Insights
Environmental, Social & Governance (ESG)

March 2020

The Trillion Dollar Energy Windfall

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Carbon Tracker Initiative is an independent financial think tank that analyses the impact of the energy transition on capital markets and the potential investment in high-cost, carbon-intensive fossil fuels. Carbon Tracker has helped to popularise the terms “carbon bubble”, “unburnable carbon” and “stranded assets”.

State Street Global Advisors has co-authored this report on the energy transition with Carbon Tracker. The original Carbon Tracker analyst note can be found here: https://carbontracker.org/reports/the-trillion-dollar-energy-windfall/

Growing fears around the threat of man-made climate change combined with the increasing attractiveness of renewable energy have led to a paradigm shift that is driving a steady transition towards renewables.

Foreword
by Carlo M. Funk

Fossil fuels have been a mainstay of the global economy since the Industrial Revolution, powering economic growth and rising living standards. But growing fears around the threat of man-made climate change combined with the increasing attractiveness of renewable energy have led to a paradigm shift that is driving a steady transition towards renewables. With policy support, this trend will continue over the coming decades with profound effects on geopolitics, economies and society.

Globally, we calculate society stands to reap a massive $1 trillion windfall from the energy transition, and potentially much more once all positive externalities are included.

The shift towards renewable energy cannot come soon enough. Scientific data provides evidence of significant unprecedented warming of the climate system, impacting the severity of weather events and cascading to economic systems and global corporations. Based on current policies in place, we are on course for 3–3.4°C of warming above pre-industrial levels by the end of this century according to Climate Action Tracker, far above the 1.5°C recommended by the UN IPCC.

At State Street Global Advisors, we use our influence as a large global asset manager to encourage corporate boards and management teams to proactively address climate-based issues that could impact on long-term performance. Our investment capabilities include climate-specific reporting so that clients can align their portfolios with the evolving science, regulatory landscape and investment risks and opportunities related to climate change.

Encouragingly, we see growing investor awareness of the importance of factoring in climate change scenarios in their portfolios. In a recent survey we conducted of 300 institutional investors and world-leading institutions, among the most significant factors driving adoption of ESG principles were risk mitigation and meeting or getting ahead of regulation. Climate change is the central ESG issue that is driving these results, as long-term investors understand that the systemic risks associated with climate change — and the policy response to it — can no longer be ignored.

As our paper shows, renewable energy will play an increasingly important role in tackling climate change as technological developments result in ever cheaper, more efficient and flexible renewables solutions that will drive down demand for fossil fuels. While investors will face climate-related risks in the coming years, there will also be opportunities for those who can mitigate risks and adapt their portfolios for the coming energy transition.

Background to the Report

This paper has been written in the context of the Inevitable Policy Response (IPR), a collaboration between the Principles for Responsible Investment, Vivid Economics, Energy Transition Advisors and the Carbon Tracker Initiative.

The IPR forecasts that climate policy is likely to become tougher in the next 3–5 years and that the longer the delay, the more disruptive and costly the policy response will be to business and investors. Therefore, investors should act now to protect and enhance value by assessing the potentially significant implications for portfolio risk.

Introduction

For the last two centuries the world has been fuelled increasingly by fossil fuels. Until very recently, renewable sources of energy remained on the fringes, lacking the affordability and scale to compete with fossil fuels.

That is now changing. We expect renewables to see continued growth to the point where they will provide all the growth in demand for energy and then start to push fossil fuels out of energy supply.

What is driving the shift from fossil fuels to renewables and what are the implications?

The New Cost Advantage

Today's renewables are cheaper than ever before in stark contrast to previous years when they were expensive compared to fossil fuels. This has transformed the renewable energy industry from one subsidised by governments to one driven by economic gain.

> **"Instead of being driven by subsidy this is now an industry driven by economic gain."**

