2023 Outlook for Sustainable Energy

The Guinness Sustainable Energy Team

January 2023

Executive Summary

Energy security replaced decarbonisation at the top of government policy agendas in 2022. The energy transition accelerated as activity in solar, wind, electric vehicles and energy efficiency were all well ahead of expectations. Improved relative economics of sustainable energy generation versus fossil fuels, despite raw material and energy inflation, was critical to this inflection. Significant investment plans from the EU and US were announced, giving greater clarity around a higher long-term growth opportunity for the sector and sustainable energy equities reacted positively to the news. Our portfolio continues to offer broad exposure to companies that are well placed to benefit from an energy transition that will gather pace through the remainder of this decade.

In 2022, **energy security** has become arguably the most important catalyst driving the energy transition, reflecting governments' desire to reduce reliance on fossil fuels, whose prices spiked due to Russia's invasion of Ukraine. This energy crisis is accelerating the transition towards sustainable energy sources that help to reduce energy-importing nations' reliance on fossil fuel imports.

Much of the key policy support for the energy transition in 2022 was enacted with a focus on improved energy security, including:

- **The REPowerEU deal** which was passed as a direct response to the invasion of Ukraine. The EU intends to invest €210bn between 2022-27 and a total of €300bn by 2030 with a particular focus on renewable energy generation (€86bn) and energy efficiency (€97bn).

- **The Inflation Reduction Act (IRA)** which included $369bn of direct funding and simplified, extended 10-year tax credits that target climate and energy security across electricity generation, transport, industrial manufacturing, buildings, and agriculture. The incentives may help increase US utility-scale annual solar installations by 5x and US wind installations by 2x over the next three or four years compared to 2020 levels.

Supporting these two significant policy steps were the **Chinese 14th renewable energy plan** and the **COP27 climate conference**. The Chinese plan targets a 50% increase in renewable energy generation in 2025 (versus 2020) while the COP27 conference kept the higher end of the ambition of the Paris Agreement (a 1.5° temperature increase target) although was short on specific new targets.

While energy transition growth plans were ratchetted higher, the actual pace of the transition in 2022 also accelerated. We saw around 380 GW of new **renewable generation capacity** installed, 90 GW higher than the record installations seen in 2021 and around double the 194 GW installed in 2019. Solar represented nearly two-thirds of the new capacity additions, with wind installations at around 25% and hydro in third place. **Renewable electricity generation** increased by around 7% to over 8,500 TWh, outpacing global electricity demand growth (estimated at 3% in 2022). **Electric vehicle sales** surged, reaching around 13% of global light auto sales, up from just over 3% in 2020 driven by China (60% of the market) with Europe now a distant second.

High energy prices catalysed the need for efficiency and the IEA estimates that global energy intensity improved by 2% in 2022. This is meaningfully higher than the 0.5-0.6% levels seen in the pandemic years but still not enough to hit net zero by 2050, according to the IEA. Investment into energy efficiency reached $560bn in 2022 (versus $400bn pa from 2015-2020).

The disruption to energy markets in 2022 brought sharp **energy price inflation** to the world economy. Companies involved in the manufacturing of sustainable energy equipment were not immune to these inflationary pressures, with energy inflation eclipsing the post-COVID raw material cost inflation and supply chain issues that have started to abate. While inflation was acute in the key battery metals of lithium and nickel, battery companies were able to adjust their cathode chemistries and deliver economies of scale, helping to contain battery price increases at 7% in 2022, leading to prices being broadly flat versus 2020.

Whilst inflationary pressures increased the cost of installing and generating renewable power in 2022, we observe that **renewable energy generation continued to become relatively more economic than fossil fuels** as the year progressed. Improved relative economics as well as security of supply considerations will help to sustain strong demand for sustainable energy activities during any potential global recession.

Against this backdrop, the **Guinness Sustainable Energy Fund** delivered a total return (USD) of -12.5%, outperforming the MSCI World Index (net return) at -18.1%. Solar equipment manufacturers were the strongest performing subsector, whilst our electrification sub sector (including electric vehicle-oriented companies) was the weakest. Eight of our top ten performing stocks were US listed companies, reflecting a strong positive swing in sentiment after the passage of the IRA. Three of the eight weakest performers were Chinese (Hong Kong) listed entities, reflecting the negative economic momentum and poor sentiment in that market.

Looking ahead to 2023 and beyond, we expect further acceleration of the transition:

- On the supply side of the energy transition, the IEA is forecasting that **renewable power additions** over the coming five years will be just over 2,400 GW; a 30+% increase on its previous five-year forecast and their largest upward revision. The world is set to add as much renewable capacity in the next five years as it did in the past 20 years, equivalent to the entire current power capacity of China.

- The IEA has described **solar power** as "the cheapest electricity in history" and large-scale solar remains at the bottom end of the cost curve. Globally, we expect solar installations to grow in 2023 by 50 GW to around 310 GW, with all key regions seeing higher installations across a broader spread of countries. Polysilicon prices have peaked, bringing cost relief for cell and module manufacturers, supporting consumer demand.

- Global **wind** installations are expected to grow in 2023 to a record level of 113 GW, driven by global policy support in China, Europe and the US. The raw material and supply chain issues of 2021 and 2022 will increasingly turn into tailwinds, helping to keep installations at the current high levels and give us confidence to increase our long-term installation rate estimates. We believe that global wind capacity should nearly triple by 2030 (20%pa growth from 2021) with offshore wind growing nearly five times.

- **EV sales should reach 12-13 million in 2023**, representing around 15% of total passenger vehicle sales, taking the global EV stock to nearly 30 million vehicles. Improved economics, better range and quicker charging times are the key drivers of improved EV sales. The end of Chinese EV subsidies in January 2023 could well affect demand this year.

- **Battery demand** for use in EVs and energy storage will accelerate further in 2023 despite battery metal prices remaining at elevated levels. Moderation of commodity prices, improvements to cell chemistry and efficiency improvements in battery pack design and manufacturing will help in achieving the $100/kWh level at which mass market EVs become affordable. This tipping point is likely delayed to 2027.

The outlook we summarise 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 COP27. 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.

RISK: *The Guinness Sustainable Energy Fund is an equity fund. Investors should be willing and able to assume the risks of equity investing. The value of an investment and the income from it can fall as well as rise as a result of market and currency movement, and you may not get back the amount originally invested. Further details on the risk factors are included in the Fund's documentation, available on our website. The Guinness Sustainable Energy Fund is managed for capital growth and invests in companies involved in the generation, storage, efficiency and consumption of sustainable energy sources (such as solar, wind, hydro, geothermal, biofuels and biomass). The Fund is actively managed with the MSCI World Index used as a comparator benchmark only.*

At 31 December 2022, the **Guinness Sustainable Energy Fund** traded on a 2023 P/E ratio of 19.1x and 2023 EV/EBITDA multiple of 11.6x (around 10-20% lower than the same one year forward metrics published in our last annual outlook). The fund trades at a premium to the MSCI World, reflecting greater expectation for growth from sustainable energy companies relative to the index. As a sense check, we see that consensus EPS growth (2021-2024E) of the portfolio (at 18.8%pa) is well ahead of the MSCI World (at 7.2%pa).

This document details how the growth outlook for the sector has improved in 2022 and the growth premium of the fund versus the MSCIWorld (11.6%pa) is markedly higher than the 7.8%pa that we published in our prior annual outlook. Looking over the next five years, we believe that the portfolio is likely to deliver normalised earnings growth of around 14%pa, well ahead of growth in the MSCI World Index, that will bring the fund P/E ratio down from the current 19.1x for 2023E to around 13x in 2026E. Our current portfolio is summarised below by investment theme:

Key themes in the Guinness Sustainable Energy Fund

	Theme	Example holdings	Weighting (%)
1	Electrification of the energy mix	sunnova, NextEra Energy	20.9%
2	Rise of the electric vehicle and auto efficiency	Sensata Technologies, APTIV	21.5%
3	Battery manufacturing	Samsung SDI	8.4%
4	Expansion of the wind industry	Vestas	8.2%
5	Expansion of the solar industry	CanadianSolar	16.6%
6	Heating, lighting and power efficiency	NIBE Industrier, Trane Technologies	15.0%
7	Geothermal	Ormat	3.6%
8	Other (inc cash)		5.8%

source: Guinness Global Investors (31 Dec 2022)

This document reviews the sustainable energy sector and fund in 2022 and provides an outlook for 2023 and beyond. We have split the document into three sections:

i) Developments in sustainable energy policy and 'macro'

ii) Analysis of the four key sustainable energy subsectors: energy displacement, electrification, generation and installation/equipment

iii) Performance, positioning and valuation of the Guinness Sustainable Energy Fund

Sustainable energy policy and macro

Energy transition policy: major strides taken in 2022

When thinking about the catalysts for the energy transition, much of the focus in 2020 and 2021 was around ambitions to control carbon emissions and reduce global temperature increases. In 2020, we saw the proposal of the EU Green Deal, plus Joe Biden setting out a clean energy spending plan as a centrepiece of his manifesto for the US presidency. Much of the rhetoric around these announcements put climate change at the forefront of the argument: reducing global carbon emissions via the adoption of low-carbon energy technologies. This rhetoric was supported in 2021 by the return of the US to the Paris Agreement, the publication of the IPCC report on climate change, then the COP26 climate conference, each event doubling down on the need to achieve net zero by 2050 and limit warming to 1.5 degrees.

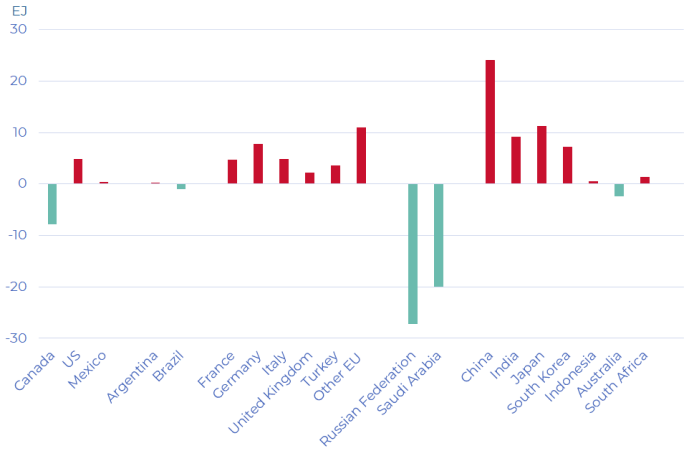
In 2022, with the fallout of the Russia/Ukraine war at the forefront of governments' minds, **energy security** has become arguably the most important catalyst driving the energy transition. Indeed, the events of last year have triggered the largest ever upward revision of the International Energy Agency's (IEA) renewable power forecasts, with the 2022-27 expansion in renewables now expected to be 30% larger than that forecasted a year earlier.

