Guinness Atkinson
Alternative Energy Fund
Managers Update – August 2023

GUINNESS ATKINSON FUNDS

COMMENTARY

BUILDING EFFICIENCY: CRITICAL TO ENERGY TRANSITION

Buildings are responsible for around 40% of global carbon emissions: 30% from their operational emissions and 10% from materials and construction. Space heating, water heating, space cooling, and lighting are key drivers of operational emissions and are collectively responsible for two-thirds of buildings' final energy use. Decarbonizing buildings means tackling each by investing meaningfully in heat pumps, insulation, lighting, and efficient cooling. Our comments this month explore these four key areas.

EQUITIES

Sustainable energy equities underperformed global stock markets in July. The Guinness Atkinson Alternative Energy Fund delivered a return of 0.63%, behind the MSCI World Index at 3.36%. Year to date, the Fund has delivered 8.87% versus the MSCI World Index at 18.95%.

In the portfolio, the strongest performers were independent power producer Ameresco and auto semi name ONSemi. Ameresco signed a new contract for battery energy storage in collaboration with United Power, while ONSemi announced a long-term Silicon Carbide supply agreement with BorgWarner estimated to be worth about $1bn. The weakest performers were our two solar inverter names: Solaredge and Enphase. The market remains concerned about a slowdown in the US residential solar market due to changing regulation in California.

As of 07.31.2023	YTD	1 Year	3 Years	5 Years	10 Years
Guinness Atkinson Alternative Energy Fund	8.87%	7.05%	16.84%	16.16%	5.78%
MSCI World NR Index	18.95%	13.48%	11.67%	9.11%	9.30%

As of 06.30.2023	YTD	1 Year	3 Years	5 Years	10 Years
Guinness Atkinson Alternative Energy Fund	8.19%	21.22%	21.55%	16.79%	7.39%
MSCI World NR Index	15.09%	18.51%	12.18%	9.07%	9.50%

All returns after 1 year annualized. Inception 03.31.2006 Expense ratio* 1.10% (net); 1.70% (gross)

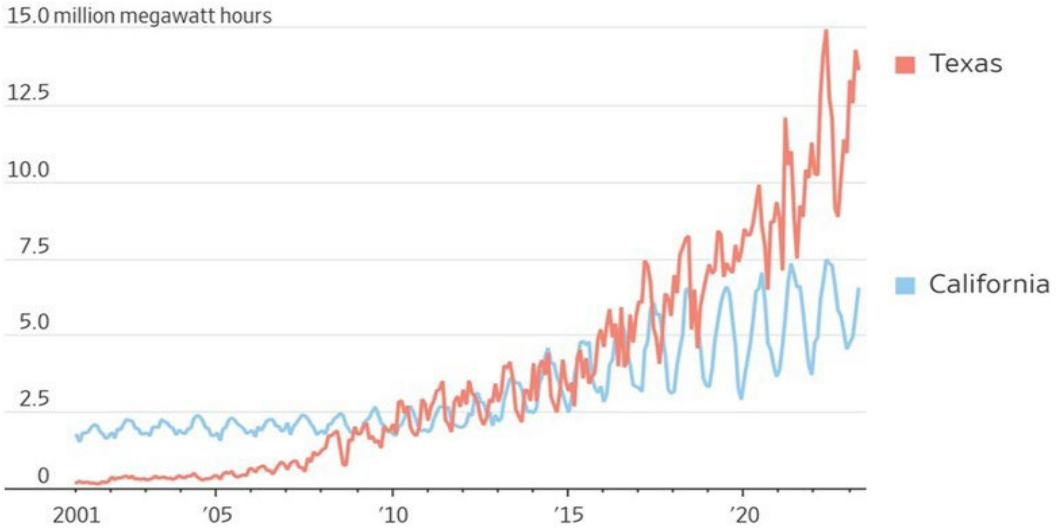
Performance data quoted represents past performance; past performance does not guarantee future results. The investment return and principal value of an investment will fluctuate so that an investor's shares, when redeemed, may be worth more or less than their original cost. Current performance of the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

* The Advisor has contractually agreed to reduce its fees and/or pay Fund expenses (excluding Acquired Fund Fees and Expenses, interest, taxes, dividends on short positions and extraordinary expenses) in order to limit the Fund's Total Annual Operating Expenses to 1.98% through June 30, 2026. To the extent that the Advisor absorbs expenses to satisfy this cap, it may recoup a portion or all of such amounts absorbed at any time within three fiscal years after the fiscal year in which such amounts were waived or absorbed, subject to the expense cap in place at the time recoupment is sought, which cannot exceed the expense cap at the time of the waiver. The expense limitation agreement may be terminated by the Board of the Fund at any time without penalty upon 60 days' notice.

CHART OF THE MONTH

This chart, showing renewable electricity generation in two states, California (a state with strict planning laws) and Texas (a highly deregulated market), highlights the important role that permitting plays in the speed of the energy transition.

Net electricity generation from renewables



Source: IEA. Data as of 07.31.2023

JULY NEWS & 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
The US Department of Energy announced an $8.5bn rebate program for upgrades to US homes including insulation, heat pumps, and efficient appliances. The program aims to save up to $1bn a year in energy costs and to support 50,000 jobs in construction and manufacturing. The rebate will begin to be available to consumers by the end of the year.	US buildings efficiency	
Samsung SDI announced the completion of its pilot line for solid state batteries and expects to begin production in the second half of the year. The batteries, which use a solid electrolyte instead of liquid, offer significantly higher energy density, longer driving range, and enhanced safety. Samsung SDI aim for full commercialization in 2027.	Battery technology	
Octopus Energy revealed the intention to invest $20bn globally in offshore wind by 2030. The investment is expected to generate 12 gigawatts (GW) of renewable electricity each year and will target projects worldwide, with a focus on Europe. The company has made five offshore deals in the last year, amounting to a total of $1bn. It manages $7.7bn worth of green energy projects globally.	Offshore wind	
Electric aviation player, Surf Air Mobility, had a difficult opening session on the NYSE, with the shares slumping 75%. The company, which currently offers traditional flights but aims to invest in electric power technology over the coming years, went public through a direct listing at around half the valuation it received in a private transaction one month before. It is expected to be years away from profit and cautioned in regulatory filings that there is a "substantial doubt" about its ability to continue as a going concern.	Electric Aviation	
Virgin Atlantic have confirmed a successful test of Sustainable Aviation Fuel (SAF) using a Rolls Royce Trent 1000 Engine. The test is a precursor to the world's first 100% SAF flight across the Atlantic from London to New York, scheduled to take place on November 28th, 2023. Current regulation only allows for a 50% SAF blend in commercial jet engines, however November's flight is intended to prove that this can safely be increased to 100%, providing a dramatic cut to carbon emissions in one of the world's hardest-to-abate sectors.	Alternative fuels	

MANAGERS' COMMENTS

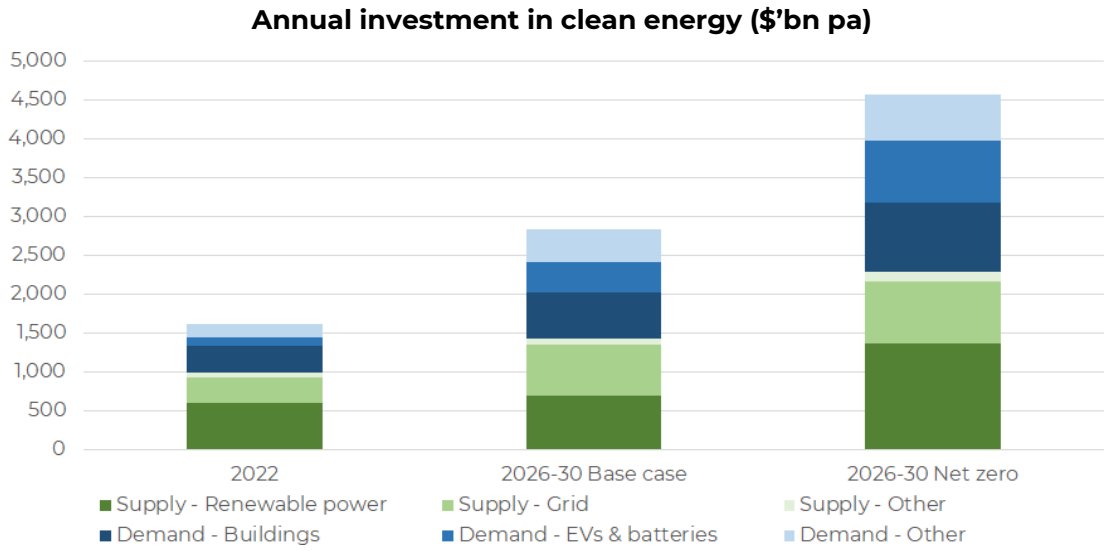
Building efficiency: critical to the energy transition

Buildings are responsible for around 40% of global carbon emissions: 30% from their operational emissions and 10% from materials and construction. Space heating, water heating, space cooling, and lighting are key drivers of operational emissions and are collectively responsible for two-thirds of the final energy use of buildings. Decarbonizing buildings means tackling each of these areas by investing meaningfully in heat pumps, insulation, lighting, and efficient cooling. This month's manager's comments explore building efficiency, focusing on these four key areas.

