

## Executive Summary

**Energy efficiency, energy security and access to critical material supply chains were the key drivers of the energy transition in 2023. A rapid increase in interest rates together with sluggish inflation negatively impacted the energy transition economics, but 2023 activity in solar, electric vehicles, batteries and energy efficiency all came in ahead of our expectations. Some clarity was provided around key policy initiatives, but we expect more to come in 2024, spurring further growth in investment and activity. With renewable energy generation continuing to be relatively more economic than fossil fuels, we see the sector representing an attractive long-term growth opportunity. Our portfolio, which offers broad exposure to companies that are well placed to benefit from the energy transition, now trades at a discount to the MSCI World Index despite offering more than double the earnings growth potential.**

After a year of highly accommodative fiscal policy in 2022, the dominant driver for 2023 became tightening **monetary policy**. A rapid rise in interest rates together with pockets of sluggish inflation led the economics of renewable projects to suffer relative to competing fossil fuel alternatives but post these factors, we find that **renewable energy generation continues to be relatively more economic than fossil fuels**. Better relative economics as well as security of supply considerations will help to sustain strong demand for sustainable energy activities during and will keep the long-term driver of renewables adoption intact.

Much of the key policy support for the energy transition in 2023 was enacted with a focus on improved energy efficiency, energy security and access to critical material supply chains, including the following:

- Further details were provided in **Europe** about how the bloc will achieve carbon neutrality by 2050, including a 55% cut to emissions, 13% lower final energy consumption and 45% renewables in the energy mix by 2030.
- In the **United States** there was a meaningful surge in activity thanks to the Inflation Reduction Act (IRA), with \$369bn of tax breaks morphing into \$1.6 trillion of capital being mobilized towards achieving net zero aims. According to the World Economic Forum, this will create over 170,000 jobs and more than 9 million jobs over the next decade. Additionally, with 2024 being an election year, 80-90% of these new jobs are within Republican states.
- From a **global** perspective, 123 countries signed up to the Global Renewables and Energy Efficiency Pledge at COP28, committing to deep emissions reductions by 2030, requiring a tripling of global installed renewable energy capacity and a doubling of the rate of annual energy efficiency improvements.

Around 520 gigawatts (GW) of **new renewable generation capacity** were installed in 2023, 100GW higher than the record installations seen in 2022 and well over double the 194GW installed pre-COVID in 2019. Solar was dominant (at just over 400 GW) with wind in second place (around 100 GW) followed by hydropower, then bioenergy. Renewable **electricity generation** in 2023 increased by around 2.5%, reaching over 9,200 terawatt hours (TWh), and outpacing global electricity demand (estimated 1% growth in 2023).

**Electric vehicles** saw continued adoption in 2023, albeit at a slower pace than seen in recent years. After growing at over 100% and over 50% in 2021 and 2022, sales of plug-in vehicles grew by around 35% in 2023 to around 14 million units, representing an 18% penetration rate. After increasing in 2022, **lithium-ion battery** pack costs fell by 14% in 2023 to \$139/kWh (kilowatt hours), driven by lithium and nickel prices that fell by 80% and 40% respectively.

The **solar** industry grew rapidly in 2023, with installations likely to have exceeded 400 GW for the full year (up tenfold over the last decade and 65% higher than 2022). This is materially ahead of our prior 2023 expectation of 310 GW and will represent the fastest annual growth rate since 2010 (following several years of 20%+ annual growth).

The **wind** industry returned to growth and is likely to have delivered record installations in excess of 100 GW, despite high-profile company profitability and growth concerns.

The onshore wind sector is likely to have delivered 91GW, with China accounting for 60% of the total and nearly 90% of the year-on-year growth. Offshore wind installations are likely to have reached 12GW (also led heavily by China) with clear policy support for the struggling industry at the end of the year.

Against this backdrop, the **Guinness Atkinson Alternative Energy Fund** delivered a total return of -2.39% in 2023 vs its benchmark the MSCI World Index (net return) of 23.79%. For comparison, the MSCI Global Alternative Energy Index was down by -25.2%. The underperformance of the Fund resulted almost entirely from multiple compression rather than earnings downgrades, with the Fund trading at a one year forward price/earnings (P/E) discount of 6% to the MSCI World Index at the end of the year. Since repositioning five years ago, the Fund has delivered a return in excess of its investment universe, based on an equal weighted average calculation.

***Performance data quoted represents past performance; past performance does not guarantee future results. The investment return and principal value of an investment will fluctuate so that an investor's shares, when redeemed, may be worth more or less than their original cost. Current performance of the Fund may be lower or higher than the performance quoted. Performance data current to the most recent month end may be obtained by visiting [www.gafunds.com](http://www.gafunds.com) or calling 800-915-6566.***

Looking ahead to 2024 and beyond, we expect further acceleration of the transition:

**Renewable power generation** is expected to grow at around 7-8%, displacing some coal and gas power, which would result in the electricity sector's CO2 emissions declining. Grid investment will increase to support the growth, growing at twice its historic rate from \$300bn in 2022 to over \$800bn per annum (pa) in the 2040s.

**Building efficiency and electrification** will see sharply greater investment, increasing from \$340bn in 2022 to \$600bn pa from 2026-30 (10% pa growth versus a historic rate of 5% pa) driven by energy security, economics, and tightening building standards.

**EV sales should exceed 16 million in 2024**, representing around 20% of total passenger vehicle sales and coming in one year earlier than our long-held target of 20% EV penetration by 2025. Improved economics (lower lithium-ion battery prices in 2024) as well as better range and quicker charging times are the key drivers of improved EV sales. We expect the EV/ICE economic parity benchmark for EVs versus internal combustion engine vehicles (ICEs) of \$100/kWh battery prices to come in 2027.











**Solar** remains the cheapest form of new electricity supply. We expect record low module prices at the end of 2023 to spur growth in all major geographies, with full-year global installations likely topping 500GW in 2024. China will still represent more than half of all installations with European and US solar demand set to rise to 70GW and 38GW respectively.

Global **wind** installations will grow in 2024 to a new record of 115GW, driven by policy support in China, Europe, and the US. Beyond 2025 many of the current bottlenecks will dissipate, allowing installations to grow to around 170GW, a growth rate of 7% pa. Offshore installations are set to grow to 40GW by 2030, a 20% pa growth rate.

The outlook we summarize here is broadly consistent with current government activity and observable investment plans. To be clear however, the growth described falls well short of the energy transition activity needed to achieve a **net zero / 1.5 degree scenario** in 2050, as targeted by the IPCC and reiterated at COP28. In a net zero scenario, the deployment of renewable generation capacity, penetration of EVs and battery storage, use of alternative fuels and implementation of energy efficiency measures will need to accelerate markedly.

We expect further positive catalysts in the year ahead. The sector would be a beneficiary of looser monetary policy and lower inflation, while higher fossil fuel prices would further improve the relative economics of renewable technologies. In terms of policy, further clarity around IRA tax credits and actions related to the EU Net Zero Industrial Act will help to bring greater investment into the sector. We expect investor interest in sustainable energy equities to recover in 2024, reflecting these catalysts, and that the current attractive valuation level will act as a further catalyst. Beyond these, the continuing importance of energy security and the increased individual, social and government pressures for consumers to become more energy efficient and for producers to increase their share of sustainable energy generation will support further growth in the sector. We believe that the Guinness Atkinson Alternative Energy portfolio of 30 broadly equally weighted positions, chosen from our universe of around 250 companies, provides concentrated exposure to the theme at attractive valuation levels that are particularly attractive relative to consensus earnings growth expectations.

Key themes in the Guinness Atkinson Alternative Energy portfolio

Theme	Example holdings	Weighting (%)
1 Electrification of the energy mix	 	25.2%
2 Rise of the electric vehicle and auto efficiency	 	21.2%
3 Battery manufacturing		7.3%
4 Expansion of the wind industry		10.1%
5 Expansion of the solar industry		13.3%
6 Heating, lighting and power efficiency	 	15.3%
7 Geothermal		3.3%
8 Other (inc cash)		4.2%

Source: Guinness Atkinson Asset Management (December 31, 2023)

This document reviews the sustainable energy sector and our portfolio in 2023 and provides an outlook for 2024 and beyond. We have split the document into three sections:

- Page 4**            Developments in sustainable energy policy and “macro”;
- Page 9**            Analysis of the four key sustainable energy subsectors: energy displacement, electrification, generation, and installation/equipment;
- Page 28**          Performance, positioning, and valuation of the Guinness Atkinson Alternative Energy portfolio.

## Sustainable Energy Policy and Macro

### Energy transition policy

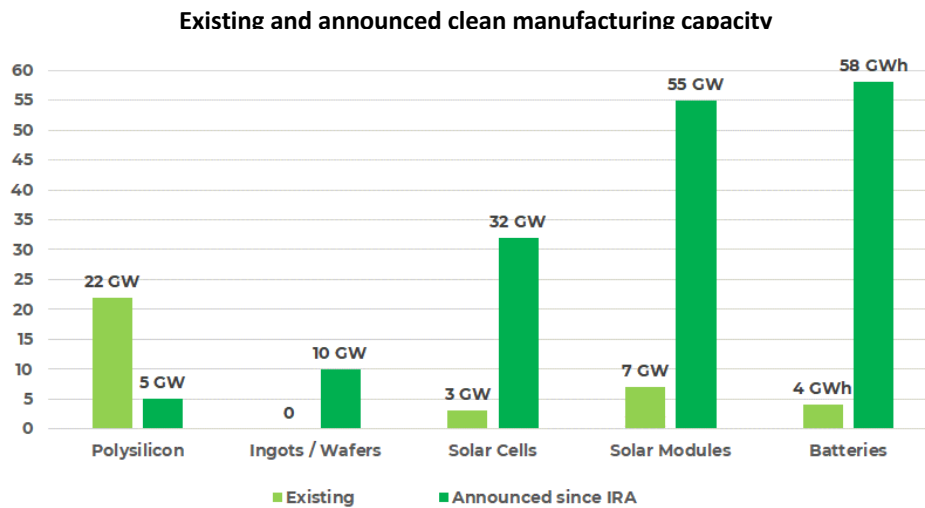
To put 2023 in context, fiscal policy was a major tailwind for the energy transition in 2022. Russia's invasion of Ukraine in the first half of the year saw fossil fuel prices skyrocketing, a jump in inflation, and energy security rise to the top of global agendas. In response, Europe announced the REPowerEU plan, ratcheting up energy efficiency and renewable generation targets to reduce the bloc's reliance on Russian fossil fuels. In the second half of the year, the Biden administration passed the US Inflation Reduction Act (IRA), providing unprecedented support for climate and energy security.

In 2023, **fiscal policy** remained broadly supportive. In **Europe**, several climate-related policy announcements in recent years have set the bloc on course for carbon neutrality by 2050 alongside a 55% cut to emissions, 13% lower final energy consumption, and 45% renewables in the energy mix by 2030. Further detail emerged in 2023 on how these targets would be met.