The issue is particularly critical for the EU, which imports 57% of its energy and, prior to the invasion of Ukraine, relied on Russia for 41% of its natural gas, 27% of its crude oil/oil product and 47% of its coal imports. Within the EU, Germany imports nearly 64% of its energy consumption (up from 59% in 2000), with Russia representing one third of both its crude oil/oil product and natural gas demand in 2021.

Whilst exports of hydrocarbons from Russia are currently the key debate, energy security across the world has long been a major strategic topic, particularly for the largest net oil & gas importing regions, being Europe and Asia. Indeed, we would say that for China, security of supply and development of strategic new industries are the most important catalysts for the energy transition, above climate concerns. Today, China is comfortably the largest net energy importer in the world, importing around 14 Bcf/day of gas and 11m b/day of oil, much of which flows from OPEC countries in the Middle East.

G20: Net oil & natural gas imports/exports (Exajoules)

*Imports in **red** and exports in **green***



Source: BP Statistical Review; Guinness Global Investors

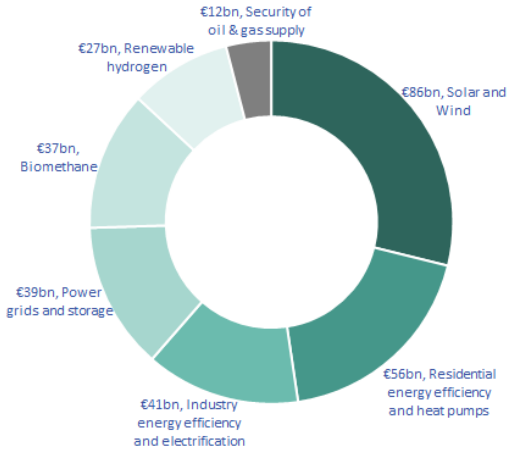
For European countries, it is proving extremely challenging to remove Russian oil and natural gas from the supply mix in the short term. However, it is a credible ambition to reduce reliance by the latter part of the decade (and beyond) via energy efficiency and a shift to non-hydrocarbon sources of energy. The simple point here is that sustainable energy tends to be localised and distributed, and reduces energy importing nations' reliance on imports.

Much of the key policy support for the energy transition that followed in 2022 was enacted with a focus on improved energy security, including:

- **REPower EU**. Building on the EU Green Deal, the REPowerEU deal was announced in April, designed to increase the resilience of the EU energy system following the Russian invasion of the Ukraine. The deal includes increasing domestic renewable energy capacity and improving energy efficiency while taking higher non-Russian LNG and pipeline gas imports together with larger volumes of biomethane and renewable hydrogen. The plan builds on the EU's 'Fit for 55' proposals which is designed to deliver a 55% reduction in GHG emissions by 2030 (vs 1990) and is expected to reduce Europe's reliance on natural gas by a further 12 bcf/day (30% of current European gas demand).

  To deliver the REPowerEU Plan, the EU intends to invest €210bn between 2022-27 and €300bn by 2030. The big winners will be renewable energy (€86bn) and energy efficiency (€97bn), benefiting from c60% of the funding.

Split of 2022-2030 funding for REPowerEU



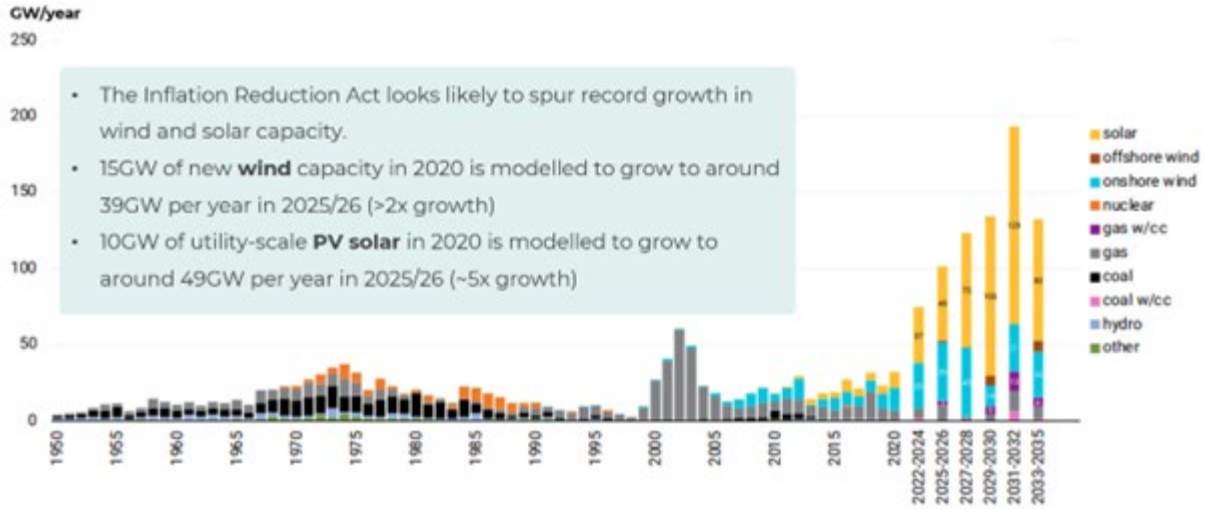
Source: European Commission

Reflecting its untenable energy position, Germany has announced the boldest moves, including the building of six new LNG import terminals and creating the Renewable Energy Sources Act which brings the 100% renewable power target forward to 2035 from 2040. Facing the threat of gas shortages, Germany has restarted some mothballed coal fired power generation capacity and has delayed the closure of two nuclear power plants.

- **Inflation Reduction Act (IRA).** Several months after the proposed Build Back Better bill foundered, key Democratic hold-out Senator Joe Manchin surprised Senate Republicans (and his own party) by striking a deal with Senate majority leader, Chuck Schumer, to advance a package of clean energy incentives as part of the IRA. The $369bn part of the package that targets climate and energy security focuses on reducing emissions from electricity generation, transport, industrial manufacturing, buildings, and agriculture. Support is provided via direct funding as well as simplified, extended 10-year tax credits which provide a higher level of certainty for investors compared to previous annually renewed tax credit schemes.

  Although smaller than President Biden's initial BBB proposal, the size and breadth of the bill is significant. Simply speaking, nearly every aspect of the energy transition is likely to benefit from the proposals, but key beneficiaries are US-domiciled companies active in solar and wind manufacturing; residential and utility-scale battery storage; commercial building energy efficiency; green hydrogen; and, over the longer-term, carbon capture projects. According to Princeton University, the incentives may help increase US utility-scale annual solar installations by 5x and US wind installations by 2x over the next three or four years compared to 2020 levels. In terms of carbon emissions, the IRA is estimated to help lower US net greenhouse-gas emissions by 40-42% below 2005 levels by 2030 (a significant increase to the pre-IRA trajectory of 27-30% but still below Biden's target reduction of 50-52% by 2030).

Annual capacity additions (GW/year, 1950–2020) vs est additions under IRA (2022-35)



source: Princetown University; Guinness Global Investors

While the United States is in a far stronger position than the EU in terms of energy security, the IRA is clearly designed to improve near-term and long-term security via the development of domestic renewable energy and energy transition industries.

Whilst energy security dominated the agenda in 2022, climate concerns came back to the fore in November, with Egypt hosting the **COP27 climate conference**. The conference was always promoted as a less important event than COP26 twelve months prior, nevertheless there was hope of countries improving their pledges around decarbonisation (Nationally Determined Contributions or NDCs) and the wider energy transition. The Final Declaration of COP27, agreed on unanimously, kept the higher end of the ambition of the Paris Agreement (a 1.5° temperature increase target) intact, and explicitly mentioned the need to reduce global GHG emissions by 43% in 2030 vs 2019 levels, but only after a challenging set of negotiations. While some countries proposed to weaken the 1.5° temperature increase target, others pushed back strongly, with the EU delegation threatening to leave the negotiations.

Interestingly, the Final Declaration from COP27 also quoted the IEA 2022 energy outlook on financing needs, highlighting that "*about USD 4 trillion per year needs to be invested in renewable energy up until 2030 to be able to reach net zero emissions by 2050, and that, furthermore, a global transformation to a low-carbon economy is expected to require investment of at least USD 4–6 trillion per year*".

Specific energy transition sector announcements were fairly thin on the ground at COP27, though we did note a strengthening of the "Global Offshore Wind Alliance" (GOWA). GOWA was launched in September by the International Renewable Energy Agency, Denmark and the Global Wind Energy Council, and was joined during COP27 by nine new members, including Germany, Ireland, Japan, Netherlands, Norway, UK and the USA. The alliance brings together governments, the private sector and international organisations, and brings pledges for a rapid ramp up of offshore wind to tackle the climate and energy security crises.

Beyond COP27, it was encouraging to see the **US and China resume climate negotiations at the November G20 summit**, hosted by Indonesia. Negotiations between the two had previously stalled in August, knocked off course by tensions over trade and security. Deals between China and the US in the past helped to pave the way for the 2015 Paris Agreement, and last year culminated in the announcement of cooperation made at COP26. The G20 summit concluded with a commitment from all participants to the goals of the Paris Agreement, and the need to keep the 1.5C limit within reach. The G20 Bali Leader's Declaration reiterated the COP push to phase down coal-fired power, though it stopped short of a wider move away from other fossil fuels.

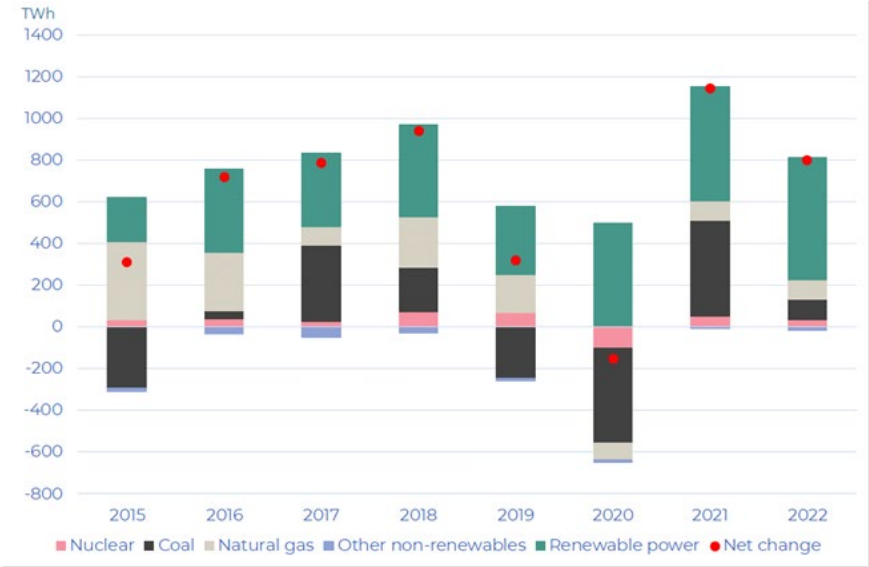
Renewable installations and generation in 2022

Around 380 GW of **new renewable generation capacity** was installed in 2022, 90 GW higher than the record installations seen in 2021 and around double the 194 GW installed in 2019. At over 250 GW, solar represented around two-thirds of the new capacity additions. Wind (at around 100 GW) came next, followed by hydropower.

