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The energy transition: metrics, expectations, and four structural tailwinds

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Executive Summary

- **The energy transition is further along than many think.** Progress looks slow if judged on primary energy supply but is much faster and deeper when measured by rates of change in useful energy demand.

- **Clean energy investment is double that in fossil fuels.** Renewables now meet more than all growth in power demand, while electric vehicles are displacing internal combustion engine sales.

- **Hype swings but the transition holds.** The decade since the Paris Agreement saw inflated expectations followed by a trough of disillusionment. We are now on the 'slope of enlightenment' toward a core role for 'electrotech' far beyond climate.

- **Systems thinking should shape expectations**. Prospects for technology depend on their inherent characteristics and their compatibility with the wider energy ecosystem. A focus on this interface is crucial.

- **Four tailwinds are set to propel the energy transition.** These tailwinds are structural and mutually-reinforcing.

1. ***Key enabling technologies*** *like solar and storage* ***are locked into self-sustaining growth loops.***

2. ***Electricity is cascading across sectors and ratcheting*** *toward reconfigured energy ecosystems.*

3. ***Economic and energy innovation frontiers****, including AI,* ***are focused on electrons*** *- while fossil fuels are hitting hard physical limits.*

4. ***Energy shocks will increasingly undermine fossil fuel foundations*** *as economic and energy security risks compound and alternatives become ever cheaper, better and available.*

- **The transition will continue to be messy and uneven**. While some areas are moving from energy 'addition' to true 'transition', others are not there yet. But overall, **the direction of travel is increasingly clear**.

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*"**We invest in companies driving the structural re wiring of the global energy system**. In our view, **investors can capture attractive returns where value is really being created**: in efficient electrons displacing wasteful molecules, and in business models aligned with powerful loops of innovation, policy and energy security".*

We live in turbulent times

Sentiment on the energy transition has whipsawed. Expectations were high in the years following the Paris Agreement in 2015. Over 2024-2025, factors combined to swing the pendulum dramatically toward pessimism. The impact of the Iran conflict may have produced another reversal.

How can we look through the short-term noise to track the long-term signal? Is the energy transition fragile, or does it have structural underpinnings? **The key is to track the right metrics and trends and set appropriate expectations.**

What is the energy transition?

> *"the process by which the **foundation of the global energy system moves away from fossil fuel consumption and toward electricity-based infrastructure and services"***

Definitions are important. Shifting the global energy system away from fossil fuels and toward 'electrotech' – core technologies such renewables, batteries and heat pumps that enable widespread electrification[i] - is core to all concepts of the energy transition. Beyond that, specifics can differ.

Some specify a purpose (e.g. limiting climate change), **endpoints and timelines** (e.g. net zero by 2050), for example. **This is too restrictive**. Transition investment may be driven as much by energy security or affordability as climate concerns. Even from a climate perspective, the transition does not become irrelevant if a specific emissions or temperature goal becomes unachievable.

However, a 'transition' is not just 'addition'. Some argue that new forms of energy have only ever added to previous ones, rather displacing each other through transition.[ii] The energy transition ***doesn't* imply elimination of fossil fuels,** but it ***does* imply decline**.

Avoiding the 'Primary Energy Fallacy'

Progress is often measured using 'primary energy' – the volume and type of energy entering the global economy. **On this basis nothing much has changed**. Since 2000 the fossil fuel share dropped from 95% to around 92% by 2024 but still grew 50% in absolute terms. **Clean energy made minor inroads but remained *additional* to fossil fuels**.

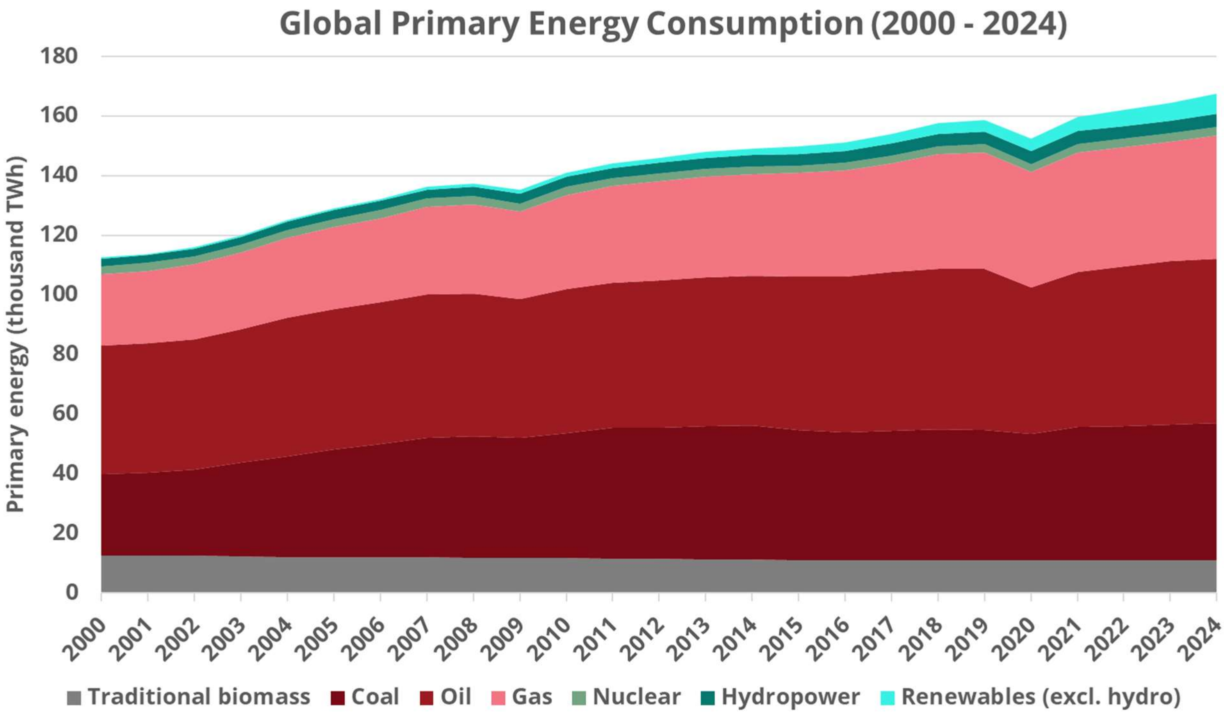

Figure 1 - Global primary energy consumption (2000-2024). Data Source: OWID (2026). Graphic created by Greenwheel. The information shown above is for illustrative purposes.

However, **this framing *overstates* the scale of the challenge and *understates* progress against it**. Assuming clean energy must replace primary energy on a 1-1 basis is known as the 'Primary Energy Fallacy'.[iii]

Reframing the challenge: flipping the script

We use energy to deliver services like light, heat and transport. Some is also used for 'non-energy' purposes, like feedstock in the chemicals industries.

However, **only around 40% of primary energy consumed actually delivers these services**. The rest is wasted in transformation, delivery and use of energy (Figure 2). Less than 20% of the energy in a barrel of oil is used to move a car. Some is lost in refining and distribution, but most is lost as heat through the engine, exhaust, braking and friction.[iv]

Physical laws mean **inefficiency is inherent to fossil fuels**. Electricity is more efficient by nature. An electric car fed by renewable energy, for example, is at least 3-4x more efficient than the example above, with less waste at almost every stage.[iv] In a system based around electrotech, **less than half of primary energy needs to be replaced** to deliver the same services.