Clean energy investment

In 2022, global clean energy investment reached $1.6 trillion. Of this, roughly 60% is spent on decarbonizing energy supply (renewable power, grids, other), while the remaining 40% is spent on the efficiency and electrification of energy demand (mainly building efficiency, EVs, & batteries). The Guinness Atkinson Alternative Energy investment universe broadly mirrors this, with 60% of names exposed to the installation and generation of sustainable energy and 40% of names exposed to the electrification and efficiency of energy demand.

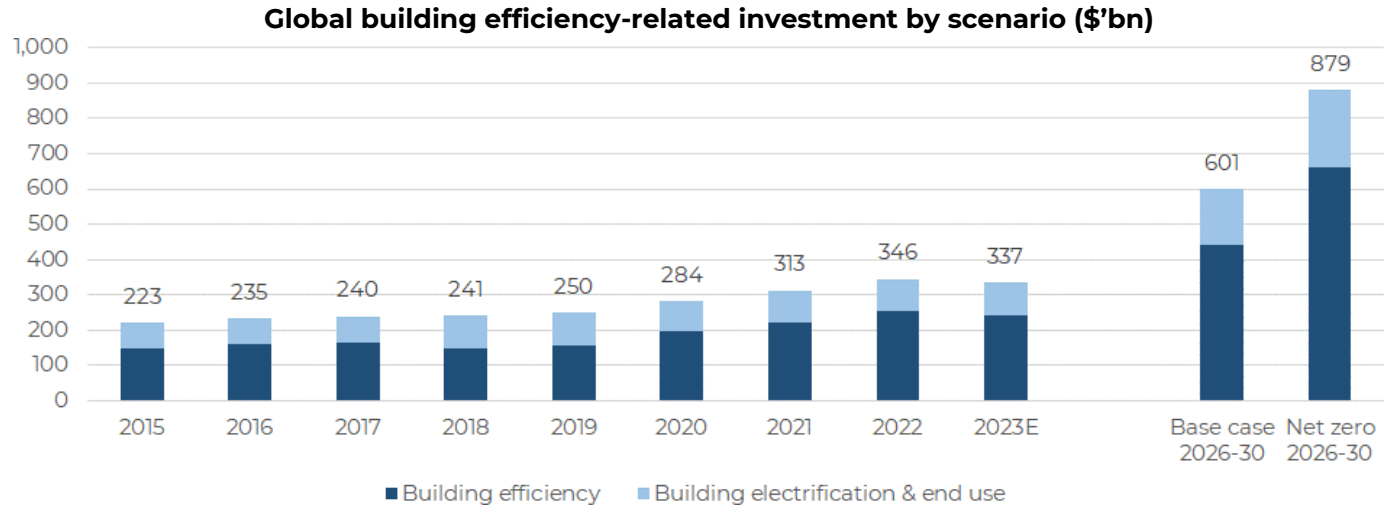
We expect overall clean energy spending to increase by around 75%, averaging $2.8 trillion per annum (p.a.) in the second half of the decade. We also expect the mix within clean energy to shift towards an equal split – i.e. 50% towards energy supply and 50% towards energy demand/efficiency. To be clear, though, spending of $2.6trn does not put the world on a "net zero" path. For the world to achieve 1.5 degrees and hit net zero emissions by 2050, spending in the short term needs to nearly triple, averaging $4.6 trillion p.a. from 2026-2030.



Source: IEA, Guinness Atkinson Asset Management estimates, as of 07.31.2023

Building efficiency spending

Despite the operation of buildings accounting for around 30% of global emissions, only 20% ($340bn) of global clean energy spending was allocated to buildings in 2022. Space heating (33%), water heating (19%), and space cooling (7%) and lighting (5%) are collectively responsible for 60% of the final energy use of buildings. Decarbonizing buildings will require investment in heat pumps to electrify space and water heating; insulation to improve thermal efficiency; and LED lighting and efficient cooling to reduce the energy consumption of key end-use devices and appliances. We see total building efficiency and electrification spending growing by around 75%, averaging $600bn p.a. from 2026-30.



Source: IEA, Guinness Atkinson Asset Management estimates, as of 07.31.2023.

Heat pumps

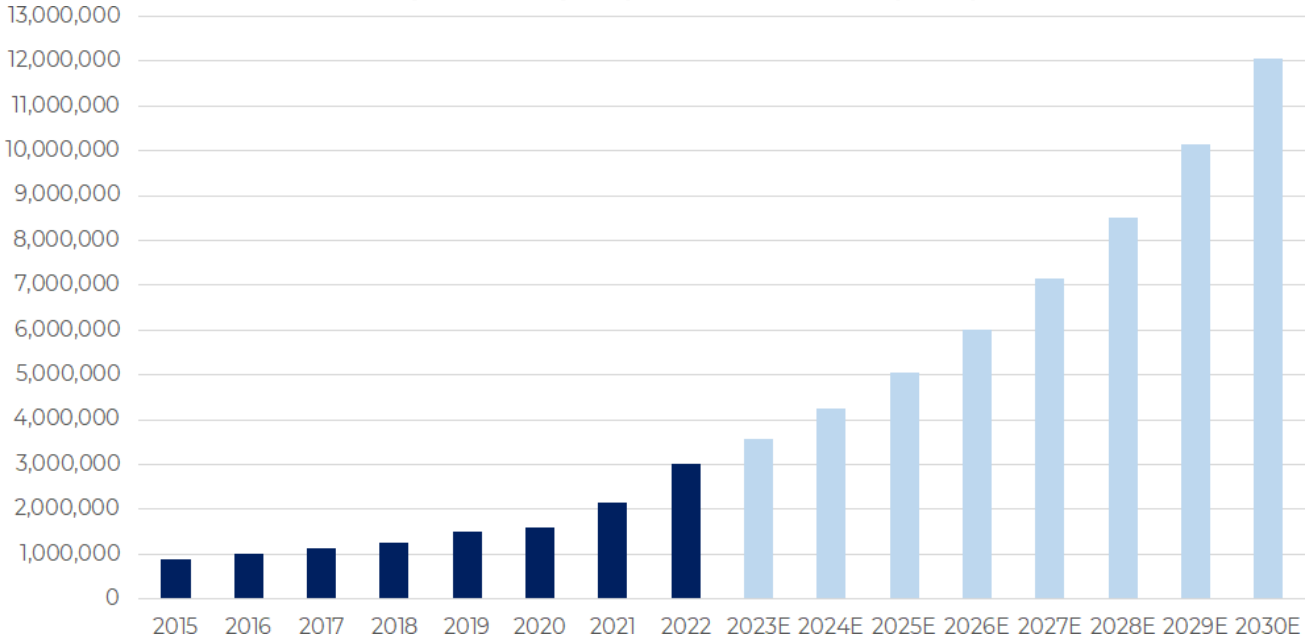
Space and water heating, used to keep homes warm in winter and provide hot water for washing and cleaning, accounts for half of all global energy use in buildings. Over one-sixth of global natural gas demand is for heating in buildings – in the European Union, this number is one-third. Heat pumps are a vital tool for decarbonizing heat and reducing reliance on natural gas imports.

Global heat pump sales grew by 11% in 2022 after growing at 13% in 2021. Despite strong growth in recent years, heat pumps still only meet around 10% of global heating needs in buildings. We see installation growing at 11% pa out to 2030, resulting in the global installed stock more than doubling to meet 18% of global heating needs. However, to get on track with a net zero trajectory, sales need to grow at closer to 20% p.a., with the global installed stock almost tripling to 600 million units, meeting 24% of global heating needs by 2030. Future growth is supported by financial incentives in over 30 countries and bans / phase outs on fossil fuel heating systems in 20 countries.