In February, the European Commission announced the Green Deal Industrial Plan, aiming to boost low-carbon manufacturing in Europe in response to the IRA. The strategy aims to quadruple the EU renewable fleet by 2030 (requiring around €1tn (approximately \$1.09tn USD) of capital investment); shorten renewable project permitting times from 4-5 years to 9-18 months; and boost domestic clean energy manufacturing. The Net Zero Industry Act and Critical Raw Materials Act built upon this, stipulating that at least 40% of renewable technologies must be manufactured locally by 2030 and that 10%, 40%, and 25% of key metals and minerals should be extracted, processed, and recycled within the bloc by the end of the decade.

Disappointingly, little new central funding was announced to support these ambitions. Instead, the European Commission loosened state aid rules, passing the responsibility onto member states. The first sign of tangible funding came in August when Germany announced its "Climate and Transformation" package, committing €212bn (approximately \$230bn USD) of funding towards building efficiency and renewables from 2024-2027. Goldman Sachs estimated that the capital mobilized by this legislation was likely to exceed €1tn over the next decade in Germany alone. Over the course of 2024, we expect to see further funding announcements from other EU member states.

In the **United States**, we have seen a meaningful surge in activity thanks to the Inflation Reduction Act (IRA). The policy works by providing tax credit visibility over the next decade to incentivize production of or investment in a renewable project. Additional incentives can be earned for projects which meet domestic content requirements or benefit low-income communities. Just over a year on, it is clear that its initial impact was understated; the \$369bn of tax breaks have morphed, by some estimates, into \$1.6 trillion of capital being mobilized towards achieving net zero aims.



Source: American Clean Power Association, December 2023

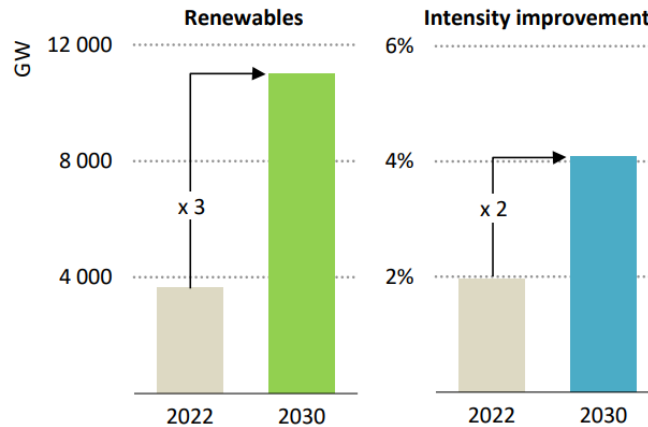
The American Clean Power Association (ACPA) have tracked over \$380bn of incremental clean energy investments since the legislation was announced, representing more than the total invested in the prior seven years combined. Over 150 GW of solar and battery manufacturing capacity has been announced alongside 263 GW of clean power projects, representing more than the entire current installed base of US renewable generation. According to the World Economic Forum, this will create over 170,000 jobs and more than 9 million jobs over the next decade. Importantly, 80-90% of these new jobs are within Republican states and, with the build out of US manufacturing being a bipartisan goal, we see lower risk of a potential Republican administration unwinding the legislation.

While this has undoubtedly attracted a huge amount of investment into US clean energy manufacturing, the publishing of qualification criteria relating to additional incentives has been delayed. This has led to purchasing and project delays as further clarity on manufacturing, domestic content and clean vehicle tax credits was released as late as December 2023. For example, it has been unclear whether certain offshore wind projects would qualify for the status of creating an "energy community" which allows for a 40% tax credit rather than the default 30%. As the majority of guidance has now been published by the US Department of the Treasury, it should provide firms with the incremental certainty they need to make expansionary investments as we head into 2024. In many cases, the uncertainty around the IRA has slowed down the development of projects that would otherwise have proceeded.

From a **global** perspective, 123 countries signed up to the Global Renewables and Energy Efficiency Pledge at COP28 in December. The pledge, which is based on a newly updated IEA Roadmap to net Zero by 2050, commits to deep emissions reductions by 2030 and requires a tripling of global installed renewable energy capacity (from 3,630GW in 2022 to 11,000GW by 2030) and a doubling of the rate of annual energy efficiency improvements (from 2% pa to 4% pa) over the same timeframe.

Increasing renewables capacity threefold requires annual capacity additions to rise at an average rate of 18%pa to 2030. Global solar PV capacity additions need to increase from 220 GW in 2022 to 820 GW in 2030 while wind capacity additions need to rise from 75 GW to 320 GW, with offshore wind accounting for around one-third of the 2030 total. Doubling the rate of energy intensity improvements will require electric vehicles to reach 65% sales penetration by 2030 and for heat pump installations to grow by almost 20% per year to 2030, versus 11% growth in 2022.

Global renewables power capacity and primary energy intensity improvements 2022-2030



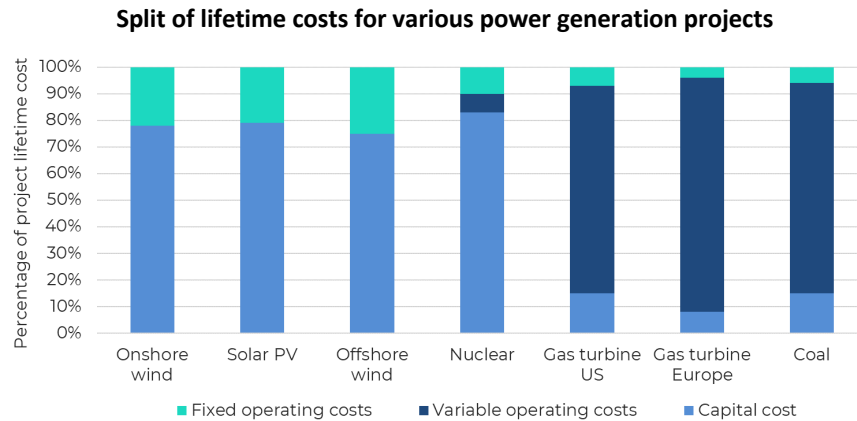
Source: IEA, December 2023

One notable absentee from the signatory list was **China**. Despite its omission, China has made sustainable energy central to its industrial and economic growth strategy and it is currently on track to hit its 2030 target of installing 1,200GW of renewable capacity five years early. One possible reason for opting out may be the energy efficiency target which is a much tougher ask from a growing economy that is keen to avoid over-promising and under-delivering. As we start 2024, we expect an announcement of a new 5-year renewable capacity target, to better reflect their current trajectory.

Tightening **monetary policy** slowed activity in 2023 as stubborn inflationary pressures across the world economy, particularly in the West, resulted in higher interest rate moves than many expected. Companies involved in the manufacturing of sustainable energy equipment, plus renewable power generators, faced challenges brought on by inflation and higher financing costs but other parts of the sector saw sharp deflation (e.g. solar modules; lithium) plus improving economics driven by greater economies of scale.

Morgan Stanley estimates that around 80% of current global wind and solar capacity was installed in a world with sub-3% US bond yields, entrenching the view that renewables were only economic because of the low interest rate environment. While we agree that low rates have helped accelerate the energy transition, we believe that **renewables continue to be the cheapest** form of new electricity supply in most situations.

In terms of renewable project **economics**, up-front capital costs make up 70-80% of the total lifetime cost of a typical wind or solar project, while fuel-related variable operating costs are non-existent. By comparison, capital costs for a typical natural gas project make up just 10-15% of lifetime cost, with fuel accounting for the remaining 80-90%. It follows therefore that the economics of renewable projects are more sensitive to interest rates and up-front capital cost inflation, while gas generation projects are more sensitive to longer-term fossil fuel prices.



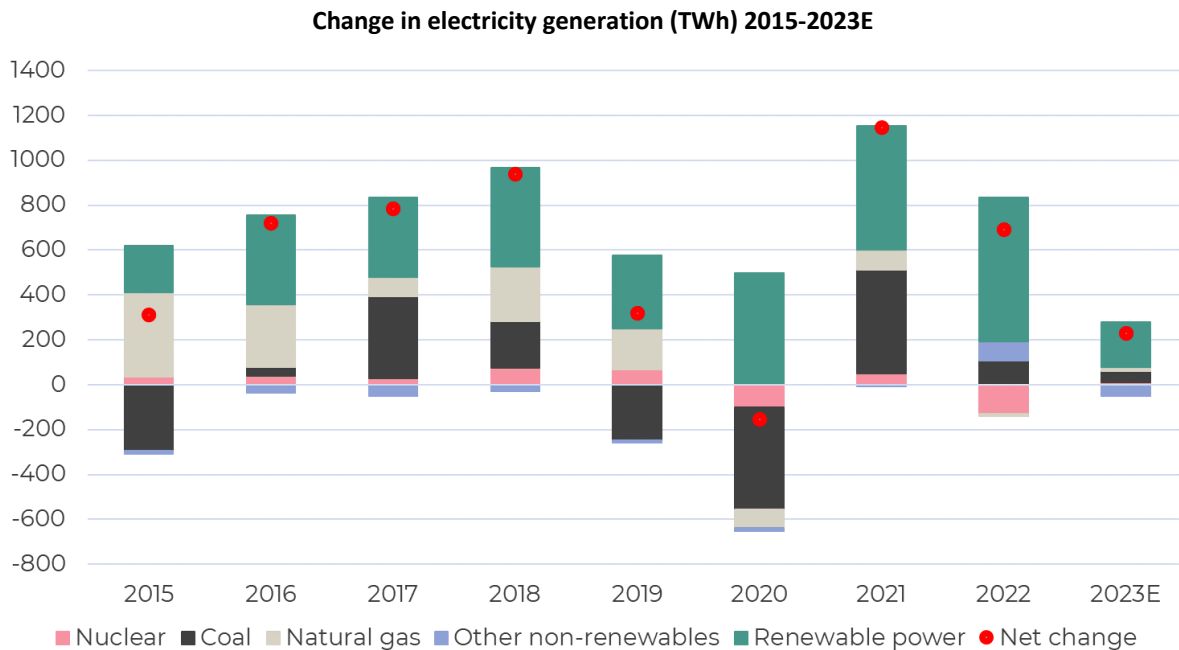
Source: Bernstein, Guinness Atkinson Asset Management, December 2023

According to Levelized Cost of Electricity (LCOE) estimates from the International Renewable Energy Agency (IRENA), the cost of wind and solar projects in 2022 ranged from \$0.03-0.05/kWh, well below the fossil fuel cost range of \$0.08-0.15/kWh. Allowing for increases in project financing costs, capital cost inflation, and fossil fuel prices, we estimate that renewable costs in 2023 have increased by around 50% to \$0.05-0.07/kWh while fossil generation costs have risen 30% to \$0.10-0.20/kWh. This illustrates that renewables remain cost competitive, and this keeps the long-term driver of renewables adoption intact.

## Renewable installations and power generation in 2023

Around 520 GW of **new renewable generation capacity** was installed in 2023, 100 GW higher than the record installations seen in 2022 and well over double the 194 GW installed pre-COVID in 2019. At around 400 GW, solar represented around three quarters of the new capacity additions. Wind (at around 100 GW) came next, followed by hydropower, then bioenergy.

