THE GUINNESS SUSTAINABLE ENERGY REPORT

Developments and trends for investors in the sustainable energy sector | September 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 Melrose (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.

Signatory of: PRI Principles for Responsible Investment

HIGHLIGHTS FOR AUGUST

IPCC: IMPLICATIONS FOR SUSTAINABLE ENERGY

The IPCC report on the state of the physical science of climate change raises significant questions about how the world will transition to achieve net zero emissions and an acceptable level of global warming. Based on their science, this month we provide a Guinness "1.5 degree scenario" for the energy industry which requires significant strengthening of policy and increases in investment and new equipment installation if it is to come to pass. Such an outcome would be highly supportive to the growth and valuation outlook for sustainable energy equities.

EQUITIES

Sustainable energy equities outperforming

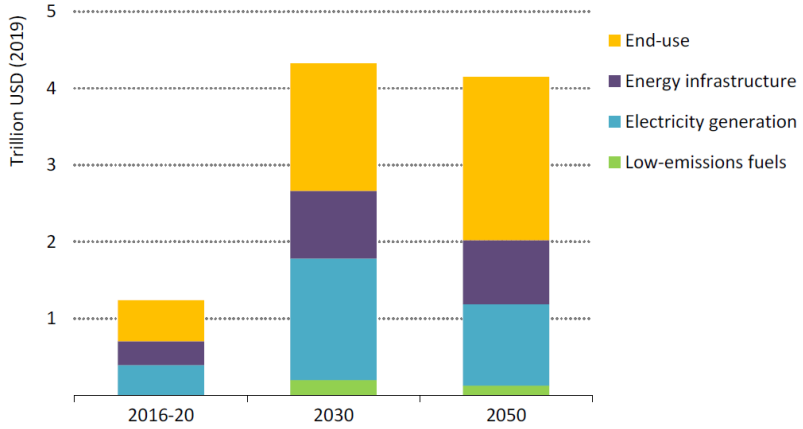
Sustainable energy equities outperformed global stock markets during August. Over the month, the Guinness Sustainable Energy fund (Class Y) delivered a return of 3.5% (in USD) which was ahead of the MSCI World at +2.5%. Year to date, the Guinness Sustainable Energy fund (Class Y) has delivered a return of +11.9% (in USD), behind the MSCI World at +17.9%.

Within the portfolio, the strongest performers were China Suntien Green Energy, Xinyi Solar Holdings, Nibe Industrier, ON Semiconductor and Infineon predominantly due to good quarterly results while the weakest performers were Tianneng Power International, Itron, TransAlta Renewables, LG Chem and Aptiv suffered from a combination of disappointing results, weaker guidance or negative news flow.

INVESTMENT IN THE IEA 2050 NET ZERO SCENARIO

The recent IEA report on achieving net zero emissions by 2050 stated that "*Achieving net-zero emissions by 2050 will require nothing short of the complete transformation of the global energy system*" and that "*the pathway is narrow but achievable, and it would bring major benefits for human prosperity and well-being, providing an opportunity to limit global warming to 1.5 °C.*" The investment required to achieve the transition is presented in the following chart.

Clean energy investment in the net zero pathway *source: IEA*



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GUINNESS ASSET MANAGEMENT

Contents

1. AUGUST 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
As a barometer of the planned energy transition in China, we were interested to see that state oil company PetroChina plans to have oil, natural gas and green energies each account for a third of its portfolio by 2035 (versus current weighting of 53% in oil and 47% in gas). As a whole, China plans the share of non-fossil fuels in total energy demand to grow from c15% in 2019 to 20% by 2025 and 62% in 2050.	China decarbonisation	
Following third quarter financial results that were negatively impacted by raw material cost inflation, Siemens Gamesa CEO Andreas Nauen has announced plans to raise wind turbine prices by 3-5% in order to defend margins. At the same time, he announced a retrenchment from the local Chinese market although the company will continue to manufacture in China for international export.	Siemens Gamesa	
General Motors have announced a recall of 73,000 of its Bolt electric vehicles due to fire risk from battery manufacturing defects. The recall is expected to cost around $1bn. The batteries were manufactured by LG Chem, the world's largest manufacturer of lithium-ion batteries, and follow a recall of batteries by Hyundai Motor Co earlier in the summer. Separately, LG Chem announced plans to power its two battery component plants in China with 100% renewable energy.	LG Chem	
A.P. Moller-Maersk ordered eight boats which will run on methanol (a derivative of hydrogen, CH3OH) in order to help decarbonise its fleet and meet increased customer demand for greener transportation. The 8 vessels, each to carry 16,000 containers, will be built by Hyundai Heavy Industries for delivery in 2024 and are expected to be 10-15% more expensive than standard vessels.	Hydrogen	
Analysis by the Centre for research on Energy and Clean Air has shown that the Chinese government approved the building of 18 steelmaking blast furnaces and 43 coal-fired power plants in the first half of this year. If built, the combined coal and steel projects would emit about 150m tonnes of carbon dioxide per year, equivalent to the total emissions of the Netherlands, according to the group. These approvals highlight the difficulty that the Chinese government faces in delivering economic growth in a low carbon manner.	China decarbonisation	

2. MANAGER'S COMMENTS

The IPCC report: positive implications for sustainable energy

The IPCC report on the state of the physical science of climate change raises significant questions about how the world will transition to achieve net zero emissions and an acceptable level of global warming. Based on their science, this month we provide a Guinness "1.5 degree scenario" for the energy industry which requires significant strengthening of policy and increases in investment and new equipment installation if it is to come to pass. Such an outcome would be highly supportive to the growth and valuation outlook for sustainable energy equities.

Last month, the Intergovernmental Panel on Climate Change (IPCC) published their sixth assessment report on the physical science of climate change. Two quotes from the report, below, state clearly the effect that human activities are having on the world's climate:

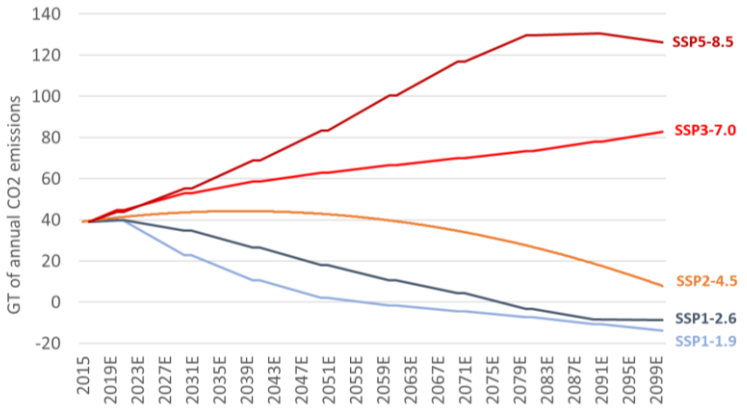
"It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred."

"Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since AR5."

