Guinness Sustainable Energy

Investment Commentary – June 2023

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
Irish Domiciled	Guinness Sustainable Energy Fund
UK Domiciled	TB 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.

CONTENTS

PRI Principles for Responsible Investment

COMMENTARY

UPDATE ON NUCLEAR POWER

Nuclear power is one of the cleanest sources of baseload generation available, yet high profile safety incidents have led to decades of underinvestment. Governments now face the challenge of meeting growing energy demand whilst balancing reactor retirements and increasing pressure to reduce power sector emissions. This month's manager's comments explore the past, the present and the future of nuclear power.

EQUITIES

Global stock markets were weak in May, with the MSCI World Net Return Index delivering -1.0% in USD. Over the month, the Guinness Sustainable Energy Fund (Class Y) delivered a flat return (in USD), outperforming the MSCI World by 1.0%. Year to date, the fund is up 5.4%, underperforming the MSCI World which is up 8.5%. Full performance details are available in Section 3.

In the portfolio, the strongest performers included our electrification names Itron and ONSemi. Itron posted strong Q1 results against low expectations, while ONSemi hosted a Capital Markets Day which highlighted the strong progress they are making in silicon carbide power semiconductors. The company stressed their intention to grow faster than the broader semi market out to 2027 and upgraded their long-term margin targets from 28% to 40%.

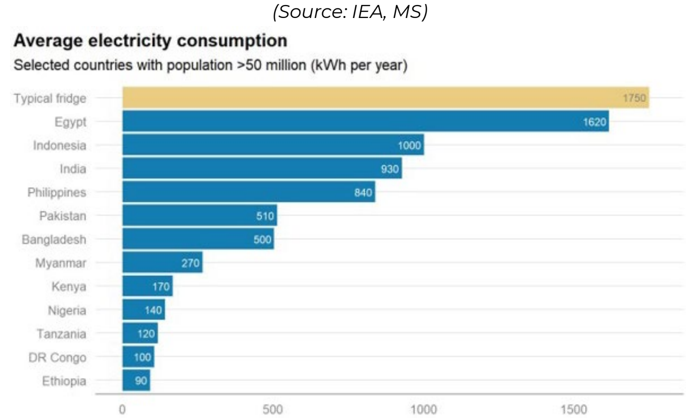
The weakest performer in the portfolio was heat-pump manufacturer Nibe, which modestly beat Q1 earnings estimates but not enough to sustain recent positive share price momentum.

CHART OF THE MONTH

In total, 3.8 billion people live in countries where the average electricity consumption-per-person is below that of a typical refrigerator in the west. Increasing living standards is a key driver of the electrification megatrend.

Electricity consumption vs a fridge

(Source: IEA, MS)



MAY 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
Fatih Birol, head of the IEA, has stated that Solar power investment in 2023 is set to outstrip spending on oil production for the first time ever. Total solar spending in 2023 is expected to reach $382bn compared to $371bn for oil production. The same numbers were $636bn and $127bn (for oil and solar respectively) just 10 years ago. Birol added “if these clean energy investments continue to grow in line with what we have seen in the past few years… we will soon start to see a very different energy system emerging and we can keep the 1.5°C goal alive”.	Solar investment	↗
The Spanish government announced an increased emissions reduction plan which aims to reduce GHG emissions by 30% vs 1990 levels. This is more ambitious than the prior plan (which aimed for a 23% reduction) and is likely to be accompanied by updated hydrogen and renewables targets (set to be announced in June).	European renewables policy	↗
The UK energy regulator Ofgem has stated that the private UK grid monopoly, National Grid, needs to materially accelerate grid connections for solar and wind farms or face “tough reforms”. Jonathan Brearley, CEO of Ofgem is quoted as saying “delays are threatening the race to net zero” and vowed to change regulations to accelerate connection speeds.	Grid investment	↗
Tesla announced the decision to open its “walled garden” charging network to rival Ford in a move likely to shake up the US charging industry. Consultancy Atlas Public Policy noted that while the US currently has 139,000 charging ports, only 32,000 of these offer 30 minute “fast charging”. Of these, Tesla owns 19,000 (60%). By opening up these chargers to rival car companies Tesla not only qualifies for greater subsidies from various federal schemes, but also increases the attractiveness of owning a non-Tesla EV, thus facilitating EV adoption.	US EV adoption	↗
May saw a number of announcements regarding a step up in biofuel investments from European oil majors; ENI announced that they are investing in farming in various African and Asian countries with the aspiration of covering 20% of their biofuel production with their own feedstock by 2025; BP also announced that they are seeking to invest in feedstock producers in order to achieve their aspiration of tripling biofuel output by 2030.	Biofuel investment	↗

MANAGER'S COMMENTS

Nuclear: renaissance or run-off?

Nuclear power is one of the cleanest sources of baseload generation available, yet high profile safety incidents have led to decades of underinvestment. Governments now face the challenge of meeting growing energy demand whilst balancing reactor retirements and increasing pressure to reduce power sector emissions. This month's manager's comments explore the past, the present and the future of nuclear power.

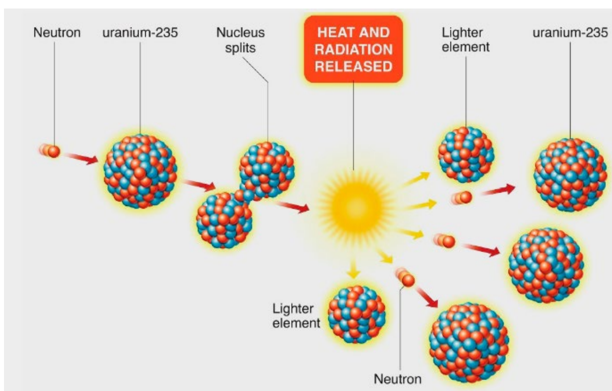
Nuclear power overview

Nuclear energy is the energy that holds protons and neutrons together in the nucleus of an atom. There are two main ways to release nuclear energy: nuclear fusion, where atoms are joined together; and nuclear fission, where atoms are split apart. Fusion is the process that powers the sun, but due to the difficulties in replicating the sun's heat and gravity on Earth, the technology is still some way from being commercially viable. On the other hand, fission has been used in power plants since the 1950s.

Nuclear fission involves firing neutrons at Uranium atoms and splitting them apart to release nuclear energy. Uranium is the most widely used fuel in fission because its atoms split relatively easily. When a neutron collides with uranium, the atom splits into lighter elements and free neutrons, releasing energy in the form of radiation and heat. The split uranium atom throws off 2-3 extra neutrons which repeat the process with other uranium atoms in a closely controlled chain reaction. This heat is used to turn water into steam, which turns a turbine to create electricity.