Europe has outpaced global sales in recent years, growing at 35% and 39% in 2021 and 2022 respectively, bringing the region's heat pump sales to over 3 million units. This expansion was primarily driven by high gas prices and increased policy support as a result of Russia's invasion of Ukraine. Heat pumps remain a

vital tool to secure Europe's energy independence from Russia. The EU's target to install 60 million additional heat pumps between 2023-30 is expected to reduce the bloc's household gas demand by 40% and would require installations to grow at around 20% p.a. over the period. In 2023, the EU made further recommendations to introduce a ban on gas boilers from 2028 in new buildings and phase out the use of fossil fuel heating systems in all buildings by 2035.

European heat pump sales 2015-2030E (units)



Source: EHPA, Guinness Atkinson Asset Management estimates, as of 07.31.2023.

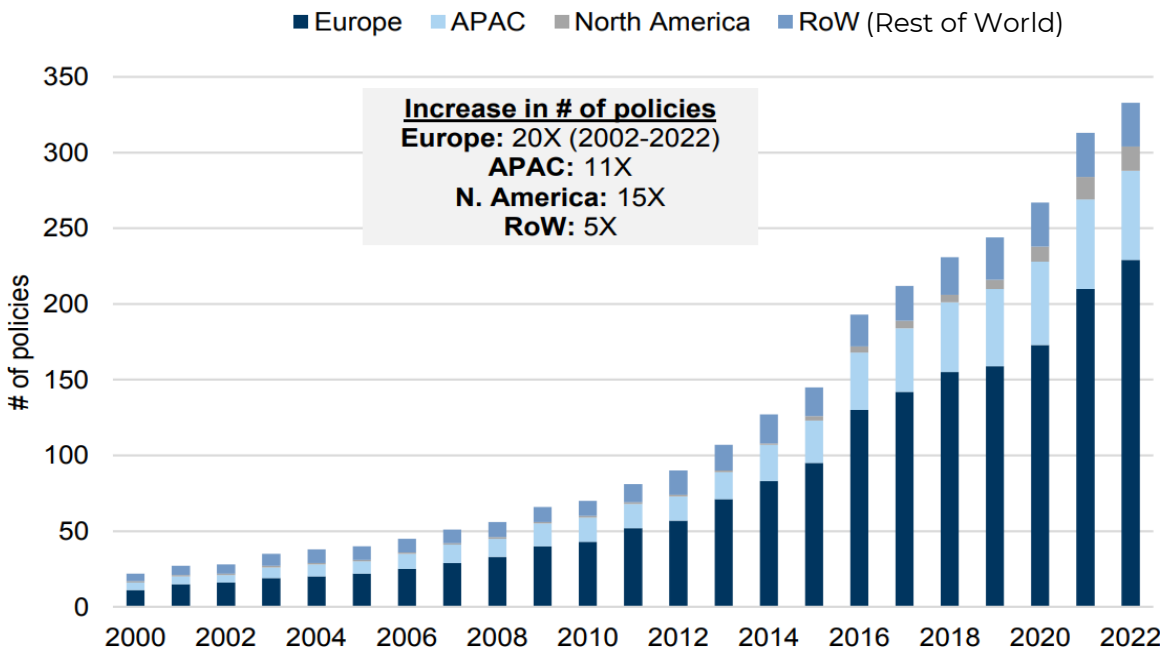
Insulation

The second law of thermodynamics states that heat moves away from hotter objects into cooler objects. Insulation can improve the thermal efficiency of a building's envelope (e.g. exterior walls, roof), helping to prevent outside heat from entering the home in hotter climates and preventing indoor heat from leaking outside in colder climates. For the lowest rated building stock across Energy Performance Certificates (EPC), proper insulation can reduce energy consumption from space heating and cooling by 40% compared to uninsulated homes, with loft insulation offering to pay for itself in as little as 1-3 years.

We estimate the global insulation market has grown at around 6.5% p.a. from 2012-22, driven by government incentives, energy efficiency requirements, stricter building codes, and higher energy costs. The sector broadly follows the building construction market but has historically seen structurally higher growth of 3-7% p.a. on average. Going forward, we expect global insulation industry revenues to grow at 5-7% p.a. out to 2030 driven by policy and economics. Thanks to a reasonably consolidated industry (the top 9 companies account for >70% of market share) and regulatory hurdles creating a barrier to new entrants, we expect this revenue growth to translate into earnings growth of 10-15% p.a..

Over the past 20 years, most regions have seen a 10x increase in policies targeting building energy efficiency, including via increased insulation usage, jumping in 2016 after the adoption of the Paris Agreement. To date, markets representing over 50% of global emissions have pledged to target Building Insulation and Green Buildings solutions to meet their 2030 decarbonization targets. This is only set to grow further, as even in developed economies such as the EU and US, 75% and 90% of all homes are still found to be under-insulated or energy inefficient.

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



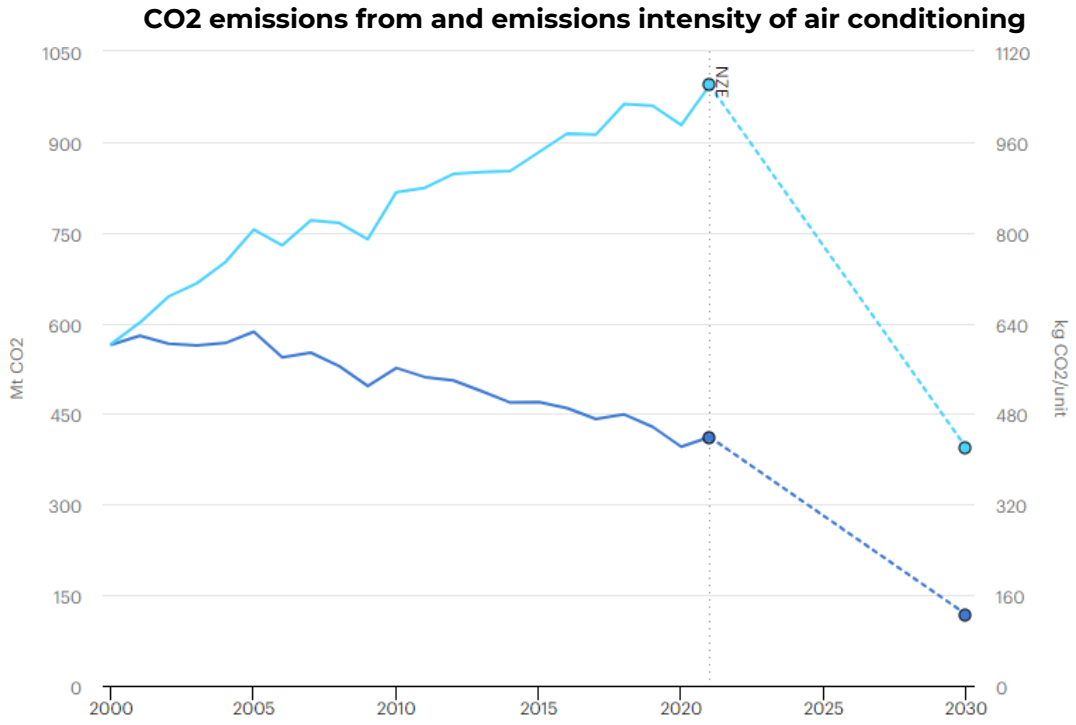
Source: IEA, Goldman Sachs, as of 12.31.2022

For instance, the European Commission launched the Renovation Wave strategy in 2020, aiming to double the current renovation rate from 1% p.a. to 2% p.a., retrofitting 35m buildings by 2030. To achieve this, it is estimated that energy renovation spending would need to triple to €275bn pa. In March 2023, this was taken one step further. The EU ratcheted up its energy efficiency target, aiming to reduce final energy consumption by at least 11.7% in 2030 (up from 9%) and required member states to renovate at least 3% of the total floor area of public buildings each year. If the renovation rate of the building stock in Europe increases by 2-3x, Goldman Sachs estimates that the region's total addressable market for insulation could double over the next 10 years, equating to growth of 7% p.a..

Efficient cooling

Space cooling is the fastest growing building-end use with cooling-related energy consumption having more than tripled since 1990. As the planet warms, ensuring access to energy efficient cooling is of primary importance. According to the IEA, between 2019-2021, the average number of heat-related deaths among people aged 65 years or older reached at least 300,000 deaths.

