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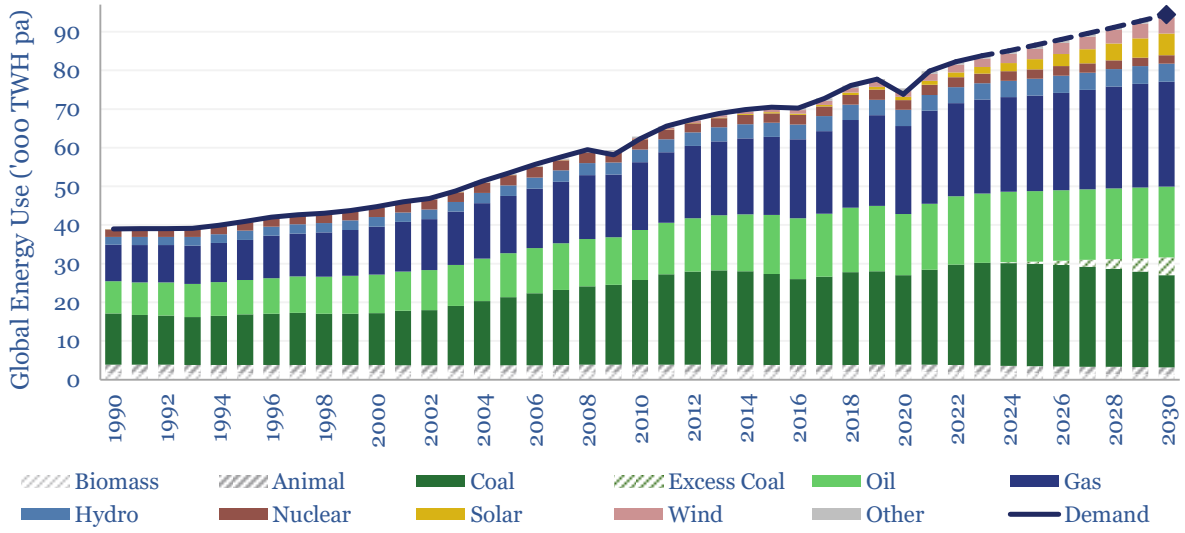
Energy transition: ten themes for 2024?

Navigating the energy transition in 2024 requires focusing in upon bright spots, because global energy priorities are shifting. Emerging nations are ramping coal to avoid energy shortages. Geopolitical tensions are escalating. So where are the bright spots? This note makes 10 predictions.

- ***Global coal use*** hit new highs of 8.5GTpa in 2023, 1GTpa higher than foreseen 2-5 years ago, as China and India are prioritizing energy security above decarbonization. What we 'want to happen' to reach net zero is simply not 'what is happening'.
- ***Thus 2024 energy markets can balance*** in our base case, as total demand rises +1,450 TWH-u, China and India ramp coal to new records, oil grows 1Mbpd, US shale falls -0.2Mbpd, solar adds 350 GW-AC (c450TWH-u), wind adds 100GW.
- ***If energy prices increase in 2024,*** it will most likely be due to disruptions, as geopolitical tensions rise between the Western world and emerging industrial superpowers, which also have growing coal use, emissions and self-determination.
- ***Resiliency matters***. It is re-shaping sentiment and priorities. But even so, macro conditions are keeping decarbonization-linked mega-projects from accelerating?
- ***The energy transition initiatives*** that excite us for 2024 include energy efficiency themes, a re-acceleration of solar sentiment, a sharp bottleneck in silver, and an emerging 'age of materials', plus opportunities in earlier-stage technologies.

Fig 1. *Emerging industrial powers keep ramping coal to prevent energy shortages?*



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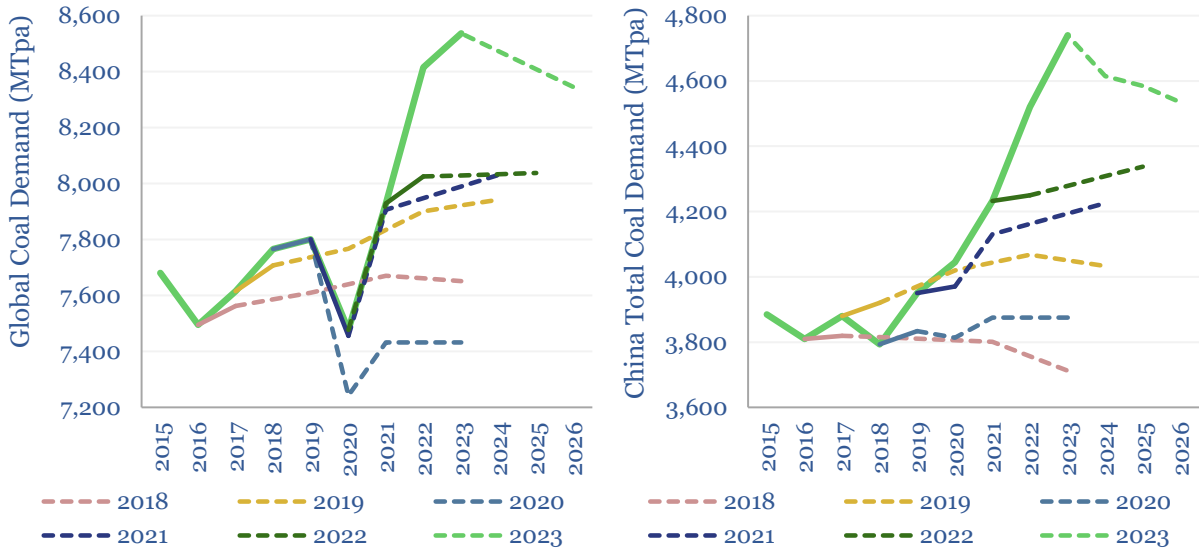
(1) The coal question: coal becomes a source of global tension?

Something is deeply unsettling about **Fig 2**. Back in 2018, the IEA predicted that global coal consumption would peak at 7.7GTpa in 2021, equivalent to 20GTpa of CO2 emissions, then start declining. Five years later, the most recent estimates are that global coal consumption will reach 8.5GTpa in 2023, or 885MTpa higher than was envisaged back in 2018. In other words, despite all of the progress made in the energy transition in the past half decade, the consumption of coal – the highest-carbon major fossil fuel in the world – is still hitting new highs. And these highs are even higher than expected. Solar may have added +400TWH of clean electricity in 2023, but our best estimate is that coal added over +600TWH of dirty electricity.

The main reason for rising global coal consumption has been higher-than-expected coal use within China, and to a lesser extent India. China consumed 4.7GTpa of coal in 2023, a full 1GTpa more than was envisaged in 2018. This coal use is equivalent to 30,000 TWH of primary energy, which is c20% of all primary energy consumed by human civilization, equivalent to 5 Saudi Arabias of oil output. On the other hand, Western nations have cut coal use and broader industrial activity. European electricity demand fell by another 4% in 2023, to the lowest level in two-decades. US coal will decline below 400MTpa by 2026, the lowest in six decades.