Renewable **electricity generation** in 2022 is likely to have increased by around 7%, reaching over 8,500 TWh, and outpacing global electricity demand (estimated 3% growth in 2022). Most of the rise in renewable power

generation can be attributed to the increase in installed capacity. However, the rise in generation is a little higher than expected due to capacity increases alone. Other contributing factors are weather conditions (for example low wind speeds in 2021 in China and the EU), the timing of capacity additions, and the rise in higher output offshore wind.

Change in electricity generation 2015-2022



source: IEA

In Europe, governments delayed coal plant phase-outs and lifted restrictions to increase the availability of coal generation, in an effort to boost security of supply. Looking into 2023, 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 by 1%.

Disruption to energy markets in 2022 brought sharp **energy price inflation** to the world economy. Companies involved in the manufacturing of sustainable energy equipment were not immune to these inflationary pressures, with energy inflation eclipsing the post-COVID raw material cost inflation and supply chain issues that have started to abate. Whilst these inflationary pressures increased the cost of installing and generating renewable power in 2022, we observe that renewable energy generation continued to become relatively more economic than fossil fuels as the year progressed. Improved relative economics as well as security of supply considerations will help to sustain strong demand for sustainable energy activities during any potential global recession.

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 de-carbonisation. 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 thirty 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

Energy efficiency is a key pillar of the RePowerEU plan. The EU had previously set itself a challenging target to consume 9% less energy in 2030 than in 2020 and the new plan saw this ratcheted up to 13%, supported by €100bn of funding for residential and industrial efficiency. A few months later the US Inflation Reduction Act included $53bn in support for building efficiency.

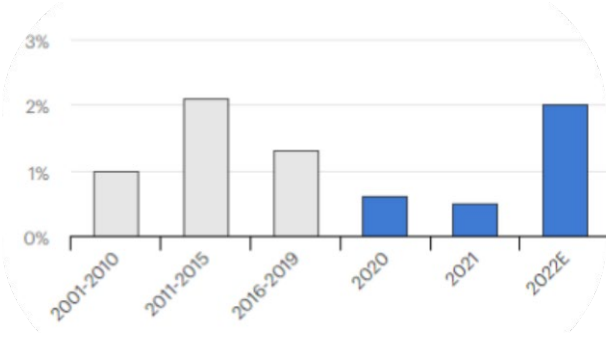
The focus on building efficiency is important, since buildings are responsible for 30% of primary energy consumption and nearly 40% of global carbon emissions. Electrifying heating (heat pumps) and improving the efficiency of heating (insulation), cooling (efficient HVAC), and lighting (LEDs) offers some of the quickest ways to decarbonise whilst lowering energy bills and improving energy security.

Despite the importance of energy efficiency, investment in energy efficiency from 2015-2020 remained flat at around $400bn per annum. More recently, rising energy costs have increased the incentive to invest, driving a 27% increase in 2021. This rose a further 16% in 2022, bringing total efficiency spending to $560bn. Building efficiency comprising heating, cooling, lighting, and appliances, made up over half of this spend at $300bn.

This higher level of efficiency spending alongside behavioural change is expected to result in a 2.0% improvement in global energy intensity in 2022. This represents a meaningful increase from the 0.5-0.6% levels seen in the pandemic years but still not enough to hit net zero by 2050, according to the IEA.

Annual global primary energy intensity improvement

Source: IEA



While a number of energy efficiency investments are already economic today (typical payback periods would be 1-3 years for LEDs and 3-5 years for loft / cavity wall insulation) others are still too expensive for most consumers. We expect global governments to continue to incentivise the roll out of these technologies through subsidies and minimum efficiency standards to improve energy security and deliver the transition to a low-carbon future.

Alternative fuels

Alternative fuels are materials or substances which can be used as fuel to displace coal, oil, and natural gas. They encompass solid biofuels (also known as biomass e.g. wood, bagasse, animal waste), biogas (e.g. renewable natural gas, biomethane), and liquid biofuels. Below we will predominantly focus on the outlook for liquid biofuels, including bioethanol (derived from corn/sugar) which displaces gasoline, bio-based diesels (derived from plant and animal fats) which displace conventional diesel, and Sustainable Aviation Fuel (SAF, derived from multiple organic/inorganic feedstocks) which displaces jet fuel or kerosene.

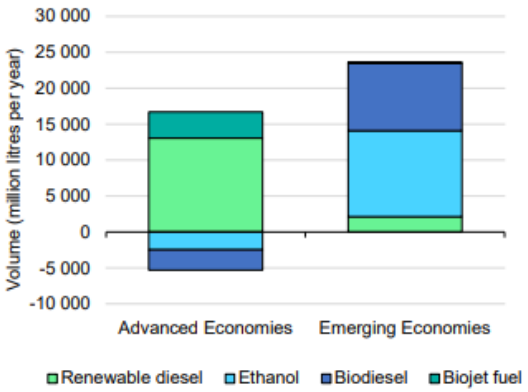
Liquid biofuel demand is expected to reach 168bn litres in 2022, representing around 4.3% of transportation fuel consumption. The US and Brazil continue to dominate the market, making up around 40% and 25% of global demand respectively, supported by strong domestic industries for corn and sugar cane.

Biofuel consumption grew 6% in 2022 versus 2021, outpacing the underlying 2% increase in world oil demand. Growth continued to benefit from government support, especially from India and Indonesia. However, high prices for retail diesel and gasoline led to a watering down of blending and environmental targets in Brazil, Finland and Sweden, lowering this year's growth by around 2ppts.

Currently, demand for biofuels is met by a roughly even split of bioethanol and bio-based diesel (biodiesel & renewable diesel) with SAF/biojet kerosene making up less than 1% of the market. By 2027, we expect global consumption of alternative fuels to increase by 20%, making up 5.4% of transport fuel. Just five countries (USA, Canada, Brazil, Indonesia, India) will be responsible for 80% of this growth.

Biofuel growth for advanced and emerging economies out to 2027

Source: IEA



In developed economies, demand will be driven by renewable diesel (which can directly replace conventional diesel) and biojet fuel. New policies introduced in the last year, namely the Inflation Reduction Act in the USA and Clean Fuel Regulations in Canada, will see the biofuel share in transport energy demand climb from 6% and 4% in 2022 to 8% and 7% respectively in 2027.

In contrast, emerging economies will see biodiesel (which is blended with conventional diesel) and ethanol make up over 90% of their increase, thanks to rising blending requirements over this period. At 30%, Indonesia currently has one of the highest blending requirements in the world and the government has ambitions to raise this over time to 40%.

However, the alternative fuel industry will continue to rely on government regulation, subsidies and tax credits for its existence. We estimate for one of the most profitable US alternative fuel manufacturers, the average level of support in 2022 amounted to around $4.50 per gallon. When compared to the relatively high average retail gasoline prices observed year to date of $4 per gallon, it is clear just how reliant government support is in decarbonising liquid fuels.

Implications of a net zero scenario on our displacement outlook

As we highlighted earlier, our base case for the energy transition assumes global energy demand growth of 1%pa, which compares to long-run average 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 with a much larger than expected share of biofuels displacing fossil fuel demand. We do not yet see the investment, industry scale or technologies in place to achieve this. Examples of changes that would be needed to align with net zero include:

- Within **efficiency**, annual energy efficiency improvements would need to jump from 2%pa currently to 4%pa by 2030 globally. This translates to building efficiency spending increasing to over $750bn per annum between 2026-2030 (from just over $400bn in a base case scenario and $300bn in 2022). Worldwide heat pump capacity would need to triple by 2030 and then double again by 2050, implying

that heat pumps meet 24% of heating demand in 2030 and 52% in 2050, up from just 8% today. Lighting sales would need to be 100% LED globally by 2030 (vs 50% in 2022).

- Demand growth for **alternative fuels** would need to increase from 4%pa to over 15%pa, taking industry production capacity from 168bn litres in 2022 to around 600bn litres by 2030. In a net zero scenario, the contribution of biofuels to transport energy demand would need to more than triple to 15% by 2030, up from 4.3% today.

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 now.

Batteries

The speedy adoption of lithium-ion batteries in recent years has been spurred on by a vast improvement in economics. According to BNEF, the volume weighted average price of a lithium-ion battery fell 88% from 2010 to 2020. Prices fell a further 6% in 2021 but this was offset by a 7% increase in 2022 due to higher prices for the key battery metals, lithium and nickel. This represented the first observed increase since 2010, taking the average price to $151/kWh.

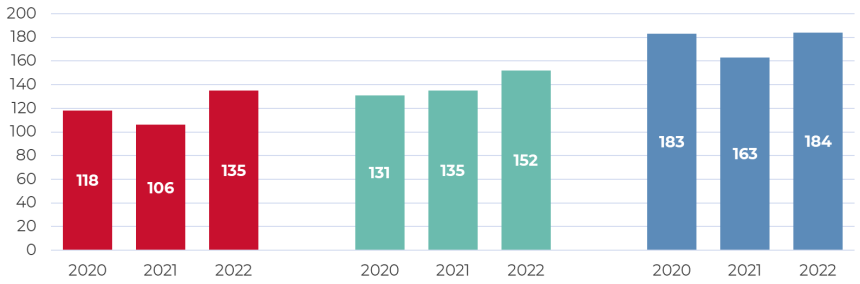
At the time of writing, lithium and nickel prices are trading 800% and 60% higher than levels seen in December 2020 as supply has struggled to keep pace with strong demand for electric vehicles. Lithium carbonate prices in China reached new peaks in 2022, exceeding $78,000 per tonne, as the market suffered from COVID-19 disruptions and long lead times (5-8 years) for new projects. Nickel prices peaked at $100,000 per tonne in April following Russia's invasion of Ukraine and a short squeeze on the London Metal exchange. This has since moderated to $29,000 per tonne, but future concerns over Russia's ability to supply its 17% share of the world's class 1 nickel could keep prices elevated.

These metals are used in the cathode, which typically represents around 60% of the cost of a cell and just under half of the cost of a battery pack. Electric vehicle batteries are dominated by three main cathode chemistries: Nickel Manganese Cobalt (NMC), Nickel Cobalt Aluminium (NCA), and Lithium Iron Phosphate (LFP) and each has specific performance and cost attributes.

