USS

For members, for the future.

The Policy Challenges of the Energy Transition

Time to get serious about climate change and the energy transition

USS Investment Management Limited

with support from

trex

Contents

USS Investment Management Limited (USSIM): A subsidiary of Universities Superannuation Scheme Limited. USSIM, the principal investment manager and adviser to the scheme, has written this paper with the support of Transition Risk Exeter.

Authors:
Naomi Clark
Mirko Cardinale
Simon Pilcher
Sandra Carlisle

Transition Risk Exeter (Trex): A commercial spin-out from Exeter University that bridges climate science and finance, it provides non-linear climate intelligence for financial resilience and competitive advantage.

Authors:
Simon Sharpe

Contributors:
Jean-Francois Mercure
Timothy Lenton
Gregor Semieniuk
Iain Weaver

Smith School of Enterprise and the Environment, University of Oxford:
Cameron Hepburn

Introduction

Climate change, extreme weather events, and the energy transition are reshaping the investment landscape, making it crucial to understand the associated risks and opportunities for global asset owners.

We see **significant room for improvement in how asset owners and other financial institutions assess and manage these risks and opportunities.** We are committed to enhancing our methods and we encourage other asset owners to do the same. We hope that the insights shared in this paper will be valuable to others as they embark on a similar journey.

However, **there are limits to what asset owners can achieve alone.** Climate change poses some of the greatest risks to society and the global economy, and also to pension funds who invest in global markets to generate returns to pay pensions. Only decisive action by governments can substantially reduce these risks and accelerate the growth of the clean energy economy.

We believe the **UK and other governments can and should take stronger action** by adopting a comprehensive policy programme to support each stage of the transition. This will make the UK a more attractive market for global investment, supporting economic growth. A fast transition to clean technologies could result in an estimated $12 trillion in savings globally by 2050[1] (relative to no transition). As a net importer of fossil fuels, the UK stands to benefit significantly[2] while also boosting energy independence and security, which is itself of great value in the current geopolitical environment.

We believe that a focus on the decarbonisation of investment portfolios will have only very limited impact on decarbonisation in the real-world. Instead, asset owners must work in collaboration and engage at a macro level with policy makers and regulators across the globe to help to bring about this change.

Our analysis suggests that a lack of appreciation of the catastrophic risks faced by the planet as a consequence of the tipping points we appear to be reaching means that **the time to act is now**.

[1]Way, R., Ives, M. C., Mealy, P., & Farmer, J. D. (2022). Empirically grounded technology forecasts and the energy transition. Joule, 6(9), 2057-2082. https://www.sciencedirect.com/science/article/pii/S254243512200410X
[2]Lynch, C., Simsek, Y., Mercure, J. F., Fragkos, P., Lefèvre, J., et al. (2024). Structural change and socio-economic disparities in a net zero transition. Economic Systems Research, 36(4), 607-629.

Climate and Transition Risks for Pension Funds

1) Improving assessment of climate change risks

The risks of climate change are non-linear in nature: a small increase in an underlying variable such as global temperature, or sea level, which changes gradually over time, can lead to a large increase in the probability of an extreme event.

For example, the UK is now over twenty times more likely to experience a temperature of above 40°C than it was in the 1960s.[3]

> **For financial institutions, it is critical to recognise how this non-linearity can drive rapid increases in risk even in the short-term.**

Just 10cm of local sea level rise experienced in the New York area in the preceding century is estimated to have increased the damages caused by Hurricane Sandy in 2012 by $8bn.[4]

Many of the risks would be magnified if tipping points in the Earth's system are crossed. Six tipping points are thought likely to be crossed at around 1.5°C – 2°C of warming (see Figure 1).[5]

Estimates of the impact of climate change on global Gross Domestic Product (GDP) have been described by leading economists as 'grossly underestimating the risks'[6] and 'close to useless'.[7] A fundamental mistake is to assume that any effect on the economy must be marginal, involving only small changes within the existing system, rather than recognising that it is system stability that is at stake.[8]

Whether the scale is local or global, estimates of the expected values of climate change damages are likely to be misleading. Climate risks do not generally have normal distributions: the likelihood of extreme impacts can be relatively high, or unknown, meaning that expected values often cannot be meaningfully calculated. This was laid bare by a recent Norges Bank Investment Management report[9] which highlighted the challenge of reconciling the order of magnitude of climate risk exposures using top down vs. bottom-up approaches. **Instead, climate risk assessments should focus on identifying plausible worst-case outcomes for assets, supply chains, or regions of interest, and working backwards to assess their probabilities.**

[3] Met Office (2025). Met Office report details rising likelihood of UK hot days.
[4] Strauss, B. H., Orton, P. M., Bittermann, K., Buchanan, M. K., Gilford, D. M., et al. (2021) Economic damages from Hurricane Sandy attributable to sea level rise caused by anthropogenic climate change. Nature communications, 12(1), 2720.
[5] Armstrong McKay, D. I. (2024). Two decades of climate tipping points research: Progress and outlook. Dialogues on Climate Change, 1(1), 30-38.
[6] Stern, N. (2013). The structure of economic modeling of the potential impacts of climate change: grafting gross underestimation of risk onto already narrow science models. Journal of Economic Literature, 51(3), 838-859.
[7] Pindyck, R.S. (2013). Climate change policy: what do the models tell us? Journal of Economic Literature, 51(3), 860-872.
[8] Hepburn, C. et al (forthcoming). Economic models and frameworks to guide climate policy. Oxford Review of Economic Policy.
[9] Norges Bank IM, Climate and nature disclosures, 2024

