios of major wars or widespread famine, the population variable is not a viable desirable solution and, in fact, continues to exert upwards pressure[10]. Similarly, reducing GDP per capita is unrealistic as a goal — emerging economies depend on GDP growth to improve living standards, while developed nations rely on economic growth to sustain their pension systems. This leaves us with two practical alternatives: i) increase energy efficiency by using less energy to produce the same amount of wealth; and/or ii) lower the emissions intensity of energy by reducing the amount of greenhouse gases emitted per unit of energy produced.

The wager on energy efficiency has its skeptics. In his 1865 book, "The Coal Question", English economist William Stanley Jevons introduced a proposition that is now known as the Jevons Paradox. He argued that greater efficiency in the use of a resource — coal, in this case — would not reduce consumption; rather, it would paradoxically lead to an increase. The mechanism is straightforward: efficiency gains lower the production costs, and thus the price of goods. Lower prices stimulate greater demand, ultimately increasing aggregate energy consumption despite lower per unit use. The efficiency gains in automobiles are an example where despite reduced unitary energy consumption there was a shift in consumer preferences toward larger,

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[8] Besides wood, there is only one other source that has seen its consumption reduced to the point of extinction: whale oil.
[9] John von Neumann.
[10] The UN projects a population growth rate of about 0.6% per year until 2050, bringing the global population close to 10 billion people by 2050.

less efficient vehicles - SUVs, which accounted for under 5% of the global fleet in 2010, rose to over 25% by 2022. Similarly, the exponential efficiency of LED lighting has not translated into proportional reduction in energy consumption[11]. A visit to the Sphere in Las Vegas[12] shows how human creativity perpetually balances saving and spending. Traditional economic doctrine, in its obsession with constant variables, must reckon with this phenomenon when modeling responses to the climate emergency. The International Energy Agency (IEA), in its Net Zero 2050 scenario, forecasts an annual reduction of over 3% in the energy intensity of GDP, leading to a total primary energy supply 15% lower than today's levels[13]. Whether this reflects an omission, negligence, or utopian optimism is unclear. More likely, it is a case of hope triumphing over experience.

The distribution of global consumption is asymmetric. The top 1 billion wealthiest individuals consume, on average, four times more per capita than the remaining 7 billion. For the 80% who consume the least, air travel is a distant dream, and vehicle ownership remains out of reach. It seems unlikely that those at the top of the pyramid will voluntarily reduce their consumption to such levels. At the same time, it is both immoral and politically untenable[14] to deny the poor the opportunity to improve their living standards. Potential energy productivity gains are not materializing quickly enough to keep pace with growing demand. As a civilized society, our goal should be to expand access to the comfort and experiences of modern life, while seeking a sustainable balance between individual benefits and collective costs.

There is only one path to controlling negative externalities — measured by greenhouse gas emissions: shifting the global energy matrix toward low-emission alternatives. Achieving long-term equilibrium requires expanding energy generation from non-carbon sources while making massive investments to electrify the economy. However, the bridge that leads us to this idyllic place is still built on hydrocarbons. After all, we cannot erect a wind turbine without the basic building blocks such as minerals, metallurgy, mills, blast furnaces, concrete, and fuel. A baroque and hyperbolic image that remains both realistic and pragmatic.

The collective imagination seeks to atone for its guilt by placing faith in the seemingly magical ability to generate clean energy from abundant sources such as the sun and wind. Even though they are omnipresent in the media and hailed as saviors of a humanity thirsty for fossil fuels, wind and solar accounted for only 2.4% of global energy production in 2023 - despite annual investments already exceeding the symbolic threshold of 1 trillion dollars.

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[11] The total demand for lighting in the year 2000 was about 9 petajoules (19% of the total demand for electricity); today it is close to 13 petajoules (15% of the total demand for electricity).

[12] The Sphere in Las Vegas is equipped with more than 1.2 million LEDs, consuming about 2.5 megawatts of energy, equivalent to the consumption of approximately 2,000 average households. With its external screen measuring 365 meters in diameter, it is the largest spherical LED structure in the world.

[13] The energy intensity of global GDP has been declining over the last 50 years at an average of 1% per year. According to the IEA's projections, this decline needs to accelerate to 3% per year.

[14] The popular reaction of the *Gilets Jaunes* (Yellow Vests) in France, which originated in 2018 against the increase in taxes on fossil fuels, illustrates the difficulty of implementing consumption restriction policies, even when supported by a consistent environmental rationale. Popular pressure in democratic regimes with periodic elections creates enormous resistance to any policy that directly affects the standards of living for the population.