Making up over half of the global cathode mix, NMC and NCA enjoy high energy densities, but require more complex and expensive thermal management to keep them stable. In contrast, LFP is much more stable and costs 10-35% less than NMC and NCA, but suffers 30% lower energy density.

Historical LFP (red), NCA (green), NMC (blue) pack prices, US$/kWh

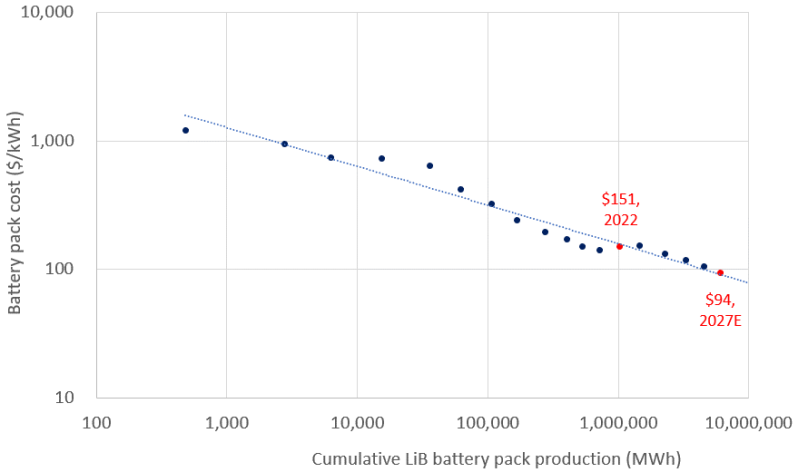
source: BNEF



Despite seeing the biggest increase in prices in 2022 (+27% for LFP vs +13% for NMC and NCA), LFP battery pack prices remain the cheapest option. Its enhanced safety and simpler supply chain (no cobalt or nickel required in the manufacturing) have made it increasingly popular among electric vehicle manufacturers, reaching a 40% share of the global cathode mix in 2022, up from just 15% in 2018. This shift towards cheaper LFP cathodes was key to limiting the increase in battery prices in 2022 to only 7%.

Cumulative demand for LiB packs (MWh) vs Battery pack price ($/kWh)

source: Bloomberg, Guinness Global Investors



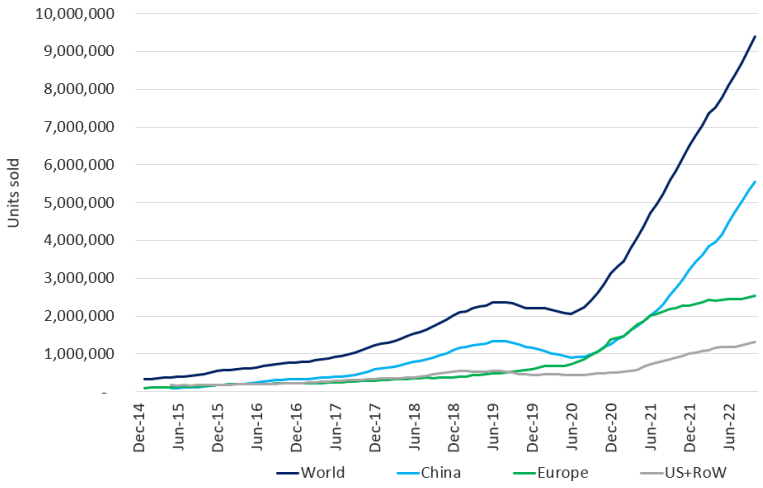
In 2020, the expectation was that the industry battery pack cost target of $100/kWh (the price at which EVs reach price parity with ICE vehicles) would be hit by 2024. On our estimates, higher lithium and nickel prices are now likely to delay this until 2027. The $50/kWh cost reduction over the next five years is likely to come equally from i) moderation of commodity prices, ii) improvements to cell chemistry (moving to higher nickel cathodes and increasing silicon content in anodes) and iii) improvements in pack design and manufacturing (moving towards cell-to-vehicle architectures, with lower scrap rates). If the current learning rate of 17% is maintained, battery pack prices could fall as low as $77/kWh by 2030 and $62/kWh by 2035.

Electric vehicles

Electric vehicle (EV) adoption continued apace in 2022 with just under 8 million plug-in vehicles sold between January and October, more than in 2019 and 2020 combined. Battery electric vehicles (BEVs) made up just under 10% of new car sales with total plug-in penetration (BEV + Plug-in Hybrids) reaching 13%. Global sales are currently growing 60% year-over-year driven largely by China, which now accounts for 60% of sales. Europe is a distant second, with around one quarter of overall EV sales, while the US trails at under 10%.

Global EV sales (rolling 12-month basis up to October 2022)

Source: Guinness, EV-Sales, Cleantechnica



Much of this growth has been driven by policy, with governments now subsidising 10-30% of the price of an electric vehicle, while bringing forward the timeline on banning internal combustion (ICE) sales. Governments cannot maintain subsidies long-term and it will be interesting to see how the Chinese markets develops in 2023 now that the long-existing NEV subsidy program has completely ended, meaning that no NEVs purchased after 1 January 2023 will be subsidised. Nonetheless, looking ahead, we believe that we are now at a tipping point where improving economics, driving range, and charging times begin to drive mass adoption.

- **Economics:** Electric vehicles cost more to buy but have lower overall running costs. Excluding China, the IEA suggest that BEVs are typically $15,000 more expensive to purchase. Assuming normalised fuel and electricity prices, we estimate that lifecycle running costs for an electric vehicle in Europe and the US are $23,000 and $13,000 lower respectively than the ICE equivalent, broadly justifying the upfront price premium.
- **Range:** The average range of a battery electric vehicle sold in 2021 was around 215 miles, just under half of an ICE equivalent. This is clearly inferior, yet average daily driving distances are only 25-55 miles, meaning that most EVs are easily capable of handling everyday distances, and the market is rapidly waking up to this reality.
- **Charge time:** Level one and two chargers (available in residential and commercial environments) are cheap and can replenish 5-30 miles of range per hour. Level three fast chargers, however, offer fast charging on longer trips, delivering at a significantly higher rate of 200-600 miles of range per hour. Once again, China is leading the regional charging infrastructure roll out with seven electric vehicles per charger whereas the EU and US lag behind at 15-20 EVs per charger.

The recent rapid growth in electric vehicle sales has caught many forecasters by surprise, leading to swift revisions to long-term adoption rates. For example, BNEF revised its 2025 forecast for EV sales penetration up to 23% in its 2022 outlook report, up from 16% in 2021. Our long-held forecast is that electric vehicles will make up 20% of new global vehicle sales by 2025, 50% by 2030 and predominantly all new vehicle sales by 2040. At that point, it implies an overall population of one billion EVs, over 60 times greater than the global stock in 2021 of 16.5 million.

Implications of a net zero scenario on our electrification outlook

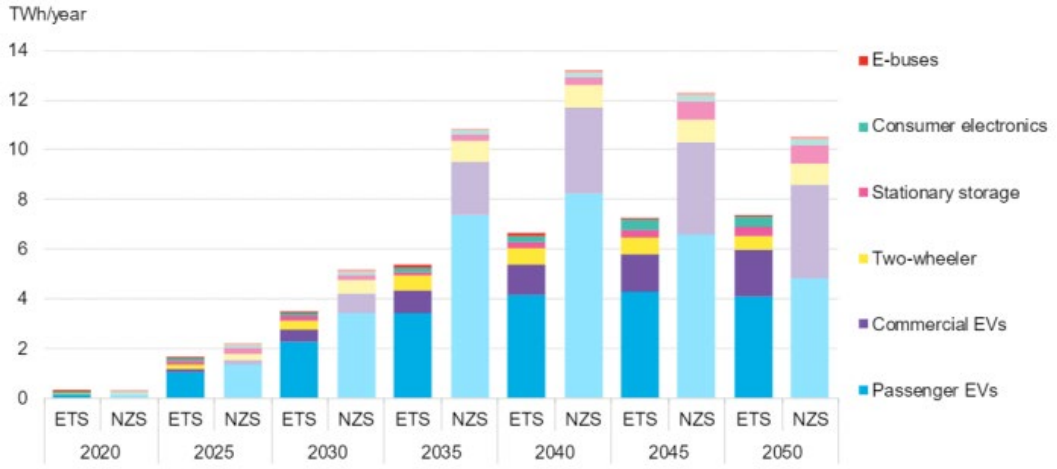
Our base case for electrification implies that there will be over one billion electric vehicles on the road by 2040, that electricity is 57% of total energy demand and that variable renewables such as wind and solar will represent 61% of global power grids. Achieving this would require annual EV sales of around 135m vehicles and annual lithium-ion battery demand of around 6,400 GWh per year in 2040.

A net zero scenario will require an even faster uptake of passenger electric vehicles (reaching 100% penetration by 2035 than 2040) and would require other transportation, such as ICE heavy trucks, to be 100% electric by 2045. To support the rollout of EVs, investment in public charging infrastructure would need to increase from $6bn in 2022 to around $40bn pa in 2030 and around $120bn pa in 2040, significantly ahead of our base case estimates.

The implication would be that electricity demand would likely grow around 3.3%pa to 2040 (faster than our base case of 2.5%pa) with variable renewables reaching 60% grid penetration in 2030 (rather than our base case of 2040) and thus rapidly displacing fossil fuels from the grid. To support the rapid electrification, according to BNEF annual battery demand would grow from 340 GWh in 2021 to 5,600 GWh by 2030 and potentially as much as 13,000 GWh by 2040 (more than double the base case estimate).

Lithium-ion battery demand under base case and net zero scenarios

source: BNEF

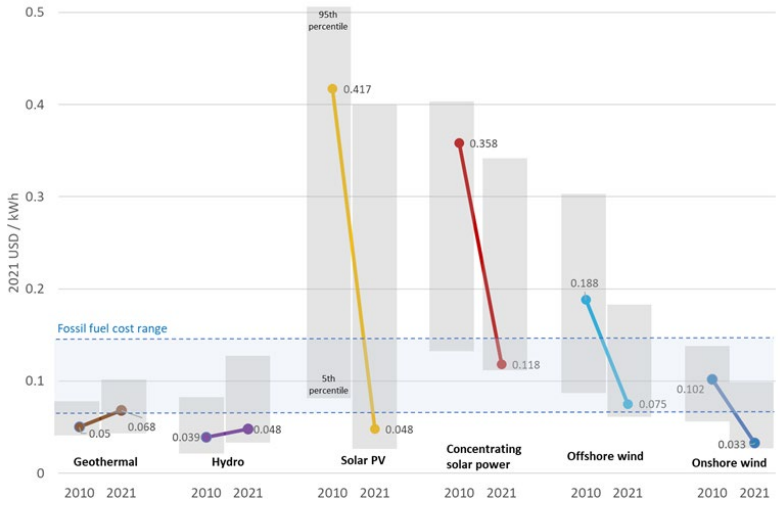


Generation & installation (equipment)

Before considering the detailed dynamics of key renewable power generation markets of wind and solar, it is worth considering the significant changes that have occurred to the economics of various renewable power generation technologies since 2010. Onshore wind and solar PV have joined hydro and geothermal power to sit at the lower end of, or below, the levelized cost of electricity (LCOE) range for new fossil fuel power generation.