<u>**How nuclear fission works**</u>

Source: ENEC



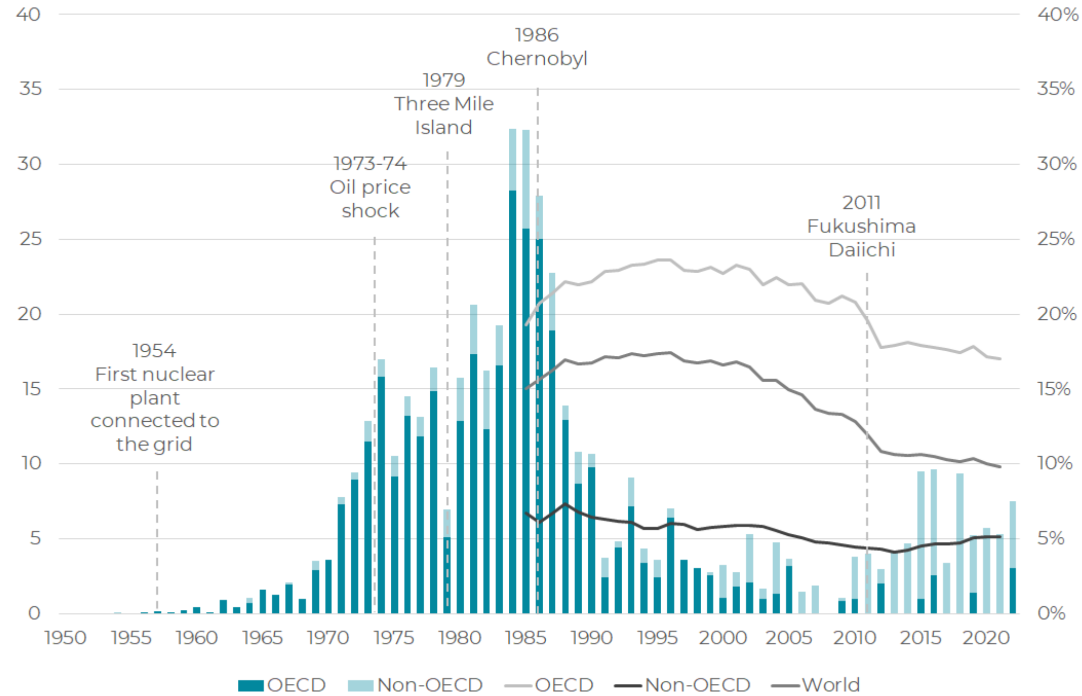
The buildout of the existing nuclear power fleet

The discovery of nuclear energy can trace its roots back to France in the 1890s where a physicist called Henri Becquerel discovered that uranium salts emitted radioactive rays. Four decades later, German chemists Otto Hahn and Fritz Strassman discovered nuclear fission (1938), making atomic bombs a theoretical possibility. This led to the creation of the Manhattan project (1939), responsible for the construction of both the first nuclear reactor in the USA (1942) and the production of the first atomic bomb (1945).

After World War II, the Cold War stimulated further research into nuclear technology, leading to the world's first grid connected nuclear power plant in Russia (1954). War in the Middle East at the start of the 1970s caused oil prices to skyrocket. Interest and investment in nuclear power surged as it offered a route to energy independence by reducing reliance on fossil fuel imports. Nuclear capacity additions peaked in the 1980s at 22GW pa before slowing to 5GW pa in the 1990s in the wake of the major nuclear accident at Chernobyl (1986). Investment dwindled in the 2000s, bringing installations down to just 3GW pa before picking again in the 2010s averaging ~6.5GW pa despite the impact of the Fukushima accident in Japan.

Global nuclear grid connections (GW), since 1954

Source: World Nuclear Association, BP



The present state of the industry

According to the International Energy Agency (IEA), at the end of 2021 there were 439 nuclear reactors in operation globally with a combined capacity of 413 GW, satisfying ~10% of global electricity demand. Generation capacity was spread across 32 countries, with ~70% concentrated in the hands of the top 5: USA (26%), France (16%), China (13%), Russia (8%) and South Korea (6%).

Today, nuclear power can be characterised by a number of advantages and disadvantages:

- **Advantages:** proven technology, clean & reliable, reduces dependence on fossil fuels.

- **Disadvantages:** lacks public support due to safety and waste concerns, lacks investor support due to large capital costs and long development cycles which are prone to cost overruns and delays.

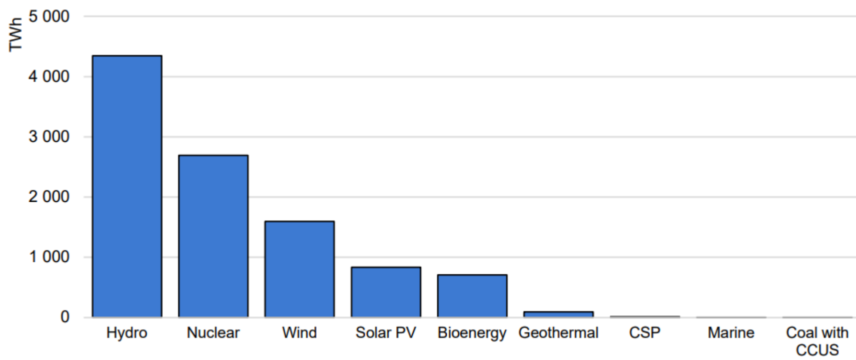
Insufficient investor appetite and decades of underinvestment means that the technology has not advanced much since the 1970s and 80s, when over 50% of current operational capacity was built. Reactors in developed economies (e.g. USA, France) are 35-40 years old on average and are increasingly being retired. In 2021, global nuclear power capacity declined by almost 3 GW globally, as new installations were not able to offset over 8 GW of retirements.

Nuclear's role in decarbonisation

Nuclear is the second largest source of emission free generation after hydropower and, according to the IEA, it has helped to avoid 66 Gt of CO_2 emissions over the past 50 years by reducing demand for fossil fuels. For context, the IAEA claims that an average human's lifetime electricity use could be met by either 88 tonnes of coal, 66 tonnes of oil, 47 tonnes of gas or a chicken-egg sized amount of uranium fuel.

Low emission electricity generation by source worldwide

Source: IEA



Nuclear is one of the few clean energy technologies which has both dispatchability (able to flex power output on demand by 10% within seconds and 20-80% within hours) as well as a high-capacity factor that make sit suitable for baseload generation (~90% vs 55% for natural gas). As a result, there is not a single credible net zero scenario which doesn't forecast growth in nuclear power generation.