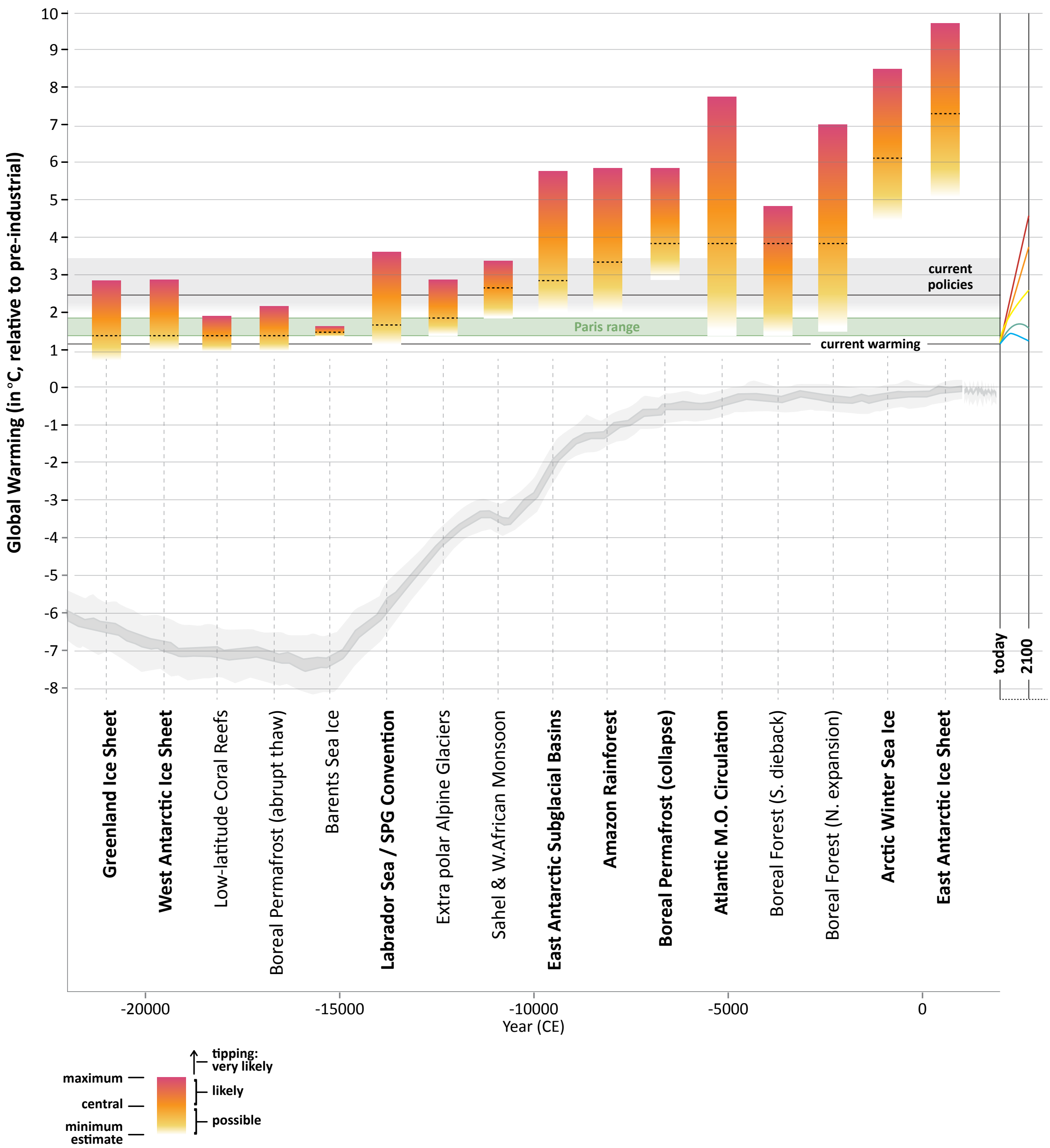


Figure 1: Illustration of the global warming thresholds for 17 non-linear tipping elements. A tipping event becomes possible when the minimum estimate is reached. It becomes more likely with each fraction of global warming beyond the minimum estimate. Source: Armstrong McKay, D. I. (2024) Two decades of climate tipping points research: Progress and outlook. Dialogues on Climate Change, 1(1), 30-38.

2) Better understanding of energy transition risks and opportunities

A realistic assessment of the risks and opportunities of the energy transition requires a good understanding of change in at least three arenas: the macroeconomy; the sectors in which the transition to clean energy is taking place; and the assets or companies in which investments are held.