Renewable **electricity generation** in 2023 is likely to have increased by around 2.5%, reaching over 9,200 TWh, and outpacing global electricity demand (estimated 1% growth in 2023). Most of the rise in renewable power generation can be attributed to the increase in installed solar and wind capacity. However, the percentage rise in renewable generation in 2023 is significantly lower than in 2022. This can be attributed to hydro power generation being sharply down in 2022, driven by drought conditions in various regions, especially China, offsetting some of the rise in solar and wind generation. Other contributing factors are weather conditions (for example lower average wind speeds in 2023) and the timing of capacity additions.



Sources: International Energy Agency; EMBER; Guinness Atkinson Asset Management, December 2023

In the OECD (Organisation for Economic Co-operation and Development) region, we saw declining electricity demand in 2023 resulting from the ongoing effects of extraordinarily high coal and natural gas prices in 2022, plus slower economic growth. The drop has been most evident in the EU, where electricity demand is expected to have fallen by around 3% in 2023 and occurred despite strong growth in electrification with a record number of electric vehicles and heat pumps sold. Instead, it has been Europe’s energy-intensive industries that have continued to see lower output and therefore lower input energy demand. By contrast, China’s power demand looks to be up by over 8% in 2023, as the move away from a zero-COVID policy, plus high summer temperatures, resulted in a sharp rebound in electricity consumption that was satisfied predominantly by higher levels of coal-fired generation.

Despite hopes for a decline in fossil fuel emissions in the power sector in 2023, adverse hydro conditions, especially in China, mean that emissions are likely slightly up on 2022. It is estimated that power sector emissions would have fallen by 2-3% had global hydro generation been at the same level as the previous year. Looking into 2024, renewable power is expected to grow at around 7-8%, displacing some coal and gas power, which would result in the electricity sector’s CO2 emissions declining.



## Sustainable Energy Subsectors

### Energy displacement

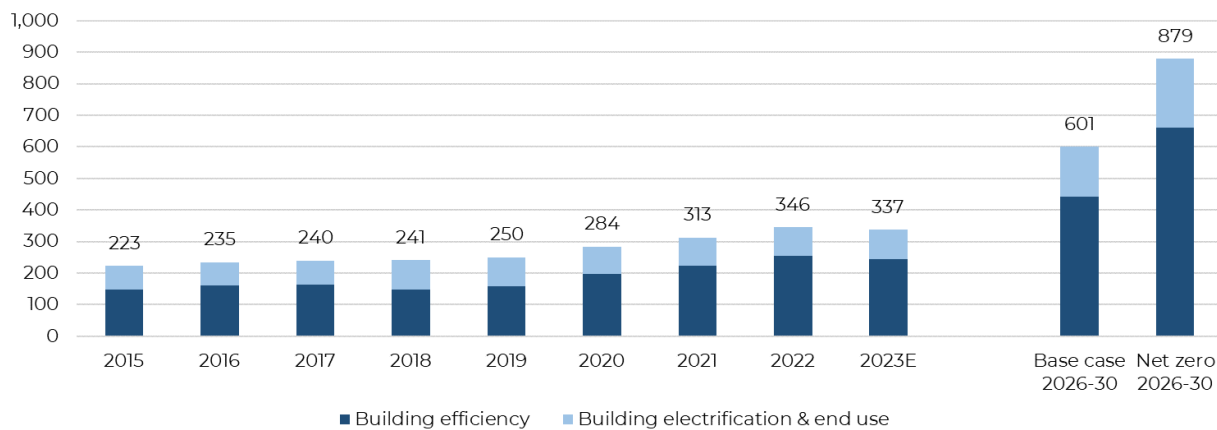
It is a common misconception that achieving rapid growth in renewable power generation will be enough to deliver government targets for pollution, energy security, and decarbonization. Renewable power generation is a key part of the solution, but we see the displacement and more efficient use of existing energy sources as just as critical, and arguably more urgent, in achieving these goals. The IEA refers to the theme of energy efficiency as being the “first fuel” that should be considered in delivering the energy transition. It is the one energy source that every country can access in abundance today.

In our base case, we assume global energy demand growth over the next 30 years of around 1% pa. This assumes significant efficiency improvements relative to an historical energy demand growth rate of around 2% pa. Within the energy displacement sector, the key areas of focus are **efficiency** and **alternative fuels**.

### Energy efficiency

Buildings account for around 30% of global emissions, with space heating, water heating, and space cooling accounting for 60% of their energy use. Decarbonizing buildings will require investment in heat pumps to electrify space and water heating, insulation to improve thermal efficiency, and efficient cooling to help inhabitants cope with rising outdoor temperatures. We see spending on building efficiency and electrification increasing from \$340bn in 2022 to \$600bn pa from 2026-30 (a forecast rate of around 10% pa versus a historic rate of around 5% pa) driven by energy security, economics and tightening building standards.

Global building efficiency-related investment by scenario (\$bn)



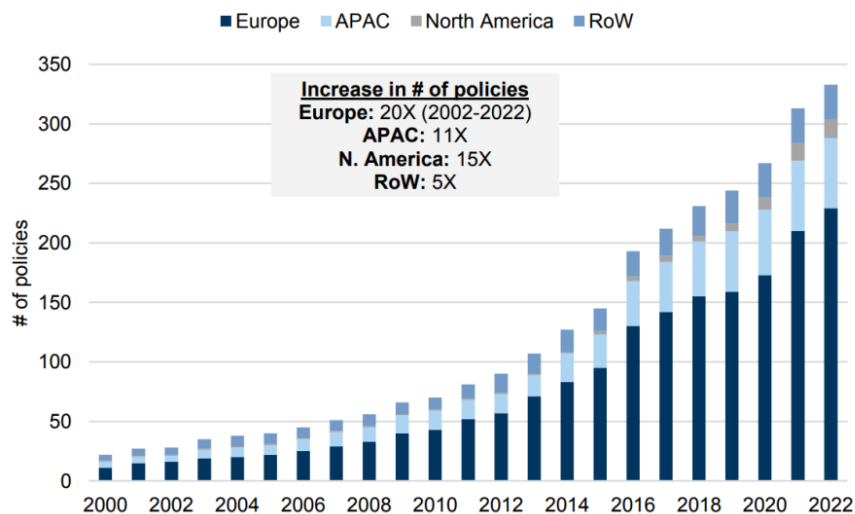
Source: IEA, Guinness Atkinson Asset Management; December 2023

**Heat pumps** are a vital tool for electrifying and decarbonizing heat and reducing reliance on natural gas imports, especially in the EU, where over one-third of natural gas is used for heating in buildings. European heat pump sales have grown strongly in recent years, increasing by 35% and 39% in 2021 and 2022 respectively, bringing annual sales to over 3 million units. This expansion was primarily driven by high gas prices and increased policy support as a result of Russia’s invasion of Ukraine since heat pumps remain a vital tool to secure Europe’s energy independence from Russia. The EU’s target to install 60 million additional heat pumps between 2023-30 is expected to reduce the bloc’s household gas demand by 40% and would require installations to grow at around 20% pa.

**Insulation** can improve the thermal efficiency of a building’s exterior walls and roof. As a result, insulation can help reduce energy consumption from heating and cooling by up to 40%, offering payback periods as short as 1-3 years.

Over the past 20 years, most regions have seen a 10x increase in government policies targeting building energy efficiency (including insulation). Government incentives, stricter energy efficiency requirements and higher energy costs have helped the global insulation market to grow at 6.5% pa from 2012-22 and we see economics and ratcheting regulation continuing to drive strong growth out to 2030.

**Global policies targeting building insulation, envelope technologies and eco-design**



Source: IEA, Goldman Sachs, December 2023

**Space cooling** is the largest driver of building electricity demand, with energy consumption more than tripling since 1990. Ensuring access to energy efficient cooling is of primary importance to minimize the number of heat-related deaths, especially among the elderly. The number of air conditioning units in operation globally has increased by 2.5x in the past 20 years and is set to grow by a further 50% by 2030. Thanks to a consolidated industry and a fragmented customer base, air conditioning manufacturers enjoy strong pricing power, and we expect this to continue out to 2030.

## Alternative fuels

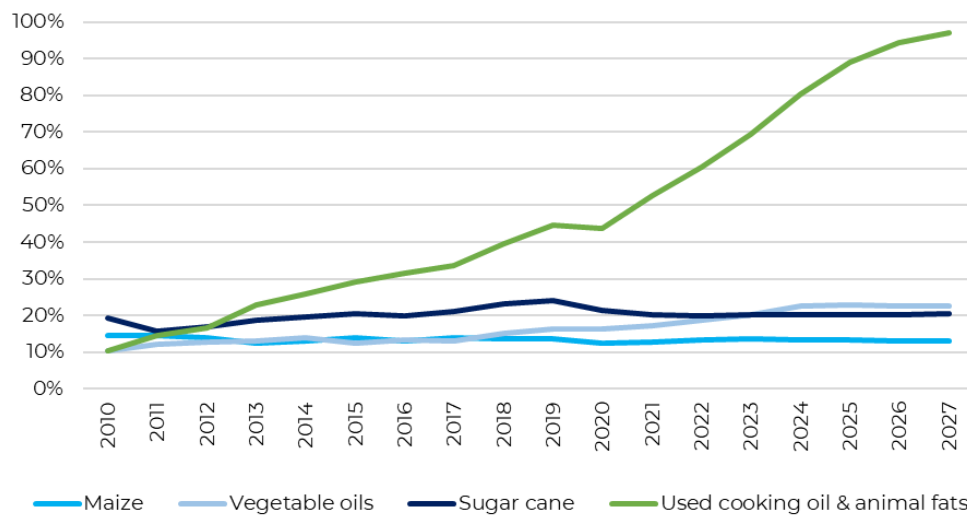
Global biofuel consumption is expected to be just under 180bn liters in 2023, displacing around 2 million barrels of oil per day, equating to 4% of oil demand from transportation. The market continues to be dominated by the USA, Brazil, Europe, and Indonesia, which make up 85% of global consumption.

Biofuel demand is expected to have grown by 6% in 2023 versus 2022, with growth continuing to be underpinned by policy and regulation. Demand benefited from prices falling from 2022 highs thanks to lower vegetable oil prices and increasing supply, while new Clean Fuel Regulations from Canada helped to provide visibility to future growth.

From 2023-2027, biofuel demand is expected to expand at 3-4% pa. Nearly two-thirds of growth will be driven by emerging economies, skewing heavily towards first-generation biofuels such as bioethanol and biodiesel. These fuels are derived from edible crops such as sugarcane and corn, and despite their sizeable role in reducing transportation related emissions, they have attracted criticism for diverting farmland away from food production.

The remaining third of demand growth will come from developed markets seeking higher volumes of second-generation biofuels such as renewable diesel and Sustainable Aviation Fuel (SAF). These fuels are derived from waste products such as animal fats and used cooking oil. They garner higher subsidy support in the United States and also meet strict EU requirements. Demand for these feedstocks is set to increase by 35% over the next four years, taking biofuels to 95% of total demand in 2027 (up from 70% in 2023).

**Biofuel demand as a percentage of total feedstock supply**



Source: IEA, Guinness Atkinson Asset Management estimates; December 2023

Despite generous incentives and strict standards creating an industry where production costs are still 2-3x that of fossil fuel equivalents, further government intervention may be required to avoid a supply crunch in the near future.