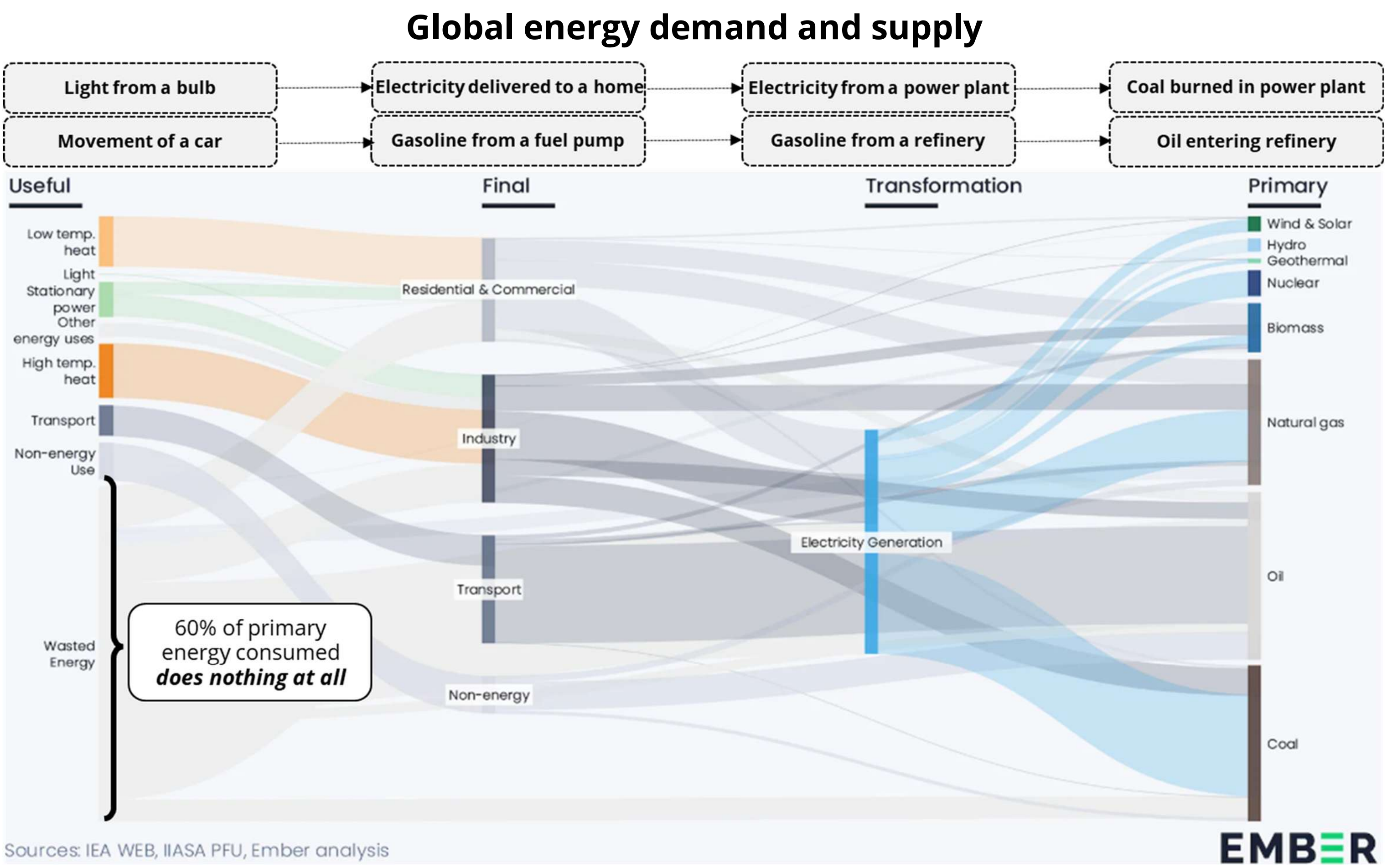

Figure 2 - Global energy demand and supply (2023, measured in EJ). Based graphic from Walter et al (2026), under CC License. Chart sourced from Ember and modified by Greenwheel. The information shown above is for illustrative purposes.

Reframing the challenge: stocks vs flows

Energy services fall into two groups: 'work' - light, electronics and movement - **and 'heat'** - low temperature for heating buildings and water, and high temperature for industrial uses.[v]

Work and heat can be delivered by electrons or molecules. Electrons or molecules **can be produced by 'electro' technologies** which produce electricity directly like solar, wind or hydropower, **or 'thermal' sources**, like coal, gas, oil or biomass, which hold energy in chemical bonds that is released when combusted.[v]

The **energy transition has electrons dominating work and heat, and electro technologies dominating electron supply**. Electrons currently cover around half of all work, but only a small share of heat. Electro-sources produce around a third of all electrons (Figure 3). This means **renewably-produced electrons already provide 15% of useful energy** globally[vi] **– *double* the share implied by primary energy**.

Electrons overtook oil as the largest supplier of useful energy 20 years ago and have continued to grow their share since.[vii]

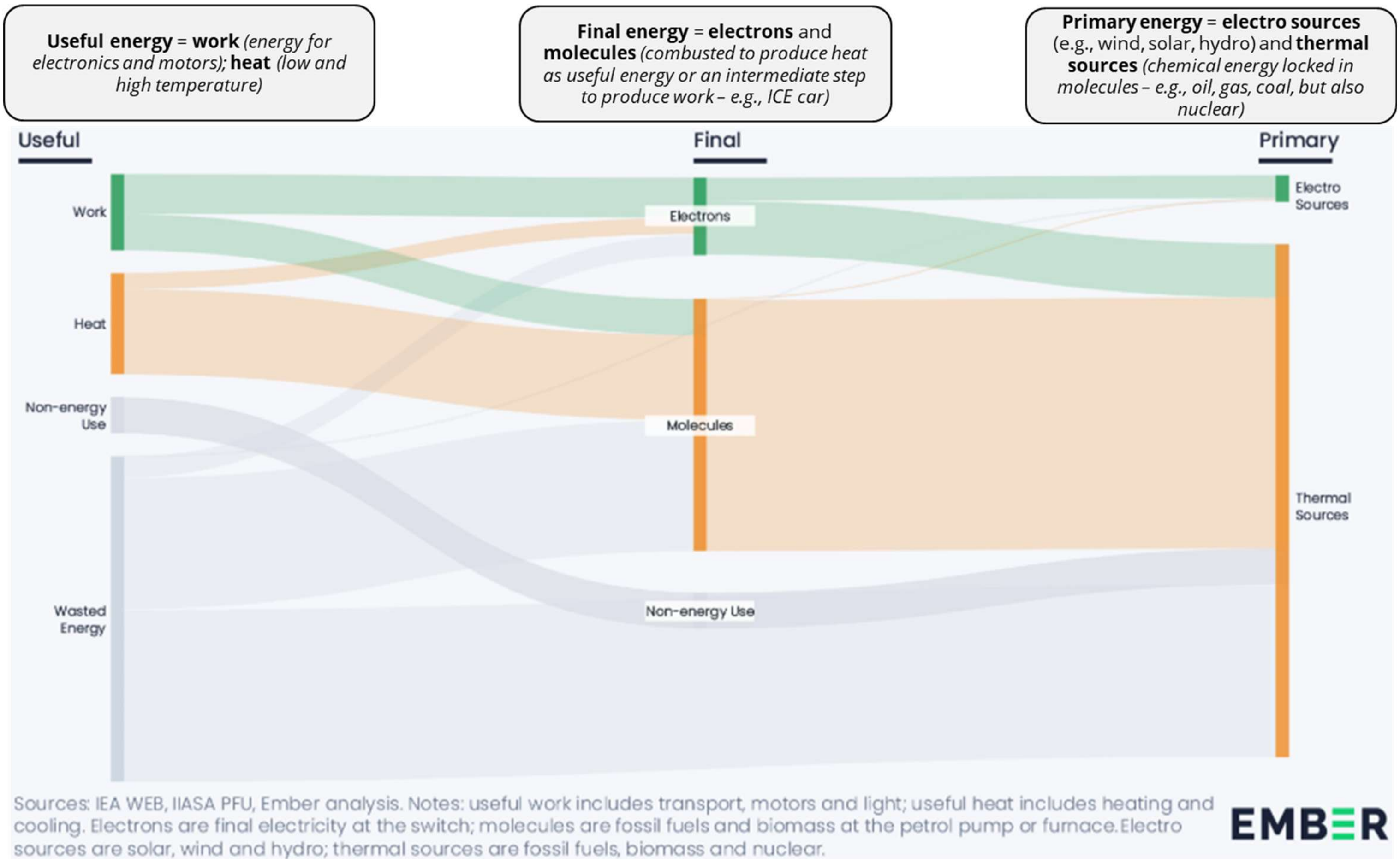

Figure 3: Global energy supply and demand - simplified (2023, measured in EJ). Based graphic from Walter et al (2026), under CC License. Chart sourced from Ember and modified by Greenwheel. The information shown above is for illustrative purposes.

Figure 3 gives a snapshot of the 'stock' of global energy patterns. However, **what helps us understand where things are heading are the changing 'flows'** (Figure 4).[v]

Solar and wind met *more than all growth* in global power demand in 2025, beginning to eat into *existing* fossil fuel generation following a consistent rise over more than twenty years.[viii] **Electric vehicles (EVs) are rapidly increasing their share** of new transport demand, hitting one quarter of all light vehicle sales in 2025, with global internal combustion engine (ICE) car sales down significantly from their peak ten years ago.[ix]

Molecules still cover most new heat demand, and fossil fuels cover almost all molecule demand. Electrifying high temperature heat has faced several challenges, including technological maturity and cost, but these are rapidly reducing.[vii] Molecules from electrons – including 'green hydrogen' and its derivatives – face significant challenges, including from the growing potential for electrons to produce heat directly.

