THE GUINNESS SUSTAINABLE ENERGY REPORT

Developments and trends for investors in the sustainable energy sector | March 2021

THE GUINNESS SUSTAINABLE ENERGY FUND

The Guinness Sustainable Energy Fund is managed for capital growth and invests in companies involved in the generation, storage, efficiency and consumption of sustainable energy sources (such as solar, wind, hydro, geothermal, biofuels and biomass). We believe that over the next twenty years the sustainable energy sector will benefit from the combined effects of strong demand growth, improving economics and both public and private support and that this will provide attractive equity investment opportunities

The Fund is run by co-managers Will Riley and Jonathan Waghorn, supported by Jamie Rosser (analyst). The investment philosophy, methodology and style which characterise the Guinness approach have been applied to the management of various energy equity portfolios at Guinness since 1998.

Please see Section 3 of this report for detailed performance data on the Guinness Sustainable Energy Fund.

HIGHLIGHTS FOR FEBRUARY

OUTLOOK FOR LOWER LITHIUM ION BATTERY COSTS

In this manager's comments we assess the long-term potential for cost reduction in lithium ion battery production. We can see current planned technologies and manufacturing improvements helping to bring costs down to less than $100/kWh in the mid-2020s, and lower thereafter, with solid state batteries driving costs lower again around the end of the decade

EQUITIES

Sustainable energy equities underperforming

Sustainable energy equities underperformed global stock markets during February. Over the month, the Guinness Sustainable Energy fund (Class Y) delivered a return of -1.1% (in USD) which was behind the MSCI World at +2.6%. Year to date, the Guinness Sustainable Energy fund (Class Y) delivered a return of +3.3% (in USD) which was ahead of the MSCI World at +1.5%.

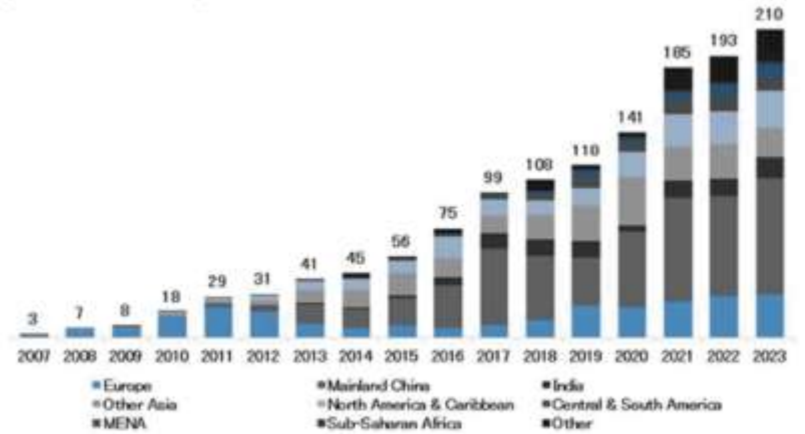
Within the portfolio, our electric vehicle subsector was the strongest performer (+9.3%) as Aptiv, ON Semi and Gentherm delivered good results/guidance while our solar and wind equipment manufacturers suffered (-2.2%) due to profit taking/de-risking, rising interest rate expectations and the rebalancing of one of the key ETFs in the sector, the iShares Clean Energy index which tracks the S&P Clean Energy Index.

SOLAR INSTALLATION GROWING FASTER THAN EXPECTED

According to Bloomberg New Energy Finance, global solar installations totalled 141GW in 2020 (up 23% vs 2019) with the outlook for new installations in 2021 likely to be in a range of 160-209GW, up about 30% growth at the mid-point, with a further increase to around 210GW in 2023. With solar installations being increasing subsidy-free on a global basis, the actual growth in 2021 will be dependent upon the economics of individual projects and the underlying costs of the solar modules.

Bloomberg New Energy Finance solar demand forecast

source: BNEF, JP Morgan



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1. FEBRUARY NEWS AND EVENTS IN REVIEW

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

News	Sub Sector	Impact
A number of car manufacturers made commitments during the month towards electrification. Ford said its passenger vehicle line-up in Europe will be all-electric by 2030 while every Jaguar and Land Rover will be offered with an electric-only version by 2030. While product ranges are shifting, Mercedes-Benz CEO, Ola Källenius, announced that it would take until 2030 before the profits of its passenger car business were split equally been EVs and internal combustion engine vehicles.	Electric vehicles	→
A new study from the World Bank has found that just 1% of the world's offshore wind resource could provide 10% of global electricity demand and that by 2030, it is expected that over 230 GW of offshore wind will be operating globally; a seven-fold increase from the 32 GW today. The report identified 115 countries with technically extractable offshore wind resources totalling 71 TW of which 29% is suitable for fixed offshore platforms and 71% is suitable for floating wind platforms.	Offshore wind power	↗
According to the IEA, Global energy-related carbon emissions were 2% higher in December 2020 than in December 2019 predominantly as a result of increased fossil fuel-powered energy generation in emerging economies, especially China and India. COVID-related lockdowns in 2020 meant that total global energy-related CO2 emissions in 2020 were about 6 per cent lower than in 2019.	Carbon emissions	↘
The Biden administration has restored the Obama-era calculation of the social cost of carbon to $51/ton CO2 emitted and introduced a 3% discount rate for use in the impact calculations. As we mentioned in last month's Manager's Comments, the cost is a key factor in driving cost/benefit analyses of new taxes and regulations on, and restrictions of, carbon emissions as we lead into COP 26 in November. The Interagency Working Group that made the recommendation has been tasked with further refining and delivering a final calculation by January 2022 and issuing recommendations on incorporating the cost in government decision making and budgeting by September.	US Climate Policy	→
Texas, the largest US energy consuming state, suffered extreme cold weather during the month which significantly pressured the electricity grid. 185 coal and gas fired generation units went offline and wind turbines froze. The event focuses attention on the upgrade that is required for the US electricity system. Separately, it was announced that Tesla is building a 100MW utility-scale grid battery in Angleton, just outside Texas	US infrastructure	↗

2. MANAGER'S COMMENTS

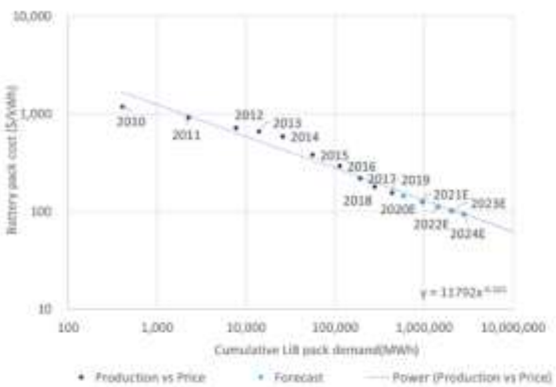
An outlook for lower EV lithium ion battery costs

In this manager's comments we assess the long term potential for cost reduction in lithium ion battery production. We can see current planned technologies and manufacturing improvements helping to bring costs down to less than $100/kWh in the mid-2020s, and lower thereafter, with solid state batteries driving costs lower again around the end of the decade.

So far this year, we have heard various commitments from existing auto manufacturers to cease the production of internal combustion engine vehicles and to convert their entire auto ranges to battery electric vehicles. As examples, Ford has said its passenger vehicle line-up in Europe will be all-electric by 2030 while every Jaguar and Land Rover will be offered with an electric-only version by 2030. The declining cost of lithium ion batteries is the key factor supporting the long-term transition while fines, such as the Eur100mn Euro fine suffered by Volkswagen for exceeding its EU carbon dioxide emission targets, provide urgency for the auto OEMs.

According to BNEF, lithium ion EV battery costs are down 89% over 2010-2020 (an implied 'learning rate' of around 18%) with the average cost being $137/kWh in 2020. Significant economies of scale from mass battery manufacturing have lowered costs and, as these continue, the cost of producing a lithium ion battery is likely to fall towards $100/kWh in the mid-2020s. This would allow **electric vehicles** to compete on price with internal combustion engine vehicles without subsidies. We expect an acceleration in the uptake of new EVs, with around 20% of new passenger vehicles sales being electric in 2025, rising to around 50% in 2030. On this basis, there will be nearly 300 million electric vehicles on the world's roads by 2030. This level of electric transportation would displace around 3m barrels of day of world oil demand in that year.

Lithium ion battery costs and cumulative capacity



Electric vehicle Update

Source: BNEF, Guinness AM, OPEC, Woodmac

Understanding the potential for further battery cost reductions

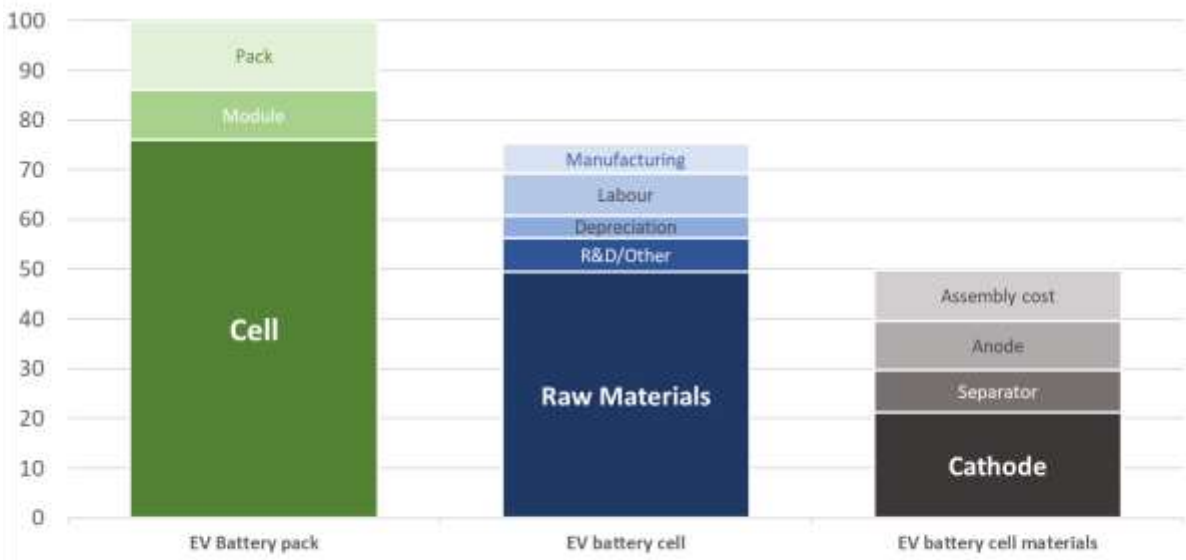
In order to understand if lithium ion battery costs can fall to $100/kWh in the mid-2020s, and lower thereafter, we need to understand current battery costs and the potential for cost reductions, energy density improvements and efficiency gains.