2024 is likely to be a year of mounting tensions, in our view, well framed by the coaly conundrum in **Fig 2**. Continued use of coal is preventing energy shortages, but challenging progress towards global decarbonization, and instead threatens a looming era of geopolitical tension, as the world bifurcates between carbon-abolitionist Western nations and carbon-irreverent emerging industrial titans.

Fig 2. Global coal consumption for 2023 came in almost 1GTpa higher than was forecast back in 2018, due to steep and consistent upwards revisions in China.



Source: Energy Institute, IEA, TSE Modelling

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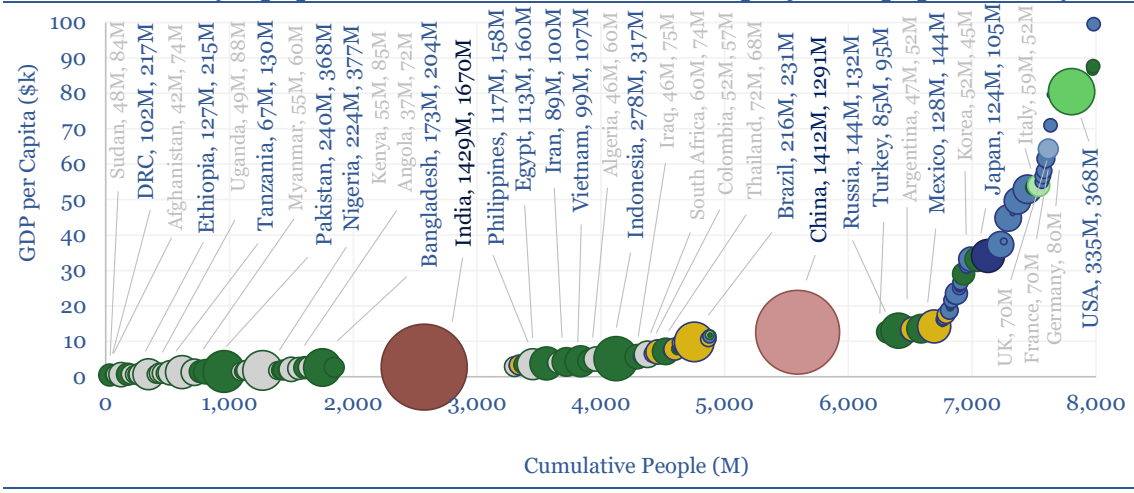
Emerging world energy ambitions have long stood out in our research. The 'top billion' people in the OECD consume 28 MWH pp pa of useful energy, 4x more than 'other 7bn' people in the emerging world, at 7MWH pp pa (reaching 11MWH by 2050); and 10x more than the 'bottom 4bn' at 3MWH pp pa (7MWH by 2050). To bring these statistics to life, 85% of all people alive today have never been on a plane. 4bn people inhabit <10 m2 pp of living space, less than a Western prison cell. A hot tub in the Alps can consume more electricity than an African village of 40 people. The US is 4% of the world's people yet uses 20% of its toilet paper. Westerners own 17x more cars and consume 10x more plastics than the poorest 4bn.

It is sheer fantasy to assume that that 7 bn people in the emerging world will choose not to consume more energy, or that somehow it will be counteracted by efficiency gains, or that any major energy commodities are easily going to peak.

It is also fantasy to assume that moralizations from the West are going to sway the policies of emerging-world nations, which are so large that their own decisions can effectively cancel out all of the decarbonization progress in the West. **Fig 3** labels many of the 42 countries that have, or will by 2050 have, populations exceeding 50M people. We call it the '50M club'. China and India, each have 1.4bn people, the same as the entire OECD. But further down the list, does the will of the West really influence Russia, Iran, Pakistan, Nigeria? Apparently my woke adopted homeland of Estonia (1.3M people) sent more delegates to COP28 than Bangladesh (173M people).

Fantasies have a habit of shattering. And we wonder if 2024 is going to be the year that shatters some of the fantasy thinking in energy transition. Mounting evidence seems to show Western nations straining to decarbonize, while emerging nations continuing to ramp up their coal, oil use, CO2 and industrial clout. Sometimes by capturing the very industrial activity that has leaked from the West. We need to think very hard about these mounting tensions to navigate 2024.

Fig 3. 42 nations on the planet have, or will have populations above 50M. (The first number is today's population, the second number is projected population by 2050).



Source: Energy Institute, IEA, TSE Modelling

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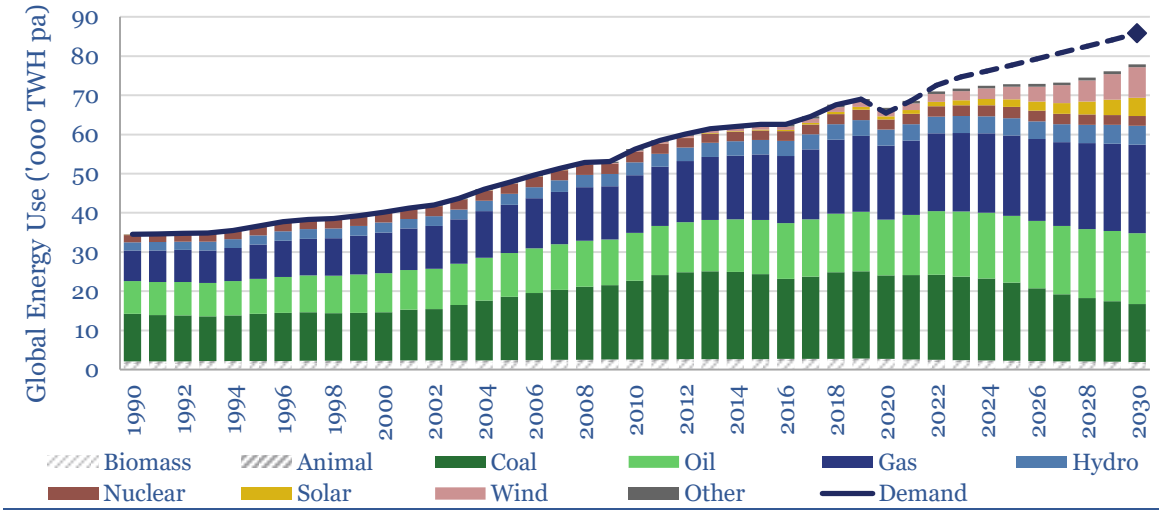
(2) Deferred energy shortages and deferred decarbonization?

The evidence now suggests that emerging world countries are more likely to continue ramping up coal production to stave off energy shortages, rather than phasing out their coal output to satisfy the developed world's decarbonization aspirations. This is not what we want to happen. It is simply a prediction. (And one of our new year's resolutions is to avoid moralizing and instead do more predicting).

To illustrate this point, let us return to **Fig 4**, which is lifted directly from our energy market outlook from January-2022. The forecasts shown for the different energy sources in **Fig 4** were taken from our 2021 energy transition roadmap. Hence we were worried about sharp and persistent energy shortages. Those shortages did materialize in 2022, and primary energy prices spiked to absorb 13% of global GDP.