The report presented five 2020-2100 scenarios linking carbon dioxide emissions to global warming temperature ranges (relative to an 1850-1900 baseline), as follows:

- Very Low (SSP1-1.9) linked to a best estimate warming of 1.4 degrees in 2100
- Low (SSP1–2.6) linked to a best estimate warming of 1.8 degrees in 2100
- Middle (SSP2–4.5) linked to a best estimate warming of 2.7 degrees in 2100
- High (SSP 3-7.0) linked to a best estimate warming of 3.6 degrees in 2100
- Very High (SSP5-8.5) linked to a best estimate warming of 4.4 degrees in 2100

Carbon dioxide emission trajectories (2015-2100) of the five IPCC scenarios



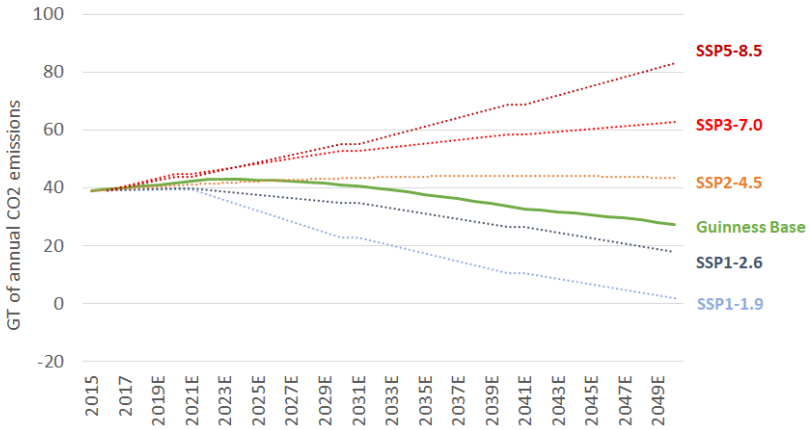
source: IPCC, Guinness Asset Management

While five scenarios are presented, the report stresses the need for policy makers to target net zero carbon dioxide emissions and to target a 1.5 degree warming scenario if the worst effects of climate change are to be avoided. The report does not set policy but it does make clear the state of play regarding the science.

The implications for sustainable energy of a 1.5 degree scenario

With the energy industry representing around 80% of global carbon dioxide emissions, the transition away from fossil fuel consumption is critical in achieving any of the lower IPCC scenarios. At Guinness, we run a long-term global energy demand model in which we forecast the underlying drivers of energy demand by hydrocarbon fuel type (oil, coal and natural gas) as well as new installations and generation of renewable power, grid storage, carbon capture and hydrogen generation. Our current base case model creates a carbon dioxide emission profile that is somewhere between SSP1-2.6 and SSP2-4.5 and, interpolating with the IPCC report based on total additional carbon emissions of around 1,200 GTCO2e, it likely implies a global warming effect of around 2.3 degrees in 2100 relative to the 1850-1990 baseline used in the IPCC report.

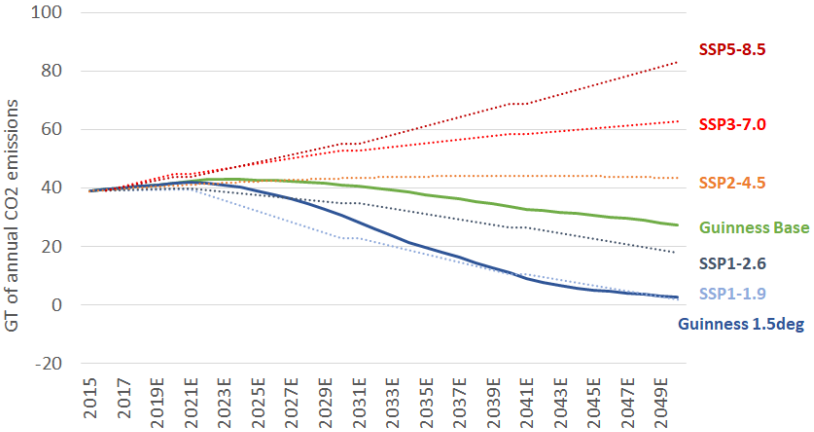
Guinness base case versus the five IPCC carbon dioxide emission trajectories (2015-2050)



source: IPCC, Guinness Asset Management

Our base case scenario, we believe, is one that reflects **a high growth and ambitious scenario** for clean energy development but, despite high investment and a fast pace of transition, it is one that still not consistent with the 2016 Paris Agreement, which targets global warming of well less than 2 degrees, and preferably to 1.5 degrees above pre-industrial levels. To assess what would be needed for a 1.5 degree warming trajectory, we have stress tested the key inputs into our energy demand model and have created a new scenario (the "Guinness 1.5 degree" scenario) that sits between the IPCC Very Low (SSP1-1.9) and Low (SSP1-2.6) scenarios discussed above.

The "Guinness 1.5 degree" scenario versus other carbon dioxide emission trajectories (2015-2050)



source: IPCC, Guinness Asset Management

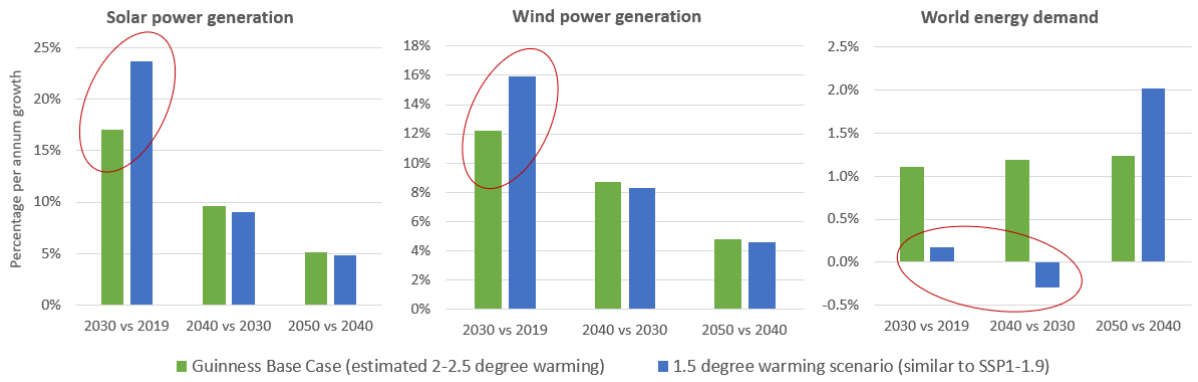
The "Guinness 1.5 degree" scenario tracks closely to the Low SSP1-2.6 scenario until the late 2020s - as it is difficult to transition world energy demand away from fossil fuels quickly enough to get to the SSP1-1.9 scenario - before then accelerating in order to track the Low SSP1.19 scenario from the late 2030s, as the full benefits of the energy transition come to bear on the global energy system. We find it difficult to create a scenario that achieves decarbonisation faster than this one unless energy demand falls sharply and global economic growth is negatively impacted in the coming decade. This scenario uses an additional carbon budget of around 700 GTCO2e by 2050 and implies an overall warming of around 1.5 degrees in 2100 relative to the 1850-1990 baseline.

The role of renewable power in the "Guinness 1.5 degree" scenario

To achieve the rapid transition from hydrocarbons to renewable energy sources, we would need to see a rapid market share increase of both wind and solar power generation together with a marked reduction in world energy demand growth.

- Solar power generation would need to grow at a rate of around 24%pa in the 2020s while wind would need to grow at a rate of around 16%pa, with both these rates being substantially higher than our base case estimates of 17%pa and 12%pa respectively. Thereafter, we would expect to see similar long term growth rates to our base case, although power generation from both wind and solar would end up in 2050 around 50% higher than our base case estimate.
- However, just adding new renewable power does not reduce carbon emissions, so this low carbon build out would need to be joined with world energy demand growth falling from our base case forecast rate of around 1%pa (a lower rate than the 30yr historical average of around 1.9%pa) to around zero over the next twenty years. It is our opinion that achieving energy efficiency of this order would be substantially more difficult than achieving the build out of new solar and wind power.