Firstly, on a percentage basis, the cost structure of a lithium ion EV battery pack is split broadly as follows:

- Of a finalised **EV battery pack,** around 76% of the cost relates to the cost of the actual battery cell while the remaining 24% relates to the cost of forming the battery cells into a module (10% of the cost) and then forming the modules into a pack (14% of the cost)
- The cost of the **battery cell** itself is predominantly (65%) made up of the cost of the raw materials with the other costs split broadly equally between R&D/Other (9%), depreciation (6%), labour (11%) and manufacturing costs (8%)
- In turn, the **raw material** costs are dominated by the cost of the cathode (43% of total raw material costs) with the anode being a further 20%, the separator being a further 17% and the assembly costs being the remaining 21%

Cost structure of a typical lithium ion EV battery pack (% cost basis)

source: BAML, Guinness Asset Management estimates



Thinking about it on a percentage of total EV battery pack cost basis, the most significant individual item is the cathode (21% of total cost), followed by the cost of battery cell to module to pack manufacturing (10% and 14% respectively), followed by the raw material assembly cost and the anode cost (at around 10% each).

Potential areas for lithium ion battery cost reductions

We consider here the potential for cost and efficiency improvements across some of the key cost categories:

- The **cathode**, representing around 21% of total EV battery pack cost, is the source of lithium ions and its construction defines the capacity and the average voltage of the lithium ion battery. Current metal oxide cathodes are steadily approaching theoretical energy density limits and hence there is a long term need to switch to a new technology in order to achieve greater battery energy densities.

  Accelerating the need for change is the fact that current cathodes typically have cobalt in their construction. Cobalt helps to lower battery operating temperature and maintain battery stability, but battery manufacturers are wary of supply concentration risks (70% of world cobalt supply in

2019 came from the Democratic Republic of Congo) as well as ethical concerns around how the metal is mined in the DRC.

Over the next ten years, we expect to see continued growth of nickel within the cathode with high nickel density cathodes (for example an 8-1-1 nickel-manganese-cobalt mix) representing around 35% of the EV battery market by 2030 (from 4% currently). More complex and potential bulkier EV battery thermal management systems will be required to keep EV batteries stable but this is considered to be more economic and socially acceptable than relying on cobalt sourced primarily from the DRC.

Longer term, in addition to increasing nickel content, there is the potential for single crystalline cathode materials that will drive much high energy densities than the current polycrystalline cathode materials.

- The role of the **anode**, which represents around 10% of the cost of an EV battery pack, is to store and release lithium ions, allowing the current to pass from the battery. Graphite, in both natural and synthetic form, is the most commonly used material for EV battery anodes (representing around 90% of current anode supply) with China providing around 70% of all natural graphite for anodes.

  The future here is in silicon-doped anodes. Silicon has a number of advantages over graphite, including i) lower raw material cost ii) lower manufacturing cost and iii) greater capacity to store lithium ions and therefore enhance battery efficiency. Theoretically, a silicon-based anode could offer over 10 times more capacity than a graphite-based anode. Current silicon anode materials have degradation issues but it is believed that enhanced silicon treatment methods will be able to offset these issues.

  Improvements in anode technology are likely to be incremental in the near term, with silicon anodes likely to have a commercial impact towards the end of the decade.

- **Enhanced manufacturing scale and techniques** will help to reduce the 24% of total EV battery pack cost that is associated with turning individual cells into modules and ultimately into battery packs. Two factors could be important here:

  1. Dramatic increases in the size of manufacturing facilities allowing economies of scale to be realised. In this respect, the lithium ion battery manufacturing industry could see unit cost reductions in line with those seen in solar module and semiconductor manufacturing.
  2. Removal of the module manufacturing stage. Chinese battery manufacturer CATL is promoting a new direct ‘cell-to-pack’ manufacturing approach while Chinese EV manufacturer BYD is promoting its ‘blade battery’ as a successful approach to bypassing the modularisation stage. Further, Tesla has discussed the potential of removing the module and the pack stage in the manufacturing process and going directly to a ‘cell-to-chassis’ manufacturing process.

Early stage analysis indicates that around 10% of total manufacturing cost could be removed via a direct battery cell to battery pack manufacturing process in the near term while the benefits of scale will be incremental and continuous through the rest of the decade.

Solid state lithium ion batteries

In many aspects, the cathode, anode and manufacturing improvements discussed above are incremental in nature and hence we have good confidence that EV battery pack costs will reach the $100/kWh level in the mid-2020s. Beyond that, together with silicon anodes and single crystalline cathode materials, we expect the next significant source of cost improvements to come from the introduction of solid state lithium ion batteries (SSBs).

Solid state batteries replace the liquid or polymer electrolyte found between the cathode and anode in lithium-ion batteries with solid components. Key benefits for solid state batteries include:

- **Greater safety** as the liquid/gel electrolyte, which can be volatile and degrade causing thermal runaway and potentially explode, is replaced with a solid electrolyte
- **Extended battery life, faster charging** and an **energy density** that is around double a typical lithium ion battery
- **More compact size** since they do not require a bulky cooling system currently required to keep lithium ion batteries cool in order to avoid thermal runaway
- Potentially **less expensive** and applicable in a wider range of **temperatures**

They are considered to be the 'holy grail' of battery technology and most battery manufacturers have either tried or are trying to perfect the manufacturing process with varying levels of success. The key issue is creating a solid electrolyte that will not degrade yet will also allow the efficient transfer of lithium ions. Just in recent days we have seen cross-currents in SSB development which give hope and yet caution over the commerciality:

- **Fisker**, a US EV company that announced a breakthrough in solid state batteries in 2017, has admitted defeat and stopped its development programme
- **QuantumScape**, a pureplay US listed SSB company backed by Volkswagen and Bill Gates, developed a 4-layer multilayer solid state battery cell that can complete close to 800 cycles at near-room temperature with over 90% capacity retention. It hopes to move to commercial production in 2024.

We are optimistic on the potential for solid state batteries to further reduce the cost of lithium ion batteries towards the $50-70/kWh level but we are cautious about the timing of commercial development. In all likelihood, this significant stage of cost reduction is a further five to ten years away and will ultimately be key to the increased adoption of electric vehicles.

3. PERFORMANCE - Guinness Sustainable Energy Fund

The Guinness Sustainable Energy fund (Class Y) delivered a return of -1.1% in the month, while the MSCI World Index (net return) delivered 2.6% (all in USD terms).

Performance overview (28 February 2021)

	1 month	3 months	6 months	1 year	YTD	Dec 31 2018 *
Guinness Sustainable Energy Fund (Class Y)	-1.1%	18.2%	43.2%	98.7%	3.3%	150.0%
MSCI World NR Index	2.6%	5.8%	11.7%	29.3%	1.5%	50.3%
Outperformance/Underperformance	*-3.6%*	*12.3%*	*31.4%*	*69.4%*	*1.8%*	*99.7%*

** The strategy was relaunched as of end December 2018*

Performance overview (28 February 2021)

1 year rolling performance to	Feb-21	Feb-20	Feb-19	Feb-18	Feb-17
Guinness Sustainable Energy Fund (Class Y)	98.7%	7.1%	0.2%	11.0%	6.1%
MSCI World NR Index	29.3%	4.6%	0.4%	17.4%	21.3%
Outperformance/Underperformance	*69.4%*	*2.5%*	*-0.2%*	*-6.3%*	*-15.2%*

Monthly performance record (28 February 2021)

Total return (all in USD)	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	YTD
Guinness Sustainable Energy Fund (Y class, 0.74% OCF)	12.2%	3.7%	-2.6%	7.2%	-8.6%	7.5%	-1.5%	-3.0%	1.8%	2.1%	2.3%	8.5%	31.4%
MSCI World NR Index	7.8%	3.0%	1.3%	3.5%	-5.8%	6.6%	0.5%	-2.0%	2.1%	2.5%	2.8%	3.0%	27.7%
Relative	*4.5%*	*0.7%*	*-4.0%*	*3.7%*	*-2.9%*	*0.9%*	*-2.0%*	*-1.0%*	*-0.3%*	*-0.5%*	*-0.5%*	*5.5%*	*3.8%*

Total return (all in USD)	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	YTD
Guinness Sustainable Energy Fund (Class Y)	-2.3%	-2.0%	-18.0%	12.1%	9.0%	9.5%	13.9%	11.0%	-0.3%	5.1%	15.6%	14.4%	84.1%
MSCI World NR Index	-0.6%	-8.5%	-13.2%	10.9%	4.8%	2.6%	4.8%	6.7%	-3.4%	-3.1%	12.8%	4.2%	15.9%
Relative	*-1.7%*	*6.5%*	*-4.8%*	*1.2%*	*4.2%*	*6.9%*	*9.1%*	*4.3%*	*3.2%*	*8.1%*	*2.8%*	*10.1%*	*68.2%*

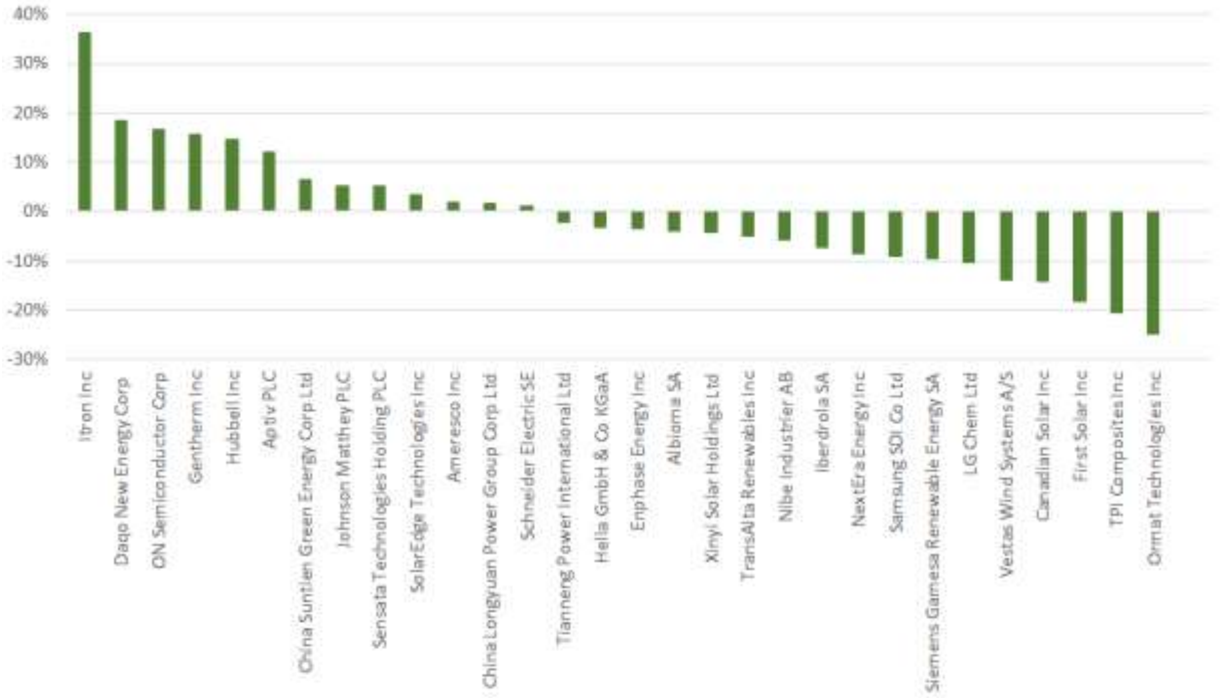
Total return (all in USD)	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	YTD
Guinness Sustainable Energy Fund (Class Y)	4.5%	-1.1%											3.3%
MSCI World NR Index	-1.0%	2.6%											1.5%
Relative	*5.5%*	*-3.6%*											*1.8%*