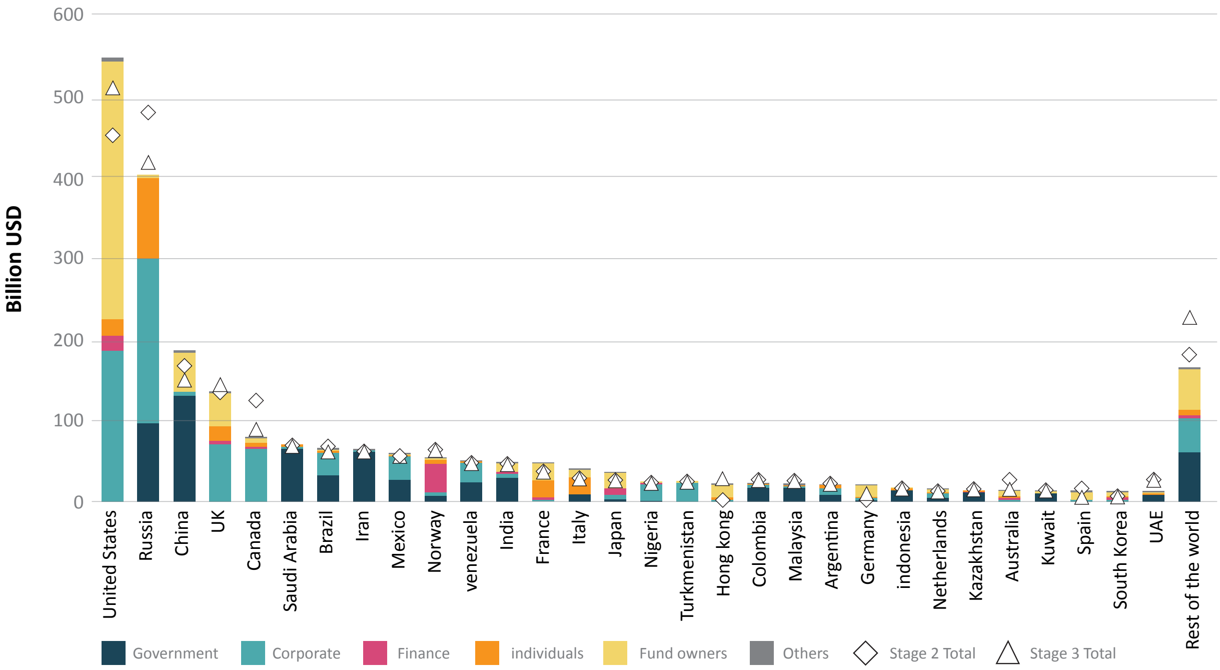


Figure 2: Asset stranding by region at the level of ultimate owners. Source: UKSIF. (2025, March). Stranding: Modelling the UK's Exposure to At-Risk Fossil Fuel Assets.

a) Asset and company level: the inverse S-curve

In a technology transition, the market share of the new technologies increases along an S-shaped curve: slowly increasing at first, then rapidly, then slowly again as market saturation approaches. Meanwhile, the market share of the old technologies follows an inverse S-curve. In the early stages of the transition, it falls only slowly, and the old technology's revenues may continue to grow if the market as a whole is growing. Rapid decline then follows.

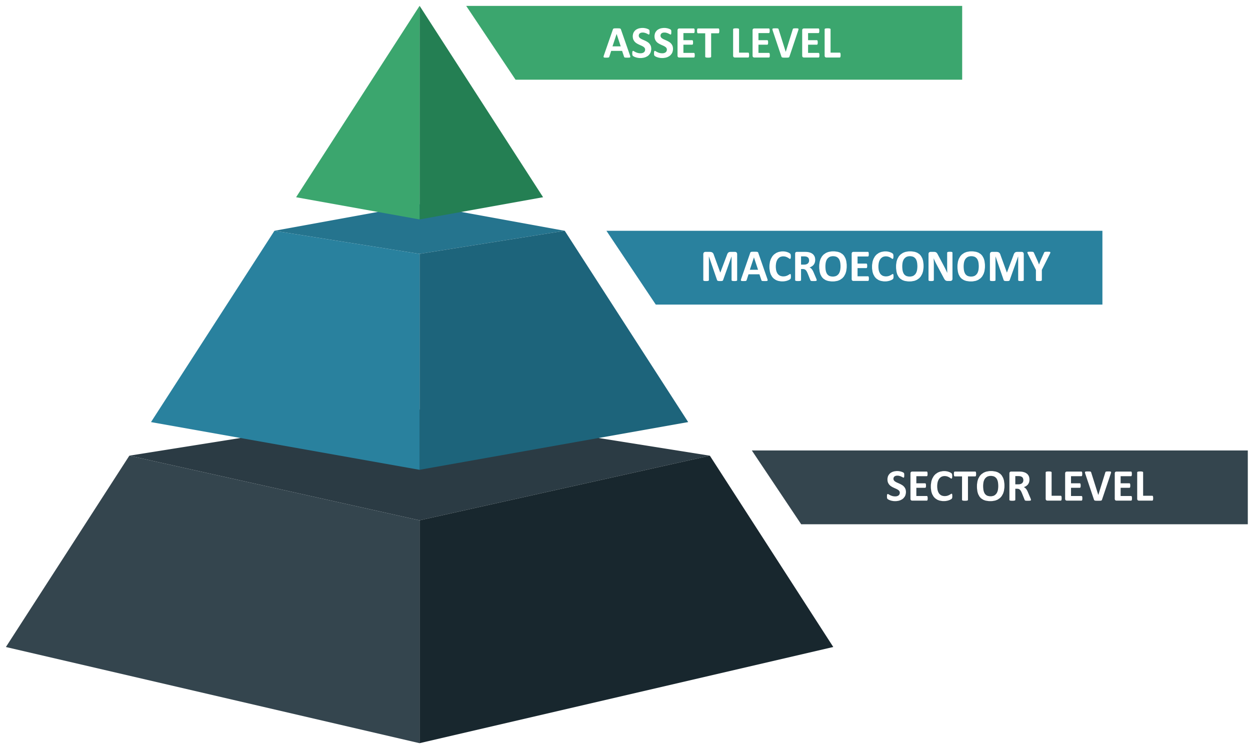
Recent analysis by Transition Risk Exeter (Trex) in partnership with the UK Sustainable Investment and Finance Association (UKSIF) finds that even with only policies that have already been announced being implemented and with governments' existing emissions targets being met, over $2 trillion of oil and gas asset value could be lost as investor expectations are realigned with the reality of lower profits between now and 2040.[10] **The UK is disproportionately exposed, to the tune of some $140bn**, the fourth highest in the world, due to UK-based companies' investments in overseas oil and gas assets (see Figure 2).

