

RISK

This is a marketing communication. Please refer to the prospectuses, KIDs and KIIDs for the Funds, which contain detailed information on their characteristics and objectives, before making any final investment decisions.

The Funds are equity funds. 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 Funds' documentation, available on our website.

Past performance does not predict future returns.

ABOUT THE STRATEGY

Launch	19.12.2007
Index	MSCI World
Sector	IA Commodity/Natural Resources
Managers	Will Riley Jonathan Waghorn
EU Domiciled	Guinness Sustainable Energy Fund
UK Domiciled	WS Guinness Sustainable Energy Fund

INVESTMENT POLICY

The Guinness Sustainable Energy Funds are 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). We believe that over the next twenty years the sustainable energy sector will benefit from the combined effects of strong demand growth, improving economics and both public and private support and that this will provide attractive equity investment opportunities. The Funds are actively managed and use the MSCI World Index as a comparator benchmark only.

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COMMENTARY

SUSTAINABLE ENERGY EQUITY PERFORMANCE

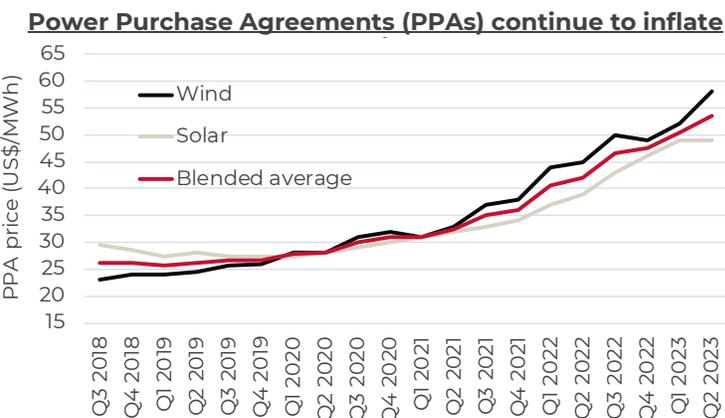
Sustainable energy equities were weaker in the third quarter due expectations of higher-for-longer interest rates and stickier inflation. This month, we assess renewable project economics under higher expectations for both and conclude that renewables will continue to be more economic than fossil fuels. The pullback leaves the Fund's 12m forward P/E at a 5% discount to the MSCI World while offering 3x greater compound earnings growth per annum to 2025.

EQUITIES

Sustainable energy equities underperformed global stock markets in September. The Guinness Sustainable Energy Fund (Class Y) delivered a return of -8.1% (in USD), behind the MSCI World at -4.3%. Year to date, the Fund has delivered -8.0%, versus the MSCI World at +11.1%. Within the Fund, the strongest stocks were auto-exposed sensor company Sensata and Chinese wind stock China Longyuan. Sensata held an upbeat capital markets day during the month in which it raised its longer-term revenue growth outlook from 5-7% to 6-8%, suggesting annual earnings growth of 14-19% out to 2026. China Longyuan announced a surprise buyback of up to 10% of its H-shares. With the shares valued at just 0.6x P/B this was taken positively by the market and the shares traded up nearly 6% on the day. On the negative side were our residential solar names Sunnova and Solaredge, still plagued by concerns around a slowdown in the US residential solar market prompted by higher interest rates and changing legislation in California.

CHART OF THE MONTH

US solar and wind Power Purchase Agreements (PPA) have increased by 16%pa on average over the last five years and, if inflation persists, it would be reasonable to expect further inflation in renewable PPA prices in coming years.



Source: Levelten, Sept 2023

SEPTEMBER NEWS AND EVENTS IN REVIEW

In this section, we review the key news items and their impact on our various portfolio sub-sectors over the last month.

News	Sub-Sector	Impact
In a State of the Union address at the European Parliament, Ursula von der Leyen pledged more support for the European wind industry. She announced that the EU will put forward a package of measures to “fast-track permitting... improve auction systems... [and] focus on skills, access to finance and stable supply chains” as the bloc continues to work towards a goal of renewables making up 42.5% of the energy mix by 2030.	European wind	
Shares of Nextera Energy Partners (NEP) fell 40% during the month as the company downgraded growth targets from 12% to 6% annually. CEO John Ketchum stated “tighter monetary policy and higher interest rates obviously affect the financing needed to grow distributions at 12% and the burden of financing this growth has had an impact on Nextera Energy Partners’ unit price and yield”. Note that NEP is distinct from Nextera Energy (a holding in the Fund), which has alternative financing options and the benefit of rising PPAs to offset interest rate pressures.	Green utilities	
US battery capex announcements continued to show positive momentum in September with both Samsung SDI and Chinese firm Gotion announcing separate \$2bn investments into battery plants in the US. The two plants will have an annual production capacity of 37 and 40GWh of battery cells respectively and highlight the pull that the Inflation Reduction Act is having on international investment into the US sustainable energy industry.	US battery investment	
The US Energy Department finalised a \$3bn loan guarantee with Sunnova Energy to build a “virtual power plant” throughout the US using residential solar. Under the scheme, Sunnova will provide loans to 75-115k households to enable them to install rooftop solar, battery systems and smart energy software, which will then feed power back into the local grid. The scheme could potentially avoid 7.1m tonnes of CO2 emissions and generate 568MW of emissions-free power over 25 years.	US residential solar	
The share of plug-in vehicles in China (battery electric vehicles + plug-in hybrids) reached 39% for the month of August (latest data available), growing 36% year over year. This suggests that China now accounts for close to 60% of the global plugin market.	EV penetration	

MANAGERS' COMMENTS

Thoughts on recent sustainable energy equity performance

Sustainable energy equities were weaker in the third quarter due to an increasing expectation of higher-for-longer interest rates and stickier inflation. This month, we assess renewable project economics under higher expectations for both and conclude that renewables will continue to be more economic than fossil fuels. The pullback in the sector leaves the Guinness Sustainable Energy Fund showing over 20%pa consensus earnings growth (2022-2025) and trading at a 5% 12m forward P/E discount to the MSCI World.

The sustainable energy sector suffered a sharp pullback in the third quarter, with iShares Clean Energy down 20.5% in USD and the MSCI Alternative Energy Index down 23.9%, leaving them down 25.9% and 33.4% for the year to date. The Guinness Sustainable Energy Fund was not immune to the weakness, falling 16.0% over the quarter and leaving it down 8.0% year to date. The performance of the sector compares to the MSCI World being down 3.5% in the quarter and up 11.1% year to date.

Weakness across global equity markets over the quarter was driven by an increasing expectation of higher-for-longer interest rates and stickier inflation. These broader macro factors caused particular weakness in certain parts of our sustainable energy universe. There were also some sector-specific issues at play, including supply chain hold-ups, manufacturing oversupply and delays in policy implementation.

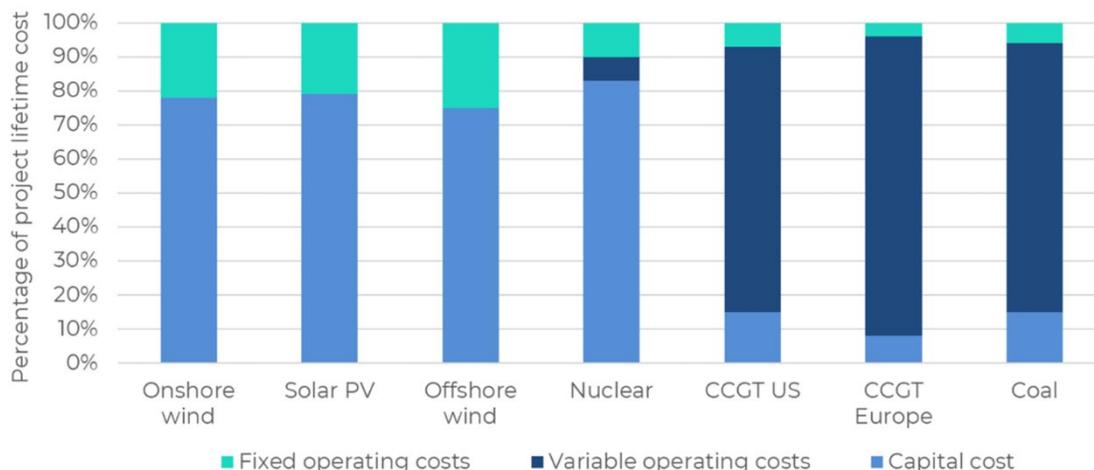
Commentary describing the most significant contributors to performance in the Guinness Sustainable Energy portfolio can be found on page 9 of this report. Below, we examine the impact on the sector of higher interest rates and inflation, changes to cash return and earnings expectations across the portfolio in recent months, and an update on valuation.

The impact of higher interest rates and cost inflation

During the third quarter, inflation remained higher than expected, leading to the US Federal Reserve indicating further monetary tightening. Inflation and the higher interest rate environment have been particular headwinds for renewable power producers and upstream equipment manufacturers in their associated wind, solar and other supply chains. In total, these companies represent just over half of our investment universe and about one third of the Fund's NAV at the end of September 2023.