Policy in key markets is strengthening in favour of investment in conventional and emerging nuclear technologies. For example:

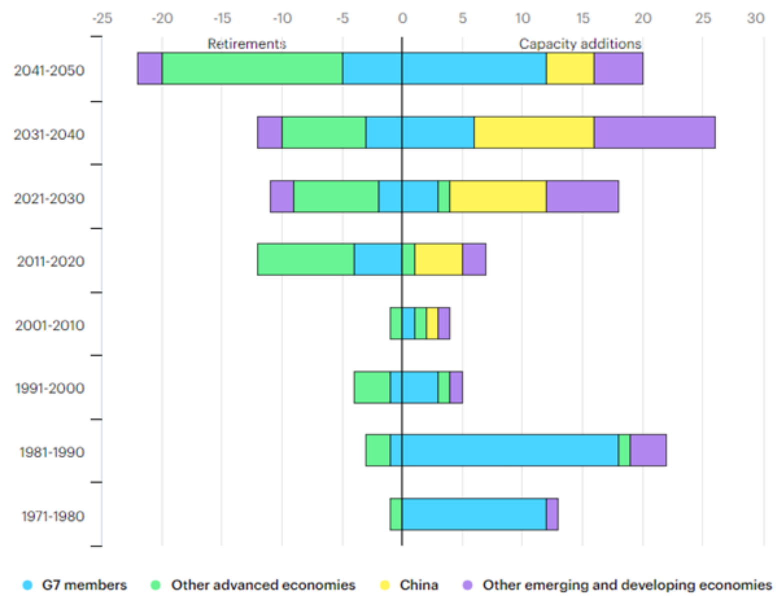
- **US:** the Inflation Reduction Act, Infrastructure Investment and Jobs Act, and several Department of Energy programmes have provided more than US$6 billion in public subsidies for uranium supply, operating nuclear capacity, small modular reactors (SMRs) and new reactor designs.
- **Europe:** the UK has a twin-track policy to build both new pressurised water reactors (PWRs) and promote SMRs. France has added eight new reactors to its nuclear growth plans. Poland has plans for six new AP1000 reactors and is considering SMR plants.
- **Asia:** China is growing rapidly in terms of both existing and new technologies (a Chinese nuclear reactor costs roughly 50% less than a similar reactor in Europe). Japan has approved an extension for existing nuclear reactors beyond 60 years. South Korea's tenth electric plan targets six new reactors and makes stable power supply a top priority. In India, more than 5 GW of nuclear power is in active development, with 22 GW targeted by 2031.

However, one of the key obstacles for the industry is the pace of nuclear power plant retirements, which are set to accelerate in the coming years. Nuclear power production in Germany came to an end in April 2023, concluding a process of nuclear power withdrawal that started in 2011. Lifetime extensions could help to slow the pace to some degree. Extensions across the US, France, Hungary, Finland, the Czech Republic and the UK have already prevented the closure of nearly 25% of total capacity that would otherwise have occurred by 2020, and 40% by 2030. Nonetheless, achieving significant net growth in nuclear power capacity globally looks challenging.

According to the IEA, to achieve a net zero scenario, annual new nuclear installations need to double this decade, to around 17 GW pa, increasing total installed capacity by 25% to 515 GW by 2030. As of 2021, there was 54 GW of capacity under construction with China representing 30% of the required growth, but this is not enough to bridge the 'net zero' gap to 2030.

Nuclear power capacity additions and retirements in a net zero scenario

Source: IEA

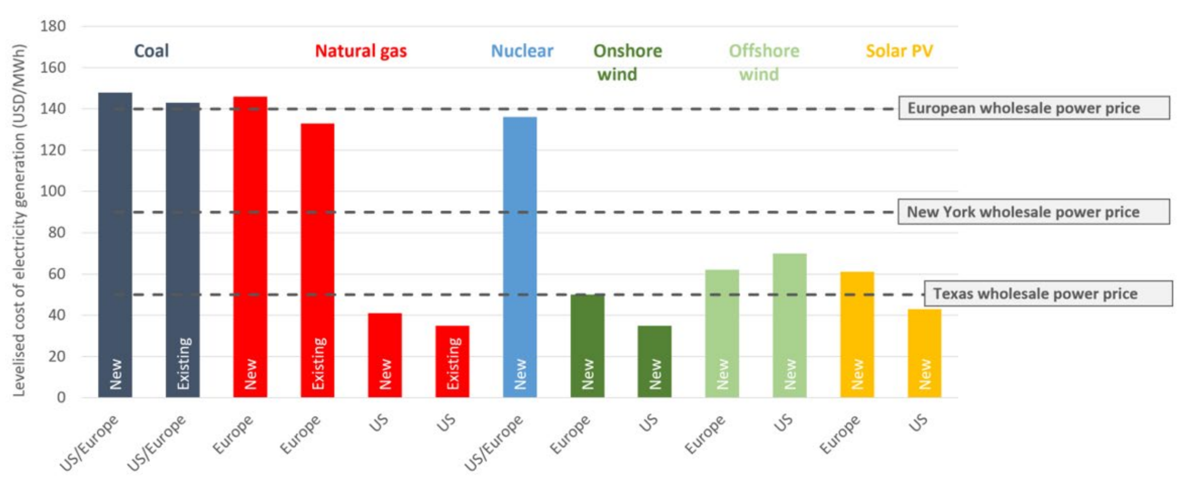


Economics of traditional nuclear power plants

High costs are arguably the biggest impediment to a nuclear renaissance. Around the world, conventional nuclear power currently has a levelised cost of electricity (LCOE) at least three times that of onshore wind and solar, and more than double that of offshore wind.

LCOE for various sources vs wholesale European and US power prices (2023)

Source: Bernstein; Guinness Global Investors



We should be careful here, as LCOE does not take into account additional grid costs which often increase the relative cost of wind and solar compared to centralised baseload power, including nuclear. Even so, the current cost gap is too great for nuclear to grow rapidly. And it means that companies like NuScale, TerraPower, Rolls Royce, Westinghouse and GE Hitachi and X-Energy are among those trying to improve the competitiveness of a new generation of reactors, including SMRs.

Small modular reactors

SMRs could offer solutions to some of the drawbacks of conventional nuclear projects and attracting fresh capital. The goal of SMRs is simple: make nuclear plants smaller, standardised, quicker and cheaper to build. Promoters of SMRs make the following claims:

- **Smaller –** Smaller reactors would be between 50-500MW compared to conventional reactors at 800-1,000+MW. At this size, SMRs could be built on brownfield sites to replace decommissioned coal fired plants, 90% of which are under 500MW.
- **Standardised –** manufacturing standardised components which should allow SMR construction to be more predictable than bespoke conventional projects, thereby reducing the risk of delays and projects overruns.
- **Quicker –** Modular units are built in one location and can be shipped by rail or road and assembled on site. This could help reduce commissioning times to ~4 years versus ~7 years for conventional nuclear, ~4 years for thermal plants and 2-3 years for renewable projects.
- **Cheaper –** Modular units are smaller than conventional reactors, reducing the upfront capex. Making modular equipment should allow for cost reductions over time e.g. Rolls-Royce expects its first 5 SMR reactors to cost £2.2bn each, falling to £1.8bn for subsequent units.

Today, all-in costs for prototype SMRs are higher than the current generation of conventional larger scale nuclear reactors and significantly higher than wind, solar, natural gas and coal power generation. We are also seeing cost expectations for SMRs being revised higher. NuScale, for example, are now targeting power price of $89/MWh (including $30/MWh of IRA subsidy), up from a target of $58/MWh announced in 2021. But the scaling up manufacturing and the supply chain for SMRs will push costs lower and give SMRs a place in the global nuclear framework.

