

Renewable, reliable and accessible to all

Triodos Bank's vision paper
on the energy transition

Summary

The global energy system is in the midst of an urgent transformation: shifting from a carbon-intensive, fossil fuel-dependent sector that contributes to climate change, environmental degradation and social inequities, to a clean, reliable and fair energy system that operates within ecological limits. Meeting this challenge requires us to fundamentally rethink how we produce, distribute and consume energy.

Fossil fuels dominate our energy systems today, accounting for more than 70% of global greenhouse gas emissions. At the same time, billions of people live without access to clean, reliable affordable energy, while extreme weather events and rising energy demand expose the vulnerabilities of our current infrastructure. In one way, the transformation has already begun: cleaner, renewable energy technologies are rapidly scaling up and, in many regions, have become the cheapest sources of new electricity generation. In another, we are off-track: our energy consumption derived from fossil fuels has not decreased the past years, as a result of growing overall demand. Moreover challenges remain as manufacturing renewable technologies like solar panels, wind turbines and batteries, relies on finite materials, sometimes extracted under unsafe or exploitative conditions. This underlines the need for responsible supply chains and careful consideration of material sourcing and more fundamentally: the need for demand reduction.

Triodos Bank has formulated a vision for the energy transition. This vision paper aims to:

1. Explain the interconnected global challenges that create the need for an energy transition.
2. Describe the current state of the transition, including how the world consumes energy, how the world produces energy and the impact of these activities on people and planet.
3. Highlight the urgent actions needed for the transition to succeed: ensuring clean supply, reliable supply, reducing demand and providing fair and inclusive access. It is essential that these actions are translated into financing considerations as well as far-reaching advocacy initiatives.

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Introduction

In 2025, the Australian government gave us a glimpse of the energy future we could one day all experience. All residents in the country will soon receive three hours of free renewable electricity each afternoon.¹ Why? Because the country now generates more renewable power than it can use during daylight hours. This is the result of two crucial ingredients: a massive Solar PV rollout and a government willing to put the interests of its citizens first. A third contributing factor was, unfortunately, a lack of storage capacity for renewable energy.²

Three free hours are just the beginning, and Australia still relies heavily on fossil fuels for its energy mix.³ However, the example symbolises a successful step in the energy transition: an abundance of renewable power produced locally and shared fairly. It shows that when technology, finance and policy align, renewable energy can deliver both lower emissions and tangible social benefits.

Yet, for most of the world, this future remains unattainable. Global energy systems are still dominated by fossil fuels.⁴ Billions of people suffer from the health effects of energy-related pollution and continue to face energy poverty, volatile prices or unreliable supply.⁵ As climate impacts intensify, from record heatwaves to grid failures, the weaknesses of our current energy system become more pressing with each passing season.⁶

1 An urgent energy transition

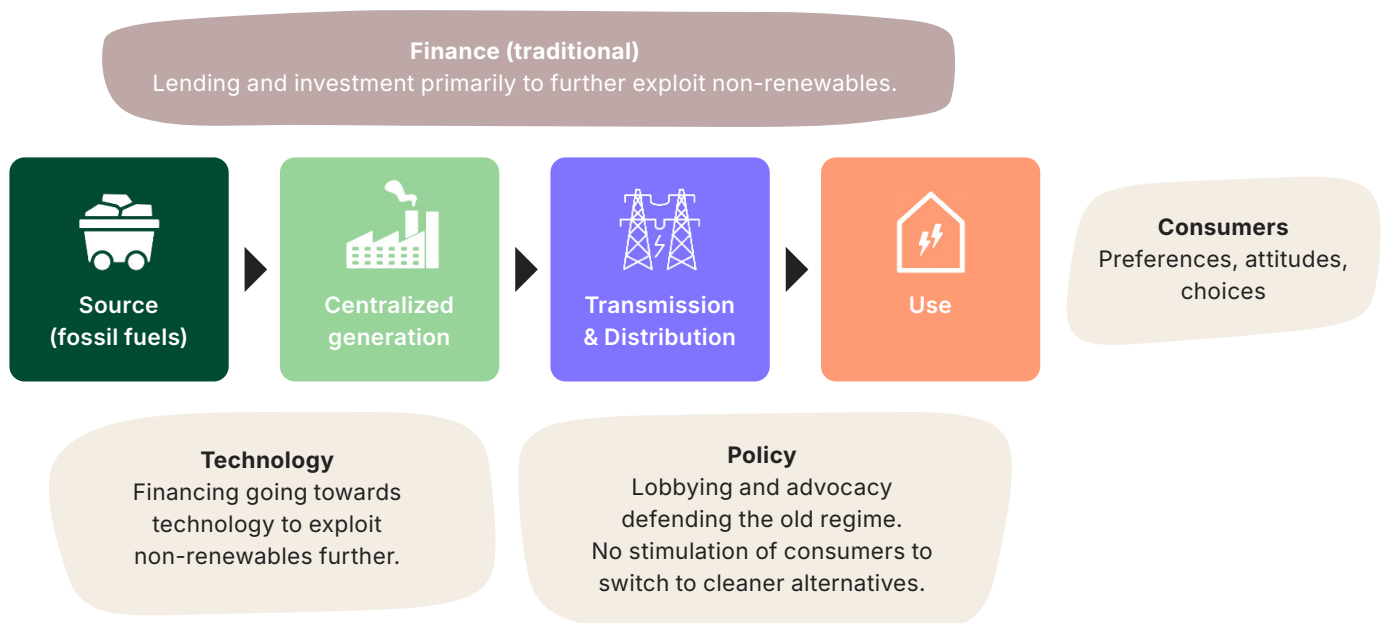
The energy transition refers to a shift from a largely fossil-based, high CO₂-intensity energy system to one that relies more on renewable sources and has a lower carbon intensity.⁷ This involves a shift not only in the production of renewable energy, but also in the wider energy system – including enabling technologies, new business models, market designs and system operations. The global energy transition is not yet fully underway: although renewable energy deployment is accelerating rapidly, fossil fuel production and use continue to grow at the global level.

Before 1990, the energy system was largely fossil fuel-based and supply-driven. Developed economies had high energy access and financing focused almost exclusively on fossil fuel exploration and production. The system was centralised, dominated by large producers responsible for generation, transport and sales.

This system led to high access to energy but also large negative externalities. Most notably climate change and air pollution which degrade ecosystems and reduce biodiversity, while a disproportionate share of financial gains accrues to large utility companies rather than to wider society.⁸

Over the last years, geopolitical tensions have highlighted the strategic dimension of energy systems. Conflicts, such as the recent one in Iran, lead to trade disputes and disruptions to global supply routes that can quickly affect the availability and price of fossil fuels.⁹ These situations expose the vulnerability of economies that rely heavily on imported energy.¹⁰ Price shocks in oil and gas markets over recent years have demonstrated how geopolitical instability can translate directly into economic volatility, inflationary pressure and social strain.¹¹ Accelerating the transition to renewable energy therefore serves not only climate goals, but also strengthens energy security and strategic autonomy.

Figure 1 The pre-transition energy system: characterised by fossil fuel use, centralisation and high energy access.



Source: Impact Institute, 'Accelerating Positive Change with Impact Measurement' (Impact Institute, Final report of Energy Transition Pilot for Triodos Bank, November 2022).