[10]UKSIF. (2025, March). Stranding: Modelling the UK's Exposure to At-Risk Fossil Fuel Assets.
Note: the analysis compares profits from upstream oil and gas assets in an investor expectations scenario (formed from an average of the US Energy Information Agency, OPEC, and ExxonMobil outlooks and Enerdata's EnerBase scenario) with the International Energy Agency's Announced Pledges Scenario in its World Energy Outlook 2024. Future profits are discounted by 6% per year.

b) Macroeconomic level: uneven impacts

The net effect of a fast global transition to clean technologies in all energy and industrial sectors of the economy has been estimated to be a saving of around $12 trillion in energy costs globally (within a wide uncertainty range) **by 2050** (and continued savings thereafter) compared to continuing to burn fossil fuels.[11]

The macroeconomic effects of the transition are likely to vary substantially across countries. Dynamic modelling of the global economy suggests that **countries that are currently net importers of fossil fuels (including the UK) are best placed to gain in productivity, growth, and economy-wide employment.** Those countries that are major exporters of fossil fuels are at greatest risk of negative effects of the transition.[12] These risks are largely outside their control, depending not on national policy, but on changes in global demand for fossil fuels.



[11]Way, R., Ives, M. C., Mealy, P., & Farmer, J. D. (2022). Empirically grounded technology forecasts and the energy transition. Joule, 6(9), 2057-2082. The estimated $12 trn saving is based on a social discount rate of 1.4% as recommended in the Stern Review. With a discount rate of 5%, the expected saving is around $5 trn.
[12]Lynch, C., Simsek, Y., Mercure, J. F., Fragkos, P., Lefèvre, J., et al. (2024). Structural change and socio-economic disparities in a net zero transition. Economic Systems Research, 36(4), 607-629.

c) Sector level: exponential change

In each of the greenhouse gas-emitting sectors of the economy, the transition to clean technologies is driven by the interplay of policy, technology and finance.

The costs of the core technologies of the energy transition are falling rapidly. The cost of solar photovoltaics (PV), wind turbines and lithium-ion batteries fell by 78%, 59% and 82% between 2013 and 2023, respectively.[13] These falls continue long-term trends: the cost of solar PV has fallen by a factor of ten thousand in the past 60 years.[14]

As clean technology costs fall, demand for them increases; investment follows demand and drives innovation; and costs fall further; thus creating a reinforcing feedback. This drives non-linear growth in their deployment; even exponential growth in the early stage of the transition, confounding expectations based on linear models.

In the past, forecasters have been wrongfooted by these exponential processes. Past estimates for global deployment of solar PV have been wrong by an order of magnitude (see Figure 3).[15] The implication for investors is clear: assessment of risks and opportunities of the energy transition must be built on an expectation of non-linear change, and an understanding of its drivers.

