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NATURAL GAS VS. RENEWABLES

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INVESTMENT RESEARCH SERIES

HOW MUCH DO LOW FOSSIL FUEL PRICES HURT WIND & SOLAR?

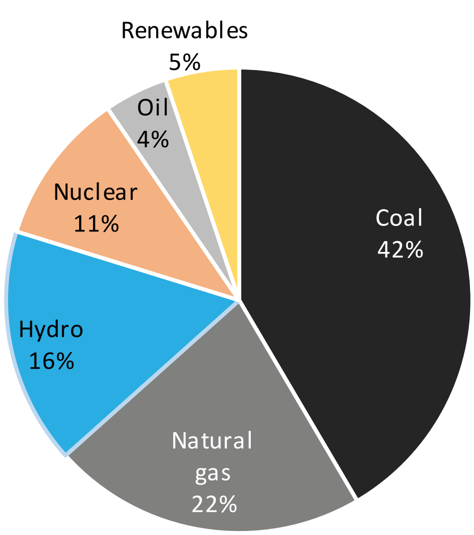
The energy sector has endured a price squeeze not seen since the 1990s. Alternative energy stocks have also suffered as part of the sell-off in energy-sector stocks over 2015 and so far in 2016. Is this fall merited given the fall in oil and natural gas prices and are the solar and wind sectors facing a real long-term threat? The main argument against using renewables has historically been that they are too expensive, but this argument has deteriorated over the last decade with dramatic reductions in the cost of renewable energy technologies. However, the recent falls in oil and, more significantly, natural gas prices have moved the goal posts for the costs that renewable energy installations need to achieve to be economically competitive.

We have analyzed levelized cost of energy (LCOE) for various technologies and shown the differences by region. Renewable energy equipment costs, natural gas prices and levels of sunshine were the major differentiator between the regions. Prior to the fall in gas prices, both wind and solar had reached a cost point where they had a competitive advantage against natural gas fired power plants. Wind and solar have lost much of their previously-gained lead over gas-fired power plants. We note that today's LCOEs – both renewables and natural gas - are at historic lows, benefiting from both low interest rates and low fuel prices. There are only limited prospects for capital cost reductions for power production from natural gas, the technology is relatively mature. Conversely, wind and solar technologies continue to fall in cost and have comparatively low running costs and free fuel.

WHO AGAINST WHOM?

Solar power in the form of photovoltaics (PV) and wind turbines generate electricity, and their main competitors are fossil-fuel-fired power plants, large and small. Coal and natural gas accounted for 64% of global electricity generation in 2013 and oil accounted for just 4% of global electricity generation. While in some island economies and the Middle East oil is an important power source, for most countries, natural gas takes a greater role as a price setter for power prices. We have therefore chosen to focus on the impact of low natural gas prices only for this report.

Global electricity generation in 2013 by fuel



Source: International Energy Agency

Power plants generally fall into one of three categories: base load, load-following and peaker plants. Base-load power generators operate continuously at close to their maximum capacity. These power plants take upwards of eight hours to power up or down, making them costly to turn on or off. Base-load plants are therefore rarely turned off other than for maintenance reasons. Coal and nuclear combined provide 52% of global electricity generation and the majority of that is from base-load power plants. Natural gas base-load power generators also exist in the form of highly-efficiency combined-cycle gas turbine (CCGT) plants.

Peaker plants are turned on and off to satisfy the additional short term demand for electricity. These plants are quick to power up and down, making them ideal for balancing quick fluctuations in electricity consumption and usually much more expensive per unit of electricity generated.

Load-following plants lie in between base-load and peaker plants in terms of start-up and shut-down times, but can be operated flexibly varying their output intraday to match demand. The cost of load-following plants also lies between that of base-load and peaker plants.

The electricity grid must be constantly balanced so that the supply of electricity matches demand, meaning there is limited space on the grid for electricity output from generators. Renewable energy plants are intermittent and are usually given priority of dispatch onto the grid. As a result, fossil-fuel-powered generators have to adjust to balance supply and demand.

