2022 Outlook for Sustainable Energy

The Guinness Atkinson Sustainable Energy Team, January 2022

Executive Summary

The year of 2021 saw continued positive momentum for the energy transition. Policy commitments and investments were made to accelerate the decarbonization of the global energy sector. Offsetting this, we saw raw material cost inflation, supply chain issues and some political tensions which have slowed the pace of growth and profitability in certain subsectors. Against this backdrop, our portfolio has seen improved cash return expectations versus twelve months ago. It continues to offer broad exposure to companies that are well placed to benefit from an energy transition that will gather pace through the remainder of this decade.

After very strong policy support in 2020, we witnessed **further policy commitment in 2021.** The most significant policy milestones last year included:

- **President Biden returning the US to the Paris Agreement**, and announcing significantly increased 2030 greenhouse gas (GHG) reduction targets;
- the influential **2021 IPCC climate report**, which highlighted the importance and urgency of pursuing a 1.5° warming or net zero 2050 scenario;
- the **COP15 Biological Diversity Conference**, at which President Xi gave more clarity on how China would meet its climate targets over the coming years, including a major expansion in solar; and
- and the **COP26 climate conference**, which introduced new net zero targets, additional country pledges and some "alliances of the willing" to reduce coal usage and methane emissions.

In addition to enhanced policy commitment, 2021 saw major steps forward for various aspects of the transition. We saw around 290 GW of new **renewable generation capacity** installed, 10 GW higher than the record installations seen in 2020 and nearly 100 GW higher than the 194 GW installed in 2019. Solar represented nearly two-thirds of the new capacity additions, followed by wind then hydro. **Renewable electricity generation** increased by around 6% to over 7,900 TWh, outpacing global electricity demand growth (4.5% in 2021). **Electric vehicle (EV) sales** surged, reaching around 7% of global light auto sales, up from just over 3% in 2020. Sales were particularly strong in China and Europe. And investment into **energy efficiency** also accelerated, with building infrastructure remaining a key focus for spending.

2021 was also a year in which the complexities of a shift to a lower carbon economy become more evident.

In Europe, **record natural gas prices became a major political headache**, forcing governments to seek protection for consumers from the extreme price spike. On the one hand, observers could point to extraordinarily high post-pandemic power demand, plus the tactics of President Putin to withhold gas exports into Europe, as reasons for the extreme prices. But on the other, the spike has been driven by an

attempt to shift away from carbon intensive coal usage in China, and the impact of a rapidly rising carbon price in Europe, which is affecting the behavior of utilities.

In the US, Democratic Senator Joe Manchin has **blocked the path of the "Build Back Better" (BBB) bill**, a cornerstone spending plan of the current administration which includes various clean energy related provisions designed to accelerate the transition. Manchin represents West Virginia, a major coal producing state, and claims the bill will "risk the reliability of our electric grid and increase our dependence on foreign supply chains".

After many years of consistent cost reductions, 2021 also saw the emergence of **inflationary conditions and supply chain pressures** across the breadth of the sustainable energy sector. Energy transition technologies and equipment are typically raw material intensive (leaving them exposed to raw material inflation) and are dominated by Chinese manufacturing (50% of all wind turbines and 70% of all solar panels are manufactured in China), leaving importers exposed to supply chain inefficiencies and higher freight costs.

Natural gas prices will moderate; there will be a resolution to Manchin's opposition to BBB, and most areas of raw material inflation will settle down and be trumped by scale and technological improvements. But the world is waking up to the fact that although the energy transition will result in economic and environmental gains, policy decisions have the potential in the short-term to cause economic and political friction.

Against this backdrop, the **Guinness Atkinson Alternative Energy Fund** has seen improved cash return expectations and delivered a total return (USD) of +8.40% vs the MSCI World Index (net return) of +21.82. Within the portfolio, outperforming sectors included Chinese wind generation, EV component suppliers, poly-silicon (for solar) and efficiency. Underperforming sectors included European green utilities, solar component manufacturers and wind developers.

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.

Looking ahead to 2022 and beyond, we expect further acceleration of the transition:

- On the supply side of the energy transition, the International Energy Agency (IEA) is forecasting that **renewable power additions** over the coming five years will be just over 1,800 GW; a near 50% increase on its previous five-year forecast published twelve months earlier. The increase is driven by a further reduction in the levelized cost of electricity for renewables.

- The IEA has described **solar power** as "the cheapest electricity in history" and, despite near term headwinds and cyclical cost inflationary factors, large-scale solar remains at the bottom end of the cost curve. Globally, we expect solar installations to grow in 2022 by over 20%, led by China, India, Middle East, and other parts of Asia. It is likely that poly-silicon prices have peaked,

bringing cost relief for cell and module manufacturers. The outlook for solar in the US this year is less certain due to various issues (stimulus spending, net metering, and Chinese import issues).

- Global **wind** installations are expected to be around flat in 2022, as changes in tax incentives, COVID-related logistics issues and raw material cost inflation are worked through. Onshore installations should pick up meaningfully in the middle of the decade, and there is clear momentum in offshore wind, albeit with a 3-4 year lead time. President Biden has recently called for the US to have 30 GW of offshore wind by 2030 (current installed base = <1 GW), which would represent a step change for the industry.

- **Energy efficiency** will continue to receive a good proportion of post-COVID stimulus spending, with a continued focus on buildings. We expect an acceleration in the penetration of LED lighting, insulation, and heat pumps, as well as a focus on grid and transmission upgrades. The IEA estimates that to meet current government policies, energy efficiency spending needs to increase from a recent average level of around $250bn pa to around $375bn this decade and nearly $550bn in the 2030s.

- **EV sales should exceed 9 million in 2022**, representing around 10% of total passenger vehicle sales, taking the global EV stock from 16 million vehicles to 25 million vehicles. Lower EV prices, greater brand choice and growing consumer appetite continue to be the key drivers of improved EV sales.

- **Battery demand** for use in EVs and energy storage will accelerate in 2022. We expect new battery capacity of nearly 300 GWh to be sold this year, up by around 25% versus 2021. Raw material cost inflation will continue to have an impact in 2022, but increasingly manufacturing capacity, coupled with technological improvements, will continue to push average battery pack costs towards $100/kWh, the level at which mass market EVs become affordable.

The outlook we summarize here is broadly consistent with current government activity and observable investment plans. To be clear, however, the growth described falls well short of the energy transition activity needed to achieve a **net zero / 1.5 degree scenario** in 2050, as targeted by the IPCC and at COP26. In a net zero scenario, the deployment of renewable generation capacity, penetration of EVs and battery storage, use of alternative fuels and implementation of energy efficiency measures will need to accelerate markedly.

As of December 31, 2021, the **Guinness Atkinson Alternative Energy Fund** traded on a 2022 P/E ratio of 24.5x and 2022 EV/EBITDA multiple of 13.2x. The fund trades at about a 20% premium to the MSCI World Index, which we see as justified given the attractive growth rates available to invest in across the sector. As a sense check, consensus earnings per share (EPS) growth (2021-2023E) of the portfolio (at 21.3%pa) is well ahead of the MSCI World (at 13.5%pa). Looking over the next five years, we believe that the portfolio is likely to deliver average earnings growth of around 13%pa, comfortably ahead of growth in the MSCI World.

Our current portfolio is summarized below by investment theme:

Key themes in the Guinness Atkinson Alternative Energy Fund

source: Guinness Atkinson Asset Management (12.31.2021)

	Theme	Example holdings	Weighting (%)
1	Electrification of the energy mix	TransAlta renewables, NextEra Energy	19.3%
2	Rise of the electric vehicle and auto efficiency	Sensata Technologies, APTIV	25.2%
3	Battery manufacturing	Samsung SDI	6.4%
4	Expansion of the wind industry	Siemens Gamesa Renewable Energy, Vestas	12.9%
5	Expansion of the solar industry	CanadianSolar	12.1%
6	Heating, lighting and power efficiency	NIBE Industrier	11.8%
7	Geothermal and biomass	Ormat, Albioma	4.4%
8	Other (inc cash)		7.9%

This document reviews the sustainable energy sector and fund in 2021 and provides an outlook for 2022 and beyond. We have split the document into three sections:

i) Developments in energy transition policy and "macro"

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

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

Sustainable energy policy and macro

Policy & macro

In this section, we review the developments in 2021 of the following key areas:

- Renewable installations and power generation
- Inflationary and cost pressures in the sustainable energy supply chain
- Policy support for the energy transition

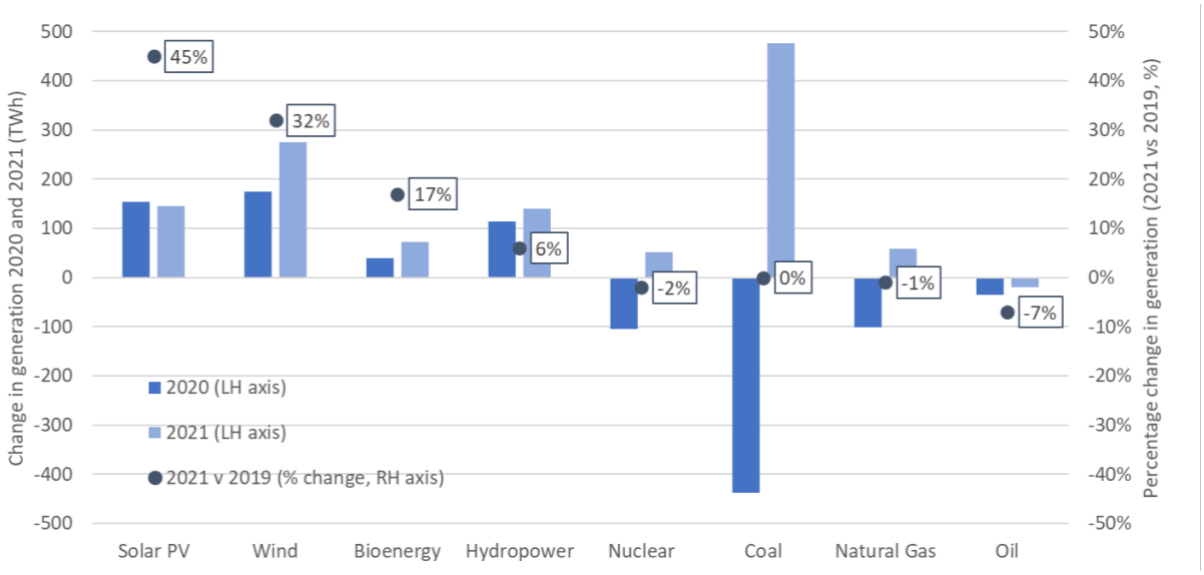
Renewable installations and generation in 2021

Around 290 GW of new renewable generation capacity was installed in 2021, 10 GW higher than the record installations seen in 2020 and nearly 100 GW higher than the 194 GW installed in 2019. At over 180 GW, solar represented nearly two-thirds of the new capacity additions. Wind (at around 89 GW) came next, followed by hydropower.