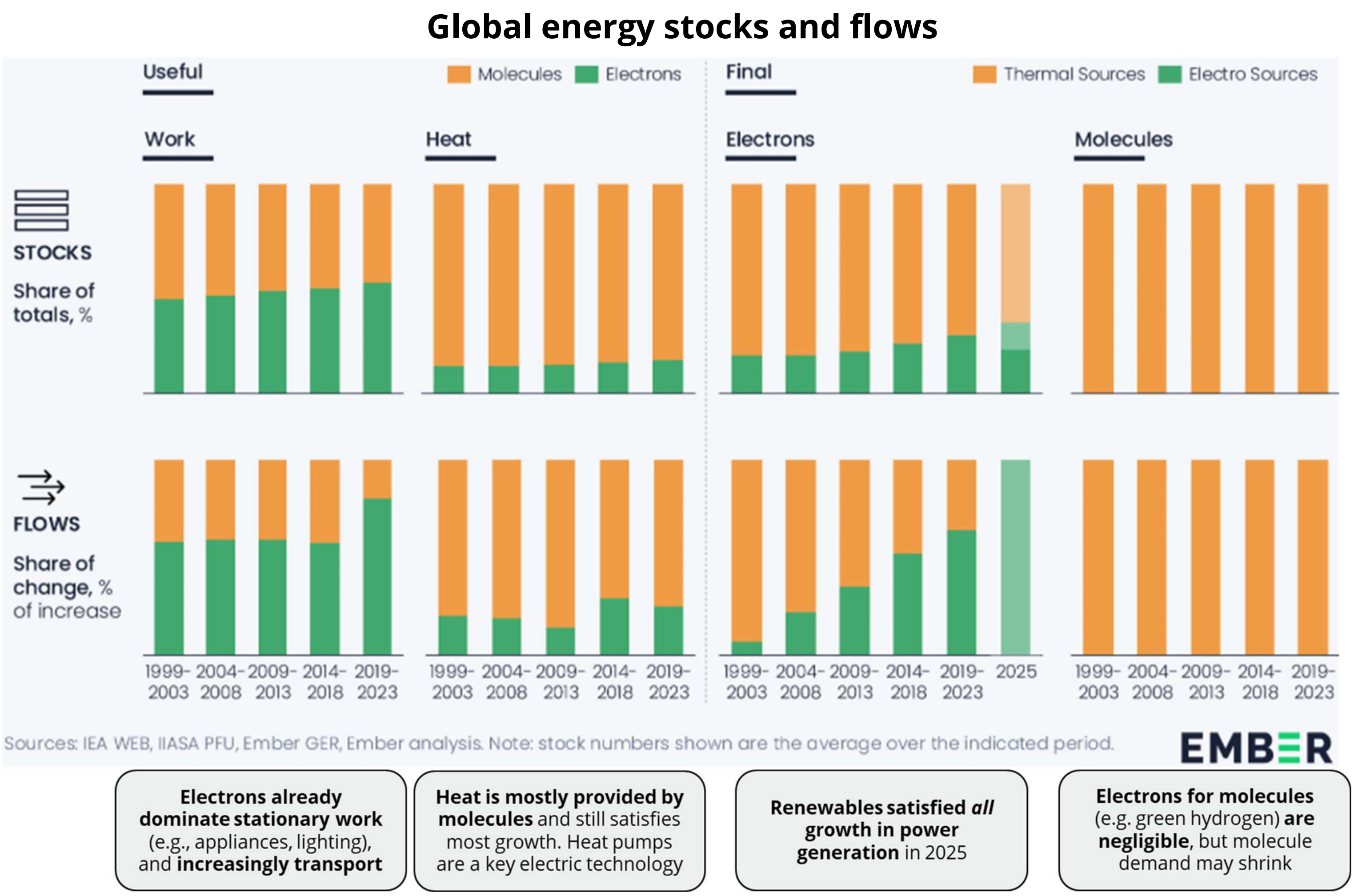

Figure 4 - Global energy stocks and flows, measured in EJ. Based graphic from Walter et al (2026), under CC License. Chart sourced from Ember and modified by Greenwheel. The information shown above is for illustrative purposes.

Hype swings but the transition holds

The hype cycle, well known to technology analysts and usually applied to individual technologies, **can apply to the wider energy transition** (Figure 5).

The hype cycle has five phases. First, a new technology is developed, and the market imagines the exciting possibilities. This equates to the signing of the Paris Agreement, and the rush of policy, technology and corporate commitments that followed.

This leads to a ‘peak of inflated expectations’ - Phase 2 - where hopes run ahead of reality (2020-23). As this is exposed by experience, sentiment craters to a ‘trough of disillusionment’ - Phase 3 (2025) – and attention moves on.

Meanwhile, the data shows **the transition has been steadily progressing**, moving not as hard and fast some hoped, or flatlining as some think. Private **investment in electrotech** and associated infrastructure **was *double* that of fossil fuels in 2024 and 2025**, as is **expected to be similar in 2026**[x] **- buying more each time as costs decline**.

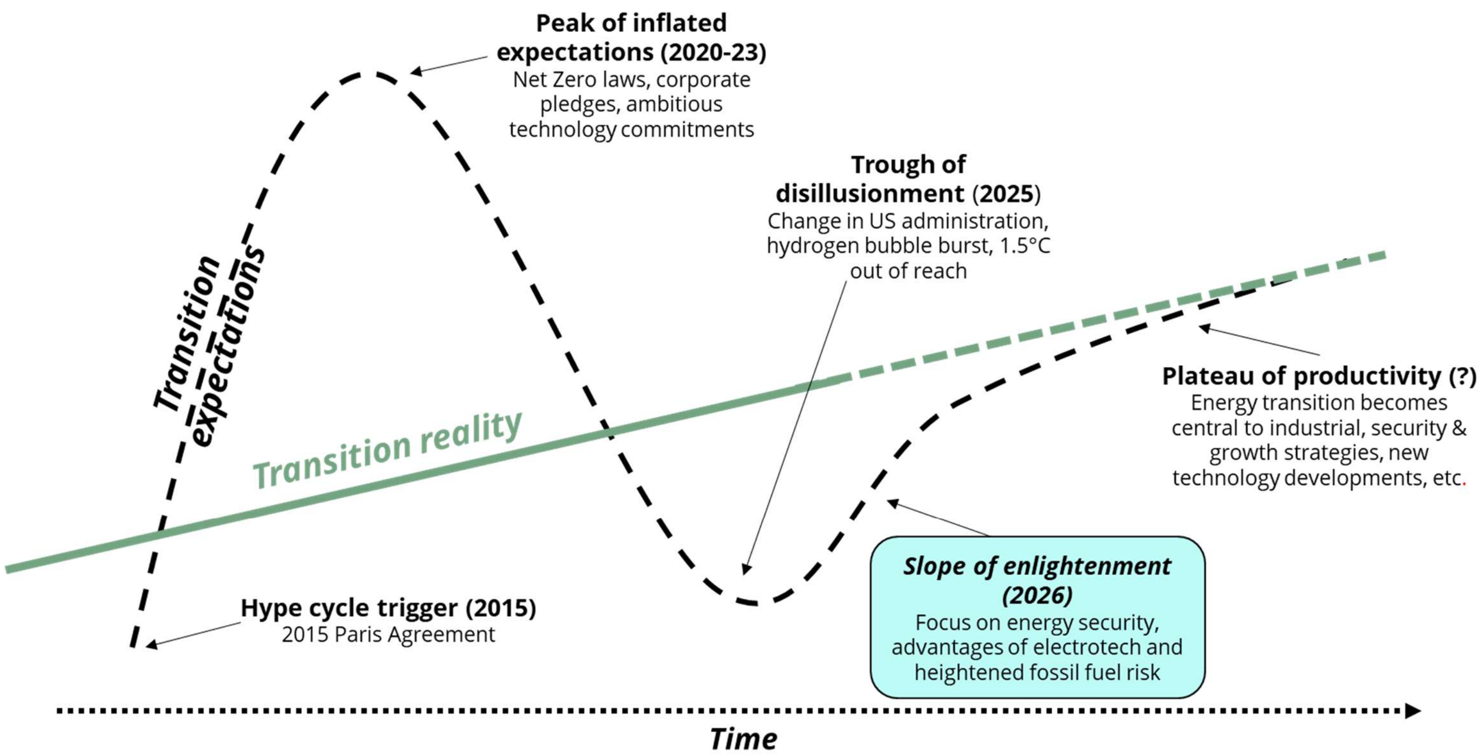

Figure 5 – Energy transition hype cycle. Graphic created by Greenwheel. The information shown above is for illustrative purposes.

We are now moving to the 'slope of enlightenment' – Phase 4 - **where the true opportunity becomes clearer** as evidence and experience builds, and as the cost, security and other advantages of electrotech beyond tackling climate change is emphasised by fragmenting geopolitics.

This may soon lead to a 'plateau of productivity' – Phase 5 - where **electrotech becomes a core and accepted component of economic, industrial and security strategies** across the world.

There are four structural tailwinds that point to this, described below. But first, it's useful to understand key factors that can help investors frame their expectations.

How should we set expectations?