Fig 4. *"Global energy under-supply runs at 2% in 2022, escalating to 10% by 2030"*



Source: Thunder Said Energy

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But as a result, China, India, and other ASEAN countries resolved to increase coal production. China now has 1.1TW of coal-fired power plants providing two-thirds of the nation's power grid. 243GW of new coal plants have been approved and another 149GW are in planning. For perspective, the entire UK power grid is 27GW. India's coal use grew by 14% in 2021, 9% in 2022, and 9% in 2023 to reach 1.3GTpa; India's domestic coal production surpassed 1GTpa for the first time in 2023; and another 20-30GW of coal plants are being built by 2026. Third, Indonesia, which is today the largest coal exporter, selling 0.5GTpa of its 0.7GTpa production internationally, is constructing 13-18GW of new capacity to feed aluminium, nickel and cobalt smelters.

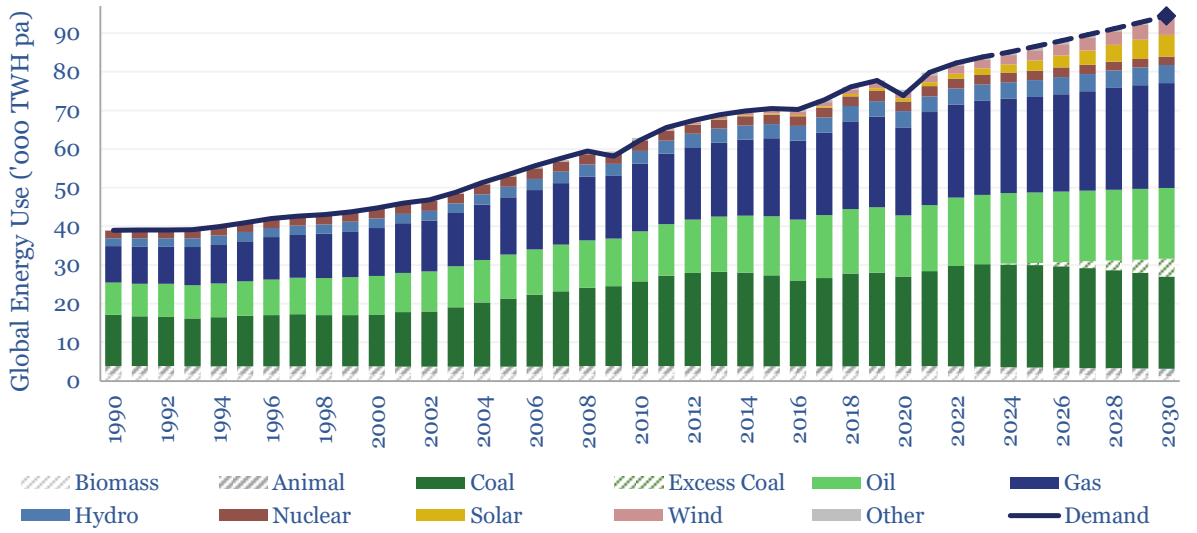
What about energy transition? Surely the quest for global decarbonization should preclude continued growth of coal, which emits 2x more CO2 per useful MWH of energy than natural gas? Surely the all-powerful divestment movement will manage to persuade China and India not to keep building out coal capacity? Quite

the opposite. 7bn people outside of the developed world are choosing not to impoverish themselves with devastating energy shortages. Even the IEA notes, *"For China and India, domestic coal production has long been the cornerstone of energy security"*. Indeed, to re-assure coal developers scared by the prospect of coal's long-term phase out, in November 2023, the Chinese government announced capacity payments for new coal power plants, to guarantee developers that their investments would be recovered irrespective of their future load factors. And India's COP 28 delegation reportedly quashed proposals for a more rapid phase-down of coal.

***Returning to our Jan-2022 forecasts in* Fig 4**, we saw 2024's global coal production running at 7.3GTpa two years ago, as we naively thought the world would prioritize decarbonization, despite persistently high energy prices. We have now penciled in 8.7GTpa of coal for 2024, which adds another 4,700 TWH of useful energy to 2024's global energy markets, while it also adds another 3.5GTpa of CO2. If coal continues growing at 1% pa through 2030, then energy markets balance (**Fig 5**).

A rift is therefore growing between what we think the emerging world is likely to do with its coal consumption, and what would *need to happen* if the world's energy system were to transition to net zero by 2050 via the most achievable roadmap. On that roadmap, coal would need to fall back to 6.4GTpa by 2030. But then, with our forecasts for solar (+430 GW pa to 2030), wind (+120 GW pa to 2030) and gas (390 bcfd in 2022 to 430 bcfd in 2030), we think the global energy system would be 4,500 TWH short of useful energy by 2030, equivalent to a monumental 5% global energy shortage. Being realistic, this is just not likely to happen. China, India, and other emerging world countries will prefer to continue ramping up coal. And as much as Western countries protest, very few options exist to stop this runaway train.

Fig 5. *What if rising industrial super-powers continue ramping up their coal output, in order to balance global energy markets and prevent shortages?*



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(3) 2024 energy markets will be driven by 'surprises'?

2024 energy markets look balanced in our new base case. This includes global energy demand rising by +1,450 TWH-u, or 1.75%, which is still subdued compared to a 15-year run-rate of 2.4% per year. Coal grows by 2% (+300 TWH-u). Global oil supplies grow by 1Mbpd (+230 TWH-u). Gas grows +2bcfd (+170TWH-u). Solar adds 350GW-AC (+450 TWH-u). Wind adds 100GW (+225 TWH-u).

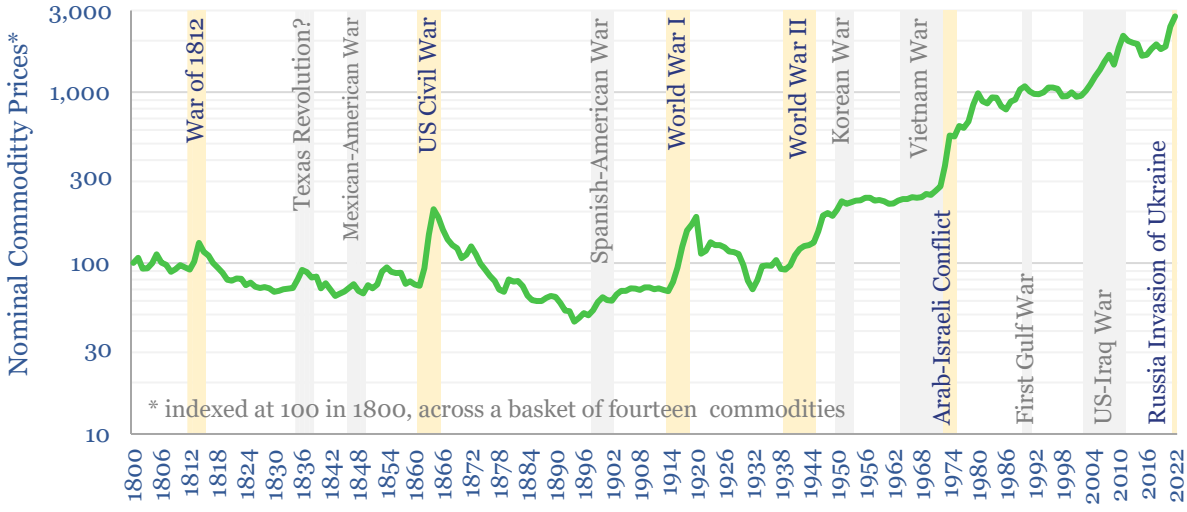
Therefore, whether 2024 turns out to be a year of generalized energy price increases, depends on disruptions, and means that risks are skewed to the upside.