The number of air conditioning units in operation globally has increased by 2.5x in the past 20 years to 2 million units and is set to grow by a further 50% to 3 million units by 2030. Thanks to industry consolidation (the top 6 players in any market hold 90% share) and a fragmented customer base (relatively few manufacturers selling to a larger number of distributors), the heating, ventilation, and air conditioning (HVAC) original equipment manufacturers (OEMs) enjoy strong pricing power. Price increases of 1-3% p.a. has allowed them to grow their revenues at 6% p.a., outpacing unit sales of 4% p.a. over the past decade. At the same time, improving operating leverage has seen profits grow at 10-12% p.a.. We expect a similar pattern to continue out to 2030, with installations growing at 4.5% p.a. and price increases of 1-3% p.a. resulting in sales growth of 6-7% p.a. and earnings growth of 10-11% p.a..



Source: IEA, as of 06.30.2023

While highly efficient HVAC units are available, most efficiency standards have efficiencies well below best-in-class models. Without a move towards high efficiency cooling and improvements in the thermal efficiency of the buildings in which they operate, electricity demand for space cooling could increase by as much as 40% globally by 2030. Despite the expected growth in demand for air conditioning, to achieve net zero emissions, final energy consumption from cooling must stay flat and emissions intensity of air conditioning must fall by 70% by 2030.

For this reason, more than 90 countries covering >86% of global residential space cooling energy consumption already have Minimum Energy Performance Standards (MEPS) and labelling policies in place for air conditioners. For example, 2022 saw China update its minimum Energy Performance Standards for room air conditioners (ACs) to allow for a transition from fixed- speed ACs to the more efficient variable-speed models. So far in 2023, we have seen further updates from the United States and India covering air

conditioners and fans. These standards are only set to become more demanding and expansive over time. As a result of tightening standards, we believe an outsized share of future growth will be captured by OEMs offering more energy efficient models.

We believe the Guinness Atkinson Alternative Energy Fund is well positioned to benefit from increased investment in building efficiency in the coming decades through its exposure to Nibe, a leader in European heat pumps; Installed Building Products, the second largest insulation installer in the US; and Trane Technologies, a specialist in efficient residential and commercial cooling in North America. The Fund is also positioned to capture increased investment in electrical end-use efficiency and building automation through its ownership of low- and medium-voltage leaders Hubbell, Eaton, Legrand, and Schneider Electric.

PERFORMANCE

As of 07.31.2023	YTD	1 Year	3 Years	5 Years	10 Years
Guinness Atkinson Alternative Energy Fund (GAAEX)	8.87%	7.05%	16.84%	16.16%	5.78%
MSCI World NR Index	18.95%	13.48%	11.67%	9.11%	9.30%

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All returns after 1 year annualized.

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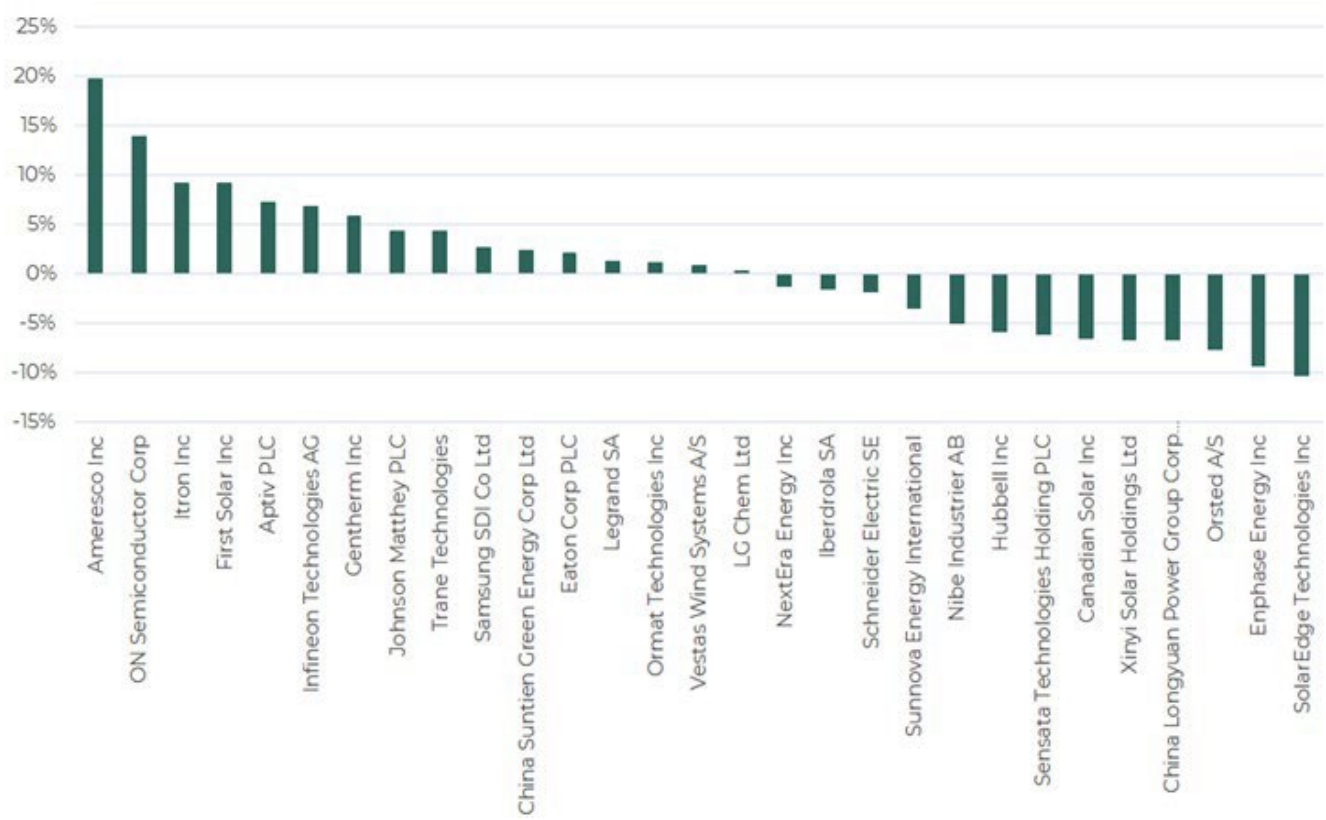
Stock by Stock Performance over the month in USD

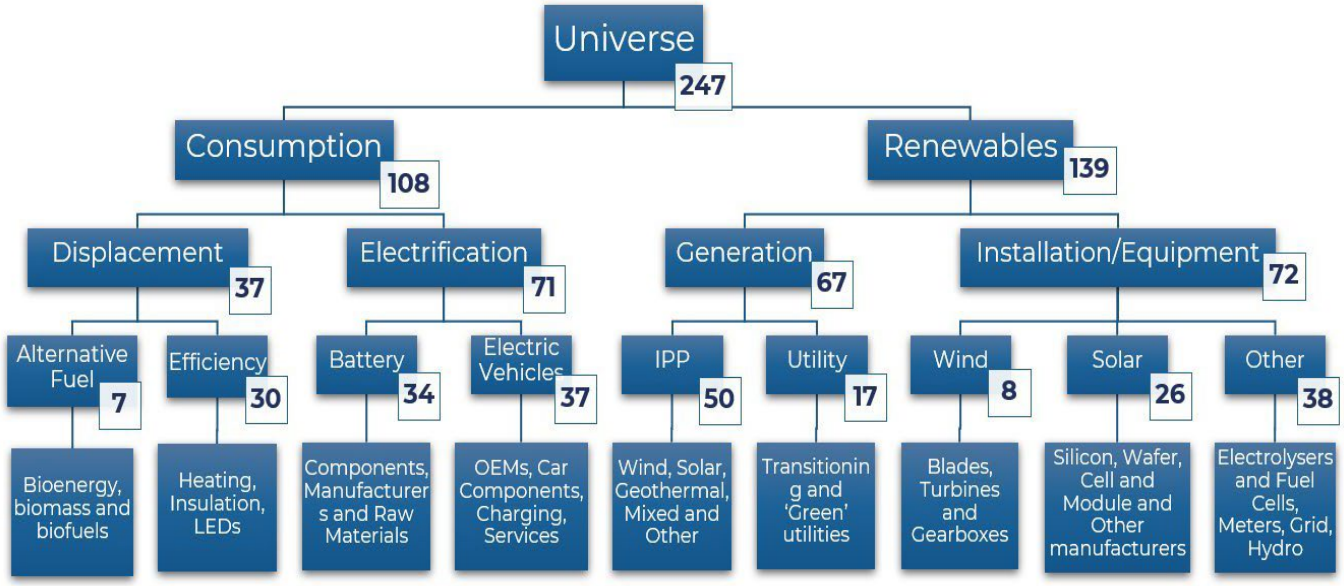


Source: Bloomberg, as of 7.31.2023

PORTFOLIO

The Guinness Atkinson Alternative 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