The early stages of the hype cycle are fuelled by expectations based on partial information, confirmation bias, and perceived momentum. Instead, analysis should **focus on the characteristics of the technologies themselves, and those of the energy systems they are entering**.

Technology characteristics

Technologies can be graded by: (a) their design complexity, and (b) the need for customisation to fit different infrastructural, policy or cultural environments (Figure 6).

Simple and standardised technologies achieve greater and more rapid deployment. Among other benefits, they are usually cheaper to buy and quicker and easier to manufacture and install. This drives demand, learning and economies of scale, producing improvements and further reducing costs, opening more markets and applications.

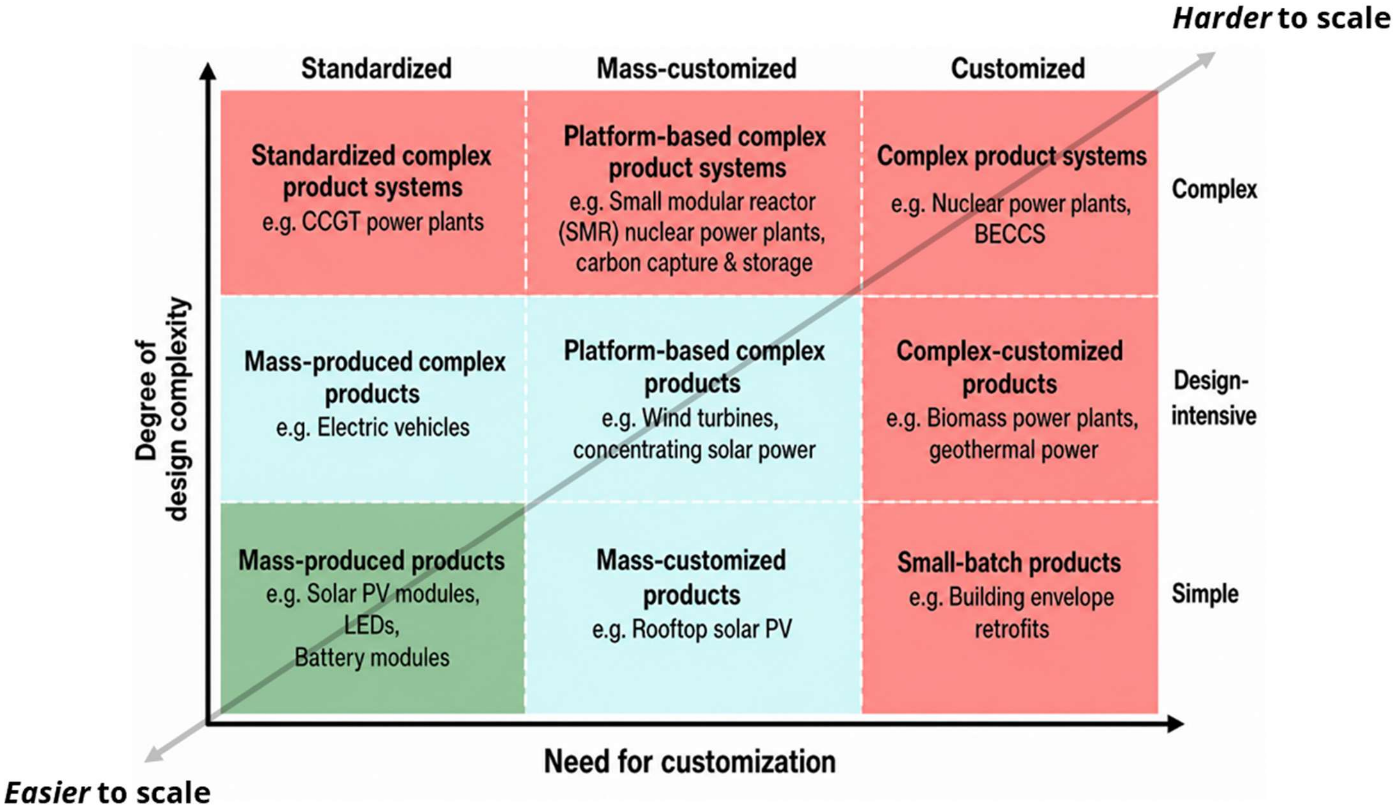

Figure 6 – Energy technologies categorised by core characteristics. Original graphic source: Malhotra & Schmidt (2020). Graphic recreated by Greenwheel. The information shown above is for illustrative purposes.

Key examples are solar modules, LEDs and batteries. This feedback loop is difficult to establish for complex, customised technologies, such as large-scale nuclear power.

System characteristics

Energy systems are ecosystems: networks of technologies, infrastructure, institutions, policies, regulations, businesses, market structures, physical and financial resources, politics, culture and values. These systems tend to be **resistant to radical change**.[xi]

However, **energy ecosystems can be disrupted by external pressures** like climate impacts, demographic shifts, geopolitics, conflict, and the rise of general-purpose technologies like the internet or artificial intelligence. This **can open windows for new technologies** that may otherwise be incompatible with the system to develop, commercialise and establish a foothold.[xi]

Over time, elements of **the ecosystem may reconfigure around the new technology**, allowing it to make further gains and change the nature of the ecosystem. This may open the space for other new technologies to enter.[xi]

Technologies & systems: focus on the interface

Technologies with clear value and **which are highly scalable and compatible with existing energy systems have few barriers** to rapid growth. They may need only modest, narrow and time-limited policy support, and have low reliance on external pressures to open windows of opportunity. **The reverse is also true**.

Figure 7 illustrates examples different combinations of technology characteristics and system compatibility.

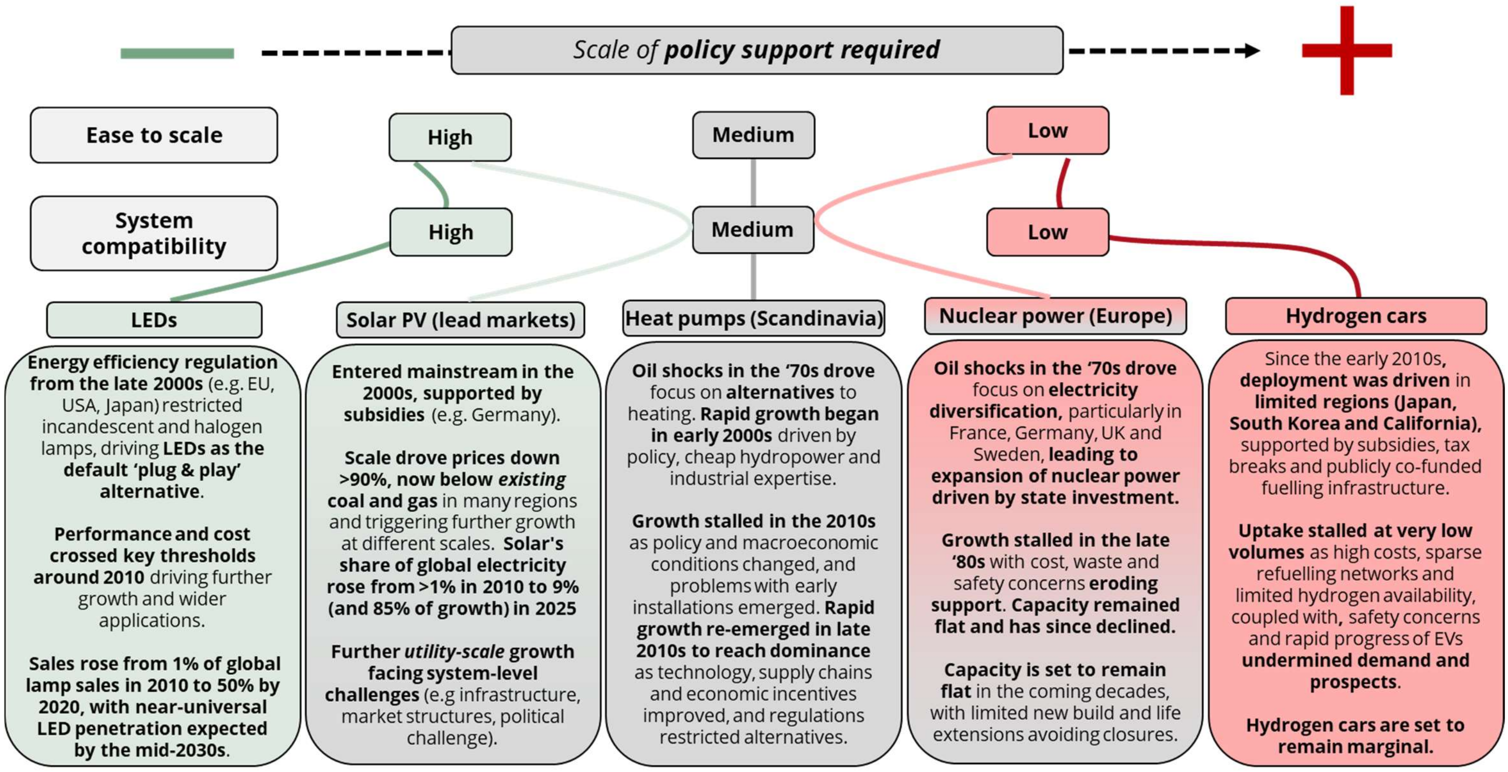

Figure 7 – Mapping technology characteristics and system compatibility – technology examples. Various data sources. Graphic created by Greenwheel. The information shown above is for illustrative purposes.