Solar, wind power generation and world energy demand growth rates over coming decades



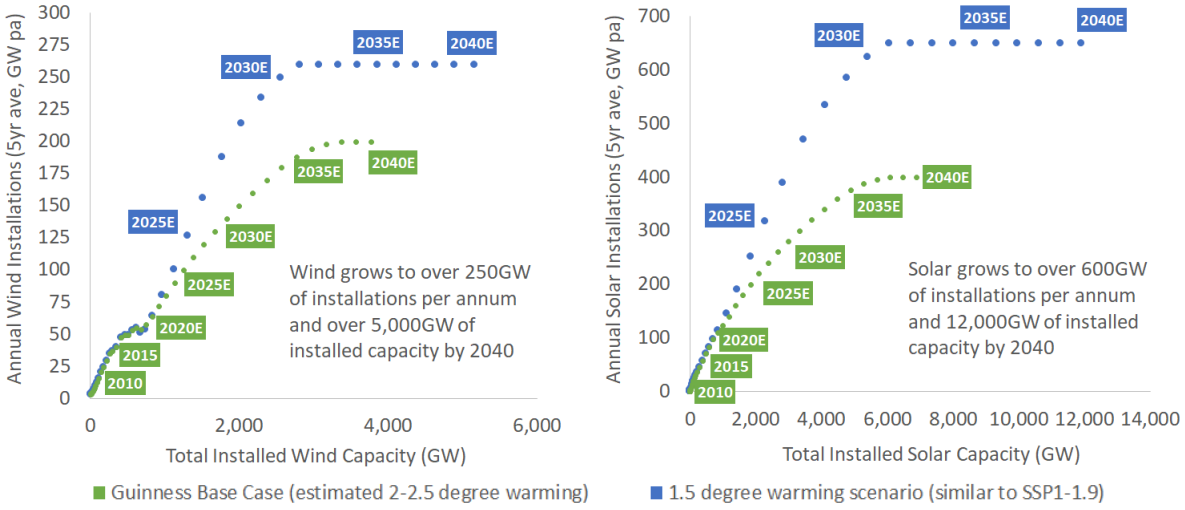
Source: IPCC, IEA, Guinness Asset Management

Implications for sustainable energy investment and equipment needs

The scale of investment required is significant and substantially higher than that seen in previous years. On our estimates, it is likely to be around $4.5-5trn per annum over the next thirty years (versus $2trn pa over the last five years) and this estimate is broadly in line with the estimates of the IEA. The investment satisfies a rapid build out of new equipment across the sustainable energy spectrum.

- For solar, our scenario implies the need for installations to increase from 98GW in 2019 (pre-COVID impacts) to 650GW in 2030, representing a doubling from our prior base case solar installation assumptions and a compound annual growth rate in installations of over 22%pa. Total installed capacity would need to reach 12,000GW in 2040 (from 586GW in 2019), reflecting a near-doubling versus our base case scenario.
- For wind, our scenario implies the need for installations to increase from 59GW in 2019 (pre-COVID impacts) to 260GW in 2030, representing a near-doubling from our prior base case solar installation assumptions and a compound annual growth rate in installations of nearly 14%pa. Total installed capacity would need to reach over 5,000GW in 2040 (from 623GW in 2019), reflecting a near 40% increase versus our base case scenario.

Solar and wind annual installations and installed capacity



There are of course a number of other implications across the broader sustainable energy technology spectrum as well. For example, the rapid growth in variable renewable power generation would require significant growth in supporting technologies and equipment, such as:

- **Electric vehicles** where sales would need to reach 77 million units in 2030 (representing 72% of all new global vehicle sales in that year) versus our current base case estimate of 52 million vehicles (representing 48% of new sales). The annual growth in EV sales would be nearly 40%pa during the 2020s
- **Energy storage** for global power grids, currently at around 6GW globally, where capacity would need to increase to around 670GW in 2030 (a growth rate of more than 50%pa in the 2020s) before reaching around 1,500GW in 2040
- **Carbon capture utilisation and storage** (CCUS) and **hydrogen** technologies where very rapid growth would be likely but where their trajectories are less certain because of their current uneconomic nature. We could conservatively see low-carbon hydrogen production increasing 50x by 2050 and demand for CCUS growing to over 6 GTCO2e by 2050 (from close to zero currently) if they can both achieve the required economies of scale.

In conclusion, the global energy transition is in progress and happening because of improved economics and supportive political will but, based on this recent work of the IPCC, the pace of the transition is just not sufficient to offset further global warming. Achieving a 1.5 degree warming scenario will require a substantially faster and more aggressive energy transition than our base case

forecast and it is one which, based on our current understanding of sustainable energy technologies, investment and policies is very unlikely without significant policy enhancements and substantially higher investment. Should this "inevitable policy response" happen and the required investment follow, then the very attractive growth rates mentioned above should happen and the implications for sustainable energy equities are positive.

3. PERFORMANCE - Guinness Sustainable Energy Fund

The Guinness Sustainable Energy fund (Class Y, 0.74% OCF) delivered a return of 3.5% in the month, while the MSCI World Index (net return) delivered 2.5% (all in USD terms).

Past performance does not predict future returns.

Performance overview (31 August 2021)

	1 month	3 months	6 months	1 year	YTD	Dec 31 2018 *
Guinness Sustainable Energy Fund (Class Y)	3.5%	8.8%	8.3%	55.1%	11.9%	170.7%
MSCI World NR Index	2.5%	5.9%	16.1%	29.8%	17.9%	74.5%
Outperformance/Underperformance	*1.0%*	*2.9%*	*-7.8%*	*25.3%*	*-6.0%*	*96.2%*

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

Performance overview (31 August 2021)

1 year rolling performance to		Aug-21	Aug-20	Aug-19	Aug-18**	Aug-17**
Guinness Sustainable Energy Fund (Class Y)		55.1%	52.9%	0.9%	2.5%	0.8%
MSCI World NR Index		29.8%	16.8%	0.3%	13.1%	16.2%
Outperformance/Underperformance		*25.3%*	*36.2%*	*0.7%*	*-10.6%*	*-15.4%*

Monthly performance record (31 August 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%	-1.4%	0.4%	0.5%	4.0%	1.1%	3.5%					11.9%
MSCI World NR Index	-1.0%	2.6%	3.3%	4.7%	1.4%	1.5%	1.8%	2.5%					17.9%
Relative	*5.5%*	*-3.6%*	*-4.7%*	*-4.3%*	*-0.9%*	*2.5%*	*-0.7%*	*1.0%*					*-6.0%*

***Simulated Past Performance prior to 16/02/2018. The Performance shown is a composite simulation for Y class performance being based on the actual performance of the Fund's E class, which has an OCF of 1.24%, and has existed since the Fund's launch. 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).*

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) of 0.74%; returns for share classes with a different OCF will vary accordingly.