Renewables supply projects, such as wind and solar, are sensitive to interest rates and inflation because upfront capital investment represents around 80% of a typical project lifetime cost (since there are no 'fuel' consumption costs over the duration of the project). New nuclear projects are similar, with over 80% of the lifetime costs being upfront capital expenditure, dwarfing the cost of the consumed uranium. Both contrast with fossil fuel projects where the higher relative cost of the consumed fuel means that variable operating costs (including carbon taxes where relevant) represent around 80-90% of total project lifetime costs, and upfront capital costs represent only 10%.

Power project lifetime costs by type



Source: Bernstein, Guinness Global Investors estimates, Oct 2023

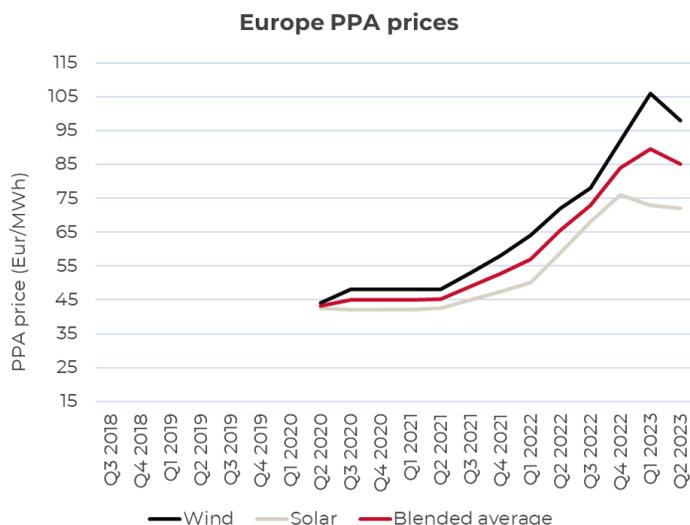
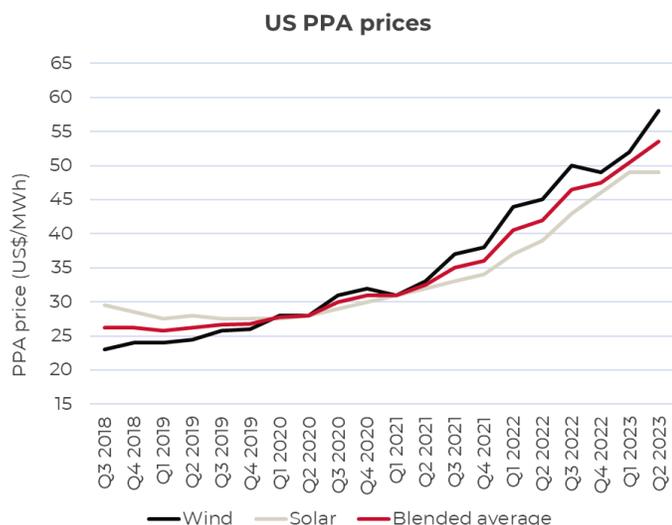
It follows therefore that the economics of solar, wind and nuclear projects are more sensitive to both interest rate increases and upfront capital cost inflation, whilst fossil fuel projects are driven more by longer-term fossil fuel pricing assumptions.

The economics of renewables post-inflation and higher interest rates

Considering the sensitivity of project economics to inflation and interest rates, our starting point is the Levelised Cost of Electricity (LCOE) analysis of commissioned projects, produced by the International Renewable Energy Agency (IRENA). In 2022, according to IRENA, the LCOE of installed onshore wind and solar PV projects was in the order of \$0.03-0.05/kWh, placing them at the bottom of the new renewable project cost curve and well below the competing fossil fuel LCOE range of around \$0.08-0.15/kWh. Allowing for increases in project financing costs and capital cost inflation, we estimate that solar PV and onshore wind continue to be at the bottom of the power cost curve, with LCOEs maybe increasing to the region of \$0.05-0.07/kWh.

Offshore wind is more capital intensive than onshore wind and, as a result of the early development stage of the industry, is more expensive than onshore wind and solar, with an LCOE last year in the region of \$0.08/kWh. Higher interest rates and cost inflation have put pressure on offshore wind project economics, resulting in some high-profile project cancellations, power purchase agreement (PPA) renegotiations and failed auctions in recent months. Allowing for higher interest rates and inflation, we see offshore wind LCOEs in the region of \$0.12/kWh, which is similar to the economics of European gas utilities but still below those of coal and nuclear.

Looking ahead, higher PPAs will be required in some regions (e.g. UK; US) to justify offshore wind development. This is not a new phenomenon – US solar and wind PPAs have increased by 16%pa on average over the last five years, and if inflation persists, it would be reasonable to expect further inflation in PPA prices in coming years.



Source: Levelten, Guinness Global Investors estimates, Oct 2023

Competitive positioning of renewables versus fossil fuels

Renewable projects like wind and solar are not developed in isolation. They typically will compete against a fossil project that will not itself be immune to interest rate increases, cost inflation or fossil fuel price inflation. With Brent oil at \$90 per barrel, European coal at \$125/tonne and European and Asian gas prices at \$12-14/mcf, we see fossil fuel LCOEs moving to the \$0.10-0.20/kWh range once inflation and higher interest rates are assumed. This is significantly higher than our LCOE expectation for renewables. In addition, it seems that nuclear will be the greatest loser in this environment since nuclear projects already have high LCOEs and are highly exposed to interest rates and capital costs.

It is worth noting that the analysis presented here is before the application of any renewable subsidies that may be available. In the US, for example, the Inflation Reduction Act brings the LCOEs for solar and wind materially lower, creating even more attractive economics versus fossil fuel power.

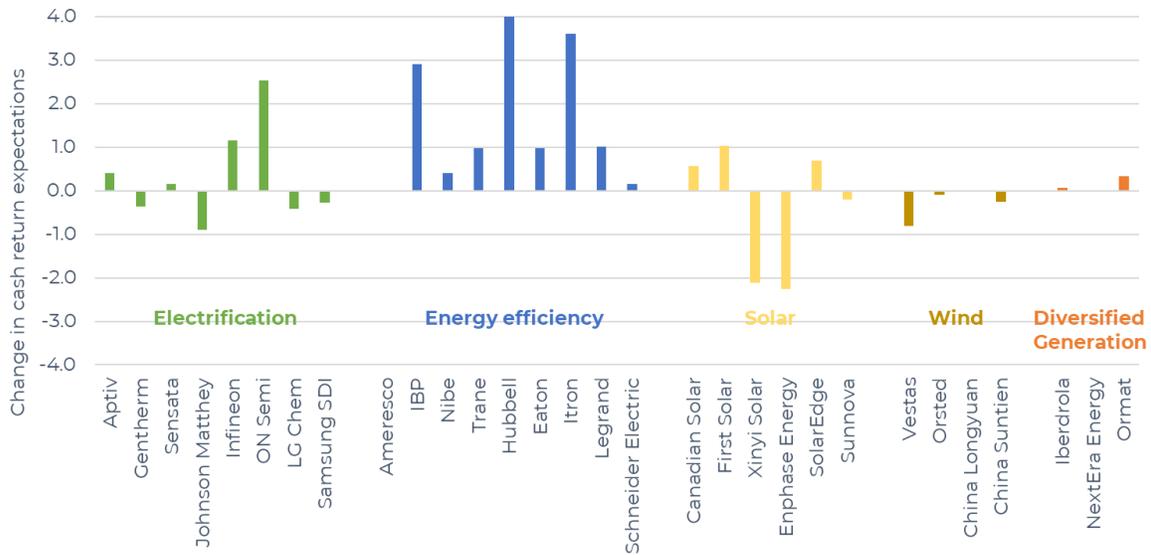
Our LCOE sensitivity work shows that **renewables should still be highly competitive versus other fossil or nuclear technologies in the future**. The higher interest rate and cost environment is slowing growth in some subsectors of renewable power generation and equipment manufacturing, but we are comfortable that the longer-term drivers remain intact.

Broader strength across the rest of the portfolio

Looking across the portfolio, using our preferred metric of **cash returns** (cash flow return on investment or CFROI), we can see downgrades showing up in parts of the solar, wind and diversified generation sectors. However, over 60% of holdings in the portfolio have delivered upgrades to cash returns. At the portfolio level, this results in 2023/24 cash return expectations increasing by 0.6% over the last six months, which is in line with cash return changes for the broader equity market.

Guinness Sustainable Energy

Percentage point change in cash return expectations (6 months to end Sept 2023)



Source: Bloomberg, CS HOLT, Guinness Global Investors estimates, Sept 30 2023

The **earnings per share** progression of our portfolio also continues to evolve satisfactorily, with earnings revisions year-to-date generally being in line with MSCI World. Estimates for 2023 earnings since the start of the year look to be slightly ahead of the MSCI World, whereas estimates for 2024 earnings look to be slightly behind.