Energy efficient LED lighting is highly scalable and compatible with existing energy systems and **may account for most lighting sales by the mid-2030s**, from very low levels thirty years prior.[xii] Solar PV is similar, with early deployment support generating scale, leading to cost reductions that made **solar the cheapest source of electricity to ever exist, across most of the world.**[xiii]

Early progress in **LEDs and solar helped launch the transition hype cycle,** leading up to and beyond the Paris Agreement in 2015. **Other technologies have since failed to match their rise**, due to less favourable characteristics or system compatibility – or both - **helping tip sentiment negative**.

Hydrogen technologies fell far short of market expectations. From around 2020 several governments set ambitious clean hydrogen strategies with targets, subsidies and other support, across different sectors and applications. Expectations were sharply revised over 2024-25 as technology and system compatibility issues, as well as competition from direct electrification, became clear (see Figure 7, on hydrogen cars).[xiv]

Rapid growth means **solar is now hitting system compatibility challenges** in lead markets. This includes grid congestion and connection queues, electricity price volatility and cannibalisation, permitting and social acceptance, and geopolitical concerns. **This also contributed to energy transition sentiment shifting negative**.

However, both developments should be expected from looking at the interface between technology characteristics and system compatibility. **This doesn't signal a failing transition – it signals maturity**.

Policy action is needed to alter market designs and permitting procedures, for example. This influences the potential pace and scale of the next phase of solar growth in these markets but is not likely to entirely dictate it. As the path for hydrogen becomes more focused on where realistic opportunities remain, attention can turn to technologies with inherently better prospects for other applications.

We **can't precisely predict technology adoption**, particularly for relatively early technologies. But we can define **reasonable expectations based on technology and system characteristics**, potential **external pressures** on these systems, and how they might **interact and evolve over time.**

Four structural tailwinds behind the energy transition

Four structural, interconnected tailwinds are set to propel the energy transition (Figure 8). How they evolve and interact will determine its pace and extent, but the direction is clear.

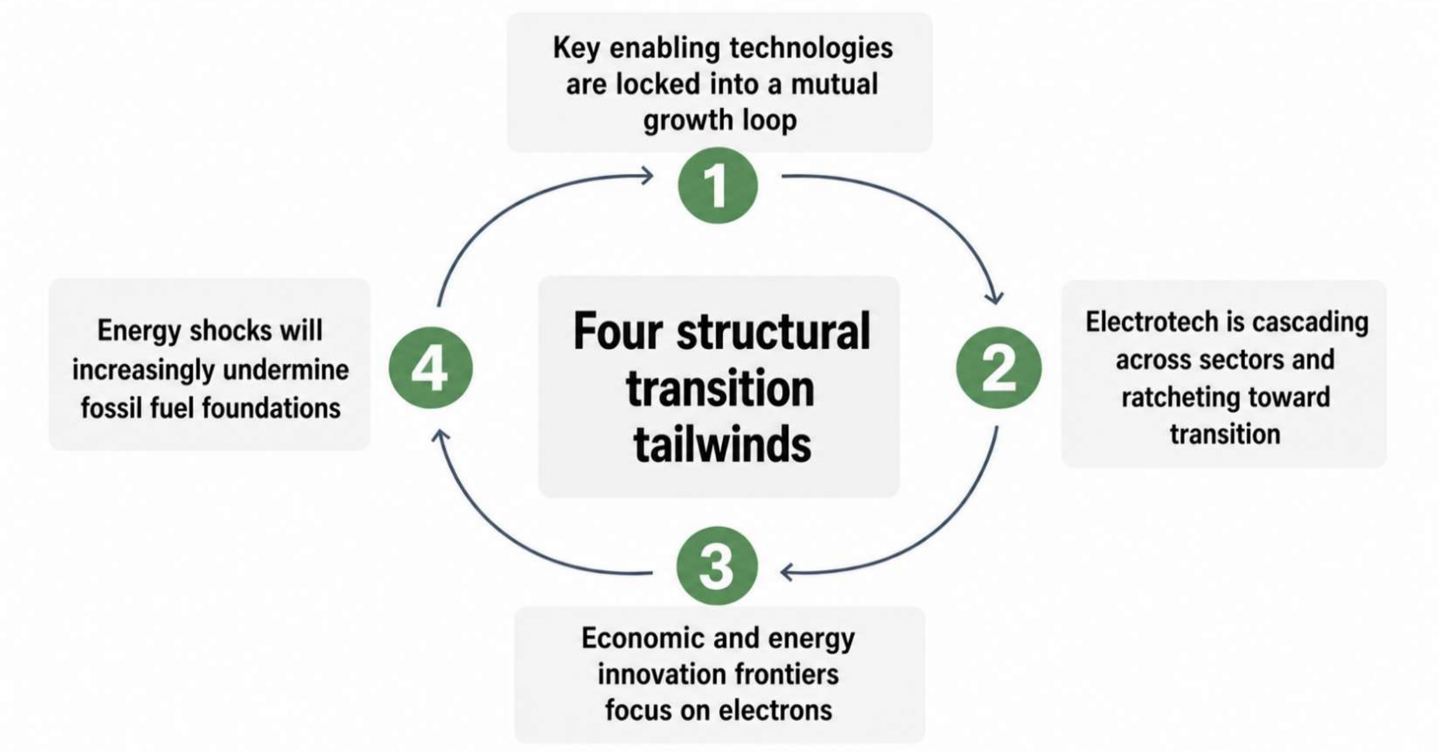

Figure 8 - Four structural tailwinds for the energy transition. Graphic created by Greenwheel. The information shown above is for illustrative purposes.

Key enabling technologies are locked into a mutual growth loop

Battery storage tackles solar intermittency. Batteries can absorb excess solar (or other intermittent renewable) power and release it when needed. They can be co-located or installed in isolation on the grid or by consumers, and can support wider grid infrastructure and management challenges better than any other technology.[xv]

Solar and batteries support each other, driving mutual growth. Built in isolation, solar or batteries cannibalise their own market over time. Built together, they expand each other's potential market (Figure 9).

Storage and intermittent renewables are mutually reinforcing

Generation profile swings make storage profitable; storage arbitrage makes more renewables feasible