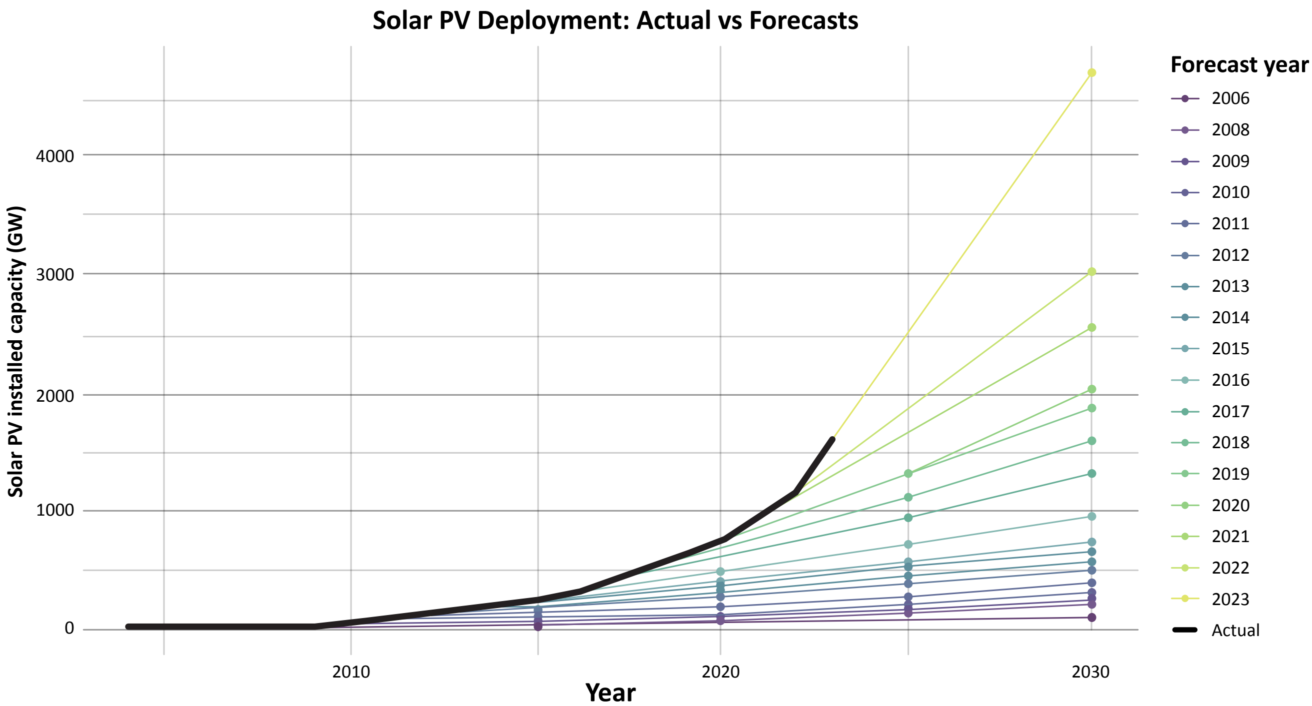


Figure 3: Comparison of projections and actual global solar photovoltaics deployment for power generation. Different coloured curves represent projections made in different years. The black line shows actual deployment. Source: Sharpe, S., et al. (2025). System archetypes of the energy transition: feedback loops and levers of change. Adapted from Beinhocker, E., Farmer, J.D. and Hepburn, C., (2018). The tipping point: how the G20 can lead the transition to a prosperous clean energy economy. Forecasts for cumulative installed solar capacity are from the International Energy Agency's World Energy Outlooks. Actual data is from the IEA.

[13] IRENA with minor processing by Our World in Data. (2024). Renewable Power Generation Costs in 2023 (dataset).
[14] Nemet, G.F. (2019). How solar became cheap. Routledge. London and New York.
[15] Sharpe, S., et al. (2025). System archetypes of the energy transition: feedback loops and levers of change. S-Curve Economics CIC.

3) What is USSIM doing to respond to these risks?

The reallocation of capital has already begun, at a pace and scale that is not yet enough to ensure the stability of the climate, but which may be enough to disrupt the stability of energy and industrial sectors and the economies of countries that are dependent on them.

In collaboration with the University of Exeter, USSIM has pioneered a new approach to understand the risks and opportunities from the energy transition through scenario analysis. This has involved modelling the macroeconomic and financial markets implications of the 'No Time To Lose' set of scenarios, in which alternative trajectories of the low carbon transition interact with pathways of global economic growth and recession.[16, 17]

USSIM uses this analysis to inform its strategic asset allocation, **aiming for a resilient portfolio that is sufficiently robust to the various alternative future scenarios for the macro-economic and investment landscape.** We seek to assess our portfolio's flexibility to handle boom-and-bust cycles, withstand market shocks, and seize opportunities as they arise. And, as set-out in USS's latest Task Force on Climate-related Financial Disclosures (TCFD) report[18], we have examined sector-level patterns in outcomes across the various scenarios, and plan to use these to help to inform sector and possibly even company-level investment decisions.

USSIM also engages with the companies in which we invest. This stewardship-based approach to responsible investment is a complement, not an alternative, to integrating rigorous climate and transition risk assessments into our investment decisions.[19] **We aim to help companies identify the right steps to take at each stage of the transition in their sector.** USSIM uses insights gained from our companies to inform our policy advocacy and how we collaborate with other investors since we all share an interest in reducing systemic risk.

The easiest way for an investor to reduce the emissions from their portfolio investments would be to sell high-emitting assets to other owners. However, this would do nothing to advance the low carbon transition, and nothing to reduce the systemic risk of climate change that threatens all investors' long-term returns.

Whereas emissions are a lagging indicator, investment is a leading indicator of the low carbon transition.[20] USSIM already has significant investments in solar and wind, both in the UK and overseas. For the energy transition to continue and accelerate, governments must create the right conditions for clean technologies to rapidly increase their market share in each of the greenhouse gas-emitting sectors of the economy. **With the right policies, asset owners will be able to invest more in the growth of clean technology industries and infrastructure.**

[16]USS. (2023). No Time To Lose – New Scenario Narratives for Action.
[17]USS. (2024). TCFD Report 2024.
[18]USS. (2025). TCFD Report 2025.
[19]USS. (2025, May 27). Responsible Investment. (Accessed on 27 May 2025)
[20]See https://www.oxfordmartin.ox.ac.uk/carbon-investment and Millar, J.M. et al, (2018). Principles to guide investment towards a stable climate. Nature Climate Change.