Renewable electricity generation in 2021 is likely to have increased by around 6%, reaching over 7,900 TWh, and outpacing global electricity demand (estimated 4.5% growth in 2021). The rate is slightly higher than the five-year average annual growth rate but is lower than it could have been, thanks to various disruptions including to hydropower generation (held back by severe drought conditions in several key countries) and wind generation (held back by low wind speeds in the northern hemisphere). The European Union, for example, saw wind generation decline by around 3% due to low wind conditions, resulting in the first annual decline in production for more than three decades. Without these adverse weather conditions, global renewable electricity generation could have been up by almost 9% in 2021 compared with 2020, well ahead of the long run average growth rate of around 5% and double the rate of global electricity demand growth.

Change in electricity generation in 2020 and 2021, vs 2019

source: IEA. Data as of 12.31.2021



Renewable power generation growth last year lagged growth in coal generation. Global coal fired power generation is likely to have increased by around 9% in 2021, driven by Chinese economic growth of 8% and Chinese electricity demand growth of 10%. Efforts to reign in coal supply in China over the first few months of the year led to a supply crunch and spiking electricity prices. The Chinese government then removed coal price restrictions in the second half of 2021, fueling a surge in coal supply and a doubling of coal prices. It was a testament to the difficulty of achieving global decarbonization targets that the COP26 climate conference in November 2021 coincided with a new high for Chinese coal production.

Inflationary factors, supply chain pressures and trade friction

After many years of consistent cost reductions, 2021 saw the emergence of inflationary conditions and supply chain pressures across the breadth of the sustainable energy sector. Broadly speaking, the inflation came from three sources:

- **Raw materials.** The energy transition is raw material intensive and increased demand brings the threat of raw material inflation. Since the beginning of 2020, prices for photovoltaic (PV)-grade polysilicon have more than quadrupled, steel has increased by 50%, aluminum by 80% and copper by 60%. Based on steel alone representing around 90% of the mass and 20% of the construction cost of

a wind turbine, we see the risk for some projects to suffer investment cost increases of as much as 25%. Over the medium term, we expect these increases to be offset by continued technology, scale, and manufacturing improvements.

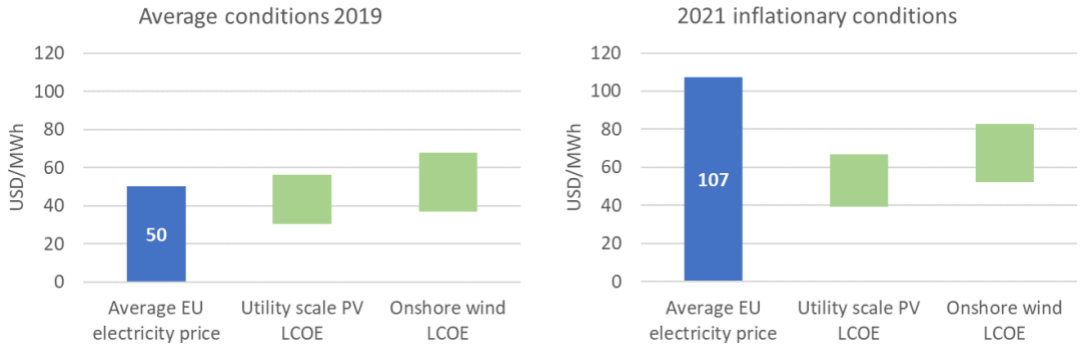
- **Supply chain and logistics.** China is a major manufacturer (50% of all wind turbines and 70% of all solar panels) and exporter of sustainable energy equipment. Movements in Chinese freight and logistics costs therefore impact the economics of clean energy projects across the world. Some international freight fees rose by as much as six-fold in 2021 and while many companies will have long-term contracts to smooth the volatility, none will have been immune from this source of inflation. Freight and logistics issues are likely to persist in the start of 2022 as China's zero COVID policy threatens to impact freight handling and exports, but we would expect these issues to subside as the year progresses.

- **Trade-related friction**. In June 2021, the US government enacted a "withhold release" order (WRO) that banned the import of silica-based products with ties to Hoshine Silicon, a company that represents 50% of the metallurgical grade silicon supply in China. The WRO has slowed imports of solar modules into the US, with importers having to demonstrate a "clean" supply chain. The US represented around 15% of total 2021 solar demand.

In absolute terms, these inflationary effects are detrimental to the economics of new renewable energy installations. However, it is important to remember that competing fossil fuel technologies also suffered inflationary pressures during the year, some being much more significant. In December 2021, European and Asian natural gas prices were in excess of $30/mcf (equivalent to over $200 per barrel of oil) and up as much as five times in 2021; coal prices were at their highest levels in more than ten years; and European electricity prices were more than double the levels seen in 2019 and 2020. While we expect natural gas and coal prices to moderate, we think they will sustain at levels higher than those seen in recent years. It is plausible then that the relative economics of renewable projects improved 2021, despite inflationary pressures. Looking at major European markets, for example, utility scale solar PV and onshore wind projects were competitive in 2019 on a "levelized cost of electricity" (LCOE) basis versus average wholesale electricity prices. In 2021, wholesale electricity prices more than doubled to around USD107/MWh (vs USD45/MWh in 2019) meaning that utility PV and onshore wind projects, even allowing for inflation described above, have become relatively more attractive.

European wholesale electricity price and clean energy project LCOEs (2019 and 2021)

source: IEA, Guinness Atkinson Asset Management estimates



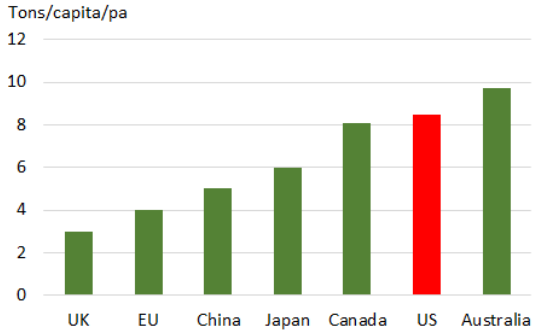
Policy support for decarbonization and the journey to COP26

After very strong policy support in 2020, we witnessed further policy commitment in 2021. The path has not always been smooth, however, with US's return to the Paris Agreement, for example, butting up against resistance to key clean energy spending plans. The most significant policy milestones in 2021 included:

- **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. To be on track to meet the new target, the US will need to have cut 2025 emissions by around 38% (up from old target of 28%). The return of the US to the UN Climate process is a key factor in global decarbonization but, even assuming the US achieves these new targets, it will still be the second highest per capita emitter of CO2 in 2030.

Target implied CO2 emissions per capita in 2030

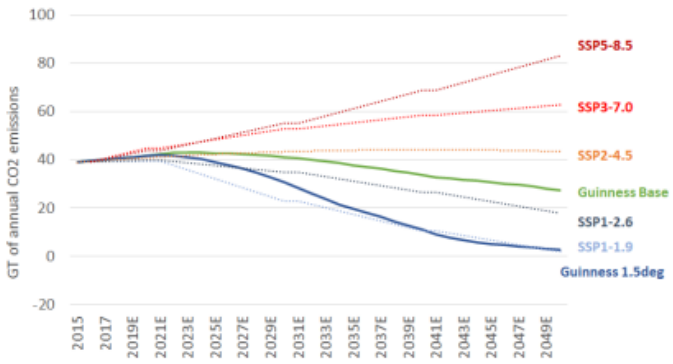
source: Goldman Sachs, Guinness Atkinson Asset Management estimates



- **The 2021 IPCC climate report.** Mid-year, the Intergovernmental Panel on Climate Change (IPCC) published their sixth assessment report on the physical science of climate change and the physical impacts of various carbon emission and warming scenarios. The report highlighted the importance and urgency of pursuing a 1.5° warming or net zero 2050 scenario and formed the basis for discussion and negotiation at the COP 26 climate conference. Based on the IPCC science, we find there is a very significant gap between our energy transition base case and our Guinness Atkinson "1.5 degree" or "net zero" scenario.

Guinness Atkinson 1.5° and base case versus IPCC carbon emission scenarios

source: IPCC, Guinness Atkinson Asset Management estimates



- **COP26 climate conference.** In November, 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. We were pleased to see Article 6 (the "Paris Rulebook") being agreed, that Nationally Determined Contributions need to be ratcheted annually and that the climate target has shifted to 1.5 degrees rather than "below 2 degrees". Despite these advances, post-COP26 policies still align with a level of climate warming that does not come close to 1.5°.

- **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 MtCO2e) while Canada introduced a federal carbon tax that will increase by 2030 to around US$130/ton. Despite these announcements, we estimate that only a quarter of global emissions are covered under an ETS. And even though European carbon prices rising during 2021 to end the year at around US$95/ton, the global average carbon price is still likely to be only around US$1/ton. By contrast the IEA forecasts that global carbon prices need to increase to average $75/ton in advanced economies and $45/ton across the larger emerging market and developing economies, to start the alignment with net zero by 2050.

Carbon prices for electricity, industry, and energy production in a net zero scenario

source: IEA

USD (2019) per tonne of CO_2	2025	2030	2040	2050
Advanced economies	75	130	205	250
Selected emerging market and developing economies*	45	90	160	200
Other emerging market and developing economies	3	15	35	55

* Includes China, Russia, Brazil and South Africa.

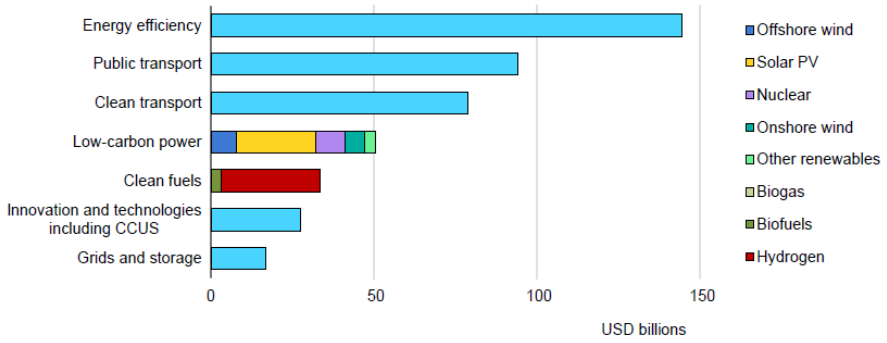
- **Post COVID stimulus and infrastructure plans.** While policy towards stimulus plans continues to be positive, the passage of actual investment into the energy transition has been slower than expected. As of October 2021, according to the IMF, around US$17trn has been mobilized by governments in the form of rebates, grants, loans and tax incentives or exemptions to mitigate the effects of COVID. The IEA believes that around 3% of this has been allocated to clean energy.