Past performance should not be taken as an indicator of future performance. The value of this investment and any income arising from it can fall as well as rise as a result of market and currency fluctuations as well as other factors. You may lose money in this investment. Returns stated above are in US dollars; returns in other currencies may be higher or lower as a result of currency fluctuations. Investors may be subject to tax on distributions. The Fund's Prospectus gives a full explanation of the characteristics of the Fund and is available at www.guinnessfunds.com.

Source: Financial Express, bid to bid, total return. Fund returns are for share classes with a current Ongoing Charges Figure (OCF) stated above; returns for share classes with a different OCF will vary accordingly. The Guinness Sustainable Energy Fund was launched on 19/12/2007 (A class, 1.49% OCF). The E Class was launched on 02/09/2008 (1.24% OCF). The Y class was launched on 16/02/2018 (0.74% OCF).

Within the Fund, the strongest performers were Itron Inc, Daqo New Energy Corp , ON Semiconductor Corp, Gentherm Inc and Hubbell Inc while the weakest performers were Ormat Technologies Inc, TPI Composites Inc, First Solar Inc, Canadian Solar Inc and Vestas Wind Systems A/S.

Stock by Stock performance over the month, in USD

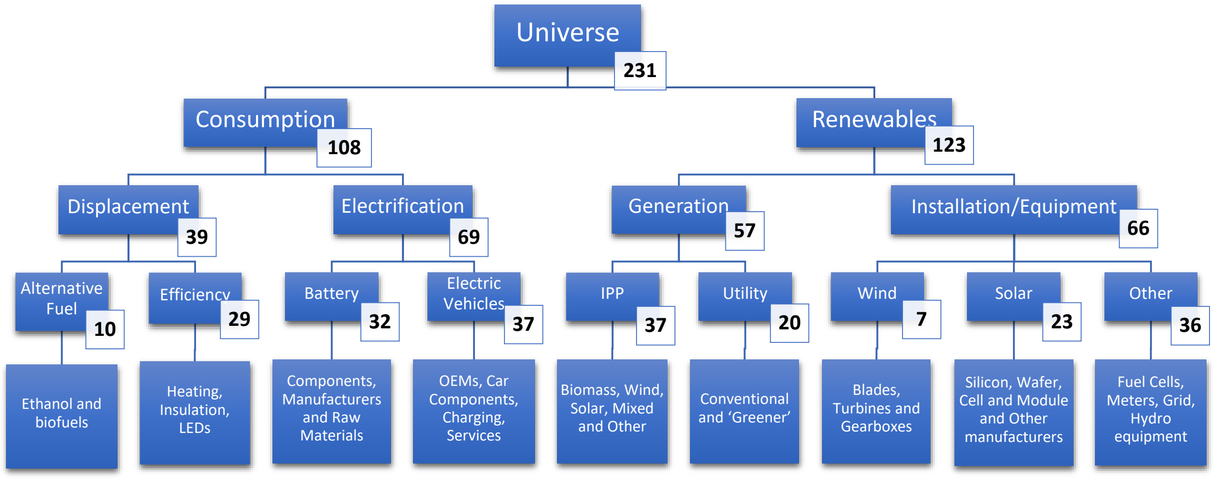


Source: Bloomberg. As of 28th February 2021

4. PORTFOLIO - Guinness Sustainable Energy Fund

The Guinness Sustainable Energy fund is positioned to benefit from many of the long-term themes associated with the transition towards a lower carbon economy and of sustainable energy generation via investment in companies with activities that are economic with limited or zero government subsidy and which are profitable. Our investment universe comprises around 230 companies which are classified into four key areas:

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



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

Guinness Asset Management is a signatory of the United Nations Principles for Responsible Investment while the Sustainable Energy Fund is aligned with the World Bank's nine principles on impact investing and is designed to help achieve four of the UN's sustainable development goals.

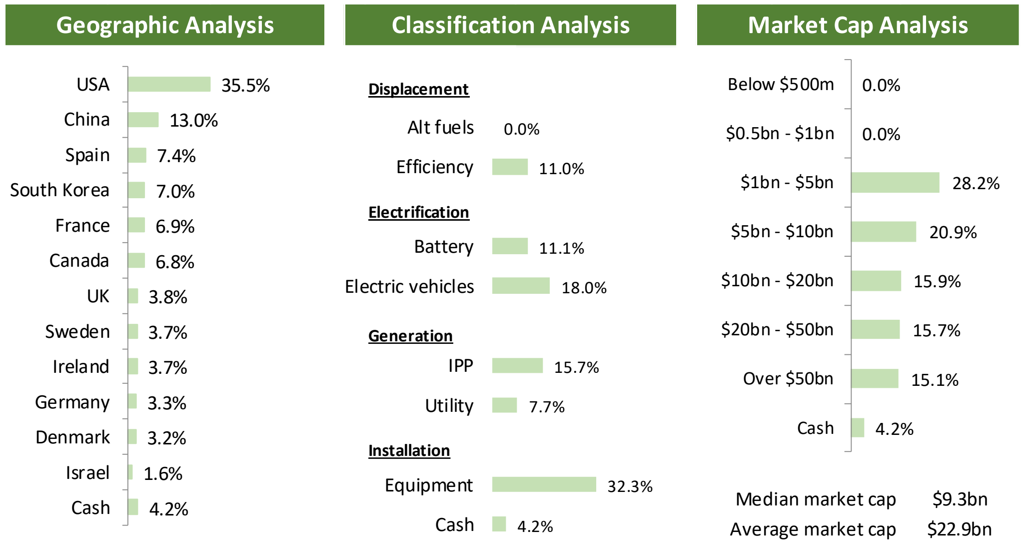
IFC International Finance Corporation WORLD BANK GROUP

Signatory of: PRI Principles for Responsible Investment

Buys/Sells

There were no buys or sells during February, but the portfolio was actively rebalanced.

Portfolio structure analysis



Source: Guinness 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	
	Feb-21		Dec-20	Dec-19	Dec-18
Consumption	**40.2%**	***3.5%***	**36.7%**	**41.7%**	**26.5%**
Displacement	11.0%	*1.1%*	9.9%	13.4%	16.4%
Alternative Fuel	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*3.9%*
Efficiency	*11.0%*	*1.1%*	*9.9%*	*13.4%*	*12.5%*
Electrification	29.1%	*2.3%*	26.8%	28.2%	10.1%
Batteries	*11.1%*	*0.3%*	*10.8%*	*12.6%*	*3.9%*
Electric vehicles	*18.0%*	*2.0%*	*16.0%*	*15.7%*	*6.2%*
Renewables	**55.7%**	***-4.7%***	**60.4%**	**54.1%**	**69.7%**
Generation	23.4%	*-1.2%*	24.6%	22.2%	27.3%
IPP	*15.7%*	*-1.3%*	*17.0%*	*18.9%*	*26.7%*
Utility	*7.7%*	*0.1%*	*7.6%*	*3.2%*	*0.6%*
Installation	32.3%	*-3.5%*	35.8%	32.0%	42.5%
Equipment	*32.3%*	*-3.5%*	*35.8%*	*32.0%*	*42.5%*
Cash	4.2%	*1.2%*	3.0%	4.2%	3.8%

Source: Guinness Asset Management.

Valuation

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

As at 28 February 2021	P/E			EV/EBITDA			Dividend Yield		EPS Growth		CFROI*		
	2019	2020E	2021E	2019	2020E	2021E	2020E	2021E	2014-19	2019-22	2019	2020E	2021E
Guinness Sustainable Energy Fund	29.3x	32.4x	24.6x	16.3x	15.7x	13.1x	1.1%	1.2%	7.2%	12.9%	6.3%	5.8%	8.4%
MSCI World Index	23.9x	33.2x	21.2x	13.8x	16.9x	13.1x	1.8%	1.9%	3.8%	8.0%	7.6%	7.0%	8.1%
Fund Premium/(Discount)	*23%*	*-2%*	*16%*	*18%*	*-7%*	*0%*							

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

Source: Guinness Asset Management.

Portfolio holdings, as at end February 2021

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

We hold c.40% 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 (11.1% weight) or the electrification of transportation (18.0% weight) while we have 11.0% 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. Johnson Matthey provides exposure to cathode chemistry while Tianneng, a large Chinese lead acid battery manufacturer that is trading on 5.6x P/E for 2021, represents the only non-lithium ion battery exposure in the portfolio.

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. ON Semiconductor is a provider of high voltage semiconductors that are a necessity for higher voltage electric vehicles to become competitive with ICE vehicles while Gentherm, Hella, 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 23.4% weight to companies involved in the generation of sustainable energy and 32.3% 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 broad-based wind/solar renewable energy generation through TransAlta Renewables and NextEra Energy (the largest producer of renewable energy in the world). Iberdrola is our only Utility company.

We maintain exposure to the solar and wind equipment and manufacturing value chains. Daqo Energy is the world’s largest and lowest cost supplier of polysilicon for solar cell manufacturing, 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 A/C 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 and Schneider Electric) gives exposure to companies that provide equipment and services to improve the efficiency and metering of electricity transmission and consumption.