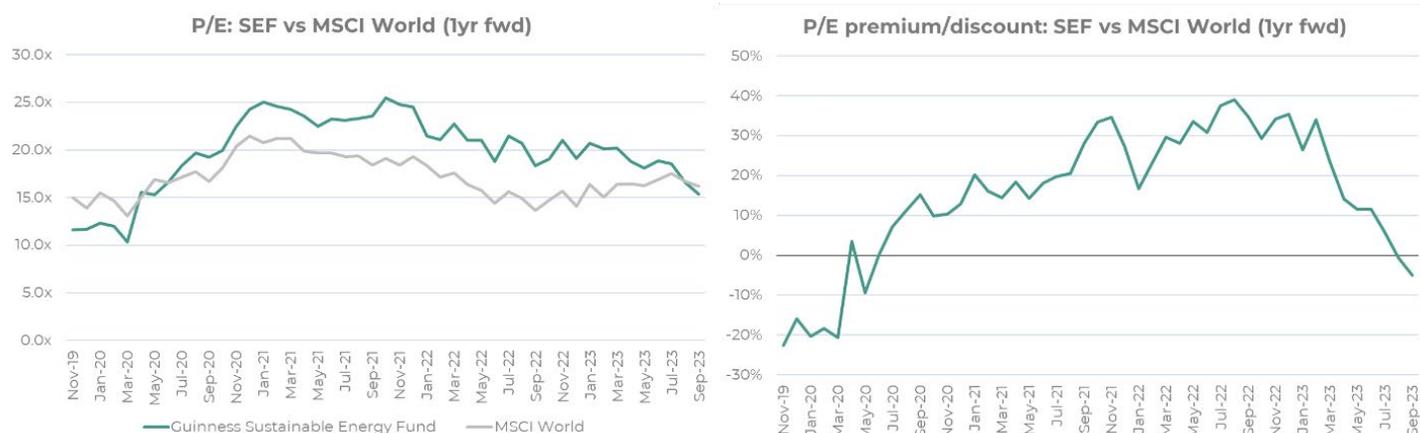
Source: Bloomberg; Guinness Global Investors, to 30.09.2023

In simple terms, then, the performance of the Fund versus MSCI World so far this year has not been driven by a weaker earnings outlook, but instead can be explained by:

- The Fund's 12-month forward P/E ratio compressing from 19.1x to 15.4x (-19%)
- MSCI World's 12-month forward P/E ratio inflating from 15.5x to 16.2x (+5%)

Attractive growth outlook trading at a discount to market multiples

The pullback in sustainable energy equities this year leaves the Guinness Sustainable Energy Fund trading on a 12-month forward P/E of 15.4x, in comparison to the MSCI World which trades on a 12 month forward P/E ratio of 16.7x. The Fund is therefore trading at a 5% forward 12-month P/E discount to the MSCI World, a discount not seen since May 2020.



Source: Bloomberg; Guinness Global Investors, to 30.09.2023

The fall in P/E premium comes at a time when the outlook for the portfolio remains strong; consensus earnings for our Fund forecast 20.7% p.a. consensus earnings per share growth in 2022-2025. This is more than three times that of the MSCI World, at around 6.4% p.a. Put simply, we think the Fund looks cheap on these metrics and is discounting an outcome that is far worse than that implied by current interest rates and inflationary conditions.

As at 30 September 2023

	P/E			EV/EBITDA			Dividend Yield		EPS Growth (%pa)		CFROI*	
	2022	2023E	2024E	2022	2023E	2024E	2023E	2024E	2014-21	2022-25	2022	2023E
Guinness Sustainable Energy Fund	20.1x	17.5x	14.7x	13.0x	11.0x	9.2x	1.5%	1.6%	6.8%	20.7%	5.4%	7.5%
MSCI World Index	15.9x	17.5x	16.3x	10.4x	11.8x	10.7x	2.0%	2.2%	5.4%	6.4%	8.1%	7.8%
Fund Premium/(Discount)	26%	0%	-10%	25%	-7%	-14%						

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

With fossil fuels still accounting for 83% of the global energy mix, portfolio fundamentals remaining robust and more policy support and accelerating investment to come, we remain confident in the ability of our portfolio companies to grow earnings in excess of the broader equity market. The energy transition is just getting started, and the Fund's holdings are well positioned to benefit from the opportunities it will bring.

PERFORMANCE

Past performance does not predict future returns.

The Guinness Sustainable Energy Fund (Class Y, 0.66% OCF) delivered a return of -8.1% in the month, while the MSCI World Index (net return) delivered -4.3% (all in USD terms).

Cumulative performance to 30.09.2023	Ytd	1 Yr	3 Yrs	5 Yrs*	10 Yrs*
Fund (Class Y)	-8.0%	2.6%	23.4%	93.7%	42.5%
MSCI World NR Index	11.1%	22.0%	26.3%	42.0%	121.3%
Out/Underperformance	-19.1%	-19.4%	-2.9%	51.7%	-58.8%

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%

The Fund was launched on 19/12/2007. *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%. Source: Financial Express, bid to bid, total return. On 31/12/2018, the benchmark became the MSCI World NR. Prior to this, the benchmark was the Wilderhill Clean Energy Index (ECO Index).

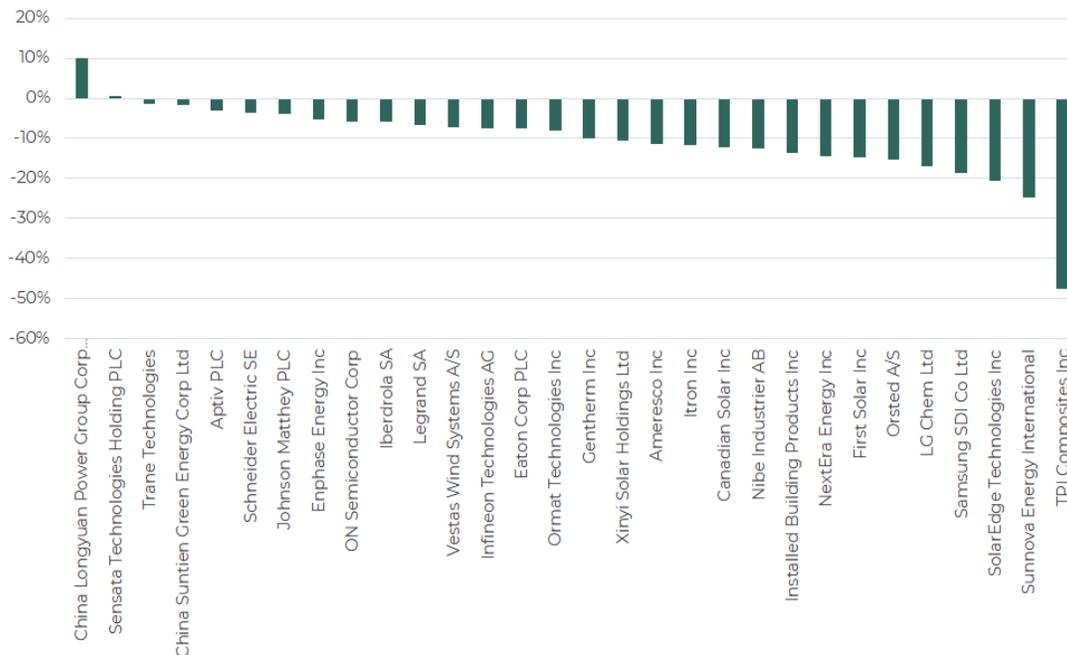
Investors should note that fees and expenses are charged to the capital of the fund. This reduces the return on your investment by an amount equivalent to the Ongoing Charges Figure (OCF). The fund performance shown has been reduced by the current OCF of 0.66% per annum. Returns for share classes with different OCFs will vary accordingly. Transaction costs also apply and are incurred when a fund buys or sells holdings. Performance returns do not reflect any initial charge; any such charge will also reduce the return.

Within the Fund, the strongest stocks were our auto-exposed sensor company Sensata and Chinese wind stock China Longyuan. Sensata held an upbeat capital markets day during the month in which it raised its longer-term revenue growth outlook from 5-7% to 6-8% suggesting a 14-19% EPS CAGR out to 2026. China Longyuan announced a surprise buyback of up to 10% of its H-shares. With the shares valued at just 0.6x P/B this was taken positively by the market and the shares traded up nearly 6% on the day.

On the negative side of the ledger were our residential solar names Sunnova and Solaredge as well as battery names LG Chem and Samsung SDI. The former group continue to be plagued by concerns around a slowdown in the US residential solar market prompted by higher interest rates and changing legislation in California, while the battery players have suffered from negative sentiment on EV demand (especially in Europe). On this latter point, the latest EV sales data continues to look robust with battery electric vehicle (BEV) sales in Europe up 82% YoY and battery prices continuing to deflate (which should help to underpin longer-term demand).