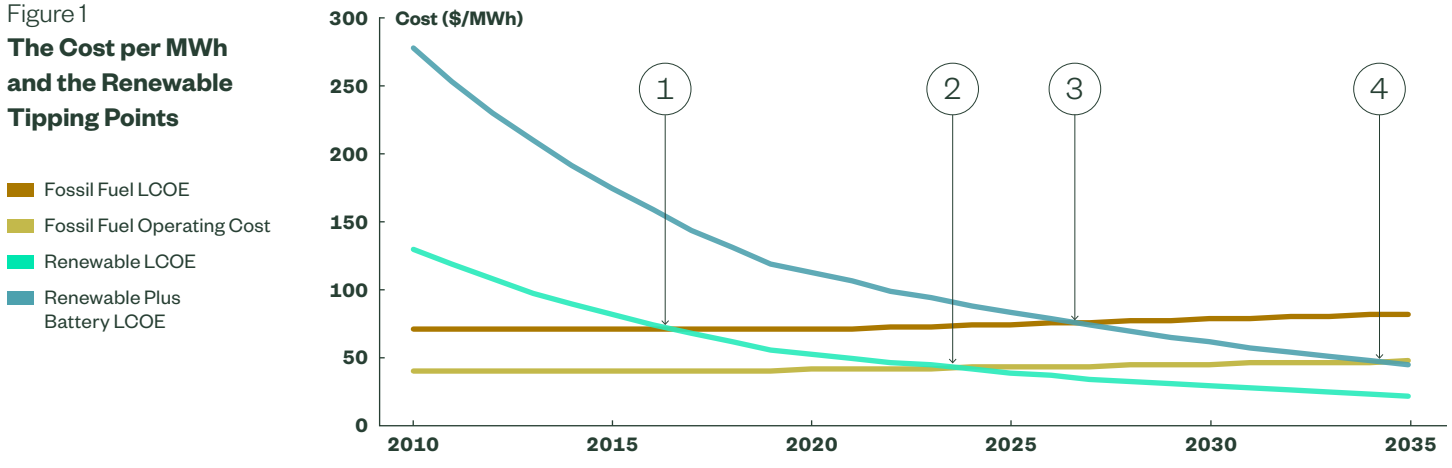
The pace of change has been remarkable. Only five years ago, variable renewable energy (solar and wind power, which this paper focusses on) were the most expensive source of new electricity in 99% of the world. In 2019, they are the cheapest in two thirds of the world, and by the early 2020s, we believe they will be the cheapest source in all major markets.

Currently, solar panel costs are falling and new technologies are increasing yields. Technological advancements are also creating cheaper batteries that will allow solar and wind energy to be dispatched on demand according to market needs. Technological advancements in the form of taller wind turbines, standardised installation costs and improvements in material efficiency will likely result in falling costs, driving further growth.

The fall in costs drives four tipping points for renewable electricity:

1. New renewables are cheaper than new fossils — this has largely happened
2. New renewables are cheaper than the operating cost of existing fossil plants — happening in renewable leaders, like India for solar power and the United States for wind power. This should be a feature of the early 2020s.
3. New dispatchable renewables are cheaper than new fossils — battery technology is dealing with the issue of intermittency. This should occur in the late 2020s.
4. New dispatchable renewables are cheaper than the operating cost of fossils — this final tipping point will likely unfold in the 2030s.

Figure 1
The Cost per MWh and the Renewable Tipping Points



Source: Carbon Tracker.
LCOE is the levelised cost of energy, which allows comparison of different methods of electricity generation on a consistent basis.
The above forecast is based upon estimates and reflect subjective judgments and assumptions. There can be no assurance that developments will transpire as forecasted and that the estimates are accurate.

Overcoming the Intermittency Challenge

Being forces of nature, the sun and wind are intermittent and often difficult to predict. Yet, a combination of technology and policy has enabled a huge increase in the maximum economical level of deployment of solar and wind technologies in an electricity system to the point where variable renewables now provide more than half of electricity in Denmark, a third in Uruguay and a quarter in Germany, according to the BP Statistical Review of World Energy.

The challenge of intermittency has been solved in five ways:

- **Flexible Demand** By incentivising businesses and consumers to reduce electricity demand at peak times or by shifting demand to a later time
- **Flexible Supply** Using existing fossil fuels as a backup
- **Bigger Grids** To provide additional capacity
- **Batteries** Enabling renewables to be dispatched and employed for up to four hours
- **System Changes** To accommodate variable renewable generation

At the cutting edge of change are the UK, Denmark and the US state of California, which among others, are aspiring to 100% renewable energy. While this may be an unrealistic aspiration for most countries, the large majority are far below their intermittency ceiling and can still deploy more solar and wind by copying the innovators.

“ The UK, Denmark and others are aspiring to 100% renewable energy.”

Other Drivers of Renewables Adoption

Aside from the favourable economics of renewable energy adoption, we believe other drivers will accelerate the energy transition.