  The influential US "Build Back Better" (BBB) infrastructure package is the clearest example of the delay between policy announcement and actual investment. After passing the House of Representatives in November, Democratic Senator Joe Manchin announced on December 19th that he would not be supporting the $1.75trn bill (as currently written) thus delaying the passage of the BBB bill through the House of Congress. The package included proposals for a higher and longer-term Production Tax Credit (PTC) for onshore wind; an extended Investment Tax Credit (ITC) for solar to

include stand-alone energy storage projects, offshore wind and hydrogen projects; as well as a higher tax credit for carbon capture projects and the introduction of a credit for clean hydrogen. While the bill in its current form will not proceed, there was hope that the $555bn investment included in the BBB for climate-related issues will be agreed upon. Senator Manchin commented in early January 2022 that "the climate thing is one that we probably can come to an agreement much easier than anything else".

Global government clean energy spending by sector and technology (October 2021)

source: IEA



- **COP15 Biological Diversity Conference**. At the 15th meeting of the Conference of the Parties to the Convention on Biological Diversity (COP15) in October 2021, Chinese Premier Xi Jinping gave more clarity on how China would meet its climate targets over the coming years. He highlighted that "the first phase" of 100 GW of renewable project capacity had started construction and, on our analysis, his growth agenda implies Chinese annual solar installations in the range of 130-150 GW (equivalent to total global PV installations in 2020 and a 80-100 GW increase on China's 2020 installations of 50 GW).

Summary of macro and policy-related factors in 2021

The high-level macro and policy events of 2021 have been supportive of the growth opportunity that exists in the energy transition but the delivery of investment plans and actual investment in 2021 has been slower than expected. We believe that the inflationary factors (raw materials, supply chain and trade-related factors) will continue to cause issues in 2022, but longer term will be trumped by technological and scale improvements that have allowed efficiency gains to be delivered in recent years. As these issues are resolved, we expect the growth agenda for sustainable energy to be highly attractive.

In the next section we consider the outlook for the key subsectors within the Guinness Atkinson Alternative Energy universe.

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-carbonization. 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, 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 measures were negatively impacted by COVID in 2020, as projects and investments were disrupted, but it appears that governments are turning their attention to efficiency measures as part of post-COVID stimulus measures. There is urgency to do this as current government policies imply that annual energy efficiency improvements need to increase by around 50% from a long-term historic 1.5%pa to a forecast level of 2.3%pa.

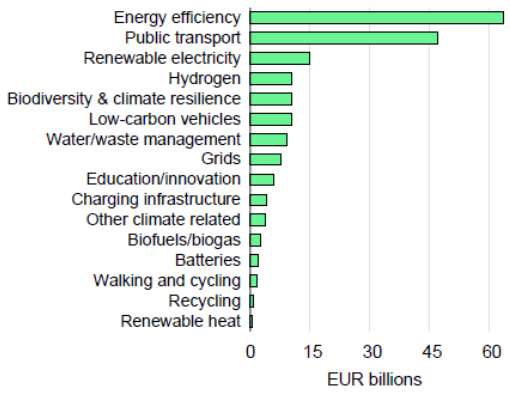
Energy efficiency measures are typically employment-intensive and offer a cheap form of carbon abatement. These factors help explain why the efficiency sector has received around US$144bn of stimulus spending since the start of COVID, the largest allocation within clean energy spending globally. The renovation of public and private buildings and energy efficiency investment in the industrial sector are the largest beneficiaries of the allocated spending.

Within the European Recovery and Resilience Facility (RFF), energy efficiency received the largest allocation of investment, at around EUR60bn. Country efficiency schemes (such as the Italian 110% superbonus tax deduction scheme for energy efficiency retrofits and the Portuguese "More Sustainable Buildings" scheme) have been extended thanks to the additional capital being made available.

Despite the acceleration of energy efficiency spending for buildings, current spending plans will only be enough to keep total building heat consumption flat over the next few years, as per square foot efficiency gains are offset by an expanding stock of buildings.

EU Recovery and Resilience Facility (RFF) fund allocation

source: IEA



Based on current government policies, the IEA estimates that energy efficiency spending needs to increase this decade from around $250bn pa to around $375bn pa, rising to $550bn in the 2030s. However, current activity, plus recent subsidy announcements, are not sufficient to deliver even the IEA's base case, which is far from net zero.

Looking ahead, buildings will remain the key focus for efficiency improvements in the energy transition. The IEA expect them to represent around 60% of total energy efficiency spending, with efficient insulation, lighting, heating, cooling, and appliances are all critical towards delivering nationally determined contributions (NDC)s.

- Within **lighting**, a transition is underway, with LEDs now representing an estimated 50% of all lighting sales in 2021 (up from around 18% in 2016). We believe that LEDs will represent nearly all lighting sales by around 2025. LED producers are increasingly focusing on controls and providing "connected" or "intelligent" lighting as well as antimicrobial lighting solutions such as UV-C lighting.

- Within **heating**, we see strong policy commitments but a limited range of efficient low carbon building heating solutions, with heat pumps leading the way. There are around 180m heat pumps installed globally (with less than 10m new pumps being installed every year) and even on conservative base case assumptions, we need to see annual installations nearly double by 2025 and nearly double again by 2030.

Alternative fuels

Alternative fuels such as ethanol (which displaces gasoline), biodiesel and renewable diesel (which displace conventional diesel) and Sustainable Aviation Fuels (SAF, which displace conventional jet fuel) serve a role in displacing existing fossil fuel demand, predominantly in transportation. In 2021, the global alternative fuel demand was nearly 160bn liters (over 2.5m b/day), representing nearly 3% of world oil transportation demand. The US has the largest alternative fuel market, at around 60bn liters (40% of the global market) where around 10% of all road fuel consumed is classified as alternative.

Alternative fuels consumption in 2021 grew by 10% versus 2020 and 3% versus 2019. Demand growth was significantly stronger than the underlying 6% increase in global oil demand, underlining the policy support for increased blending of alternative fuels in the transportation mix. Renewable diesel demand in the US and biodiesel demand in Asia were the biggest growth drivers.

That said, alternative fuel prices rose sharply in 2021 as a result of rising feedstock prices. At the end of November 2021, typical feedstock prices had doubled versus November 2019 levels. Without these price rises, the IEA estimate that global demand would have been around 3% higher. Over the next five years, alternative fuel demand is likely to grow at around 4%pa, reaching 186bn liters and continuing to outgrow global oil demand growth.

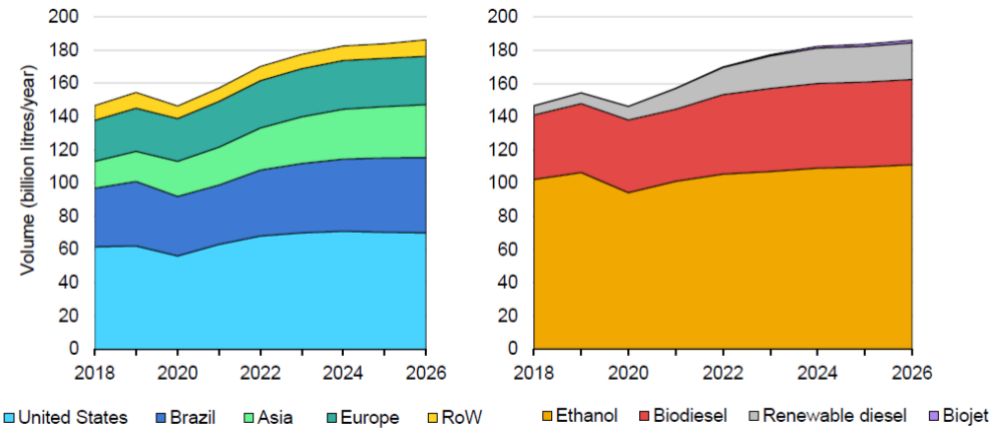
In regard to product mix, we see ethanol having the largest absolute demand growth, but its market share recedes to around 60% as demand for renewable diesel (using feedstocks such as used cooking oil, corn oil or rendered animal fats) accelerates and overtakes the current leading biodiesel technology. Combined, ethanol and renewable diesel satisfy 80% of the demand growth over the next five years.

We expect Asia to be the fastest growing market, driven for example by India's 20% ethanol blending target for 2025. However, North America will remain the largest market (40% market share) followed by Latin America (27% market share, driven by ethanol in markets like Brazil) and Asia (17% market share) and overtaking Europe (<15%).

The use of alternative fuels in aviation is a key policy goal for many countries, but sustainable aviation fuels continue to be very small, with market share hovering around 1%.

Alternative fuel demand by region (left) and fuel (right) (2018-2026)

source: IEA



On an unsubsidized basis, alternative fuels typically look expensive. Reliance on government subsidies increases the risk around the medium-term growth outlook. For example, in the US, there was significant uncertainty in 2021 around the Renewable Volume Obligation (RVO), a volume-driven subsidy. Various price-related subsidies in the US have also been volatile. In October 2021, the aggregate value of the subsidies, including Renewable Identification Numbers (RINs), Low Carbon Fuel Standards credits (LCFS) and the biodiesel Blenders Tax Credit (BTC), was around $4/gallon. With wholesale conventional diesel prices at around $2.50/gallon, it is clear how important subsidy is in delivering the growth of the biodiesel and renewable diesel industry in the US.

Implications of a net zero scenario on our displacement outlook

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

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

- Within **efficiency**, annual building energy efficiency improvements would need to jump from less than 1%pa currently to 2.5%pa by 2030 globally. This translates to energy efficiency investment

increasing to over $500bn per annum this decade (from $375bn in a base case scenario) and to over $800bn pa in the 2030s (from $500bn in a base case scenario). Installation of heat pumps, for example, would need to increase from 180m currently to around 600m by 2030 (implying a growth rate of around 15%pa) and requiring annual installations to increase from less than 10mn pa currently to around 80mn pa by 2030.

- Demand growth for **alternative fuels** would need to increase from 4%pa to over 15%pa, taking industry production capacity from 160bn liters in 2021 to around 560bn liters by 2030. With new biodiesel capacity costing around $3/gallon, this implies investment of around $300bn.

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.