For demand, it is not unimaginable that in advance of the 2024 election, US policymakers ease interest rates and unfurl some form of economic stimulus.

Weather is unpredictable. For example, dry or wet weather sways global energy supplies by as much 1% by impacting hydro output, wind, solar and coal. For example, one factor that supported India's coal production in 2023 was weaker-than-usual monsoon conditions in 2023. Heating and cooling degree days also determine gas and power demand, and vary by 8% year-on-year across nations such as the US.

Finally, asset disruptions are likely to provide the largest reason for global energy prices to surprise to the upside. As the most extreme example, across a dozen conflicts, going back to 1800, 95% of commodities saw higher prices, the average commodity doubled and the most extreme disruptions unlock 2-10x upside, with oil screening as one of the 'most disruptable' commodities during conflicts. This theme matters as Russia continues its attempt to invade Ukraine, China continues to make threatening overtures on Taiwan, and hostilities intensify in the Middle East. These geopolitical tensions seem to strangely mirror CO2-related tensions per pages 2-4.

Fig 6. *The median commodity price rose 110% (trough-to-peak) during conflicts?*



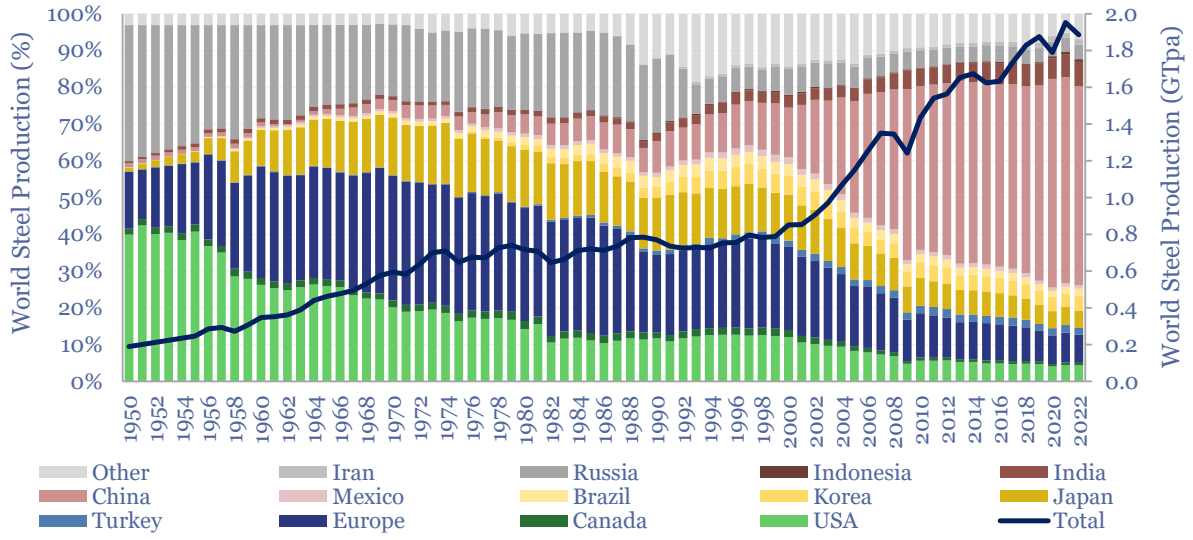
Source: US Censuses, World Bank, Technical Papers, TSE Download the data?

(4) Geopolitical resiliency re-shapes sentiment?

Geopolitical tensions are now re-shaping the entire energy transition. Back in the halcyon era of 2019, the moral compasses for many of us in the developed world, had started pointing towards environmental objectives and decarbonization of the global energy system. But horrific world events of 2022 and 2023 have now re-oriented many of our moral compasses. Levels of geopolitical conflict, unseen since WWII, are making resiliency crucially important, as part of energy and industrial policy.

For example, in 1950, the US, Europe and the Soviet Union were the world's three super-powers, producing 90% of all global steel (**Fig 7**). Today these three regions produce just 17% of the world's steel. By contrast, China produces half of all world steel, around 1GTpa, while India produces 125MTpa of steel, becoming the world's second largest producer, when its output overtook Japan for the first time in 2018. Similar points could be made for other metals, materials and industrial commodities.

Fig 7. *Global steel consumption rose by 10x from 0.2GTpa in 1950 to 2GTpa in 2023*



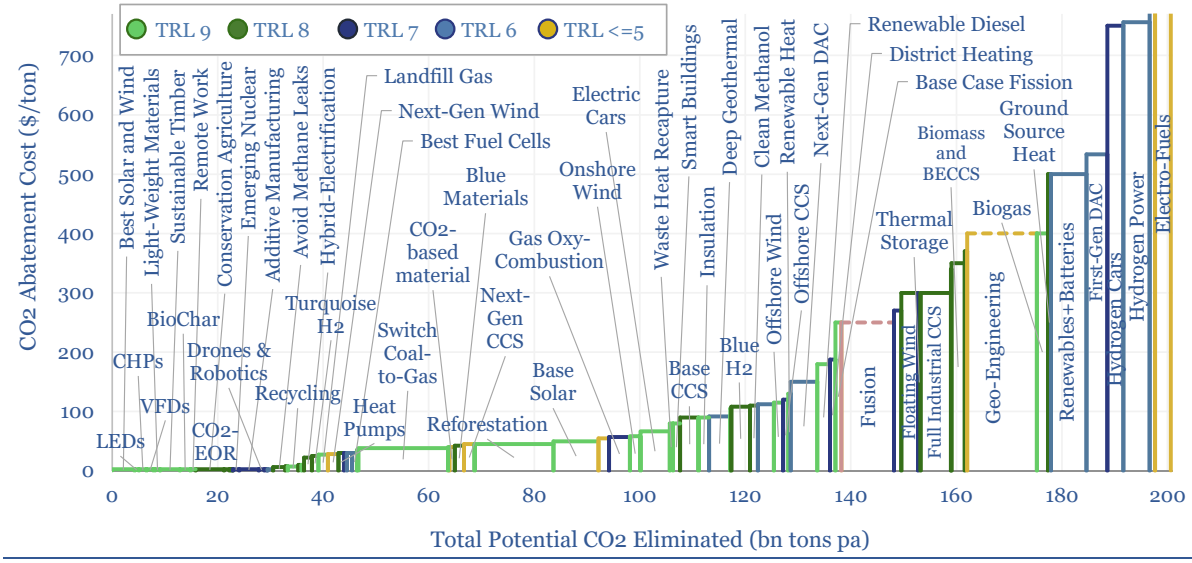
Source: World Steel Association, Thunder Said Energy Download the Data?