2 Why we need an energy transition

Energy lies at the centre of our lives, powering homes, transport, food production, industry, digital infrastructure and essential public services such as schools and hospitals. But it is also the single largest source of greenhouse gas emissions.¹²

2.1 Climate mitigation and adaptation

Mitigation

The energy system is the most important lever for mitigating climate change.¹³ Most global greenhouse gas emissions come from fossil fuels: coal, oil and gas.¹⁴ Under the 2015 Paris Agreement, countries committed to deep, rapid and sustained reductions in greenhouse gas emissions to limit global warming to well below 2°C above pre-industrial levels, preferably to 1.5°C.¹⁵ The world's ability to achieve this goal hinges on the energy sector's ability to reach net-zero emissions by 2050.¹⁶

Adaptation

Climate change already affects energy production and infrastructure. Heatwaves strain grids, droughts reduce hydropower output and storms disrupt supply chains. These impacts underscore why financing the energy transition must go beyond mitigation and simply building renewable capacity. Investment must also strengthen resilience and adaptability: upgrading grids, decentralising generation, incorporating storage and supporting technologies that can withstand extreme weather events. A huge aspect of this is integrating climate and nature strategies. As explained in the Triodos Bank Climate and Nature strategy, climate change and biodiversity loss interact and aggravate each other. The destruction of ecosystems accelerates global warming, while rising temperatures reduce nature's ability to store carbon and regulate the climate. Without protecting and restoring nature, as an important part of a broader adaptation strategy, we cannot effectively combat climate change.¹⁷

2.2 Energy at the heart of sustainability transition themes

Energy intensity across our economies is growing. This reliance is particularly evident in our food systems, which currently account for at least 15% of global fossil fuel use, due to increased mechanisation, growing use of fossil fuel-based inputs (such as pesticides and fertilisers), globalised supply chains and an ever growing demand for meat, dairy and ultra-processed foods.¹⁸

The story is no different when it comes to **resource use**. Our energy consumption is intertwined with the extraction of materials: from the metals used in solar panels and wind turbines to the water consumed in cooling power plants or AI data centres.¹⁹ Without a reduction in overall demand, responsible sourcing, exploration of alternative low-impact materials and much better reuse of existing material reserves, the energy transition risks shifting environmental and social pressures from fossil fuels to new forms of extraction. Not to mention, the rising need for critical materials intensifies competition between countries and regions, making energy security and strategic independence a key consideration in the next phase of the energy transition.²⁰

Energy's connection to broader **society** and **individual wellbeing** extends beyond material supply chains.²¹ In emerging markets, the energy transition is above all about access and development. More than 700 million people still live without electricity, while millions more rely on unsafe or polluting fuels for cooking and heating.²² Expanding clean, decentralised energy systems can support healthcare, education and small businesses while reducing deforestation and indoor air pollution.²³ A key concern when developing renewable energy projects is the impact on Indigenous peoples, who often bear the burden of infrastructure projects without directly benefiting from the power produced.²⁴ The growth of renewable energy also presents a historic opportunity for local job creation, skills development and new forms of community ownership.²⁵

In advanced economies, the energy transition focuses on affordability, fairness and resilience. Although electricity access is high in advanced economies, the recent energy price shocks between 2021–2023 have exacerbated existing energy vulnerabilities, particularly for households living in inefficient housing and facing rising living costs.²⁶ When we talk about the energy transition, we often focus on technologies and emissions, but ultimately the energy transition is about people. Our goal is to ensure the systems we transform enhance human wellbeing and social justice. In both emerging and advanced economies, the path forward must be clean, reliable and accessible to all.

3 The state of the transition

Understanding the current state of the energy transition requires examining how the world produces and uses energy, as well as how financial flows shape both opportunities and obstacles in the shift away from fossil fuels.

3.1 Energy demand: How the world is using energy

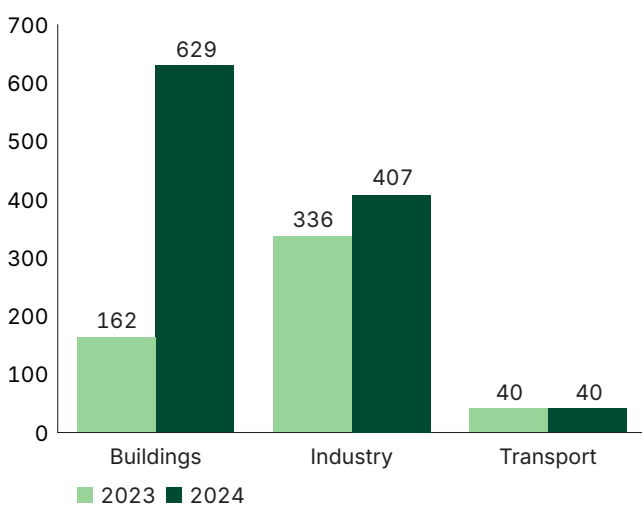
After a decade of steady growth, during which energy demand increased by 15% between 2013 and 2023, energy demand surged in 2024.²⁷ There were several reasons for this including record temperatures, electrification and digitalisation.

Demand by sector

Electricity generation (the power sector) accounted for 60% of the total increase in global energy demand.²⁸ Electricity demand, a subset of overall energy demand, grew faster than total energy demand, rising by 4.3% in 2024.²⁹ In some ways this is good news because it demonstrates that sectors which previously relied fully on fossil fuels are moving towards greater electrification and could therefore be largely driven by renewables in the future. For example, the industrial sector accounted for nearly 40% of the growth in electricity demand, with electricity use increasing by nearly 4% in 2024.³⁰

The change was driven by expanded activity in electro-intensive manufacturing, but unfortunately also by industrial growth more broadly. This is unfortunate because

Figure 2 Annual change in electricity consumption by sector (TWh)



Source: International Energy Agency, 'Global Energy Review 2025' (Report, March 2025).

it shows that we have not been able to lower electricity demand across the economy. The biggest rise in electricity demand was driven by the need for cooling during extreme temperatures. But a large chunk also came from expansion of industry, especially the expansion of data centres. Across advanced economies, data centres are expected to account for over 20% of electricity demand growth through 2030, reversing years of stagnant or declining power consumption in many regions.³¹

Other key sectors also contribute to rising demand. Buildings and transport each made up around 30% of global energy demand, and the remainder is made up of demand from sectors like agriculture.

Demand in advanced economies

In advanced economies, energy demand is shaped by both systemic factors and climate-related drivers. Heatwaves across southern Europe and North America have increased the use of cooling systems, while cold spells in other regions have led to higher heating demands.³² This contributed to a global increase in electricity consumption in buildings of more than 600 TWh (5%) in 2024. Electricity consumption in buildings therefore accounted for nearly 60% of total growth in electricity use.³³ In the European Union, these dynamics are reflected in a divergence between primary and final energy consumption: in 2024, primary energy consumption increased by an estimated 1.3% compared to 2023, while final energy consumption declined by 0.9%. Primary energy consumption measures total energy demand including losses, while final energy consumption measures the energy actually used by end consumers.³⁴ Rising primary consumption and falling final consumption tells us the energy system is becoming more electricity intensive, even as end-use demand is being constrained.

Beyond weather-sensitive demand, systemic trends such as rising digitalisation, electrification of transport and energy-intensive industrial activity also drive consumption. For example, rising data centre electricity use is already having strong local impacts on energy demand, partly due to the growing use of AI.

Demand in emerging markets

Other drivers have also contributed to the increase in overall energy demand. The economic recovery that followed the pandemic and energy price variability following Russia's invasion of Ukraine drove significant increases in industrial output and freight activity across Asia, the Middle East and parts of Africa.³⁵ These economies rely heavily on fossil fuels, particularly coal and gas for industrial production. At the same time, population growth, urbanisation and rising living standards are lifting

baseline demand, driven by an expansion of access to modern appliances, mobility and cooling. As such, in emerging markets, which account for almost 85% of the world's population, energy demand has been increasing at around 2.6% per year over the last decade.³⁶

Demand-side challenges

The described state-of-the-art on the demand side of the energy transition creates a complex set of challenges including rebound effects, risks of increased inequality and growth in sectors downstream from fossil extraction.