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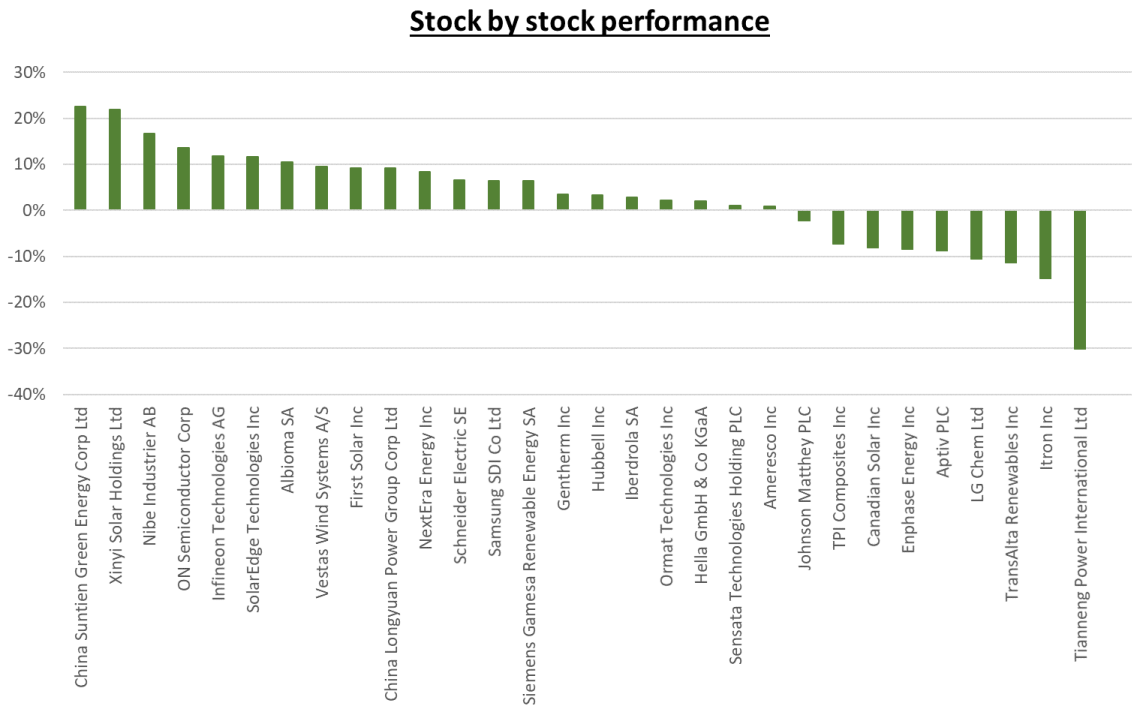
Within the Fund, the strongest performers were China Suntien Green Energy, Xinyi Solar Holdings, Nibe Industrier, ON Semiconductor and Infineon Technologies while the weakest performers were Tianneng Power International, Itron, TransAlta Renewables, LG Chem and Aptiv.

Stock by Stock performance over the month, in USD

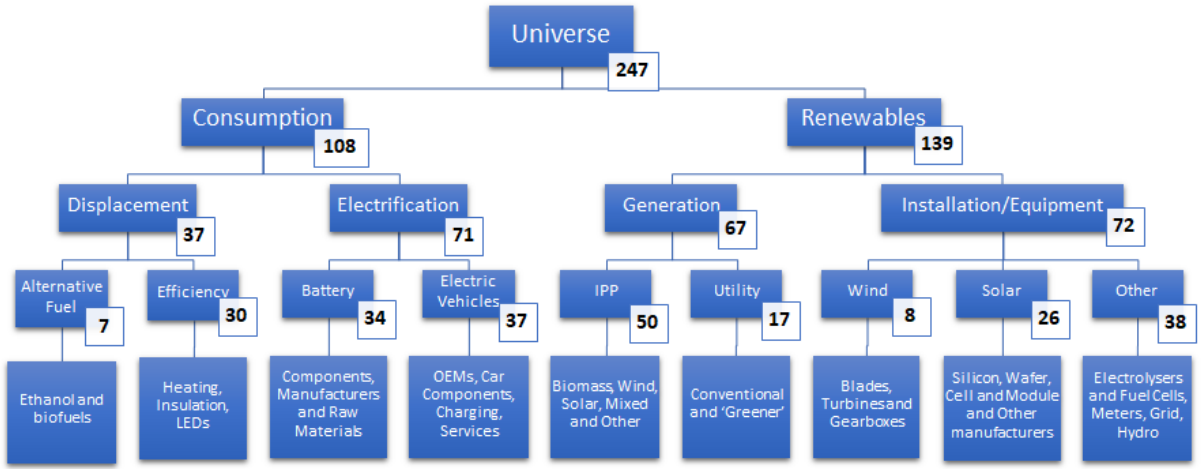


Source: Bloomberg. As of 31 August 2021

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 250 companies which are classified into four key areas:

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



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

Guinness 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.

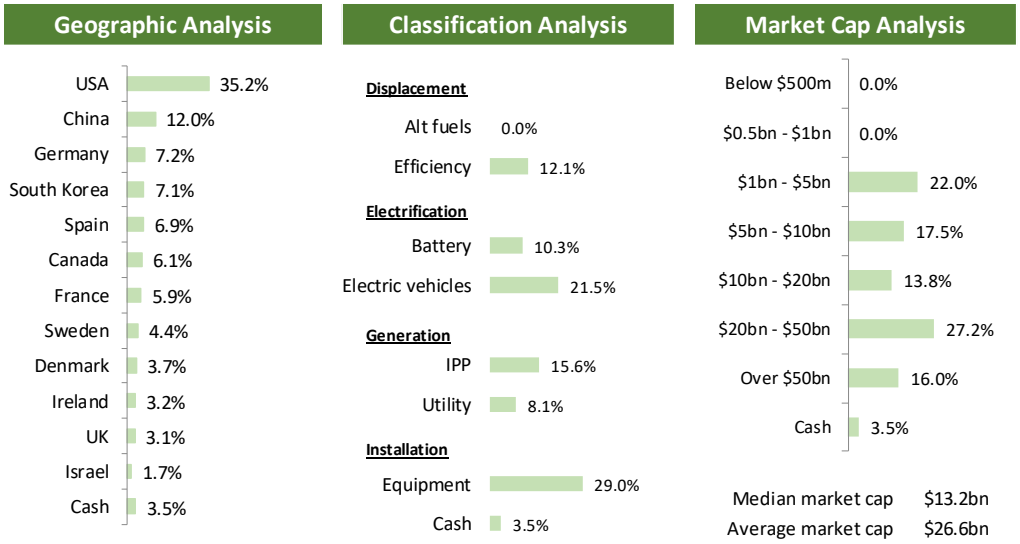
IFC International Finance Corporation WORLD BANK GROUP

Signatory of: PRI Principles for Responsible Investment

Buys/Sells

There were no stock switches during the month, 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	
	Aug-21		Dec-20	Dec-19	Dec-18
Consumption	**43.9%**	***7.2%***	**36.7%**	**41.7%**	**26.5%**
Displacement	12.1%	*2.2%*	9.9%	13.4%	16.4%
Alternative Fuel	*0.0%*	*0.0%*	*0.0%*	*0.0%*	*3.9%*
Efficiency	*12.1%*	*2.2%*	*9.9%*	*13.4%*	*12.5%*
Electrification	31.8%	*5.0%*	26.8%	28.2%	10.1%
Batteries	*10.3%*	*-0.5%*	*10.8%*	*12.6%*	*3.9%*
Electric vehicles	*21.5%*	*5.5%*	*16.0%*	*15.7%*	*6.2%*
Renewables	**52.6%**	***-7.8%***	**60.4%**	**54.1%**	**69.7%**
Generation	23.7%	*-0.9%*	24.6%	22.2%	27.3%
IPP	*15.6%*	*-1.4%*	*17.0%*	*18.9%*	*26.7%*
Utility	*8.1%*	*0.5%*	*7.6%*	*3.2%*	*0.6%*
Installation	29.0%	*-6.8%*	35.8%	32.0%	42.5%
Equipment	*29.0%*	*-6.8%*	*35.8%*	*32.0%*	*42.5%*
Cash	3.5%	*0.5%*	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 31 August 2021	P/E			EV/EBITDA			Dividend Yield		EPS Growth		CFROI*		
	2020	2021E	2022E	2020	2021E	2022E	2021E	2022E	2014-19	2019-23	2020	2021E	2022E
Guinness Sustainable Energy Fund	36.5x	25.6x	22.2x	17.6x	14.4x	12.5x	1.1%	1.2%	6.6%	14.0%	5.0%	7.2%	8.2%
MSCI World Index	38.1x	20.3x	18.9x	19.1x	13.6x	12.7x	1.8%	1.9%	3.8%	10.7%	6.8%	8.2%	8.5%
Fund Premium/(Discount)	*-4%*	*26%*	*17%*	*-8%*	*6%*	*-2%*							