Moreover, our progress to decarbonize in the West is enabled by China. 70% of all energy transition value chains are manufactured in China. Including 90% of all photovoltaic silicon, and 70-90% of the supply chains behind lithium ion batteries. Furthermore, one of our great fears is that attempts to decarbonize the West simply raise production costs in a way that causes more industrial capacity to leak away, to the very regions that are not levying ESG standards upon their industrial output.

These tensions have long existed, but we wonder if they will intensify in 2024. A terrifying statistic is that China's now absorbs 38MTpa of coal to produce 10MTpa of oil products (200kbpd), seen growing at 8% pa to 2026. Coal-to-liquids are high-cost, 3x more CO2 intensive than conventional oil, and only really makes sense from a military perspective, which is the reason Germany built-up CTL in the 1930s.

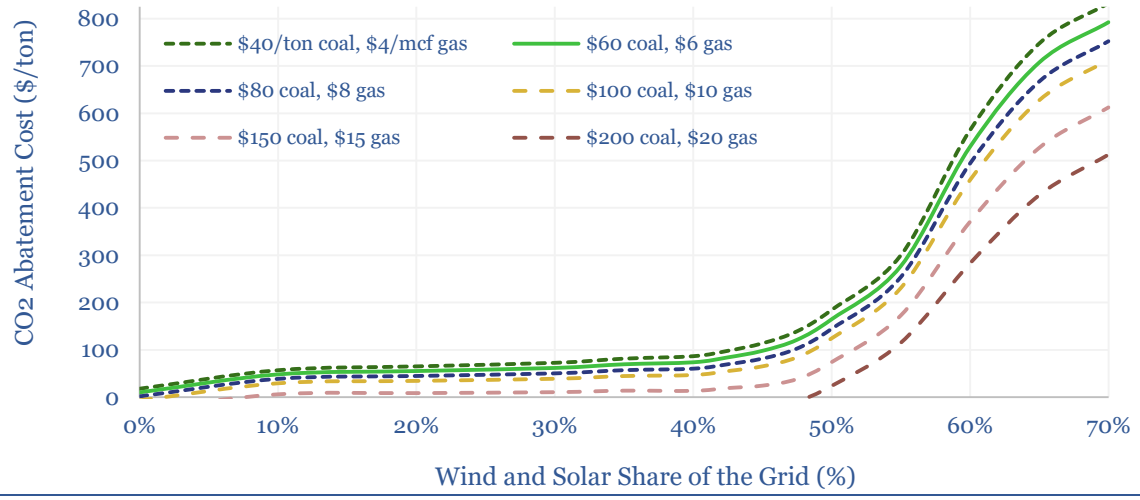
Growing tensions also make us think geopolitical resiliency is going to become a crucial driver of sentiment in 2024. Infrastructure adds resiliency. Efficiency adds resiliency. Domestic resources add resiliency. Diversification adds resiliency. Thus renewables are going to see policy support and keep ramping for the next decade, to 40-60% of many grids, but likely not further per **Fig 9** (note here). Major efforts are also going to be undertaken to re-shore strategic supply chains to the West, which we think is going to be challenging within Europe, but create an investment boom on the US Gulf Coast (note here). Conversely, ultra-high cost transition technologies can hinder competitiveness, hinder resiliency, and are thus likely to be deprioritized, per our cost curve in **Fig 8** (note here). These are major trends for the 2020s.

Fig 8. *Cost curve of technologies that can decarbonize the global energy system*



Source: TSE Modelling — Download the data?

Fig 9. *The 'best' renewables cost $0-60/ton up to 10% of the global grid, 'base' renewables cost $60/ton up to 40% of the grid, ramping wind and solar to 50% of the grid costs $100/ton, ramping to 60% costs $300/ton, to 70% costs $700/ton.*



Source: TSE Modelling — Download the data?

(5) New projects: paralysis persists?

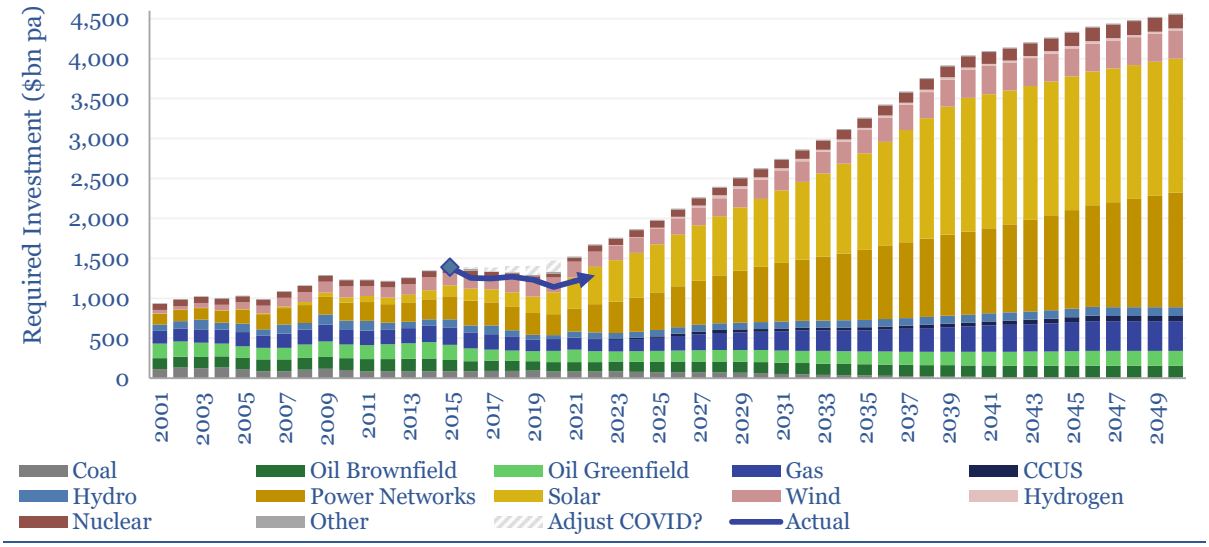
While sentiment is improving for projects and technologies that add resiliency, we are also braced for the possibility that physical progress in constructing new projects could remain quite slow in 2024. Multiples may shift faster than cash flows.

Specifically, if we review the evidence, commodity prices are back to moderate levels, which is not likely to incentivize rapid progress. There are also growing fears over economic weakness. High interest rates are a major drag on project economics and the ability to finance new projects. A major US policy pivot could be coming in November, depending on election results. Technological uncertainty and long-term policy uncertainty also remain very high. None of these factors motivate rushing large projects through to final investment decisions. They motivate waiting.

Projects that might therefore remain moribund for most of 2024 include large offshore wind developments, pre-sanction US LNG projects, large-scale CCS projects, blue value chains – such as blue ammonia, blue steel, blue chemicals, next generation nuclear projects, pipeline infrastructure and larger-scale power grid investments. Unfortunately, faster investment into all of these categories looks quite badly needed in our roadmap to net zero. While slow progress means that the West will lack resiliency, and see even sharper price spikes, amidst future disruptions.