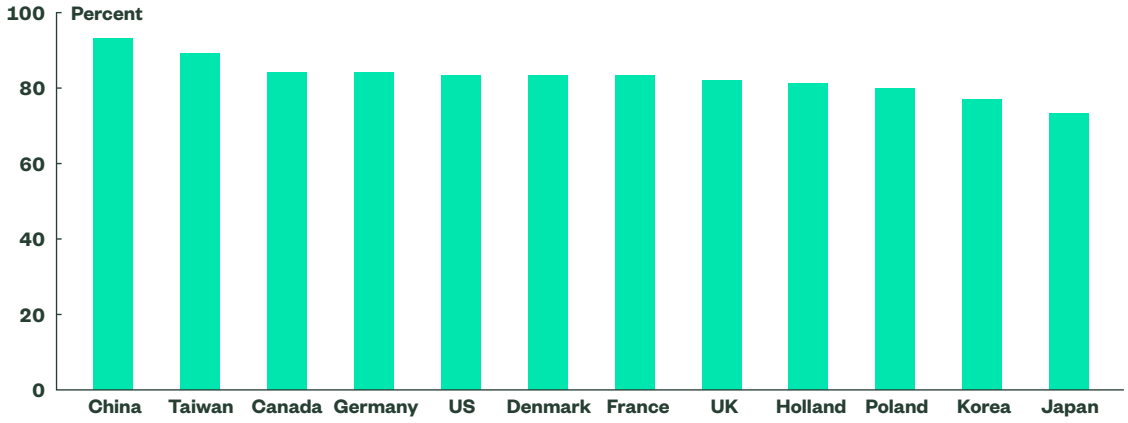
Pressure to adopt renewables is mounting:

- **Paris Agreement** The world is heading for 3°C warming above pre-industrial levels by the end of the century, far above the targets set in the Paris agreement. Policymakers can help meet the Paris targets by increasing the deployment of renewables in the electricity sector.
- **Air Pollution** Ambient air pollution kills four million people a year and is a major public health issue in the emerging markets. It will only worsen if fossil fuel use continues.
- **Geopolitical Advantage** 80% of people live in countries that import fossil fuels. With growth, energy dependency will only increase. Renewables are a local and continuous energy source and will reduce import dependency, increasing countries’ geopolitical influence.
- **Industrial Advantage** The new environment allows countries an opportunity to seize dominance in the new energy technology sectors, as China has done in electric vehicles
- **Votes** Renewable energy is very popular across the world as shown in a 2017 survey of 28,000 people across 13 countries conducted by Orsted, a Danish renewable energy company. Over 80% want to move to a world powered by renewable energy and over 80% want to phase out coal (see Figure 2).

- **Jobs** The fossil fuel sector employs 30 million people and according to the International Renewable Energy Association, a shift to renewable energy would require an extra 17 million jobs by 2030.

- **Justice** A world powered by renewables would create abundant energy for the billion people lacking energy in emerging markets and the energy poor in rich countries. Renewables will also reduce the massive rents which are currently amassed by the leaders of the fossil fuel system.

Figure 2
Share of Those Who Replied 'Yes, it is Important to Create a World Fully Powered by Renewables'



Source: Orsted, Green Energy Barometer.

Where Will the Energy Transition Play Out?

Broadly, three characteristics define which countries are most likely to embrace renewable energy:

- **Fossil Fuel Importers** The governments and people of countries that import much of their coal and gas for electricity generation like Japan and India are more likely to embrace domestic energy sources.

- **Growth Markets** In countries with rising energy demand like Vietnam there could be less resistance to use renewables to fill the energy gaps.

- **Pollution and Vulnerability to Climate Change** Countries with high levels of pollution or those that are exposed to the negative effects of climate change are more likely to embrace renewables. Not surprisingly, the push for renewables has been especially strong in India and China.

In contrast, countries that are resistant to renewable electricity will likely feature one or more of the following:

- **Fossil Fuel Exporters** Most coal and gas exporters will likely want to retain the status quo, although Norway is a notable exception.

- **Declining Demand** Where demand is declining, it is harder to embrace new capacity as it means writing down existing assets.

- **Large Domestic Fossil Fuel Sources for Electricity** Countries with large fossil fuel deposits and large amounts of electricity generation from fossil fuels may resist change.