### Implications of a net zero scenario on our displacement outlook

Our base case for the energy transition assumes global energy demand growth of 1% pa, which compares to historic long-run average demand growth of 2% pa. Reducing energy demand growth to 1% pa requires significant investment in energy efficiency across buildings, heating, transportation, and industry.

To be clear, however, reducing energy demand growth to 1% pa does not align with net zero. A net zero scenario would require world energy demand to be broadly flat over the next two decades and we do not yet see the investment, industry scale or technologies in place to achieve this. Examples of changes to energy efficiency or alternative fuel production that would be needed to align with net zero include the following:

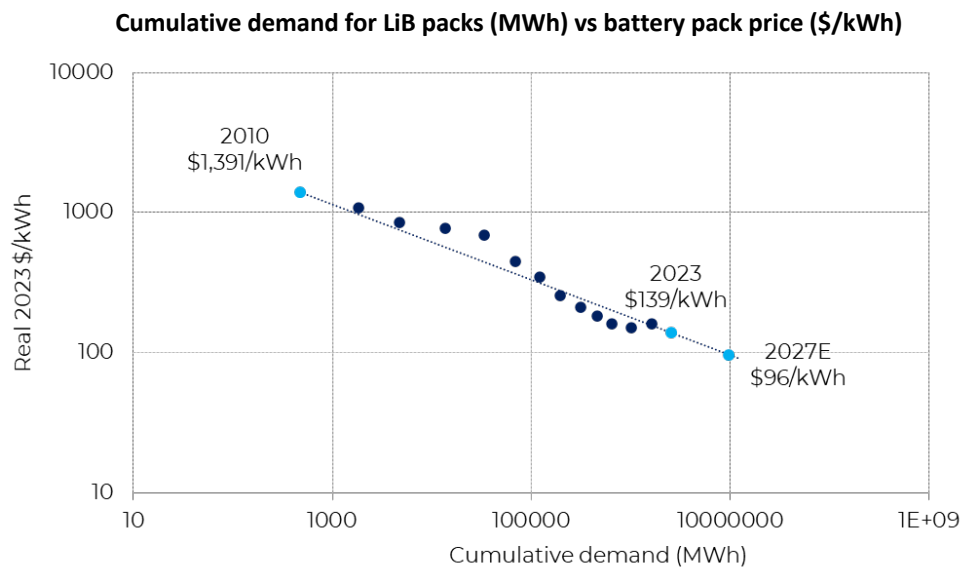
- Within **efficiency**, annual improvements in energy intensity would need to double from 2% in 2022 to average 4% pa out to 2030 globally. This translates into building efficiency, electrification and end-use investment increasing to over \$800bn pa this decade (from \$350bn today). Installation of heat pumps would need to increase globally by 20% pa out to 2030 while air conditioner efficiency must improve by more than 50% by the end of this decade.
- **Alternative fuel** production growth would need to more than double, averaging over 11% pa out to 2030 to help reduce emissions from new and existing trucks, planes, ships, and passenger vehicles. SAF would face the biggest challenge of growing from less than 0.1% of aviation fuel demand today to around 10% in 2030.

## Electrification

The steps required to transition to a low-carbon economy can broadly be summarized into three actions: i) reduce demand, ii) clean up electricity supply and iii) electrify the remaining demand. Our electrification sector includes enablers across lithium-ion battery and electric vehicle supply chains which do all three of these. **Batteries** serve a key role in cleaning up electricity, capturing excess clean energy during the day, and releasing it when supply is low. They contribute towards electrification, acting as the power source for **electric vehicle** (EV) drivetrains. On top of this, EVs contribute towards greater energy efficiency, converting over 85% of energy stored into motion, compared to less than 40% for internal combustion engines. We consider each of these areas in turn below.

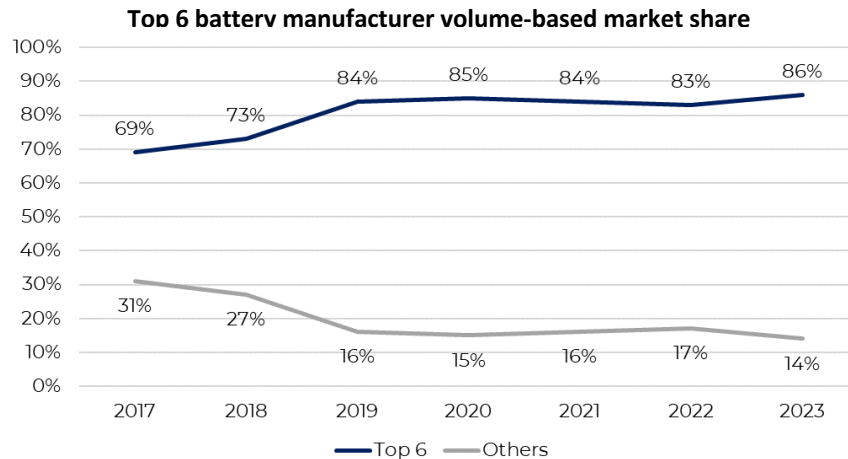
## Batteries

In last year’s outlook, we reported that 2022 was the first year on record that **lithium-ion battery** pack costs had increased, driven by soaring metal prices. In 2023, this trend reversed, with lithium and nickel prices cooling by 80% and 40% respectively due to slower electric vehicle demand growth. Shrinking commodity costs helped to drive a 14% decline in average battery pack prices to \$139/kWh. According to Bloomberg New Energy Finance (BNEF), this meant that real battery prices have fallen by 90% since 2010 and are forecast to fall below the EV/ICE parity benchmark of \$100/kWh in 2027.



Source: BNEF, Guinness Atkinson Asset Management, December 2023

In the year, the industry faced **oversupply concerns**, with CRU Group suggesting that planned Chinese capacity would be 2.5-3x higher than global demand from 2025-2030. While we do see overcapacity in the sector, we believe this is likely overstated. The top six battery manufacturers (CATL, BYD, LGES, Samsung SDI, SK On, and Panasonic) are responsible for 85% of electric vehicle battery volumes. These companies are behind just 50% of planned capacity additions out to 2025, with capital expenditure plans typically underpinned by supply arrangements with EV manufacturers. The remaining 50% of additions are expected to be brought online by more indebted and less profitable tier-2 suppliers. A lot of this tier-2 capacity ultimately may not come online, as declining share and poor cashflows lead to funding constraints and sector consolidation.

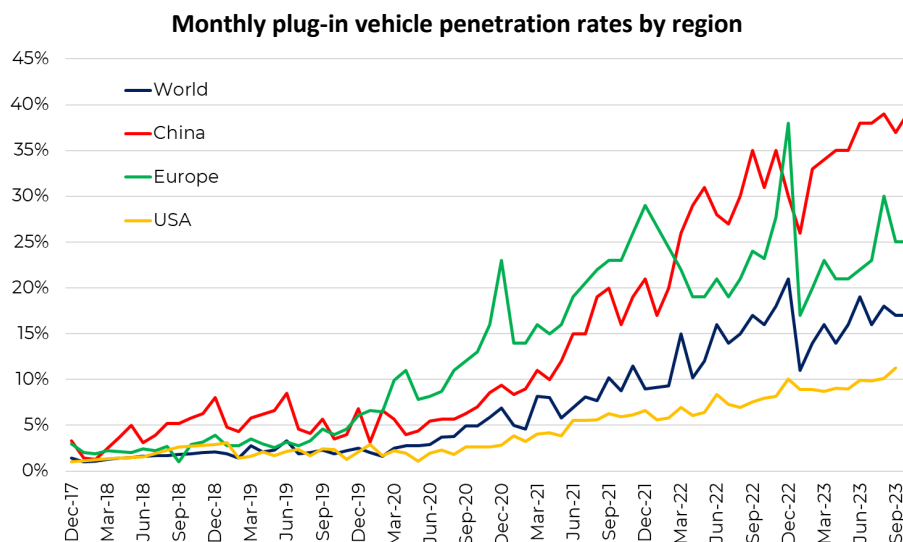


Source: EV-Volumes, HSBC, Guinness Atkinson Asset Management, December 2023

The last 12 months have also seen legislators wrestle for control over **battery supply chains** to reduce their dependence on Chinese imports. The EU announced its Critical Raw Materials Act and the US released guidance that EVs with Chinese battery components would not be eligible for full IRA tax benefits. With China processing around 75% of the world’s lithium and supplying over 50% of battery components globally, we believe it will be extremely challenging to extricate Chinese companies from Western supply chains.

## Electric vehicles

Electric vehicles saw continued adoption in 2023, albeit at a slower pace than seen in recent years. After growing at over 100% and over 50% in 2021 and 2022, sales of plug-in vehicles are expected to have grown by around 35% in 2023 to around 14 million units, representing an 18% penetration rate. China will retain its crown as the largest market for EVs, representing 60% of global plug-in vehicle sales, with monthly penetration rates approaching 40%. Europe will come in second, at 25% of global sales and penetration rates of around 25%, with the USA in third at around 10% of global sales, breaching 1 million units and seeing EVs making up over 10% of monthly sales for the very first time.

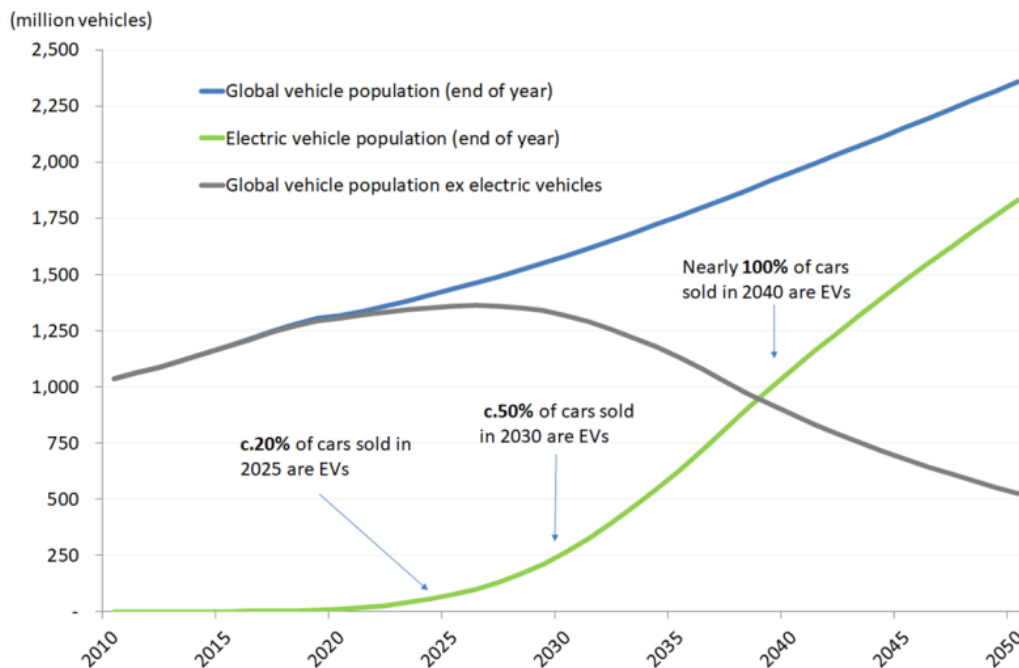


Source: Cleantechnica, AtlasEVhub, Guinness Atkinson Asset Management, December 2023

These regional differences largely reflect the main driver of adoption: affordability.