“IT DOESN’T MATTER IF A CAT IS BLACK OR WHITE, SO LONG AS IT CATCHES MICE”[15] & “DEVELOPMENT IS THE ONLY HARD TRUTH”[15]

China possesses a distinct capacity for planning and execution due to its unique political system. Responsible for 40% of the global installed capacity for solar and wind power, it has used the energy transition as a key component of its development platform. By securing a privileged position in the supply chain of green energy technologies - managing mining rights and processing capacity essential for producing solar panels and batteries[16] - it has become a force to be reckoned with in the current geopolitical zeitgeist. However, behind this seemingly rosy picture lies an agnostic and insatiable appetite for energy. Twenty years ago, China accounted for 12% of all global energy consumption; today that figure has surged to nearly 30%. Over this period, China alone has been responsible for 57% of the increase in global energy demand. Clean energy has indeed grown from 7% to 18% of its energy mix, adding 26 exajoules[17] of carbon-free energy, more than any other country in history. However, focusing solely on this milestone obscures a critical reality and constitutes a significant analytical flaw. During the same timeframe, China has added more than 50 exajoules of coal. The Communist Party seems to distance itself from the absolute morality of Confucius, aligning instead with Machiavelli: The prince should do good whenever possible, but evil when necessary.

Due to its immense complexity and reach, topics related to carbon emissions and energy transition have become politicized and thus an analytical minefield. Forecasts often blur with aspirations and interpretations meld with desires. Narratives are simplified to conveniently align with preexisting worldviews. As long-term investors, we strive to avoid such traps and preserve a degree of intellectual independence. The existential threat posed by carbon is undeniable. Yet, the challenge of structuring society with the right incentives brings to mind the Riddle of the Sphinx of Thebes: “Decipher me, or I’ll devour you.”

"THE FIRST PRINCIPLE IS THAT YOU MUST NOT FOOL YOURSELF, AND YOU ARE THE EASIEST PERSON TO FOOL"[18]

Despite overwhelming evidence of smoking’s negative impacts, more than 1 billion people continue to smoke, fueling an industry that generates hundreds of billions of dollars in annual revenue. Each year millions die as a direct consequence of this self-inflicted behavior. While many smokers rationally understand that this habit could cost them their lives, most of the individuals are either unable or unwilling to break free from addiction. This kind of conduct constitutes ample material for behavioral scientists. At first glance, this kind of action seems to defy evolutionary logic. A decision that accelerates death should, theoretically, vanish from the

[15] Deng Xiaoping.
[16] In 2021, China controlled 72% of global polysilicon manufacturing capacity, 98% of ingots, 97% of wafers, 81% of cells, and 77% of solar modules, in addition to holding about 80% of global lithium-ion battery manufacturing capacity.
[17] As a scale reference, Brazil's primary energy consumption in 2023 was 14 EJ, 5 EJ more than 20 years ago.
[18] Richard Feynman.

gene pool over time. However, this assumption holds only if the gene encoding nicotine addiction offered no associated benefits[19] and if smoking-related deaths occurred in time to prevent reproduction. In the absence of these conditions natural selection has no mechanism to play its role.

Darwin's insight into the tail feathers of peacocks is one of the conceptual cornerstones of his work. The prominence of a trait that, at first glance, seems to hinder survival—a disproportionately large tail—appears to contradict the principles of natural selection. Yet survival is only part of the equation. The real evolutionary advantage lies in reproductive success. A peacock's extravagant tail, while a potential burden, enhances its ability to attract mates and produce more offspring, ensuring the longevity of its genes. Ultimately, it is the females—guided by their values, preferences, and desires—who determine which genes are passed on. Transposing this concept to the realm of investments, it is profit that endows a business with the potential for growth and replication. Cash generated by an operation allows for reinvestment and facilitates additional financing, which in turn enables further expansion through the opening of new stores, development of new products, or building of new factories. In this analogy, the consumer plays the role of the female, acting collectively as the final arbiter on which businesses endure. Consumers commit their resources not through their reproductive apparatus, but through their financial capital. Companies that stand the merciless test of time are those that successfully develop a symbiotic relationship with their customers, offering products or services that assist in their own strategy of survival and reproduction.

Richard Dawkins defines the body as a vehicle for the survival of genes. The behavior of this collection of genes, that we have come to call an individual, is shaped by evolutionary dynamics that escape our understanding, operating on time scales far beyond our comprehension. If individuals struggle to avoid self-imposed risks even to their own lives — such as smoking or excessive sugar consumption — it is hardly reasonable to expect economic agents to override their primal impulses in favor of a multi decade potential humanitarian risks. Such altruistic ideals may appear noble, but they fail to align with the realities of human behavior.

We approach the energy transition with diligence, aiming to distinguish empty rhetoric and politically driven agendas from strategies that make economic sense. We are skeptical of initiatives that fail to align economic incentives, regardless of how forcefully they are propelled by political narratives, or how much they enhance social reputation and provide a comfortable part for their evangelists to play. Our skepticism deepens when the numbers don't add up. Economic reality has a way of asserting itself, inevitably and inexorably. It may take time, but it always prevails.

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This piece is the first installment in a trilogy exploring the energy transition. In the next editions , we will explore the deeper implications of this transition for Brazil, and how these considerations influence our investment portfolio.

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[19] The CHRNA5 gene encodes a protein that plays a role in the production of structures that are part of nicotinic receptors, creating a predisposition to smoking. However, these same receptors are also responsible for the rapid transmission of signals between neurons.