Rebound effects: the paradox of efficiency

The energy transition is often presented as a technological puzzle: replace fossil fuels with renewables and the transition is complete. But it's not that simple.³⁷ The context in which this transition takes place is not neutral: it's an economy that is fundamentally dependent on continuous growth and driven by profit. On the demand side of the energy transition, this dynamic is driven by rebound effects: even as energy efficiency improves and cleaner technologies are adopted, systemic pressures for growth continue to push energy demand upward.

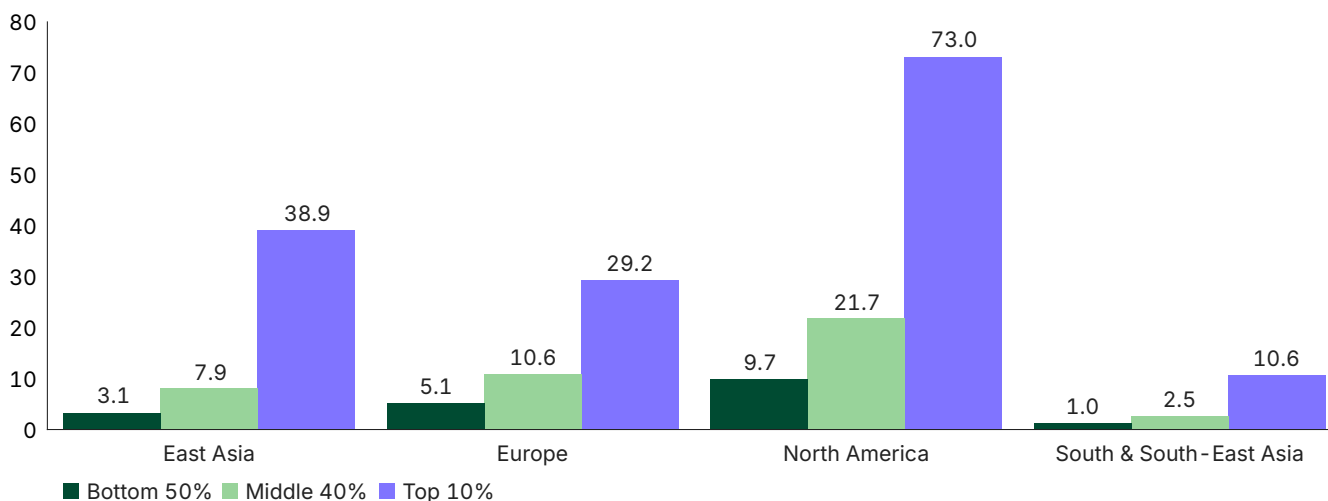
As energy efficiency improves, the cost of using energy-intensive services falls, which can lead to higher consumption.³⁸ Rebound effects can take three different forms. First, the direct rebound occurs when cheaper energy costs encourage higher consumption. For example, motorists drive more kilometres when the cost per kilometre becomes cheaper, or more efficient heating, cooling or industrial processes encouraging longer operating hours or increased usage.³⁹ Second, the indirect rebound happens when money or time saved is spent elsewhere

on energy-intensive goods, like using fuel savings for air travel. Third, the economy-wide rebound emerges when efficiency gains lower costs, boost productivity and increase overall economic output, leading to higher total demand for energy and materials.⁴⁰ Together, these rebound effects help explain why substantial improvements in energy efficiency and the rapid deployment of cleaner energy have not translated into absolute reductions in global energy use or emissions. Carbon intensity (CO₂ per unit of energy) has fallen due to significant improvements in efficiency and cleaner energy, but population and prosperity growth continue to exert upward pressure.⁴¹

Consumption shifts

Another demand-side challenge lies in the changing structure of consumption. As economies develop, they tend to move from heavy industry to the services sector.⁴² This process lowers measured energy intensity but often hides a growing energy footprint elsewhere. Consumption shifts toward high-carbon and energy-intensive activities such as air travel, digital services, global logistics and the production and transport of complex consumer goods.⁴³ The rapid expansion of data centres, AI and e-commerce adds further layers to this energy demand. This gives the appearance of a cleaner economy, but much of the energy and material use has simply moved upstream and to other countries. The service sector appears to be a low-carbon investment, but its indirect energy and material impacts can be substantial.⁴⁴ Integrating full lifecycle and supply chain emissions into financial decision-making would help expose this hidden demand growth and align financing with genuine decarbonisation.

Figure 3 Carbon footprints 2019 (tCO₂e per year per person)



Source: Chancel, L., Piketty, T., Saez, E., Zucman, G. et al. World Inequality Report 2022, World Inequality Lab

Lifestyles, inequality and affordability

Progress on behavioural and lifestyle changes in energy consumption remains limited. Although awareness campaigns and efficiency programmes encourage energy-saving habits (reducing heating, optimising transport, moderating consumption) large-scale behavioural shifts have yet to take place.⁴⁵ As explained, rebound effects from rising living standards and population growth continue to offset individual efficiency gains. Without addressing the underlying drivers of consumption, we will not reduce total energy use.

Energy demand is also profoundly shaped by inequality.⁴⁶ The wealthiest households consume far more energy per capita than low-income groups, both directly through transport, housing and air travel, and indirectly through material consumption and investments.⁴⁷ A just energy transition must therefore address not only how energy is produced but who can afford to use it.

Growth of sectors downstream from fossil extraction

Finally, even as renewables accelerate in the power sector, fossil fuel demand continues to rise in other parts of the economy. The petrochemical sector, which produces plastics, fertilisers and synthetic materials, has become a key growth area for oil and gas companies seeking to offset losses in the power and transport sectors.⁴⁸

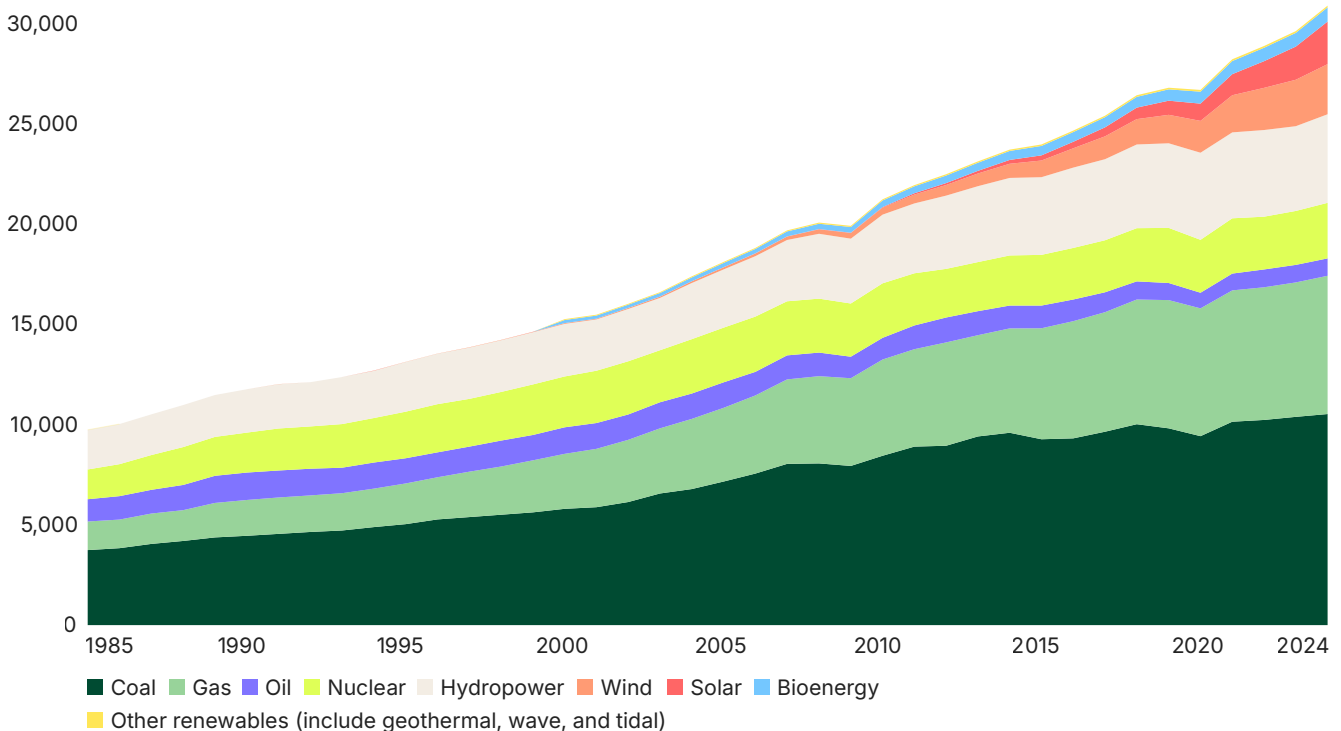
Global investment in new plastics and petrochemical infrastructure remains high, locking in decades of future fossil fuel demand.⁴⁹