Conclusion

In summary, nuclear is an important clean energy technology that cannot be ignored. In countries where it is accepted, we believe it can help ensure secure, diverse low emissions electricity systems.

Policymakers need to establish clearer rules for planning, permitting, regulation and safety. Economies of scale need to be achieved via developers prioritising a few technologies and designs. And most importantly, in our view, offtake agreements will have to be long-term in nature, placing suitable value on nuclear power’s ability to generate low carbon baseload power. Overall, we expect net growth in nuclear to be skewed to China, where the existing fleet is younger, government policies are most supportive and construction costs are lower.

The Guinness Sustainable Energy Fund is exposed to nuclear generation via its positions in low carbon power generators, Iberdrola and NextEra Energy.

PERFORMANCE (to 31.05.2023)

Past performance does not predict future returns.

The Guinness Sustainable Energy Fund (Class Y, 0.67% OCF) delivered a return of 0% in the month, while the MSCI World Index (net return) delivered -1% (all in USD terms).

1 year rolling performance to	May-23	May-22	May-21	May-20	May-19
Guinness Sustainable Energy Fund (Class Y)	7.4%	-7.9%	97.4%	13.7%	-11.0%
MSCI World NR Index	2.1%	-4.8%	40.6%	6.8%	-0.3%
Outperformance/Underperformance	*5.3%*	*-3.1%*	*56.8%*	*6.9%*	*-10.7%*

	Ytd	1year	3 years	5yrs	Since launch *
Guinness Sustainable Energy Fund (Class Y)	5.4%	7.4%	95.3%	97.6%	-47.4%
MSCI World NR Index	8.5%	2.1%	36.6%	45.5%	144.6%
Outperformance/Underperformance	*-3.1%*	*5.3%*	*58.7%*	*52.2%*	*-191.9%*

** Performance data taken from Financial Express*

Annual performance	2022	2021	2020	2019	2018*
Guinness Sustainable Energy 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%
Outperformance/Underperformance	*5.6%*	*-11.4%*	*68.2%*	*3.7%*	*-6.5%*

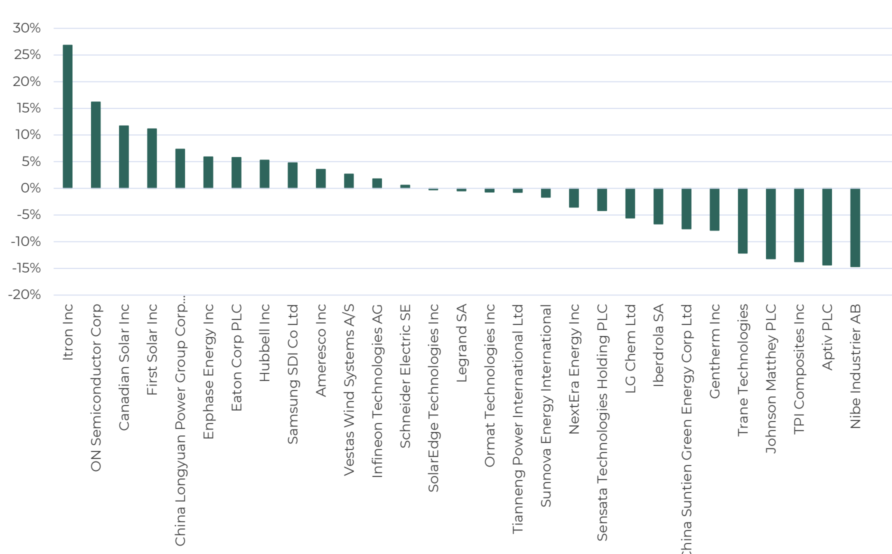
Annual performance	2017*	2016*	2015*	2014*	2013*
Guinness Sustainable Energy Fund (Class Y)	20.2%	-15.4%	-12.0%	-12.1%	70.8%
MSCI World NR Index	22.4%	7.5%	-0.9%	4.9%	26.7%
Outperformance/Underperformance	*-2.2%*	*-23.0%*	*-11.2%*	*-17.0%*	*44.1%*

*The Guinness Sustainable Energy 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 Dec 2018, the index for the Guinness Sustainable Energy fund 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 0.67% 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 performers were Itron, ON Semi, Canadian Solar and China Longyuan. The weakest performers were Nibe, Aptiv, TPI Composites and Johnson Matthey.

Stock by stock performance over the month, in USD

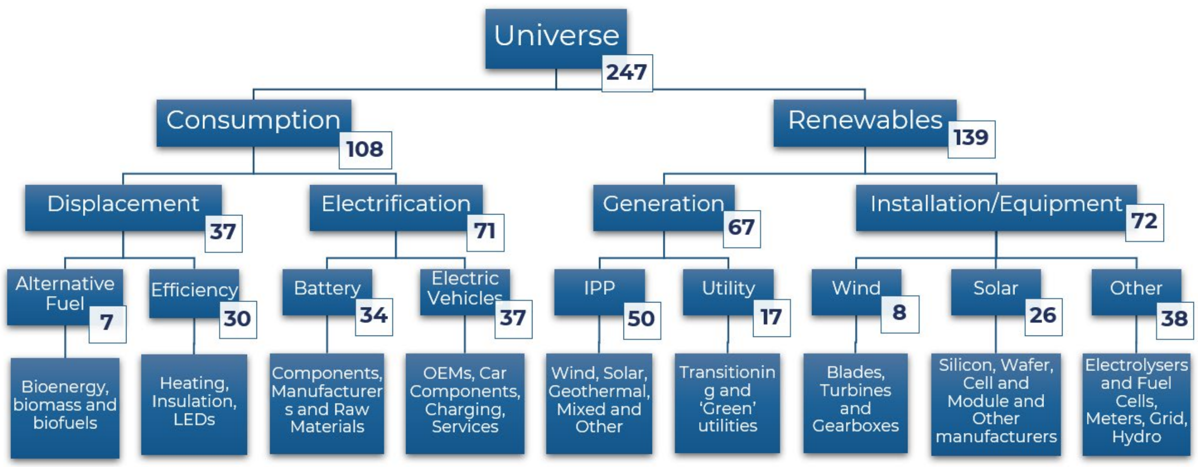


Source: Bloomberg. As of 31 May 2023

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:

Signatory of:

PRI Principles for Responsible Investment

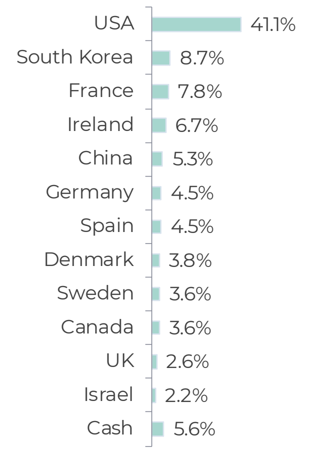
7 AFFORDABLE AND CLEAN ENERGY
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
11 SUSTAINABLE CITIES AND COMMUNITIES
13 CLIMATE ACTION

Buys/Sells

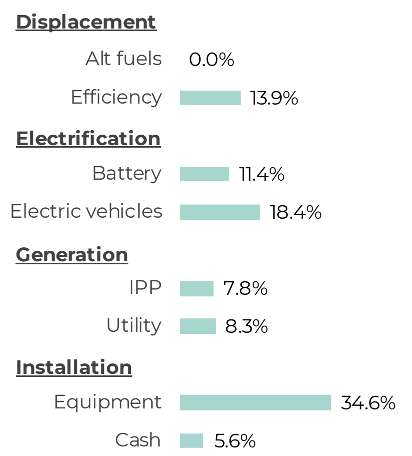
There were no stock switches during the month, but the portfolio was actively rebalanced.