Timing of power production is important when comparing renewable energy and fossil fuel LCOEs. PV only generates power when there is enough daylight (not just when it is sunny), and therefore typically replaces generation that would have been delivered from peaker plants. Peaker plants and load-following plants are predominantly natural gas plants. Wind power plants generate whenever enough (but not too much) wind blows, irrespective of day or night, meaning that they replace power that would have been generated by all three categories of fossil fuel power plants. However, wind is easily curtailable and can be turned off if needed for grid purposes.

While wind and solar may be intermittent, they are also both highly predictable in terms of output both intraday and annually. When considering the economic competitiveness of renewable energy technologies, the different categories and their costs all need to be taken into consideration. We believe that solar plants are comparable to gas peaker plants, whereas wind plants fall somewhere between peaker and base-load plants. We have not analyzed the cost of coal-fired power generation. Coal remains the cheapest form of fossil fuel generation today, but far fewer coal plants are now being built as a result of more stringent emissions regulations. Gas, which emits half the amount of carbon dioxide per unit of electricity from power generation compared to coal, has been looked at much more favorably. Gas can also be 'cleaner', as it does not harbor traces of mercury or other dangerous elements, unlike some types of coal.

Coal miners and coal power plant operators in the United States have been caught in a storm between the cheapest gas in years, a public more aware of air quality concerns and rising support for lower-emission power sources. Although unloved in the West, China continues to invest in coal plants to meet ever rising electricity demand despite experiencing severe air quality concerns. India is also racing to build as much power generation capacity as possible, mainly from coal. However, in countries with growing demand and pollution problems, there is an enthusiasm for building as much renewables as possible, and competitiveness with coal is not a major part of the economic equation.

THE REAL COMPETITION: FALLING GAS PRICES

While international prices for crude oil are broadly comparable, the natural gas market is not one single homogenous global markets due to transport constraints. Liquefied natural gas (LNG) growth is starting to equalize regional natural gas prices closer together, but full global convergence is likely to be years away. Japan has historically had much higher natural gas prices than Europe, who in turn have had much higher natural gas prices than the US.

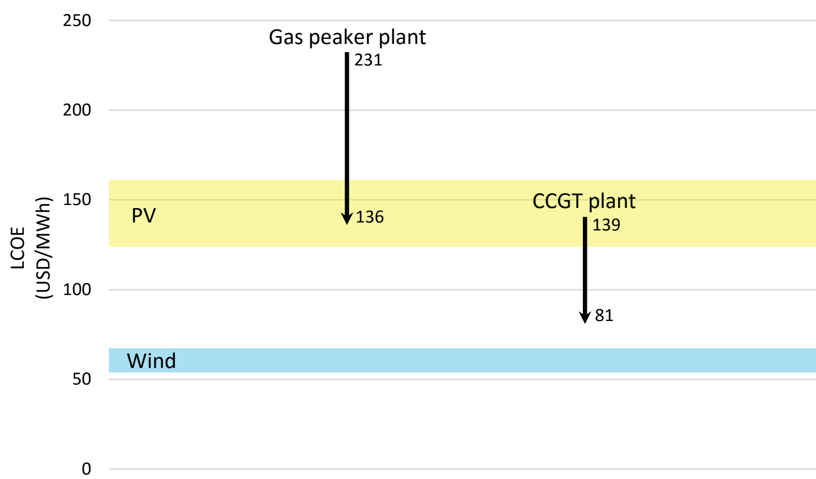
Our LCOE analysis takes these different natural gas prices, utility-scale renewable energy installation costs and costs of capital as a basis for comparison. To view all of our assumptions, please see the assumptions table in the appendix.

JAPAN

After the Fukushima disaster of 2011, Japan has tried to veer away from nuclear power and has turned to renewable energy and natural gas to compensate. However, Japan does not have natural gas resources and buys most of its natural gas in the LNG market.