Portfolio themes, as at end February 2021

	Theme	Example holdings	Weighting (%)
1	Electrification of the energy mix	TransAlta renewables, NextEra Energy	19.6%
2	Rise of the electric vehicle and auto efficiency	Sensata, APTIV	21.8%
3	Battery manufacturing	Samsung SDI	7.3%
4	Expansion of the wind industry	tpi composites, Vestas	14.8%
5	Expansion of the solar industry	大全新能源公司 DAQO NEW ENERGY CORP	15.7%
6	Heating, lighting and power efficiency	NIBE	11.0%
7	Geothermal and biomass	ORMAT, ALBIOMA	5.6%
8	Other (inc cash)		4.2%

Portfolio at end January 2021 (for compliance reasons disclosed one month in arrears)

Guinness Global Energy Fund (29 January 2021)		P/E			EV/EBITDA			Price/Book			Dividend Yield			ROCE			Net Debt/Equity		
Stock	% of NAV	2019	2020E	2021E	2019	2020E	2021E	2019	2020E	2021E	2019	2020E	2021E	CY 2017	CY 2018	CY 2019	CY 2017	CY 2018	CY 2019
Displacement/Efficiency																			
Hubbell Inc	3.1%	19.3x	20.5x	18.7x	12.8x	13.7x	12.5x	4.3x	4.1x	3.8x	2.2%	2.3%	2.5%	20%	32%	36%	1.1x	2.3x	1.9x
Nibe Industrier AB	3.9%	70.5x	56.1x	51.2x	43.1x	32.0x	30.0x	9.5x	7.4x	6.7x	0.4%	0.5%	0.6%	27%	26%	24%	1.8x	1.6x	1.5x
Ameresco Inc	3.6%	72.4x	56.0x	46.1x	31.6x	27.0x	23.0x	6.4x	5.7x	5.2x	n/a	n/a	n/a	n/a	55%	n/a	2.8x	2.1x	3.7x
	10.6%																		
Electrification/Battery																			
LG Chem Ltd	3.8%	154.8x	48.0x	31.3x	28.3x	15.7x	12.2x	4.5x	3.7x	3.5x	0.4%	0.9%	1.0%	14%	9%	3%	0.1x	0.7x	2.4x
Samsung SDI Co Ltd	3.9%	104.0x	83.0x	45.0x	43.3x	29.3x	22.1x	4.2x	3.9x	3.7x	0.1%	0.1%	0.1%	16%	16%	7%	0.3x	1.3x	1.8x
Johnson Matthey PLC	3.6%	14.1x	16.2x	18.7x	10.1x	10.4x	10.9x	2.4x	2.2x	1.9x	2.7%	2.1%	2.0%	14%	18%	11%	1.1x	1.3x	2.0x
Tianneng Power International Ltd	0.3%	11.6x	7.2x	5.7x	5.4x	3.3x	2.9x	2.4x	1.7x	1.4x	2.6%	4.0%	4.8%	26%	26%	31%	-0.9x	-1.5x	-1.5x
	11.5%																		
Electrification/Electric Vehicles																			
Aptiv PLC	3.2%	28.6x	74.5x	33.1x	10.6x	26.3x	15.8x	9.2x	4.9x	4.6x	0.7%	0.1%	0.3%	36%	27%	25%	1.2x	1.8x	2.1x
ON Semiconductor Corp	3.3%	22.9x	43.5x	21.4x	13.4x	16.8x	12.6x	4.3x	4.1x	3.4x	n/a	n/a	n/a	n/a	18%	8%	1.7x	1.3x	2.7x
Sensata Technologies Holding PLC	3.4%	15.4x	25.6x	16.7x	12.1x	16.0x	12.7x	3.4x	3.2x	2.9x	n/a	n/a	n/a	n/a	n/a	n/a	3.0x	2.6x	3.0x
Hella GmbH & Co KGaA	3.3%	11.6x	37.1x	20.3x	6.1x	8.7x	7.7x	2.1x	2.3x	2.4x	2.7%	0.3%	1.3%	13%	19%	n/a	0.2x	-0.1x	0.2x
Gentherm Inc	2.9%	30.2x	34.4x	24.1x	15.0x	15.9x	12.4x	4.1x	3.7x	n/a	n/a	n/a	n/a	8%	10%	10%	0.3x	0.8x	0.3x
	16.2%																		
Generation/IPP																			
NextEra Energy Inc	4.2%	38.6x	35.3x	32.3x	21.7x	21.0x	19.3x	4.0x	3.9x	3.8x	1.5%	1.7%	1.9%	n/a	11%	8%	4.3x	4.4x	4.3x
China Longyuan Power Group Corp Ltd	3.9%	20.1x	15.8x	13.8x	10.2x	8.5x	7.7x	1.6x	1.4x	1.3x	1.0%	1.3%	1.4%	9%	9%	9%	4.8x	4.4x	4.3x
Ormat Technologies Inc	3.5%	60.7x	67.2x	72.4x	20.4x	19.0x	18.6x	3.8x	3.9x	3.9x	0.4%	0.4%	0.4%	9%	7%	6%	2.7x	3.7x	3.4x
TransAlta Renewables Inc	3.9%	27.6x	53.0x	27.6x	14.8x	13.7x	12.9x	2.8x	2.5x	2.6x	4.2%	4.4%	4.4%	2%	16%	12%	3.8x	3.2x	3.3x
Albioma SA	2.9%	33.4x	28.3x	21.7x	14.0x	11.1x	10.5x	3.3x	2.9x	2.7x	1.5%	2.0%	2.3%	6%	6%	6%	4.2x	4.0x	3.6x
China Suntien Green Energy Corp Ltd	2.3%	5.2x	5.2x	4.7x	12.4x	10.8x	9.5x	0.7x	0.5x	0.5x	7.2%	7.5%	7.2%	14%	10%	10%	5.8x	5.7x	5.6x
	20.8%																		
Generation/Utility																			
Iberdrola SA	3.9%	23.5x	20.0x	18.9x	13.7x	11.9x	11.1x	2.0x	1.8x	1.7x	3.1%	3.7%	3.8%	n/a	7%	7%	4.3x	4.1x	4.1x
	3.9%																		
Installation/Equipment																			
Schneider Electric SE	3.9%	27.1x	28.6x	23.9x	18.0x	17.5x	15.3x	3.5x	3.1x	3.0x	1.8%	2.1%	2.2%	41%	45%	40%	1.1x	1.2x	1.1x
Itron Inc	3.0%	27.3x	57.1x	39.8x	15.4x	25.0x	18.4x	4.6x	6.8x	7.5x	39.4%	n/a	n/a	13%	n/a	16%	2.0x	12.3x	3.2x
Xinyi Solar Holdings Ltd	3.0%	56.2x	33.2x	22.8x	39.6x	24.2x	17.1x	9.6x	7.0x	5.8x	0.9%	1.4%	2.1%	20%	14%	16%	1.9x	2.5x	1.2x
SolarEdge Technologies Inc	1.5%	71.8x	72.6x	62.4x	53.2x	61.2x	48.3x	17.9x	14.0x	11.4x	n/a	n/a	n/a	n/a	27%	23%	-1.3x	-2.4x	-1.7x
Enphase Energy Inc	1.7%	204.7x	145.8x	99.9x	196.3x	108.4x	70.7x	116.9x	50.1x	30.9x	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.3x	-1.1x
First Solar Inc	3.6%	43.0x	25.6x	27.0x	23.7x	20.3x	17.3x	1.0x	1.9x	1.8x	n/a	n/a	n/a	-4%	3%	n/a	-10.3x	-12.2x	-23.9x
Canadian Solar Inc	3.4%	30.5x	32.8x	26.2x	15.0x	13.5x	10.9x	2.3x	1.9x	1.7x	n/a	n/a	n/a	26%	35%	19%	6.8x	2.7x	3.4x
Daqo New Energy Corp	3.5%	218.0x	43.7x	19.0x	71.3x	25.3x	11.6x	10.7x	8.6x	4.9x	n/a	n/a	0.4%	27%	9%	6%	0.9x	1.0x	3.5x
Vestas Wind Systems A/S	3.6%	53.8x	59.1x	38.3x	24.8x	22.8x	17.1x	11.3x	9.8x	8.1x	0.6%	0.5%	0.8%	34%	27%	28%	-2.0x	-2.2x	-1.8x
Siemens Gamesa Renewable Energy SA	3.9%	54.2x	n/a	84.6x	23.0x	78.5x	24.9x	4.1x	4.4x	4.7x	0.2%	0.0%	0.9%	n/a	4%	11%	n/a	-0.6x	-1.0x
TPI Composites Inc	2.2%	n/a	n/a	35.2x	27.5x	24.0x	14.7x	10.1x	11.3x	8.5x	n/a	n/a	n/a	20%	n/a	-9%	-0.3x	1.0x	2.4x
	31.2%																		
Cash	3.8%																		

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

5. OUTLOOK - Sustainable Energy and the Energy Transition

Sustainable energy: the long term and the effect of COVID

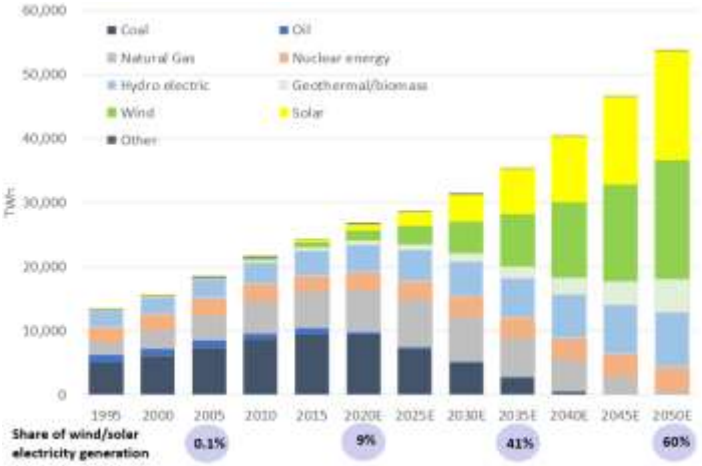
Over the next thirty years, the world will continue its transition to a sustainable energy system. The key factors driving the transition are:

- **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.