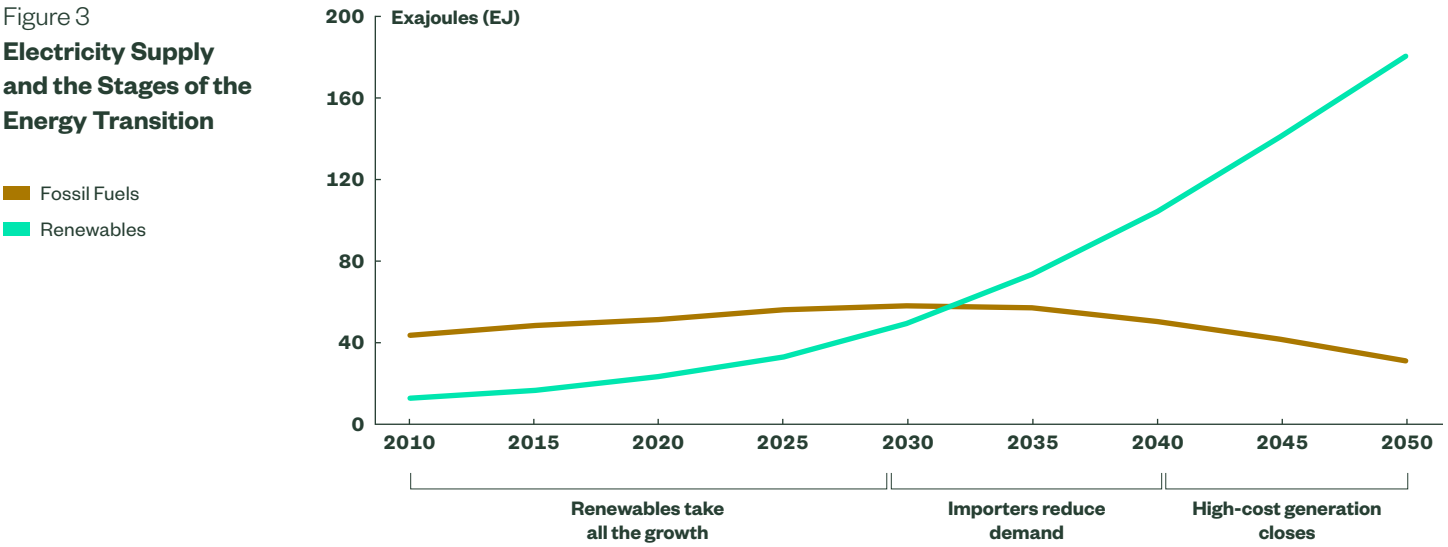
Given this, we can split the energy transition into three phases. Importantly, the transition can start in spite of countries and sectors that resist change:

Phase 1 — Renewables Take Growth Renewables already make up 50% of the growth in electricity supply, expected to increase to 100% over the next five years.

Phase 2 —Importers Reduce Demand Importers turn to renewables and reduce fossil fuel demand.

Phase 3 —Closure of Existing Assets The most challenging phase requiring political leadership. Those with large amounts of fossil fuel generation and fossil fuel exporters will take longer than countries with smaller fossil fuel generation and importers.

Figure 3
Electricity Supply and the Stages of the Energy Transition

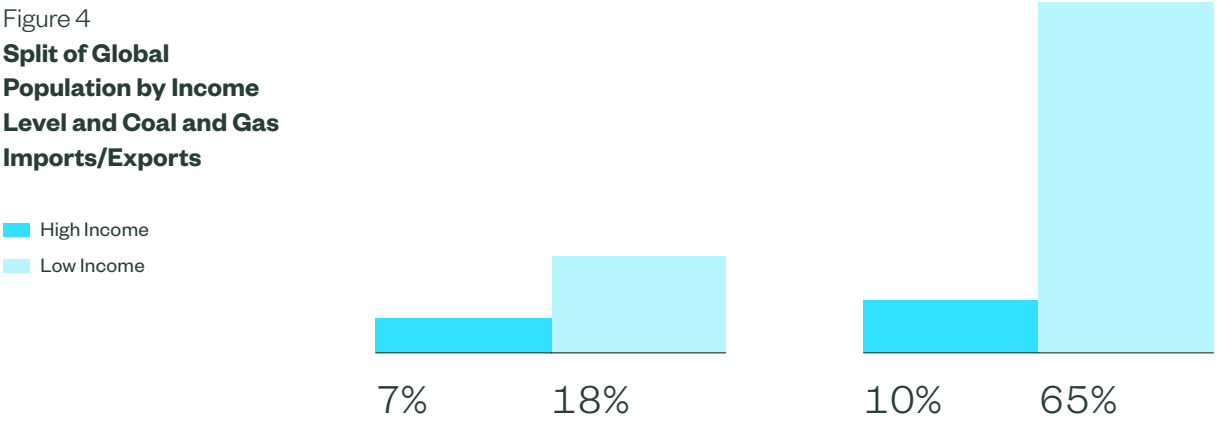


Source: Shell Sky Scenario (Carbon Tracker annotation).
Projected characteristics are based upon estimates and reflect subjective judgments and assumptions. There can be no assurance that developments will transpire as forecasted and that the estimates are accurate.

