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**The future will be cold and dark if we don’t have a radical rethink**

**With energy, we’re tinkering around the edges — new sources such as nuclear fusion are the only solution**

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Adam Smith’s *The Wealth of Nations* is rightly hailed as an 18th-century masterpiece, but it contains a fascinating omission: throughout its 1,008 pages (in my edition), the word “energy” is not mentioned once. The same is true of more modern classics on economics such as David Warsh’s *Knowledge and the Wealth of Nations* and Eric Beinhocker’s *The Origin of Wealth*.

This is curious when you consider that it is impossible to conduct economic activity — indeed, to sustain life itself — in the absence of energy. Think of purchasing a bagel: it takes energy to turn natural gas into fertiliser, to transport the fertiliser to the field, to power the tractor, to sow and plant the wheat seeds, to till, harvest, and grind the wheat into flour, to boil the water, and to power the toaster. As Charles Hall, professor at the State University of New York, puts it: “Energy is used at every step of every economic process.”

Hall is one of a number of researchers — other luminaries include Michael Muthukrishna of the London School of Economics and Kent Klitgaard of Wells College — who are patiently seeking to put economics on a new footing. Instead of thinking of the subject through the laws of supply and demand they do so through the laws of thermodynamics; in other words, energy. Economists have long regarded energy as a commodity like any other, and a relatively minor one, given that the energy sector constitutes only 5 per cent of a modern economy. Hall and his colleagues retort that without that 5 per cent the rest of the economy would grind to a halt.

Take a step back and you notice that all revolutions are ultimately triggered by transformations in energy. The emergence of complex life was facilitated by harnessing energy in a new way: photosynthesis, which allowed single-cell organisms to store the sun’s energy as sugars for later use. The invention of fire, described by the scholar Nicholas Georgescu-Roegen as the “promethean innovation”, allowed us to burn one organism (dead trees) to unlock the energy of another (chemical energy in food). The industrial revolution was another energy revolution: we burnt stored sunlight in the form of fossil fuels to construct the modern world.

Energy is uppermost in many minds today as the cause of [our most recent economic crisis](https://www.thetimes.co.uk/article/britain-on-a-tightrope-just-how-bad-will-a-recession-be-qb7g7k6qb), but Hall argues that this has been a long time coming. One of the key concepts in his work is “energy return on investment”, or EROI. When we first came across oil, we drilled the easy stuff first: sweet crude near the surface. In 1919 it took one barrel of oil in terms of energy to extract a hundred barrels in return. Today, though, we are having to drill ever deeper to reach hard-to-refine sources such as tar sands or via hydraulic fracturing.

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Now we only obtain five barrels back for every barrel expended; the EROI has fallen from 100 to five. Moreover, the EROI of renewables to which we are turning, not least to avert climate change, aren’t yet close to matching fossil fuels.

And this, Hall argues, sits at the centre of our predicament. For as the easy availability of dense, transportable energy sources falls, the productive capacity of an economy runs up against fundamental constraints. Think of it this way: if the amount of energy required to power an economy increases, the non-energy sector must shrink. This is not something that can be wished away by interest-rate tweaks or tax cuts, it is a constraint imposed by the laws of physics. And this may help to explain why productivity has been stagnant over recent decades across the western world — the so-called Great Stagnation — to the mystification of mainstream economists.

It is perhaps a stretch to infer that we are heading, like ancient Rome, towards civilisational collapse, although the parallels are uncomfortable. Back then the principal energy sources that kept Roman elites in luxury were things such as the burning of wood, and slave labour. The historian John Perlin calculates that, to run the baths at Caracalla for one year, 14 million tons of wood was required, which had to be transported over ever-greater distances from foreign colonies as the empire expanded.

As the complexity of managing these energy processes overwhelmed administrative capacity, the energy return on investment began to decline. The republic responded by debasing the currency, with the denarius adulterated from being 98 per cent silver in AD63 to 0 per cent in AD270. The result was rampant inflation and recession. Stagflation, in this sense, is nature’s way of reminding us that the laws of thermodynamics cannot be breached.

So what to do? A brilliant book by Muthukrishna, due for publication next year, puts energy front and centre. To arrest declining EROI in the near-to-medium term, he proposes a sharp rise in the use of nuclear-fission technology, although this will only get us so far. The ultimate goal, he argues, is to harness [nuclear fusion](https://www.thetimes.co.uk/article/what-is-nuclear-fusion-and-can-it-really-happen-3cs5txnxn) — the technology used by the reactor in the sky known as the sun — which offers almost unlimited clean energy. Muthukrishna’s point is that innovation that unlocks new energy sources is fundamentally different from innovation that harnesses existing supplies. The former is the only route to long-term growth of the kind that homo sapiens have become accustomed to since the 19th century and which supports the nearly eight billion inhabitants of the planet. “The question is simple,” he says. “Do we have both the ability and the proclivity to reach the next energy transition, the next level of human abundance and civilisation?”

Yet my dominant emotion reading these paradigm-shifting books — I should also include the work of Vaclav Smil, the Czech-born scientist much admired by Bill Gates — is frustration. It is shocking that only a handful of scholars today are working at the interface of energy and economics, for it means that 99 per cent of researchers are missing the big picture. Hall puts it starkly: “Economics lives in a contrived world of its own, one only tangentially connected to what occurs in real economic systems.”

I am not suggesting that this new approach has all the answers, and I am conscious that I have here offered only the most cursory overview of its richness. You will doubtless have more questions than answers — and I feel the same way. But as we head towards an energy crisis that will define the next half century, it is dangerously parochial to fixate on left v right, tax cuts v spending increases, or anything else that so fundamentally fails to address the underlying tectonics. I can’t be alone in listening to the Tory leadership debate and feeling that the candidates are not just asking the wrong questions but speaking the wrong language.

The ancients may not have understood energy but they appreciated its significance. Figures such as Prometheus, Hephaestus, Brigid, Agni, Vulcan and Alexa have all been worshipped in times gone by. Today, we have the knowledge to put the science of energy where there was once myth and superstition. Our future depends on it.

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