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

Global power generation by type (TWh)

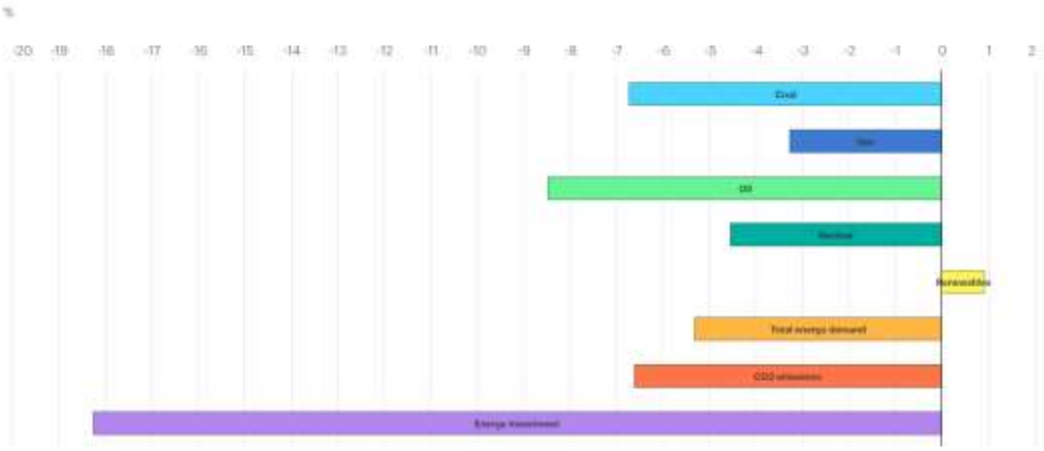


Sources: BP Statistical Review; Guinness Asset Management forecasts

The effect of COVID-19 on the energy industry and the energy transition

The COVID pandemic has had a number of short-term and long-term effects on the global energy market and the energy transition, most notably causing global energy demand to contract by over 5% in 2020 vs 2019 as a result of lockdowns and reduced transportation. Renewable energy sources have performed better in the weaker demand environment (since operating costs are close to zero) and we expect that renewable energy demand will have increased by around 1% in 2020 relative to coal demand (down around 7%) and crude oil (down around 9%). A net benefit of COVID lockdowns and reduced global transportation has been lower CO_2 emissions (down nearly 7% on 2019 levels) although these emissions will rebound once economies unlock and transportation resumes. More worrying on a longer-term basis is the fact that investment across the entire energy industry is likely to be down 18% in 2020 versus 2019; energy investment was already at the low end of the required range to facilitate the energy transition.

<u>Key estimated energy demand, CO2 emissions and investment indicators, 2020 relative to 2019 (%)</u>



Source: IEA World Energy Outlook 2020

Governments across the world are agreeing stimulus packages to kick start their economies back into growth-mode post-COVID. These investment programmes have been heavily focused on sustainable energy technologies and activities because they satisfy near-term post COVID government and social needs on a number of levels, including:

- **Employment** investment in low carbon infrastructure tends to be more up front capital-intensive and local economy/employee-intensive than traditional energy developments. A recent analysis by the International Renewable Energy Agency (IRENA) estimated that 40m jobs could be created in the area globally by 2050.
- **Economic materiality.** The same analysis estimates that investments in the energy transition could have a 5x multiplier effect on GDP.
- **Interest rate sensitive** low carbon infrastructure projects require greater upfront capital (and have lower operating costs) so they are more sensitive to the cost of financing. They are more likely to benefit relative to conventional projects in the post-COVID ultra low interest rate environment.

The near-term economic benefits of sustainable energy combined with increasing decarbonisation commitments triggered several key government policy commitment announcements during the year. The three most significant announcements, in our opinion, came from China, the US and the EU. China announced plans to become 'carbon neutral' by 2060; clean energy and infrastructure targets were central to US President Elect Biden's manifesto; and the long-awaited EU Green Deal was proposed, with its plan to achieve 'climate neutrality' by 2050.

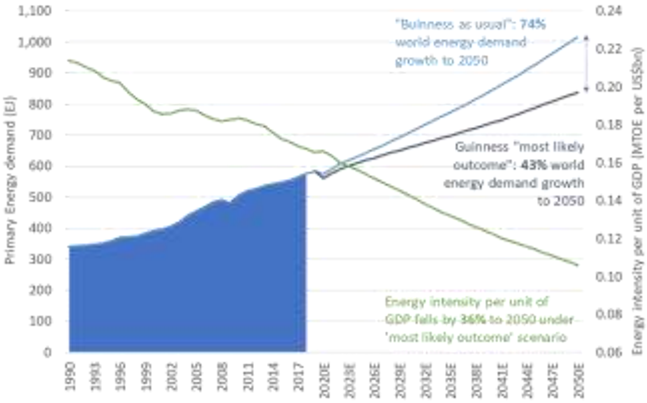
Combined, these three commitments represent major political momentum and investment to support an acceleration globally towards energy efficiency, electrification and clean energy, all of which are core themes in the energy transition.

Displacement: energy efficiency and alternative fuels

Our 'big picture' view: being energy efficient is as important as producing cleaner energy
It is a common misconception that achieving rapid growth in renewable power generation will be enough to deliver government pollution, energy security and de-carbonisation targets. Renewable 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 immediately.

We carry out two demand scenarios as part of our modelling of long-term world energy demand. Our 'business as usual' case sees world energy demand growing by 74% to 2050 as per capita energy demand and the energy intensity of GDP follow historic patterns. The level of global energy demand implied by 'business as usual' looks unsustainable, in our opinion. We believe that a more likely outcome for world energy supply and demand is one where energy demand growth is moderated substantially via the displacement and more efficient use of existing sources.

Guinness Energy demand scenarios



Source: BP Statistical Review, Guinness Asset Management

Our 'most likely outcome' scenario reflects this view and sees global energy demand grow by 43% from 2019 to 2050 despite the global population growing by 26% and global GDP more than doubling. While per capita energy demand stays broadly flat at 1.8-1.9 tonnes of oil equivalent (TOE), we see every $1bn of global GDP requiring only 95 tonnes of oil equivalent (Toe) in 2050 relative to the current intensity of 170 Toe in 2018. Delivering on energy efficiency is worth tens of trillions of dollars to world GDP by 2050; there are clear economic, as well as climate-related reasons, for the world to consume energy more efficiently.

Review of 2020: efficiency efforts fall further behind long term required levels
The COVID pandemic has had a substantial impact on energy efficiency activity in 2020, likely leading to 2020 being another year of energy efficiency improvements that are well below the required long term run rate to deliver on Paris de-carbonisation goals. Energy efficiency is difficult to measure, and the pandemic will make the measurement of efficiency gains even harder, but initial indications from the IEA are that energy intensity is expected to improve by only 0.8% in 2020, roughly half the weather-adjusted rates seen in 2019 (1.6%) and 2018 (1.5%).

The pandemic also delayed investment in future energy efficiency projects, with investment here likely to fall by 9% versus 2019. Globally, we find Europe leads the way in energy efficiency investment, with the continent representing 86% of the US$66bn of funding for energy efficiency-related measures announced as part of governments' stimulus packages at end of October 2020.

Outlook for 2021 and beyond: buildings still a focus but more government policy required
The near-term outlook for improving energy efficiency continues to look weak. Energy intensity improvements typically track global GDP with a one-year delay and, with global GDP likely to have fallen by 4.4% in 2020 according to the IMF, we expect that energy efficiency measures in 2021 will still be impressive in certain areas but below the long term required level globally. Moreover, current low energy prices make it even more difficult to justify investing to save energy on a purely economic basis.

Government intervention, along the lines of what was announced in 2020, will be required to make the saving of energy a necessity for companies and individuals rather than an optional extra. We note that government standards and specifications on energy efficiency cover only 35% of global energy end use.

We expect that building efficiency will be a key focus in the near term as, amongst other aspects, investments in the efficiency of buildings are estimated to create around 15 jobs for every US$1m spent. Buildings account for ~30% of global final energy consumption and energy-related CO2 emissions and in order to achieve the goals of the Paris Agreement, energy intensity (consumption per unit of floor area) of buildings needs to fall by >2.5% per year, more than double the current rate of 0.5-1% pa.

The economic benefit of achieving greater energy efficiency is very significant in the near term. The 0.8% improvement in energy efficiency in 2020 meant that the world generated around US$1trn more GDP for the same amount of energy used in 2019. Had the 2019 level of energy efficiency been sustained, at 2%, the GDP saving could have been closer to US$2.5trn.

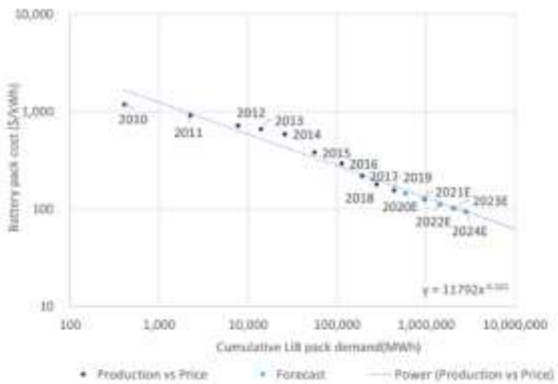
Electrification: lithium ion batteries and electric vehicles

Our 'big picture' view: rapid growth in battery storage and electrified transportation
The energy transition will see energy demand being 'electrified' as it moves away from predominantly hydrocarbon fuels and gases towards the consumption of electricity directly. Our 'electrification' sector includes those companies involved in the key enablers of this transition: the lithium-ion battery and the electric vehicle. 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.

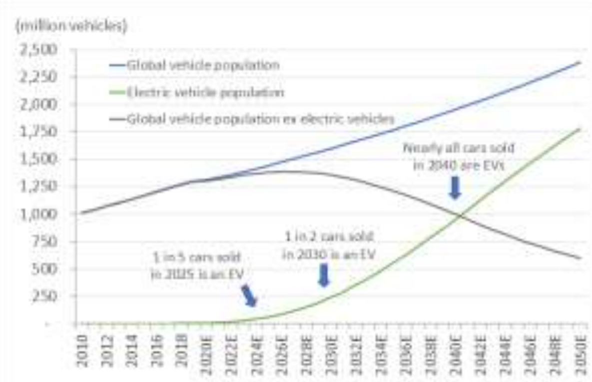
The catalyst for greater **lithium-ion battery** use has been sharp falls in the cost of manufacturing. According to BNEF, battery costs are down 89% over the decade from 2010 to 2020 (an implied 'learning rate' of around 18%) with the average cost being $137/kWh in 2020. Significant economies of scale from mass battery manufacturing have lowered costs and, as these continue, the average cost of producing a lithium ion battery for an EV is likely to fall towards $100/kWh in the mid-2020s. Of note, BNEF reported the first instance of a sub $100/kWh battery pack being manufactured for an e-bus in 2020.

This would allow **electric vehicles** to compete on price with internal combustion engine vehicles without subsidies. We expect an acceleration in the uptake of new EVs, with around 20% of new passenger vehicles sales being electric in 2025, rising to around 50% in 2030. On this basis, there will be nearly 300m electric vehicles on the world's roads by 2030. This level of electric transportation would displace nearly 4m barrels of day of world oil demand in that year.