The LNG price that Japan pays has dropped from circa (c.) $16 per one million British Thermal Units (MMBtu) in 2013 to c.$8 per MMBtu today. Solar and wind power in Japan have historically been expensive, but not for technological reasons. Rather, local manufacturers have taken advantage of the language and cultural barrier for foreign companies to maintain high solar installation costs. This has been supported by very low interest rates and some of the most generous feed-in tariffs for renewable energy.

Japan CCGT and gas peaker plant LCOE vs. Wind and PV LCOE
(high & low fuel price scenarios)



Note: Assumptions in appendix and footnote[1]

Source: Lazard LCOE of energy 2015, Bloomberg, Guinness Atkinson Asset Management; MWh = megawatt/hour

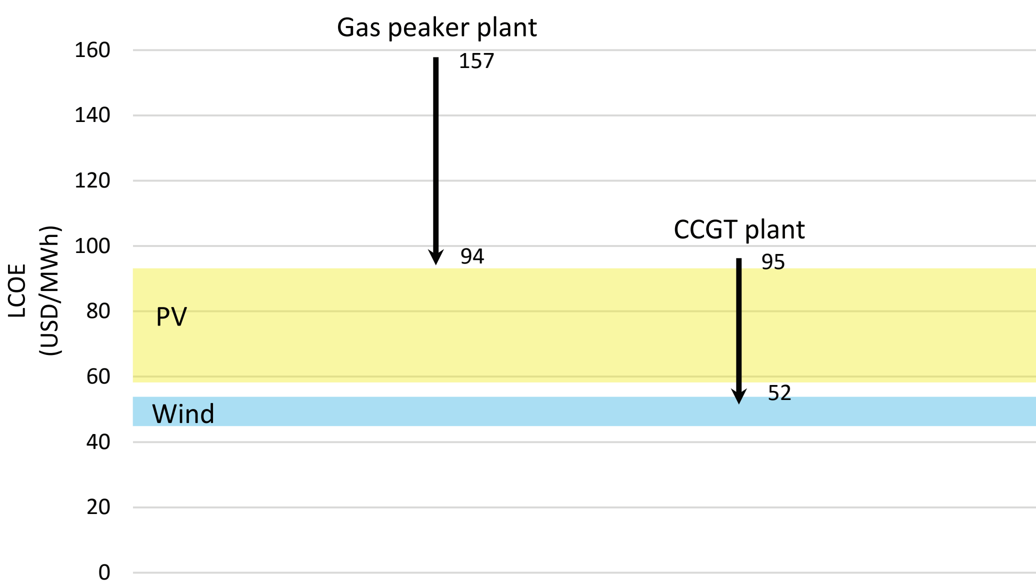
As a result of the high natural gas prices, solar in Japan had reached competitiveness with baseload CCGT plant, and was meaningfully cheaper than gas peaker plants which we see as the more relevant comparator. While the decline in the LNG price in Japan means that PV is no longer directly competitive with baseload CCGT plants, utility-scale PV remains competitive with gas peaker plants. However, with feed-in tariff reductions on the horizon, PV installation costs are expected to fall as Chinese panels dominate and foreign installers gain market share. If Japanese PV installation costs were to match current Chinese installation costs, representing a fall of 40% in capex, then this would bring solar costs in line with estimated CCGT costs, with natural gas at $8 per MMBtu, and would again make solar much cheaper than gas peaker plants. Wind, however, has so far remained cheaper than both gas peaker and CCGT plants throughout the decrease in Japanese gas prices. However, Japanese onshore wind installations are limited by grid and land availability constraints. The country is looking into developing offshore wind.

[1] For PV we assume a capex of $1.5/ watt peak (Wp), PV operating & maintenance (O&M) costs of $30,000/megawatt(MW)-year, capacity factors of 10-13%, weighted average cost of capital (WACC) of 4.5%. For wind we assume a capex of $1.3/Wp, O&M costs of $20,000/MW-year, capacity factors of 20-25% and WACC of 4.5%. For the gas plants we assume a gas price of $16/MMBtu and $8/MMBtu and a 8.5% WACC. For the gas peaker plants we assume a capex of $0.8/Wp, fixed O&M costs of $5,000/MW-year, variable O&M cost of $4.5/MWh and load factor of 20%. For the CCGT plants we assume a capex of $1/W, fixed O&M costs of $5,400/MW-year, variable O&M costs of $2.5/MWh and load factor 60%.