Guinness Sustainable Energy

Stock by Stock performance over the month, in USD



Source: Bloomberg. As of 30 September 2023

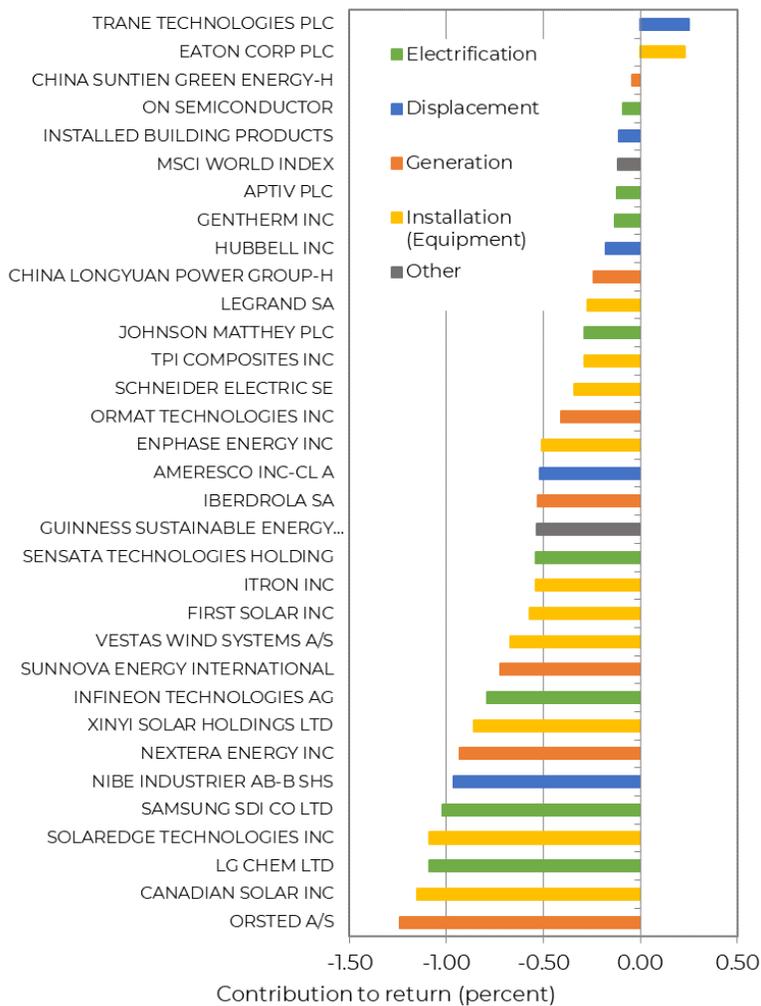
In some regards, this performance trend was similar to what we have seen through the bulk of the third quarter, with auto and electrical names tending to contribute positively, and pure play solar and wind names proving a drag.

Looking at 3Q performance, our best relative performing segments were our auto exposed names as well as our electric equipment providers. Underperforming segments included wind and solar names, which continue to suffer from rising interest rates and (in the case of solar) regulatory changes in California.

On the positive side, **auto exposed** Onsemi and Aptiv both benefited from ongoing momentum in the electrification of the auto fleet. Onsemi built on the strength from its Capital Markets Day (hosted earlier in the year) which highlighted the progress it is making in silicon carbide power semiconductors. The company's August quarterly results confirmed this progress as it posted 35% year-on-year automotive growth (11% ahead of consensus) and upgraded Q3 guidance. Aptiv also delivered strong results in the quarter, delivering revenue growth of 30% year-on-year (materially above auto production) driven by strength in high voltage power and active safety solutions.

Our **electrical equipment** providers continue to experience the same positive operational momentum that they have had all year, with Eaton in particular performing strongly throughout the quarter. Eaton reported strong results, delivering 13% organic growth and booking close to \$18bn of new electrical orders. Trane Technologies performed strongly after delivering results 6% ahead of consensus driven by continuing strength in America and a 40% pickup in Asia Pacific.

Guinness Sustainable Energy



Source: Bloomberg. As of 30 September 2023

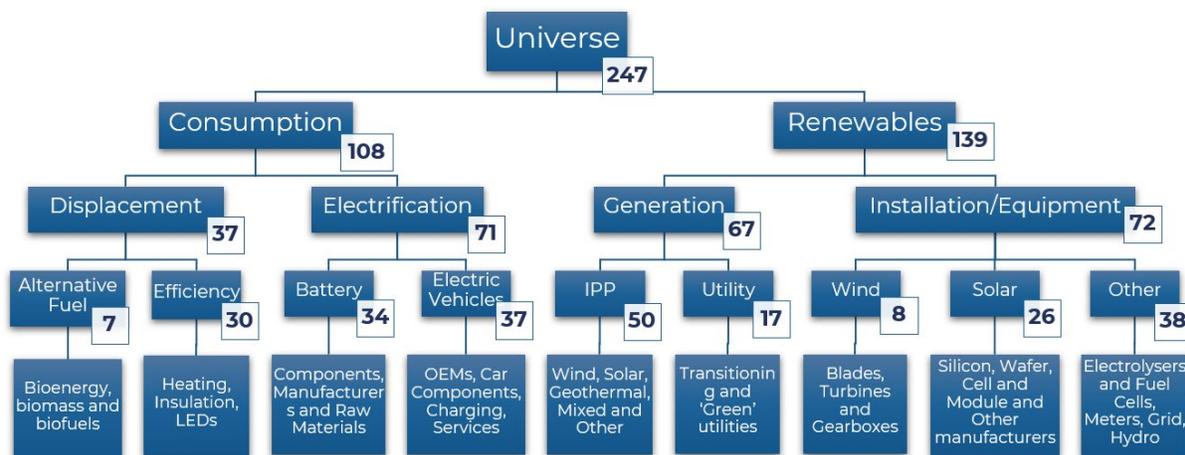
Two of the weaker names in the portfolio were **residential solar** exposed SolarEdge and Sunnova. Solaredge, a leading provider of solar inverters, has historically benefited from high returns on capital, a duopolistic industry structure and structural growth. More recently, as a function of changing legislation in California and distributor destocking, there has been a slowdown in the US, prompting the company to downgrade near-term guidance. Sunnova provides leasing solutions for residential solar in the US and the market has grown concerned about an increased cost of financing as evidenced by a recent company bond issuance. While this may begin to impact growth rates, we note that the shares presently trade at a c.50% discount to the existing lease book (assuming no further growth).

Offshore wind bellwether Orsted announced another impairment in the quarter, driven by rising interest rates, increased supply chain costs and an inability to revise up its IRA tax credits. The company maintained its longer-term EBITDA guidance but the share price reaction was dramatic – effectively writing off the entirety of the company’s growth pipeline out to 2030. The company explicitly stated that it will not develop any projects which no longer meet its threshold of a 200-300bp spread over cost of capital.

PORTFOLIO

The Guinness Sustainable Energy Fund is positioned to benefit from many of the long-term themes associated with the transition towards a lower-carbon economy and of sustainable energy generation via investment in companies with activities that are economic with limited or zero government subsidy and which are profitable. Our investment universe comprises around 250 companies which are classified into four key areas:

- **Generation** includes companies involved in the generation of sustainable energy, either pureplay companies or those transitioning from hydrocarbon-based fuels
- **Installation** includes companies involved in the manufacturing of equipment for the generation and consumption of sustainable energy
- **Displacement** includes companies involved in the displacement or improved efficient usage of existing hydrocarbon-based energy
- **Electrification** includes companies involved specifically in the switching of hydrocarbon-based fuel demand towards electricity, especially for electric vehicles



We monitor each of the industry areas very closely and hope that detailed top-down (macro) analysis of each (complemented with disciplined equity screening and stock valuation work) will allow us to deliver attractive fund performance via an equally weighted portfolio of 30 stocks. The portfolio is designed to create a balance between maintaining fund concentration and managing stock-specific risk.

Guinness Global Investors is a signatory of the United Nations Principles for Responsible Investment. The Guinness Sustainable Energy Fund prioritises returns whilst delivering concentrated exposure to companies playing a key role in global decarbonisation. The Fund’s holdings align most closely with four of the UN’s sustainable development goals:

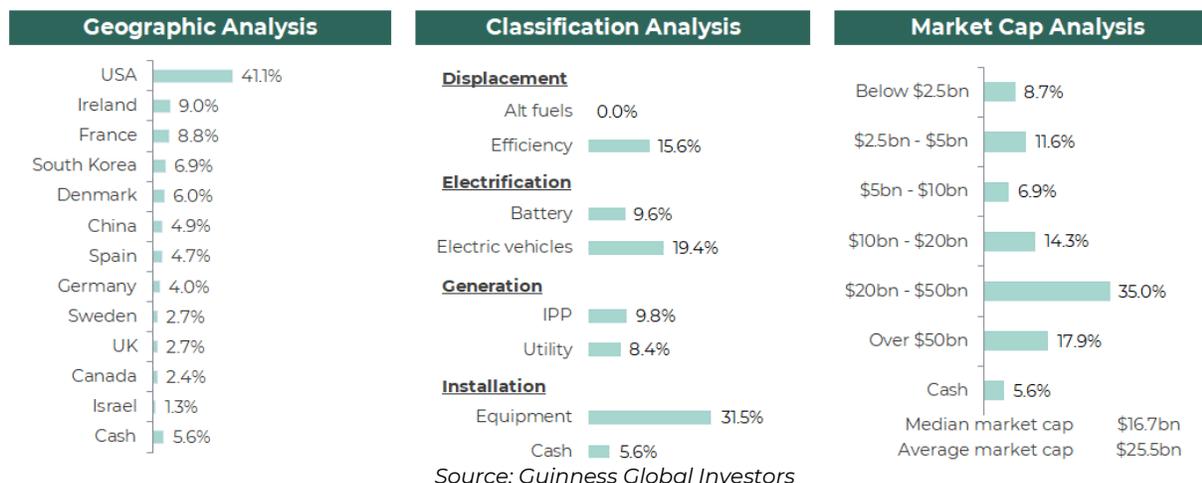


Guinness Sustainable Energy

Buys/Sells

There were no stock switches during the month but the portfolio was actively rebalanced.

Portfolio structure analysis



Portfolio sector breakdown

The following table shows the asset allocation of the Fund at month end and at previous year ends.