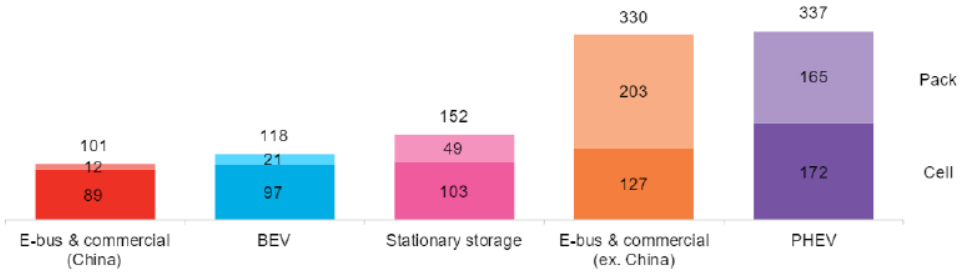
Batteries

The catalyst for greater **lithium-ion battery** use has been sharp falls in the cost of manufacturing. According to Bloomberg New Energy Finance (BNEF), battery pack costs are down 89% over the period 2010 to 2021 (an implied "learning rate" of around 18%) with the average cost being $132/kWh in 2021 (split $101/kWh for the cell itself and an additional $31/kWh for the pack).

The $132/kWh survey outcome for 2021 is an average calculated across a wide range of uses and regions. China was typically the lowest cost manufacturer with some individual passenger EV battery packs at below $100/kWh (and e-bus and commercial vehicle packs at $101/kWh on average) while BNEF calculated that Tesla's estimated average pack price in 2021 was around $112/kWh. The survey also includes stationary storage solutions which saw a fall in cost of around 16% in 2021, to $152/kWh, as manufacturers turned to simple and cheaper battery chemistries, such as lithium-ion phosphate, to offset raw material inflation.

BNEF lithium-ion battery survey 2021 ($/kWh)

source: BNEF



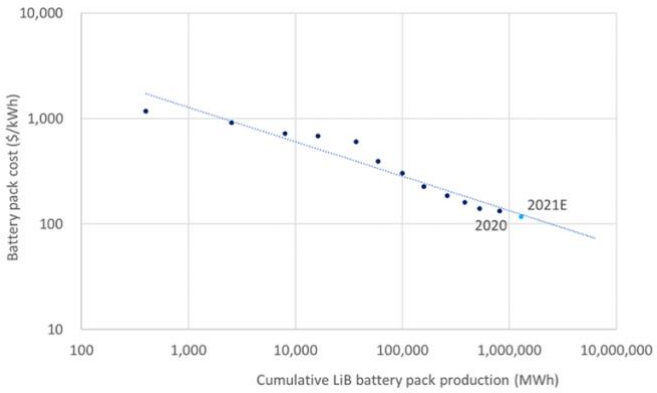
Raw materials make up around 50% of the cost of a lithium-ion battery pack, with cathode materials alone representing around 20% of the total cost. The key catalyst material is lithium carbonate, whose price in China rose by 270% in 2021. While battery manufacturers have long-term contracts and approaches in place to mitigate such inflation, they ultimately have little choice but to pass on the costs to consumers. In Q4 2021, BYD increased its battery prices by 20%.

Raw material cost inflation will continue to have an impact in 2022 and we see the likelihood that the cost of manufacturing may exceed levels seen in 2020. Rapidly increasing manufacturing capacity, (bringing further efficiencies of scale) together with reduced supply chain disruptions should help to alleviate the cost pressures in subsequent years and allow the average cost of producing a lithium-ion battery for an EV is likely to fall towards $100/kWh in the mid-2020s, maybe a year or so later than we previously expected.

While the $100/kWh cost level is a key target, we note that in 2021 the battery and EV industry started focusing on manufacturing costs well below $100/kWh. EV manufacturers started to vertically integrate with battery manufacturers and form battery manufacturing JVs such as BlueOvalSK (Ford/SK) and Ultium Cells (GM/LG Energy Solutions) in efforts to improve manufacturing efficiencies with $60/kWh targets discussed for the end of the decade. The US Department of Energy also set $60/kWh as its “stretch” goal, a level would be achieved by 2030 if the current 18% learning rate is maintained.

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

source: Bloomberg, Guinness Atkinson Asset Management



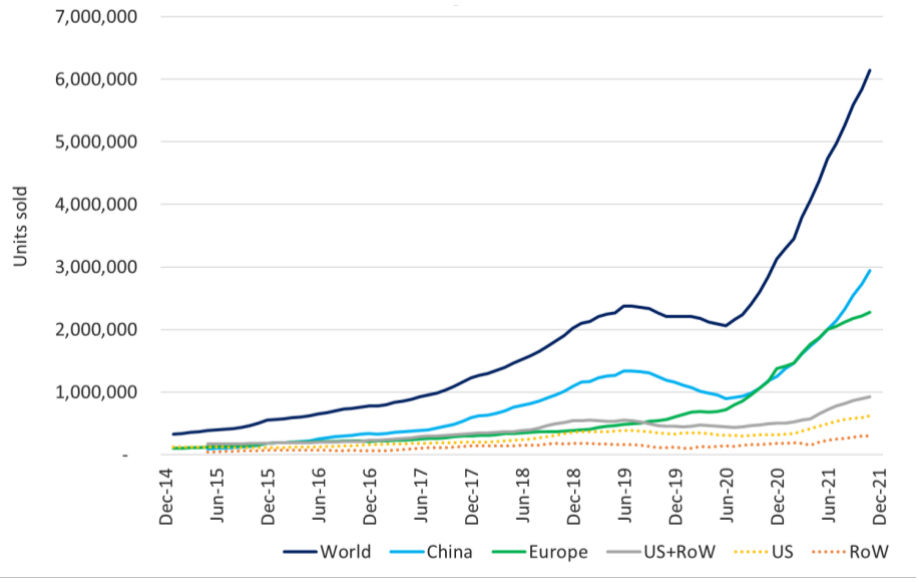
Electric Vehicles

Strong momentum in EV sales growth continued through 2021. On our estimates, nearly 6.1m new EVs were sold in the twelve months to November 2021, a growth of around 116% versus sales in the same period twelve months earlier (affected by COVID) and 178% higher than the same period in 2019. This growth compares very favorably to overall global light vehicle sales growth of 6.8%% and -9.4% for the same periods in 2021 and 2020 respectively. Accordingly, the market share for EVs has increased to around 7.6% for 2021 versus 3.4% and 2.4% in 2020 and 2019 respectively.

Regionally, China has regained its position as the largest EV market with total sales of new EVs of 2.9m in the twelve months to November 2021, up 150% on 2020. Europe, which overtook China to be the largest EV market at the end of 2020, saw total new EV sales of 2.27m units, up 94%. The US still lags Europe and China with new EV sales of 0.6m, up 95% on the same period twelve months earlier.

Global EV sales (rolling 12-month basis up to November 2021)

Source: Guinness Atkinson, EV-Sales, Cleantechnica



Lower EV prices, greater brand choice and growing consumer appetite continue to be the key drivers of improved EV sales. The strength in Europe has been helped by new generous EV incentives offered by Germany and France (among other countries) for passenger vehicles and increasing compliance with stricter emissions standards that came into effect at the start of the 2020. While passenger EVs are benefitting, EU data indicates that trucks are still witness the electrification trend; only 6 electric trucks were registered in Europe in the 12 months to the end of July 2020, versus 167,000 new diesel/petrol powered trucks. In China, after stagnating in 2019 as a result of the removal of EV subsidies, EV sales activity rebounded as a result of a broader range of EV models, including a number at lower price points.

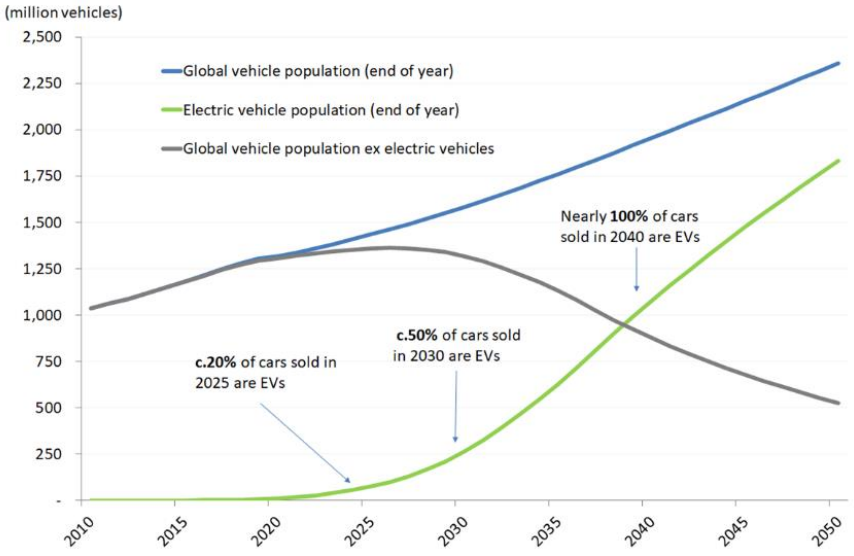
Government support for EVs will reduce in 2022. Europe will continue rolling back its EV "super-credits", and China plans to reduce EV subsidies further. Despite this, we expect global EV sales to exceed 9 million in 2022, representing around 10% of total passenger vehicle sales, taking the global EV stock from 16m vehicles to 25m vehicles.

US EV sales are expected to lag again. As part of the currently stalled BBB plan, the Biden administration is attempting to increase the tax credit for EVs to US$12,500, but this will be applicable only to a small number of vehicles as the limits for individual manufacturers have not been lifted. In December, the Environmental protection Agency (EPA) announced tougher emissions standards for US passenger cars and light trucks, requiring the 2026 model year vehicles to deliver average fuel economy of around 55 miles per gallon, around 23% greater than existing legislation.

On a global basis, we expect EVs will represent around 20% of new vehicle sales in 2025 (concurrent with the cost of EV lithium-ion batteries falling to around $100/kWh), 50% of new vehicle sales in 2030 and nearly all new vehicle sales by 2040. At that point, it implies an overall EV population of around 1bn vehicles, over sixty-five times greater than current global population of around 15m EVs. With EVs using roughly one third of the energy of a typical internal combustion engine vehicle, this transition alone will have substantial impact on global energy efficiency and global decarbonization.