EUROPE

Europe has dramatically increased the renewable share of electricity supply in the last decade. The region has also experienced a fall in the UK National Balancing Point (NBP) natural gas price from c.$12 per MMBtu in [2013] to c.$5 per MMBtu today. Nevertheless, low installation costs for renewables mean that utility-scale PV remains cheaper than gas peaker plants, but slightly more expensive than baseload CCGT plants. Europe is increasing quantities of imported LNG as a way to decrease dependence on Russian gas, and will become more exposed to LNG prices. The fall in the gas price in Europe has propelled the LCOE of CCGT plants downwards to match current wind costs. Nonetheless, wind turbine manufacturers are lowering costs further, which should allow wind to remain cheaper than CCGT plants in future. Furthermore, around 7 gigawatts (GW) of German wind power was installed before 2004, meaning these plants could be 'repowered' over the next eight years as they reach the end of their original planned 20-year life. Repowering is where old turbines are exchanged for newer, more efficient turbines rather than repairing the old turbines. These new turbines cost less to install as they can take advantage of the existing civil engineering work (foundations, roads). As more plants are 'repowered' wind power will likely remain cheaper than CCGT in Europe.

Europe CCGT and gas peaker plant LCOE vs. Wind and PV LCOE (high & low fuel price scenarios)

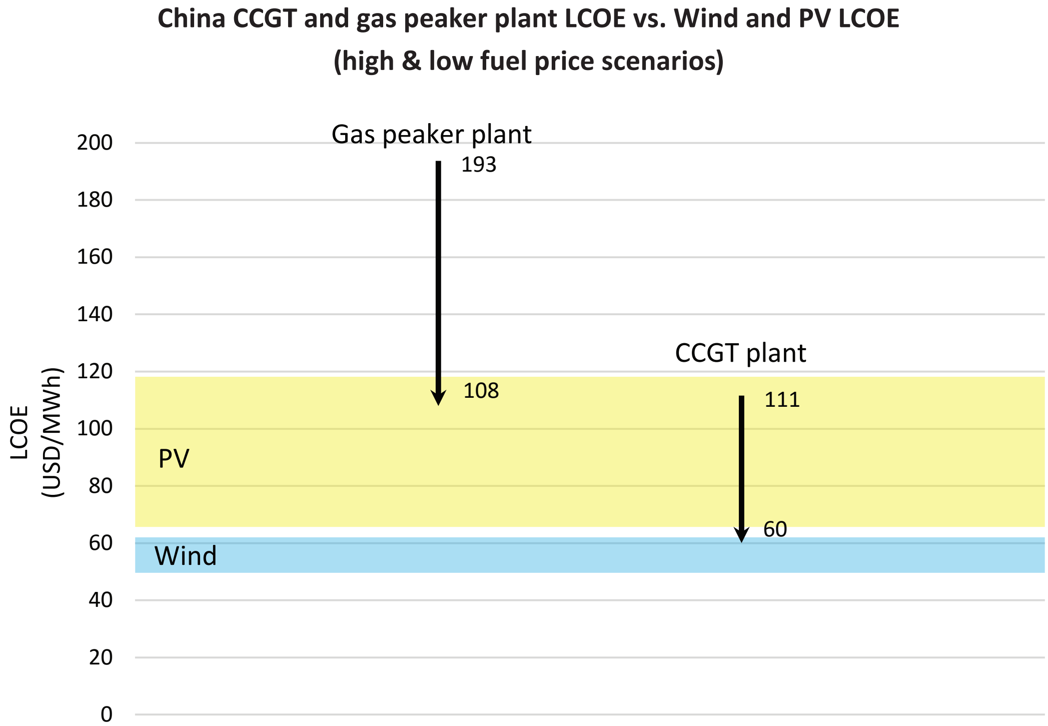


Note: Assumptions in appendix and footnote[2]