The structural story of cost reduction that we have witnessed for a number of years has recently been complicated by cyclical raw material, energy and logistics cost inflation. However, while the cost of renewable power generation is likely biased upwards short-term, the relative economics of renewables versus hydrocarbons continue to improve thanks to fossil fuel generation inflation.

Global LCOE of utility-scale renewable power generation technologies (2010–2021)

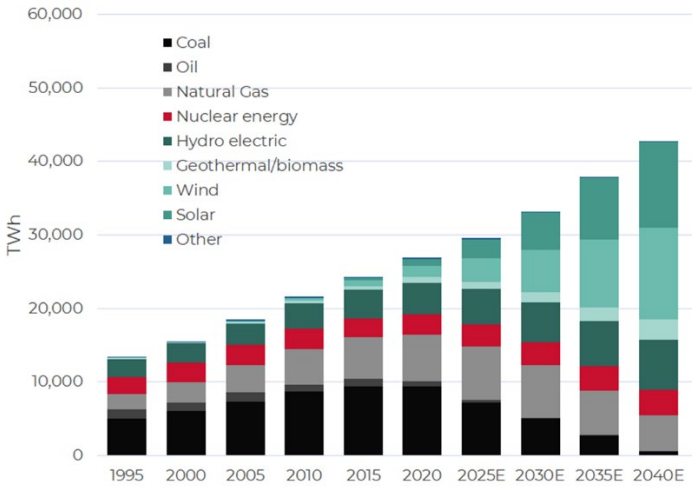


source: IRENA, Guinness Global Investors estimates

Renewable generation technologies continued to take market share in 2022, with forecasts for future renewable penetration also being raised. In its recently published 2022 Renewables Outlook, the IEA estimates that renewable power additions over the coming five years would be just over 2,400 GW; a 30+% increase on its previous five-year forecast published twelve months earlier. We expect this to drive generation from renewables to a level of over 12,000 TWh in 2026, representing around 39% of world electricity generation in that year. Around 40% of this 2026 level will be from hydropower (staying relatively flat over the period) implying the growth comes predominantly from wind and solar.

Global electricity generation by key source (1995–2040)

source: IEA, BP, Guinness Global Investors estimates

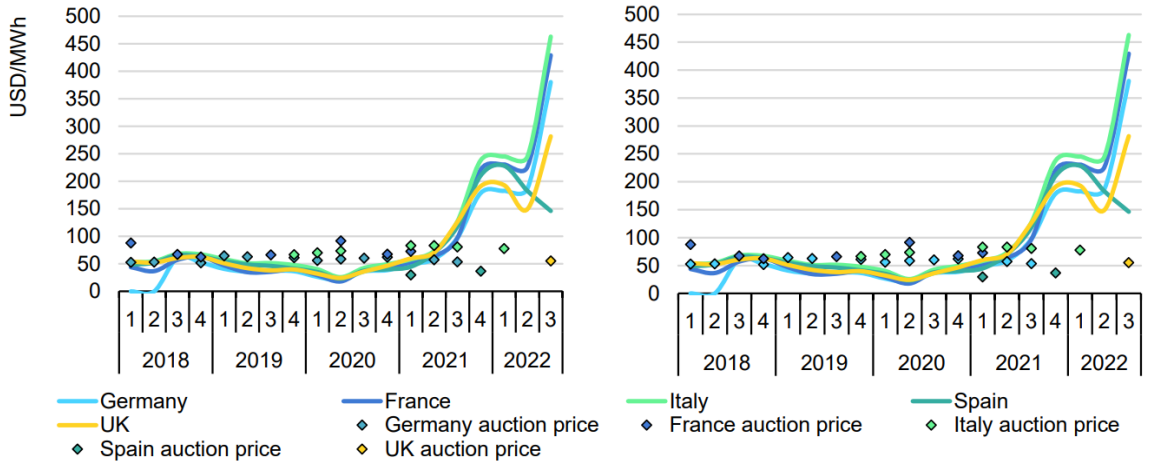


The solar sector

The relative economic attractiveness of solar power generation continued to improve in 2022. On one hand, the structural story of cost deflation that we have witnessed for a number of years has stalled as a result of cyclical raw material, energy and logistics cost inflation. But, on the other hand, industry growth has brought improved economies of scale, plus the relative economics of solar versus hydrocarbons continues to improve thanks to inflation in competing fossil fuel generation. According to the IEA, the cost of solar in 2022 (as implied by auction prices in the chart below) sits comfortably below competing fossil fuel-based options and current wholesale electricity prices, meaning that solar (or sometimes wind) is typically the most economic option for new supply that can also help to alleviate energy security concerns.

Wholesale European power prices versus solar PV (LHS) and onshore wind (RHS) auction prices

Source: IEA estimates



Solar's improved relative economics and the increased need for security of supply mean that installations in 2022 are likely to be around 260 GW, substantially higher than the 200 GW estimate that we made at the start of the year. With momentum strong, especially following the US IRA and RePowerEU deals, we introduce an estimate for 2023 module demand of 310 GW, another record year for global installations, with growth of 50 GW versus 2022.

Regionally, the key moving parts in 2022 and 2023 are as follows:

- In the **United States** we initially expected installations in 2022 (20 GW) to be lower than 2021 (30 GW) as a result of i) the Withhold Release Order (WRO) placed on various solar product imports from China, ii) concerns around the level of residential solar support coming from a clean energy infrastructure bill and iii) the impact of new net metering rules (NEM3.0) in California which reduce the attractiveness of solar economics for residential consumers. Actual installations in 2022 are now likely to be around 25 GW as demand is less likely to be impacted by NEM3.0 and the WRO. While the IRA is a clear positive for solar, we expect the effect of the bill to be felt only from 2023 and for it to be spread over a number of years, with installations reaching the 2021 peak of 30 GW again in 2023 and growing thereafter.

- Demand in **Europe** is expected to be around 45 GW in 2022, up sharply from 24 GW in 2021, as the region reacted to higher electricity prices and the need for energy security. It is here that the relative economics of solar have improved the most, and the RePowerEU deal has already started to incentivise new demand for solar installations. Looking to 2023, we see further installation increases, with Europe reaching a new record of 62 GW spread well across an increasing number of countries, leading to substantially more growth in future years.

- In **China** module demand is also likely to beat our initial estimates, reaching 95 GW in 2022 (up 30 GW on 2021) as first half 2022 installations of 40 GW were more than double the levels seen in 1H 2021. Growth has come across utility, residential and commercial and we note plans for the development of significant offshore utility scale plants in 2023. As with Europe, higher power prices have been a key factor in driving stronger demand. In mid-2022, China published its 14th five year plan for renewables which suggested that solar (and wind) installations in 2021-2025 should be double the levels seen in 2015-2020. Accordingly, we expect China will see more growth in 2023, reaching around 115 GW, double the levels seen in 2020/2021, and representing around 37% global market share.

- The rest of the **non-OECD** has also seen greater than expected growth in demand, reaching around 60 GW in 2022 (up 23 GW on 2021 levels) with demand increases well spread across Latin America (especially Brazil), African and Middle Eastern countries.

Global solar module installations, 2010-2023E (GW)

Source: BP, BNEF, PV InfoLink, IEA and Guinness Global Investors estimates

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022E	2023E
OECD solar installations (annual)														
North America	1	2	4	6	7	8	14	11	10	11	19	30	23	30
Germany	7	7	8	3	2	1	2	2	4	4	5	5	8	11
Spain	0	0	0	0	0	0	0	0	0	5	3	4	7	9
Rest of Europe	3	4	5	5	5	6	4	3	4	6	8	15	30	42
Australia	0	1	1	1	1	1	1	2	4	4	4	5	6	8
South Korea	0	0	0	1	1	1	1	1	2	3	4	4	5	6
Japan	1	1	2	7	10	11	8	8	7	7	9	7	9	9
Total OECD	**17**	**23**	**24**	**24**	**25**	**29**	**29**	**26**	**31**	**40**	**51**	**70**	**88**	**115**
Change	*10*	*7*	*0*	*0*	*2*	*4*	*0*	*-3*	*5*	*9*	*11*	*19*	*18*	*27*
Non-OECD solar installations (annual)														
China	0	3	3	14	13	19	30	53	44	33	52	65	95	115
India	0	0	1	1	1	2	5	10	11	12	4	12	17	18
Rest of non-OECD	1	3	3	4	6	6	11	9	22	34	37	37	60	62
Total Non-OECD	**2**	**5**	**8**	**18**	**21**	**27**	**46**	**72**	**77**	**78**	**93**	**114**	**172**	**195**
Change	*1*	*3*	*2*	*11*	*2*	*6*	*19*	*26*	*5*	*1*	*15*	*21*	*58*	*23*
Total solar installations (annual)	**19**	**29**	**31**	**42**	**46**	**56**	**75**	**98**	**108**	**118**	**144**	**184**	**260**	**310**
Change	*11*	*10*	*2*	*11*	*4*	*10*	*19*	*23*	*10*	*10*	*26*	*40*	*76*	*50*

Solar supply chain in 2022 and 2023

All parts of the solar module manufacturing chain, except polysilicon, appear to have been in oversupply again in 2022 and are likely remain so in 2023. We treat nameplate capacity estimates here with some caution because technological advances and cost improvements can bring rapid capacity obsolescence, meaning that actual supply may well be lower than nameplate capacity. Nonetheless, significant new manufacturing capacity is planned across the entire value chain which will likely bring lower module prices and will likely help to support global solar module demand.

- **Polysilicon** is a key raw material for a solar wafer. The poly market continued to be the tightest part of the solar market in 2022, evidenced by prices rising through the year to reach nearly $40/kg in August. Poly prices have been high enough over the past two years to incentivise new supply and we can now see signs that the new supply is on the cusp of arrival. BNEF estimates that the capacity of the polysilicon industry rose to 900 mtpa in 2022 (sufficient to support over 300 GW of solar module manufacturing) but that new capacity additions of nearly 2,500 mtpa are being planned by either existing players or new entrants. While many plants will not be built and many will take longer than expected to reach full production capacity, the scale of capacity growth leads us to believe that poly prices will fall in 2023 and beyond, allowing margin expansion elsewhere in the value chain as well as lower solar module prices.