Asset allocation as %NAV	Current	Change	Year end		Previous year ends		
	Sep-23		Dec-22	Dec-21	Dec-20	Dec-19	Dec-18
Consumption	44.6%	-0.3%	44.9%	43.4%	36.7%	41.7%	26.5%
Displacement	15.6%	0.6%	15.0%	11.8%	9.9%	13.4%	16.4%
Alternative Fuel	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.9%
Efficiency	15.6%	0.6%	15.0%	11.8%	9.9%	13.4%	12.5%
Electrification	29.0%	-0.9%	29.9%	31.6%	26.8%	28.2%	10.1%
Batteries	9.6%	-2.1%	11.6%	8.9%	10.8%	12.6%	3.9%
Electric vehicles	19.4%	1.2%	18.2%	22.8%	16.0%	15.7%	6.2%
Renewables	49.8%	0.5%	49.3%	51.3%	60.4%	54.1%	69.7%
Generation	18.3%	0.6%	17.7%	23.1%	24.6%	22.2%	27.3%
IPP	9.8%	1.2%	8.7%	14.5%	17.0%	18.9%	26.7%
Utility	8.4%	-0.6%	9.0%	8.6%	7.6%	3.2%	0.6%
Installation	31.5%	-0.1%	31.6%	28.2%	35.8%	32.0%	42.5%
Equipment	31.5%	-0.1%	31.6%	28.2%	35.8%	32.0%	42.5%
Cash	5.6%	-0.3%	5.8%	5.3%	3.0%	4.2%	3.8%

Source: Guinness Global Investors

Valuation

At the month end, the Guinness Sustainable Energy portfolio traded on the following multiples:

As at 30 September 2023	P/E			EV/EBITDA			Dividend Yield		EPS Growth (%pa)		CFROI*	
	2022	2023E	2024E	2022	2023E	2024E	2023E	2024E	2014-21	2022-25	2022	2023E
Guinness Sustainable Energy Fund	20.1x	17.5x	14.7x	13.0x	11.0x	9.2x	1.5%	1.6%	6.8%	20.7%	5.4%	7.5%
MSCI World Index	15.9x	17.5x	16.3x	10.4x	11.8x	10.7x	2.0%	2.2%	5.4%	6.4%	8.1%	7.8%
Fund Premium/(Discount)	26%	0%	-10%	25%	-7%	-14%						

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

Source: Guinness Global Investors, Bloomberg

Portfolio holdings as at end September 2023

Our portfolio is typically allocated across 30 equally weighted equities providing exposure across the value chain of sustainable energy.

We hold c.45% weight to companies associated with the consumption (or demand) of sustainable energy. Our largest exposure here is to companies involved in the electrification of demand, either via the creation of new batteries (10%) or the electrification of transportation (19% weight) while we have 16% weight to those companies involved in either displacing existing energy sources or improving overall energy efficiency.

We hold two lithium-ion battery manufacturers. LG Chem is a large Korean chemicals company that is the largest lithium-ion battery manufacturer in the world, while Samsung SDI is a pure play lithium-ion battery manufacturer, currently in the top 10 in the world.

The portfolio holds five names in the electric vehicle sub-category, giving it exposure to companies that provide semiconductors, electronics, components and software/services to the growing EV and autonomous vehicle industry. Onsemi and Infineon are providers of power semiconductors that are a necessity for higher-voltage electric vehicles to become competitive with ICE (internal combustion engine) vehicles, while Gentherm, Aptiv and Sensata are component manufacturers and service providers that should benefit from the ever-increasing amount of electronics present in electric vehicles.

Our displacement holdings provide pure play quality exposure to heating industries (Nibe Industrier), energy efficient electrical equipment and services (Hubbell) and energy efficiency projects (Ameresco), and the group as whole will benefit from the increasing industry focus on energy efficiency that is expected to be a very long-term trend.

In terms of the supply of sustainable energy, we hold a 19% weight to companies involved in the generation of sustainable energy and 32% weight to those exposed to the installation of or equipment used in the process of sustainable energy generation.

China Suntien and China Longyuan are our two pure play Chinese wind power producers and they represent 2 of our 6 generation holdings. The remaining exposure comes in the form of geothermal (Ormat), US residential solar (Sunnova) and then offshore wind and broad-based wind/solar renewable energy generation through Orsted and NextEra Energy (the largest producer of renewable energy in the world). Iberdrola is our one utility.

We hold exposure to the solar and wind equipment and manufacturing value chains. Xinyi Solar is the world's largest supplier of the glass used in solar cell modules and both EnPhase and SolarEdge manufacture the inverters required to convert DC solar power into consumable AC electricity. Canadian Solar and First Solar give integrated exposure to the solar cell and module manufacturing process. Vestas provides broad exposure to the strong growth that we expect in the onshore and offshore wind markets, while TPI Composites offers niche exposure to the high-skilled business of manufacturing wind turbine blades.

Our remaining exposure to Installation (Itron, Eaton and Schneider Electric) gives exposure to companies that provide equipment and services to improve the efficiency and metering of electricity transmission and consumption.

Portfolio themes as at end September 2023

Theme	Example holdings	Weighting (%)
1 Electrification of the energy mix		25.6%
2 Rise of the electric vehicle and auto efficiency		22.1%
3 Battery manufacturing		6.9%
4 Expansion of the wind industry		9.0%
5 Expansion of the solar industry		12.0%
6 Heating, lighting and power efficiency		15.6%
7 Geothermal		3.2%
8 Other (inc cash)		5.6%

Portfolio at end August 2023 (one month in arrears for compliance reasons)

Guinness Sustainable Energy Fund (31 August 2023)			P/E				EV/EBITDA			Price/Book			Dividend Yield		
Stock	ISIN	% of NAV	2022	2023E	2024E	2025E	2022	2023E	2024E	2022	2023E	2024E	2022	2023E	2024E
Displacement/Efficiency															
Hubbell Inc	US4435106079	4.4%	31.3x	21.5x	20.3x	19.2x	21.3x	15.0x	14.3x	7.4x	6.2x	5.4x	1.3%	1.4%	1.6%
Nibe Industrier AB	SE0015988019	2.9%	38.5x	30.0x	26.2x	23.2x	24.3x	19.2x	16.7x	6.1x	5.2x	4.5x	0.7%	0.9%	1.1%
Trane Technologies PLC	IE00BK9ZQ967	4.6%	28.6x	23.2x	21.2x	19.4x	18.9x	16.1x	15.2x	8.2x	7.3x	6.6x	1.3%	1.4%	1.5%
Installed Building Products Inc	US45780R1014	0.8%	16.7x	15.3x	14.3x	13.0x	10.8x	10.2x	9.7x	8.7x	6.2x	4.7x	1.3%	1.3%	0.9%
Ameresco Inc	US02361E1082	2.3%	23.3x	23.5x	17.1x	12.7x	15.7x	15.4x	11.5x	2.8x	2.4x	2.1x	n/a	n/a	n/a
		15.0%													
Electrification/Battery															
LG Chem Ltd	KR7051910008	3.7%	17.0x	21.1x	11.2x	7.3x	8.5x	8.3x	5.5x	1.3x	1.3x	1.2x	1.8%	1.7%	2.1%
Samsung SDI Co Ltd	KR7006400006	4.0%	21.0x	21.2x	16.8x	13.7x	12.8x	12.3x	9.7x	2.4x	2.2x	2.0x	0.2%	0.2%	0.2%
Johnson Matthey PLC	GB00BZ4BQC70	2.6%	7.9x	9.1x	9.8x	8.5x	5.4x	6.2x	6.3x	1.2x	1.2x	1.1x	4.6%	4.7%	4.7%
		10.3%													
Electrification/Electric Vehicles															
Aptiv PLC	JE00B783TY65	3.9%	30.3x	21.5x	16.6x	13.1x	14.9x	11.9x	9.9x	3.3x	2.9x	2.5x	0.1%	0.2%	0.4%
ON Semiconductor Corp	US6821891057	4.8%	18.6x	18.9x	17.3x	15.2x	12.8x	12.9x	11.7x	6.9x	5.1x	4.0x	n/a	n/a	n/a
Infineon Technologies AG	DE0006231004	3.9%	18.3x	12.6x	12.6x	11.5x	10.5x	7.7x	7.3x	3.4x	2.6x	2.2x	0.9%	1.1%	1.3%
Sensata Technologies Holding PLC	GB00BFMBMT84	3.4%	11.3x	10.0x	9.0x	7.8x	9.4x	9.2x	8.3x	1.9x	1.7x	1.5x	0.9%	1.2%	1.3%
Gentherm Inc	US37253A1034	2.9%	30.3x	23.7x	17.5x	12.1x	15.7x	11.3x	9.0x	n/a	n/a	n/a	n/a	n/a	n/a
		18.9%													
Generation/IPP															
China Longyuan Power Group Corp Ltd	CNE100000HD4	1.5%	7.6x	6.1x	5.1x	4.4x	10.7x	9.4x	8.2x	0.7x	0.7x	0.6x	2.5%	3.3%	3.9%
Ormat Technologies Inc	US6866881021	3.2%	56.3x	35.5x	28.5x	22.5x	15.0x	13.4x	11.9x	2.2x	1.8x	1.8x	0.6%	0.6%	0.6%
NextEra Energy Inc	US65339F1012	4.0%	23.2x	21.4x	20.1x	18.1x	19.0x	15.0x	13.9x	3.0x	2.8x	2.6x	2.5%	2.8%	3.1%
Sunnova Energy International I	US86745K1043	1.4%	n/a	n/a	n/a	n/a	71.3x	41.5x	25.8x	1.0x	0.7x	0.6x	n/a	n/a	n/a
Orsted A/S	DK0060094928	2.8%	10.8x	24.6x	18.4x	16.5x	8.5x	10.9x	9.3x	2.6x	2.1x	1.9x	3.0%	3.3%	3.5%
China Suntien Green Energy Corp Ltd	CNE100000TW9	1.1%	4.5x	4.7x	3.9x	3.2x	8.7x	9.4x	7.8x	0.5x	0.5x	0.5x	7.7%	7.7%	8.8%
		13.9%													
Generation/Utility															
Iberdrola SA	ES0144580Y14	4.6%	17.0x	14.8x	14.2x	13.3x	10.5x	9.1x	8.7x	1.7x	1.5x	1.4x	4.2%	4.8%	5.0%
		4.6%													
Installation/Equipment															
Schneider Electric SE	FR0000121972	4.3%	22.3x	19.9x	18.6x	17.1x	15.3x	13.9x	13.1x	3.5x	3.3x	3.0x	1.9%	2.3%	2.4%
Legrand SA	FR0010307819	4.3%	22.0x	19.6x	19.1x	17.6x	14.1x	12.8x	12.4x	3.8x	3.4x	3.2x	2.0%	2.2%	2.4%
Eaton Corp PLC	IE00B8KQN827	5.0%	30.5x	26.2x	23.7x	21.5x	23.8x	20.2x	18.4x	5.5x	5.0x	4.6x	1.4%	1.5%	1.6%
Itron Inc	US4657411066	3.5%	135.7x	31.6x	25.6x	17.8x	42.2x	19.0x	15.4x	2.7x	2.5x	2.2x	n/a	n/a	n/a
Xinyi Solar Holdings Ltd	KYG9829N1025	2.0%	12.8x	14.4x	9.8x	8.1x	9.9x	9.8x	7.1x	1.8x	1.8x	1.6x	3.6%	3.1%	4.7%
SolarEdge Technologies Inc	US83471M1045	1.4%	34.3x	17.0x	14.3x	11.8x	19.0x	12.0x	9.4x	4.4x	3.5x	2.8x	n/a	n/a	n/a
Enphase Energy Inc	US29355A1079	1.6%	28.9x	25.5x	19.6x	15.1x	22.6x	18.8x	14.8x	31.5x	15.2x	9.2x	n/a	n/a	n/a
First Solar Inc	US3364331070	3.9%	n/a	24.9x	15.0x	9.9x	102.4x	16.9x	10.3x	3.5x	3.1x	2.6x	n/a	n/a	n/a
Canadian Solar Inc	CA1366351098	2.5%	9.1x	5.0x	4.6x	4.0x	6.5x	3.7x	3.0x	0.8x	0.7x	0.5x	n/a	n/a	n/a
Vestas Wind Systems A/S	DK0061539921	3.4%	n/a	797.3x	28.1x	16.6x	n/a	21.2x	11.1x	6.3x	6.8x	5.5x	0.1%	0.1%	0.9%
TPI Composites Inc	US87266J1043	0.2%	n/a	n/a	n/a	10.0x	13.9x	n/a	8.0x	2.4x	1.4x	1.6x	n/a	n/a	n/a
		32.1%													

