SURPLUS ENERGY ECONOMICS

Energy, not money

THE SURPLUS ENERGY ECONOMY EXPLAINED

Foreword

The shock impact of the release and instant popularity of DeepSeek's R1 AI product has destroyed the capital-intensive, 'Big Tech' business model favoured in America for the development of artificial intelligence.

If a Chinese competitor can produce an equivalent product so cheaply (reportedly $5.8m) that it can be given away for free, US-style AI has zero chance of earning a return on - and much less of ever recouping - the billions of dollars already invested in AI, primarily by America's 'magnificent seven' tech corporations.

But behind this narrative lies a deeper reality. **The capital-intensive AI business model was destined to fail anyway**, with or without DeepSeek. This business model required the commitment of vastly too much energy for any vague and problematic benefits that it might deliver. This energy demand is both direct and indirect, because the real cost of raw materials is the energy required to supply them.

Following the re-election of Donald Trump, this is **the second unnecessary shock** delivered, in quick succession, to America's tech-heavy business and political hierarchy. Both shocks were "unnecessary" because **they were eminently predictable**, on the basis of understanding the economy as an energy system rather than a monetary one.

From this perspective, Kamala Harris was routed by Mr Trump because the Biden administration had **not** delivered "the greatest economy ever". Energy-based analysis could alone reveal that this supposed "growth" was purely cosmetic, and did not accord with trends in material prosperity as experienced by voters. The economic "success" of the Biden years was attributable to the under-reporting of systemic inflation and the spending of massive amounts of money borrowed by the government.

Politicians, commentators, corporate leaders and the markets might have bought this narrative of golden economic times, but the electorate, basing their judgements on their own experiences, weren't fooled.

To have known **ahead of the event** that capital-intensive AI would fail – and that "the greatest economy ever" wouldn't win the election for the Democrats – we needed to **benchmark** the financial economy to underlying material trends, and these are determined by energy.

We could go on, from this same perspective, to identify a series of outcomes not yet anticipated by the markets, or by leaders in business and government.

But **how** is energy-based economics able to enhance forward visibility by benchmarking the economy of money and credit to underlying material realities?

This briefing note has been complied to introduce the energy-based approach to economic analysis and projection.

https://surplusenergyeconomics.wordpress.com/

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Introduction

The Surplus Energy Economics philosophy is that the economy is primarily an energy system, and only in a secondary sense a financial one. The fatal error of orthodox or ‘classical’ economics is that it puts money and energy in the wrong order.

The defining purpose of the economy is the supply of material products and services to society. **None of this can be done without energy**.

Services are every bit as material as goods. We can’t deliver parcels without vehicles, or provide on-line services without networks and other hardware.

The idea of an ‘immaterial’ economy is a myth, and neither can we “de-couple” economic prosperity from the use of energy. Properly understood, this would require de-coupling the economy **from itself**.

No material product or service can be supplied without using energy. Money acts in a subsidiary role for the allocation and exchange of the goods, services and artefacts **made available by energy**.

We have to **follow the energy**, not “follow the money”, to know what’s really happening in the economy.

1. Money as claim

There have been numerous forms of money throughout history, from the cowrie shells of long-ago times to the cryptocurrencies of today. All of these have a single shared characteristic, that of being **token, not substance**.

Money has no **intrinsic** worth. We can’t eat *fiat* currency, or power our cars with precious metals. Money can be likened to the checks issued when attendees hand in their hats and coats at a function. These checks can’t keep these people warm and dry on their way home. For this, they must be exchanged for actual hats and coats.

Lacking intrinsic worth, money has value **only** in terms of the material things for which it can be exchanged. This is the principle of **money as claim**. The more money a person has, the larger are his or her **claims** on the material economy. We cannot create wealth by expanding the supply of money. Printing additional checks doesn’t increase the number of hats and coats available at the end of a function.

Money has only one worthwhile purpose. It is a medium for the exchange of goods and services. If a person is *isolated from exchange* – lost in a desert, perhaps, or cast adrift in a lifeboat – any money that he or she may have is worthless.