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

Source: Guinness Asset Management; Bloomberg

Portfolio holdings, as at end July 2021

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

We hold c.44% weight to companies associated with the consumption (or demand) of sustainable energy. Our largest exposure here is to companies involved in the electrification of demand, either via the creation of new batteries (10%) or the electrification of transportation (22% weight) while we have 12% 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 represents the only non-lithium-ion battery exposure in the portfolio.

The portfolio holds six 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 and Infineon are providers of power semiconductors that are a necessity for higher voltage electric vehicles to become competitive with ICE (internal combustion engine) vehicles while Gentherm, 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 24% weight to companies involved in the generation of sustainable energy and 29% 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 hold exposure to the solar and wind equipment and manufacturing value chains. Xinyi Solar is the world's largest supplier of the glass used in solar cell modules and both EnPhase and SolarEdge manufacture the inverters required to convert DC solar power into consumable 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 August 2021

	Theme	Example holdings	Weighting (%)
1	Electrification of the energy mix	TransAlta renewables, NextEra Energy	18.7%
2	Rise of the electric vehicle and auto efficiency	Sensata Technologies, APTIV	24.6%
3	Battery manufacturing	Samsung SDI	7.2%
4	Expansion of the wind industry	tpi composites, Vestas	15.9%
5	Expansion of the solar industry	CanadianSolar	13.8%
6	Heating, lighting and power efficiency	NIBE Industrier	12.1%
7	Geothermal and biomass	ORMAT, ALBIOMA	4.2%
8	Other (inc cash)		3.5%

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

Guinness Sustianable Energy Fund (31 July 2021)			P/E			EV/EBITDA			Price/Book			Dividend Yield		
Stock	% of NAV	Market Cap USD	2020	2021E	2022E	2020	2021E	2022E	2020	2021E	2022E	2020	2021E	2022E
Displacement/Efficiency														
Hubbell Inc	3.9%	10,901	26.4x	23.5x	21.1x	17.3x	16.0x	14.3x	5.3x	4.8x	4.4x	1.8%	1.9%	2.1%
Nibe Industrier AB	4.0%	24,099	79.7x	68.7x	62.9x	44.1x	39.4x	36.7x	10.4x	10.4x	9.4x	0.4%	0.4%	0.6%
Ameresco Inc	3.8%	3,514	68.5x	53.2x	44.6x	33.0x	25.9x	22.2x	7.0x	5.3x	4.9x	n/a	n/a	n/a
	11.6%													
Electrification/Battery														
LG Chem Ltd	3.5%	51,615	42.9x	15.4x	19.3x	14.0x	8.1x	8.5x	3.3x	2.9x	2.6x	1.0%	1.2%	1.3%
Samsung SDI Co Ltd	3.9%	44,247	81.3x	46.1x	35.1x	28.5x	22.6x	18.0x	3.8x	3.6x	3.3x	0.1%	0.2%	0.2%
Johnson Matthey PLC	3.2%	7,994	16.5x	16.8x	12.1x	10.4x	9.7x	7.9x	2.3x	1.9x	1.9x	2.0%	1.9%	2.7%
Tianneng Power International Ltd	0.2%	2,156	7.0x	5.2x	4.6x	3.0x	2.5x	2.2x	1.7x	1.3x	1.0x	4.1%	3.7%	4.1%
	10.7%													
Electrification/Electric Vehicles														
Aptiv PLC	3.9%	45,127	93.1x	44.7x	32.1x	29.9x	19.2x	15.8x	6.1x	5.3x	4.7x	0.1%	0.1%	0.3%
ON Semiconductor Corp	3.4%	16,679	49.3x	16.1x	14.5x	18.8x	10.5x	9.2x	4.7x	4.2x	3.4x	n/a	n/a	n/a
Infineon Technologies AG	3.3%	49,767	52.3x	28.1x	23.8x	21.9x	14.6x	12.8x	4.0x	3.8x	3.5x	0.8%	0.8%	1.0%
Sensata Technologies Holding PLC	3.4%	9,284	27.6x	16.5x	14.3x	17.0x	12.3x	11.1x	3.4x	3.1x	2.6x	n/a	n/a	n/a
Hella GmbH & Co KGaA	3.7%	7,782	42.5x	20.3x	18.2x	9.8x	8.1x	7.1x	2.7x	2.8x	2.5x	0.3%	1.4%	1.7%
Gentherm Inc	3.7%	2,750	45.3x	21.5x	19.1x	20.6x	13.0x	11.4x	5.0x	3.8x	n/a	n/a	n/a	n/a
	21.4%													
Generation/IPP														
NextEra Energy Inc	4.0%	152,821	34.0x	30.9x	28.6x	20.4x	19.6x	17.3x	3.8x	3.5x	3.4x	1.8%	2.0%	2.2%
China Longyuan Power Group Corp Ltd	4.3%	15,012	20.3x	16.7x	14.5x	10.6x	9.6x	8.4x	1.8x	1.6x	1.4x	1.0%	1.2%	1.4%
Ormat Technologies Inc	2.4%	3,904	41.0x	50.9x	34.4x	11.2x	11.3x	9.3x	2.4x	2.2x	2.1x	0.7%	0.7%	0.8%
TransAlta Renewables Inc	4.1%	4,700	51.3x	28.7x	26.9x	14.6x	13.5x	12.9x	2.7x	2.8x	2.9x	4.2%	4.3%	4.3%
Albioma SA	1.7%	1,275	20.9x	19.0x	17.6x	9.3x	9.0x	8.6x	2.3x	2.2x	2.1x	2.5%	2.6%	2.8%
China Suntien Green Energy Corp Ltd	3.2%	4,773	9.4x	6.5x	6.0x	15.9x	11.9x	9.9x	0.9x	0.8x	0.7x	4.3%	5.4%	6.0%
	19.7%													
Generation/Utility														
Iberdrola SA	3.6%	76,703	17.7x	17.4x	15.7x	11.7x	11.2x	10.3x	1.5x	1.7x	1.6x	4.2%	4.3%	4.6%
	3.6%													
Installation/Equipment														
Schneider Electric SE	4.0%	95,352	32.5x	24.6x	22.3x	20.7x	16.9x	15.5x	3.6x	3.6x	3.4x	1.8%	2.0%	2.1%
Itron Inc	3.3%	4,451	65.5x	40.7x	31.1x	28.4x	21.8x	17.4x	10.1x	3.4x	3.1x	n/a	n/a	n/a
Xinyi Solar Holdings Ltd	3.4%	17,840	30.4x	23.9x	22.3x	21.4x	17.2x	16.3x	6.4x	4.6x	3.9x	1.5%	1.8%	1.9%
SolarEdge Technologies Inc	1.6%	13,487	65.4x	52.4x	39.4x	55.2x	38.2x	28.8x	12.6x	10.5x	8.6x	n/a	n/a	n/a
Enphase Energy Inc	2.0%	25,524	149.5x	94.9x	71.4x	122.2x	79.0x	54.6x	52.1x	36.2x	25.9x	n/a	n/a	n/a
First Solar Inc	3.5%	9,148	22.5x	20.1x	28.6x	18.4x	14.4x	16.1x	1.7x	1.5x	1.5x	n/a	n/a	n/a
Canadian Solar Inc	2.8%	2,415	24.5x	28.6x	11.7x	12.8x	10.9x	7.1x	1.4x	1.3x	1.1x	n/a	n/a	n/a
Vestas Wind Systems A/S	3.3%	37,222	50.2x	38.5x	30.6x	20.8x	16.5x	14.1x	8.4x	6.0x	4.9x	0.6%	0.7%	0.9%
Siemens Gamesa Renewable Energy SA	2.8%	18,983	n/a	n/a	60.7x	53.4x	36.7x	17.4x	3.0x	3.5x	3.4x	0.0%	0.1%	0.1%
TPI Composites Inc	1.3%	1,437	n/a	n/a	32.2x	16.7x	18.8x	11.0x	7.4x	8.9x	6.7x	n/a	n/a	n/a
	28.0%													