Conversely, projects that may be well-suited to surprise in 2024 are ones that are more economically attractive, have short-cycle economics, have lower up-front capex, do not rely on policy support. This could include US shale, solar, electric vehicles, electrification projects, efficiency initiatives (insulation, LEDs, light-weighting, VFDs, heat pumps, smart energy, SiC) and nature-based solutions.

Fig 10. Energy investment trebles from $1.3trn pa to $4.5trn pa in the transition?



Source: TSE Modelling (note chart excludes power electronics) Download the data?

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(6) Shale: total production flat-lines at $80/bbl oil?

Brent oil prices have averaged $80/bbl in 2023, yet capital discipline has truly entrenched in the US shale industry, productivity gains have slowed down per our shale review of September-2023 (note here) and thus production is flatlining.

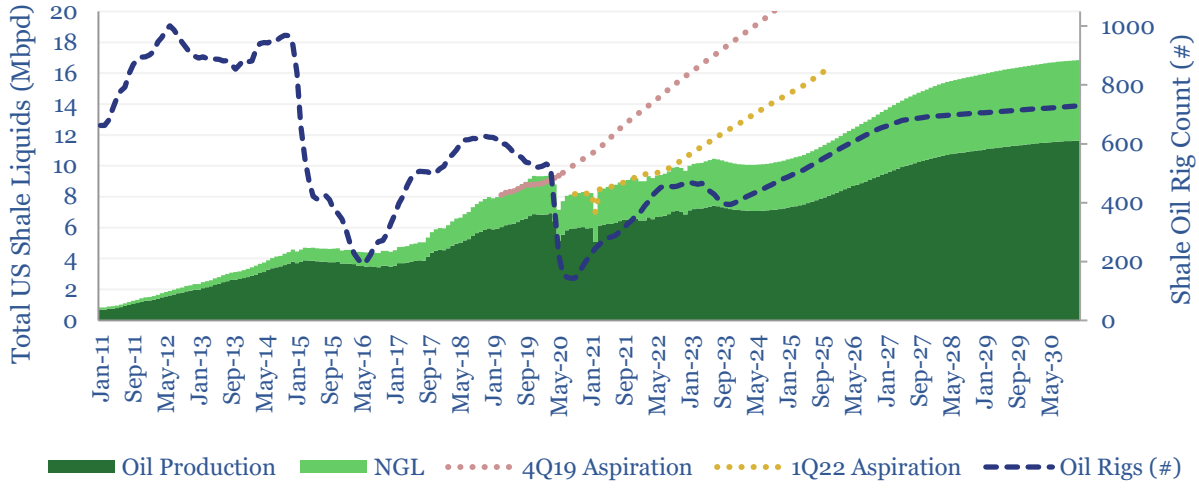
Specifically, initial productivity rates for wells in the Permian basin have now 'moved sideways' since 2019, averaging 780 bpd in 2023, a stark contrast from their 7x ascent 2011-19. And when we reviewed the technical papers published at 2023's *URTEC* conference, they did not entirely augur for productivity to re-accelerate.

Hence despite oil prices remaining around $80/bbl, US shale production could modestly decline in 2024, falling by -0.2Mbpd in the 'big three basins', the Permian, Bakken and Eagle Ford. Even this requires the rig count in the big three' basins to rise from 430 on average in 2023 to 445 on average in 2024. This adds almost 0.6 Mbpd/month of new oil to offset 0.6Mbpd/month of declines.

This weak growth profile is despite the fact that our own economic models of a shale well suggest a typical $7M well generates a 20% IRR at $50/bbl oil, 33% IRR at $60/bbl oil, 45% at $70/bbl oil and a 60% IRR at $80/bbl. If production does remain flat, and oil does remain around $80/bbl in 2024, then the US shale industry would most likely generate $85bn of free cash flow, comparable to 2023.

If oil prices are weaker, and/or if the rig count remains flat, then we think total liquids production will fall by 400kbpd in 2024. But overall, we expect US oil output to flat-line in 2024, and this should support stable oil prices. (Although an interesting wildcard to consider is whether OPEC policy could impact the US election!)

Fig 11. *Liquids production from the 'big three' US shale basins could flat-line in 2024, or even gently decline, from 10.3Mbpd in 2023 to 10.1Mbpd in 2024.*



Source: EIA, Companies, TSE

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(7) Solar: the sun also rises, and solar surpasses +340GW-AC

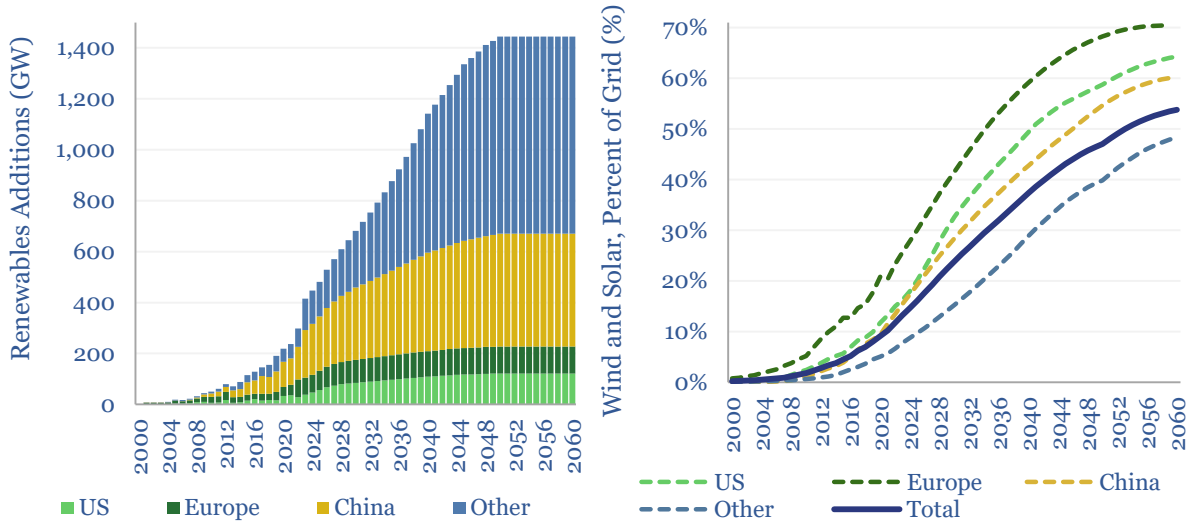
Solar is the new energy source that excites us most, with potential to abate over 11 GTpa of CO2 emissions by 2050, ramping up by 18x from 2022, to supply 24,000 TWH of useful energy in 2050, or 20% of total global useful energy. This is a very large 'upgrade' from our 2022 forecasts, which saw solar at 15,000 TWH by 2050.