The Fund's portfolio may change significantly over a short period of time; no recommendation is made for the purchase or sale of any particular stock.

OUTLOOK - sustainable energy & the energy transition

Sustainable energy: the long-term outlook

Over the next thirty years, the world will continue its transition to a sustainable energy system. The key factors driving the transition are:

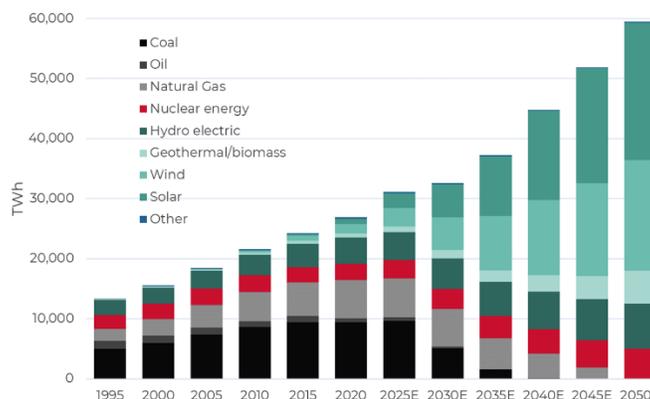
- **Population and GDP growth** putting a significant strain on today's energy supply
- **Economics** as sustainable sources of energy will be cheaper than the incumbents
- **Climate change** leading the world to reduce carbon emissions via cleaner energy
- **Pollution** forcing governments to drive air pollution out of cities via cleaner energy
- **Energy security** as sustainable energy sources, which are more evenly spread across all countries, facilitate lower reliance on energy imports.

The outcomes of the energy transition will of course be wide-ranging. On the **supply** side, we see a sustained shift towards renewable power generation, fulfilling global power generation needs which are set to double by 2050. On the **demand** side, we believe that improved energy efficiency will be key to limiting energy consumption growth to a manageable level so that it can be increasingly satisfied by renewable sources.

The long-term direction is clear and is driven by economics, in our opinion, while near term geopolitical issues (such as the invasion of Ukraine in February 2022) could potentially have an effect on the speed of the transition and the relative importance of the factors stated above.

Within the power generation industry, we expect a radical change in energy mix. Today, the global power mix is predominantly driven by coal and natural gas (35% and 24% respectively), whilst variable renewable generation (wind and solar) have less than a 10% share. By 2035, we expect wind and solar to have grown to around 40% of the generation mix, increasing to over 60% by 2050.

Global power generation by type (TWh, 1995-2040E)



Sources: BP Statistical Review; IEA; Guinness Global Investors estimates; as of 31.12.2022

Policy support for decarbonisation

Policy commitment in recent years has been particularly supportive. However, the path has not always been smooth and it is unlikely to be a smooth ride from here. The most significant policy milestones in the recent period include:

- **President Biden returning the US to the Paris Agreement** and announcing significantly increased 2030 GHG reduction targets. The new target - a 52% reduction in emissions by 2030 (vs 2005 levels) - was substantially ahead of the old target of a 28% reduction by 2025.

- **The 2021 IPCC climate report.** The Intergovernmental Panel on Climate Change (IPCC) published its sixth assessment report on the physical science of climate change and the physical impacts of various carbon emission and warming scenarios.
- **COP26 climate conference.** In November 2021, the COP26 climate conference was held in Glasgow. The conference produced results which we considered to be better than feared, but not as good as hoped. Key headlines included new net zero targets, additional country pledges and some 'alliances of the willing' to reduce coal usage and methane emissions.
- **Carbon pricing.** Developments in carbon pricing remain hopeful with momentum towards the introduction of emissions trading schemes (ETS) as a tool for decarbonisation. At the start of 2021, China commenced a new national ETS scheme which immediately became the world's largest carbon market (covering around 2,225 entities in the power generation industry with annual emissions of around 4,000 MtCO₂e) while Canada introduced a federal carbon tax that will increase by 2030 to around US\$130/tonne.
- **The RePowerEU deal.** In response to the invasion of Ukraine, the REPowerEU deal was passed. It is designed to increase the resilience of the EU energy system in the short term to deal with the loss of Russian gas imports and it provides a greater emphasis on energy efficiency and increasing domestic renewable energy capacity. It builds on the EU's 'Fit for 55' proposals which are designed to deliver a 55% reduction in GHG emissions by 2030 (vs 1990).
- **The US Inflation Reduction Act.** In response to the invasion of the Ukraine and increased need for energy security, the Inflation Reduction Act was passed. It brings a potential \$369bn in support for energy security and climate change, specifically targeting financial support for clean sources of electricity and energy storage as well as tax credits for clean fuels and clean commercial vehicles.

While policy towards stimulus plans continues to be positive, the passage of actual investment into the energy transition has been slower than expected and still remains a positive catalyst from here. Both the REPowerEU deal and the Inflation Reduction Act are unlikely to yield new investments until 2023/2024 and well into the second half of this decade.

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. For our base case scenario to be achieved, per capita energy demand over the next thirty years needs to stay broadly flat, whilst the energy intensity of global GDP needs to fall by around 40%.

Within the energy displacement sector, key areas of focus are **efficiency** and **alternative fuels**.

Energy efficiency

Energy efficiency is a key pillar of new policy. For example, the EU had previously set itself a challenging target to consume 9% less energy in 2030 than in 2020 and the new RePowerEU deal 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.

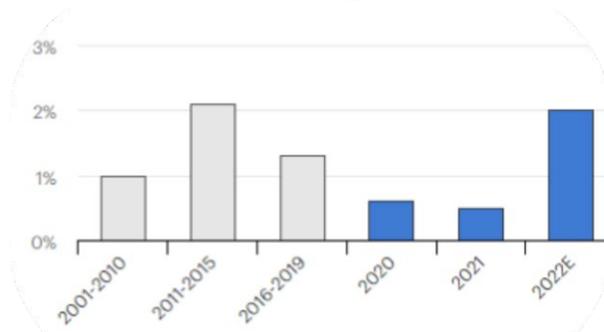
The focus on building efficiency is important, since buildings are responsible for 30% of primary energy consumption and nearly 40% of global carbon emissions. Electrifying heating (heat pumps) and improving the efficiency of heating (insulation), cooling (efficient HVAC), and lighting (LEDs) offers 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 have resulted 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.