4) What could governments do to drive the transition?

Concerted action by governments is essential to reduce the risks of climate change. Ongoing adaptation of infrastructure and other social systems, and a rapid reduction of global emissions, are equally important to limit costs and avoid extreme negative consequences.

We believe that governments need to focus on specific policies to support progress at each stage of the energy transition. What is needed in the very early stages of the transition will not be the same as at later stages, and we believe that the government must respond to this across sectors, supporting the macroeconomy so that sectors and companies can thrive.

Below we have set out some examples across the stages of the transition and across various sectors, which we believe would support the UK economy and transition. While the transition requires significant upfront investment, the right policies could set the UK on course to benefit from the long-term cost savings and growth opportunities discussed above.

Sector	Stage of transition	Example policies
Energy intensive industries	Early	Public procurement of near-zero emission steel; targeted subsidies for hydrogen, carbon capture, utilisation and storage, and other early-stage clean technologies.
Road transport	Middle	Zero emission vehicle mandate for trucks; investment in charging infrastructure to enable wider use of electric vehicles.
Residential heating	Middle	Address bottlenecks preventing heat pump adoption; planning reform; rebalance energy levies from electricity to gas.
Electricity generation	Late	Electricity market reform; policies to deploy long-duration energy storage; grid upgrades.

The UK is the first major economy to halve its emissions, having cut them by 50% between 1990 and 2022 while also growing the economy by 79%,[21] however, most of this reduction is accounted for by progress in one sector: electricity generation (see Figure 4). The government's commitment to accelerating the transition to clean power is welcome, but there is an equally urgent need for policy improvements in each of the other emitting sectors.

[21]Department of Energy Security and Net Zero (2024). UK first major economy to halve emissions. **Note:** when calculated on a consumption basis (i.e. adjusting for emissions embedded in traded goods and services) UK emissions fell by 36% between 1990 and 2021. See: Office for National Statistics.

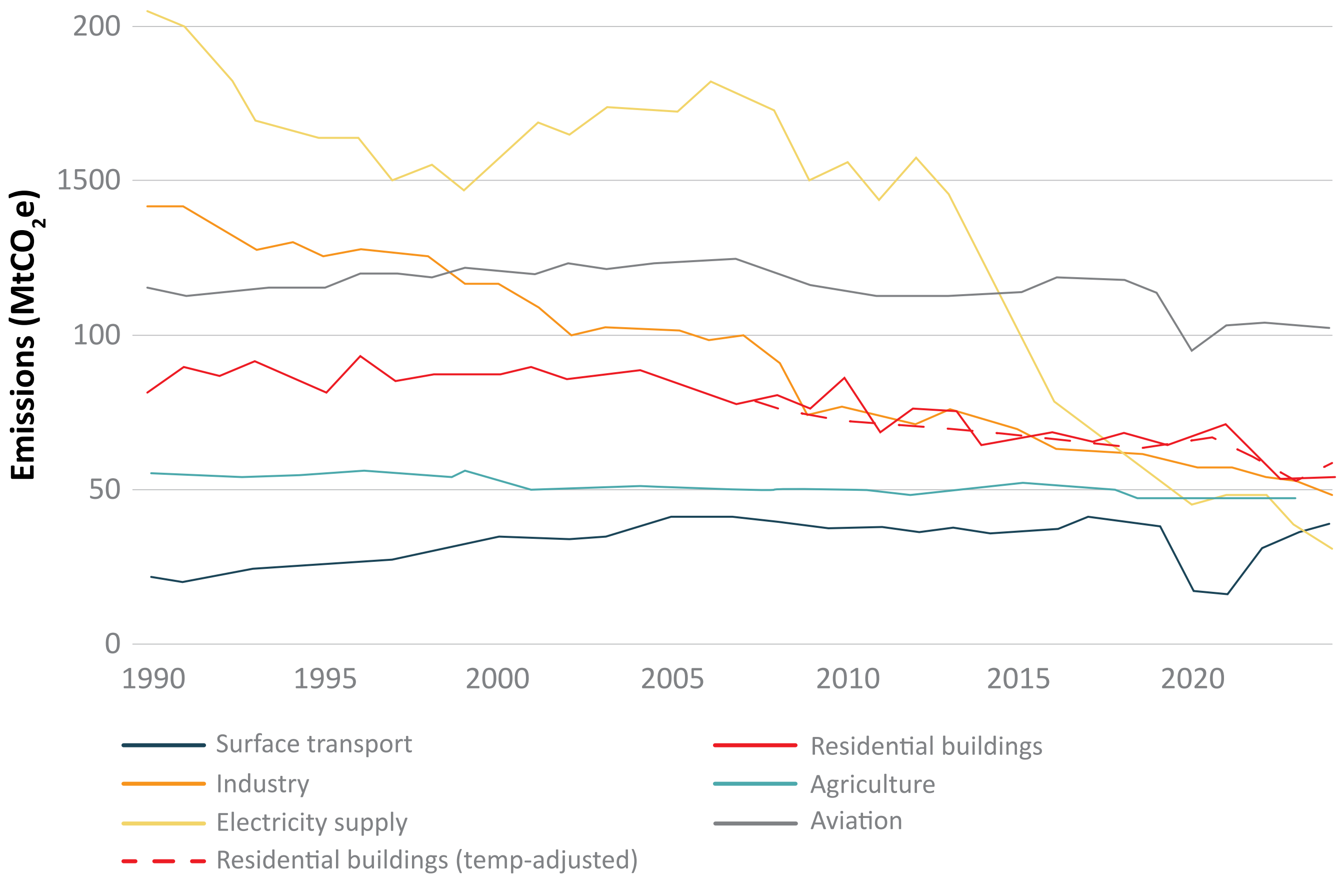


Figure 4: UK emissions by sector since 1990. Source: Climate Change Committee / Department of Energy Security and Net Zero (2025).[22]