Our latest estimates are that the world added 400 GW of solar modules on a DC basis in 2023, which is equivalent to 325 GW of solar project capacity on an AC-basis, and a 50% increase from 2022 additions. It is also well above our forecast published a year ago in January 2022, which was for 240GW of solar project additions in 2023.

How does solar keep surprising? As opposed to all prior forms of useful energy historically, which have come from 'turning or burning', PV solar is a semiconductor technology. Incoming electromagnetic radiation promotes electrons into a higher energy state at a PN junction, whose doping then funnels a direct current towards the cell's electrical contacts. Semiconductors are prone to improving rapidly, which we have seen from 2021 to 2023, in the industry's evolution from PERC modules, to TOPCON modules, to HJT modules, just in the past 3-years. Today's best modules are 25% efficient and there is theoretical running room to double again. This is also deflationary, as a 2x more efficient module, all else equal, halves per kWh costs.

We understand that 2023 has been a challenging year for solar developers, but in our view, solar momentum could re-accelerate in 2024. As long as China continues supplying the PV silicon and solar modules to the world. We see 350GW of solar additions in 2024 on an AC-basis adding +430 TWH of useful energy YoY.

Fig 12. *Our numbers have wind and solar ramping to around 50% of the global electricity grid by 2050, as capacity additions 'quintuple' to 1,400 GW pa*



Source: TSE Modelling

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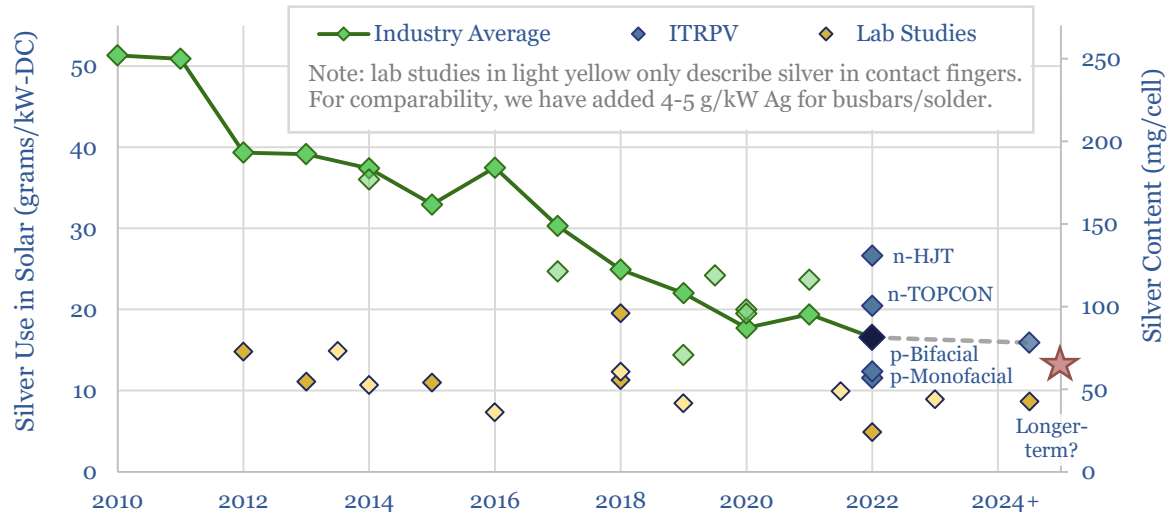
(8) Silver: the biggest commodity bottleneck of 2024?

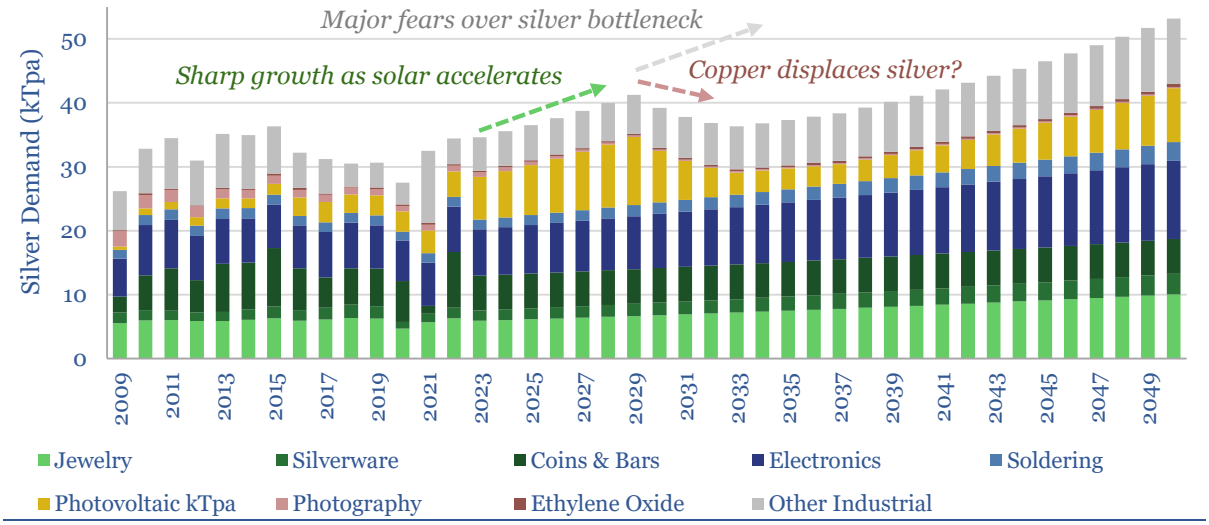
Silver is the commodity that seems most worthwhile to watch closely in 2024, given the sharp solar growth numbers above. Our best estimate is that the average solar module used 15 grams of silver per kW of DC capacity for its front contacts. Multiplying by 400 GW of DC solar additions, this implies 6kTpa of silver use. Within a total global silver market of 35kTpa. So solar modules are now consuming 20% of the world's silver. And yet silver prices ran flat in 2023, ending the year at $24/Oz. It is possible to switch silver front contacts for copper contacts, but higher manufacturing costs require silver prices above $50/Oz (notes here, here and here).

Fig 13. Silver use in solar has halved since 2015. Lab studies have neared 10 g/kW (albeit using high cost techniques). We see another 40% thrifting potential?



Source: Technical Papers, Companies, TSE Estimates Download the Data?

Fig 14. *A silver spike is needed to motivate the switch towards copper contacts?*



Source: Silver Institute, Technical Papers, TSE Modelling Download the data?

(9) A new age of materials: high-grading for efficiency gains?

The median average commodity market that we have assessed sees its total market demand trebling between now and 2050 (**Fig 15**, underlying note here). In the upper quartile are commodities whose demand must rise by 5-30x. And our ranked outlook for each of thirty commodities leaves us seeing the largest bottlenecks in lithium, silver, binders, polyurethanes, SiC, Indium, copper, LNG, tin.