- **Wafer and solar cell** manufacturing capacity, according to PV InfoLink, will reach 583 GW in Q4 2022 and will grow a further 15% in 2023. In 2022, wafer and cell companies have generally been able to pass through cost inflation and to defend reasonable margins but, similar to polysilicon, this may come under pressure in 2023 as new capacity is added. Unlike polysilicon however, the wafer business is highly concentrated, with nearly 80% of 2022 wafer capacity in the hands of the five largest producers. This may be a factor to help support prices in 2023. Technological changes in wafer manufacturing could lead to existing capacity becoming obsolete, leaving this part of the market tighter than it appears.

- **Solar module** prices moderated in the second half of 2022 with prices likely to average the same level as 2021. With elevated polysilicon and power prices, it is the module manufacturers that suffered the greatest margin compression in 2022. Module manufacturing nameplate capacity in 2022 is estimated to have been around 470 GW, of which around 310 GW is newer 'Tier 1' capacity with lower costs resulting from the scale of manufacturing and new technologies. In 2023, this likely expands to 660 GW and potentially to as high as 820 GW by the end of the year.

Polysilicon and solar module pricing

source: Bloomberg

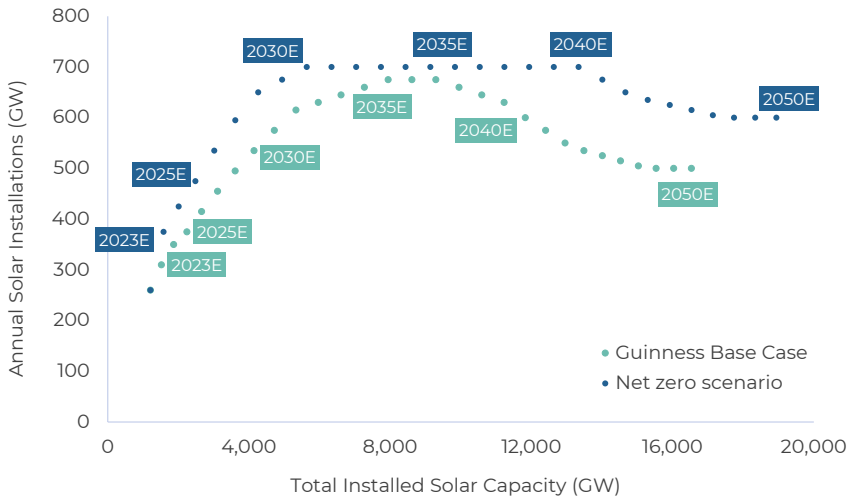
Implications of a net zero scenario on our solar outlook

The long-term outlook for solar has improved through 2022. In August, BNEF updated its long-term projections, increasing its 2030 module installation forecast to 460 GW from the prior year's forecast of 334 GW, an increase of 37%. The impact of the increase is that a total of 3.4 TW of solar is forecast to be installed globally this decade (up 0.8 TW, or 30%, on the previous forecast) with total capacity in 2030 being 4.2 TW (versus prior estimate of 3.4 TW). This, however, is not consistent with a net zero scenario.

In BNEF's net zero scenario, total installed solar capacity would need to be around 5.3 TW by 2030 (25% higher than their base case). For comparison, the Guinness net zero scenario indicates that total installed capacity would need to be 5.6 TW in 2030 (a compound growth rate of 22%pa from 2021) and that reaching this level of installed capacity would require annual installations to reach as much as 700 GW pa. While solar is a key and well-placed component of any net zero energy transition scenario, the industry still has to deliver more growth in order to be fully aligned.

Global solar annual installations, base case and NZE scenario

source: IEA, IPCC, Guinness Global Investors



The wind sector

Despite recent headwinds, the long-term outlook for the wind industry remains very positive as the sector plays a critical role in global decarbonisation and the energy transition. Global wind generation capacity today is around 918 GW, but installations have temporarily paused as the industry has wrestled with COVID-related disruptions and various "regulatory airpockets". Looking forward, we expect these issues to inflect positively over the next few years, leading to a sustained ramp in global wind installations out to 2030.

Below, we discuss some of this new legislation and consider the key factors for the onshore and offshore wind markets in 2023 and beyond. We conclude that the near-term issues are likely a bump in the road on the journey to delivering wind as the second most significant renewable power generation source.

Annual onshore and offshore wind installations (GW)

source: BP, IEA, BNEF, Guinness Global Investors estimates

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022E	2023E
Onshore wind installations (annual)																
North America	9	11	6	8	15	2	7	10	9	8	8	10	17	16	12	12
Latin America	0	0	0	0	0	0	5	3	3	3	4	4	2	5	4	6
Europe	6	9	9	10	12	11	11	11	12	13	8	9	12	15	18	19
China	6	14	17	18	14	15	21	29	22	17	19	26	54	41	49	51
India	2	1	1	1	2	2	2	3	4	4	2	2	1	3	2	3
RoW	3	3	3	4	4	3	4	5	5	5	4	4	5	3	3	4
Total onshore	**27**	**38**	**35**	**40**	**46**	**33**	**49**	**61**	**55**	**49**	**46**	**55**	**91**	**83**	**88**	**95**
Change		*12*	*-3*	*5*	*6*	*-14*	*17*	*11*	*-6*	*-6*	*-3*	*9*	*36*	*-8*	*5*	*7*
World ex China	*21*	*24*	*18*	*22*	*32*	*18*	*29*	*32*	*33*	*32*	*27*	*29*	*37*	*42*	*39*	*44*
Offshore wind installations (annual)																
China	0	0	0	0	0	0	0	1	1	1	2	3	4	14	6	10
UK	0	0	1	0	1	1	0	1	0	1	2	2	1	1	3	2
Germany	0	0	0	0	0	0	0	2	0	2	0	2	0	1	0	1
RoW	0	0	0	0	0	1	0	0	0	1	0	1	2	1	1	6
Total offshore	**0**	**0**	**1**	**0**	**2**	**2**	**1**	**4**	**1**	**4**	**4**	**8**	**7**	**17**	**10**	**18**
Change		*0*	*1*	*-1*	*1*	*1*	*-1*	*4*	*-4*	*3*	*0*	*3*	*-1*	*11*	*-7*	*8*
World ex China	0	0	1	0	1	2	1	3	0	4	3	5	3	3	4	8
Total wind installations	**27**	**38**	**36**	**40**	**48**	**35**	**50**	**65**	**56**	**53**	**50**	**63**	**98**	**100**	**98**	**113**
Change		*12*	*-2*	*4*	*8*	*-13*	*16*	*15*	*-9*	*-3*	*-2*	*12*	*35*	*3*	*-2*	*15*

Onshore wind

The global onshore wind market currently sits at an installed capacity of 853 GW, with China and the US accounting for around 60% of capacity and Europe making up most of the remainder. Installations have been volatile but were reasonably consistently between 40-60GW from 2011 until 2020. Since 2020 there has been an uptick in installation activity driven, in large part, by both Chinese and US developers rushing to complete projects before subsidies expired. Following this period, it was widely thought that we would subsequently revert to a lower absolute level of installations, with a subdued 5-6% growth rate thereafter. Instead, we have witnessed unprecedented global policy support, which serves not only to keep installations at the current high levels, but also to triple the subsequent growth rate out to 2030, should current government policies be followed through. The three key policy announcements were as follows:

- **Europe's REPowerEU plan** committed a further EUR 86bn in incremental renewables investment out to 2030 and also sought to remove Europe's permitting bottlenecks by setting set out plans to streamline the arduous permitting process from 6 years on average to 2 years. Streamlining this process is critical, in our opinion, since the backlog of projects awaiting permitting is around five times the level of annual installations. Overall, the plan represents a dramatic shift, with a target to increase European capacity from 190 GW at present to 510 GW by 2030.
- The **Chinese 14th 5 year renewable energy plan** aims to double the installed capacity of both wind and solar by 2030. This has led to China's major state-owned power companies setting goals to increase total wind and solar capacity by 600 GW by 2025 (5 years ahead of schedule).
- The **US Inflation Reduction Act** outlined a $369bn package that targets climate and energy security focusing on reducing emissions from (amongst other things) electricity generation and transport. This not only provides very material tax credits, it also guarantees them out to 2033 (providing much needed policy visibility). According to Princeton University, the combined incentives may help increase US wind installations by 2x over the next 3 years compared to 2020 levels.

The result of these policy initiatives is that we no longer expect a dip in installations in the next few years, but instead think that installations stay higher and grow faster, with global capacity nearly tripling by 2030.

Offshore wind

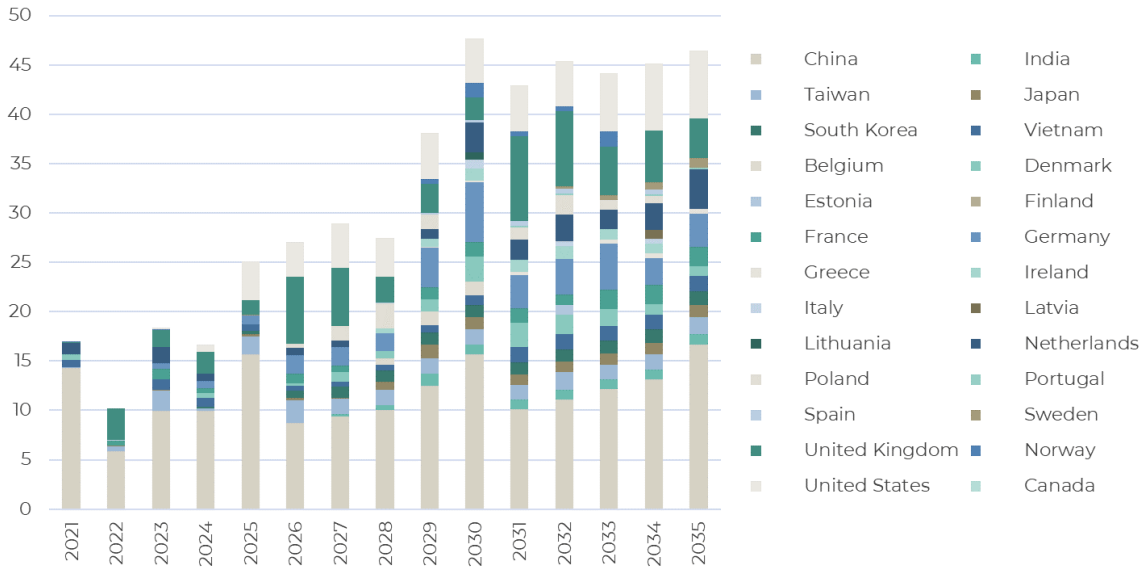
Offshore wind remains a nascent industry, at only 7% of global wind capacity, but it has doubled over the last 2 years and should grow nearly five times by the end of the decade driven by improving economics, further geographical adoption and the support of many of the packages outlined above.