Lithium ion battery costs and cumulative capacity



Electric vehicle Update



Source: BNEF, Guinness Asset Management, OPEC, Woodmac

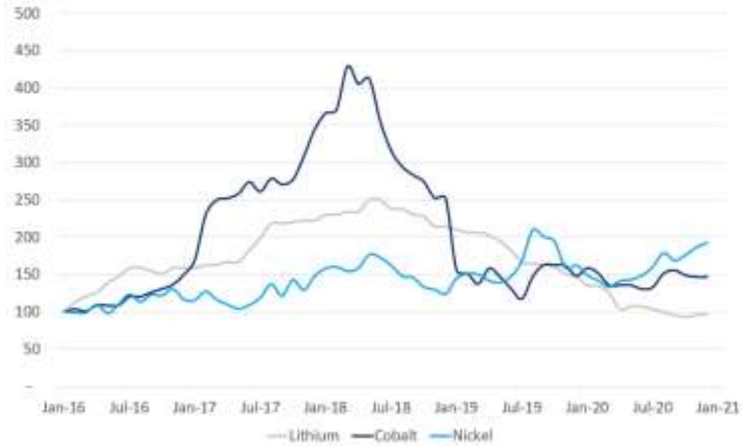
The demand for lithium-ion batteries in **grid (stationary) storage** is likely to grow very rapidly as the cost of delivering a 'renewable + storage' power system improves. Higher levels of variable renewable power in many electricity grids is resulting in low intraday power prices and incentivising developers to make new renewable power projects fully 'dispatchable' (via the addition of storage) in order to supply electricity at different points in the day and benefit from higher power prices. In 2019 there was 173 GW of grid storage globally (representing maybe 2% of global power generation capacity) and around 90% of this was in the form of pumped hydro.

Review of 2020: very strong growth across batteries, EVs and stationary storage
2020 was another year where **lithium-ion batteries** took more share of both the global auto and global grid (stationary) storage industries as investment and capacity of lithium ion battery manufacturing continued to ramp.

According to Bloomberg New Energy Finance, **lithium-ion battery** manufacturing is expected to have reached 470 GWh in 2020 (up from 352 GWh in 2019 and 249 GWh in 2018) with most of the capacity additions being taken by auto manufacturers for their new EV models. At around 70% market share, China dominates manufacturing capacity but in 2020 we saw many new lithium-ion battery factories outside China being announced. Lithium-ion batteries typically degrade during long distance seaborne travel, hence new manufacturing facilities are being planned closer to auto manufacturing plants and to customer demand centres.

Despite the growing demand, the prices of the main raw materials were reasonably flat during 2020. Cobalt and Nickel (at $31,400/tonne and $13,700/tonne respectively) in 2020 were broadly flat on 2019 levels while Lithium carbonate (at $6,800/tonne) was down around 40% on average versus 2019. While nickel prices were flat on average in 2020, there was strong positive price momentum into year end.

Lithium Carbonate, Nickel and Cobalt prices ($/MT, indexed to 100, Jan 2016)

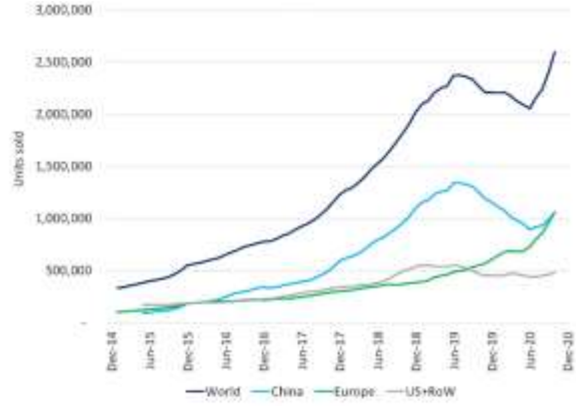


source: Guinness Asset Management, Bloomberg

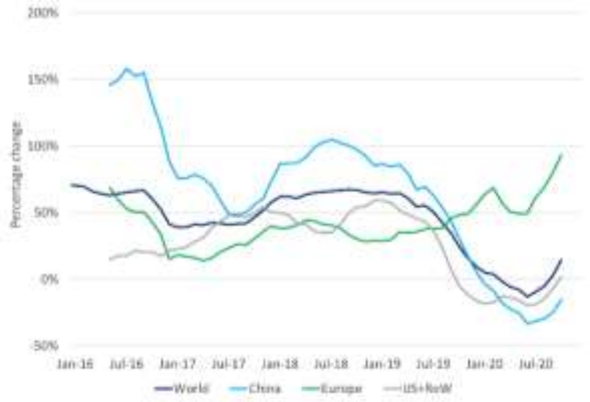
By our estimates, the total global **electric vehicle** passenger vehicle fleet reached nearly 10m vehicles at the end of 2020 with new sales in 2020 being about 2.8m vehicles, a growth of around 25% versus sales of 2.2m in 2019. This growth compares very favourably to overall global light vehicle sales of around 75m vehicles in 2020, down 16% on 2019 levels.

The global auto industry suffered due to COVID lockdowns at the start of 2020, but global electric vehicle sales growth recovered quickly after the initial lockdowns and turned positive at the end of 3Q 2020. The sharp recovery in EV demand was dominated by Europe, with the European EV market being the biggest globally at the end of 2020.

Global EV sales (rolling 12-month basis)



Global EV sales growth (rolling 12-month basis)



Source: Guinness, EV-Sales

The strength in Europe was driven by new generous EV incentives offered by Germany and France (amongst other countries) and stricter emissions standards that went into effect at the start of the 2020, which incentivised auto manufacturers to either increase their EV offerings and sales levels or purchase emissions credits to make up for carbon shortfalls. A key milestone was achieved in Europe during 2020 as new registrations for the broader category of ‘electrified vehicles’ - including light-hybrid cars (HEVs) as well as PHEVs and BEVs – reached 25% and overtook that of diesel vehicles. After stagnating in 2019, the Chinese market also saw a rebound in EV sales activity by the third quarter leaving the market broadly flat over the year.

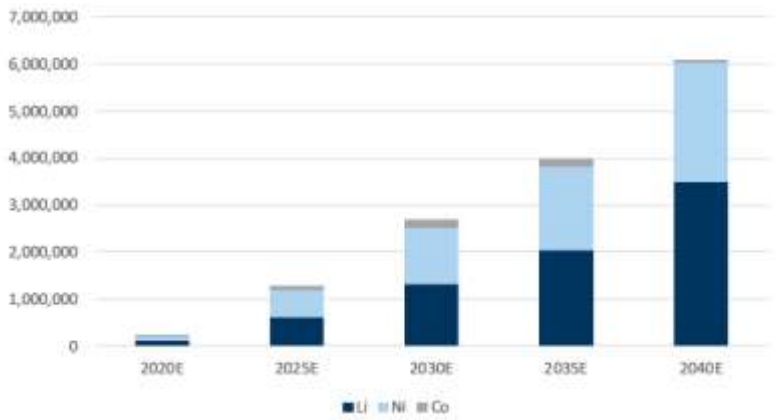
The market for **grid (stationary) lithium-ion battery storage** also grew handsomely in 2020, with deployments expected to have reached around 10,000 MWh, up around 50% on the levels seen in 2018/2019. The reduction in manufacturing cost spurred demand for batteries for use in a variety of grid-attached ancillary services, and the falling cost of large-scale renewables-plus-storage means that grid operators and utilities started to see credible paths to replacing coal and gas generators, justified by economics during the year.

Outlook for 2021 and beyond: rapid growth across batteries, EVs and stationary storage
We expect sustained growth in **lithium-ion battery manufacturing** capacity in 2021 and beyond, taking large scale manufacturing capacity to more than 1,200GWh in 2023 and then significantly higher by the end of the decade. These facilities are being built globally, but China will still maintain its dominance, with its share of global capacity staying in the 65-70% range.

As an illustration of the scale of the potential growth and the volatility around long-term forecasting, Tesla recently indicated that its annual battery needs alone will reach 3,000 GWh by 2030 - from 44 GWh currently. While this target also includes batteries for storage and other applications, if it is achieved, it would imply an overall lithium-ion battery market of around 6,000 GWh (based on 50% market share). This implies a dramatic impact on the demand outlook for lithium-ion battery raw materials as shown in the scenario from Goldman Sachs below.

Long term demand outlook for lithium, nickel and cobalt (tonnes per annum)

source: Goldman Sachs



To help fulfil demand, we also expect to see increasing focus in the coming years on the recycling of lithium-ion battery raw materials. Current recycling rates are estimated to be very low (around 10%) because recycling old batteries is a complex and expensive task. In the coming years, we expect government funded and mandated support for the battery recycling industry to bring about growth and economies of scale and, with the evolution of a re-use market, lithium-ion battery recycling will become a mainstream activity thus alleviating pressure on raw material production.

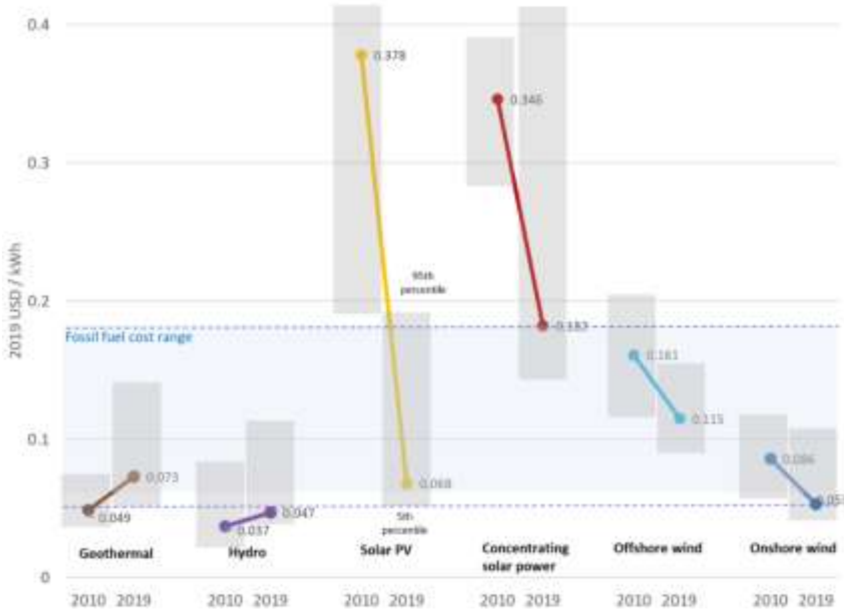
The recent growth trends for **electric vehicles** will continue through 2021 supported by clear commitments from governments towards the electrification of transportation. We expect new EV sales to be in excess of 4m vehicles in 2021, up over 50% versus 2020 sales and representing around 5% of global total light vehicle sales of 83m units (up 11% in 2020 levels). Looking longer term, we expect that predominantly all passenger vehicle sales will be EVs by 2040.