Global EV population (to 2050)

Source: IEA; Guinness Atkinson Asset Management



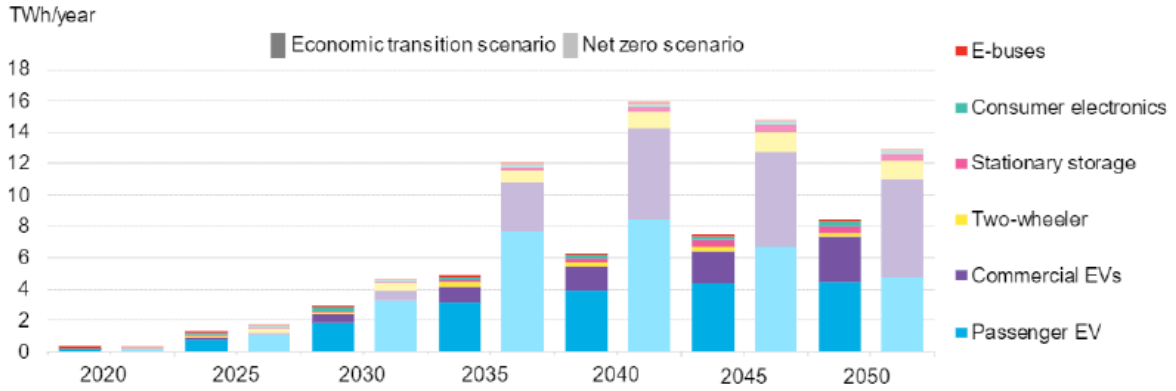
Despite these rapid EV growth assumptions, we calculate that oil demand from passenger vehicles will not peak until around 2024/25 and that, even by 2030, passenger vehicle oil demand will be similar to 2021 levels. With transportation generating just over 7bn tons of carbon emissions in 2020, accelerating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

Implications of a net zero scenario on our electrification outlook

For batteries, BNEF estimate that in a net zero scenario, global battery demand could be around 12 TWh by 2035 and 16 TWh in 2040. This is around 150% higher than the "base case" economic transition assumptions for each year, which themselves still imply significant growth over current levels.

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

source: BNEF



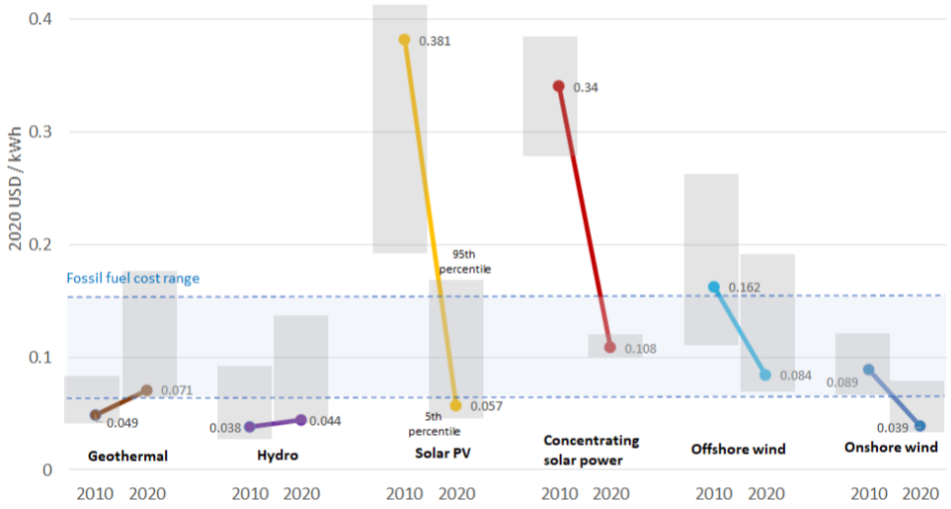
Generation & installation (equipment)

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 several years has recently been complicated by cyclical raw material, energy, and logistics cost inflation. However, while the cost of renewable power generation is likely biased upwards short-term, the relative economics of renewables versus hydrocarbons continue to improve thanks to fossil fuel generation inflation.

Global LCOE of utility-scale renewable power generation technologies (2010–2020)

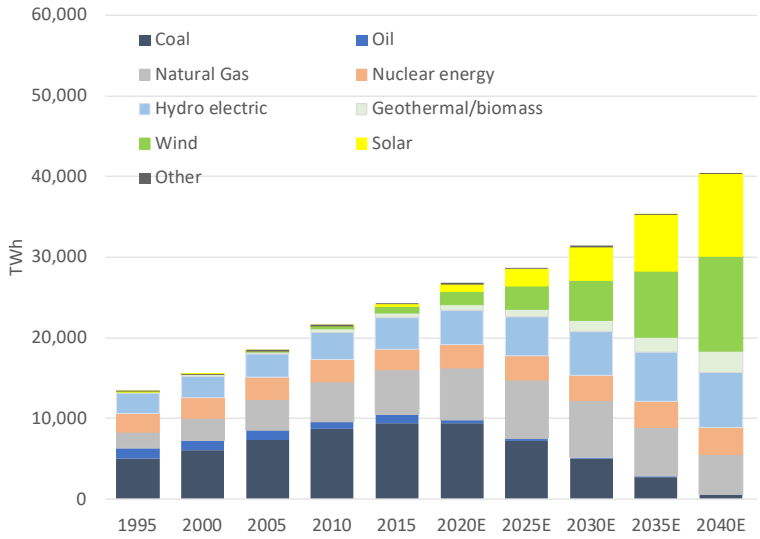
source: IRENA, Guinness Atkinson Asset Management estimates



Renewable generation technologies continued to take market share in 2021, with forecasts for renewable penetration being raised. In its recently published 2021 Renewables Outlook, the IEA estimated that renewable power additions over the coming five years would be just over 1,800 GW; a near 50% increase on its previous five-year forecast published twelve months earlier. We expect this to drive generation from renewables to a level of nearly 12,000 TWh in 2026, representing around 36% of world electricity generation in that year. Around half of this 2026 level will be from hydropower (staying relatively flat over the period) implying all the growth comes from wind and solar.

Global electricity generation by key source (1995–2040)

source: IEA, BP, Guinness Atkinson Asset Management estimates



The Solar Sector

2021 was a year of record installations, but one that also witnessed a tick up in the cost of solar module manufacturing as a result of raw material, power and logistics inflation. These issues slowed installation growth in the fourth quarter and lead us to forecast 173 GW for 2021. Even so, it is level comfortably above our 155 GW forecast for 2021 that we made at the start of the year. In 2020, the IEA described solar power as "now the cheapest electricity in history" and, despite near term headwinds and cyclical cost inflationary factors, large-scale solar remains at the bottom of the cost curve.

We introduce an estimate for 2022 installations of 215 GW (up 42 GW on 2021) and note that the factors creating uncertainty around 2021 installations will also impact 2022 installations. Most projects being installed today utilize projects with modules purchased some months earlier, so full effect of higher costs in 2021 is still to be witnessed in 2022. On the other hand, our checks generally show that affected projects are being delayed rather than cancelled, so projects falling out of 2021 are likely to be delivered in 2022.

Global solar module installations, 2010-2022E (GW)

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021E	2022E
OECD solar installations (annual)													
North America	1	2	4	6	7	8	14	11	10	11	19	30	25
Germany	7	7	8	3	2	1	2	2	4	4	5	5	6
Spain	0	0	0	0	0	0	0	0	0	5	3	4	5
Rest of Europe	3	4	5	5	5	6	4	3	4	6	8	15	19
Australia	0	1	1	1	1	1	1	2	4	4	4	5	6
South Korea	0	0	0	1	1	1	1	1	2	3	4	4	5
Japan	1	1	2	7	10	11	8	8	7	7	9	7	9
Total OECD	**17**	**23**	**24**	**24**	**25**	**29**	**29**	**26**	**31**	**40**	**51**	**70**	**75**
Change in OECD annual installations	*10*	*7*	*0*	*0*	*2*	*4*	*0*	*-3*	*5*	*9*	*11*	*19*	*5*
Non-OECD solar installations (annual)													
China	0	3	3	14	13	19	30	53	44	33	52	55	75
India	0	0	1	1	1	2	5	10	11	12	4	12	19
Rest of non-OECD	1	3	3	4	6	6	11	9	22	34	37	36	46
Total Non-OECD	**2**	**5**	**8**	**18**	**21**	**27**	**46**	**72**	**77**	**78**	**93**	**103**	**140**
Change in non-OECD annual installations	*1*	*3*	*2*	*11*	*2*	*6*	*19*	*26*	*5*	*1*	*15*	*10*	*37*
Total solar installations (annual)	**19**	**29**	**31**	**42**	**46**	**56**	**75**	**98**	**108**	**118**	**144**	**173**	**215**
Change in world annual installations	*11*	*10*	*2*	*11*	*4*	*10*	*19*	*23*	*10*	*10*	*26*	*29*	*42*

Solar supply chain

Most parts of the solar module manufacturing chain were oversupplied in 2021 and will likely remain so in 2022 as new capacity is added across the breadth of the chain, including poly silicon, wafers, cells, and modules.

- **Poly-silicon** is a key raw material for a solar wafer. This was the tightest part of the solar market in 2021, evidenced by poly-silicon prices nearly trebling over the year to end the year at around US$30/kg. Prices rose because i) manufacturing poly-silicon is energy intensive and rises in power prices in China (which produces 70% of the world's poly silicon) caused sharp increases in the raw silicon metal prices) and ii) increased demand from new wafer manufacturing capacity. The price strength allowed poly-silicon manufacturers to realize super normal profits and is incentivizing a supply response. Capacity averaged around 460 MT in 2021 but around 190 MT of new Chinese supply (representing 40% of 2021 capacity) has either recently started or is about to start production. In December, new entrant Xinyi Solar announced a 60 MT capacity new plant in Yunnan which has the potential to be expanded to 200 MT. The scale of capacity growth leads us to believe that poly prices will fall in 2022 and further in 2023.

- **Wafer and solar cell** manufacturing capacity increased by over 60% in 2021 while mono wafer prices have increased by around 75%. The increase in capacity leaves this part of the value chain as oversupplied in 2022 as it was in 2021 although 78% of 2022 wafer capacity is in the hands of the five largest producers. The sharp price increase appears to be mostly a cost pass-through with manufacturing margins remaining very slim.

- **Solar module** prices have increased around 25% during 2021 (to around US$0.28/Watt according to BNEF) – back to where they were in mid-2018. With elevated polysilicon and power prices, module manufacturers are reporting slim margins. Margin pressure has led to some manufacturing delays (Canadian Solar reduced its supply guidance from 16-17 GW to 14-15 GW while JA Solar guided to the bottom end of its range) but the full effect of raw material, power and logistics inflation is still

likely to be witnessed. Module manufacturing continues to be significantly oversupplied with around 470 GW of available capacity in 2022, of which around 310 GW is newer "Tier 1" capacity with lower costs resulting from the scale of manufacturing and new technologies.

Poly-silicon and solar module pricing

source: Bloomberg

Solar installations by region

Installations by country and region are affected by a wide range of factors:

- **China**, which represents around one third of global solar installation demand, is likely to see lower installations in 2021 than initially expected. Uncertainty on final numbers is high still as a large proportion (around 40%) of Chinese solar demand typically occurs at the very end of the calendar year (due to subsidy changes and the achievement of political targets). Cost inflation could therefore cause actual 2021 installations to be biased lower. Any shortfall is expected to be only a short-term delay and to be delivered in 2022, leading to an upside bias here. Looking further ahead, China is focusing on utility scale projects (typically around 100 GW in size) in desert regions, supporting the country's recent increase of its non-fossil fuel generation target to 25%. Recent comments from President Xi at COP15 indicate that annual Chinese solar installations could rise to 130-150 GW (versus around 50 GW in 2020).