Money is not an effective store of value, because its worth is limited to the sum of material things for which it can be exchanged *at any given time*. If the monetary and the material move in different directions, or change at different speeds, the value of money **becomes a variable**.

This is why, across half a century, the American dollar has lost 85% of its purchasing power, whilst the value of the British pound has fallen by 93%.

Neither is money a reliable unit of account. When we use the *variable notation* of money to measure the economy, we are measuring the stock and flow of *claims*, **not** the material substance which **alone** imbues those claims with value.

Literally **no** product or service can be supplied without using energy. This makes money a **claim on energy**. Likewise, debt, as a 'claim on future money', is, in reality, 'a claim on future *energy*'.

2. The two economies

Effective interpretation of economic trends and prospects requires that we put energy, the material and the monetary in their proper places. This leads to the critical concept of the **two economies**.

One of these is the "**real**" (or *material*) economy of physical products and services. The other is the parallel "**financial**" (or *claim*) economy of money, transactions and credit.

All value that exists in the latter economy consists of claims on the former. The general level of prices at any time is the rate at which the monetary is exchanged for the material. Prices are *the two economies interface*. This *monetary-material rate of exchange* rises or falls in accordance with changes in the relative sizes of the "real" and "financial" economies.

3. The productive process

There is no mystery about how material products and services are supplied to society. Energy is used to convert non-energy raw materials, such as minerals and chemicals, into products, and into the physical infrastructure necessary for the provision of services.

All of these products and artefacts are either consumed, or wear out over time. The material economy is a continuous cycle of creation, disposal and replacement.

The productive process is a **dual equation**. As raw materials are converted into products and services, so energy is converted from a dense into a diffuse form. This is a **productive-dissipative system**, in which the productive and dissipative processes are of corresponding lengths.

Accordingly, if we truncate the dissipative process – by substituting an energy input of lesser density – we correspondingly shorten the productive process. The scale of material economic output is a function, not just of the quantity of energy available to the system, but of its energy-density as well.

4. The critical role of ECoE

Energy is **never** "free". The sun shines and the winds blow freely, but neither can be put to use without solar panels, wind turbines batteries and grids. Likewise, fossil fuels have no economic value without mines, wells, refineries, processing plants and transport systems such as pipelines and tankers.

All of this infrastructure is material. It cannot be created, operated, maintained or replaced without the use of energy. Colloquially, we have to "use" energy to "get" energy.

Stated more formally, "whenever energy is accessed for our use, a proportion of that energy is **always** consumed in the access process, and is unavailable for any other economic purpose".

This "consumed in access" component is known in Surplus Energy Economics as the **Energy Cost of Energy**. This is abbreviated ECoE, and measured as a percentage of total energy available to the system.

At an ECoE of 1%, we are left with 99% of energy supply for all other economic uses. If ECoE rises to 10%, this residual or "surplus" energy falls to 90%.

What this means is that **surplus** energy – available energy minus its ECoE cost – corresponds to material economic **prosperity**. Prosperity, therefore, moves inversely with ECoEs.

5. ECoE – a short history

The dynamics that drive changes in ECoEs over time are known. Three processes push ECoE downwards, and one process pushes it up.

The first of the three positives is *geographic reach*. Historically, we have extended our search for energy across the globe, finding lower-cost energy resources as our reach has extended. Thus, the ECoE of petroleum declined when we discovered, in the Middle East, oil reserves far cheaper to extract than those in America or elsewhere.

The second cost-lowering factor has been *economies of scale*. Doubling the size of a refinery or a pipeline doesn't double the cost of building and operating it. As the fossil fuel industries expanded in size, their ECoEs declined.

The third positive factor is *technology*. Over time, successive improvements in the techniques used to access energy have lowered the material costs of supply.

6. The limits of energy technology

Here, though, a strong cautionary note is required. The potential scope of any technology is **always** confined to an envelope established by the laws of physics. In energy technology, these limits are set by the physical characteristics of energy itself. These characteristics include the portability, and above all the energy-density, of the energy source in question.