A similar dynamic is visible in hard-to-abate sectors such as aviation and shipping, where fossil fuel use is still dominant.⁵⁰ The forces shaping demand remind us that the transition cannot be achieved through renewable technologies alone. Without changes to the underlying systems and mindsets regarding how we use, value and distribute energy, any new capacity will simply keep up with the ever-rising demand. On the demand side, the transition is stagnating. The question then, is whether the transition is beginning to take hold on the supply side.

3.2 Energy supply: How the world is producing energy

In a positive trend, 40% of the described growth in energy demand in 2024 was met by clean energy. Renewables accounted for the largest share of the growth in total energy supply (38%), followed by natural gas (28%), coal (15%), oil (11%) and nuclear (8%).⁵¹ This means renewables are growing faster than any other energy source in absolute terms of added supply.

Figure 4 Electricity produced by source, world 2025 (measured in TWh)



Source: Ember (2026); Energy Institute – Statistical Review of World Energy (2025)

We see this shift to renewables in the countries where Triodos Bank operates. For the first time, the Netherlands, Spain, Belgium and the United Kingdom each generated more than half of their electricity from renewable sources – Spain and Belgium achieved this in 2023,⁵² followed by the Netherlands and the UK in 2024.⁵³ Together, these milestones signal a fundamental shift in Europe’s energy landscape and the growing role of renewables in energy supply. While electricity generation does not fully reflect overall energy consumption patterns, it remains a key indicator of progress on the supply side of the energy transition.

Renewables

Technologies like solar, wind and hydropower are already delivering clean electricity at scale, and their costs have fallen dramatically over the past decade.⁵⁴

Supply-side challenges

The described state-of-the-art on the supply side of the energy transition creates a complex set of challenges: from resource dependency and human rights risks to grid instability and technological lock-in.

Material dependency caused by the transition

The production of every solar panel, wind turbine, electric vehicle and battery requires vast quantities of metals and minerals. As fossil fuels are phased out, the extraction

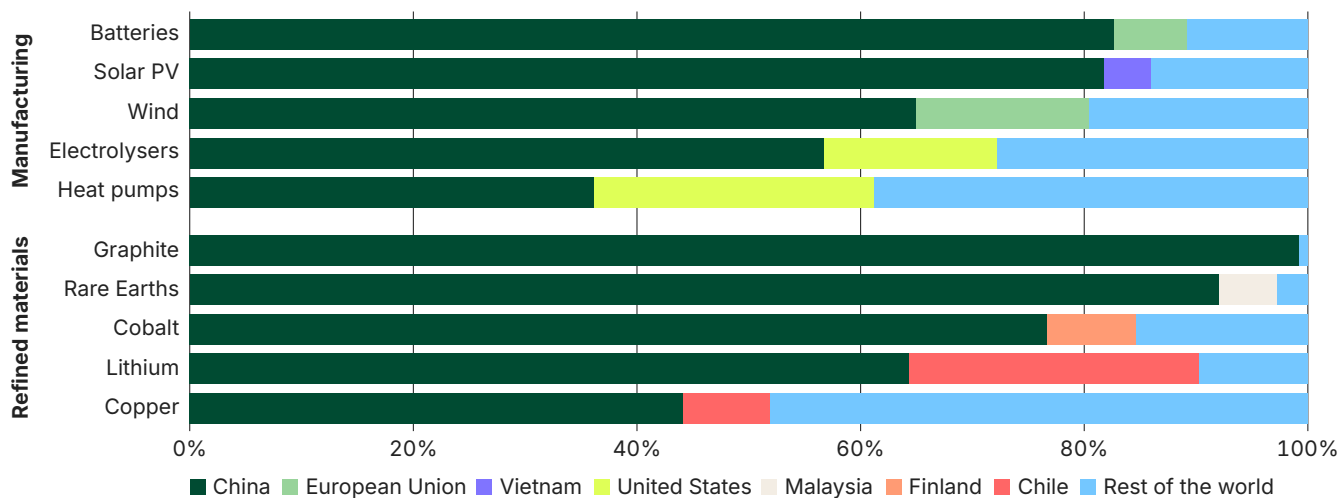
and processing of these critical raw materials (CRMs) such as lithium, cobalt, nickel, copper and rare-earth elements, is becoming a major dependence at the centre of the transition.

The natural deposits, mining and processing of these materials are unevenly distributed. China currently dominates global refining and production for renewable energy supply chains, see Figure 5.⁶⁵ Other countries are home to major supplies of other CRMs: Australia, the United States and Brazil are major producers of lithium and nickel.⁶⁶ Countries in Africa remain a crucial source of the world’s cobalt supply (with over 70% coming from the Democratic Republic of Congo) and platinum group metals (primarily mined in South Africa).⁶⁷ This geographic concentration creates new geopolitical dependencies and exposes the transition to supply chain fragility and ethical risks.

Recycling and recovery are important for easing the strain on virgin resource extraction. Estimates suggest that by 2050, secondary sources could meet up to one-third of global demand for key metals such as copper, nickel and lithium.⁶⁸ Yet today, less than 1% of critical minerals, such as rare earths, are recycled.⁶⁹ In line with the Triodos Bank Resource Vision, investment in circular supply chains (from collection networks to advanced refining technologies) could turn waste into a strategic asset, reducing both environmental impacts and geopolitical dependencies.⁷⁰

Technology	Description	Investment USD (globally, 2023)	Opportunities	Challenges
Solar	Photovoltaic and solar thermal technologies converting sunlight into electricity or heat.	~ 380 billion ⁵⁵	Currently the fastest-growing source of new electricity worldwide and increasingly cost-competitive.	Grid congestion; land-use conflicts for large-scale projects; supply chain transparency and reliance on critical minerals.
Wind	Onshore and offshore turbines generating electricity from wind.	~ 171 billion ⁵⁶	Delivers large amounts of clean electricity at competitive cost. ⁵⁷	Investment in wind power has largely varied in response to changing policy circumstances, partly due to permitting issues and subsidies for fossil fuels. ⁵⁸
Hydro	Electricity generation from flowing or stored water.	~ 50 billion ⁵⁹	Small-scale or projects may support local resilience.	Risk of biodiversity impact; displacement risks; climate vulnerability (droughts); limited scope for new projects meeting strict sustainability criteria.
Bioenergy	Energy from biomass, biogas or biofuels.	~ 13 billion ⁶⁰	Potential role in circular systems using genuine waste streams; bioenergy can support grid flexibility and rural income when sustainably sourced.	Most biofuels and biogases are derived from conventional food crop feedstocks. ⁶¹ Triodos Bank restricts this to ensure positive climate and ecosystem impacts. ⁶²
Nuclear	Electricity generation through nuclear fission.	~ 65 billion ⁶³	Low operational emissions; advances in nuclear fusion; new technologies including small modular reactors designed to improve safety, cost and project timelines.	Nuclear waste; safety concerns across a plant lifespan; and very long time horizons (from the first planning phase through operation to eventual decommissioning, the full lifecycle of a plant can stretch over a century). ⁶⁴

Figure 5 Share of clean energy technology supply chains, 2023



Source: International Energy Agency, World Energy Outlook 2024.