- **China** saw the withdrawal of government EV subsidies at the end of 2022, resulting in a slowing of sales at the start of 2023, sparking a year-long price war among manufacturers. This, combined with a bias for cheaper lithium iron phosphate (LFP) chemistries and smaller average battery sizes, resulted in sales prices for electric vehicles across multiple segments reaching price parity with internal combustion engine vehicles.
- **Europe** has a more nuanced picture, where moderate subsidies and higher gasoline prices led to certain models being cheaper to own than petrol or diesel counterparts. However, the threat of cheap Chinese imports in 2023 has impelled local manufacturers to cut costs to avoid losing out to imports.
- The market for electric vehicles in the **United States** is generally less competitive. Import tariffs and subsidies for local producers have led to higher prices, allowing cost-advantaged Tesla to take a 50% market share. A preference for larger vehicles (SUVs, trucks) with larger batteries (100kWh+) alongside lower average pump prices mean that the relative economics of owning an EV are not as attractive as in other regions. Despite record EV sales and penetration rates in 2023, further battery price declines are needed to see continued adoption.

**Global auto, ICE and EV population to 2050**



Source: US Department of Energy, Guinness Atkinson Asset Management estimates; December 2023

The decline in battery prices (and commensurate improvement in EV affordability) observed over recent years has coincided with climbing expectations of EV sales (Bloomberg New Energy Finance has upgraded its electric vehicle sales estimates by 100% and 50% for 2025 and 2030 in the past five years alone). We estimate that EV sales should exceed 16 million in 2024, representing around 20% of total passenger vehicle sales and coming in one year earlier than our long-held target of 20% EV penetration by 2025. Beyond that, we maintain our long-held view that electric vehicles continue to take share, reaching 50% of global light vehicle sales by 2030 and

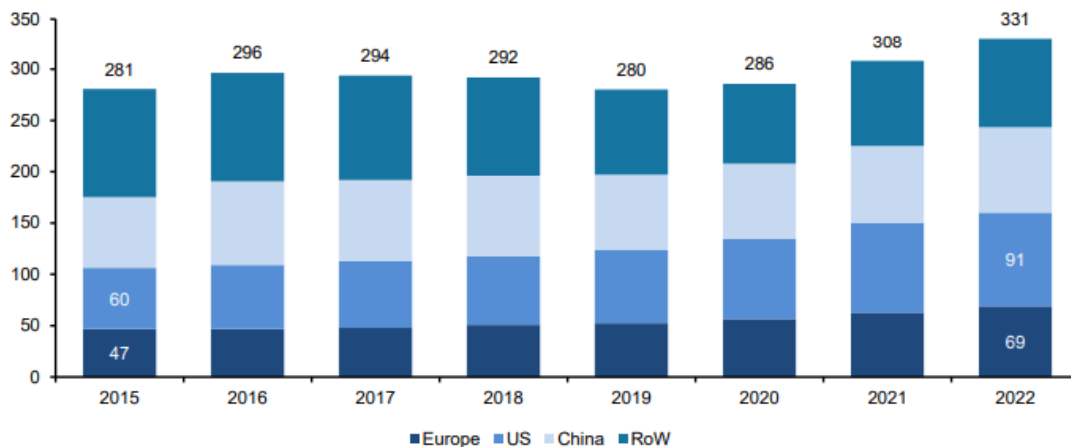
nearly all new vehicle sales by 2040. At that point, it implies an overall population of one billion EVs, over 35 times greater than the global stock in 2022 of 27 million.

## Power grids

The global power grid consists of over 2.6 million miles of transmission lines, over 43 million miles of distribution lines and over 700,000 substations. A significant proportion of this infrastructure in the US and Europe is ageing, analog (rather than digital) and increasingly capacity constrained.

According to the IEA, global grid investment averaged c.\$300bn from 2018-22 and has been growing slowly (2% pa) over the past eight years. Growth has predominantly been driven by Europe and the US (c.6% pa) due to decarbonization and replacement spending. Distribution (low and medium-voltage) accounted for roughly two-thirds of the spend with transmission (high-voltage) making up the rest.

Annual transmission and distribution investments (\$bn)



Source: Bernstein, IEA, December 2023

Our base case assumes that annual grid investment grows by around 4% pa, twice the historic rate, rising from \$300bn in 2022 to over \$800bn pa in the 2040s. Around two-thirds of this will be spent on distribution and one-third on transmission, with a rising share of this being digital. Around c.40% will be spent on replacing ageing assets, c.40% reinforcing the network to improve reliability and efficiency and c.20% extending the existing grid to new generation facilities.

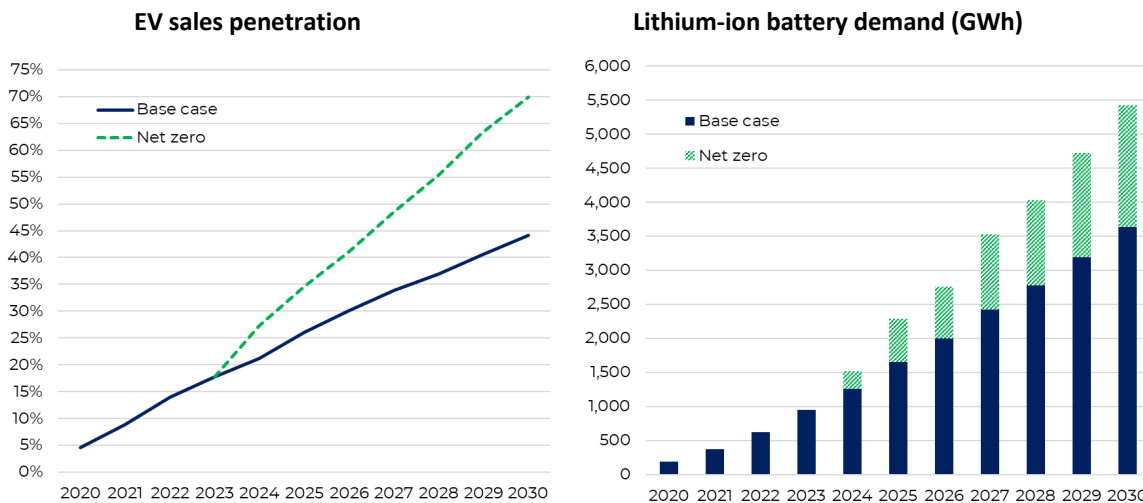
Greater residential adoption of heat pumps and electric vehicles leads us to expect that **distribution** will attract a higher proportion of the investment than transmission. Heat pumps and EVs increase residential electricity demand by c.90% and c.50% respectively. Moreover, the addition of EVs requires modernization and digitization of the distribution grid to facilitate bidirectional charging and allow EV batteries to help balance the grid. Bernstein estimate that to ensure grid reliability, US utilities will need to spend nearly \$1,600 on transmission and distribution infrastructure for each electric vehicle on the road.

- The continued adoption of renewables, characterized by smaller and more distributed power plants, will drive demand for more **transmission** lines. We see transmission investment enjoying a further tailwind from the building of more interconnectors to facilitate the international trade of electricity. We think these will be vital for ensuring energy security by allowing regional renewable energy surpluses and deficits to be equalized.

- We see investments in **digitalization** of the grid increasing from c.19% in 2020 to 42% in 2050. Integrating the physical grid into computer-based systems through the use of smart meters and sensors, communication networks and data analytics can help identify outages faster, automate grid performance, and improve uptime and efficiency. For network operators, data insights allow them to reduce maintenance costs through predictive maintenance. For consumers, smart meters can help reduce energy bills by enabling smart charging of electric vehicles at off-peak tariffs.

## Implications of a net zero scenario on our electrification and grid outlook

For **electric vehicles**, BNEF estimate that in a net zero scenario, global EV penetration rates must hit 35% by 2025 and 70% by 2030 (versus their current base case estimates of 26% and 44% respectively). This translates into global battery demand of 2.3 TWh in 2025 and 5.5 TWh in 2030 compared to 0.95 TWh today. This is 40-50% higher than their “base case” economic transition assumptions for each year, which themselves still imply annual growth rates of 20-30% pa from current levels.



Source: BNEF, Guinness Atkinson Asset Management, December 2023

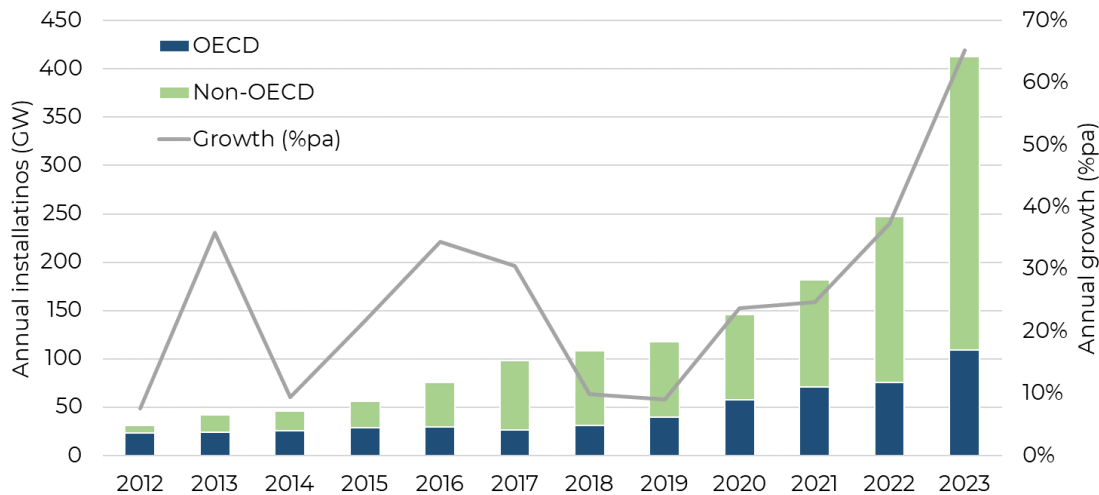
For **grids**, the IEA net zero scenario requires investment to nearly double from the current \$300bn to around \$580bn pa for the remainder of this decade and to more than double again to around \$1.4tn per annum in the 2040s (nearly double the investment levels implied by their base case).

## The solar sector

The solar industry has grown rapidly in 2023, with installations likely to have exceeded 415GW for the full year (up tenfold over the last decade and 65% higher than 2022). This is materially ahead of our prior 2023 expectation of 310GW and will represent the fastest annual growth rate since 2010 (following several years of robust (20%+) growth). The non-OECD continues to dominate the global market.