Where renewable energy is concerned, these characteristics are **physically inferior** to those of fossil fuels, and this **can't** be 'fixed' by technological advance. The potential maximum rate of conversion from wind energy into electricity is set by Betz' Law. The potential conversion efficiency of solar power is determined by the Shockley-Quiesser Limit.

Technology cannot "repeal" the laws of physics.

The defining issue here is that **the energy-densities of wind and solar power are inherently lower than those of fossil fuels**. This is an intrinsic characteristic that technology cannot change. A larger material infrastructure is required per unit of these renewable energies than was needed for oil, natural gas and coal in their low-cost heyday. Battery technology will continue to advance, but cannot be expected to match the extraordinary energy density of the humble fuel tank.

These problems show up as intermittency, and as the high material and monetary costs of generating, transporting and storing renewable energy. But their **causation** lies in the inferior characteristics – the lesser energy densities - of renewable energy sources.

Being higher in material cost than fossil fuels, renewables have a much lesser capability for profit. When Henry Ford and others were pioneering motoring for the masses, giant energy companies – most obviously John D. Rockefeller's Standard Oil Trust – expanded in tandem with car-makers.

Today, by contrast, there are no "renewables majors" taking over the role of the oil industry's "Seven Sisters". There is no Standard Solar Trust or Gulf Wind Inc. sharing profitably in the endeavours of BYD and Tesla.

Rather, renewables require subsidy, which means that they **cannot** become independently super-profitable for investors. In *material* rather than simply financial terms, these subsidies are sourced from the fossil fuel economy.

It's not impossible for the ECoEs of renewables to fall below those of fossil fuels, but this will be a function, not of renewables becoming ever-cheaper, but of the ECoEs of oil, gas and coal continuing to rise.

Even this *crossover* potential is limited by the fact that "renewable" energy is not truly renewable. We cannot build and operate wind turbines and solar panels without using raw materials made available through the use of legacy energy from fossil fuels.

This **connects the potential ECoEs of renewables to those of carbon fuels**. These fossil fuel ECoEs are rising rapidly, and this brings us to the process that has been pushing ECoEs back upwards just as *reach*, *scale* and *technology* had previously been pushing them down.

7. ECoE & the reality of depletion

The word "depletion" describes the natural human preference for using lowest-cost resources first, and leaving costlier alternatives for later.

This process is applicable equally to energy and non-energy natural resources, such as minerals, agricultural land and accessible water.

All of these resources have been depleted over time:

- The mineral content in ore bodies has been falling relentlessly.
- The productive capability of farmland has declined, mainly through over-intensive cultivation and the excessive use of chemical inputs.
- We have to travel further, both literally and in the figurative forms of investment and physical infrastructure, to meet our rising needs for fresh water.

The natural environment, too, has been subjected to rapid depletion. The ability of the environment to absorb the by-products of human economic activity is, ultimately, subject to finite material limits. Although the environment is capable of self-renewal, this process, too, is measurably finite. The quality of the environment deteriorates whenever climate-harming emissions are generated at rates *in excess of* the maxima of natural self-renewal capability.

We should be clear that environmental and ecological deterioration are real trends. Temperatures are rising, and supplies of economic necessities - such as productive farmland and accessible water - are being undermined as a result.

Part of the problem with the pursuit of environmental sustainability is the inability of orthodox, 'money-only' economics to put meaningful values on these processes. We will **only** be able to attach valid economic numbers to these trends and their consequences when we place the energy-material, rather than the monetary, at the centre of economic notation.

8. The trend in ECoEs

In terms of economic performance and prospects, the most significant of the various depletion processes is the one that applies to energy.

The following charts combine a stylized, long-term picture of the **ECoE parabola** with a more recent illustration of segment trends, the latter running from 1965 to projections for 2050.