Achieving this will require a policy landscape that encourages better product design for disassembly, harmonised recycling standards and infrastructure to capture materials before they are lost to landfills or exported as waste.

At current consumption rates, even these advances are not enough. Without reducing the overall demand for new materials, the transition risks simply replacing fossil fuel extraction with new forms of environmental and social exploitation. It is essential that companies begin to use fewer materials per unit of energy, extending the lifespan of assets and expanding reuse and recycling. 'Repowering' is a clear example of this approach. By repairing, replacing or upgrading existing wind turbines with more efficient models on the same sites, developers can generate significantly more renewable energy without the material, spatial and ecological costs of building entirely new projects.⁷¹ Meanwhile, better design and recycling of wind turbine materials, for example, can prevent thousands of tonnes of blades from ending up in landfills each year.⁷² Emerging technologies such as sodium-ion batteries and solid-state alternatives offer substitutes for lithium and cobalt, while extraction from unconventional sources like coal ash ponds, mine waste and industrial residues can help ease the pressure on virgin deposits.⁷³ It is essential that sustainable financiers and investors not only focus on generation but also ensure that they actively contribute to resolving some of the supply chains bottlenecks.

Human rights and labour rights

Almost every renewable energy technology relies on minerals or components sourced from complex global supply chains. For example, solar panels require polysilicon

and quartz, which have been linked to forced labour in production.⁷⁴ Wind turbines and electric motors depend on rare-earth elements often extracted under unsafe working conditions.⁷⁵ Hydrogen electrolysers, fuel cells and grid infrastructure all depend on nickel, platinum and copper.⁷⁶ Even beyond resource extraction, reports of modern slavery, child labour and unsafe conditions are increasingly common in the processing and production phase of these value chains.⁷⁷

The challenge is compounded by a lack of transparency. Long, multi-tiered supply chains make it difficult to trace the origin of the materials or the conditions under which they were produced. Recent research has even suggested that meeting Europe's climate and energy goals could expose tens of thousands of African miners to modern slavery risks by 2040.⁷⁸ This highlights a troubling disparity: while some countries reap the benefits of the energy transition, others (often those supplying critical raw materials) pay the price through exploitative labour practices. The EU's Corporate Sustainability Due Diligence Directive (CSDDD) was intended to address such systemic risks by strengthening corporate accountability and supply chain transparency. However, its recently reduced scope, exemptions and weak enforcement mechanisms risk limiting its effectiveness.⁷⁹ By narrowing the range of companies and value-chain relationships subject to mandatory due diligence, the revised framework will likely fail to meaningfully improve visibility into upstream labour conditions. As a result, these structural risks remain largely unaddressed.

Grid stability requires interconnection

Modern grids must transmit electricity from a growing mix of renewable sources, withstand extreme weather, respond dynamically to demand, and integrate storage and decentralised generation. They must be designed to handle both centralised power plants and distributed energy resources, such as rooftop solar, community wind projects and local battery systems.

Resilience at the national level is difficult to achieve independently and requires collaboration with neighbouring countries. We saw this in April 2025, when the electricity systems of Spain and neighbouring Portugal collapsed following a sudden large drop in supply and the disconnection of the FrenchSpanish interconnector.⁸⁰ The Iberian system has been described as effectively an 'energy island' with limited external interconnection, making it more vulnerable to such large imbalances.⁸¹ The restoration of power in Spain was supported by neighbouring systems through interconnections with France and Morocco.⁸² This example demonstrates the importance of regional grid interconnection, and the need to continue developing it.

Technological lock-in

Innovation isn't neutral: it follows profit rather than social necessity.⁸³ In energy storage, costs have fallen, but deployment lags because revenue is uncertain. Batteries are still limited in scale and duration, while old gas plants with predictable cash flows attract investment. This is precisely what the theory of directed technological change predicts: without strong incentives towards clean technologies, R&D and adoption will remain stuck at historically profitable levels.⁸⁴

This pattern is reinforced by lock-in: we have built capital, skills and institutions around centralised, fossil fuel-based systems.⁸⁵ This embedded infrastructure attracts new money and makes the transition more sustainable than it appears on paper.⁸⁶ Renewable energy, on the other hand, is often decentralised, modular and distributed: consisting of thousands of small wind and solar projects, with lower entry barriers and smaller margins. From a societal perspective, this is positive because it democratises energy production, but from a profit perspective, it makes it more difficult to scale and concentrate. This also explains why large energy companies and banks only really get involved when renewable projects either reach a very large scale (offshore wind farms) or are embedded in financial structures that make their returns predictable (green bonds, subsidies). In a market environment, profit determines the direction and pace of innovation – not the lowest costs, and certainly not the lowest ecological costs.

3.3 Financing the energy transition

The role of finance

Finance plays a significant role in the energy transition. In November 2024, the Independent High-Level Expert Group on Climate Finance estimated that the global energy transition will require USD 6.3 trillion per year by 2030, covering not only mitigation but also adaptation across a wide range of sectors.⁸⁷ However, the challenge is not a shortage of capital – there are sufficient resources available. The question is how to channel them into bankable projects that can drive the transition forward. Many projects are technically viable, but their deployment sometimes runs into an array of risks that hinder their ability to attract sufficient private financing (insufficient distribution capacity, maturity of markets, saturation, technological readiness). These projects can include innovative technologies like hydrogen or energy storage, which carry significant risks. They can also involve new ownership models (energy cooperatives with hundreds or thousands of participants) or small-scale projects that are not profitable individually but can become bankable when bundled into portfolios.

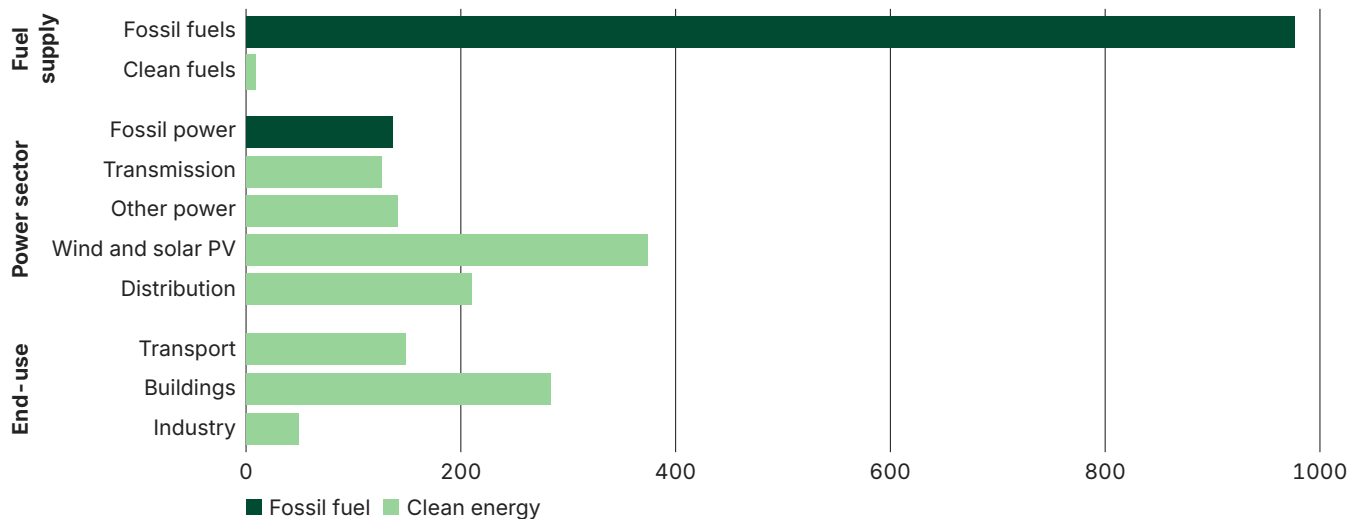
A key part of the challenge is the interdependence between different developments and technologies. For example, adequate electricity supply is only financeable if there is sufficient demand, or vice versa. When supply- and demand-side transitions are not aligned in time, financing becomes more difficult. This is where public finance plays a crucial role. By absorbing some of the risk and providing patient, coordinated support, it can bridge gaps that private investors are often reluctant to take on, in earlier stages of the transition. Unlocking the full potential of the transition therefore requires financiers, both public and private, to actively shape and structure projects.