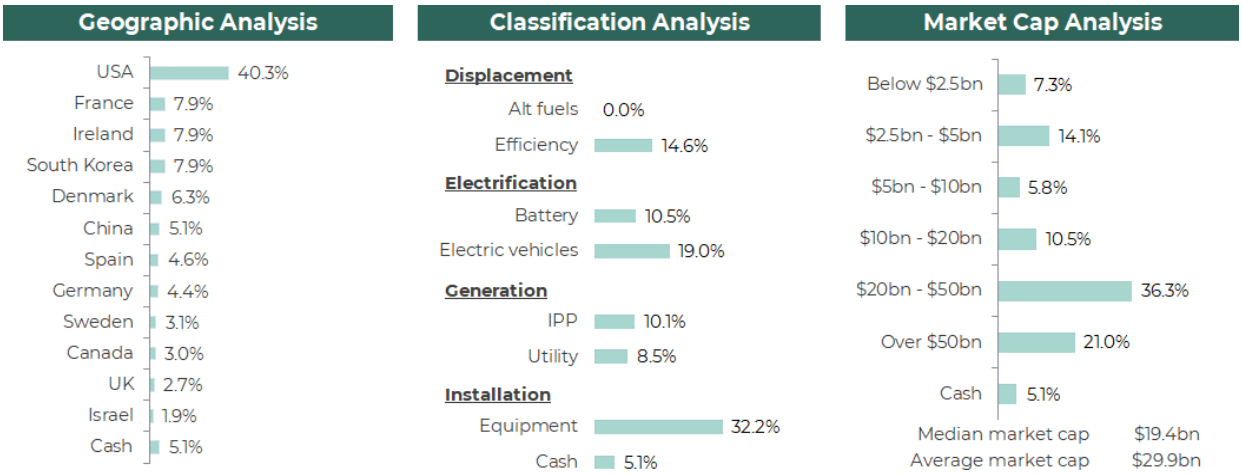


We monitor each of the industry areas very closely and hope that detailed top-down (macro) analysis of each (complemented with disciplined equity screening and stock valuation work) will allow us to deliver attractive fund performance via an equally weighted portfolio of 30 stocks. The portfolio is designed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

Buys/Sells

During the course of the month the fund initiated a position in Orsted, the world leader in offshore wind. The portfolio was also actively rebalanced.

Portfolio structure analysis



Source: Guinness Atkinson Asset Management

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			
	Jul-23		Dec-22	Dec-21	Dec-20	Dec-19	Dec-18
Consumption	**44.1%**	**-0.8%**	**44.9%**	**43.4%**	**36.7%**	**41.7%**	**26.5%**
Displacement	14.6%	-0.4%	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	*14.6%*	*-0.4%*	*15.0%*	*11.8%*	*9.9%*	*13.4%*	*12.5%*
Electrification	29.5%	-0.4%	29.9%	31.6%	26.8%	28.2%	10.1%
Batteries	*10.5%*	*-1.1%*	*11.6%*	*8.9%*	*10.8%*	*12.6%*	*3.9%*
Electric vehicles	*19.0%*	*0.7%*	*18.2%*	*22.8%*	*16.0%*	*15.7%*	*6.2%*
Renewables	**50.8%**	**1.5%**	**49.3%**	**51.3%**	**60.4%**	**54.1%**	**69.7%**
Generation	18.6%	0.9%	17.7%	23.1%	24.6%	22.2%	27.3%
IPP	*10.1%*	*1.5%*	*8.7%*	*14.5%*	*17.0%*	*18.9%*	*26.7%*
Utility	*8.5%*	*-0.5%*	*9.0%*	*8.6%*	*7.6%*	*3.2%*	*0.6%*
Installation	32.2%	0.6%	31.6%	28.2%	35.8%	32.0%	42.5%
Equipment	*32.2%*	*0.6%*	*31.6%*	*28.2%*	*35.8%*	*32.0%*	*42.5%*
Cash	5.1%	-0.8%	5.8%	5.3%	3.0%	4.2%	3.8%

Source: Guinness Atkinson Asset Management

Valuation

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

As of 07.31.2023	P/E		EV/ EBITDA		EPS Growth (% p.a.)		CFROI*	
	2022	2023E	2022	2023E	2014-21	2022-25	2022	2023E
Guinness Atkinson Alternative Energy Fund (GAAEX)	24.4x	20.6x	15.2x	12.5x	6.8%	22.3%	5.4%	7.4%
MSCI World NR Index	16.0x	18.4x	10.4x	12.2x	5.4%	6.5%	8.3%	8.1%
Fund Premium / (Discount)	*53%*	*12%*	*46%*	*2%*				

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

Source: Guinness Atkinson Asset Management, Bloomberg

Portfolio holdings as of July 31, 2023

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

We hold about 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 (19% weight) while we have 15% 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 around a third of our generation exposure. The remaining exposure comes in the form of biomass (Albioma), geothermal (Ormat), 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 and Siemens Gamesa are both well placed providers 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 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 of July 31, 2023

	Theme	Example holdings	Weighting (%)
1	Electrification of the energy mix	sunnova, NextEra Energy	24.2%
2	Rise of the electric vehicle and auto efficiency	Sensata Technologies, APTIV	21.7%
3	Battery manufacturing	Samsung, Samsung SDI	7.9%
4	Expansion of the wind industry	Vestas	9.2%
5	Expansion of the solar industry	CanadianSolar	14.4%
6	Heating, lighting and power efficiency	NIBE Industrier, Trane Technologies	14.6%
7	Geothermal	ORMAT	3.1%
8	Other (inc cash)		5.1%

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.

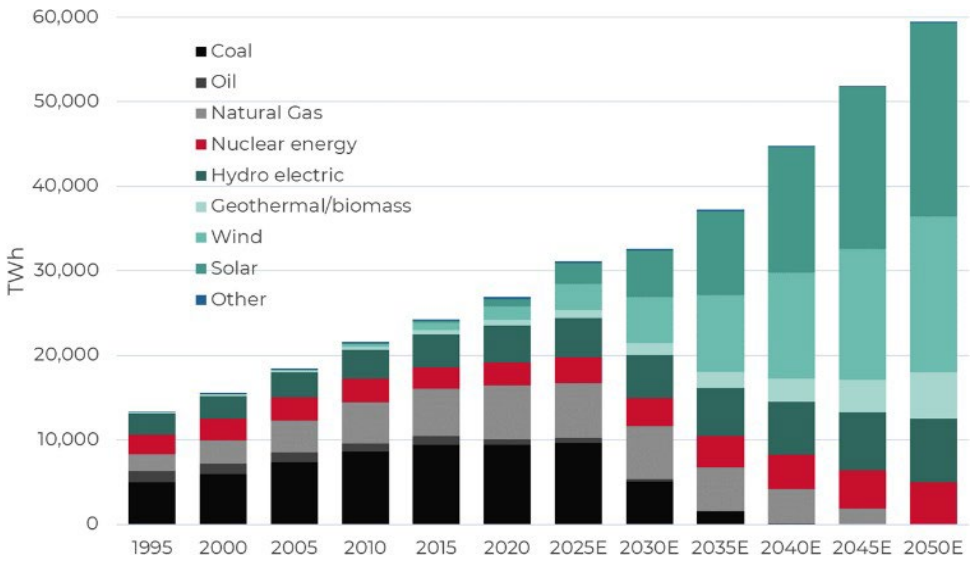
The outcomes of the energy transition will of course be wide-ranging. On the supply side, we see a sustained shift towards renewable power generation, fulfilling global power generation needs which are set to double by 2050. On the demand side, we believe that improved energy efficiency will be key to 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), while 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 Atkinson Asset Management estimates; as of 12.31.2022

Policy support for decarbonization

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 greenhouse gas (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 decarbonization. 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

metric tons of carbon dioxide equivalent (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.