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

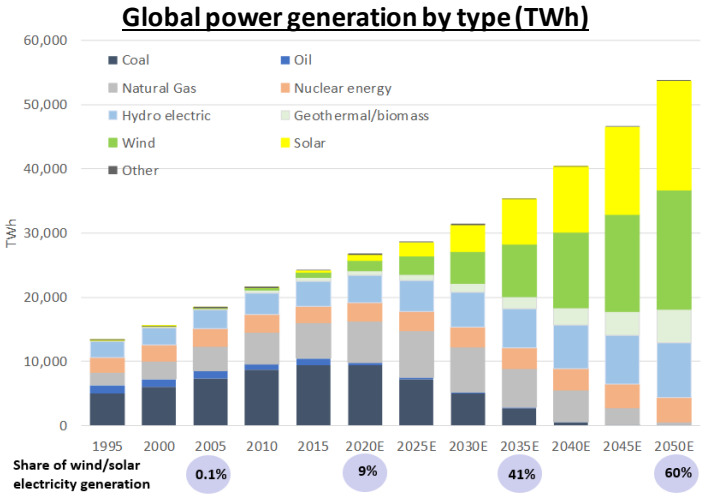
Sustainable energy: the long term and the effect of COVID

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.



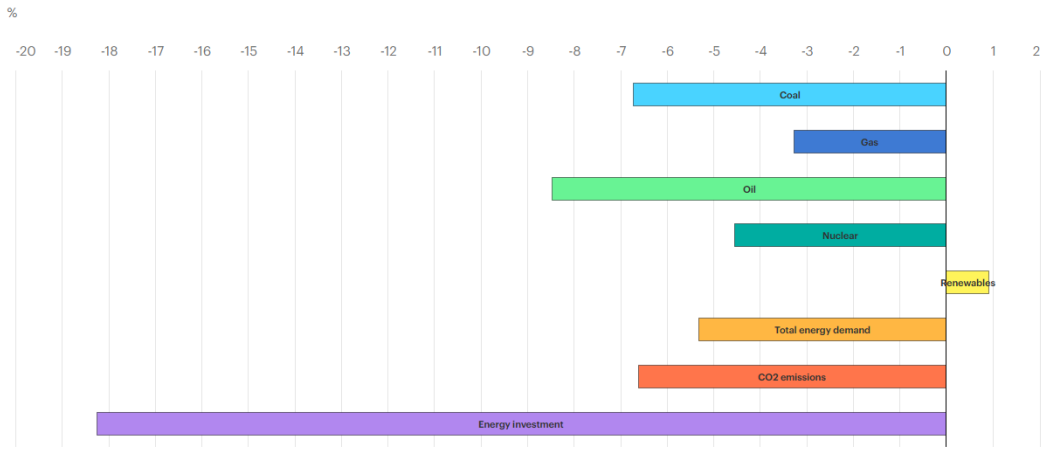
Sources: BP Statistical Review; Guinness Asset Management forecasts

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 CO2 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.

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



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 proposed investment to support an acceleration globally towards energy efficiency, electrification and clean energy, all of which are core themes in the energy transition.

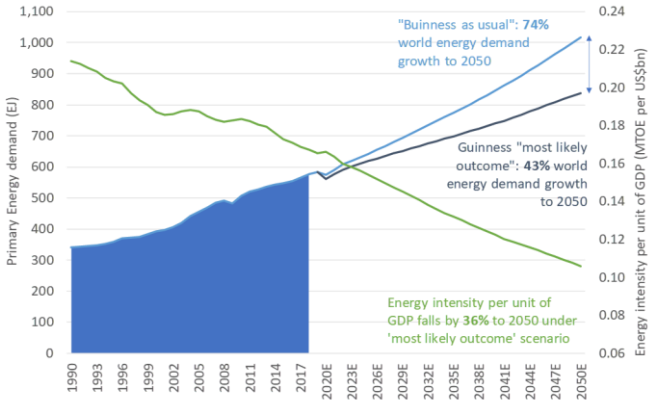
At the end of March 2021, President Biden unveiled a $2.25 trillion "Build Back Better" spending plan. The plan included significant incentives for sustainable energy, including a ten-year extension of the solar investment tax credit (the ITC, which currently expires at the end of 2023) and the inclusion of energy storage projects within the extended ITC. The plan also includes the building of a network of 500,000 EV chargers by 2030, up from about 40,000 currently.

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 have improved 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 expected 0.8% improvement in energy efficiency in 2020 would mean 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.

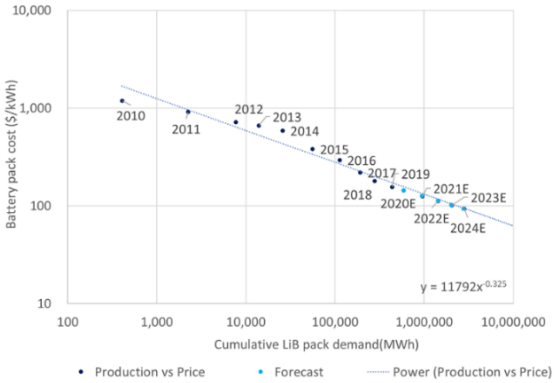
Electrification: lithium-ion batteries and electric vehicles

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.