Investment and financing patterns

Despite major technological shifts, the financial foundations of the energy sector have remained largely unchanged in the last 10 years. Since 2015, the balance between debt and equity investment has remained at roughly equal.⁸⁸ Debt tends to power the electricity sector, especially in Asia, while equity continues to drive fuel supply projects and investments in the Middle East and Eurasia.

Even though renewables are the fastest growing sector in energy supply, fossil fuels still dominate the total energy supply. In 2013, they made up about 82% of the world's energy supply. A decade later, that number has only dropped to around 80%.⁸⁹ In other words, the phase-out has barely begun and most of the world's energy still comes from fossil fuels.

Figure 6 Average annual energy-related investment by sector and by technology, 2015–2023 (billion USD)



Source: International Energy Agency, World Energy Investment 2024.

This continued use of fossil fuels is partly due to the continued support from public finance. Government investment in global energy assets has remained at around 37% since 2015, but a vast majority of that goes to the fossil fuel sector.⁹⁰ Almost a quarter of financing for fossil fuel projects comes from public sources, primarily due to high government shareholding in national oil companies. Public finance mostly supports the energy sector in regions such as the Middle East, Russia and Eurasia, as well as in some producer economies in Latin America and Africa. In addition, fossil fuel subsidies (tax exemptions, price controls) continue to lower the effective cost of fossil energy, reinforcing its competitiveness relative to renewable alternatives and further slowing the reallocation of capital towards clean energy.⁹¹

Public money isn't the only force keeping fossil fuels afloat; commercial finance also plays a major role. In 2024, the world's largest banks increased their fossil finance by USD 162 billion.⁹² This is both a worrying policy setback and a missed opportunity: the same sum could instead have created hundreds of thousands of jobs, funded the energy transition of entire countries or financed nature restoration on a global scale.⁹³

More than 70% of financing for clean fuels and renewable energy generation comes from commercial sources. End-use sectors also see much higher shares of commercial financing: 75% for industry, 80% for buildings and 85% for transport.⁹⁴ But where the money comes from is only part of the story; how it is structured matters too. In clean power projects, high upfront costs and lower returns mean roughly half of the funding takes the form of debt.

End-use sectors show a similar pattern, with debt covering about 45% of spending.⁹⁵ For newer, riskier technologies like clean fuels, hydrogen or battery storage, debt financing is far less common, and developers often depend on venture capital instead.

Delays in global climate finance

In recent years, climate negotiations at the UN Framework Convention on Climate Change have increasingly been dominated by discussions around financing, particularly the accessibility of climate finance for developing economies. At COP29 in Baku, developed nations pledged to provide USD 300 billion annually until 2035 for mitigation and adaptation,⁹⁶ falling far short of the USD 1.3 trillion that scientists say is needed.⁹⁷ Much of the pledge remains in the form of loans (rather than grant-based support), burdening countries already struggling with debt. The 'loss and damage fund' although recognised, was not firmly embedded in the new climate finance target. Without that, there is no enforceable obligation to help the nations most affected by climate change to deal with the climate impacts that can no longer be avoided or adapted to.

At COP30 in Belém, negotiators affirmed and expanded the finance agenda by calling for a threefold increase in adaptation finance by 2035, operationalising the loss and damage fund and initiating a work programme and roadmap to scale up climate finance toward the USD 1.3 trillion goal.⁹⁸

However, deeper commitments on fossil fuel phaseout and more immediate, enforceable financing for vulnerable nations once again remained contested and unfinished.

4 Key actions to accelerate the energy transition

The energy transition is not a single shift but a series of interconnected changes. The previous sections on the state of the transition have demonstrated how achieving a resilient, equitable and low-carbon energy system requires progress on all fronts: from how energy is produced, stored and distributed, to how it is consumed and governed. At Triodos Bank we have defined four key actions that together provide an over-arching approach to the transition: clean supply, reliable supply, demand reduction and fair and inclusive access.

Figure 7 The four key actions to accelerate the energy transition



Each step addresses a distinct part of the energy system but reinforces the others – all four depend on financing as well as strong advocacy.⁹⁹ The advocacy influences the regulatory frameworks and policy design needed to create the enabling environment for a fair and resilient energy transition.

4.1 Clean supply

The foundation of the energy transition lies in clean supply, focusing on the deployment of renewable energy generation. The expansion of renewable energy capacity remains one of the most visible and measurable indicators of progress toward a sustainable energy system. Our definition of 'clean' includes ensuring that the associated impacts of power projects remain positive, while minimising negative environmental and social impacts.

Scaling renewables while protecting nature

Renewable energy projects are expanding rapidly around the world, and this growth must continue if the world is to meet the net-zero targets. However, scaling renewables must go hand in hand with protecting biodiversity and managing land use responsibly. The next phase of the transition will depend on smarter spatial planning and innovation that integrates energy and ecology. For instance, agrivoltaics which combines solar production with sustainable agriculture, or offshore wind farms which reduce some of the land-use change pressures of current wind and solar projects.¹⁰⁰ The energy system must work *with* nature, not against it.

Reducing the negative impacts across supply chains

Energy cannot be considered fully clean unless its supply chain is responsible when it comes to social and environmental impact. In an ideal world, renewable energy supply chains would fully respect human rights and labour standards; however, the current reality is complex. Banks and investors currently depend on countries with sometimes weak regulation on human rights, making full supply chain transparency and certification challenging.¹⁰¹ At Triodos Bank, we strive to promote high social and environmental standards by engaging with clients, supporting certification and traceability initiatives, and prioritising technologies and suppliers that meet rigorous criteria wherever possible. By working consistently toward greater transparency and accountability, we aim to make sustainable supply chains a reality.



Solarvation shows an innovative clean energy approach in the Netherlands. The company has turned an old farm with asbestos roofs into a 41 MWp solar park, supplying enough electricity for 27,500 households.

Supported by Triodos Groenfond and crowdfunding, Solarvation goes beyond conventional solar with modular, movable panels that allow crops to grow underneath, combining renewable energy with agriculture. Collaboration with Wageningen University and Aeres College ensures biodiversity is carefully monitored.

4.2 Reliable supply

Energy supply must be dependable, meaning consistently available when and where it is needed. Part of the solution lies in advancing storage and building a resilient, robust energy infrastructure.

Storage

The renewable energy sector is breaking record after record. For example, in the Netherlands in the first half of 2024, 53% of generated electricity came from renewable sources, such as solar and wind.¹⁰² This is good news, but this growth must be accompanied by an essential component of the energy transition: storage. When it is not, a significant amount of generated energy is lost. Such losses during low-generation periods drive reliance on fossil fuels.

Ideally, storage should be located as close as possible to the source where the energy is generated. This includes large-scale industrial batteries close to industrial generation sites, but also batteries installed in homes.¹⁰³ A home battery can temporarily store electricity, allowing households to use generated energy (often from solar panels on their roof) at a later time. This makes households less dependent on the electricity grid and allows them to benefit more from the solar panels on their roofs.¹⁰⁴

On a larger scale, battery farms, pumped hydro and emerging solutions such as compressed air or gravity-based systems are helping grid operators stabilise voltage and balance electricity flows.¹⁰⁵ Battery energy storage systems play a particularly vital role in this mix. These systems enable grids to operate more efficiently, integrate higher shares of renewables and reduce reliance on carbon-intensive peak generation.¹⁰⁶ Together, these layers of storage form the foundation of a flexible and renewable energy system.