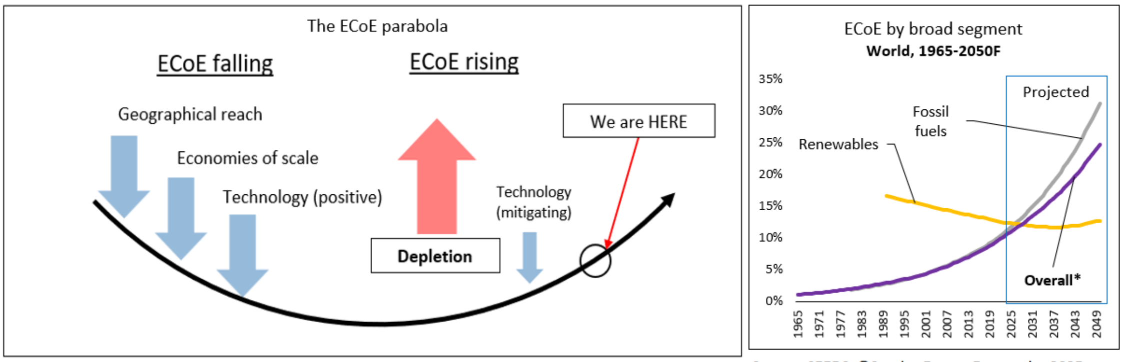
The ECoEs of fossil fuels – which continue to provide more than 80% of primary energy supply – fell for more than 150 years as geographic *reach*, economies of *scale* and evolving *technology* reduced the material costs of supply.

This trend hit its nadir in the quarter-century after 1945, which explains why so much robust growth in the material economy was enjoyed in that period. That nadir ECoE was, in all probability, well below 1%.

Latterly, as the potential benefits of reach, scale and technology have reached their limits, **depletion has taken over**, driving the trend ECoEs of fossil fuels up from 1.9% in 1980 to a projected 11.7% this year. This has pushed ECoEs from **all** sources of energy up from 2% to 11% over that same period.

Fig. 1

Long- and medium-term ECoE



Source: SEEDS graphic ©Surplus Energy Economics 2025

Source: SEEDS ©Surplus Energy Economics 2025
* Includes nuclear & hydroelectric power

For reasons previously discussed, the ECoEs of renewables are unlikely to fall significantly below the 12% level already reached. Accordingly, overall, all-sources ECoEs are likely to carry on climbing, reaching a projected 13% by 2030, 18% by 2040 and 25% by 2050.

9. The critical link - ECoE & prosperity

For context, growth in material economic prosperity per capita in the western Advanced Economies inflected into contraction at ECoEs of around 5%. This threshold was crossed in the years preceding the global financial crisis of 2008-09, which is why so much debt and quasi-debt was poured into these economies in a **futile** effort to reverse what was then known as "secular stagnation".

By virtue of their lesser complexities and correspondingly lower maintenance demands, Emerging Market (EM) economies enjoy greater resilience than the West in the face of rising ECoEs. But these countries, too, are now at, or very close to, the ECoE levels at which growth inflects into contraction.

This pattern explodes one long-standing myth, and explains one recent conundrum. The myth is that the EM countries have out-performed the Western economies because people in countries like China and India are somehow 'more diligent and energetic' than Westerners.

In reality, no such stereotyped explanation is required. The EM countries' economic outperformance of the West can be explained and quantified in terms of the **timing differentials** between ECoE-determined inflexions in these differing economies.

The conundrum is that of why rates of economic growth are falling in the EM world, and most notably in China. The People's Republic has experienced marked economic deceleration even as its burden of debts and quasi-debts has expanded rapidly. What China has been experiencing is its own version of ECoE-driven inflexion, something *which no amount of credit stimulus can reverse*.

10. Found in translation

The material economy is in the process of inflecting from growth into contraction. **The critical indicator of this process is the relentless rise in ECoEs**. What we are witnessing is the fading out of the impetus – otherwise called the *carbon pulse* – initially imparted to the economy by the harnessing of fossil fuels.

Something like this has happened before, during the inter-war years, when the coal-based economy started to falter. This caused the Wall Street Crash and the Great Depression.

Back then, though, we had a superior, **ready-and-waiting** successor available in the form of oil.

This time, **no** suitable successor has yet been found, and, even if an equivalent or higher-value new source of energy was discovered, it could not be put in place quickly enough to prevent severe economic, financial and social disruption.