Annual solar installations split by OECD and non-OECD

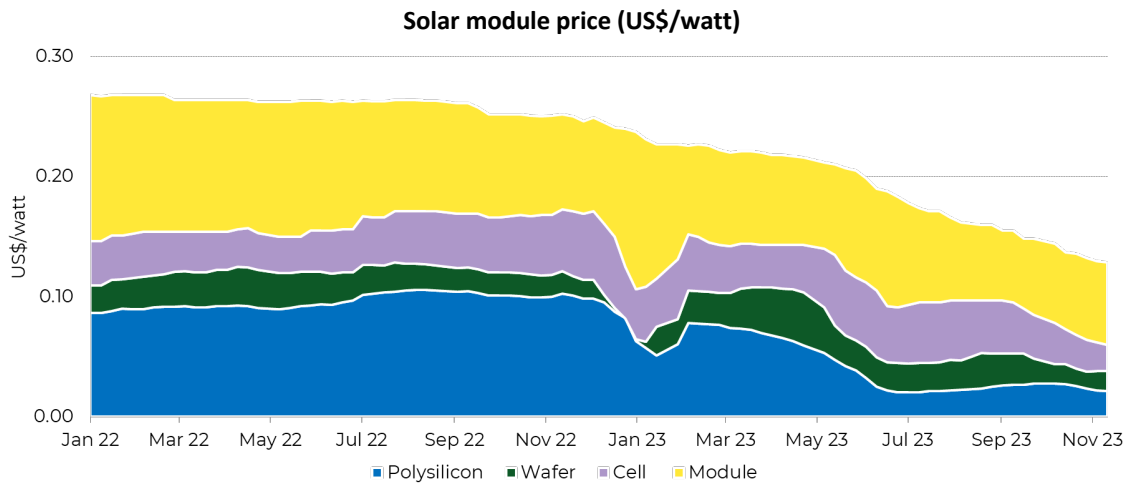


Source: BP, BNEF, PV InfoLink, IEA and Guinness Atkinson Asset Management estimates, December 2023

On a regional basis, the key driver of the industry continues to be China – accounting for nearly 60% of all installations and 80% of the year-on-year growth. This has been largely driven by utility-scale “megabase” projects, where the government allocates huge areas of land for multi-gigawatt projects, thereby avoiding many of the permitting pitfalls seen in the US and Europe.

Outside China, there has a more mixed picture. Commercial and Utility solar (which account for c.80% of the market) continue to grow apace, with installations hitting record highs. Offsetting this, however, is the residential market, which has seen pockets of weakness in both the US and Europe as a function of higher interest rates, changing regulation and the waning impact of the war in Ukraine. Taken in aggregate, however, both geographies are expected to grow well more than 30% in 2023 and account for 8% and 13% of global installations respectively.

Underpinning much of this growth has been the ever-improving economics of solar relative to fossil fuel-based options and current wholesale electricity prices. Over the year, the cost of solar modules declined by more than 50%, driven by a normalization of global supply chains and material growth in polysilicon supply. According to BNEF, the global capacity for solar-grade polysilicon increased to 2.4m tons during the year, more than double what is required for current PV installation levels. The consequent deflationary impact on the polysilicon price has reverberated throughout the solar supply chain meaning that solar module prices now sit at a **record low level** of \$0.13/watt.



Source: BNEF, Guinness Atkinson Asset Management estimates, December 2023

Looking to 2024, we expect these improved economics to continue to spur growth in all major geographies with full-year global installations likely topping 500GW. In China, we see a continued tailwind from a second and third round of “megabase” auctions as the government seek to achieve 1,200GW of installed capacity by 2030. In Europe and the US, the lagged benefits (and increased clarity) of policy support coupled with robust utility capital expenditure should serve to drive utility installations to new highs. This will be somewhat tempered by continuing sluggishness in the residential market, but this should begin to clear in the second half. All in, we expect European and US solar demand to rise to 70GW and 39GW respectively.

**Global solar module installations, 2010-2024E (GW)**

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024E
<b>OECD solar installations (annual)</b>															
North America	1	2	4	6	7	8	14	11	10	11	19	25	24	34	39
Germany	7	7	8	3	2	1	2	2	4	4	5	6	7	13	15
Spain	0	0	0	0	0	0	0	0	0	5	3	5	7	8	9
Rest of Europe	3	4	5	5	5	6	4	3	4	6	12	19	21	36	42
Australia	0	1	1	1	1	1	1	2	4	4	4	5	4	5	5
South Korea	0	0	0	1	1	1	1	1	2	3	6	4	3	3	3
Japan	1	1	2	7	10	11	8	8	7	7	9	6	6	6	5
<b>Total OECD</b>	<b>17</b>	<b>23</b>	<b>24</b>	<b>24</b>	<b>25</b>	<b>29</b>	<b>29</b>	<b>26</b>	<b>31</b>	<b>40</b>	<b>58</b>	<b>71</b>	<b>76</b>	<b>109</b>	<b>122</b>
Change	10	7	0	0	2	4	0	-3	5	9	18	13	18	33	13
<b>Non-OECD solar installations (annual)</b>															
China	0	3	3	14	13	19	30	53	44	33	52	69	107	240	256
India	0	0	1	1	1	2	5	10	11	12	4	12	18	15	18
Rest of non-OECD	1	3	3	4	6	6	11	9	22	34	32	30	47	49	105
<b>Total Non-OECD</b>	<b>2</b>	<b>5</b>	<b>8</b>	<b>18</b>	<b>21</b>	<b>27</b>	<b>46</b>	<b>72</b>	<b>77</b>	<b>78</b>	<b>88</b>	<b>111</b>	<b>172</b>	<b>304</b>	<b>379</b>
Change	1	3	2	11	2	6	19	26	5	1	10	23	58	132	75
<b>Total solar installations (annual)</b>	<b>19</b>	<b>29</b>	<b>31</b>	<b>42</b>	<b>46</b>	<b>56</b>	<b>75</b>	<b>98</b>	<b>108</b>	<b>118</b>	<b>146</b>	<b>182</b>	<b>250</b>	<b>413</b>	<b>501</b>
Change	11	10	2	11	4	10	19	23	10	10	28	36	76	163	88

Source: BP, BNEF, PV InfoLink, IEA and Guinness Atkinson Asset Management estimates, December 2023

## The wind sector

Despite a return to growth in 2023, the wind industry continues to experience a bumpy recovery. On the one hand, it is having to navigate the near-term impact of supply chain disruptions and increased financing costs, while on the other hand it has a very favorable long-term outlook driven by relative economics and supportive policy. Despite the cross-currents, the industry globally is likely to have installed a **new record of around 103 GW of new capacity**, up 15 GW on 2022 levels.

In 2022, the key issue for the sector was high raw material prices which adversely impacted the economics of the supply chain and pushed margins for all the major turbine producers into negligible or negative territory. In 2023 the issue passed to the developers as turbine manufacturers looked to pass on cost increases, while at the same time financing costs increased in line with global interest rates. This issue was particularly acute within the offshore wind sector, where the lag between securing projects and locking in costs is far longer, prompting high-profile project cancellations from the likes of Orsted, Shell, and Vattenfall.

Despite these headwinds we continue to expect a positive outlook for the global wind sector – both on and offshore – with the industry likely to deliver record installations again in 2024. In the medium term, we take confidence from the book-to-bill ratio for turbine manufacturers – a key leading indicator for growth in the sector – continuing to inflect positively.

Beyond 2025 we see many of the current bottlenecks dissipating and supportive policy from all key regions in the world prompting a near 70% increase in installations by the end of the decade, reaching around 170GW. We detail some of these drivers, both positive and negative, individually for the onshore and offshore industries below.

### Global onshore and offshore wind installations (GW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024E
<b>Onshore wind installations (annual)</b>															
North America	6	8	15	2	7	10	9	8	8	10	17	14	10	8	10
Latin America	0	0	0	0	5	3	3	3	4	3	3	6	4	6	5
Europe	9	10	12	11	11	11	12	13	8	9	14	14	15	16	13
China	17	18	14	15	21	29	22	17	19	26	54	42	44	54	57
India	1	1	2	2	2	3	4	4	2	2	1	2	2	3	4
RoW	3	4	4	3	4	5	5	5	4	4	4	8	5	4	6
<b>Total onshore</b>	<b>35</b>	<b>40</b>	<b>46</b>	<b>33</b>	<b>49</b>	<b>61</b>	<b>55</b>	<b>49</b>	<b>46</b>	<b>55</b>	<b>93</b>	<b>84</b>	<b>79</b>	<b>91</b>	<b>95</b>
Change	-3	5	6	-14	17	11	-6	-6	-3	9	38	-9	-5	12	3
World ex China	18	22	32	18	29	32	33	32	27	29	40	43	36	38	38
<b>Offshore wind installations (annual)</b>															
China	0	0	0	0	0	1	1	1	2	3	4	14	5	8	12
UK	1	0	1	1	0	1	0	1	2	2	1	1	3	1	2
Germany	0	0	0	0	0	2	0	2	0	2	0	1	0	1	1
RoW	0	0	0	1	0	0	0	1	0	1	2	1	1	2	6
<b>Total offshore</b>	<b>1</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>4</b>	<b>1</b>	<b>4</b>	<b>4</b>	<b>8</b>	<b>7</b>	<b>17</b>	<b>9</b>	<b>12</b>	<b>21</b>
Change	1	-1	1	1	-1	4	-4	3	0	3	-1	10	-8	3	9
World ex China	1	0	1	2	1	3	0	4	3	5	3	3	4	4	9
<b>Total wind installations</b>	<b>36</b>	<b>40</b>	<b>48</b>	<b>35</b>	<b>50</b>	<b>65</b>	<b>56</b>	<b>53</b>	<b>50</b>	<b>63</b>	<b>100</b>	<b>101</b>	<b>88</b>	<b>103</b>	<b>115</b>
Change	-2	4	8	-13	16	15	-9	-3	-2	12	38	1	-13	15	12

Source: BP, IEA, BNEF, Guinness Atkinson Asset Management estimates, December 2023

## Onshore wind

The onshore wind sector is likely to have delivered 91GW of new installations in 2023, with China accounting for 60% of the total and nearly 90% of the year-on-year growth. As with solar, the key driver here is the latest set of centrally-planned megaprojects – generally located in windy parts of northern China. The first set of such projects (40GW) was announced in 2021, with commissioning set for end 2023. This is to be followed by both a second and third wave of projects spanning 2024 and 2025. The combination of this, coupled with new state directives on repowering (the process of swapping older turbines with new, more efficient ones) should see installations average more than 55GW out to the end of the decade.