Hydrogen and green molecules

Hydrogen's potential as a clean energy carrier is currently gaining renewed attention.¹⁰⁷ Green hydrogen, produced by splitting water with renewable electricity, generates zero direct CO₂ emissions and can replace fossil-based grey or blue hydrogen in industrial processes.¹⁰⁸ Yet only around 4% of global hydrogen production is currently green, with the rest still derived from gas or coal.¹⁰⁹

Triodos Bank views green hydrogen as essential for hard-to-abate sectors where direct electrification is not yet feasible, such as steel, cement, chemicals and long-haul transport. As a storage solution, it also complements batteries in balancing renewable supply and demand.¹¹⁰ Unlike batteries, which are best suited for short-term

energy storage, hydrogen can store energy for weeks or months and feed it back into the grid or industrial processes when needed.¹¹¹ Despite its potential, green hydrogen remains costly and resource-intensive. Electrolysers require large amounts of clean electricity and water, and efficiency losses occur when converting energy to and from hydrogen.¹¹² Water use is a major concern – electrolysis requires around 9 litres of purified water for every kilogram of hydrogen produced.¹¹³

We support efforts to address these barriers through targeted investment in innovation, while maintaining clear sustainability boundaries: projects must be powered by renewable energy and located in regions with sufficient water resources.¹¹⁴ Triodos Bank does not finance grey or blue hydrogen, as doing so would effectively support fossil fuel use. Nor do we finance pink hydrogen, which relies on nuclear power. Only green hydrogen produced with renewable electricity aligns with our minimum sustainability standards.



In 2025, Triodos Bank Belgium granted its first green hydrogen loan, financing three plants in France and one in Germany operated by **Lhyfe**. Previously equity-funded, Lhyfe's hydrogen will serve

clean mobility and chemical and pharmaceutical industries. By supporting early movers, we highlight hydrogen's potential as a key part of a low-carbon energy future.

Nuclear energy, a challenge for public financiers

Once associated primarily with large, centralized power stations, nuclear energy is now being reimagined through advances that promise cleaner, safer, and more flexible applications.¹¹⁵ Progress in reactor design, waste management, and fuel cycles, along with long-awaited breakthroughs in nuclear fusion, are reshaping what nuclear energy could mean in the future.¹¹⁶

Despite its potential, Triodos Bank continues to fully exclude nuclear from its own financing, although we closely follow the ongoing discussion on the use of nuclear and possible innovative breakthroughs. This exclusion is based in two practical reasons. Firstly, the fundamental challenges associated with nuclear energy remain unresolved: the long-term management of radioactive

waste has not been adequately tackled, key novel technologies are still immature, and security risks (both in relation to accidents and geopolitical instability) persist. Secondly, nuclear projects span very long time horizons: from the first planning phase through operation to eventual decommissioning, the full lifecycle of a plant can stretch over a century.¹¹⁷ Oversight and accountability across such a timeframe is better provided by public financiers, with access to long-term funding and state-backed guarantees. We prefer investing in sustainable solutions for energy that are commercially viable and easy to scale.

Resilient and robust energy infrastructure

While renewable energy generation continues to grow at record rates, many projects are now stalled due to insufficient transmission and distribution capacity. In the UK, for example, more than 700 gigawatts of renewable energy projects are waiting for grid connection, with some expected to wait until well into the late 2030s.¹¹⁸

To effectively meet the challenge of delivering and balancing electricity supply, the financial sector must focus on grid capacity, flexibility and resilience as critical investment priorities. Smart grids are part of the solution. They combine real-time monitoring, smart meters and demand-response technologies to allow for precise balancing of supply and demand.¹¹⁹ This helps to reduce stress on networks during peak loads or extreme weather events.

Grid congestion management and power distribution are essential. Congestion management balances electricity flows when transmission lines are full, ensuring renewable power reaches where it's needed.¹²⁰ Strengthening local grids that connect households, businesses and small producers is equally critical. Across Europe, tens of billions of euros are needed annually to modernise networks for rising demand.¹²¹ Cross-border transmission projects can balance intermittent renewables, improve energy security and reduce costs through price convergence. While large national grids are primarily a government responsibility, Triodos Bank focuses on local networks often paired with solar, wind and battery storage, highlighting the

important role private financiers can play in supporting interconnected regional systems.¹²²

4.3 Reducing demand

The energy transition is gaining momentum, but our economic system focused on profit and GDP growth remains a barrier.¹²³ Energy efficiency gains are often outweighed by overall increases in consumption.¹²⁴ Reducing energy demand should not create poor quality of life, it should allow us to use energy more efficiently.¹²⁵ For households, this could involve better insulation, smart heating systems and appliances that use less energy while maintaining comfort. For industry, this means optimising production processes, shifting to circular and regenerative practices, as well as redesigning business models and products to require fewer materials and less energy across their lifecycle. A great example of this are the broader mobility considerations in the transport sector, especially when looking beyond electric vehicles.

Transport

The transport sector, along with the broader context of mobility, has the potential to reshape how our societies move and connect (as well as to lower emissions). The sector accounts for roughly a quarter of global CO₂ emissions, with road transport responsible for the majority. Electrification of vehicles is now advancing rapidly. Global sales of electric cars rose by more than 25% in 2024, surpassing 17 million units and accounting for one-fifth of all new car sales.¹²⁶ Yet true transformation goes far beyond replacing petrol cars with electric ones. It requires redesigning the systems, infrastructure and behaviours that shape transport and mobility.

Electric vehicles

Electrifying transport directly reduces fossil fuel demand. Additionally, when smart charging allows electric vehicles to charge during periods of excess solar or wind generation, it helps to balance the grid and ensures that renewable energy is not lost.¹²⁷ Vehicle-to-grid and vehicle-to-home technologies take this further, turning



Due to the important role walkable and cyclable cities play in smarter and lower demand for energy across the transport sector, we support bicycle shops and bicycle-sharing initiatives across various business units. Below is an example from our Spanish branch:

Triodos Bank Spain – La Factoria Bike-In, located in Madrid, rents out electric bicycles. Through the application of Internet of Things software, they are able to manage the fleet efficiently and provide users with an intuitive experience.

vehicles into mobile storage units that can supply electricity back to the system.¹²⁸ At the same time, distributed charging infrastructure (outside homes, workplaces and public sites) decentralises the energy system, boosting resilience.¹²⁹ The sector is maturing quickly, moving from small, fragmented operators to larger, well-capitalised networks backed by institutional investors.¹³⁰ New financing models, including green loans and infrastructure funds, are making the rollout commercially viable while ensuring long-term returns.

Broader mobility

Electrification, while essential, is only the starting point. For a deeper transformation, we need to redefine the concept of mobility itself. This includes designing cities around people rather than cars and prioritising walking, cycling and public transport.¹³¹ Better access to convenient and affordable mobility solutions enables access to jobs, education, healthcare and a richer social life. Currently millions remain excluded due to cost, location or poor infrastructure.¹³² Some business models that will contribute to this broader mobility transformation include community-based and shared mobility models such as electric car sharing, bicycle sharing, local shuttle services and micro-mobility hubs. Such models help shift behaviour away from private car ownership towards more efficient, shared and low-impact forms of movement.¹³³

Heating and cooling systems

In 2022, residential and commercial gas demand in Europe dropped by more than 15% compared to 2021. While around 40% of this reduction was due to a milder winter, the rest came from households and businesses taking active measures such as switching to alternative fuels, improving building insulation and installing heat pumps and other efficient systems.¹³⁴ Another application which will play a large role in creating lower demand is housing built with energy efficiency in mind, including heating and cooling. Heating and cooling are currently the largest energy end-use applications.¹³⁵ Decarbonising heating and cooling are becoming a priority for governments. For example, the EU Innovation Fund's first pilot auction is targeting specifically heating systems.¹³⁶ In the next

major wave of industrial transformation, we must reduce energy intensity and finance interconnected systems that do not waste heat.¹³⁷ In these systems, excess heat from one process (such as industrial production, data centres or power generation) is captured and reused to provide heating for nearby homes, businesses or district networks, so that heat, power and waste streams are co-optimised.¹³⁸ Financing sustainable heat infrastructure, from home retrofits and local heat networks to innovative carbon-positive systems, lowers demand and helps build long-term resilience into the energy system.