Source: Lazard LCOE of energy 2015, Bloomberg, Guinness Atkinson Asset Management

[2] For PV we assume a capex of $0.9/Wp, PV O&M costs of $15,000/MW-year, capacity factors of 10-16%, WACC of 4.5%. For wind we assume a capex of $1.3/Wp, O&M costs of $20,000/MW-year, capacity factors of 25-30% and WACC of 4.5%. For the gas plants we assume a gas price of $12/MMBtu and $5/MMBtu and a 8.5% WACC. For the gas peaker plants we assume a capex of $0.8/Wp, fixed O&M costs of $5,000/MW-year, variable O&M cost of $4.5/MWh and load factor of 20%. For the CCGT plants we assume a capex of $1/W, fixed O&M costs of $5,400/MW-year, variable O&M costs of $2.5/MWh and load factor 60%.

CHINA



Note: Assumptions in appendix and footnote[3]

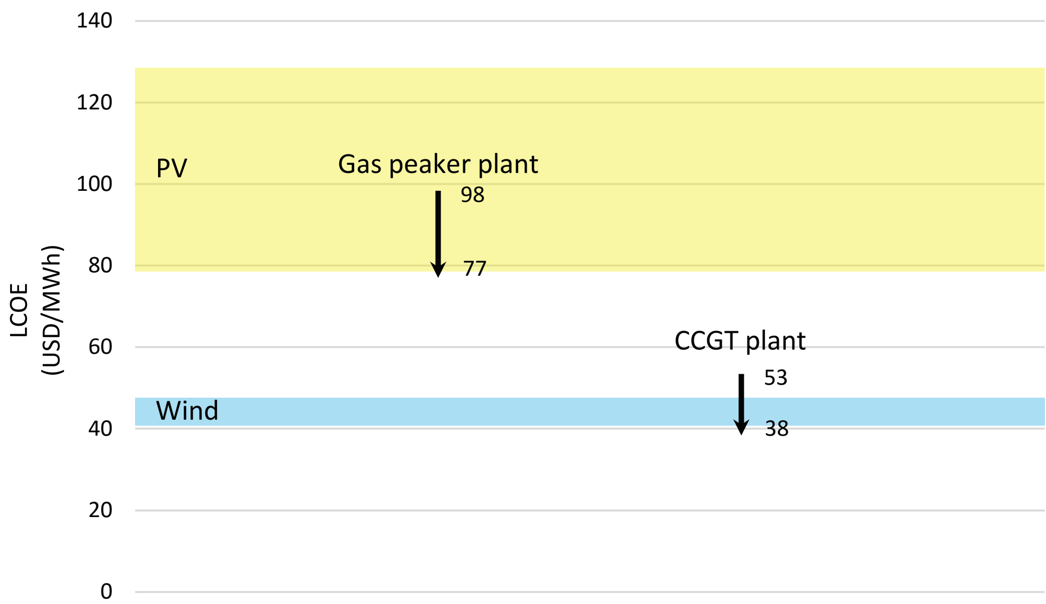
Source: Lazard LCOE of energy 2015, Bloomberg, Guinness Atkinson Asset Management

In China, the LCOEs of gas peaker and CCGT plants have halved since 2013. The natural gas price, as measured by Asian LNG import prices, has fallen from $12 per MMBtu in 2013 to $5/MMBtu today. This has allowed gas peaker plants to be economically competitive with PV plants, while CCGT plants are now on a par with wind projects and the best of Chinese solar projects. However, China is relatively insulated from the change in price of fossil fuels as air pollution and related health issues are driving increasing levels of government support for renewables. Despite a slowdown in growth in China, the country remains structurally short of electricity, and investments in high voltage transmission capacity are targeted at maximizing the utilization for their renewable resource to allow for growth supported by fewer new coal-fired power plants.