To achieve a net zero scenario, 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).

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.

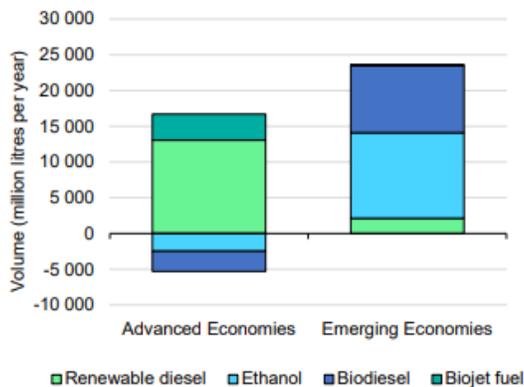
Liquid biofuel demand is expected to have reached 168bn litres in 2022, representing around 4.3% of transportation fuel consumption. The US and Brazil continue to dominate the market, making up around 40% and 25% of global demand respectively, supported by strong domestic industries for corn and sugar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

To achieve a net zero scenario, 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. This would mean that 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 energy transition is seeing energy demand being ‘electrified’ as it moves away from predominantly hydrocarbon fuels and gases towards the consumption of electricity. Our ‘electrification’ sector includes some key enablers of this transition: the lithium-ion battery and the electric vehicle industries. The battery industry is critical here in that it will serve electric vehicles and also provide a stationary energy storage solution in electricity grids, allowing variable renewable energy (i.e. solar & wind) to play an expanding role in the global power stack.

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 end of 2022, lithium and nickel prices were 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

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(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

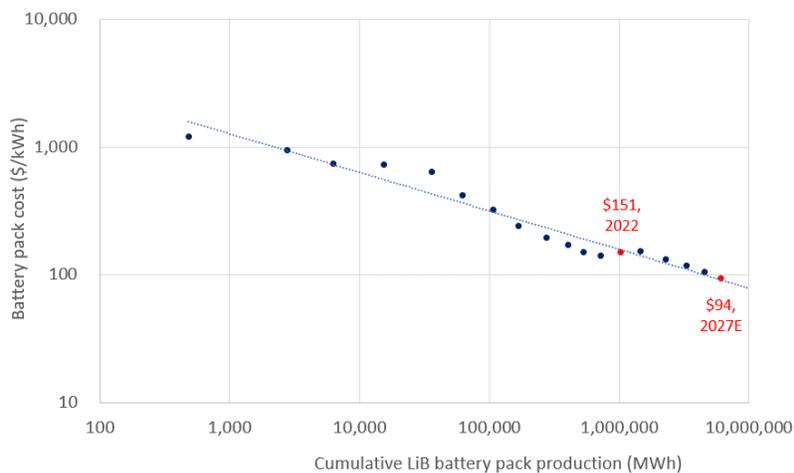
source: BNEF



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



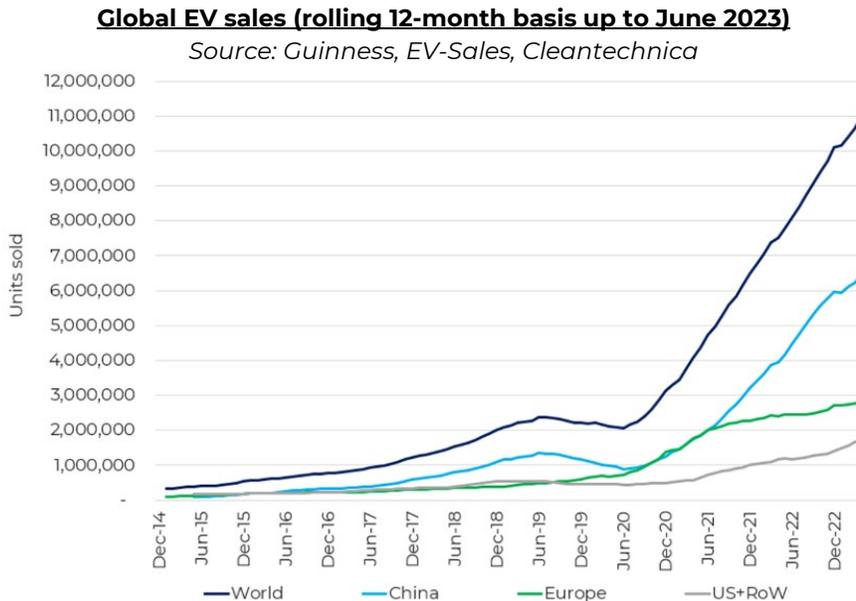
In 2020, the expectation was that the industry battery pack cost target of \$100/kWh (the price at which EVs reach price parity with ICE vehicles) would be hit by 2024. On our estimates, higher lithium and nickel prices are now likely to delay this until 2027. The \$50/kWh cost reduction over the next 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 over 10 million plug-in vehicles sold throughout the year, more than in 2019 and 2020 combined. Battery electric vehicles (BEVs) made up just under 10% of new car sales with total plug-in

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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%.



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 market continues to develop 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.

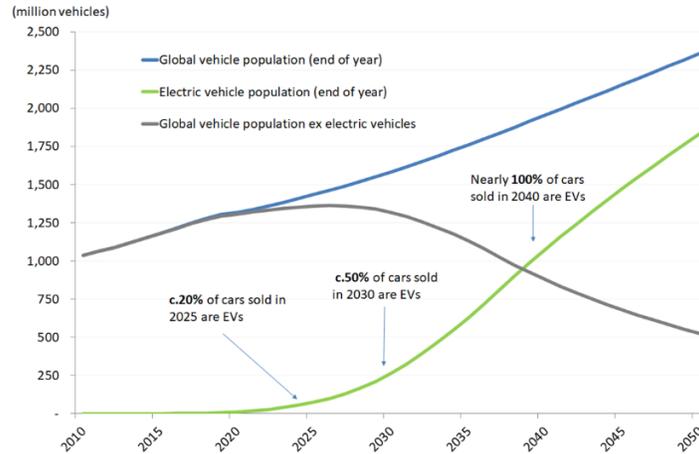
- Economics:** Electric vehicles cost more to buy but have lower overall running costs. Excluding China, the IEA suggest that BEVs are typically \$15,000 more expensive to purchase. Assuming normalised fuel and electricity prices, we estimate that lifecycle running costs for an electric vehicle in Europe 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.

Despite our rapid base case EV growth assumptions, we calculate that oil demand from passenger vehicles will not peak until around 2024/25 and that, even by 2030, passenger vehicle oil demand will be similar to 2021 levels. With transportation generating just over 7bn tonnes of carbon emissions in 2020, accelerating the transition and reducing associated oil demand is critical to achieving a net zero 2050 scenario.

Global EV population (to 2050)

Source: IEA; Guinness Global Investors estimates



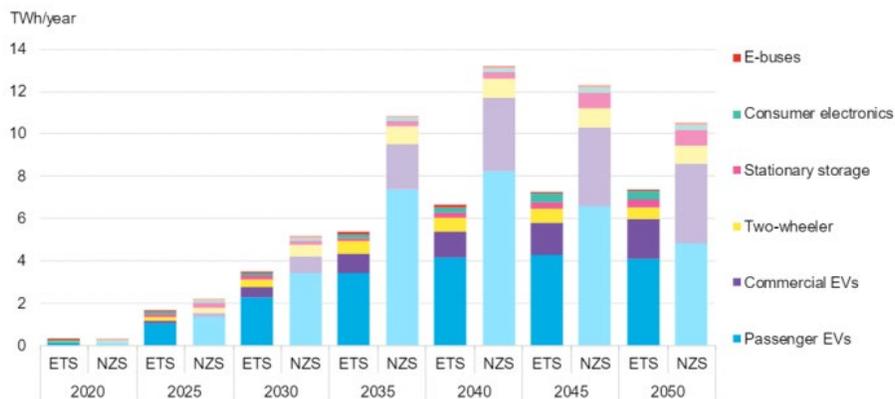
Our base case for electrification implies that there will be over one billion electric vehicles on the road by 2040, that electricity is 57% of total energy demand and that variable renewables such as wind and solar will represent 61% of global power grids. Achieving this would require annual EV sales 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)