- **India** is still small in terms of global solar installations (4GW in 2020 and potentially 12GW in 2021) but installations could grow by around 50% in 2022. The Indian market has good potential and is being driven by the large conglomerates such as Ambani, Tata Power and Adani Green that publicly stated plans to install 100GW, 30 GW and 45GW respectively by 2030, thus forming a large part of India's overall 450 GW installation plan for 2030.

- The **Middle East** is also showing increasing signs of enjoying its significant solar potential. **Saudi Arabia** has announced a plan for 40 GW of installations by 2030 (up from current installations of less than 1GW) while Kuwait has a stated national goal of 15% renewable energy generation by 2030 and Dubai has a 25%/75% target for 2030 and 2050 respectively.

- As an illustration of improved solar economics over the last couple of years, **Indonesia** has introduced a new 2030 solar installation target of 4.7GW, up from the previous target of 0.9GW that was made as recently as 2019.

- Solar installations in the **United States** continued in 2021 to surprise to the upside. The estimated 30 GW of installation in 2021 has been supported by the investment tax credit (ITC) and support for local manufacturing of clean power equipment. Installations may though be lower in 2022 than 2021 as a result of i) the WRO placed on various solar product imports from China, ii) concerns around the level of residential solar support that comes from either an adjusted BBB infrastructure bill or similar and iii) the impact of new net metering rules (NEM3.0) in California which reduces the attractiveness of solar economics for residential consumers. Offsetting these factors in 2022, we expect higher fossil fuel energy prices (improving the relative attractiveness of solar) and for higher interest in "solar + storage" installations which carry much greater profit potential for US solar installers.

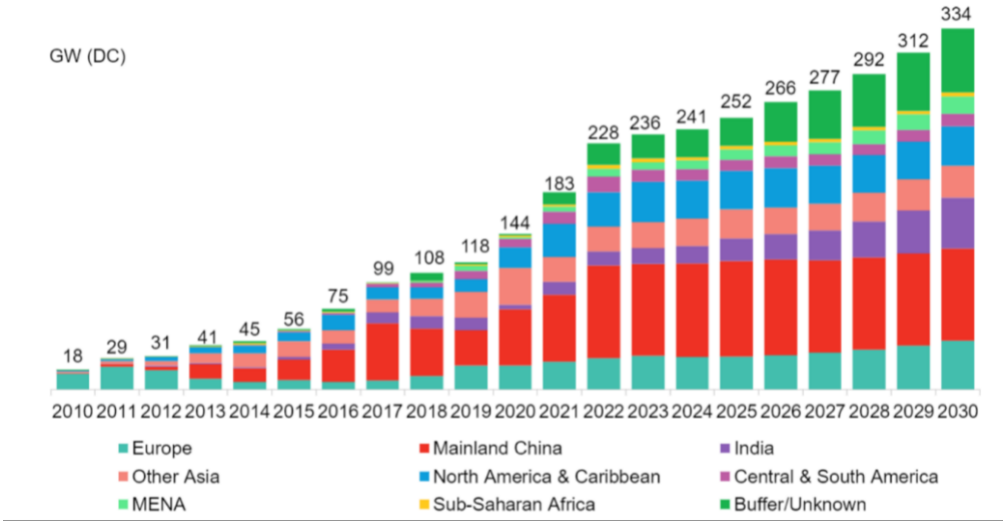
- The new coalition government in **Germany** has a target of installing 200 GW of solar by 2030, biased to residential projects.

Implications of a net zero scenario on our solar outlook

A combination of advantaged economics and policy commitments leads us to believe that global solar installations will continue to increase in the years ahead. Our base case estimate is for 300 GW of average installations in this decade, implying an annual growth rate in installations of around 10%pa and taking total installed capacity to around 3,700 GW in 2030. This estimate is broadly consistent with the estimates of BNEF of annual installations and total installed capacity of 3,400 GW in 2030.

Global solar module installations, mid case, 2010-2030E (GW)

Source: BNEF

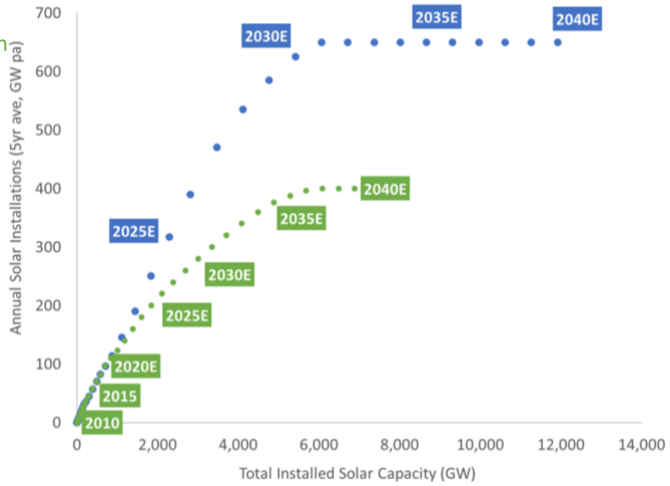


However, our base case is not consistent with a 1.5° warming or net zero scenario. A net zero scenario, based on IPCC analysis and our own estimates, would require installations to reach around 650 GW pa, growing at around 18% pa growth and leading to installed capacity of 5,400 GW in 2030.

Global solar annual installations and installed capacity (5 year average)

source: IEA, IPCC, Guinness Atkinson Asset Management

Guinness Atkinson base case: Between 2020 and 2040, solar installations are 5,900GW (10x more than were installed between 1998 and 2019) with the 5yr average rate reaching a maximum rate of 400GWpa in the late 2030s



Achieving the **IPCC 1.5° scenario** would require installations to reach nearly 700GWpa with a total of 11,900GW being installed between 2020 and 2040

The wind sector

The long-term outlook for the wind industry remains very positive as wind power will play a critical role in global decarbonization and the energy transition. Global wind generation capacity today is around 700 GW with annual installations in 2022 expected to be around 84 GW.

However, the wind industry is suffering short-term pressures as recent sharp peaks in installation demand (a 50% increase to 98 GW in 2020, driven by tax incentives and policy changes) have moderated and have been compounded by COVID-related project delays, raw material cost inflation, logistics issues and permitting constraints.

Wind turbine manufacturing is raw material intensive. According to Vestas in December 2021, steel plate prices were up 2x and resin up 2.5x versus the start of 2020. In terms of logistics, the cost of shipping containers was up 4x and the cost of delivery vessels was up 2x in 3Q 2021 vs 2020. While these cost increases are significant, they were compounded by supply chain issues, such as a 4x increase in the average time that equipment spent waiting in Chinese ports and a 50% reduction in the reliability of scheduling.

Below, we consider the key factors for the onshore and offshore wind markets in 2021 and beyond, concluding 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 Atkinson Asset Management estimates

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021E	2022E
Onshore wind installations (annual)															
North America	9	11	6	8	15	2	7	10	9	8	8	10	17	16	8
Latin America	0	0	0	0	0	0	5	3	3	3	4	4	2	5	5
Europe	6	9	9	10	12	11	11	11	12	13	8	9	12	16	18
China	6	14	17	18	14	15	21	29	22	17	19	26	54	29	31
India	2	1	1	1	2	2	2	3	4	4	2	2	1	3	4
RoW	3	3	3	4	4	3	4	5	5	5	4	4	5	9	5
Total onshore	**27**	**38**	**35**	**40**	**46**	**33**	**49**	**61**	**55**	**49**	**46**	**55**	**91**	**78**	**71**
Change in onshore annual installations		*12*	*-3*	*5*	*6*	*-14*	*17*	*11*	*-6*	*-6*	*-3*	*9*	*36*	*-13*	*-7*
World ex China	*21*	*24*	*18*	*22*	*32*	*18*	*29*	*32*	*33*	*32*	*27*	*29*	*37*	*49*	*40*
Offshore wind installations (annual)															
China	0	0	0	0	0	0	0	1	1	1	2	3	4	5	3
UK	0	0	1	0	1	1	0	1	0	1	2	2	1	1	2
Germany	0	0	0	0	0	0	0	2	0	2	0	2	0	1	2
RoW	0	0	0	0	0	1	0	0	0	1	0	1	2	3	6
Total offshore	**0**	**0**	**1**	**0**	**2**	**2**	**1**	**4**	**1**	**4**	**4**	**8**	**7**	**11**	**13**
Change in onshore annual installations		*0*	*1*	*-1*	*1*	*1*	*-1*	*4*	*-4*	*3*	*0*	*3*	*-1*	*4*	*2*
World ex China	0	0	1	0	1	2	1	3	0	4	3	5	3	5	10
Total wind installations (annual)	**27**	**38**	**36**	**40**	**48**	**35**	**50**	**65**	**56**	**53**	**50**	**63**	**98**	**89**	**84**
Change in world annual installations		*12*	*-2*	*4*	*8*	*-13*	*16*	*15*	*-9*	*-3*	*-2*	*12*	*35*	*-9*	*-5*

Onshore wind

Global onshore wind installations in 2021 were around 78 GW, down 13 GW from the record level seen in 2020 but still up 23 GW on the pre-pandemic installation level of 55 GW in 2019.

Onshore wind installations had been growing very steadily since 2008, averaging an increase of around 3GW pa, with China representing around 70% of the annual growth. The dramatic increase in 2020 installations, up 36 GW or 65% on the 2019 levels, was driven almost entirely by a dramatic increase in Chinese onshore installations (+28 GW in 2020) as developers rushed to complete projects before subsidies expired. China's onshore wind plans likely moderate to the longer-term trend resulting in around 30 GW of installations in 2022.

Outside China, onshore installations reached a new high in 2021, averaging 49 GW, up 12 GW on 2020 levels. Onshore installations outside China are expected to be lower in 2022, averaging around 40 GW, as the surge of policy and tax incentive-led demand falls off and post-COVID supply chain issues and cost inflation start to impact the value chain. A level of 40 GW is still higher than any year prior to 2020.

Over the first half of this decade, onshore wind installations are likely to be slightly higher on average than they were in 2021. Regionally, we expect China, Europe, and the United States together to account for around 80% of the expansion. Challenges with permitting, social acceptance, grid connection and integration combine to limit the growth potential of the onshore industry. While the growth in percentage terms is small, we note that the absolute level of installations (at around 75-80 GW pa) is still around 50% higher than the pre-2020 average. Wind projects typically have a 3–4-year development timeline and, as a result of strong levels of current interest and demand for wind power generation projects, we expect that installations will grow significantly in the second half of this decade.

Combined with underlying new project increases, we note that by 2030 around one third of the world's total installed capacity will be more than 13 years old and will be strong candidates for refurbishing.

Offshore wind

Offshore wind remains a nascent industry, at only 14% of the size of onshore (by annual installations in 2021), but one where the growth trajectory is becoming increasingly visible.