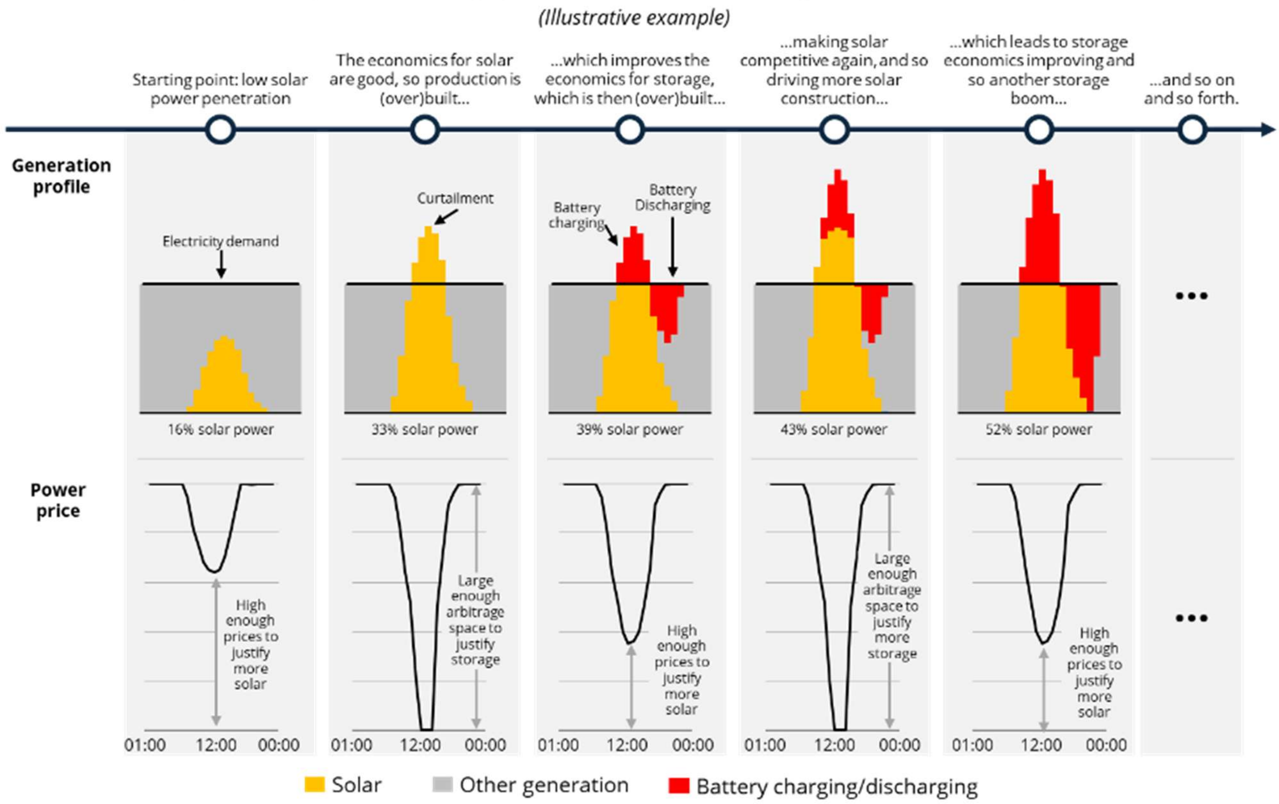

Figure 9 - Interaction between intermittent renewables and storage. Source: Drummond (2026), based on Ember (2025). Chart sourced from Ember and modified by Greenwheel. The information shown above is for illustrative purposes.

Battery costs dropped more than 80% over the last decade, with annual capacity growth averaging 90% over the last five years. This growth has concentrated in markets with significant solar such as California, Texas, China, the UK, Germany, Italy and Australia.[xv]

Both individually and together**, 'solar plus storage' is a *key enabling technology*** – almost a general-purpose technology - **around which the wider energy transition can build**. Batteries aren't the only form of storage, but they are the most easily scalable.

There **are five key reasons why solar plus storage is now locked into a self-sustaining growth spiral**, for which there is no clear floor on cost and no clear ceiling on growth potential.

Solar plus storage has already passed key economic tipping points

Combining solar with batteries for 24/7 power is already highly attractive. Co-located systems are now able to provide reliable, round-the-clock power **at lower costs than fossil fuel alternatives – including *existing* coal and gas plants in some cases** - in regions with high solar resources, such as parts of China and the Middle East, but also the United States given record high gas turbine prices.[xvi]

As both solar and batteries are technologies that reduce in cost with scale, **the cost of solar plus storage systems are projected to fall another 30% by 2030 and 40% by 2035**,[xvi] becoming even more cost-effective than building solar alone.[xvii] Other benefits such as installation speed, energy security and grid management services further support growth.

China anchors global supply and demand

China controls over 80% of the global solar supply chain[xviii] and produces over three-quarters of the world's batteries.[xix] It also deployed two-thirds of new solar and batteries (in both battery storage and electric vehicles) in 2025.[viii] **China's dominance in both supply and demand underpins the global growth loop**, **resilient to demand shocks from even large external markets**. Near-term supplier consolidations and slower solar deployment in China due to weakening policy support won't change this.

Demand outside China is diversifying

As well as continuing deployment in lead markets, **most deployment growth is happening in emerging markets and new consumer segments**.[viii] Even excluding China, emerging markets will account for most population and electricity demand growth in the coming decades, and a larger share of the global economy.[xx] **Emerging economies have among the best solar resource in the world**, with solar and batteries available, quick, easy and flexible to install, clean, secure, and not reliant on existing infrastructure.

High electricity prices are driving household and business adopters in markets as diverse as Pakistan, Germany and Australia.[xxi] Households and businesses now account for around 40% of global solar additions and 25% of new battery storage[xxii] - although this market is likely to be underestimated.[viii]

Household access is rapidly expanding. 'Plug-in' (or 'balcony') solar, where solar panels with inbuilt inverters simply plug into domestic sockets, dramatically expands household access. There is significant growth potential, with Germany fully legalising first in 2021. Five US states started permitting it in recent months, with active bills in another 21.[xxiii] Other countries are exploring plug-in solar.

A China export shock would be deep but not fatal, and is highly unlikely

A severe shock to China's solar and battery exports would dramatically slow growth outside China for some years, and potentially within China depending on the shock. However, unlike fossil fuels, **a supply shock would only impact growth, leaving existing capacity unaffected** and continuing to operate.

The clear advantages of solar plus storage with large and diversifying international demand means **global supply chains would likely be rebuilt**, potentially within a few years - although costs would initially be higher. Supply chain diversification to drive resilience and capture economic benefits driving supply chain growth outside China. [xviii]

However, **China's strategy is built around growing exports**, meaning a broad, policy-driven export shock is highly unlikely. In March 2026 the value China's exports of solar and battery technologies and components reached $15 billion (excluding other clean technologies, such as EVs) - close to the value of the USA's fossil fuel exports in the same month ($17 billion), despite high oil and gas prices.[xxiv]

Mutually supportive but not mutually dependent

Solar grew to provide 7% of the world's electricity largely without batteries and could grow significantly more. Intermittency has been managed through geographic diversity, other flexible generators, interconnection, demand management, and mature forms of storage, like pumped hydro. These options, plus other emerging forms of storage, still allow for significant further global growth without batteries.[xxv]

Electric vehicles are likely to remain the main market for batteries. EVs accounted for over 70% of battery deployment in 2025,[xxvi] and as EVs have also passed (or are passing) their own economic tipping points[xxvii], meaning they are likely to remain dominant in driving battery demand for some time.[xxviii] However, storage is the fastest growing segment[xxvi] and is also supported by continuing growth of other intermittent renewables like wind, and on its standalone merits as a grid management asset.

2 Electrotech is cascading across sectors and ratcheting toward transition

Over time, energy uses centre around available energy sources most suited to their needs - oil for transport, natural gas for heat, coal for power generation, and electricity for lighting, appliances and stationary motors. Core energy sources change over time as relative advantage shifts, in different places, for different reasons.

Electricity is the largest and fastest growing supplier of useful energy, covering over two-thirds of useful demand, overtaking oil in 2007.[vii] **It is a uniquely attractive form of energy**. It is highly efficient, easily converted to work or heat, can be produced anywhere by different means, and is increasingly cheap and storable.

This means it is **likely to push out and tie together other forms of energy demand,** cascading via increasingly **shared technologies, infrastructure and actors** (Figure 10)

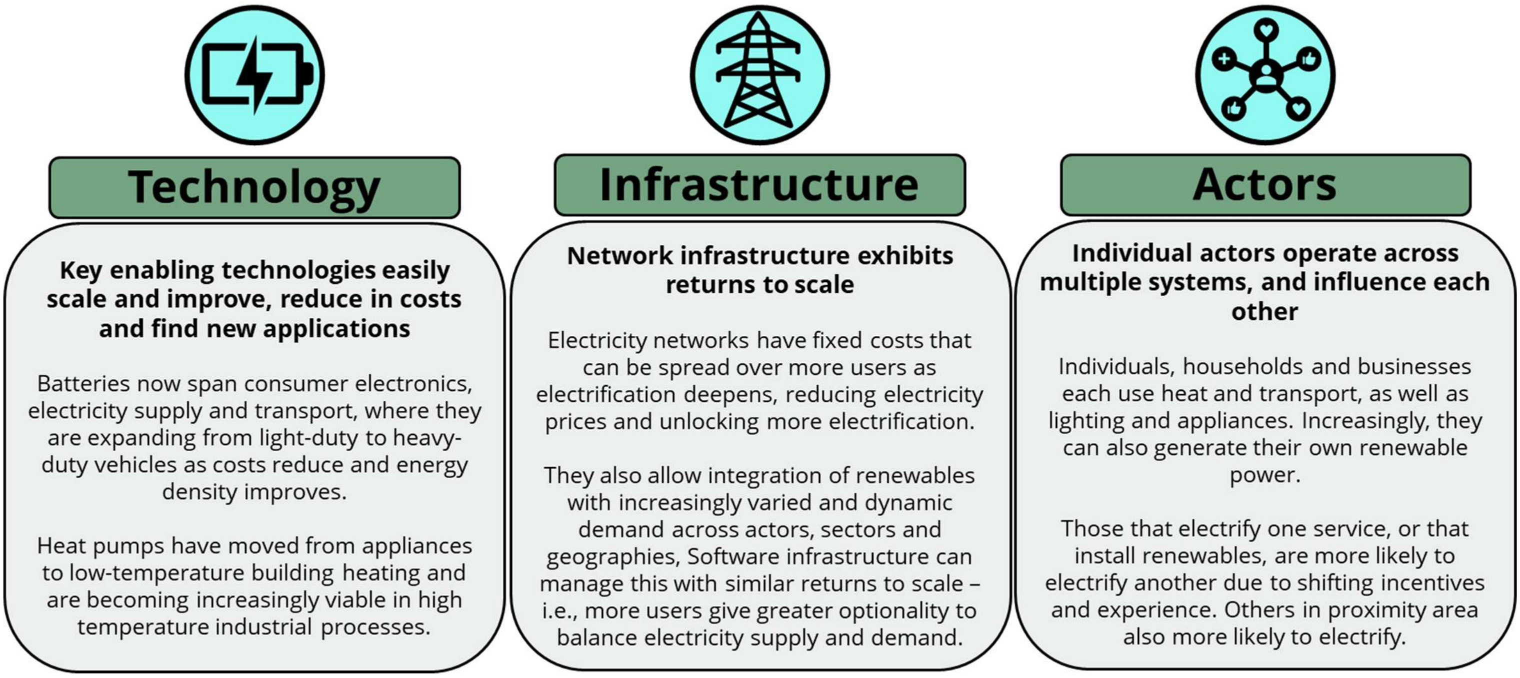

Figure 10 – Channels connecting forms of energy demand via electricity. Various sources, including Turk et al (2024), Kale & Brown (2025), O'Shauighnessy et al (2023) Graphic created by Greenwheel. The information shown above is for illustrative purposes.