Portfolio structure analysis

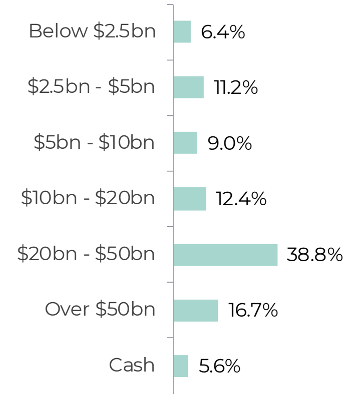
Geographic Analysis



Classification Analysis



Market Cap Analysis



Median market cap	$18.8bn
Average market cap	$27.5bn

Source: Guinness Global Investors

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			
	May-23		Dec-22	Dec-21	Dec-20	Dec-19	Dec-18
Consumption	**43.7%**	***-1.2%***	**44.9%**	**43.4%**	**36.7%**	**41.7%**	**26.5%**
Displacement	13.9%	*-1.1%*	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	*13.9%*	*-1.1%*	*15.0%*	*11.8%*	*9.9%*	*13.4%*	*12.5%*
Electrification	29.8%	*-0.1%*	29.9%	31.6%	26.8%	28.2%	10.1%
Batteries	*11.4%*	*-0.2%*	*11.6%*	*8.9%*	*10.8%*	*12.6%*	*3.9%*
Electric vehicles	*18.4%*	*0.2%*	*18.2%*	*22.8%*	*16.0%*	*15.7%*	*6.2%*
Renewables	**50.7%**	***1.4%***	**49.3%**	**51.3%**	**60.4%**	**54.1%**	**69.7%**
Generation	16.1%	*-1.5%*	17.7%	23.1%	24.6%	22.2%	27.3%
IPP	*7.8%*	*-0.8%*	*8.7%*	*14.5%*	*17.0%*	*18.9%*	*26.7%*
Utility	*8.3%*	*-0.7%*	*9.0%*	*8.6%*	*7.6%*	*3.2%*	*0.6%*
Installation	34.6%	*3.0%*	31.6%	28.2%	35.8%	32.0%	42.5%
Equipment	*34.6%*	*3.0%*	*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 31 May 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	23.9x	19.5x	16.2x	14.9x	12.1x	10.2x	1.2%	1.4%	6.8%	21.9%	5.8%	7.6%
MSCI World Index	15.9x	16.7x	15.6x	10.1x	10.1x	10.3x	2.2%	2.4%	5.4%	6.0%	8.3%	8.0%
Fund Premium/(Discount)	*50%*	*17%*	*4%*	*48%*	*20%*	*-1%*						

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

Source: Guinness Global Investors, Bloomberg

Portfolio holdings as at end May 2023

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

We hold c.44% 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 (11%) or the electrification of transportation (18% weight) while we have 14% 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 a top 3 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, Trane Technologies), 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 16% weight to companies involved in the generation of sustainable energy and 35% 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 around a third of our generation exposure. The remaining exposure comes in the form of geothermal (Ormat), US residential solar (Sunnova) and then broad-based wind/solar renewable energy generation through 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 is a well placed provider of wind turbines in the world providing 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, Legrand 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 May 2023

	Theme	Example holdings	Weighting (%)
1	Electrification of the energy mix	sunnova, NextEra Energy	24.1%
2	Rise of the electric vehicle and auto efficiency	Sensata Technologies, APTIV	21.0%
3	Battery manufacturing	Samsung SDI	8.8%
4	Expansion of the wind industry	Vestas	7.4%
5	Expansion of the solar industry	CanadianSolar	15.9%
6	Heating, lighting and power efficiency	NIBE Industrier, Trane Technologies	13.9%
7	Geothermal	ORMAT	3.4%
8	Other (inc cash)		5.6%