[3] For PV we assume a capex of $0.9/Wp, PV O&M costs of $15,000/MW-year, capacity factors of 10-18%, WACC of 8.5%. For wind we assume a capex of $1.0/Wp, O&M costs of $10,000/MW-year, capacity factors of 20-25% and WACC of 8.5%. For the gas plants we assume a gas price of $12/MMBtu and $5/MMBtu and a 10% WACC. For the gas peaker plants we assume a capex of $0.8/Wp, fixed O&M costs of $5,000/MW-year, variable O&M cost of $4.5/MWh and load factor of 20%. For the CCGT plants we assume a capex of $1/W, fixed O&M costs of $5,400/MW-year, variable O&M costs of $2.5/MWh and load factor 60%.

UNITED STATES

US CCGT and gas peaker plant LCOEs at current natural gas prices vs Wind and PV LCOEs (high & low fuel price scenarios)



Note: Assumptions in appendix and footnote[4]

Source: Lazard LCOE of energy 2015, Bloomberg, Guinness Atkinson Asset Management

It is in the United States that the argument for renewables has been hit hardest. The United States has the cheapest gas on the market, with Henry Hub now at c.$2 per MMBtu compared to c.$4/MMBtu in [2013]. This can also be attributed to relatively expensive PV installation costs in the United States. As a result, gas peaker plants have become more competitive than PV and a CCGT plant is now cheaper than wind. Nevertheless, the United States has good PV cost-reduction potential. We have assumed a capital cost of $1.3/Wp for the United States compared to $0.9/Wp in Europe and China. By matching these costs, United States could reduce its PV costs by 30%, which would make PV competitive with electricity from gas peaker plants.

CONCLUSIONS

Overall, we conclude that the recent falls in fossil fuel prices have created a more challenging economic environment for solar and wind, particularly in the US, which has historically had low electricity costs. However, both wind and solar today offer competitively priced energy to gas peaker plants, and their competitiveness is only likely to improve as a result of falling installation costs, higher natural gas prices or both.

[4] For PV we assume a capex of $1.3/Wp, PV O&M costs of $20,000/MW-year, capacity factors of 11-18%, WACC of 5.5%. For wind we assume a capex of $1.3/Wp, O&M costs of $20,000/MW-year, capacity factors of 30-35% and WACC of 5.5%. For the gas plants we assume a gas price of $4/MMBtu and $2/MMBtu and a 10% WACC. For the gas peaker plants we assume a capex of $0.8/Wp, fixed O&M costs of $5,000/MW-year, variable O&M cost of $4.5/MWh and load factor of 20%. For the CCGT plants we assume a capex of $1/W, fixed O&M costs of $5,400/MW-year, variable O&M costs of $2.5/MWh and load factor 60%.

APPENDIX

Methodology

Basic discounted cash flow (DCF) analysis assuming 20-year lifetime of projects. We did not assume replacement of wind turbines or inverters of wind and solar projects.