The spread of electricity is likely to 'ratchet' - and be difficult to reverse. Lower operational costs mean electrotech typically outcompetes fossil fuels (e.g. when available, renewables provide power over gas or coal plants due to near-zero marginal costs). This increases the risk associated with fossil fuel infrastructure (power stations, gas distribution networks, vehicle fuelling stations), reducing investment. This raises their costs and reduces availability and use, pushing a rhythm toward stagnation and decline.[xxix]

This process will be messy and uneven, and more hype cycles are likely. Some sectors and regions will electrify rapidly, while others will move slowly or stutter, depending on technology characteristics and the structure of the local energy ecosystem – and how these factors change and interact over time.

3 Economic and energy innovation frontiers focus on electrons

Energy innovation is overwhelmingly focused on electrotech

Global **corporate R&D spending on energy supply and infrastructure doubled in the decade to 2024, focused on renewables and grids**. R&D in fossil fuels stayed flat, reducing to one-third of the total.[xxx]

Even before this jump, clean energy - electrotech, low-carbon fuels and energy efficiency - accounted for 80% of all energy technology patenting. Only 20% of energy technology patents filed worldwide in 2015 were fossil fuel related.[xxx]

Since then, fossil fuel patenting has doubled while clean energy patenting increased 6x, raising **clean energy to 95% of all new energy technology patent activity** globally in 2024.[xxx] **Energy storage alone now accounts for half of energy patent activity,** and around 5% of *all new technology patents of any kind.*[xxx] These patents will continue to improve electrotech availability, cost and performance, and expand applications.

Fossil fuels are running out of road

Fossil fuels are fixed in volume, type and location. Over time high-grade, easily extractable resources become depleted and harder to find, forcing focus on lower quality or more difficult to extract resources. This means that **in stark contrast to electrotech, there has been no structural decline in global oil prices** or extraction costs for at least 50 years, with innovation largely countering depletion to prevent structural price rises.[xxxi] However, there has been **plenty of price volatility** (Figure 11).

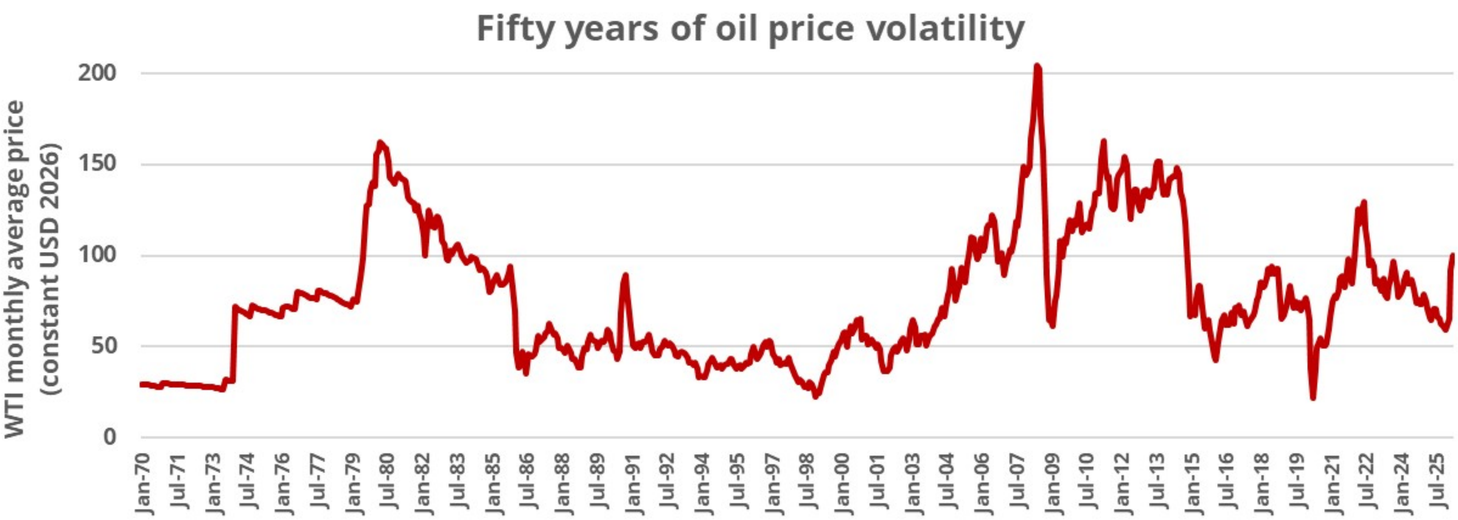

Figure 11 – Monthly average WTI oil spot price, Jan 1970 to April 2026. Inflation-adjusted to April 2026 real USD. Data source: FRED (2026), data series WTISPLC and CPIAUCSL. Graphic created by Greenwheel. The information shown above is for illustrative purposes. Past performance is not a guide to the future.

Coal and gas cost trends have been mixed but are now flat or rising in key markets.[xxxi] This includes the shale gas regions in the US, as the shale revolution that began nearly 20 years ago matures.[xxxii]

We are approaching hard limits to fossil fuels use efficiency. The useful energy produced by combustion is governed by the Carnot Efficiency limit, which is reduced further by real world constraints. Best-in-class technologies in power generation vehicle engines and boilers are already close to these practical limits.[xxxiii]

Future economic and energy services depend on electricity

AI and digital services are at the forefront of economic growth. The IEA project a global doubling in demand from data centres to 2030 in their base case.[xxxiv] This is equivalent to adding the electricity demand of Germany in less than five years. The upstream value chain, such as chip manufacture, is also electricity-hungry.[xxxiv]

Clean energy and electrification are themselves set to be major economic growth drivers, in 2025 accounting for over 11% of GDP and a third of GDP growth in China.[xxxv] Clean tech value chains are also heavily electricity dependent.

In the coming years, **almost all other growth in energy demand will come from emerging markets, and this will be predominantly electric.** Rising incomes and temperatures mean appliances, air conditioning and transport dominate demand growth.[xxxvi] The first two are already electric, and the third increasingly so. The benefits of EVs, including reducing fuel import dependence, means growth in many emerging markets is quickly outstripping many developed markets.[xxxvii] **Leapfrogging fossil fuels to renewables and electrification is increasingly evident** in several countries.[xxxviii]

4 Energy shocks will increasingly undermine fossil fuel foundations

Oil shocks in the 1970s cracked the foundations

The 1970s oil crises had profound consequences for OECD countries, when oil was widely used across energy services and was almost entirely imported. **This led to policy actions with long-term implications** such as the nuclear build-out in France, heat pumps across Scandinavia, vehicle efficiency standards in the USA, building efficiency standards in Europe, and renewables RD&D across several countries.

The '70s oil crises permanently broke the tight coupling between global oil demand and GDP growth. Global fossil fuel demand per capita also permanently decoupled.[xxxix]

Broader energy shocks are now undermining them

In 2022, **Russia's invasion of Ukraine produced the first truly global energy crisis**.[xl] Oil price spikes affected a wider range of countries, and although gas supplies from Russia were only halted to Europe, prices had become internationalised through liquified natural gas (LNG) markets. As LNG demand in Europe surged global prices spiked for all importers, with some countries – particularly in Asia – priced out entirely.[xli]

This time, electrotech was a ready alternative, benefiting from decades of innovation, learning and increasing scale. In Europe a range of measures led to a surge in renewables and electrification to reduce gas dependence in power and heating. **In 2025, wind and solar together generated more European power than fossil fuels, while total gas demand was over 20% lower** than in 2021.[xlii]

In Asia, **China and India doubled down on renewables and electrification** (as well as domestic coal).[viii] Vietnam significantly dialled down its LNG plans.[xliii] Spiking electricity prices **kicked off a solar and battery boom by Pakistani households and businesses,** with installed solar capacity now larger than the total capacity of Pakistan's utilities.[xliv]

The Iran conflict hammered home the energy security opportunity. Following quickly from the previous crisis came the largest energy supply shock in history.[xlv] As a result, **Chinese exports of electrotech jumped to record highs** in early 2026[xlvi]

This is **despite global policy focused on holding down fossil fuel price rises** to shield consumers from its immediate effects. Of more than 100 countries tracked by the IEA, 91 have introduced either price caps, subsidies, reduced taxes or other measures to reduce consumer energy prices. Just 24 have introduced measures to reduce structural dependence, but this number is growing.[xlvii] This demonstrates **the economics of electrotech becoming unmoored from early policy support** needs.