a) Early-stage policies

In the early stage of a transition, the critical policies include support for research, development and demonstration of new technologies, and measures such as targeted subsidies and public procurement to enable their first deployment.

These policies have already been used successfully to develop and deploy clean technologies in the power and road transport sectors.

Similar policies are needed now to support the first deployment of zero emission solutions in sectors such as steel, cement, chemicals, shipping and aviation. The UK government committed in 2023 to adopt a target for low carbon steel and cement in public procurement.[23] The **focus now should be to use this policy lever to create demand for near-zero emission materials,** since only these are compatible with the goal of eliminating emissions economy-wide.

[22]Climate Change Committee (2025).Progress in reducing emissions: 2025 report to Parliament. Underlying source: Department for Energy Security and Net Zero (DESNZ) (2025) Provisional UK greenhouse gas emissions national statistics 2024; DESNZ (2025) Final UK greenhouse gas emissions national statistics: 1990 to 2023.
[23]Industrial Deep Decarbonisation Initiative, (2023). Green public procurement pledge announcement.

b) Middle-stage policies

In the middle stage of a transition, subsidies and taxes can give the new technologies an advantage over the old, but **regulations can be even more powerful in driving the reallocation of investment on a large scale.** In the road transport transition, zero emission vehicles (ZEV) mandates have proven outstandingly effective in growing markets for electric vehicles in California, Canada and China.

The UK's ZEV mandate has made progress in its first year of implementation; the UK has overtaken Germany to become the largest electric vehicle market in Europe.[24] However significant challenges remain. The demand for electric cars is constrained by inadequate charging infrastructure and expensive upfront and insurance costs.

The Electric Car Grant announced in July 2025 is a step in the right direction. The government should resist all pressure to further weaken the ZEV mandate, while at the same time strengthening investment in charging infrastructure.

The government should adopt a similar zero emission vehicle mandate in heavy road transport, which is further behind in the transition. This should set a trajectory towards all new trucks being zero emission by 2040 at the latest, consistent with the Global Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles.[25] In the buildings sector, the 'clean heat market mechanism' is designed to shift investment from gas boilers to heat pumps, supported by heat pump subsidies. However, this effort is undermined by government levies that add around £140 to a typical household's electricity bill, compared to only £50 for a gas bill.[26] This effectively penalises heat pump users and encourages the use of gas.

Additionally, planning challenges and a shortage of trained engineers have been significant obstacles. The May 2025 planning reform, which classifies heat pump installation as "permitted development," is a step in the right direction. However, Energy Performance Certificates (EPCs) are still penalising heat pump users, further discouraging the transition.

Other European countries have progressed much faster. For instance, in 2023, around 57,000 heat pump units were installed in the UK, compared to over 600,000 in France.[27] To realign policies and make it easier for people to switch to clean heating, it is crucial to **rebalance energy levies—shifting the burden from electricity to gas—and to address other bottlenecks preventing heat pump adoption.** There is also a need to tighten building regulations so that all new buildings come with clean heating and high standards of energy efficiency.

[24]International Council on Clean Transportation, (2025). What the European Union can learn from the United Kingdom's EV success in 2024 – and what's next on both sides of the channel.
[25]Global MoU on ZE MDHVs. https://globaldrivetozero.org/mou-nations/
[26]Sissons, A., (2024). To make energy cheaper, we need to raise levies on gas. Nesta.
[27]EHPA (2024) Pump it down: why heat pump sales fell in 2023