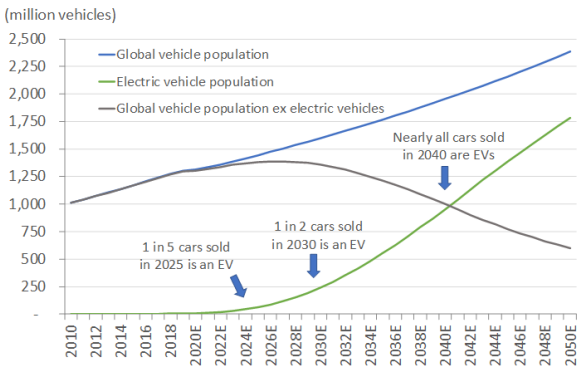
The catalyst for greater **lithium-ion battery** use has been sharp falls in the cost of manufacturing. According to BNEF, battery costs are down 89% over the decade from 2010 to 2020 (an implied 'learning rate' of around 18%) with the average cost being $137/kWh in 2020. Significant economies of scale 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 ICE 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

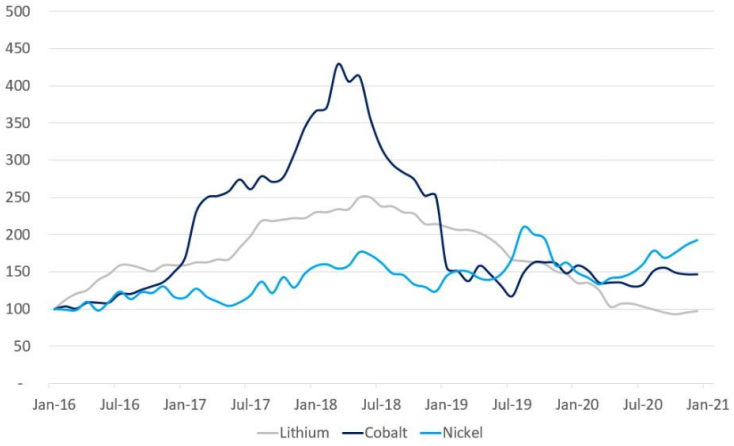
The demand for lithium-ion batteries in **grid (stationary) storage** is likely to grow very rapidly as the cost of delivering a 'renewable + storage' power system improves. Higher levels of variable renewable power in many electricity grids is resulting in low intraday power prices and incentivising 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.

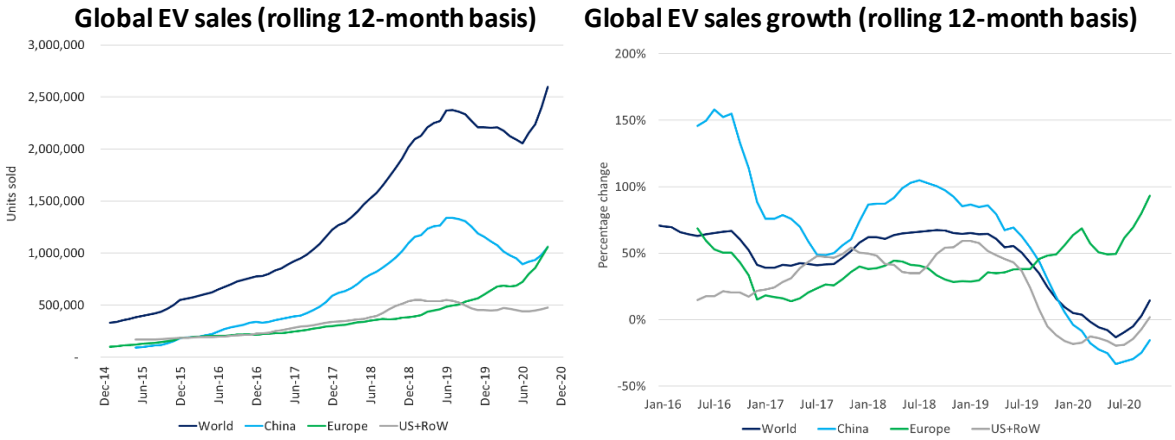
Lithium Carbonate, Nickel and Cobalt prices ($/MT, indexed to 100, Jan 2016)



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.



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 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.

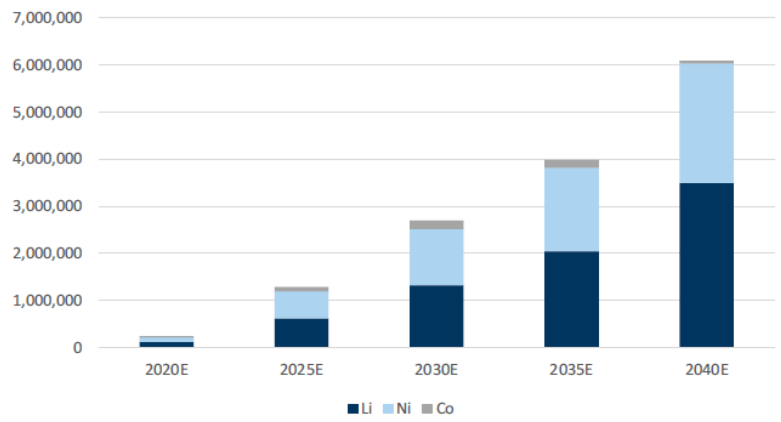
Outlook for 2021 and beyond: rapid growth across batteries, EVs and stationary storage

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.

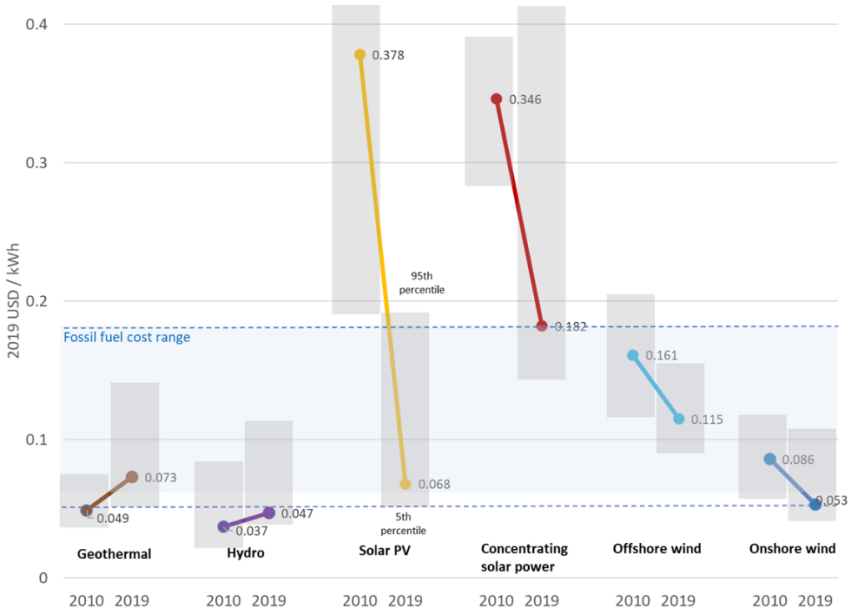
The recent growth trends for **electric vehicles** will continue through 2021 supported by clear commitments from governments towards the electrification of transportation. We expect new EV sales to be in excess of 4m vehicles in 2021, up over 50% versus 2020 sales and representing around 5% of global 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)



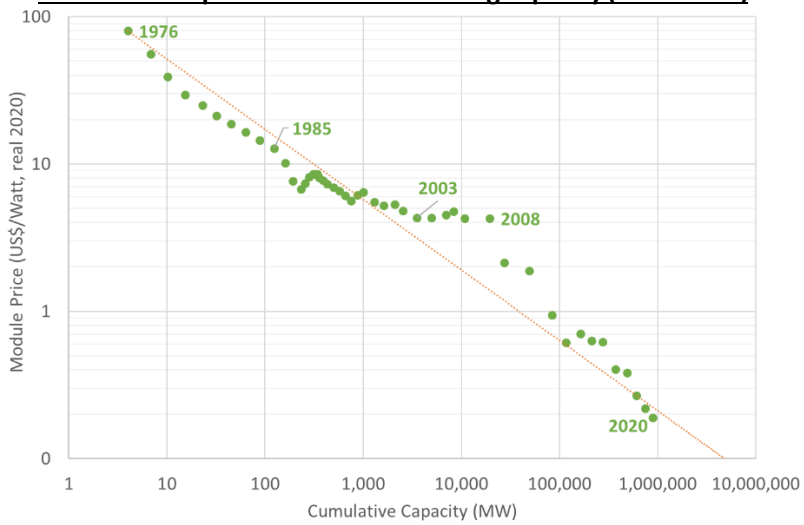
*Source: IRENA; Guinness Asset Management. *LCOE – The levelized cost of energy, also referred to as the levelized cost of electricity or the levelized energy cost (LEC), is a measurement used to assess and compare alternative methods of energy production. The LCOE of an energy-generating asset can be thought of as the average total cost of building and operating the asset per unit of total electricity generated over an assumed lifetime.*

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 52 GW in a global total of 141 GW.