While starting from a lower base, the outlook for **stationary lithium-ion battery storage** continues to look very strong in 2021 and beyond as utility scale solar developers focus more on 'solar + storage' projects in order to benefit from higher power prices at certain times of the day. While residential deployment in areas like the US is still dependent upon tax credits, we expect utility scale operations to grow rapidly and to be more economic than other large-scale storage options (for example hydrogen) on an unsubsidised basis.

Generation and installation: renewables versus fossil fuels

Before considering the detailed dynamics of key renewable power generation markets of wind and solar, it is worth considering the significant changes that have been seen across 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 the cost range for new fossil fuel power generation. As we will highlight in the coming sections, however, there is still further room for both wind and solar power generation technologies to deliver further cost reductions.

Global LCOE of utility-scale renewable power generation technologies (2010–2019)



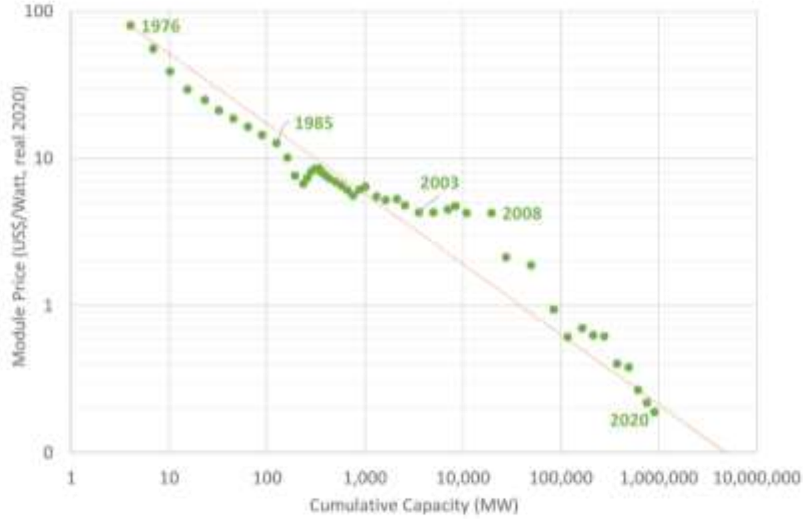
Source: IRENA; Guinness Asset Management

Generation and installation: solar power

Our 'big picture' view: solar module cost reductions continue to support rapid growth

The fact that solar PV is being taken seriously today as a variable renewable energy source owes much to the significant fall in the price of crystalline silicon PV modules. In their infancy, in the late 1970s, a PV module cost around $80 per watt ($/W). By 2010, this had been reduced to around $2/W, a rapid decrease but one that still left solar as being uneconomic versus most other energy generation sources. Critically, the learning rate this decade (the cost reduction for every doubling of cumulative industry capacity) continued at a similar level – around 28% - bringing us to a module cost of around $0.18/W in 2020, around 90% lower than the cost in 2010.

Solar module prices and manufacturing capacity (1976-2020)



Source: IRENA; Guinness Asset Management

Falling costs have caused rapid growth, with annual solar installations growing from 19 GW in 2010 to an estimated 129 GW in 2020. In the initial years (2010-2014) OECD countries dominated the market but, by 2015, non-OECD countries (predominantly China) increased their rate of new installations and brought the global market to a 50/50 balance between the OECD and non-OECD. China's annual installations grew by 34 GW p.a. over the subsequent two years, representing nearly all of the 42 GW p.a. of growth in installations globally over that period. Growth has been more balanced since then, with the OECD increasing its installation rate by 16 GW p.a. and the non-OECD increasing by 23 GW pa. As of 2020, China still dominated the global solar module installation market, at 40 GW in a global total of 129 GW.

Global solar module installations, 2008-2021E (GW)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021E
OECD solar installations (annual)														
North America	0	1	1	2	4	6	7	8	14	11	10	11	15	24
Germany	2	4	7	7	8	3	2	1	2	2	4	4	4	5
Italy	0	1	4	8	4	1	0	0	0	0	0	1	1	1
Spain	3	0	0	0	0	0	0	0	0	0	0	5	3	3
Rest of Europe	0	1	3	4	5	5	5	6	4	3	4	6	8	9
Australia	0	0	0	1	1	1	1	1	1	2	4	4	3	4
South Korea	0	0	0	0	0	1	1	1	1	1	2	3	3	4
Japan	0	0	1	1	2	7	10	11	8	8	7	7	7	7
Total OECD	**6**	**7**	**17**	**23**	**24**	**24**	**25**	**29**	**29**	**26**	**31**	**40**	**44**	**56**
Change in OECD annual installations	*4*	*0*	*10*	*7*	*0*	*0*	*2*	*4*	*0*	*-3*	*5*	*9*	*5*	*11*
Non-OECD solar installations (annual)														
China	0	0	0	3	3	14	13	19	30	53	44	33	40	45
India	0	0	0	0	1	1	1	2	5	10	11	12	5	10
Rest of non-OECD	0	1	1	3	3	4	6	6	11	9	22	34	40	44
Total Non-OECD	**0**	**1**	**2**	**5**	**8**	**18**	**21**	**27**	**46**	**72**	**77**	**78**	**85**	**99**
Change in non-OECD annual installations	*0*	*1*	*1*	*3*	*2*	*11*	*2*	*6*	*19*	*26*	*5*	*1*	*6*	*15*
Total solar installations (annual)	**7**	**8**	**19**	**29**	**31**	**42**	**46**	**56**	**75**	**98**	**108**	**118**	**129**	**155**
Change in world annual installations	*4*	*1*	*11*	*10*	*2*	*11*	*4*	*10*	*19*	*23*	*10*	*10*	*11*	*26*

Sources: BP, Bloomberg, Guinness Asset Management

Review of 2020: COVID and cyclical tightness in solar manufacturing slows demand growth

The cost reductions discussed above have come from a number of technological and economic improvements, including more efficient use and lower pricing of polysilicon, the shift from multi-crystalline to mono-crystalline polysilicon and scale/manufacturing improvement across the other parts of the solar PV system. Further technology and manufacturing improvements were made in 2020 across the various components of the solar value chain:

- **Poly-silicon** is the initial raw material for a solar wafer. Poly prices hit record lows in the middle of 2020 as a result of oversupply and then, in 3Q, an explosion and floods disrupted supply from some Chinese factories, forcing poly prices up nearly 50%.
- **Poly silicon wafer manufacturing** remained significantly in excess of poly silicon capacity throughout the year, keeping manufacturing margins under pressure. Capacity continues to switch to mono silicon wafers (now at 180 GW capacity) and away from multi silicon wafers (capacity down from 55 GW in 2019 to 24 GW in 2020).
- **Solar cell and module manufacturing** saw significant capacity expansion in 2019 (maintaining a high level of oversupply) with new larger diameter cell capacity coming online. Higher cost producers shut in production leaving even the Tier 1 manufacturers and vertically integrated companies facing very challenging manufacturing economics. Solar glass prices increased by around 50% in the second half of the year as a result of limited supply and growing demand from bifacial panels (which utilise larger amounts of solar glass) further compressing module margins.

Solar module installations on a global basis were much less affected by COVID than initially feared. In the middle of the crisis, it was mooted that the rate of global installations would decline in 2020, registering the first year of module installation rate declines in recent history. Ultimately, new installations likely increased by 11 GW in 2020, to reach 129 GW. **China** was the largest market globally with installations averaging around 40 GW in 2020 (up from 33 GW in 2019) as the country recovered from COVID faster than other countries. **India** was the weakest of the larger markets, suffering weak demand due to the impacts of COVID-19, border conflicts at the China-India border and a clearer demand response to higher module prices. **OECD** demand, at 44 GW, was 10% higher than 2019 with North America dominating the growth (+4 GW versus 2019) predominantly resulting from continued attractive tax credits in the United States.

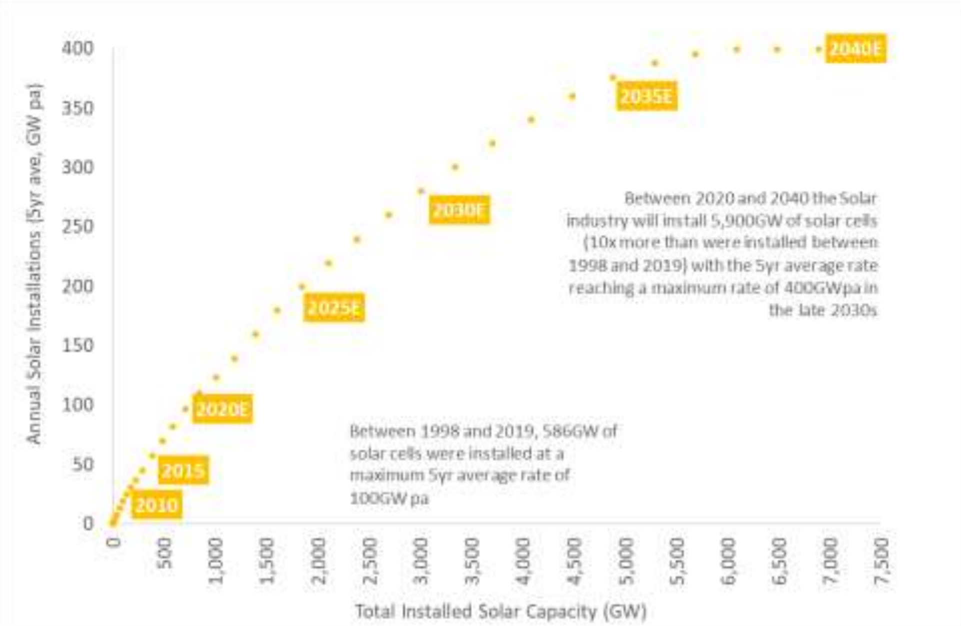
Outlook for 2021 and beyond: global demand becomes more price sensitive
The outlook for solar installations in 2021 depends very much on solar module pricing and how it is affected by the developments in the polysilicon, wafer, cell and module (including solar glass) markets.