In terms of pure theory, trends in the material economy might best be quantified in energy units. But, if our aim is to **benchmark** the financial economy to its underlying material counterpart, it's essential that both are measured in the common unit of money. This, by convention, is the notation used in economic debate.

In this sense, the development of SEEDS – the Surplus Energy Economics Data System – has been an exercise in economic linguistics, the aim being to **express material economic processes in the idiom of money**.

It is submitted here that this exercise has been very worthwhile. SEEDS analysis has delivered predictive accuracy whilst identifying the two critical fallacies at the heart of orthodox 'classical' economics.

One of these fallacies are that we can stimulate the **material** economy using **monetary** tools.

This is **not true**. The accumulation of vast debts and quasi-debts in modern times has put the "**financial**" economy into sequential crises **without changing** the material fundamentals that shape the "**real**" economy.

The other fallacy is that there need never be any end to economic expansion. If the human artefact of money really *was* the sole driver of economic outcomes, growth need never end, unless or until a collective decision was made to pursue alternative objectives.

This is **not true either**. Prior economic growth is in the process of going into reverse, and this is a trend that we are powerless to reverse. Our choices are limited to acceptance and adaptation, or denial and futile gimmickry.

These fallacies have had a very long history.

11. The class of '76

As coincidence would have it, the industrial economy and the orthodoxy in economics began in the same place – Scotland – and at the same time.

In 1776, James Watt completed the first truly efficient means for converting heat into work. That same year, Adam Smith published *An Inquiry into the Nature and Causes of the Wealth of Nations*, which became the founding treatise of the classical economics orthodoxy.

Whatever their other innovations, later economists have never departed from Smith's central proposition, which is that **economic processes can be explained in terms of money alone**.

Critically, Adam Smith was writing in agrarian, pre-industrial times. In his day, the vast bulk of the energy used in the economy was sourced from human and animal labour. This labour, thought it might rise or fall in quantity, had unvarying **qualitative** characteristics, because the activities performed by humans and animals do not become materially more or less energy-efficient over short or medium periods of time.

Accordingly, the physical **characteristics** of energy, being invariable, could safely be left out of the contemporary economic calculus. At the same time, the concept of resource or environmental finality was meaningless when the rate at which resources could be extracted was limited by reliance on picks and shovels.

Economics **has not moved on** with the pace of change from the agrarian to the industrial. Rather, attempts have been made to adapt pre-industrial precepts to an age of resource-intensive activity.

We're told, for instance, that resource constraints can always be circumvented using a combination of monetary stimulus and technological innovation. But **no** change in price can conjure forth resources that do not exist in nature. The potential scope of technology, as we have noted, is bounded by the limits of physical possibility.

Water shortages illustrate these problem. There is no substitute for water. Access to it can be increased, most obviously with desalination. But this requires large amounts of energy, not just to operate desalination plants, but also to build them in the first place.

In other words, our 'water problem' is **an energy problem**. This applies to all other forms of material economic constraint.

Perhaps the die was cast when the economics orthodoxy dismissed *The Limits to Growth* when it was published in 1972. Critics alleged that *LtG* disregarded the "laws of economics". But these so-called laws are, in reality, nothing more than *behavioural observations* about the human artefact of money. They are in no way analogous to the laws of science.

What really began in 1972 was the start of a process whereby general systems dynamics became the future of economics, and money-only interpretation started being pushed into its past.

The classical school of economics still offers enduringly valuable insights, not least the importance of free, fair and transparent competition. But the future of economics involves the introduction of the material to a pre-industrial notation hitherto confined to money alone.

12. Application

The central philosophy of Surplus Energy Economics is that supposed trends in the economy of money **can be tested** against developments in the economy of energy.

The enthusiasm for capital-intensive AI could not be validated in this way, and neither could the supposition that the Biden administration had delivered enough economic growth for the Democrats to remain in government.

A multiplicity of other outcomes can be anticipated by assaying the monetary against the material. National economic prospects, and the fate of the "everything bubble" in capital markets, fall within this range of energy-based predictability.

The material economy, and the energy basics that drive it, provide a unique tool for the **independent benchmarking** of all monetary assumptions and expectations.

Tim Morgan
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