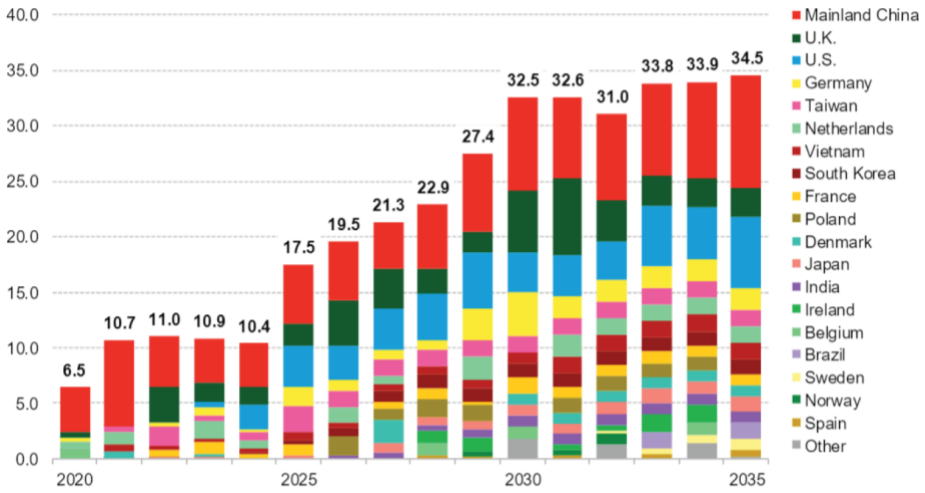
Annual installations of offshore wind capacity have increased from 0.9 GW in 2010 to a new high of 11 GW in 2021. Chinese offshore installations reached 5 GW in 2021 while ex-China installations are likely to grow from 5 GW in 2021 to a new high of 10 GW in 2022.

The economics of offshore wind continue to improve and there was further constructive cost data in 2021 suggesting that the LCOE for the median offshore wind project halved between 2010 and 2020, and now sits at the bottom end of the competing fossil fuel generation cost range. The growing interest underlines the significant potential of the offshore industry which benefits from better operational (higher and more reliable wind speed) and visual characteristics as well as being close to key demand areas which are often coastal.

In the later part of this decade, we expect annual offshore wind installations to represent around 20% of the total wind market with cumulative installations in offshore between 2020 and 2030 likely to be around 140GW. A broader spread of countries including the United States, Chinese Taipei, Korea, Vietnam, and Japan means that cumulative installations will be split around 30 GW in the Americas, 90 GW in Europe, Middle East, and North Africa and around 20 GW in Asia Pacific. The current European market will continue to grow, as excess offshore wind generation will be utilized for the generation of green hydrogen via electrolyzers, and while the Chinese market will also grow it will not be as dominant globally as it is in the onshore market.

The outlook for offshore wind installations

source: BNEF



Implications of a net zero scenario on our wind outlook

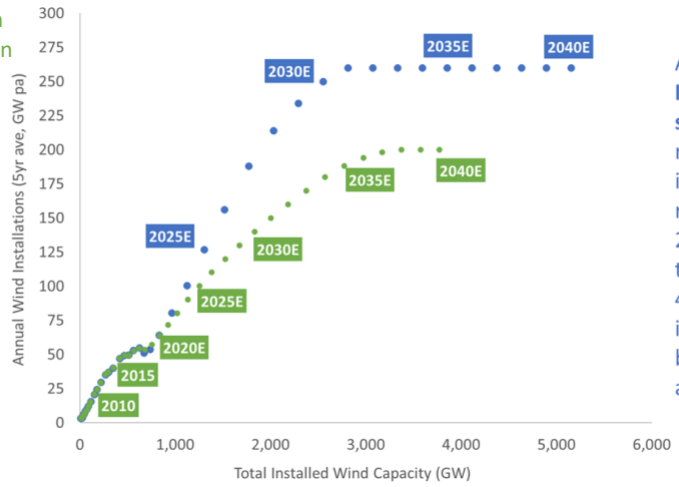
Our base case assumes that, between 2020 and 2040, total wind installations are 2,950 GW (>5x more than were installed between 1998 and 2019) with the 5yr average rate reaching a maximum rate of 200 GWpa in the late 2030s.

However, our base case presented above is not consistent with a 1.5° warming or net zero scenario. A net zero scenario, based on IPCC analysis and our own estimates, would require installations to reach around 260 GWpa with a total of nearly 4,500 GW being installed between 2020 and 2040.

Global wind annual installations and installed capacity (5 year average)

source: IEA, IPCC, Guinness Atkinson Asset Management

Guinness Atkinson base case: Between 2020 and 2040, wind installations are 2,950GW (>5x more than were installed between 1998 and 2019) with the 5yr average rate reaching a maximum rate of 200GWpa in the late 2030s



Achieving the **IPCC 1.5° scenario** would require installations to reach around 260GWpa with a total of nearly 4,500GW being installed between 2020 and 2040

The Guinness Atkinson Alternative Energy fund

We witnessed continued positive momentum for the energy transition in 2021 with various policy commitments, stimuli and investments being made to decarbonize the global energy sector in a sustainable manner. Offsetting this, we saw raw material cost inflation, supply chain logistics issues and some trade-related friction which has slowed the pace of margin expansion and profitability improvement and has negatively impacted near term earnings estimates. Against this backdrop, the fund has seen improved cash return expectations and continues to offer broad exposure to companies that are very well placed to benefit from an energy transition that will accelerate through the remainder of this decade.

2021 saw a slowdown in absolute and relative share price momentum for sustainable energy stocks, with the Guinness Atkinson Alternative Energy Fund delivering a total return (USD) of +8.40% vs the MSCI World Index (net return) of +21.80%.

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.

As detailed earlier, there have been cross currents in 2021 including record installations in wind and solar and strong policy support offset by cost inflation, supply chain issues and slow actual investment.

The outlook for company earnings, profitability and cash returns improved on average in 2021 versus 2020, although momentum slowed in the second half of the year. The sustainable energy universe, on average, saw

forecast cash returns increase by 0.4% vs 2020 with over 60% of the companies seeing an increase in forecasts.

Fund performance

The largest positive contributors to the fund in 2021 were our two Chinese **generation** companies (independent power producers) China Longyuan and China Suntien. At the start of the year, China Longyuan announced a corporate transaction with its parent company CNH Energy and its sister company Pingzhuang Energy that provided China Longyuan with a China A share listing while China Suntien's share price increase reflected strong profit growth resulting from the start-up of new wind projects. Their strong performance was sustained through the third quarter of 2021 as the Chinese economy rebounded strongly and warm weather increased air conditioning demand, driving higher electricity prices and better margins for both.

Within **electrification**, Onsemi enjoyed numerous earnings upgrades through the year, as demand and pricing for its semiconductor products both rose. The company announced plans to prune both its revenue base and manufacturing footprint to invest in high-value, high-growth applications served by its power and sensing-biased semiconductor portfolio. Growth will be sacrificed in the 2022/2023 period while it focuses on higher margin businesses. Also within electrification, Gentherm delivered strong results and good new contract awards, including a first production vehicle award for its new "ClimateSense" product which combines several individual product lines (such as thermal products, electronics and software) into a system solution.

With **displacement**, Nibe Industrier was the greatest contributor, with the shares reacting to strong demand for heat pumps, solid underlying business performance and a share split that increased accessibility of its shares. Of note was the company's North American Climate Solutions business returning to growth and signs that Nibe's decentralized business model was providing good insulation against raw material cost inflation. Ameresco and Hubbell also delivered strong contribution over the year.

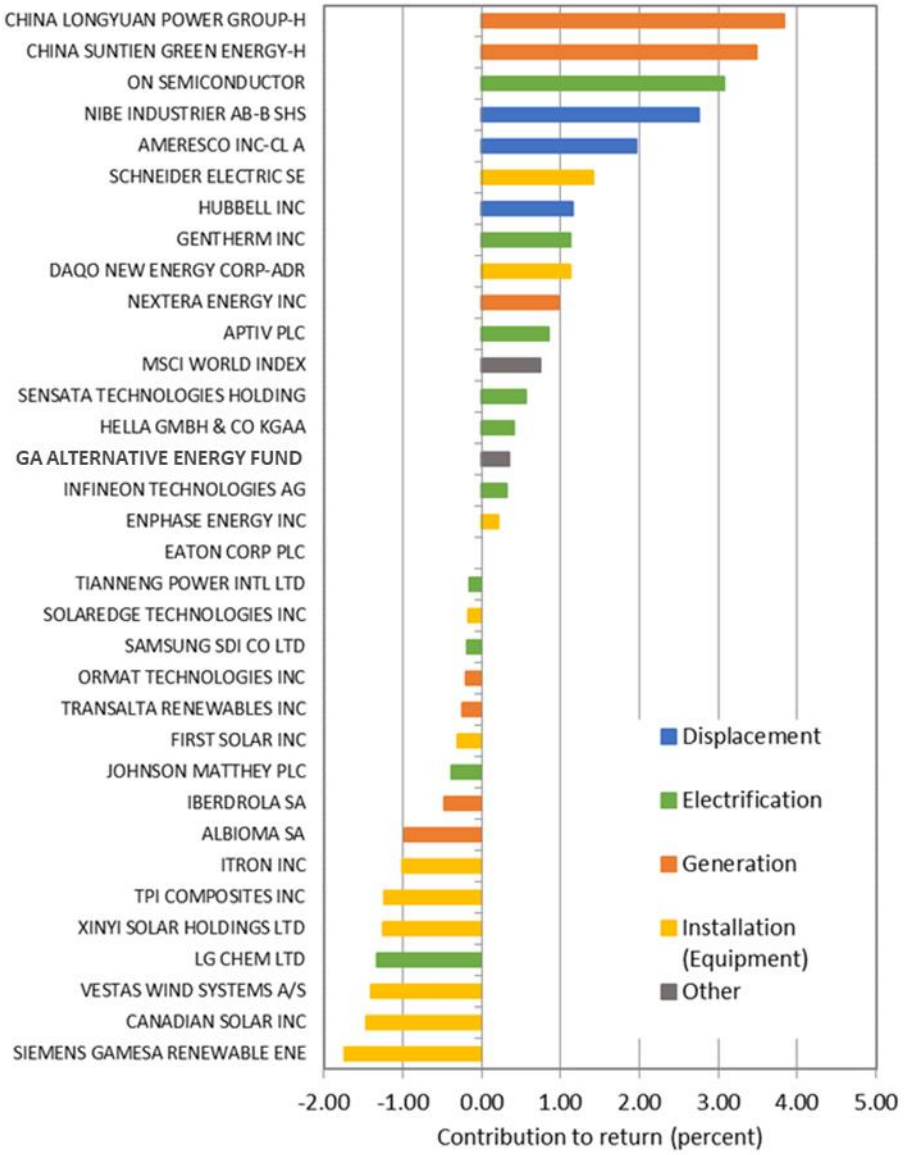
The **equipment (installation)** sector was the weakest contributor with only three companies delivering a positive contribution over the year. Of note was Schneider Electric, whose shares reacted positively to consistent improvements in business performance, and polysilicon manufacturer Daqo New Energy which delivered a significant contribution to the fund during the first quarter of the year (prior to its sale from the portfolio) as a result of strong polysilicon demand and rising polysilicon prices.