- **Poly-silicon** capacity will grow to 630k mtpa at the end of 2021 (growing 80k mtpa in 2021) with the marginal cost of new capacity being in the region of $4-6/kg. Prices should weaken, alleviating margins for module manufacturers.
- **Poly-silicon wafer manufacturing** capacity is likely to increase further in 2021, leaving the wafer industry even further oversupplied (and probably price pressured) than it was in 2020. With the start of a large plant from GCL during the year, the industry will effectively complete its transition to mono-grade manufacturing by the end of 2021.
- **Solar cell and module manufacturing** New capacity additions will increase oversupply again with cell and module prices likely to remain under pressure. With limited new solar glass capacity planned for 2021 (and therefore prices unlikely to recede) there will be more module margin pressure bringing the risk of price cutting to defend market shares.

Solar module installations are expected to reach around 155 GW in 2021, up 26 GW on the level achieved in 2020. **China** will implement the 14th Five-Year Plan starting in 2021, under which solar projects will no longer be subsidized and the move to grid parity will be completed. With strong government support and individual installation targets for each province (rather than subsidy allowances), the key factor affecting demand will be module price, with upside risk to our 45 GW estimate if prices fall. **India** solar module demand is likely to be around 10GW, up 5 GW on the 2020 activity that was held back by COVID. In the **United States**, a Biden presidency leads to installations of around 22 GW in 2021 driven by the solar Investment tax credit (ITC) which has been extended for a further two years as part of the country's COVID stimulus. **Europe** will register around 25-30 GW of new installation demand in 2021, broadly unchanged on 2020 levels.

In **conclusion**, the global outlook for solar looks robust and the improved cost competitiveness of solar energy opens the way for a rapid expansion of solar in the global electricity grid. Between 2020 and 2040, the solar industry will install 5,900 GW of solar cells (10x more than were installed between 1998 and 2019) with the 5yr average rate reaching a maximum rate of 400 GW p.a. in the late 2030s

Annual and cumulative solar installations (2005-40)



Source: Guinness Asset Management estimates, BP

Generation and Installation: wind power

Our 'big picture': a lower growth industry with great offshore potential still to come
The decline in the cost curve for wind power installations over the last ten years has not been as dramatic as solar, but it started from a lower base that was already competitive with some fossil fuel power generation. Indeed, the overall learning rate for the development of wind turbines since the early 1980s has been around 11%, versus a learning rate for all-in wind project capex of round 7%, implying a shallower pricing decline for other wind plant components.

The success of the wind industry is being driven by turbines becoming larger. The median size of onshore turbines in 2010 was around 2GW, and today this has risen to around 3.5GW. By 2050, BNEF estimate that the median size will be over 5GW. The scale improvements offshore are even more striking, with a move up from 7GW today to around 19GW by 2050. Larger wind turbines bring overall economies to the installation process because less foundation work and less cabling is needed and there are fewer parts to install and maintain. Improved performance monitoring systems are increasing the efficiency of installation and maintenance work.

The greater scale and improved design of turbines has set onshore wind costs on a path of declining costs. In 2008, onshore wind power cost an average of 8.5c/kwh, falling to a below 4.5c/kwh in 2020 and expected to fall further to 3.8c/kwh by 2030.

Having peaked in 2015 at 63GW of newly installed wind capacity (versus 36GW in 2010), the world wind market looks to have accelerated again (to around 72 GW), making 2020 a record year for installations and the highest year-on-year increase in new capacity.

Annual onshore and offshore wind installations (GW)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021E
Onshore wind installations (annual)														
North America	9	11	6	8	15	2	7	10	9	8	8	10	15	15
Latin America	0	0	0	0	0	0	5	3	3	3	3	4	5	6
Europe	6	9	9	10	12	11	11	11	12	13	8	9	12	16
China	6	14	17	18	14	15	21	29	22	17	19	26	32	25
India	2	1	1	1	1	1	1	1	2	3	2	2	1	3
RoW	3	3	3	4	4	3	4	5	5	5	6	5	6	8
Total onshore	**27**	**38**	**35**	**40**	**45**	**32**	**48**	**59**	**54**	**48**	**45**	**52**	**71**	**73**
Change in onshore annual installations		*12*	*-3*	*5*	*5*	*-13*	*16*	*11*	*-6*	*-6*	*-2*	*7*	*19*	*2*
Offshore wind installations (annual)														
China	0	0	0	0	0	0	0	1	1	1	2	3	4	5
UK	0	0	1	0	1	1	0	1	0	1	2	2	1	0
Germany	0	0	0	0	0	0	0	2	0	2	0	2	0	0
RoW	0	0	0	0	0	1	0	0	0	1	0	1	2	3
Total offshore	**0**	**0**	**1**	**0**	**2**	**2**	**1**	**4**	**1**	**4**	**4**	**8**	**6**	**9**
Change in onshore annual installations		*0*	*1*	*-1*	*1*	*1*	*-1*	*4*	*-4*	*3*	*0*	*3*	*-1*	*3*
Total wind installations (annual)	**27**	**38**	**36**	**40**	**46**	**34**	**49**	**63**	**54**	**52**	**50**	**60**	**77**	**82**
Change in world annual installations		*12*	*-2*	*4*	*6*	*-13*	*15*	*14*	*-9*	*-3*	*-2*	*10*	*17*	*5*

Source: Bloomberg, BP and Guinness Asset Management

Review of 2020: onshore installations likely to be plateauing; offshore still hopeful
The wind industry likely generated around 6% of world power generation in 2020, with about 95% of the installed capacity being onshore turbines. Here we will separately consider the key factors for the onshore and offshore wind markets in 2020.

Comparing the **onshore wind** industry to other high growth parts of the sustainable energy industry, it is interesting to think that the installation rate of onshore wind likely started to reach a near term plateau level in late 2020. Total onshore installations were around 71 GW (up 19 GW on 2019 and 26 GW on 2018 levels respectively) and, while likely to grow again somewhat in 2021, the momentum has slowed. Installations in China surprised to the upside during the year, consistent with the Q3 carbon neutrality announcement, while similar to solar, the extension of tax credits in the United States helped to sustain further onshore demand growth.

There was constructive cost data for the **offshore wind** industry suggesting that the LCOE for offshore wind has fallen over 30% from 2010-2020, from $161/MWh to less than $115/MWh, putting it well within the cost range of fossil fuel generation. Despite these improving economics, much of the offshore industry still relied on some form of subsidy to be economic in 2020. Grid parity is starting to appear and during 2020 we saw subsidy-free offshore wind projects being signed in the UK, Germany, and the Netherlands. These underline the significant potential of the offshore industry which benefits from better operational and visual charcteristics as well as being close to key demand areas which are often coastal.

Annual installations of offshore wind capacity increased from 0.9 GW in 2010 to 8 GW in 2019 before receding a little, predominantly as a result of COVID, to 6 GW in 2020. According to Bloomberg, at the end of 2020, total installed offshore wind capacity was estimated to be 36 GW with China leading at nearly 11 GW, followed by the UK at 10 GW and Germany at 7.5 GW.

Outlook for 2021 and beyond: Onshore plateau; offshore suffers COVID related decline
In 2021, global **onshore wind** installations are expected to plateau at around 73 GW (up around 2 GW on 2019 levels). The reason for the decline is mostly China, where wind projects have yet to fully reach the grid parity requirements that are necessary within the 14th Five Year Plan. Excluding China, the global onshore market will see strong growth, driven by delays due to COVID-19, and installations could reach nearly 50 GW in 2021 (versus 39 GW in 2020), marking a similar increase to that seen in 2019. Within this, the outlook for installations in the United States has improved as a result of the twelve-month extension of the 60% Production Tax Credit (PTC) for wind projects.

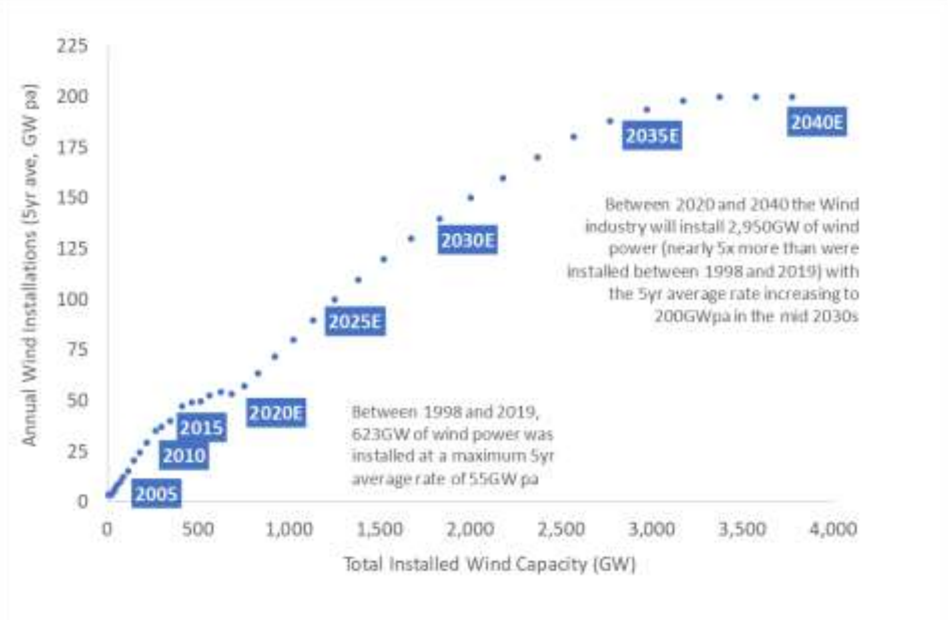
Despite the improving long term growth outlook, new **offshore wind** capacity additions in 2021 will likely be lower than those seen in 2020 as a result of project delays stemming from COVID lockdowns in 2020.

Ultimately, COVID is likely to act as a significant stimulus to longer term offshore wind growth as offshore projects are more capital intensive and project economics will benefit from the current environment of ultra-low interest rates. We can see over 20 GW of offshore project tenders to be awarded in 2021.

Looking longer term, increasing scale and larger turbine power capacities should allow the offshore sector to grow faster than onshore in the years ahead with new installations increasing every year from 2021 to 2030, reaching 12-15 GW p.a. in 2025 and more than doubling again by 2030. By the end of the decade, offshore installed capacity could be close to 200 GW and will likely be dominated by China, the UK, the United States and Germany but with the addition of new entrants such as the Netherlands, Taiwan, Japan, France, Korea, Denmark and India. The EU alone is targeting 60 GW of offshore wind capacity by that time, with some of it dedicated towards the new hydrogen economy.

In **conclusion**, putting our views for the onshore and the offshore together, we expect the wind industry to install a further 2,950 GW of new capacity between 2020 and 2040, reaching a peak installation rate of around 200 GWpa in the mid-2030s. The total installed capacity would be around five times as much as was installed between 1998 and 2019.

Annual and cumulative wind installations (2005-30)



Source: Bloomberg, BP, Guinness Asset Management

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