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

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021E
OECD solar installations (annual)												
North America	1	2	4	6	7	8	14	11	10	11	17	22
Germany	7	7	8	3	2	1	2	2	4	4	5	5
Italy	4	8	4	1	0	0	0	0	0	1	1	1
Spain	0	0	0	0	0	0	0	0	0	5	3	4
Rest of Europe	3	4	5	5	5	6	4	3	4	6	8	10
Australia	0	1	1	1	1	1	1	2	4	4	4	4
South Korea	0	0	0	1	1	1	1	1	2	3	4	4
Japan	1	1	2	7	10	11	8	8	7	7	8	6
Total OECD	**17**	**23**	**24**	**24**	**25**	**29**	**29**	**26**	**31**	**40**	**49**	**55**
Change in OECD annual installations	*10*	*7*	*0*	*0*	*2*	*4*	*0*	*-3*	*5*	*9*	*9*	*6*
Non-OECD solar installations (annual)												
China	0	3	3	14	13	19	30	53	44	33	52	70
India	0	0	1	1	1	2	5	10	11	12	4	11
Rest of non-OECD	1	3	3	4	6	6	11	9	22	34	40	48
Total Non-OECD	**2**	**5**	**8**	**18**	**21**	**27**	**46**	**72**	**77**	**78**	**92**	**129**
Change in non-OECD annual installations	*1*	*3*	*2*	*11*	*2*	*6*	*19*	*26*	*5*	*1*	*14*	*37*
Total solar installations (annual)	**19**	**29**	**31**	**42**	**46**	**56**	**75**	**98**	**108**	**118**	**141**	**184**
Change in world annual installations	*11*	*10*	*2*	*11*	*4*	*10*	*19*	*23*	*10*	*10*	*23*	*43*

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:

- **Polysilicon** 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%.

- **Polysilicon wafer manufacturing** remained significantly in excess of polysilicon 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.

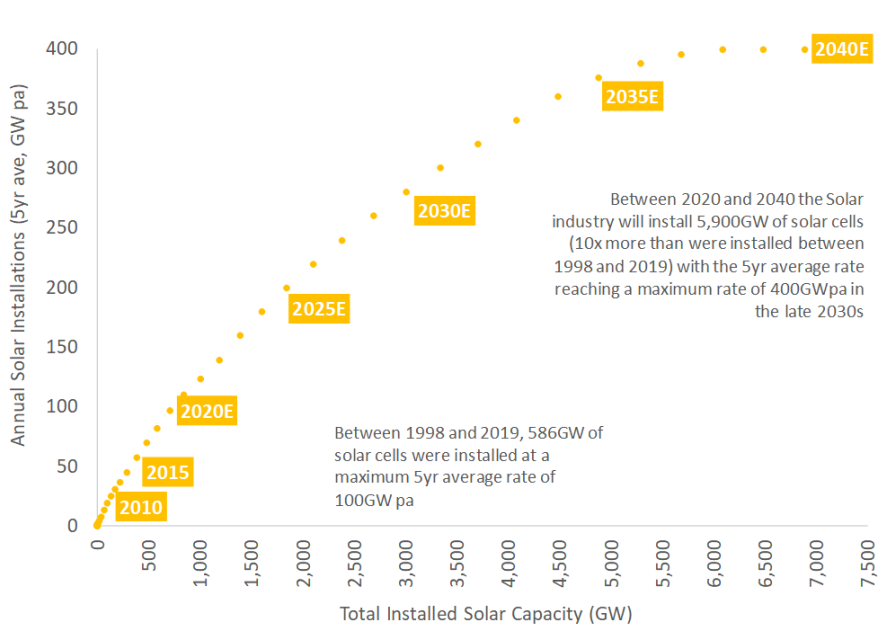
Solar module installations on a global basis were much less affected by COVID than initially feared. In the middle of the crisis, it was mooted that the rate of global installations would decline in 2020, registering the first year of module installation rate declines in recent history. Ultimately, new installations increased by 23 GW in 2020, to reach 141 GW. **China** was the largest market globally with installations averaging around 52 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 49 GW, was 20% 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 184 GW in 2021, up 43 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 our 70 GW estimate at risk if prices rise. **India** solar module demand is likely to be around 11GW, up 7 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 20-25 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. Most forecasters expected total onshore installations to be around 71 GW in 2020 (up 19 GW on 2019 and 26 GW on 2018 levels respectively) but recent data from the Global Wind Energy Council (GWEC) indicates that onshore installations were as high at 87 GW in 2020. We expect further clarity over time but note that any growth surprise in 2020 will likely not be repeated again in 2021. Onshore installations in China surprised to the upside during 2020 (at 49 GW according to GWEC), 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

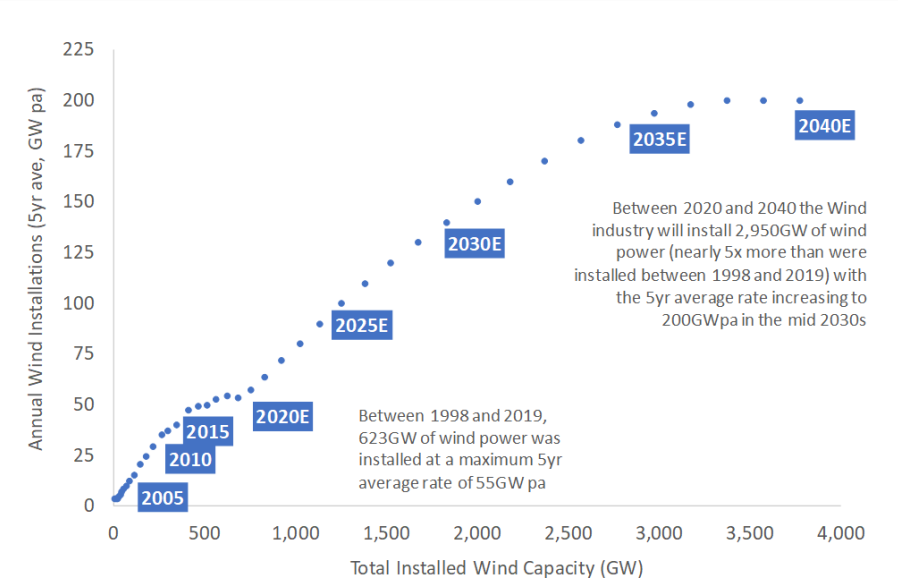
In 2021, global **onshore wind** installations are expected to plateau at around 73 GW (up around 2 GW on 2019 levels). The reason for the decline is mostly China, where wind projects have yet to fully reach the grid parity requirements that are necessary within the 14th Five Year Plan. Excluding China, the global onshore market will remain robust, 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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