While the strongest performers came from all four sub sectors, the weaker performers came predominantly from the equipment (installation) sector. Siemens Gamesa, TPI Composites and Vestas Wind Systems suffered from slowing momentum within the near-term wind macro environment (compounded by supply chain pressures and raw material inflationary concerns) that trumped longer-term positive wind industry developments.

Other weak contributors included LG Chem whose shares were weak following a $1.9bn product recall with GM regards battery faults on the Chevrolet Bolt, and two generation companies, Albioma and Iberdrola, which de-rated as a result of general market concerns around rising interest rates and the risk of greater regulation to compensate for higher fossil fuel prices.

2021 individual stock contribution, in USD

source: Bloomberg, Guinness Atkinson Asset Management estimates



In terms of attribution relative to the Guinness Atkinson Alternative Energy universe, the fund delivered positive sector allocation and stock selection within **efficiency** (due to a small sector overweight and advantaged stock selection as described above); **electric vehicles** (due to a bias towards power semiconductors and electronics and avoidance of recently listed US SPACs); within **independent power producers** (due to exposure to Chinese wind-dominated IPPs and the avoidance of US residential solar and pure-play high-growth solar IPPs that were weaker as a result of rising interest rate concerns); and within **other equipment** (due to avoidance of weak hydrogen fuel cell and electrolyzer companies as well as newly listed energy storage stocks).

The fund delivered negative sector allocation and stock selection within **batteries** (due to lack of exposure to battery raw material companies as well as pure-play cathode and anode manufacturers); and within **solar**

and wind equipment (where we held overweight positions to sectors and manufacturing companies that suffered from raw material cost inflation and supply chain issues).

Attribution of Guinness Atkinson Alternative Energy Fund versus the universe (2021)

source: Guinness Atkinson Asset Management estimates, Bloomberg

Subsector	Weight			Indicative attribution	
	Fund	Universe	Relative	Sector allocation	Stock selection
Alternative Fuel	0.0%	3.1%	Underweight	Negative	Neutral
Efficiency	12.4%	10.7%	Overweight	Positive	Positive
Battery	9.4%	13.8%	Underweight	Negative	Negative
Electric Vehicles	24.1%	21.1%	Overweight	Positive	Positive
Generation - IPP/Utility	24.4%	26.7%	Underweight	Positive	Positive
Other equipment	10.0%	13.2%	Underweight	Positive	Positive
Solar equipment	12.8%	8.2%	Overweight	Negative	Negative
Wind equipment	6.9%	3.1%	Overweight	Negative	Negative

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

Attribution of Guinness Atkinson Alternative Energy Fund versus the universe (2019-2021)

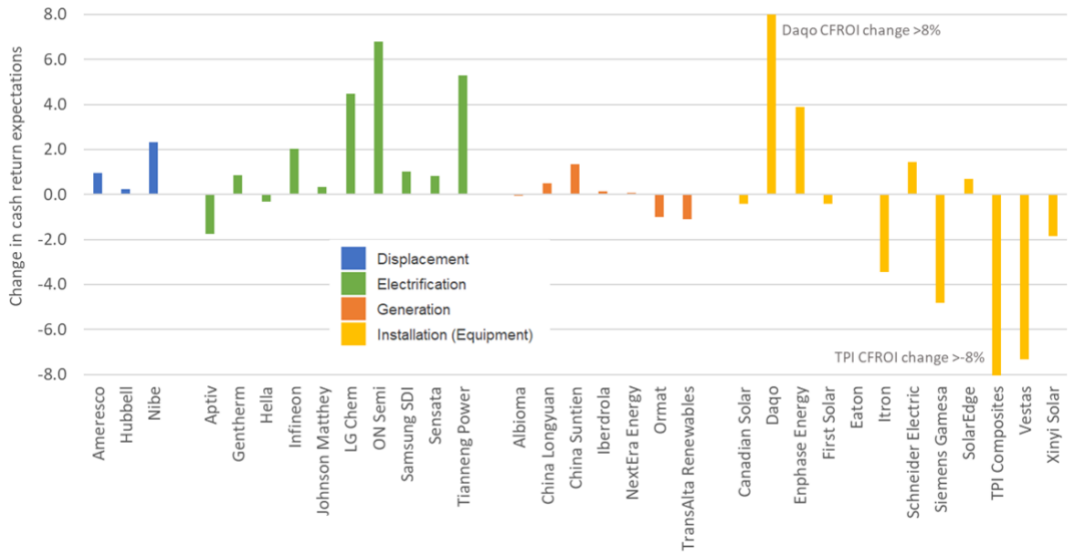
source: Guinness Atkinson Asset Management estimates, Bloomberg

Subsector	Average weight		Fund position vs universe	Indicative attribution	
	Universe	Fund		Sector allocation	Stock selection
Alternative Fuel	4%	0%	Underweight	Positive	Negative
Efficiency	11%	12%	Overweight	Positive	Positive
Battery	14%	11%	Underweight	Negative	Negative
Electric Vehicles	17%	19%	Overweight	Positive	Negative
Utility	9%	7%	Underweight	Positive	Positive
IPP	19%	18%	Underweight	Positive	Positive
Equipment	26%	33%	Overweight	Positive	Positive

Returning to the portfolio in 2021, we can see from our analysis that underlying earnings and profitability metrics for the fund's holdings improved over the year. Across the fund, the displacement and electrification sectors saw consistently positive CFROI improvements while generation was broadly unchanged, and electrification was mixed (although dominated by weakness in the wind equipment manufacturers). On average, the forecast cash return increased by 0.3% with over 60% of portfolio companies seeing an increase in forecast cash returns over the year.

Percentage point change in cash return expectations over 2021

source: Bloomberg, CS HOLT, Guinness Atkinson Asset Management estimates



Over the period, the weighting to consumption (i.e. the demand side of the energy transition) increased to 45.3% at the end of December 2021 while the weighting to renewables (i.e. supply side) fell to 51.8%. Within these subsectors, our exposure to electric vehicles increased to 24.6% while our weighting to installation (equipment) fell to 27.5%.

Valuation

As of December 31st, 2021, the Guinness Atkinson Alternative Energy fund traded on a 2022 P/E ratio of 24.5x and 2022 EV/EBITDA multiple of 13.2x. The P/E premium of the fund relative to the MSCI World Index for 2021 increased over the year from around 15% to a peak in November of 34%, before ending the year at around 27%

The valuation premium reflects a greater expectation for growth from sustainable energy companies relative to the MSCI World. As detailed in this document, the sector provides very attractive growth opportunities and as a sense check, we see that consensus EPS growth (2021-2023E) of the portfolio (at 21.3%pa) is well ahead of the MSCI World (at 13.5%pa). Looking over the next five years, we believe that the portfolio is likely to deliver normalized earnings growth of around 13%pa, ahead of growth in the MSCI World Index, that will bring the fund P/E ratio down from the current 24.5x for 2022E to around 15.5x in 2025E.We also note that the cashflow return on investment (CFROI) of the portfolio rises from 6.8% in 2021 to 8.2%, versus the MSCI World which stays flat at 9.6%.

Guinness Atkinson Alternative Energy fund key financial and valuation metrics

source: Bloomberg, CS HOLT, Guinness Atkinson Asset Management estimates

As at 31 December 2021	P/E			EV/EBITDA			EPS Growth (%pa)		CFROI*	
	2021	2022E	2023E	2021	2022E	2023E	2014-21	2021-23	2021E	2022E
GA Alternative Energy Fund	28.1x	24.5x	20.5x	15.0x	13.2x	11.3x	6.0%	21.3%	6.8%	8.2%
MSCI World Index	23.2x	19.3x	17.8x	14.8x	12.7x	12.0x	5.5%	13.5%	9.6%	9.6%
Fund Premium/(Discount)	*21%*	*27%*	*15%*	*1%*	*4%*	*-6%*				

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

Key themes in the portfolio

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

Key themes in the Guinness Atkinson Alternative Energy Fund

source: Guinness Atkinson Asset Management estimates

	Theme	Example holdings	Weighting (%)
1	Electrification of the energy mix	TransAlta renewables, NextEra Energy	19.3%
2	Rise of the electric vehicle and auto efficiency	Sensata Technologies, Aptiv	25.2%
3	Battery manufacturing	Samsung SDI	6.4%
4	Expansion of the wind industry	Siemens Gamesa Renewable Energy, Vestas	12.9%
5	Expansion of the solar industry	CanadianSolar	12.1%
6	Heating, lighting and power efficiency	NIBE Industrier	11.8%
7	Geothermal and biomass	Ormat, Albioma	4.4%
8	Other (inc cash)		7.9%

In aggregate, we expect investor interest in sustainable energy equities will grow further in 2022 as a result of increased individual, social and government pressures for consumers to become more energy efficient and for producers to increase their share of sustainable energy generation. We believe that the Guinness Atkinson Alternative Energy portfolio of 30 equally weighted equities, chosen from our universe of around 250 companies, provides concentrated exposure to the theme at attractive valuation levels.

Jonathan Waghorn and Will Riley

January 2022

Performance

as of 12.31.2021 (in USD)	YTD	1 year	3 years	5 years	10 years
Guinness Atkinson Alternative Energy Fund (GAAEX)	8.40%	8.40%	38.06%	21.83%	8.75%
MSCI World NR USD	21.82%	21.82%	21.68%	15.02%	12.69%

All returns after 1 year annualized.

Inception 03.31.2006 Expense ratio* 1.98% (net); 2.46% (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, 2025. 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.

Total returns reflect a fee waiver in effect and in the absence of this waiver, the total returns would be lower.

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 12/31/2021:

1. Nextera Energy Inc	4.79%
2. ON Semiconductor Corp	4.59%
3. Schneider Electric SE	4.38%
4. Nibe Industrier AB - B Shares	4.38%
5. Sensata Technologies Holding	4.37%
6. Gentherm Inc	4.37%
7. Infineon Technologies AG	4.36%
8. Aptiv PLC	4.34%
9. Ameresco Inc	4.17%
10. China Longyuan Power Group Corp Ltd - H Shares	4.09%

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.

Enterprise value (EV)/EBITDA, also known as Enterprise Multiple, is a ratio used to determine the value of a company. It looks at a company the way a potential acquirer would by considering the company's debt.

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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