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

Guinness Sustainable Energy Fund (30 April 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%	25.9x	19.8x	18.9x	17.5x	17.7x	13.7x	13.3x	6.1x	5.4x	4.8x	1.6%	1.7%	2.0%
Nibe Industrier AB	SE0015988019	4.3%	57.3x	44.2x	39.2x	34.2x	34.1x	27.0x	24.2x	9.0x	7.4x	6.4x	0.5%	0.6%	0.7%
Trane Technologies PLC	IE00BK9ZQ967	4.0%	25.9x	22.1x	20.4x	18.7x	17.1x	15.3x	14.5x	7.4x	6.6x	6.0x	1.4%	1.5%	1.6%
Ameresco Inc	US02361E1082	2.1%	22.2x	23.3x	17.3x	12.3x	14.7x	14.4x	11.1x	2.7x	2.3x	2.0x	n/a	n/a	n/a
		14.7%													
Electrification/Battery															
LG Chem Ltd	KR7051910008	4.6%	21.4x	23.5x	13.9x	8.8x	8.8x	8.1x	5.8x	1.7x	1.7x	1.6x	1.5%	1.4%	1.6%
Samsung SDI Co Ltd	KR7006400006	4.2%	23.4x	22.9x	18.9x	15.2x	14.0x	13.3x	10.8x	2.6x	2.5x	2.2x	0.2%	0.1%	0.2%
Johnson Matthey PLC	GB00BZ4BQC70	3.0%	9.4x	10.9x	10.5x	9.5x	6.1x	7.1x	6.8x	1.4x	1.5x	1.4x	3.9%	3.9%	4.0%
Tianneng Power International Ltd	KYG8655K1094	0.1%	4.9x	4.0x	3.3x	3.6x	1.3x	0.9x	0.7x	0.6x	0.5x	0.5x	5.4%	4.7%	4.7%
		11.8%													
Electrification/Electric Vehicles															
Aptiv PLC	JE00B783TY65	3.7%	30.8x	23.4x	16.6x	13.1x	14.5x	11.8x	9.6x	3.4x	2.9x	2.6x	0.1%	0.2%	0.3%
ON Semiconductor Corp	US6821891057	4.0%	13.6x	15.0x	13.5x	11.9x	9.3x	10.0x	9.0x	5.0x	4.0x	3.3x	n/a	n/a	n/a
Infineon Technologies AG	DE0006231004	4.5%	18.6x	13.6x	13.2x	11.9x	10.7x	7.8x	7.5x	3.4x	2.6x	2.3x	0.9%	1.2%	1.3%
Sensata Technologies Holding PLC	GB00BFMBMT84	3.7%	13.1x	11.3x	10.2x	9.2x	10.4x	10.1x	9.1x	2.1x	2.0x	1.7x	0.8%	0.8%	0.9%
Gentherm Inc	US37253A1034	2.7%	30.0x	24.2x	16.9x	11.2x	15.7x	11.2x	8.7x	n/a	n/a	n/a	n/a	n/a	n/a
		18.6%													
Generation/IPP															
China Longyuan Power Group Corp Ltd	CNE100000HD4	1.8%	10.0x	7.7x	6.5x	5.6x	10.4x	8.5x	7.4x	0.9x	0.8x	0.7x	1.9%	2.5%	3.0%
Ormat Technologies Inc	US6866881021	3.4%	63.6x	46.4x	33.9x	29.9x	15.6x	13.9x	12.2x	2.5x	2.3x	2.2x	0.6%	0.6%	0.6%
NextEra Energy Inc	US65339F1012	3.9%	26.6x	24.6x	22.5x	20.9x	20.7x	16.9x	15.3x	3.4x	3.2x	3.1x	2.2%	2.5%	2.7%
Sunnova Energy International I	US86745K1043	1.3%	n/a	n/a	n/a	n/a	73.9x	40.8x	26.8x	1.3x	1.1x	1.0x	n/a	n/a	n/a
China Suntien Green Energy Corp Ltd	CNE100000TW9	1.4%	5.6x	5.3x	4.6x	3.9x	8.4x	8.2x	6.8x	0.6x	0.6x	0.5x	6.2%	6.6%	7.6%
		11.9%													
Generation/Utility															
Iberdrola SA	ES0144580Y14	4.8%	18.6x	16.4x	15.8x	14.8x	11.5x	10.1x	9.6x	1.8x	1.7x	1.6x	3.8%	4.3%	4.5%
		4.8%													
Installation/Equipment															
Schneider Electric SE	FR0000121972	4.3%	22.6x	20.1x	18.8x	17.4x	15.2x	13.7x	12.9x	3.5x	3.3x	3.0x	1.9%	2.2%	2.3%
Legrand SA	FR0010307819	3.6%	21.1x	19.9x	18.9x	17.6x	13.6x	12.6x	12.1x	3.6x	3.2x	3.0x	2.0%	2.3%	2.4%
Eaton Corp PLC	IE00B8KQN827	3.9%	22.1x	20.2x	18.3x	16.8x	17.7x	15.8x	14.6x	4.0x	3.7x	3.5x	1.9%	2.0%	2.1%
Itron Inc	US4657411066	3.0%	106.0x	58.3x	24.3x	12.9x	34.2x	26.7x	14.2x	2.1x	2.0x	1.9x	n/a	n/a	n/a
Xinyi Solar Holdings Ltd	KYG9829N1025	2.2%	16.4x	14.8x	11.1x	9.2x	12.2x	10.2x	7.7x	2.3x	2.3x	2.0x	2.8%	3.2%	4.2%
SolarEdge Technologies Inc	US83417M1045	2.2%	60.2x	32.3x	24.3x	19.6x	36.2x	20.5x	16.0x	7.7x	6.2x	5.0x	n/a	n/a	n/a
Enphase Energy Inc	US29355A1079	1.9%	37.5x	29.7x	22.5x	17.4x	29.8x	22.2x	16.9x	40.9x	15.0x	9.0x	n/a	n/a	n/a
First Solar Inc	US3364331070	4.3%	n/a	25.4x	14.9x	9.1x	104.0x	17.8x	10.5x	3.3x	2.9x	2.4x	n/a	n/a	n/a
Canadian Solar Inc	CA1366351098	3.2%	12.1x	7.6x	6.2x	6.9x	7.6x	4.9x	3.8x	1.0x	0.8x	0.7x	n/a	n/a	n/a
Vestas Wind Systems A/S	DK0061539921	3.7%	n/a	336.5x	33.8x	20.3x	n/a	24.2x	12.5x	7.5x	8.0x	6.5x	0.1%	0.1%	0.8%
TPI Composites Inc	US87266J1043	0.5%	n/a	n/a	515.0x	23.5x	13.3x	12.7x	6.0x	5.8x	2.6x	2.7x	n/a	n/a	n/a
		32.8%													
Cash	Cash	**5.3%**													

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:

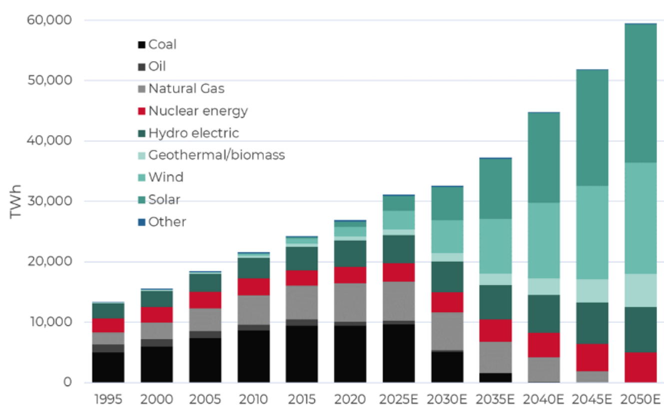
- **Population and GDP growth** putting a significant strain on today's energy supply
- **Economics** as sustainable sources of energy will be cheaper than the incumbents
- **Climate change** leading the world to reduce carbon emissions via cleaner energy
- **Pollution** forcing governments to drive 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. Within the energy displacement sector, key areas of focus are **efficiency** and **alternative fuels**.

• **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.

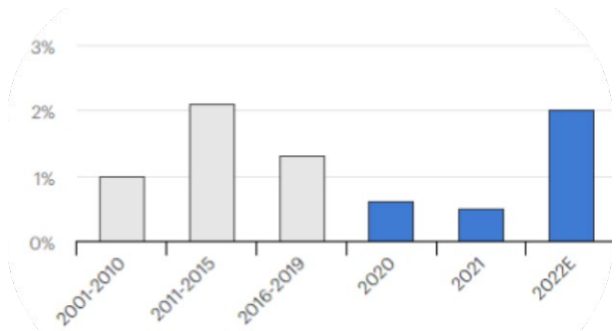
The focus on building efficiency is important, since buildings are responsible for 30% of primary energy consumption and nearly 40% of global carbon emissions. Electrifying heating (heat pumps) and improving the efficiency of heating (insulation), cooling (efficient HVAC), and lighting (LEDs) offers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