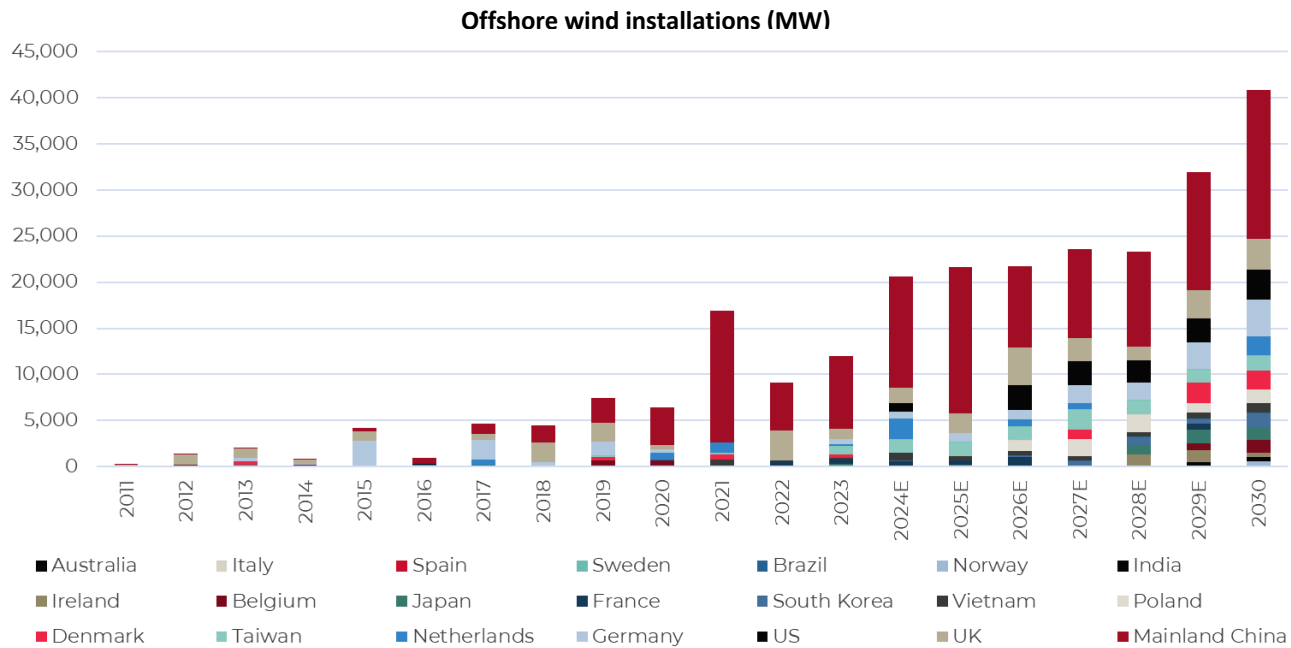
In Europe, the 16GW of installations we expect this year represents a record. However, installations may flatline in the near term as the impact of permitting and grid constraints coupled with poorly designed auction processes temporarily stalls progress. For example, the latest 1,500 megawatts (MW) onshore auction in Spain saw just 45MW of capacity awarded as developers shied away from a price cap which failed to reflect the current cost environment. Ultimately, such auctions are highly likely to be redesigned and will be offset by other factors (such as more countries implementing the EU's new permitting recommendations which, in the case of Germany, have seen close to a 40% jump in permitting year-over-year).

In the US, the combination of cost pressures and the lack of clarity on the IRA tax credits has caused a temporary lull in activity meaning installations are likely to be down in 2023. That said, the US Treasury has now provided finalized guidance for the wind industry, and we are beginning to see rising project pipelines as a consequence. This will lead to increased activity in 2024, but will really begin to impact from 2025 onwards, when, coupled with large new transmission lines being commissioned in the Midcontinent and the Southwest, we expect to see installation activity grow at over 10% a year.

## Offshore wind

The offshore industry remains a small and presently troubled segment of the market, but it is critical to the overall growth of the wind market out to 2030. Installations in 2023 are likely to have reached 12GW, led heavily by China, but this figure is set to grow to 40GW by 2030 – a 20% pa growth rate. This means that despite accounting for just 12% of the overall market in 2023, offshore wind will account for over 40% of the expected growth in total global wind installations to 2030.

Despite negative recent headlines, the fundamental attractions of the offshore wind industry remain the same: in addition to generally experiencing higher wind speeds, offshore wind installations tend to be easier to permit, allowing for bigger turbines close to large urban centers. Recent project cancellations, particularly in the US, have raised concerns about the viability of offshore wind in general, but we view these issues to be largely transitory and US-specific. Unlike the key offshore wind centers, the US has not yet built out its supply chain, making it more vulnerable to disruption. Furthermore, unlike the rest of the world, most legacy US contracts did not include mechanisms to account for inflation. While this has wreaked havoc on a certain era of offshore projects, we don't expect it to repeat in the future and thus don't think it appropriate to extrapolate to the whole industry or indeed future US projects. Instead, we see robust state level commitment to offshore wind targets, project economics underpinned by structurally higher global electricity prices (ex-US) and the proliferation of offshore wind technology beyond the handful of existing core geographies.



Source: BNEF, Guinness Atkinson Asset Management estimates, December 2023

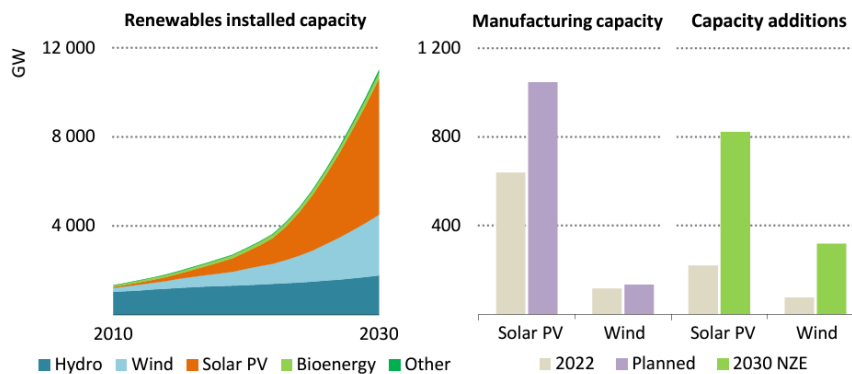
## Implications of a net zero scenario on our solar and wind outlook

The IEA net zero scenario envisages that renewables have a 60% share of global electricity generation in 2030, up from 30% in 2022. Solar and wind generation dominate, with their combined shares increasing from 12% in 2022 to 40% in 2030 thereby accounting for over 90% of the overall increase in renewables capacity to 2030 and 85% of the increase in renewable electricity generation.

In terms of new installations, global **solar** capacity additions increase from 220GW in 2022 to 820GW in 2030 while **wind** installations rise from 75GW in 2022 to 320GW in 2030. Offshore wind accounts for around one-third of the total installations in 2030.

The solar industry is clearly targeting very high levels of growth and is arguably positioned to deliver sufficient manufacturing capacity to satisfy the net zero scenario. However, the wind industry appears to be lagging substantially and therefore much more in need of policy support to achieve the required manufacturing capacity.

**Global renewables installed capacity and solar/ wind manufacturing capacity in a net zero scenario, 2022 and 2030**



Source: IEA, December 2023

## Alternative Energy Fund Outlook

The Guinness Atkinson Alternative Energy Fund delivered a total return of -2.39% in 2023 vs its benchmark, the MSCI World Index (net return), of 23.79%. For comparison, the MSCI Global Alternative Energy Index was down by -25.2%. Further performance information is shown on page 28.

Four of the top five contributors were in the **electrical equipment** subsector. Eaton, Schneider, Trane, and Hubbell all performed strongly, driven by an acceleration in global electrification activity and an easing of supply chain bottlenecks that propelled further positive operational momentum. Hubbell noted particular strength in its utility division due to a sustainable step up in grid modernization activity; Schneider, Eaton and Legrand all cited strength in their core low-voltage markets while Trane delivered strong backlog growth and looks likely to benefit from a growing higher-margin service opportunity. LeGrand saw similar operational improvements although it was a smaller positive contributor over the year.

Within **electrification**, our two semiconductor holdings ONSem and Infineon delivered positive contribution resulting from the general strength in the semiconductor space, but also from improved idiosyncratic outlooks. ONSem continued to position itself well within silicon carbide power semiconductors while Infineon continued to increase revenue and margin guidance driven by robust activity in the core auto and industrial end markets. The improving auto supply chain also benefited our auto equipment manufacturers Aptiv, Gentherm, Sensata and Johnson Matthey in the first half of the year but a weaker global auto sales outlook in the second half of the year led to all delivering slightly negative contribution over the year as a whole. It was a similar case for our two lithium-ion battery manufacturers, Samsung SDI and LG Chem, which were weaker on the auto outlook but also on margin pressures resulting from an increased supply of cheaper Chinese lithium-ion batteries.

Our **displacement** subsector saw a spread of outcomes. At one end, Itron shares re-rated as supply chains eased in the early part of the year, allowing them to procure critical components, while at the other end Ameresco shares suffered from missed earnings, delays at the key Southern California Edison battery storage development and delivery issues with some of its biogas development projects.

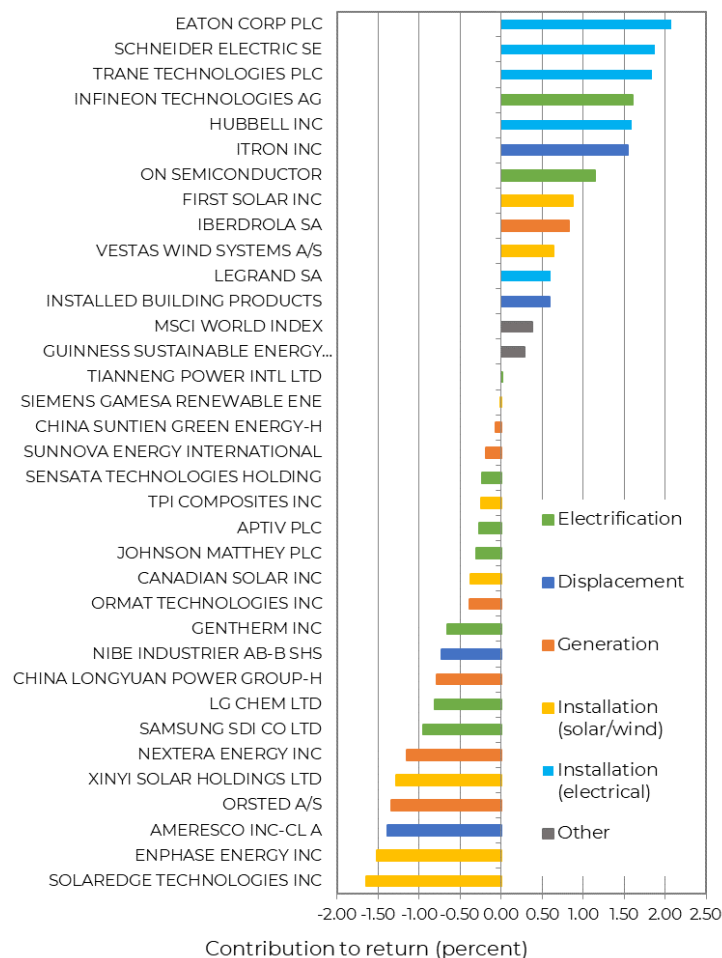
Rising interest rates throughout 2023 were negative for the sector as a whole but especially for our **generation** companies, with all but one delivering negative contribution over the year. Iberdrola was the standout positive name as a result of good operational performance, increases in regulated returns (as a result of higher interest rates), and the effect of increased investment allowances. Weakness was particularly acute at Orsted as the company issued profit warnings and impairments driven by rising interest rates,

increased supply chain costs and weaker than expected IRA tax credit capture on its new US offshore wind developments. US renewable bellwether NextEra Energy delivered similar negative contribution as its 50% owned subsidiary NextEra Energy Partners downgraded its shareholder distribution growth guidance as a result of higher funding costs.