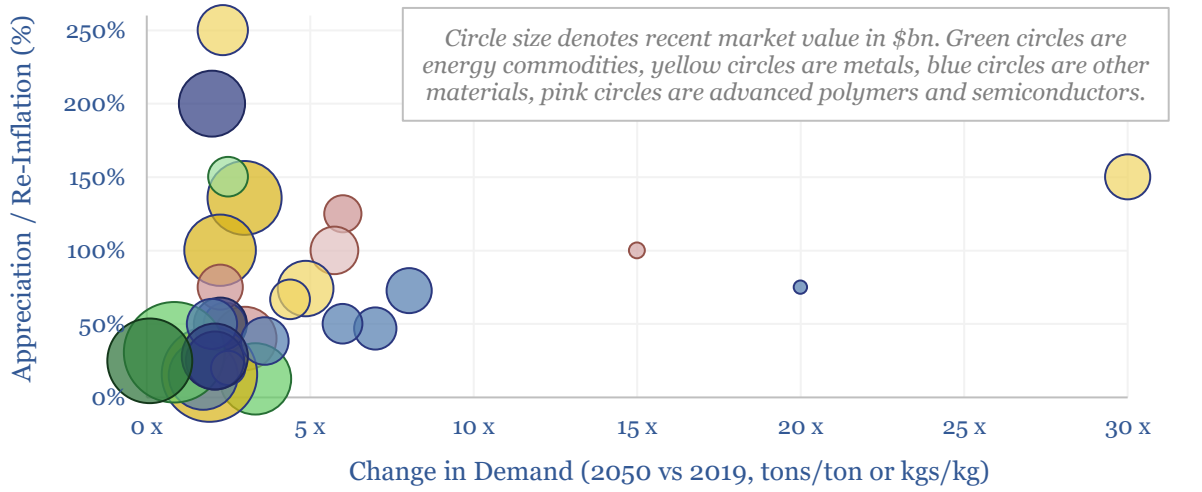
However a crucial view that emerged in our work in 2023 was that the energy transition is unlocking a new age of materials, where continued efficiency gains in new energies are going to be driven by using higher-grade premium materials. This is the best antidote to materials bottlenecks, because if you can increase the efficiency of solar modules (from c23% today) or the voltage of a lithium ion battery (from 3.7V today) then you get more power/energy overall. Increasing the kW (or kWh) rating deflates the per kW (or per kWh) materials usage and materials cost.

As materials now comprise over half of the costs of new energies, and manufacturing costs have fallen by 80-90% for solar and batteries in the past decade, there is simply no other way to continue the trajectory of cost deflation.

Examples that have featured in our research to-date include the use of advanced battery binders and additives to improve battery voltage (e.g., from Solvay, now re-branded as Syensqo), the use of improved solar encapsulants (e.g., from Mitsui Chemicals) or ultra-high purity ITO for HJT solar cells (e.g., from Umicore).

We expect that our research in 2024 will be highly focused on finding enabling materials, which can drive the next stage of energy transition. Returning to Theme #4, developing and producing these materials also supports geopolitical resiliency.

Fig 15. *Thirty commodities for the energy transition: the median average one sees volumes rise by 3x and prices appreciate/re-inflate by 60%. Means are 1.5x and 0.8x.*



Source: Thunder Said Energy Modelling Download the Data?

(10) New year's resolutions: clear conclusions and companies?

Our new year's resolutions, as articulated in the video here, are to publish more regular overviews of our key conclusions, not to shy away from predictions even when they are not exactly what we *want* to happen, and to help our clients get information so that they can 'build cool stuff' that resolves tensions discussed above.

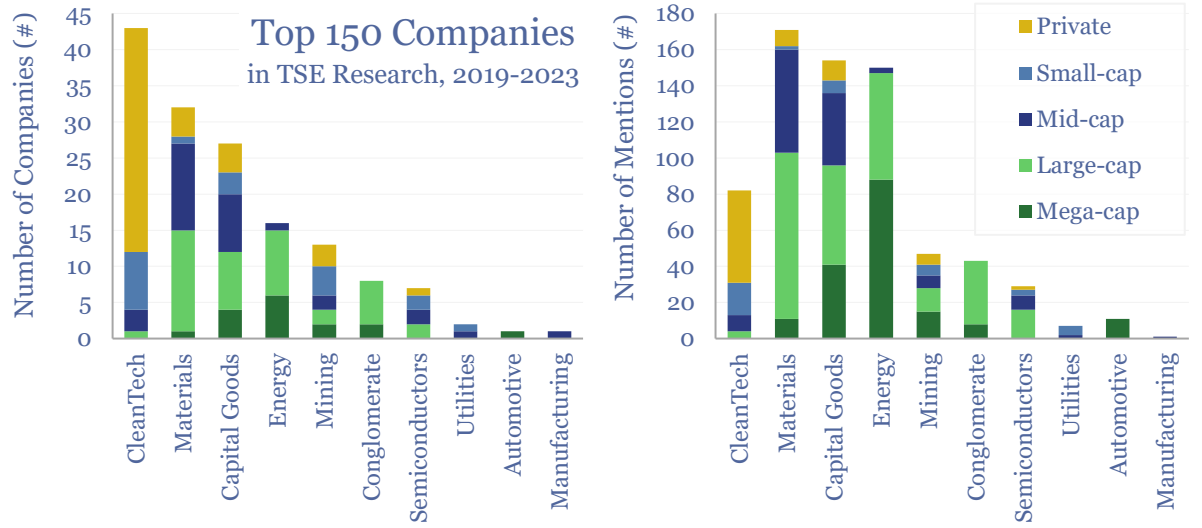
To help organize our biggest thematic conclusions in the energy transition, which may be relevant for companies, we publish an annual 'roadmap to net zero'.

We are also maintaining a database with our outlook for 30 commodities and materials value chains in the energy transition (**Fig 15**, note here, database here).

And finally, we are cataloguing the companies that are being mentioned in our research, in case this helps decision-makers to identify overlooked angles. 150 core companies have been mentioned 700 times across all of our research since 2019; within a broader list of 1,300 total companies, diversified by geography, by size and by segment. Geographies most represented in our research have been the US (450 companies), Europe (400), China (110), Canada (90), Japan (65), Australia (35) and Korea (35). Among company types, 55% were private. 45% were public, of which 20% were mega-caps, 45% were large-caps, 20% were mid-caps and 15% were smaller-caps. 30% were clean-tech companies, plus 20% materials, 20% capital goods, 10% energy, 10% mining, 5% semiconductors, 5% conglomerates and other.

The most discussed companies in our 2023 research, and as we head into 2024, have been Air Products, Linde, Rio Tinto, ExxonMobil, Siemens, Atlas Copco, Infineon, Huntsman, Syensqo, Umicore, plus another 40 companies in the note here.

Fig 16. *150 core companies have been mentioned 700 times in our research since 2019*



Source: Thunder Said Energy Research

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Thunder Said Energy's Research is written by Rob West, the company's sole research author.

There is no fixed timetable for publication of our research.

All reasonable efforts are made to minimise conflicts of interest in our research.

In 2022, Rob's wife, Lisett Luik, co-founded Arbonics OÜ, which is a start-up company aiming to streamline the verification of nature-based CO2 removals.

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Units and conversions. For an overview of the units, acronyms and energy conversion factors used across all of our research, please see our note here.

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