In 2022 the LCOE for the median offshore wind project continued to improve relative to the bottom end of competing fossil fuel generation, with key attractions being better operational and visual characteristics as well as being close to key demand areas which are often coastal. 2022 also marked the completion of the first *floating* offshore wind project by Equinor, which while uneconomic today, when industrialised, offers the hope of multiplying the number of potential installation sites.

Positive dynamics for offshore wind in 2022 lead us to increase our 2030 capacity outlook to close to 300 GW, implying 20%pa growth versus 2021. By then, we expect the industry to be primarily made up of Europe and China, with the US still accounting for less than 10% (if President Biden's target 30GW plan is enacted).

Outlook for offshore wind installations (GW per annum, to 2035)

source: BNEF

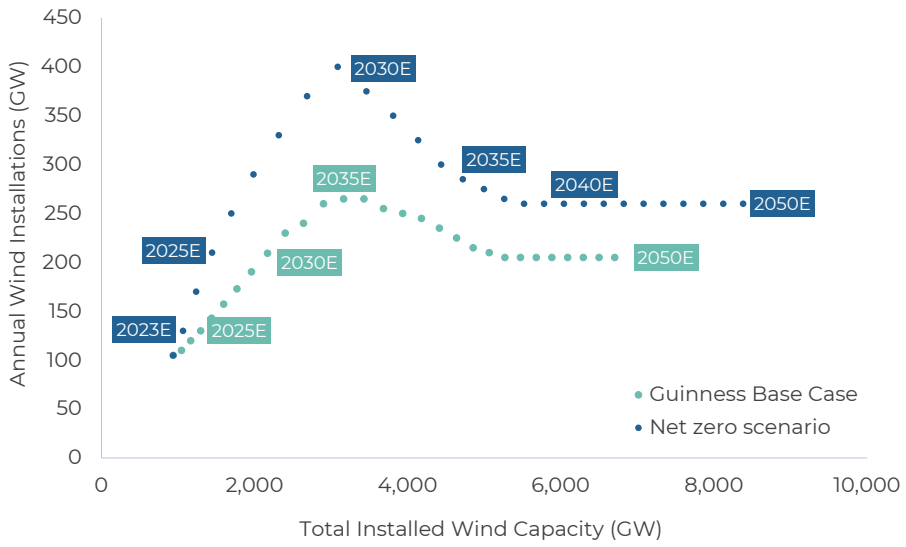


Implications of a net zero scenario on our wind outlook

Our base case assumes that total wind installed capacity will be around 2.2 TW in 2030. The Guinness net zero scenario indicates that total installed capacity would need to be 3.1 TW in 2030 (a compound growth rate of 16%pa from 2021) and that reaching this level of installed capacity would require annual installations to reach as much as 400 GW pa. While there appears to be significant policy support to grow the wind industry, we note that it has a very significant way to go in order to be fully aligned.

Global wind annual installations, base case and NZE scenario

source: IEA, IPCC, Guinness Global Investors



The Guinness Sustainable Energy Fund

Past performance does not predict future returns.

The Guinness Sustainable Energy Fund delivered a total return (USD) of -12.5% in 2022 vs the MSCI World Index (net return) of -18.1%. Further performance information is shown on page 23.

The strongest of our four subsectors during the year was **equipment** and within that, solar equipment manufacturers substantially outperformed their wind peers and the other sustainable energy equipment manufacturers. The two largest positive contributors to the fund were both solar equipment manufacturers. First Solar rose 72% over the year (contributing nearly 300bps to fund performance) as it was seen as the biggest beneficiary of the US IRA while Enphase rose 45% (contributing over 100bps to fund performance) due to its continued strong operating performance as well as its advantaged exposure to the IRA. Other solar equipment manufacturers, Canadian Solar (-1%) and SolarEdge (+1%) outperformed the fund. Not all solar equipment manufacturers outperformed, however; Xinyi Solar (-34%) was weaker due to margin compression and broader Chinese market weakness.

It was a better year than 2021 for wind equipment manufacturers, with our three holdings outperforming the fund on average. Vestas was the strongest contributor as the shares rallied 56% in Q4 while the acquisition of SiemensGamesa by Siemens Energy reflected the potential deep value that exists in some of the wind industry companies.

All of our **electrification** holdings delivered negative contribution as the global auto cycle continued to remain under pressure from China COVID-related slowdowns and growing recessionary fears. Our lithium-ion battery companies (LG Chem and Samsung SDI) were the better performers, as raw material deflation started to crystalise. On the other hand, our EV related holdings suffered as, despite growing EV sales, many have exposure to the ICE vehicle market. Infineon (-33%), Sensata (-34%) and Aptiv (-44%) were within the bottom five performers for the year because of this. Stronger EV oriented performers were Johnson Matthey and Hella (acquired by Faurecia in early 2022) while Onsemi performed well as a result of continued financial and operational improvements as well as a growing take up of its silicon carbide technology.

Our **generation** companies were a safe haven, as a result of their lower volatility earnings profile, with all but our two Chinese IPPs (China Longyuan and China Suntien) and our new mid-year addition Sunnova outperforming relatively. Albioma was the best individual performance as it was subject to a bid from private equity firm KKR at a 43% premium to the unaffected share price, while Ormat performed well after the passage of the IRA.

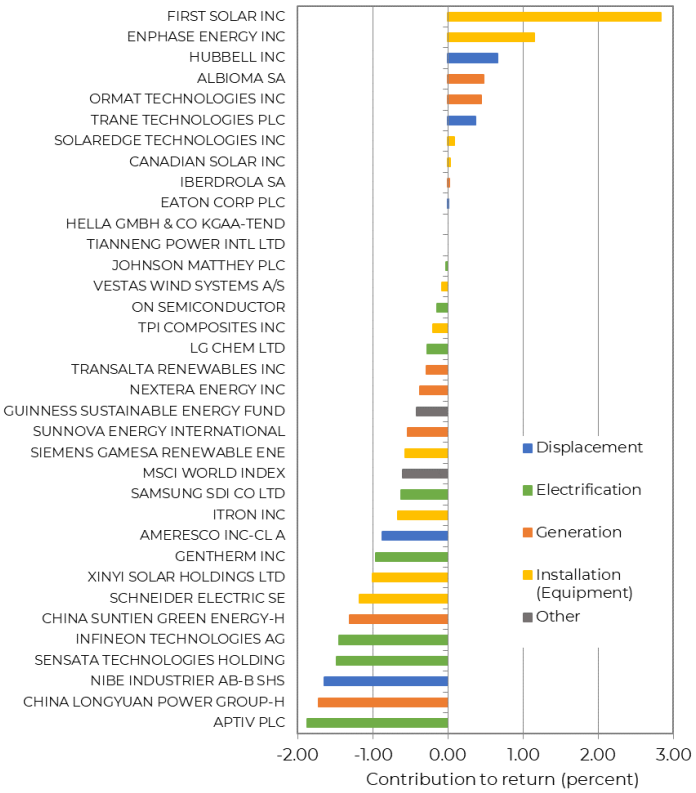
The performance of our **displacement** holdings was diverse. At the upper end of the portfolio, Hubbell (+15%) and Trane Technologies (+10% since it entered the portfolio) benefitted from the passage of the IRA while Ameresco (-30%) and Nibe (-38%) were weaker due to project related concerns, the broader weaker economic outlook and the unwinding of premium valuation for quality/growth companies that we have seen across the market.

Geographically, eight of our top ten performing stocks were US listed companies, reflecting a strong positive swing in sentiment after the passage of the IRA. On the other hand, three of the eight weakest performers were Chinese (Hong Kong) listed entities, reflecting the negative economic momentum and poor sentiment in that market.

M&A activity was high across the portfolio, indicating pockets of value. As mentioned above, KKR announced an acquisition of Albioma and Siemens announced a deal for Siemens Gamesa. In addition, Standard Investments announced a new 5%+ ownership stake in Johnson Matthey.

2022 individual stock contribution, in USD

source: Bloomberg, Guinness Global Investors estimates



The fund outperformed the Guinness sustainable energy universe over the year. Active stock selection was positive across all sub sectors except generation where our Chinese IPP exposure was a significant drag (the average IPP in our universe was down 13% while our two Chinese holdings were down 45% on average). Across all other subsectors, the average return of our portfolio holdings was ahead of the average return of the stocks in the universe.

In terms of sector allocation, our 3% underweight position in alternative fuel detracted from performance as ethanol names and biofuel manufacturers performed well in the higher oil price environment, while our 3% underweight to battery names was broadly neutral. Our similar sized overweight positions to efficiency, electric vehicles and wind equipment were detractors to performance but our larger (near 8%) overweight to solar equipment manufacturers delivered significant positive sector allocation, compensating for the other underperforming overweight positions.

Attribution of Guinness Sustainable Energy Fund versus the universe (2022)

source: Guinness Global Investors estimates, Bloomberg

Subsector	Average weight		Fund position vs universe	Indicative attribution	
	Universe	Fund		Sector allocation	Stock selection
Alternative Fuel	2.9%	0.0%	Underweight	Negative	Neutral
Efficiency	10.8%	12.5%	Overweight	Negative	Positive
Battery	13.8%	10.9%	Underweight	Neutral	Positive
Electric Vehicles	15.4%	18.3%	Overweight	Negative	Positive
Generation - IPP/Utility	9.2%	11.1%	Overweight	Positive	Negative
Other equipment	13.2%	10.8%	Underweight	Positive	Positive
Solar equipment	8.2%	15.8%	Overweight	Positive	Positive
Wind equipment	3.1%	6.7%	Overweight	Negative	Positive

The Guinness Sustainable Energy fund was repositioned at the start of 2019 and, over the last four years, there has been some substantial volatility across various sustainable energy sectors. Over this period, the fund has on average been correctly overweight the equipment, efficiency and electric vehicle sub sectors at the expense of underweights to other sub sectors. In terms of stock selection, our fundamental value-oriented approach has facilitated good stock selection within the efficiency, utility, IPP and equipment sub sectors while stock selection has been negative in other sub sectors.

Attribution of Guinness Sustainable Energy Fund versus the universe (2019-2022)

source: Guinness Global Investors estimates, Bloomberg

Subsector	Average weight		Fund position vs universe	Indicative attribution	
	Universe	Fund		Sector allocation	Stock selection
Alternative Fuel	4%	0%	Underweight	Positive	Neutral
Efficiency	11%	13%	Overweight	Positive	Positive
Battery	14%	11%	Underweight	Negative	Negative
Electric Vehicles	16%	18%	Overweight	Positive	Negative
Utility	9%	7%	Underweight	Positive	Positive
IPP	20%	17%	Underweight	Positive	Positive
Equipment	26%	34%	Overweight	Positive	Positive

Over the year, the weighting to consumption (i.e. the demand side of the energy transition) increased from 43.4% at the end of 2021 to 44.9% at the end of December 2022 while the weighting to renewables (i.e. supply side) fell from 51.3% to 49.3%. Within these subsectors, our exposure to equipment, batteries and efficiency increased by around 3% each while our weighting to electric vehicles and IPPs fell by around 4.5% and 6% respectively, reflecting disposals from the portfolio.