We are already starting to see new investment driven by the Inflation Reduction Act (IRA) in 2023. We believe the IRA, greater clarity on funding from the EU's Net Zero Industrial Act, and an expected upgrade to Chinese renewables targets will continue to drive investment in 2024/2025 and well into the second half of the 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 decarbonization. Renewable power generation is a key part of the solution, but we see the displacement and more efficient use of existing energy sources as just as critical, and arguably more urgent, in achieving these goals. The International Energy Agency (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% p.a.. This assumes significant efficiency improvements relative to an historical energy demand growth rate of around 2% p.a.. For our base case scenario to be achieved, per capita energy demand over the next thirty years needs to stay broadly flat, while 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

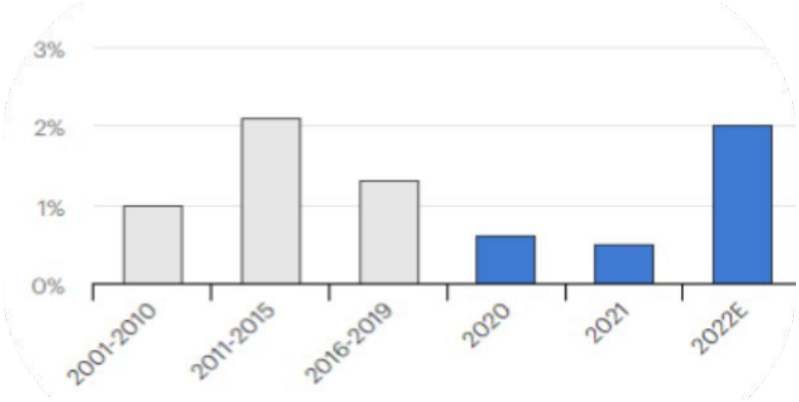
Energy efficiency is a key pillar of new policy. For example, the EU had previously set itself a challenging target to consume 9% less energy in 2030 than in 2020 and the new RePowerEU deal saw this ratcheted up to 13%, supported by €100bn (approximately %109bn USD) of funding for residential and industrial 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 decarbonize while 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 behavioral 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 incentivize 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% p.a. currently to 4% p.a. by 2030 globally. This translates to building efficiency spending increasing to over $750bn p.a. 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

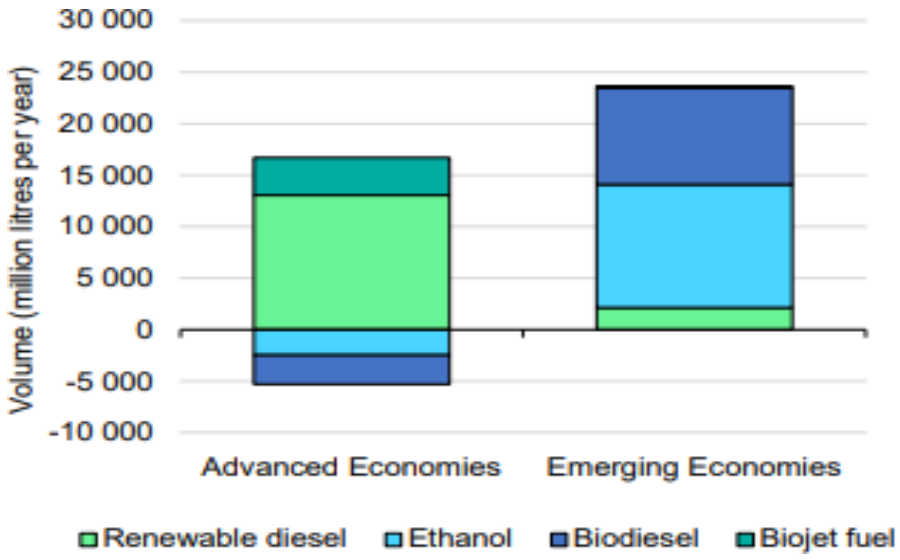
Alternative fuels are materials or substances which can be used as fuel to displace coal, oil, and natural gas. They encompass solid biofuels (also known as biomass e.g. wood, bagasse, animal waste), biogas (e.g. renewable natural gas, biomethane), and liquid biofuels. Below we will predominantly focus 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 liters 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 2%.

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 decarbonizing liquid fuels.

To achieve a net zero scenario, demand growth for alternative fuels would need to increase from 4% p.a. to over 15% p.a., taking industry production capacity from 168bn liters in 2022 to around 600bn liters 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/kilowatt hour (kWh).

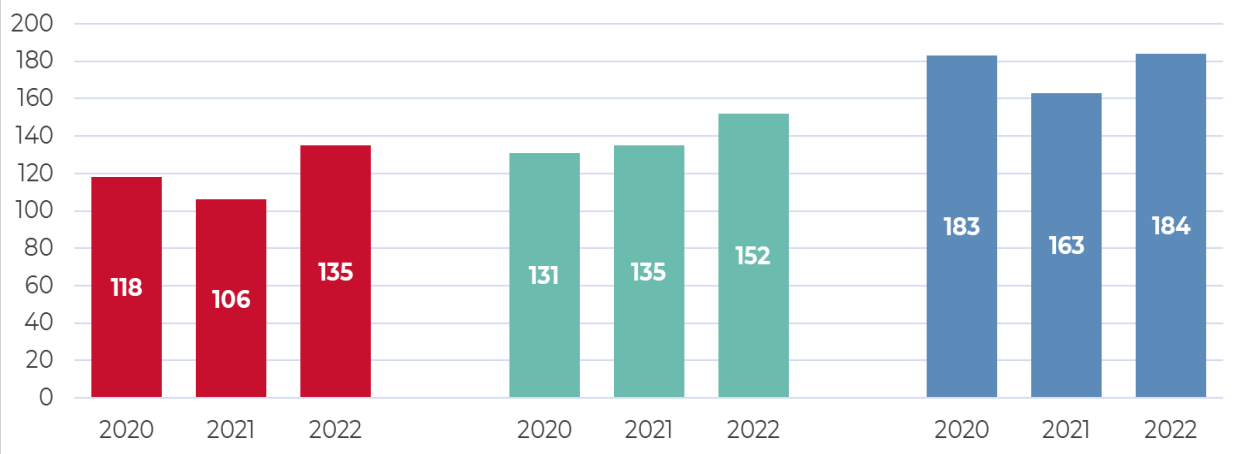
At the end of 2022, lithium and nickel prices were trading 800% and 60% higher than levels seen in December 2020 as supply has struggled to keep pace with strong demand for electric vehicles. Lithium carbonate prices in China reached new peaks in 2022, exceeding $78,000 per tonne, as the market suffered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

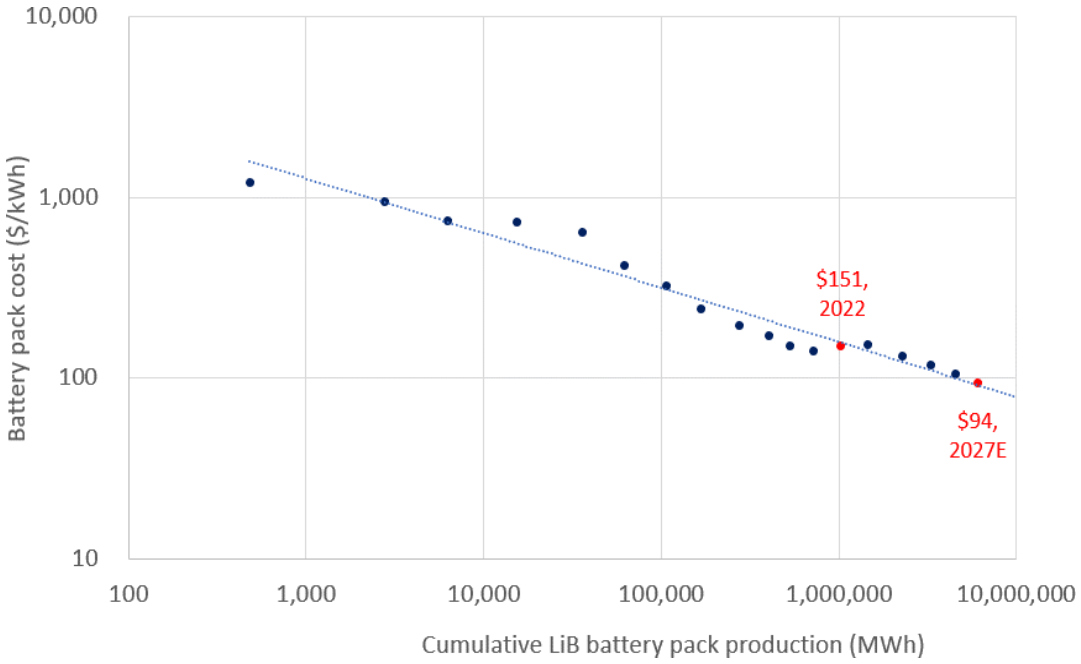
Historical LFP (red), NCA (green), NMC (blue) pack prices, US$/kWh



Source: Bloomberg New Energy Finance. As of 12.31.2022.