The solar and wind equipment subsector delivered the weakest overall contribution to the portfolio. It was led by solar inverter manufacturers Enphase and SolarEdge, which reported a sharp slowdown in activity driven by higher interest rates, distributor destocking, and changing regulation in California. This slowdown caused both companies to sharply downgrade near-term guidance, although it is likely to be temporary in nature. The collapse of Silicon Valley Bank in the first quarter also put pressure on the funding available for the broader US residential solar sector.

While US residential and offshore wind faced issues, there were pockets of strength within the broader solar and wind sectors. The strongest individual contributor in the sub sector was First Solar, just as it was in 2022, reflecting the fact that First Solar’s predominantly US solar module manufacturing process will allow the company to receive significant tax credits from the Inflation Reduction Act. Consensus estimates for First Solar’s 2026 EPS increased by 25% over the year, leaving the shares trading on around 7x P/E for that year. Vestas also delivered positive contribution for the year following very strong Q4 performance as it appears that supply chain, inflation and interest rate issues are being addressed and new wind equipment orders were above expectation.

2023 individual stock contribution in USD



Source: Bloomberg, Guinness Atkinson Asset Management estimates

The funds underperformed the Guinness Atkinson Alternative Energy universe over the year as positive subsector allocation was offset by weaker individual stock selection. Positive attribution from overweight positions in efficiency and electrical equipment companies was offset by negative attribution from our overweight positions in wind and solar equipment manufacturers. Underweight positions in battery companies and IPPs (independent power producers) was supportive over the year. Individual stock selection within electrical equipment manufacturers (Schneider Electric, Eaton, Trane and Hubbell especially) helped to offset weaker stock selection across other solar equipment manufacturers and battery companies.

The Guinness Atkinson Alternative Energy Fund was repositioned at the start of 2019 and, over the last five years, there has been some substantial volatility across various sustainable energy sectors. Over the entire period, the fund has on average been correctly positioned (overweight or underweight) to all subsectors except wind equipment and other equipment manufacturers. In terms of stock selection, our fundamental value-oriented approach has facilitated good stock selection within the efficiency, battery, EV, utility, and solar equipment sub sectors while stock selection has been negative within IPPs and other equipment manufacturers. Over the five year period, the Guinness Atkinson Alternative Energy Fund has delivered a return that has been in excess of its investment universe, based on an equal weighted average calculation.

**Attribution of Guinness Atkinson Alternative Energy Fund versus the universe (2019-2023)**

Subsector	Average weight			Indicative attribution	
	Universe	Fund	Relative	Sector allocation	Stock selection
Alternative Fuel	3.9%	0.0%	Underweight	Positive	Neutral
Efficiency	10.1%	13.3%	Overweight	Positive	Positive
Battery	14.3%	12.0%	Underweight	Positive	Positive
Electric Vehicles	19.9%	18.6%	Underweight	Positive	Positive
IPP	16.8%	14.7%	Underweight	Positive	Negative
Utility	10.4%	7.4%	Underweight	Positive	Positive
Equipment - solar	8.7%	16.6%	Overweight	Positive	Positive
Equipment - wind	2.6%	8.1%	Overweight	Negative	Neutral
Equipment - other	13.3%	9.3%	Underweight	Negative	Negative

Source: Guinness Atkinson Asset Management estimates, Bloomberg; to December 31, 2023

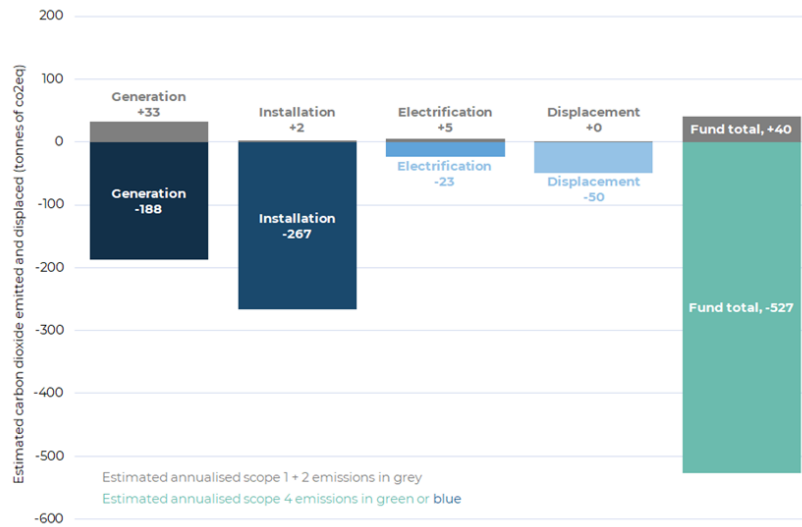
**Positive decarbonization impact of portfolio companies**

The Guinness Atkinson Alternative Energy strategy invests in companies playing a key role in global decarbonization, providing a vehicle for investors to align their capital with this positive impact.

In September 2023, we published our latest impact report which detailed the positive decarbonizing impact of the companies held in the portfolio at the end of 2022 (based on calendar year 2022 data). Our headline finding was that the companies in our portfolio sold products and services that helped to displace 527 tonnes of CO2e per USD\$1m of portfolio assets. This figure is based on estimates for energy saved, electric miles traveled, and clean energy generated compared to the continued use of incumbent fossil fuel technologies. In delivering this positive impact, we estimate that the companies in our portfolio generated an annualized “carbon cost” of around 40 tonnes of CO2e per USD\$1m of portfolio assets, based on scope 1 and 2 emissions data.



Estimated annualized carbon cost vs carbon displaced (tonnes) per US\$1m of AUM by sector



Source: Guinness Atkinson Asset Management estimates; to December 31, 2022

## Key themes in the portfolio

Within the portfolio, the weighting to consumption (i.e. the demand side of the energy transition) decreased from 44.9% at the end of 2022 to 43.9% at the end of December 2023 while the weighting to renewables (i.e. supply side) grew from 49.3% to 51.9%. We currently reflect the consumption (i.e. displacement and electrification sub sectors) and renewables (i.e. installation and generation sub sectors) by combining them into the following investment themes:

### Key themes in the Guinness Atkinson Alternative Energy Fund

Theme	Example holdings	Weighting (%)
1 Electrification of the energy mix		25.2%
2 Rise of the electric vehicle and auto efficiency		21.2%
3 Battery manufacturing		7.3%
4 Expansion of the wind industry		10.1%
5 Expansion of the solar industry		13.3%
6 Heating, lighting and power efficiency		15.3%
7 Geothermal		3.3%
8 Other (inc cash)		4.2%

Source: Guinness Atkinson Asset Management estimates; December 31, 2023

We expect investor interest in sustainable energy equities will recover in 2024, reflecting the importance of energy security and increased individual, social and government pressures for consumers to become more energy efficient and for producers to increase their share of sustainable energy generation. We believe that the Guinness Atkinson Alternative Energy portfolio of 30 broadly equally

weighted positions, chosen from our universe of around 250 companies, provides concentrated exposure to the theme at attractive valuation levels that are particularly attractive relative to consensus earnings growth expectations.

Jonathan Waghorn, Will Riley, Jamie Melrose, and Dan Hobster

January 2024

## Performance

As of 12/31/2023	YTD	1 Year	3 Years	5 Years	10 Years
<b>GAAEX</b>	-2.39%	-2.39%	-2.60%	17.54%	3.71%
<b>MSCI World Index NR</b>	23.79%	23.79%	7.27%	12.80%	8.60%
<b>MSCI Global Alternative Energy Index</b>	-25.20%	-25.20%	-16.68%	9.22%	3.78%

All returns after 1 year annualized.

Inception 03.31.2006 Expense ratio\*1.10% (net); 1.70% (gross)

**Performance data quoted represents past performance; past performance does not guarantee future results. The investment return and principal value of an investment will fluctuate so that an investor's shares, when redeemed, may be worth more or less than their original cost. Current performance of the Fund may be lower or higher than the performance quoted. Performance data current to the most recent month end may be obtained by visiting [www.gafunds.com](http://www.gafunds.com) or calling 800-915-6566.**

\* The Advisor has contractually agreed to reduce its fees and/or pay Fund expenses (excluding Acquired Fund Fees and Expenses, interest, taxes, dividends on short positions and extraordinary expenses) in order to limit the Fund's Total Annual Operating Expenses to 1.10% through June 30, 2026. To the extent that the Advisor absorbs expenses to satisfy this cap, it may recoup a portion or all of such amounts absorbed at any time within three fiscal years after the fiscal year in which such amounts were waived or absorbed, subject to the expense cap in place at the time recoupment is sought, which cannot exceed the expense cap at the time of the waiver. The expense limitation agreement may be terminated by the Board of the Fund at any time without penalty upon 60 days' notice.

MSCI World Index captures large and mid cap representation across 23 Developed Markets countries. With 1,546 constituents, the index covers approximately 85% of the free float-adjusted market capitalization in each country.

MSCI Global Alternative Energy Index includes developed and emerging market large, mid, and small cap companies that derive 50% or more of their revenues from products and services in Alternative energy.

Cash Flow Return on Investment (CFROI) is a valuation metric that acts as a proxy for a company's economic return. This return is compared to the cost of capital, or discount rate, to determine value-added potential. CFROI is defined as the average economic return on all a company's investment projects in a given year.

Price-to-Earnings (P/E) Ratio is the ratio for valuing a company that measures its current share price relative to its earnings per share.

Earnings Per Share (EPS) is a company's net profit divided by the number of common shares it has outstanding.

Scope 1 Emissions are direct greenhouse gas emissions that occur from sources that are controlled or owned by an organization (for example, emissions associated with fuel combustion in boilers, furnaces, vehicles).

Scope 2 Emissions are indirect greenhouse gas emissions associated with the purchase of electricity, steam, heat, or cooling. Although scope 2 emissions physically occur at the facility where they are generated, they are accounted for in an organization's greenhouse gas inventory because they are a result of an organization's energy use.

Fund holdings and/or sector allocations are subject to change at any time and are not recommendations to buy or sell any security.

One cannot invest directly in an index.

Earnings Growth is not a measure of future performance.

Opinions expressed are subject to change, are not guaranteed and should not be considered investment advice.

*The Guinness Atkinson Alternative Energy Fund's investment objectives, risks, charges and expenses must be considered carefully before investing. The statutory and summary prospectuses contain this and other important information and can be obtained by calling 800- 915-6565 or visiting [www.gafunds.com](http://www.gafunds.com). Read and consider it carefully before investing.*

**The Fund invests in foreign securities which will involve greater volatility and political, economic and currency risks and difference in accounting methods. The risks are greater for investments in emerging markets. The Fund also invests in smaller and mid-cap companies, which will involve additional risks such as limited liquidity and greater volatility than larger companies. The Fund's focus on the energy sector to the exclusion of other sectors exposes the Fund to greater market risk and potential monetary losses than if the Fund's assets were diversified among various sectors.**

Top 10 Holdings as of 12/31/2023:

1.	Iberdrola SA	4.54%
2.	Vestas Wind Systems A/S	4.48%
3.	Schneider Electric SE	4.47%
4.	Infineon Technologies AG	4.43%
5.	Trane Technologies PLC	4.38%
6.	Eaton Corp PLC	4.33%
7.	Legrand SA	4.29%
8.	ON Semiconductor Corp	4.25%
9.	Nextera Energy Inc	4.15%
10.	Hubbell Inc	4.03%

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