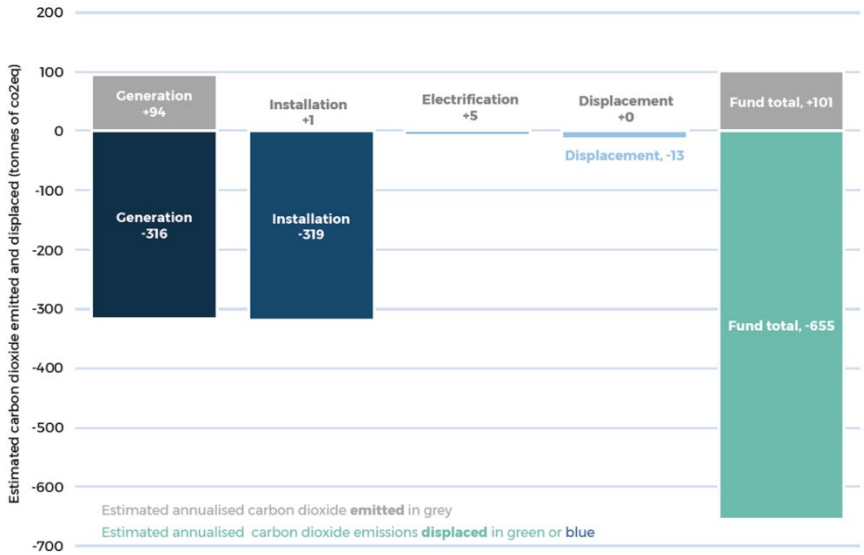
Positive decarbonisation impact of portfolio companies

The Guinness Sustainable Energy Fund invests in companies playing a key role in global decarbonisation, providing a vehicle for investors to align their capital with this positive impact.

In September 2022, we published our latest impact report which detailed the positive decarbonising impact of the companies held in the portfolio at the end of 2021 (based on calendar year 2021 data). Our headline finding was that the companies in our portfolio sold products and services that help to displace 655 tonnes of CO2e per USD$1m of portfolio assets. This figure is based on estimates for energy saved, electric miles travelled, 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 annualised 'carbon cost' of around 101 tonnes of CO2e per USD$1m of portfolio assets, based on scope 1 and 2 emissions data.

Estimated annualised carbon cost vs carbon displaced (tonnes) per US$1m of AuM by sector

source: Guinness Global Investors estimates



The full 2022 impact report, which also discusses portfolio alignment with UN Sustainable Development Goals and our engagement activities, can be viewed here.

Valuation

At 31 December 2022, the Guinness Sustainable Energy fund traded on a 2023 P/E ratio of 19.1x and 2023 EV/EBITDA multiple of 11.6x (around 10-20% lower than the same one year forward metrics published in our last annual outlook).

The fund trades at a premium to MSCI World, reflecting greater expectation for growth from sustainable energy companies relative to the index. As a sense check, we see that consensus EPS growth (2021-2024E) of the portfolio (at 18.8%pa) is well ahead of the MSCI World (at 7.2%pa). This document details how the growth outlook for the sector has improved in 2022 and the growth premium of the fund versus the MSCI World (11.6%pa) is markedly higher than the 7.8%pa that we published in our prior annual outlook. Looking over the next five years, we believe that the portfolio is likely to deliver normalised earnings growth of around 14%pa, well ahead of growth in the MSCI World Index, that will bring the fund P/E ratio down from the current 19.1x for 2023E to around 13x in 2026E.

We also note that the cashflow return on investment (CFROI) of the portfolio rises from 5.8% in 2022 to 6.5%, albeit still below the MSCI World which grows slightly to 8.3%.

Guinness sustainable energy fund key financial and valuation metrics

source: Bloomberg, CS HOLT, Guinness Global Investors estimates

As at 31 December 2022	P/E			EV/EBITDA			Dividend Yield		EPS Growth (%pa)		CFROI*	
	2022	2023E	2024E	2022	2023E	2024E	2023E	2024E	2014-21	2021-24	2022E	2023E
Guinness Sustainable Energy Fund	23.2x	19.1x	15.6x	14.2x	11.6x	9.8x	1.3%	1.4%	5.8%	18.8%	5.8%	6.5%
MSCI World Index	15.2x	14.1x	13.1x	10.3x	9.8x	9.4x	2.5%	2.6%	6.7%	7.2%	8.1%	8.3%
Fund Premium/(Discount)	*53%*	*35%*	*19%*	*38%*	*18%*	*4%*						

*Portfolio = median CFROI; Index data = Credit Suisse MSCI World ETF median CFROI

Key themes in the portfolio

In our portfolio, we currently reflect the displacement, electrification, installation and generation sectors by combining them into the following investment themes:

Key themes in the Guinness Sustainable Energy Fund

source: Guinness Global Investors estimates

	Theme	Example holdings	Weighting (%)
1	Electrification of the energy mix	sunnova, NextEra Energy	20.9%
2	Rise of the electric vehicle and auto efficiency	Sensata Technologies, APTIV	21.5%
3	Battery manufacturing	Samsung SDI	8.4%
4	Expansion of the wind industry	Vestas	8.2%
5	Expansion of the solar industry	CanadianSolar	16.6%
6	Heating, lighting and power efficiency	NIBE Industrier, Trane Technologies	15.0%
7	Geothermal	Ormat	3.6%
8	Other (inc cash)		5.8%

We expect investor interest in sustainable energy equities will continue to be high in 2023 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 Sustainable Energy portfolio of 30 equally weighted equities, chosen from our universe of around 250 companies, provides concentrated exposure to the theme at attractive valuation levels.

Jonathan Waghorn, Will Riley, Jamie Melrose and Dan Hobster

January 2023

Performance

Past performance does not predict future returns.

The Guinness Sustainable Energy Fund (Class Y, 0.74% OCF) delivered a return of -12.5% in 2022, while the MSCI World Index (net return) delivered -18.1% (all in USD terms).

	Ytd	1 Yr	3 Yrs	5 Yrs*	10 Yrs*
Fund (Class Y)	-	-12.5%	77.8%	98.1%	166.0
MSCI World NR Index	-	-18.1%	15.6%	34.7%	133.6
Out/Underperformance	-	*5.6%*	*62.3%*	*63.4%*	*32.4%*

Annual performance	2022	2021	2020	2019	2018*
Fund (Class Y)	-12.5%	10.4%	84.1%	31.4%	-15.2%
MSCI World NR Index	-18.1%	21.8%	15.9%	27.7%	-8.7%
Out/Underperformance	*5.6%*	*-11.4%*	*68.2%*	*3.7%*	*-6.5%*

Annual performance	2017*	2016*	2015*	2014*	2013*
Fund (Class Y)	20.2%	-15.4%	-12.0%	-12.1%	70.8%
MSCI World NR Index	22.4%	7.5%	-0.9%	4.9%	26.7%
Out/Underperformance	*-2.2%*	*-23.0%*	*-11.2%*	*-17.0%*	*44.1%*

**Simulated Past Performance prior to the launch of the Y class on 16/02/2018. The Performance shown is a composite simulation for Y class performance being based on the actual performance of the Fund's E class, which has an OCF of 1.24%. The Guinness Sustainable Energy Fund was launched on 19/12/2007. Source: Financial Express, bid to bid, total return.*

Investors should note that fees and expenses are charged to the capital of the Fund. This reduces the return on your investment by an amount equivalent to the Ongoing Charges Figure (OCF). The Fund performance shown has been reduced by the current OCF of 0.67% per annum. Returns for share classes with different OCFs will vary accordingly. Performance returns do not reflect any initial charge; any such charge will also reduce the return.

UK investors should be aware that the Guinness Sustainable Energy strategy is available as a UK-domiciled fund denominated in GBP. The TB Guinness Sustainable Energy Fund is available from 0.67% OCF. For more information click here.

IMPORTANT INFORMATION

Issued by Guinness Global Investors, a trading name of Guinness Asset Management Limited, which is authorised and regulated by the Financial Conduct Authority.

This report is primarily designed to inform you about recent developments in the energy markets invested in by the Guinness Sustainable Energy Fund. It also provides information about the Fund's portfolio, including recent activity and performance. This document is provided for information only and all the information contained in it is believed to be reliable but may be inaccurate or incomplete; any opinions stated are honestly held at the time of writing, but are not guaranteed. The contents of the document should not therefore be relied upon. It is not an invitation to make an investment nor does it constitute an offer for sale.

Documentation

The documentation needed to make an investment, including the Prospectus, the Key Information Document (KID) / Key Investor Information Document (KIID) and the Application Form, is available in English from www.guinnessgi.com or free of charge from:-

- the Manager: Link Fund Manager Solutions (Ireland) Ltd (LFMSI), 2 Grand Canal Square, Grand Canal Harbour, Dublin 2, Ireland; or,
- the Promoter and Investment Manager: Guinness Asset Management Ltd, 18 Smith Square, London SW1P 3HZ.

LFMSI, as UCITS Man Co, has the right to terminate the arrangements made for the marketing of funds in accordance with the UCITS Directive

Investor Rights

A summary of investor rights in English is available here:

https://www.linkgroup.eu/policy-statements/irish-management-company/

Residency

In countries where the Fund is not registered for sale or in any other circumstances where its distribution is not authorised or is unlawful, the Fund should not be distributed to resident Retail Clients. **NOTE: THIS INVESTMENT IS NOT FOR SALE TO U.S. PERSONS.**

Structure & regulation

The Fund is a sub-fund of Guinness Asset Management Funds PLC (the "Company"), an open-ended umbrella-type investment company, incorporated in Ireland and authorised and supervised by the Central Bank of Ireland, which operates under EU legislation. If you are in any doubt about the suitability of investing in this Fund, please consult your investment or other professional adviser.

Switzerland

This is an advertising document. The prospectus and KIID for Switzerland, the articles of association, and the annual and semi-annual reports can be obtained free of charge from the representative in Switzerland, Carnegie Fund Services S.A., 11, rue du Général-Dufour, 1204 Geneva, Switzerland, Tel. +41 22 705 11 77, www.carnegie-fund-services.ch. The paying agent is Banque Cantonale de Genève, 17 Quai de l'Ile, 1204 Geneva, Switzerland.

Singapore

The Fund is not authorised or recognised by the Monetary Authority of Singapore ("MAS") and shares are not allowed to be offered to the retail public. The Fund is registered with the MAS as a Restricted Foreign Scheme. Shares of the Fund may only be offered to institutional and accredited investors (as defined in the Securities and Futures Act (Cap.289)) ('SFA') and this material is limited to the investors in those categories

Telephone calls will be recorded and monitored.