4.4 Fair and inclusive access

Our vision for the energy transition must be clean, reliable and accessible to all. We've talked a lot about how to ensure it will be clean and reliable, but how can we ensure it is also accessible to all?

Ownership

The current energy system remains highly centralised, dominated by large corporate and state-owned entities.¹³⁹ While they will continue to help scale renewable infrastructure, relying on them alone will not deliver a just transition. Private actors often prioritise profit, public utilities have been weakened, and state-owned fossil fuel companies remain major emitters.¹⁴⁰ In response, decentralised ownership models are emerging worldwide. Steward ownership ensures that decisionmaking remains with people committed to the mission and that profits are reinvested into the organisation.¹⁴¹ The model builds social and ecological purpose into a company's legal structure, so that creating lasting value for people and the planet comes before short-term profit.¹⁴² Similar principles underpin local energy cooperatives, community-owned solar parks and benefit-sharing initiatives, which put financial returns and control in the hands of local communities.¹⁴³ Financial institutions can support these models by designing instruments that make community energy projects bankable and simplifying due diligence for them.



Triodos Investment Management is co-financing 28 rural mini grids in Nigeria with **PowerGen Renewable Energy**, providing clean electricity to over 55,000 people. They are the country's largest mini-grid project. PowerGen, Africa's leading distributed energy developer, has installed 200+ mini grids across seven countries. The Nigerian project will cut over 2,000 tonnes of CO₂ annually and support households, businesses and community services. Similar projects are needed to expand global renewable access.

Affordability and access

To address affordability and access issues, financial institutions can contribute by investing in distributed, off-grid solutions. These include solar home systems, home batteries and mini grids. Such solutions bring reliable power to underserved regions. In advanced economies, financing building retrofits, efficient appliances and local storage systems can help low-income households cut energy costs.

Climate transition must be just, or it will fail

The shift to a low-carbon, nature-positive economy will require the transformation of industries, supply chains and labour markets worldwide.¹⁴⁴ Without careful planning, there is a risk of leaving behind workers, communities and entire regions.¹⁴⁵ This risk is the highest in the Global South, which often bears the negative social and environmental impacts of resource extraction for the energy transition. Regions dependent on fossil fuel industries face job losses and declining revenues.¹⁴⁶ Mining communities are facing new pressures from critical mineral extraction.¹⁴⁷ The rush for critical minerals is already linked to labour rights abuses, land grabs and environmental damage in vulnerable regions. A just transition means ensuring that climate policies protect livelihoods, strengthen rights and share benefits fairly. This requires investing in skills, supporting affected communities and embedding social safeguards into every stage of the transition.¹⁴⁸

5 Advocating for system change

The energy transition cannot succeed through technology or finance alone; it requires systemic change. True progress requires shifting the rules that govern markets and institutions. Financial institutions can influence these through public policy work. Below are four central messages that Triodos Bank is working to advance through its advocacy and thought leadership:

1) Phase-out fossil fuels

Triodos Bank has been calling on governments to phase out fossil fuels alongside a broad coalition of scientists, cities, Indigenous groups, and businesses. We call for a binding plan to end the expansion of new coal, oil and gas, which is the only way in which we can limit global warming to 1.5°C.¹⁴⁹ We were the first bank to join the global campaign for a Fossil Fuel Non-Proliferation Treaty, aimed at ending the expansion and accelerating the phase-out of coal, oil and gas.¹⁵⁰ Alongside a broad coalition of scientists, cities, Indigenous groups and businesses we have been calling on governments to commit to declaring a firm 'no' to fossil fuels once and for all.

2) Sufficiency-based policies

Through our advocacy efforts, we will continue to argue that an over-emphasis on efficiency gains will not lead us to a complete energy transition.¹⁵¹ In a growth-driven system, lower costs tend to increase consumption, offsetting savings. Addressing this requires sufficiency-based policies, which can include absolute ceilings on energy and material use (especially in the Global North), volume limits on transport and buildings and spatial planning that prioritises low-energy lifestyles. Carbon pricing is necessary but works best combined with standards, regulations and strategic public investment to prevent rebound and ensure equity.¹⁵²

3) Stimulating energy efficiency in the built environment

Buildings account for a significant share of energy use and emissions, making energy efficiency in the built environment a critical lever for the energy transition. This is why it is vital to advocate for strong policy frameworks at both national and European levels to accelerate energy-saving renovations and the adoption of low-carbon building standards.¹⁵³ At the EU level, we already actively engage with initiatives such as the European Energy Efficiency Financing Coalition, which is working to create a favourable market environment for energy efficiency investments and scale up the private financing needed in energy efficiency.¹⁵⁴

4) Mandatory phase-out of harmful practices and true pricing

Voluntary frameworks alone are insufficient.¹⁵⁵ Alliance memberships and net-zero pledges (such as those of the Net-Zero Banking Alliance) have fuelled the conversation. However, without enforcement, sanctions and explicit phase-out paths, pledges quickly erode and coalitions built on them collapse.¹⁵⁶ The transition requires regulation that sets enforceable rules:

- Legal bans on financing new fossil fuel projects.
- Mandatory climate and nature transition plans for companies.
- Prudential requirements, such as higher capital charges for high-carbon or biodiversity-risk assets.
- True pricing mechanisms that internalise environmental and social externalities, combining carbon taxes with financial incentives for positive impact.

6 Conclusion

The coming decade will determine whether we can align our energy systems with the ecological boundaries of our planet while ensuring fair access and resilience. A sustainable energy future rests on four interconnected actions: clean supply, reliable supply, demand reduction, as well as fair and inclusive access. Together, these principles define what the energy transition needs to achieve, and how it can do so in a way that serves both people and planet.

A broad range of actors have key roles to play:

- **Governments** can begin phasing out fossil fuel subsidies and setting firm deadlines tomorrow. Governments must also invest directly in the physical backbone of the transition (grids, storage and public infrastructure) while embedding sufficiency into planning and regulation.
- **Financiers and investors** can set ceilings on fossil fuel lending and publish year-on-year reduction targets, as long as there is no governmental credit and investment guidance. Beyond this, they can actively channel funding towards the infrastructure, technologies and business models that make the transition possible: decentralised renewables, storage, circular supply chains and efficiency solutions.
- **Grid operators** and energy companies can rearrange their priorities – not just by expanding capacity but also by explicitly creating room for flexibility, demand reduction and decentralised solutions. Energy companies that embrace distributed ownership, storage integration and cross-border collaboration will define the next era of energy security.
- **Civil society**, including communities, NGOs and citizens, hold the power to democratise energy. Their contribution can come in different forms: from launching initiatives exploring alternative ownership models, to awareness building, incitement of behavioural change, and advocacy that keeps justice at the centre of the agenda

The arguments presented demonstrate that the energy transition is not only a technical shift but, perhaps more importantly, a societal one. If governments, financiers, companies and citizens each act within their sphere of influence and in alignment with one another, we can swiftly move to an energy future like the one we glimpsed in Australia in 2025 – clean, reliable and accessible to all.

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