List of Inputs

Region	Plant type	Scenario	Capex $/W (Watt)	Fixed O&M ($/MW/year)	Variable O&M ($/MWh)	Load Factor	Fuel price ($/MMBtu)	WACC
China	CCGT	High	1.0	5,400	2.5	60%	12	10.0%
China	CCGT	Low	1.0	5,400	2.5	60%	5	10.0%
China	Peaker	High	0.8	5,000	4.5	20%	12	10.0%
China	Peaker	Low	0.8	5,000	4.5	20%	5	10.0%
China	PV	High	0.9	15,000		10%		8.5%
China	PV	Low	0.9	15,000		18%		8.5%
China	Wind	High	1.0	10,000		20%		8.5%
China	Wind	Low	1.0	10,000		25%		8.5%
EU	CCGT	High	1.0	5,400	2.5	60%	10	8.5%
EU	CCGT	Low	1.0	5,400	2.5	60%	4	8.5%
EU	Peaker	High	0.8	5,000	4.5	20%	10	8.5%
EU	Peaker	Low	0.8	5,000	4.5	20%	4	8.5%
EU	PV	High	0.9	15,000		10%		4.5%
EU	PV	Low	0.9	15,000		16%		4.5%
EU	Wind	High	1.3	20,000		25%		4.5%
EU	Wind	Low	1.3	20,000		30%		4.5%
Japan	CCGT	High	1.0	5,400	2.5	60%	16	8.5%
Japan	CCGT	Low	1.0	5,400	2.5	60%	8	8.5%
Japan	Peaker	High	0.8	5,000	4.5	20%	16	8.5%
Japan	Peaker	Low	0.8	5,000	4.5	20%	8	8.5%
Japan	PV	High	1.5	30,000		10%		4.5%
Japan	PV	Low	1.5	30,000		13%		4.5%
Japan	Wind	High	1.3	20,000		20%		4.5%
Japan	Wind	Low	1.3	20,000		25%		4.5%
US	CCGT	High	1.0	5,400	2.5	60%	4	10.0%
US	CCGT	Low	1.0	5,400	2.5	60%	2	10.0%
US	Peaker	High	0.8	5,000	4.5	20%	4	10.0%
US	Peaker	Low	0.8	5,000	4.5	20%	2	10.0%
US	PV	High	1.3	20,000		11%		5.5%
US	PV	Low	1.3	20,000		18%		5.5%
US	Wind	High	1.3	20,000		30%		5.5%
US	Wind	Low	1.3	20,000		35%		5.5%
Future	CCGT	High	1.0	5,400	2.5	60%	2	10.0%
Future	CCGT	Low	1.0	5,400	2.5	60%	4	10.0%
Future	Peaker	High	0.8	5,000	4.5	20%	2	10.0%
Future	Peaker	Low	0.8	5,000	4.5	20%	4	10.0%
Future	PV	High	0.7	15,000		10%		4.5%
Future	PV	Low	0.7	15,000		20%		4.5%
Future	Wind	High	0.8	20,000		30%		4.5%
Future	Wind	Low	0.8	20,000		40%		4.5%

Source: Lazard LCOE of energy 2015, Bloomberg. Note: $ denotes USD.

Caveats

There are several factors we have not taken account of in our analysis. First, natural gas peaker plants are a dispatchable source of electricity, whereas PV and wind are intermittent. We have not included extra balancing costs associated with high penetration of intermittent renewables or potential necessary upgrades to the grid. Second, we have not included the potential application of battery storage to fully replace certain peaker plants in the near future. Grid-scale storage would also smooth the intermittent output of PV and wind plants, making them more reliable. Third, we have not analyzed the cost of offering demand response instead of building power plants. Fourth, these are raw LCOEs and do not include subsidies or capacity payments that renewables or fossil generators may receive, respectively. Fifth, this article only looks at large-scale ground-mounted solar and wind, and does not take the competitiveness of rooftop solar against retail electricity prices into account. Sixth, the lifetime for all projects is 20 years. In reality, some gas-fired power plants and PV systems can operate for twice as long. Seventh, we have not taken into account the pollution, climate change and health costs of fossil fuel use into account. Taking the first factor alone, we would need to adjust our LCOEs for wind and solar upwards, but we believe these are more than outweighed by the other six factors above.

GUINNESS ATKINSON ALTERNATIVE ENERGY TEAM

The Fund is managed by Edward Guinness. Edward joined Guinness Atkinson Asset Management in January 2006. Prior to joining Guinness Atkinson, he worked from 2002 as a merger arbitrage analyst for the Arbitrage Associates Fund at the Tiedemann Investment Group in New York. In 1998 he joined HSBC Investment Bank, where he worked in the Corporate Finance Department in the Energy & Utilities Team and in the Telecoms & Technology Team. Edward graduated from the University of Cambridge with a Master's degree in Engineering and Management Studies.

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Capex, or capital expenditure, are funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment.

Load factor is the ratio of the average or actual amount of some quantity and the maximum possible or permissible.