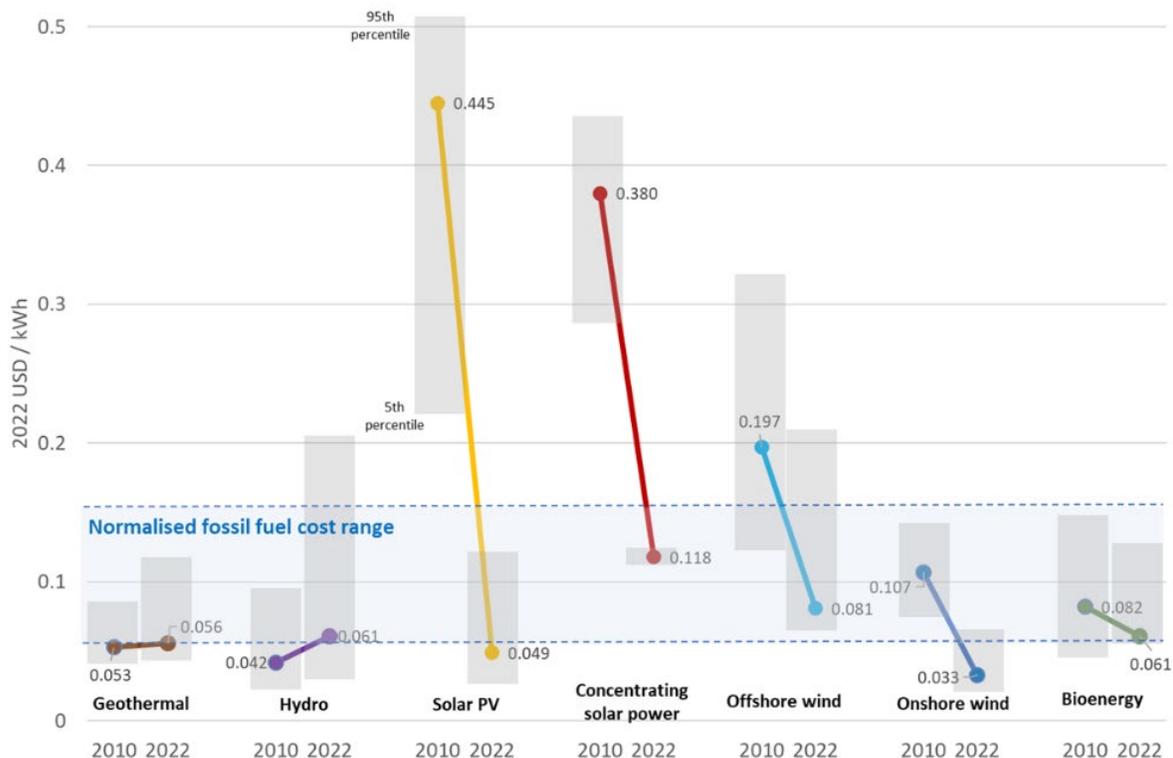
Before considering the detailed dynamics of key renewable power generation markets of wind and solar, it is worth considering the significant changes that have occurred to the economics of various renewable power generation technologies since 2010. Onshore wind and solar PV have joined hydro and geothermal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

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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 (Levelised Cost of Electricity) of utility-scale renewable power generation technologies (2010–2022)

source: IRENA, 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.

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, our initial estimate for 2023 module demand of 310 GW has now increased to 345 GW, another record year for global installations, with growth of nearly 100 GW versus 2022.

Regionally, the key moving parts 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 2023 are now likely to be around 33 GW as demand is less likely to be impacted by NEM3.0 and the WRO.

- Demand in **Europe** was 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 was around 107 GW in 2022 (up nearly 40 GW on 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.
- 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	2022	2023E
OECD solar installations (annual)														
North America	1	2	4	6	7	8	14	11	10	11	19	25	24	33
Germany	7	7	8	3	2	1	2	2	4	4	5	6	7	10
Spain	0	0	0	0	0	0	0	0	0	5	3	5	7	8
Rest of Europe	3	4	5	5	5	6	4	3	4	6	12	19	21	29
Australia	0	1	1	1	1	1	1	2	4	4	4	5	4	5
South Korea	0	0	0	1	1	1	1	1	2	3	6	4	3	3
Japan	1	1	2	7	10	11	8	8	7	7	9	6	6	6
Total OECD	17	23	24	24	25	29	29	26	31	40	58	71	76	98
<i>Change</i>	10	7	0	0	2	4	0	-3	5	9	18	13	18	22
Non-OECD solar installations (annual)														
China	0	3	3	14	13	19	30	53	44	33	52	69	107	154
India	0	0	1	1	1	2	5	10	11	12	4	12	18	16
Rest of non-OECD	1	3	3	4	6	6	11	9	22	34	32	30	47	78
Total Non-OECD	2	5	8	18	21	27	46	72	77	78	88	111	172	247
<i>Change</i>	1	3	2	11	2	6	19	26	5	1	10	23	58	75
Total solar installations (annual)	19	29	31	42	46	56	75	98	108	118	146	182	250	345
<i>Change</i>	11	10	2	11	4	10	19	23	10	10	28	36	76	95

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 to 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.

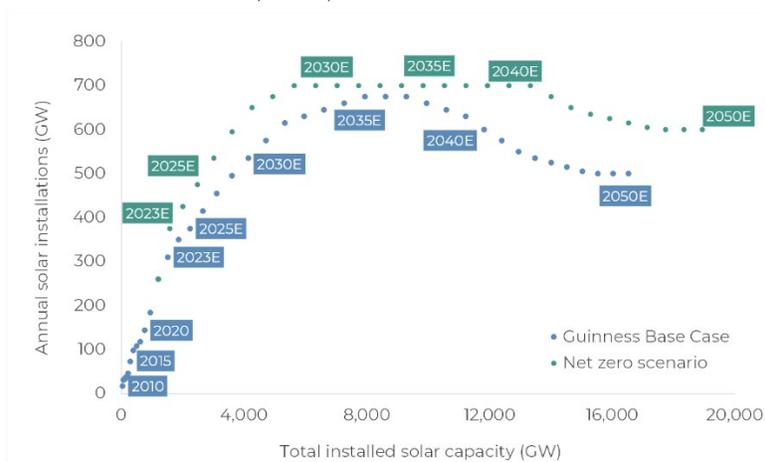
- Solar module** prices moderated in the second half of 2022 with prices likely to average the same level as 2021. With elevated polysilicon and power prices, it is the module manufacturers that suffered the greatest margin compression in 2022. Module manufacturing nameplate capacity in 2022 is estimated 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.

The long-term outlook for solar improved through 2022. In August 2022, 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.

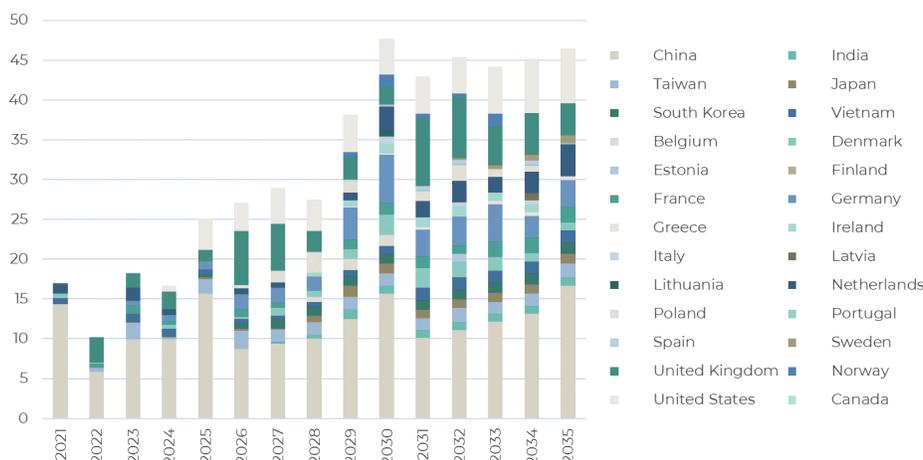
Guinness Sustainable Energy

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). The first half of 2023 brought a number of problems for offshore wind companies including significant impairments and profit warnings from turbine manufacturers (example Siemens Gamesa) as well as developers (example Orsted) reflecting a number of shorter term supply chain-related issues as well as more structural longer term issues around the economic viability of the resource.

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

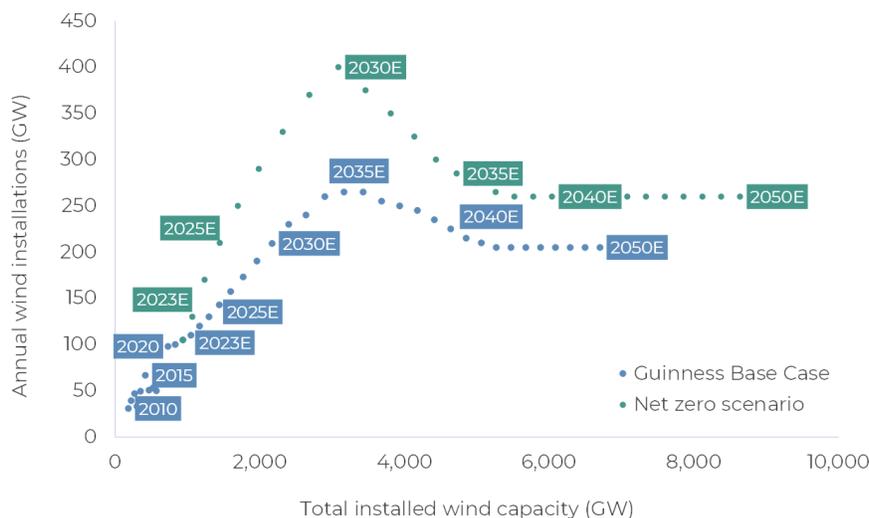
source: BNEF



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 and recent announcements in 2023 are slowing the momentum.

Global wind annual installations, base case and NZE scenario

source: IEA, IPCC, Guinness Global Investors



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GUINNESS SUSTAINABLE ENERGY FUND

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