Future shocks will push toward structural collapse

There have been eight oil price spikes since the early 1970s (where prices increase over 30% in a year), **averaging one every seven years.**[xlviii] **They are likely to continue**, particularly with an increasingly fragmenting geopolitical order.

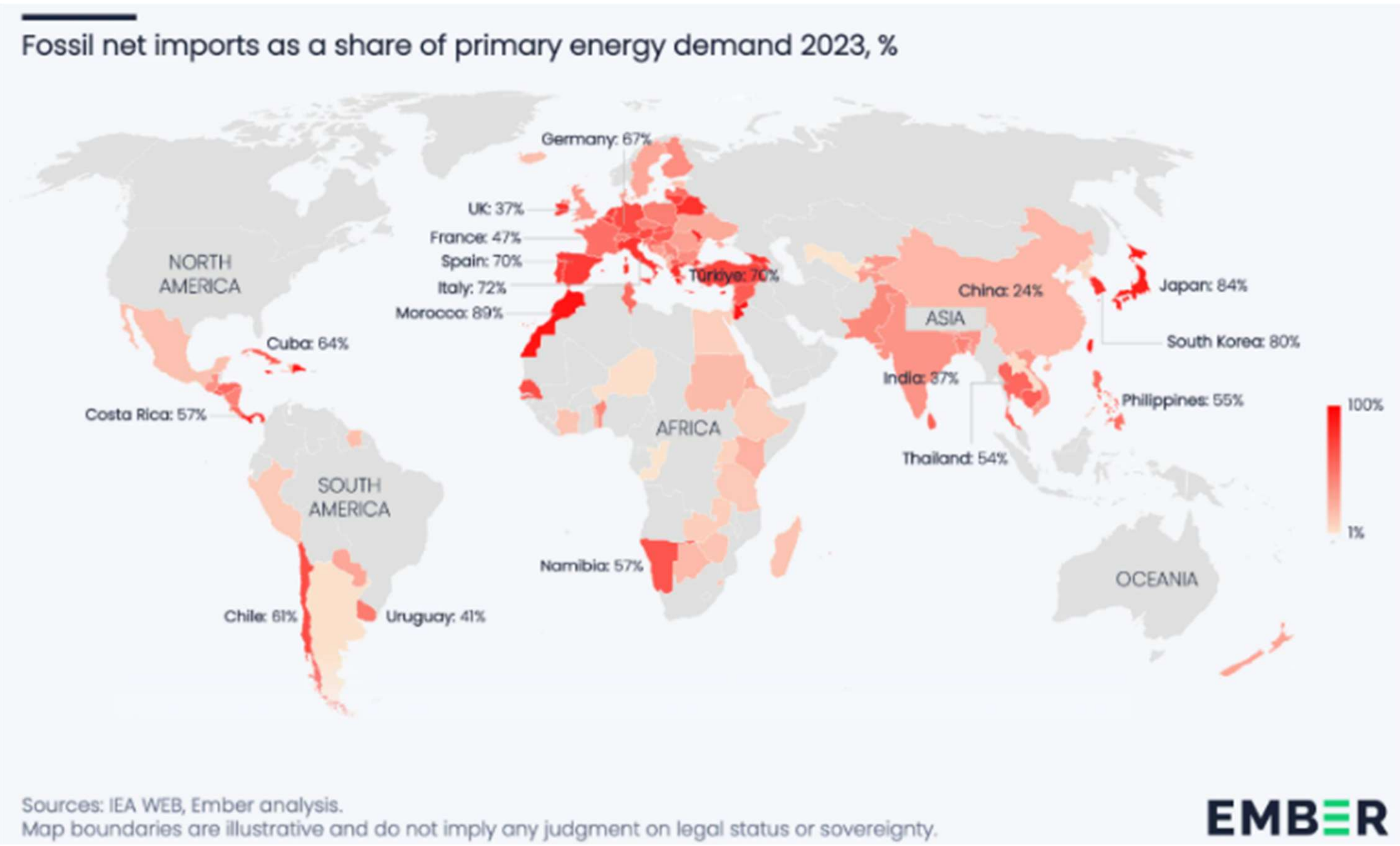

Figure 12 – global fossil fuel import dependence. Source Walter (2026), reproduced under CC licence. The information shown above is for illustrative purposes.

Most of global population are in net fossil fuel importing countries (Figure 12), spending $1.5 trillion on these (single use) imports in 2024**.** Fifty countries import over half their primary energy - including almost all of Europe.[xlix]

With each shock, electrotech is likely to be more available, better and cheaper and more compatible with the systems they are trying to enter as they increasingly reconfigure. **The space for consumer support on rising fossil fuel prices is also likely to shrink**, as each crisis chips away at the available tools and budgets.

From energy 'addition' to energy 'transition'

The growth of electrotech is **likely to produce a messy picture of energy addition *and* transition** in the coming years:

- **Power generation is tipping from addition to transition**, driven by relentless progress in renewables and storage. Rapidly growing power demand (particularly from AI) may complicate this in some regions, but the global direction is set.

- **The imminent shift to transition in transport was set a decade ago**. Cars account for a quarter of global oil demand. Total ICE sales are down 25% from their peak ten years ago, offset by EVs.[ix] Oil is set to structurally decline after 2030 as cars sold at this peak are scrapped.[xxxvi] EVs already dominant in sales of two- and three-wheelers, are growing in new car sales, and are quickly emerging in the heavy-duty sector. [ix]

- **Heat remains in the 'addition' phase, but with growing electron share**. The four tailwinds will accelerate electrification in demand addition, first in low-temperature heat (homes and businesses), and increasingly in high-temperature industrial heat.

- **Fossil fuels will continue to dominate slowing molecule demand growth** as transport tips toward transition and new heat demand increasingly electrifies. Electrons for molecules (i.e. green hydrogen) may grow in key niches.

An absolute **decline in global use of fossil fuels in energy is increasingly likely,** driven by existing trends and these four strengthening tailwinds. Simply **extrapolating current rates of change** in useful energy demand, clean energy and fossil fuels **sees a global tip into transition in global energy from around 2040**, from apparently slow and linear change currently. A decade or so later, fossil fuels would meet less than a quarter of global energy demand.[l]

The real world is messy and the future is inherently uncertain, but **the direction of travel is clear**, even if the timeframes are not.

Endnotes

[i] Bond et al (2025)
[ii] Frezzoz (2025)
[iii] Rosenow (2025)
[iv] Albatayneh et al (2020)
[v] Walter et al (2026a)
[vi] Ember (2026a)
[vii] Walter (2025)
[viii] Fulghum et al (2026)
[ix] IEA (2026a)
[x] IEA (2026b)
[xi] Geels (2024)
[xii] Zissis & Bertoldi (2023)
[xiii] IRENA (2025)
[xiv] IEA (2025a)
[xv] Drummond (2026)
[xvi] IRENA (2026)
[xvii] IEA (2024a)
[xviii] Cui et al (2025)
[xix] BNEF (2025)
[xx] S&P Global (2024)
[xxi] IEA (2025b)
[xxii] IEA (2026c)
[xxiii] Pluginsolarusa.com
[xxiv] BEA (2026)
[xxv] Nijsse et al (2023)
[xxvi] IEA (2026d)
[xxvii] Eliot et al (2026)
[xxviii] IEA (2024b)
[xxix] Le Quere et al (2026)
[xxx] IEA (2026e)
[xxxi] Pindyk (2023)
[xxxii] Enverus (2025)
[xxxiii] Dahham et al (2022)
[xxxiv] IEA (2025c)
[xxxv] Carbon Brief (2026)
[xxxvi] IEA (2025d)
[xxxvii] Ember (2025)
[xxxviii] Walter et al (2026b)
[xxxix] Butler-Sloss et al (2026)
[xl] EURACTIV (2022)
[xli] Russell (2023)
[xlii] European Commission (2026)
[xliii] Reynolds (2026)
[xliv] Jowett (2026)
[xlv] IEA (2026f)
[xlvi] Ember (2026b)
[xlvii] IEA (2026)
[xlviii] Liebreich (2026)
[xlix] Walter (2026)
[l] Liebreich (2025)

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