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 Lithium-Ion Battery (LiB) packs (MWh) vs Battery pack price ($/kWh)



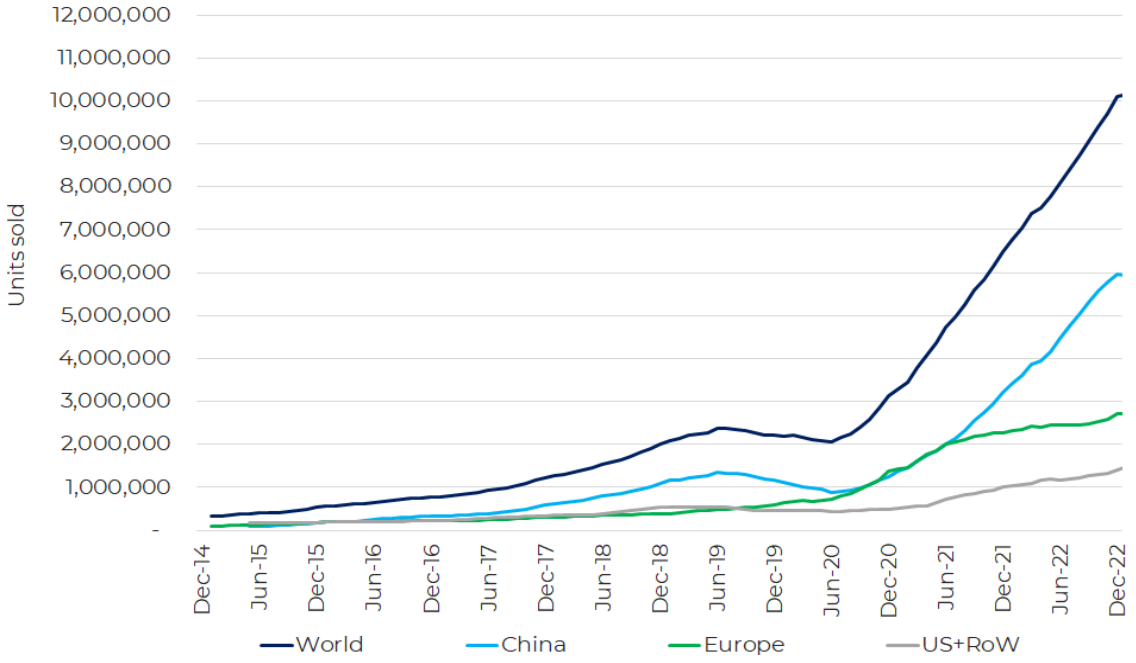
Source: Bloomberg, Guinness Atkinson Asset Management as of 12.31.2022

In 2020, the expectation was that the industry battery pack cost target of $100/kWh (the price at which electric vehicles reach price parity with internal combustion engine 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 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 December 2022)



Source: Guinness Atkinson Asset Management, EV-Sales, Cleantechnica as of 12.31.2022

Much of this growth has been driven by policy, with governments now subsidizing 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 (neighborhood electric vehicle) subsidy program has completely ended, meaning that no NEVs purchased after January 1st, 2023 will be subsidized. 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 normalized 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.

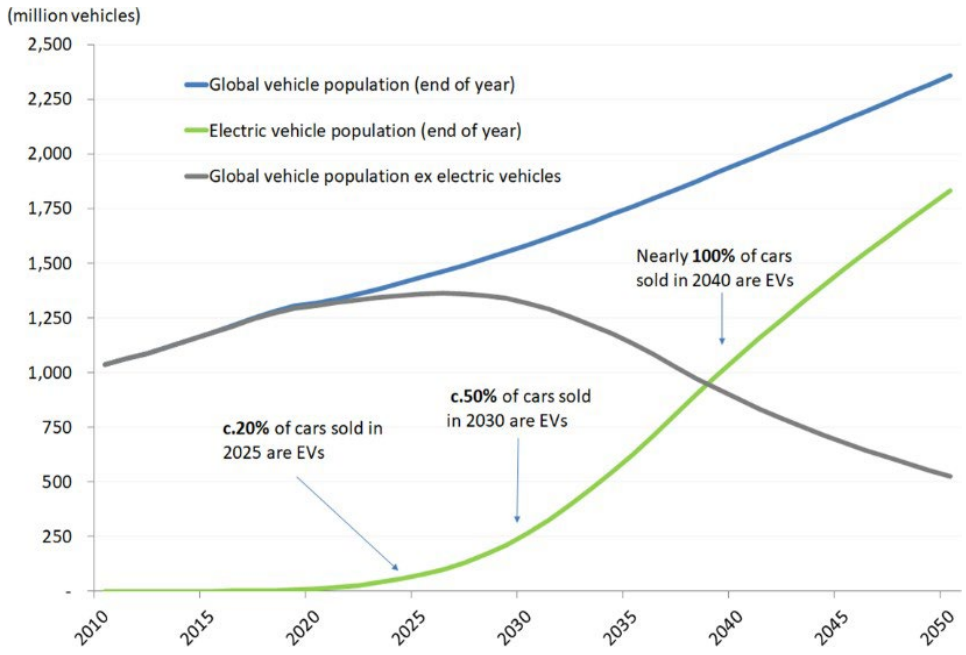
• **Charge time:** Level one and two chargers (available in residential and commercial environments) are cheap and can replenish 5-30 miles of range per hour. Level three fast chargers, however, offer fast charging on longer trips, delivering at a significantly higher rate of 200-600 miles of range per 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 Atkinson Asset Management 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 gigawatt hours (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 p.a. in 2030 and around $120bn p.a. in 2040, significantly ahead

of our base case estimates.

The implication would be that electricity demand would likely grow around 3.3% p.a. to 2040 (faster than our base case of 2.5% p.a.) 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

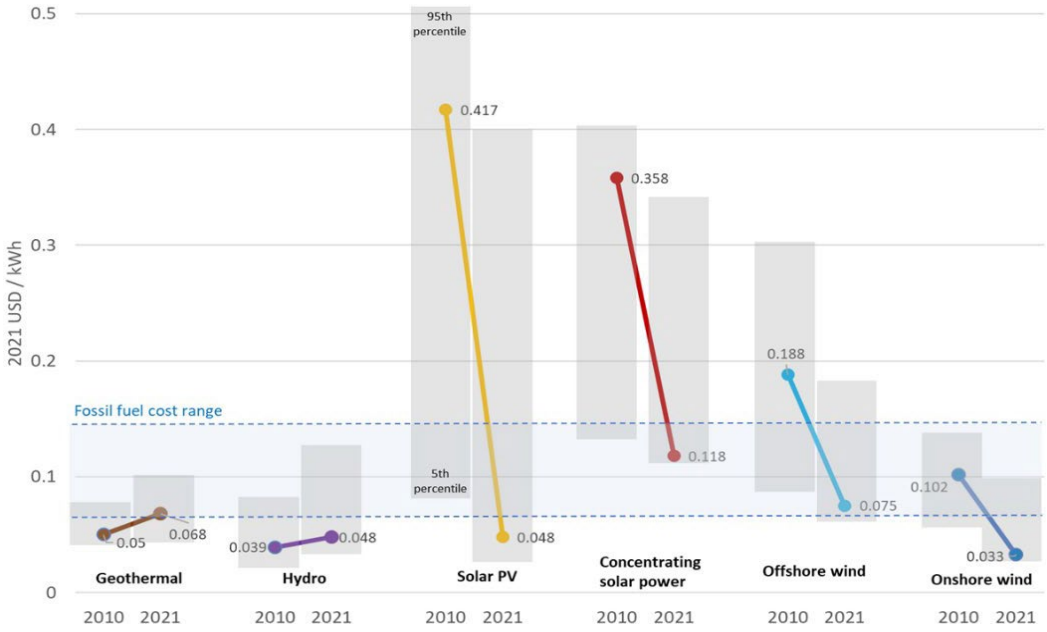
Source: BNEF

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 (photovoltaic cells) 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 (Levelized Cost of Electricity) of utility-scale renewable power generation technologies (2010–2021)



Source: International Renewable Energy Agency, Guinness Atkinson Asset Management 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 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 have been around 25 GW as demand is less likely to be impacted by NEM3.0 and the WRO.