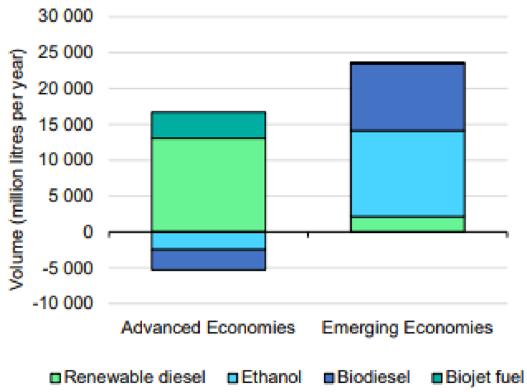
Liquid biofuel demand is expected to have reached 168bn litres in 2022, representing around 4.3% of transportation fuel consumption. The US and Brazil continue to dominate the market, making up around 40% and 25% of global demand respectively, supported by strong domestic industries for corn and sugar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

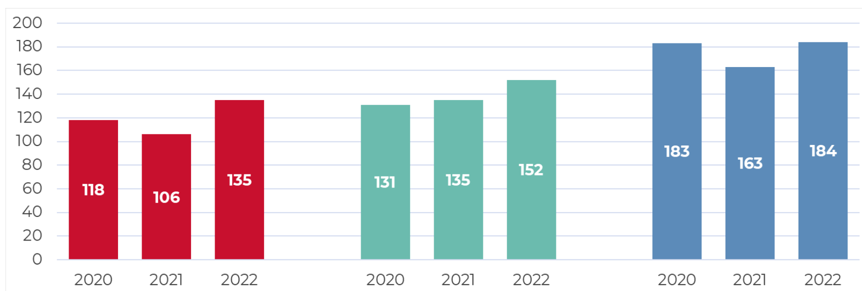
At the end of 2022, lithium and nickel prices were trading 800% and 60% higher than levels seen in December 2020 as supply has struggled to keep pace with strong demand for electric vehicles. Lithium carbonate prices in China reached new peaks in 2022, exceeding $78,000 per tonne, as the market suffered 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 (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

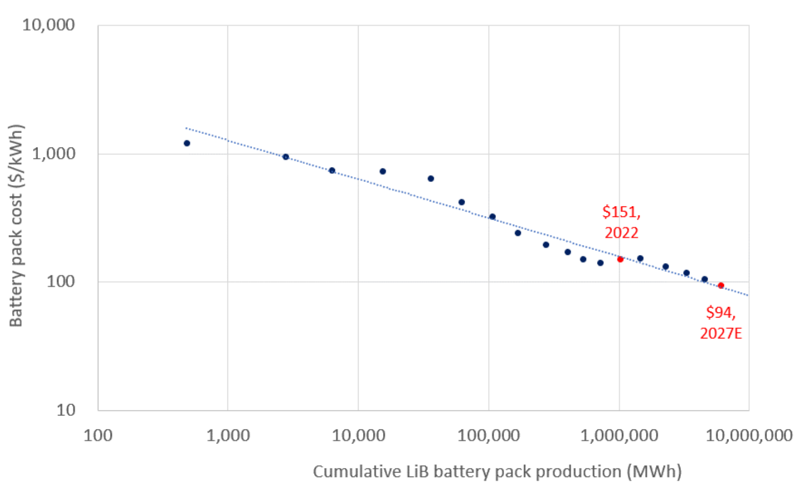
source: BNEF



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



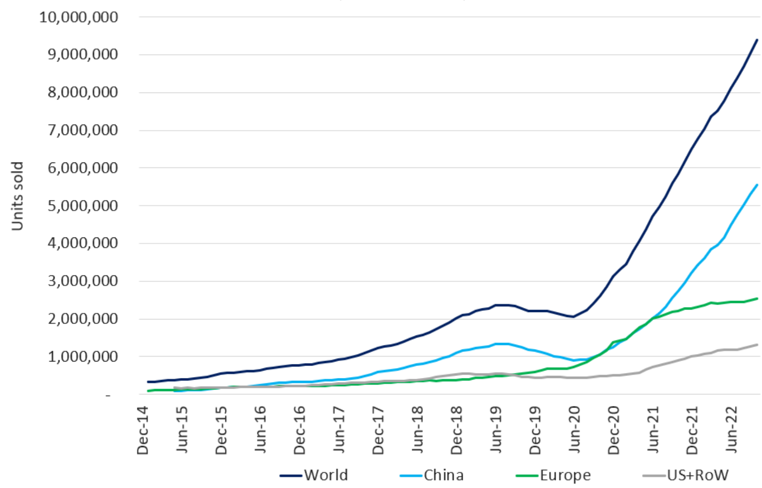
In 2020, the expectation was that the industry battery pack cost target of $100/kWh (the price at which EVs reach price parity with ICE vehicles) would be hit by 2024. On our estimates, higher lithium and nickel prices are now likely to delay this until 2027. The $50/kWh cost reduction over the next 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.

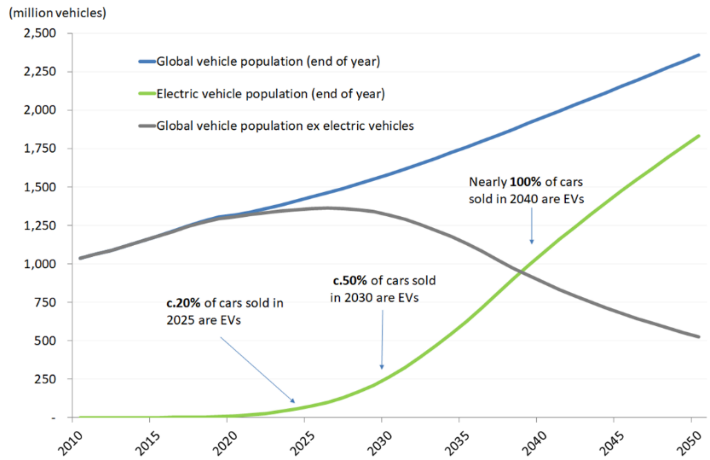
• **Economics:** Electric vehicles cost more to buy but have lower overall running costs. Excluding China, the IEA suggest that BEVs are typically $15,000 more expensive to purchase. Assuming normalised fuel and electricity prices, we estimate that lifecycle running costs for an electric vehicle in Europe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

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



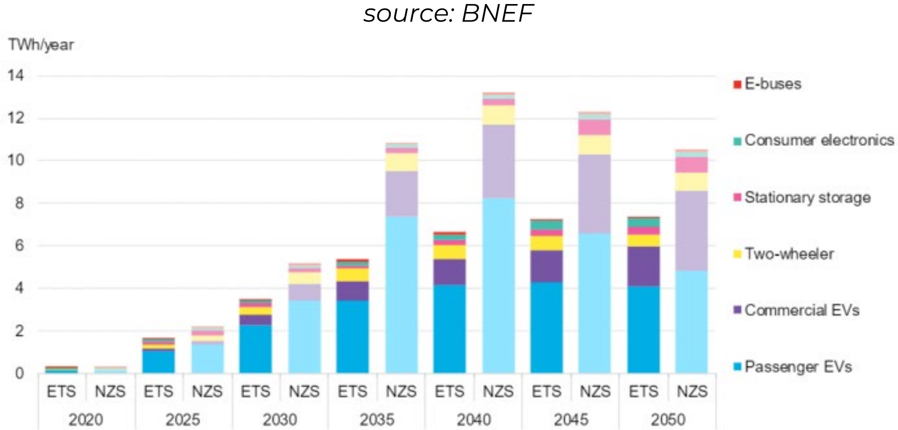
Our base case for electrification implies that there will be over one billion electric vehicles on the road by 2040, that electricity is 57% of total energy demand and that variable renewables such as wind and solar will represent 61% of global power grids. Achieving this would require annual EV sales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