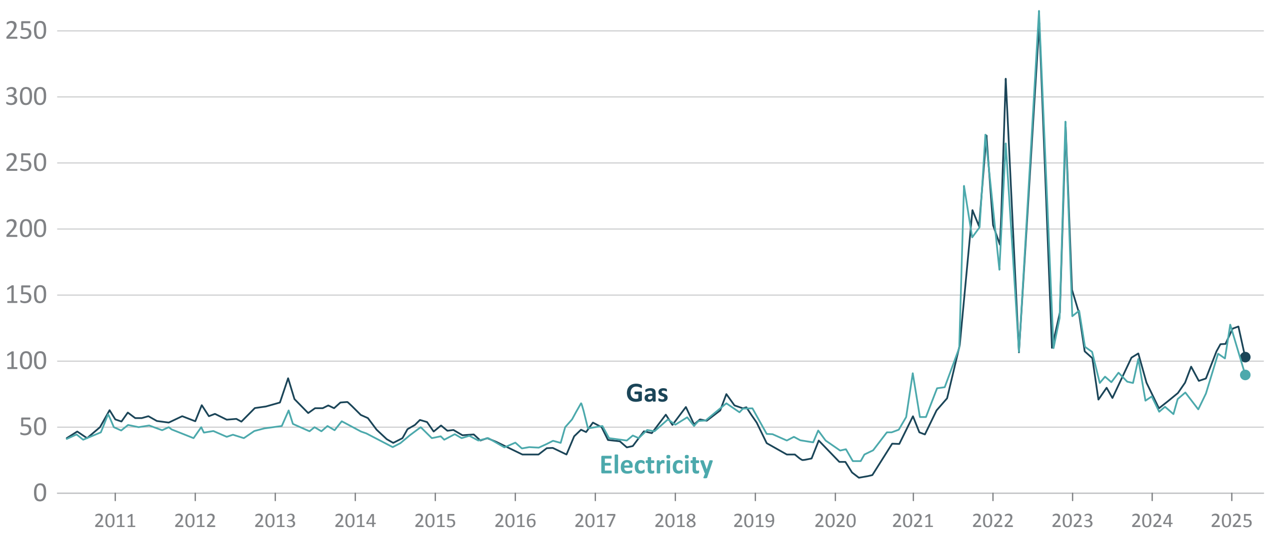
c) Late-stage policies

In the late stage of a transition, **a deeper restructuring of markets is often needed to make best use of the new technologies.**

Many countries are approaching this situation in the power sector. Solar and wind already generate electricity more cheaply than coal and gas in most parts of the world, and as clean technology costs fall, the difference continues to increase.[28]

In the UK, onshore wind, offshore wind and solar power can all generate electricity more cheaply than gas power plants,[29] but electricity prices are overwhelmingly dependent on gas prices (see Figure 5). **In 2021, expensive gas set the electricity price 98% of the time, despite generating only 40% of the power.**[30] Government levies adding to electricity costs compound this challenge. Addressing how both levies and gas price linkage affect electricity bills should be a priority for the government. Policies to enable the deployment of long-duration storage and to expand all forms of flexibility in the power system will be crucial to reducing the role of gas. There is also an urgent need to invest in upgrading transmission and distribution infrastructure to enable better use of the available renewable resources.

Monthly average day ahead prices, p/therm (gas) and £/MWh (electricity)



Source: Ofgem

Figure 5: UK electricity prices are dictated by gas prices, which remain three times higher than before the global energy crisis. Monthly average day ahead prices, p/therm (gas) and £/MWh (electricity). Source: Carbon Brief (2025, May 20) based on Ofgem data.[31]

The policies highlighted above are only a sample of those that are needed to develop and diffuse zero emission technologies and solutions that displace fossil fuels from each sector of the UK's economy. **We present these as examples of where more progress could and should be made.**

[28]IRENA. (2025). https://www.irena.org/Publications/2024/Sep/Renewable-Power-Generation-Costs-in-2023
[29]Department for Energy Security and Net Zero, (2023). Electricity generation costs 2023.
[30]Zakeri, B. & Staffell, I. (2023). The Role of Natural Gas in Electricity Prices in Europe. UCL Institute for Sustainable Resources. Series Navigating the Energy-Climate Crises Working Paper #1.
[31]Evans S., & Lempriere, M. (2025, May 20). Factcheck: Why expensive gas – not net-zero – is keeping UK electricity prices so high. Carbon Brief.

Conclusion

History shows that neither the Earth's climate nor the global economy exist in a state of static equilibrium. Understanding the dynamics of change must be at the centre of rigorous risk assessment and effective risk management.

As we improve our methods of assessment, we see new ways to manage the risks to our investments, and to capture the opportunities of the energy transition. We aim to make full use of the levers that we have, in pursuit of these objectives. But asset owners such as pension funds operate within a larger context. The scientific evidence shows that the risks arising from loss of stability in the Earth's climate are extreme. These are risks which cannot be avoided by adopting a diversified investment portfolio.

But these risks don't have to materialise, a fast transition could be as much as $12 trillion in energy costs better for the global economy (relative to no transition) by 2050.[32] Any speeding up of the transition will have significant beneficial financial impact given the non-linearity of climate risks.

Strong government policy is essential to make faster progress towards a clean energy economy. The best available economic evidence points to a large net saving from this transition globally, as well as further gains being available from innovations in clean technology.

As a net importer of fossil fuels, and with strong capabilities for innovation in many sectors, the UK could gain even more than most countries. If it is managed well, the transition could catalyse investment of over £25 billion per year in the UK between now and mid-century, driving productivity gains and job-creation.[33] **We urge the government to double-down on its commitment, and act in all sectors to accelerate the growth of the zero-emission economy.**

[32]Way, R., Ives, M. C., Mealy, P., & Farmer, J. D. (2022). Empirically grounded technology forecasts and the energy transition. Joule, 6(9), 2057-2082. The estimated $12 trn saving is based on a social discount rate of 1.4% as recommended in the Stern Review. With a discount rate of 5%, the expected saving is around $5 trn.
[33]Climate Change Committee. (2025, February). The Seventh Carbon Budget – Advice for the UK Government.

USS *For members, for the future.*

For further information on responsible investment and stewardship at USS, please visit: **www.uss.co.uk**