• Demand in **Europe** is expected to have been 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 incentivize new demand for solar installations.

Looking ahead, 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** (Organisation for Economic Co-operation and Development) 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)

	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*

Source: BP, BNEF, PV InfoLink, IEA, and Guinness Atkinson Asset Management estimates as of 12.31.2022

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 incentivize 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 metric tonnes per annum (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.

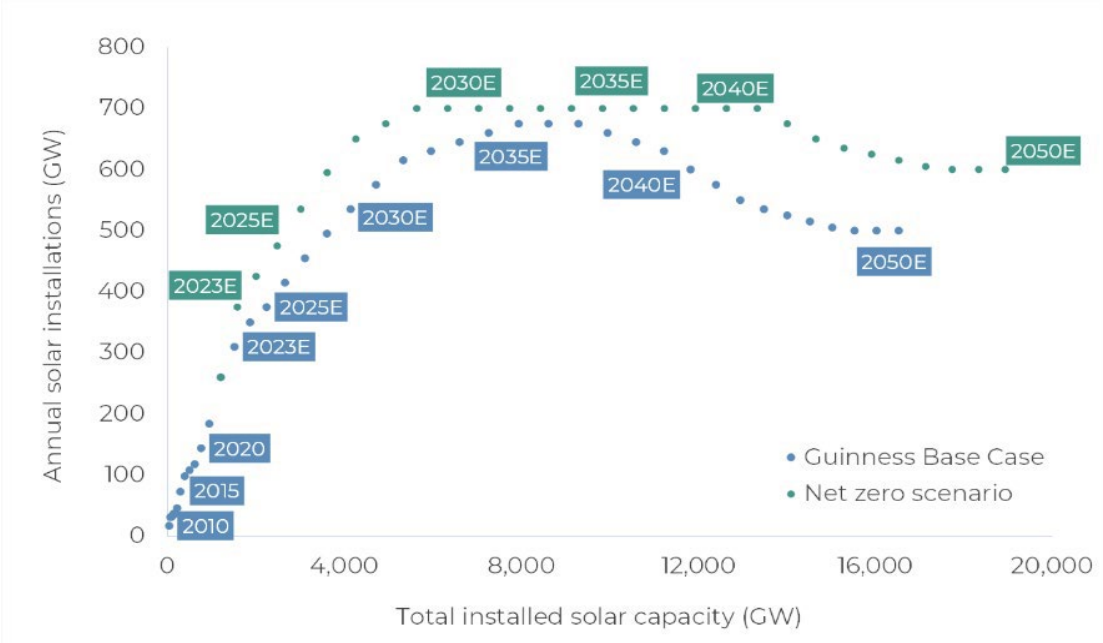
• **Solar module** prices moderated in the second half of 2022 with prices likely to average the same level as 2021. With elevated polysilicon and power prices, it is the module manufacturers that suffered the greatest margin compression in 2022. Module manufacturing nameplate capacity in 2022 is estimated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

indicates that total installed capacity would need to be 5.6 TW in 2030 (a compound growth rate of 22% p.a. from 2021) and that reaching this level of installed capacity would require annual installations to reach as much as 700 GW p.a.. 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 net zero scenario



Source: IEA, IPCC, Guinness Atkinson Asset Management

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 decarbonization 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 air pockets". 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. 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)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022 E	2023 E
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*

Source: BP, BNEF, IEA, and Guinness Atkinson Asset Management estimates

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 (approximately $93.7bn USD) 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 (among other things) electricity generation and transport. This not only provides very material tax credits, but 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.

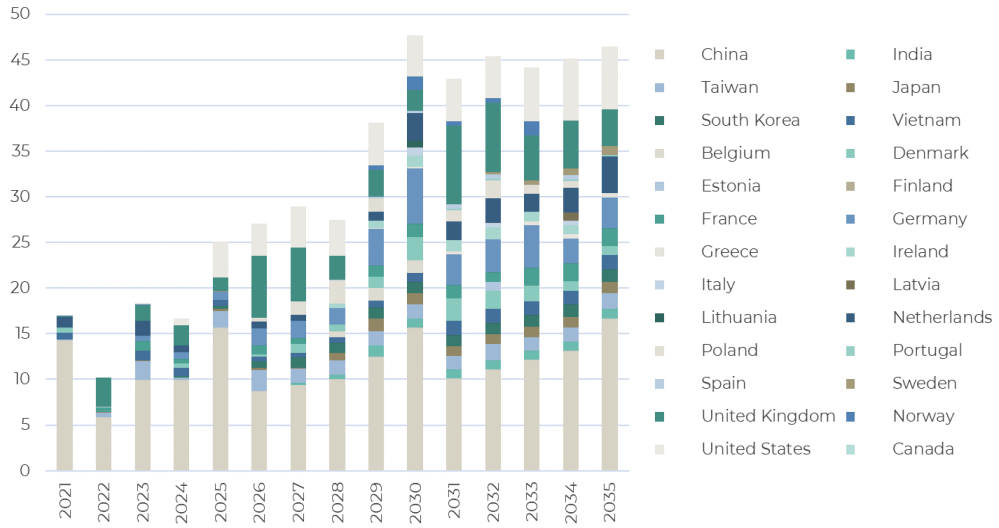
Offshore wind

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 levelized cost of electricity (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 industrialized, 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).

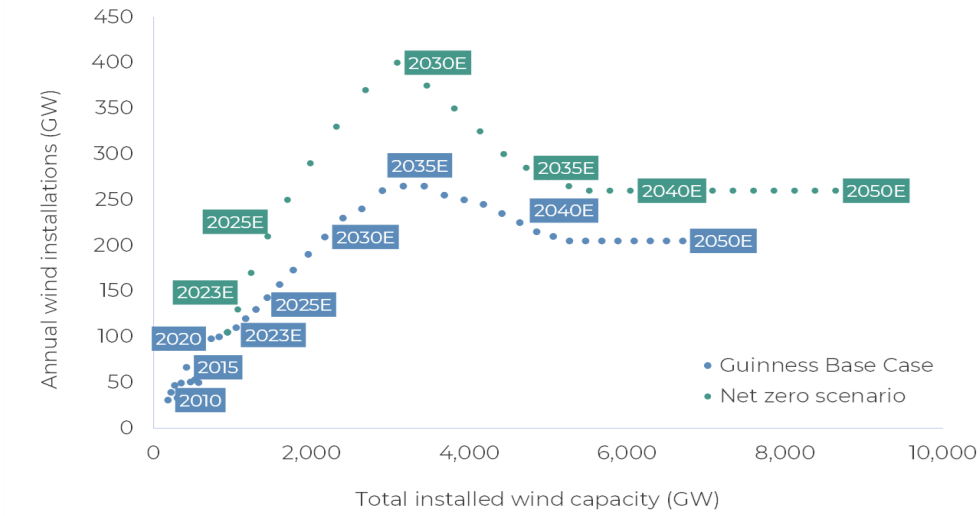
Outlook for offshore wind installations (GW per annum, to 2035)



Source: BP, BNEF, IEA, and Guinness Atkinson Asset Management estimates

Our base case assumes that total wind installed capacity will be around 2.2 terawatts (TW) in 2030. The Guinness Atkinson net zero scenario indicates that total installed capacity would need to be 3.1 TW in 2030 (a compound growth rate of 16% p.a. from 2021) and that reaching this level of installed capacity would require annual installations to reach as much as 400 GW p.a.. 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, and Guinness Atkinson Asset Management estimates

IMPORTANT INFORMATION

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

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

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

Top 10 Holdings as of 7/31/2023:

1.	ON Semiconductor Corp	4.88%
2.	Infineon Technologies AG	4.36%
3.	Eaton Corp PLC	4.13%
4.	Iberdrola SA	4.11%
5.	Schneider Electric SE	4.02%
6.	Samsung SDI Co Ltd	3.96%
7.	Trane Technologies PLC	3.92%
8.	Legrand SA	3.89%
9.	LG Chem Ltd	3.85%
10.	Aptiv PLC	3.82%

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

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

Earnings Growth is not a measure of the Fund's future performance.

Price-to-Earnings (P/E) Ratio is the ratio for valuing a company that measures its current share price relative to its earnings per share. The ratio is used for valuing companies and to find out whether they are overvalued or undervalued.

Cash Flow Return on Investment (CFROI) is a valuation model that assumes the stock market sets prices based on cash flow, not corporate performance and earnings.

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

One cannot invest directly in an index.

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