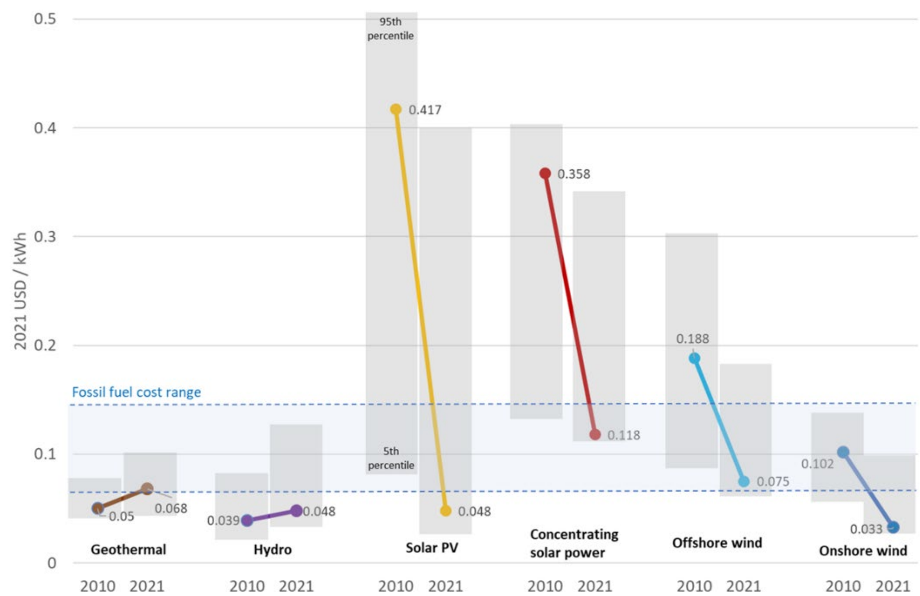
Generation & installation (equipment)

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.

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 (2010–2021)

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, 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.

- 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.
- 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.

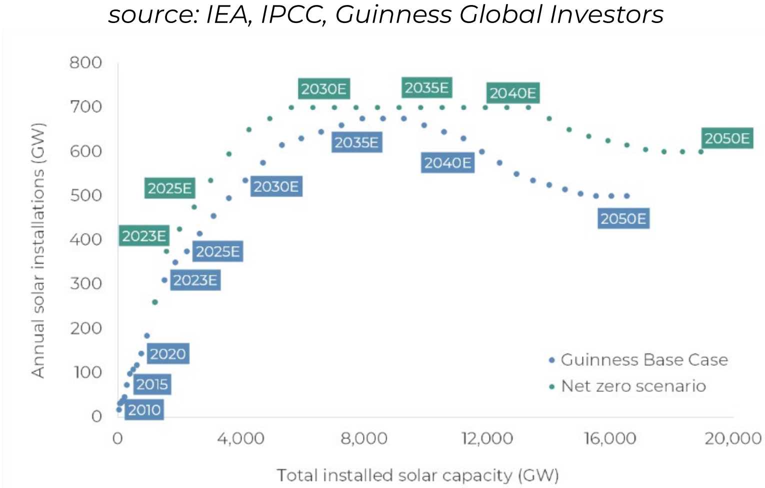
• **Solar module** prices moderated in the second half of 2022 with prices likely to average the same level as 2021. With elevated polysilicon and power prices, it is the module manufacturers that suffered the greatest margin compression in 2022. Module manufacturing nameplate capacity in 2022 is estimated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

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

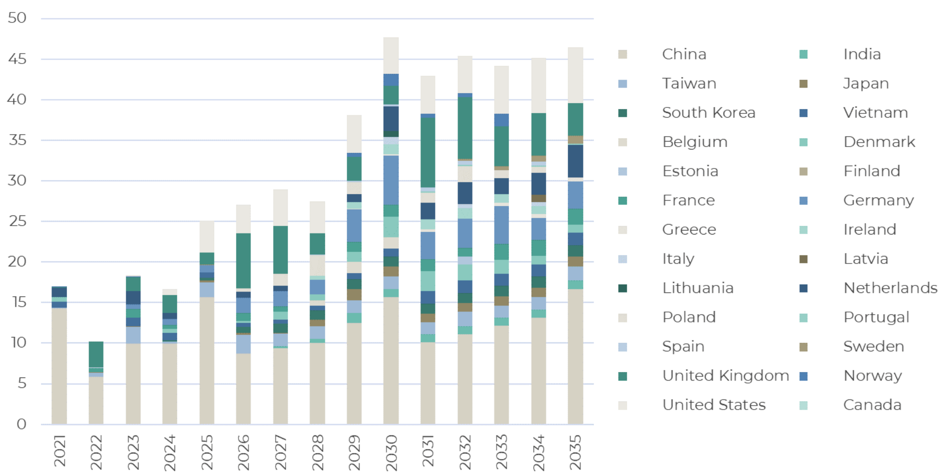
Offshore wind remains a nascent industry, at only 7% of global wind capacity, but it has doubled over the last 2 years and should grow nearly five times by the end of the decade driven by improving economics, further geographical adoption and the support of many of the packages outlined above.

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)

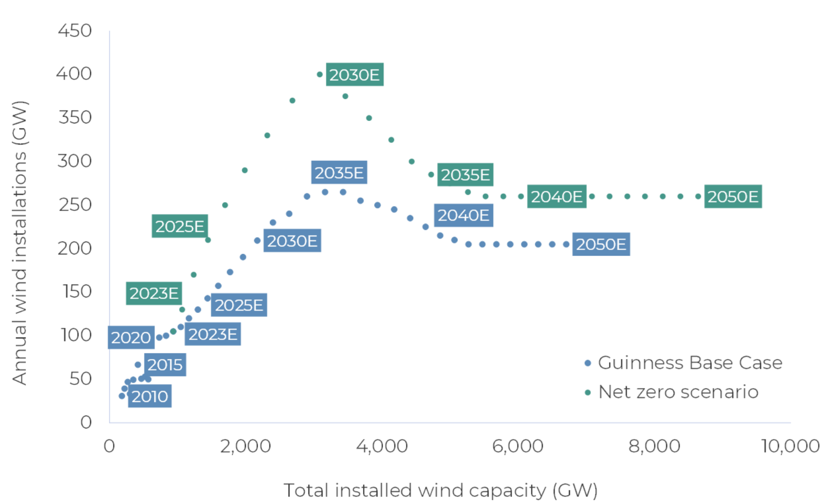
source: BNEF



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



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