To summarise, we can categorise countries along two lines — exporter or importer of coal and gas, and high-income versus the rest. High income is a proxy for weak demand growth and lower pollution problems (both indicative of greater resistance to renewables adoption).

Through this categorisation, four groups of markets emerge. The group that will be least resistant to the energy transition are the low-income importers of coal and gas and account for 65% of the world's population (including China and India). The smallest group, just 7% of the world population (including Australia, the US and Poland) is the most intractable group — the high-income exporters.

Figure 4
Split of Global Population by Income Level and Coal and Gas Imports/Exports



Source: World Bank. December 2017.

Tipping Points

As shown, tipping points for renewables adoption will happen sooner in countries that import fossil fuels than those that have cheap domestic sources. Labour and land costs are also relevant — the lower these are the faster tipping points can occur.

Following this logic, we can categorise countries into innovators, early adopters, the majority and the laggards:

Figure 5
The Different Stages of Renewables Adoption

Category	Example Country/Region	Key Drivers of Renewables Adoption
Innovators	Denmark	Excellent domestic solar and/or wind resources; high fossil fuel import costs
Early Adopters	Texas, US	Excellent solar and/or wind resources; low financing costs; large amounts of free space
Early Majority	India	Low labour costs; high fossil fuel import costs
Late Majority	China	Wind costs have only just fallen below coal
Laggards	Japan	High labour and land costs

Source: Carbon Tracker.

Laggards like Japan are behind because they lack the scale necessary to bring down costs. Building at scale is usually dependent on policymakers creating a favourable legislative environment in which new technologies can be implemented. When this occurs, technology costs can fall very rapidly, as in Argentina which saw renewables costs brought to below fossil fuel alternatives within a year in 2016, following the implementation of an enabling framework by the government.

While the laggards are only just crossing the first tipping point, the early adopters are crossing the second tipping point and the innovators the third. Over time, the energy intensive sectors will likely migrate to those countries with lower costs, speeding up the transition.

The Role of Policy

As the Argentina example shows, governments have a major role to play in facilitating the energy transition. Domestic policymakers should work alongside international counterparts, including policy forums such as the G20 and OECD to set high international performance standards.

Perhaps the most important policy governments can introduce is removing barriers which could involve amending electricity codes, reducing the cost of energy innovation and providing more policy certainty. Deregulation of electricity markets has been a particularly successful policy for those countries that want to increase take-up of lower carbon energy sources. Cross-ministry alignment on key issues can send a market signal that governments are committed to tackling climate change.

Another lever is fiscal support, which could include policies like ending fossil fuel subsidies, reforming tax policy on green finance and investing in new technologies. In the knowledge that fossil fuels cause ambient air pollution and global warming, governments can introduce higher taxes on fossil fuel electricity generation. Fossil fuel producers facing competition from cheaper renewables will have to absorb higher taxes which will reduce superprofits in the sector.

Ultimately, policymakers may need to force the transition through bans on combustion engines and coal fire power plants. Improved implementation of environmental policy would remove industry uncertainty, reward first-movers and could facilitate increased efficiency.

A likely impact of the energy transition is disruption to the livelihoods of the 30 million people working in the fossil fuel sector. This challenge can be managed in various ways, but ignoring the change is not a sensible strategy. Fossil fuel demand will not disappear overnight; it will peak and then fall gradually, enabling many to complete their careers. Meanwhile, others can be retrained and reskilled for the 'wells-to-wind' transition.

Successful policy can reap significant and varied rewards:

Figure 6
The Varied Benefits of Renewables Adoption

Economic	Social	Political
Save money as the cost of renewables falls below fossil fuels	**Improve public health** from lower pollution	**Enhance energy independence** from lower imports
Avoid stranded assets as changing technology and lower costs puts assets at risk of redundancy	**More jobs** as the renewables systems grow leading to more localised job opportunities	**Gain / retain political power** as renewables are embraced
Reduce imports resulting in more stable currencies and lower risk of external shocks		

Source: Carbon Tracker.

The Gigafall

The falling costs of renewables combined with the rising penetration of renewables in the energy mix promises a huge energy windfall, which we refer to as a 'Gigafall'. We can estimate the value of the Gigafall over the next decade with some simple calculations on the size of the opportunity, the value of each new MWh and a capitalisation factor.

Over the course of the next decade, solar and wind can add 6,000 TWh to the global energy mix without running up against the intermittency ceiling. The cost advantage of renewables technology over the cheapest fossil fuels will vary by country and location but a conservative estimate of the average annual cost advantage is $10 per MWh.

Combining the size of the opportunity (6,000 TWh) and the benefit ($10) we get an annual windfall of $60 billion. However, this also needs to be capitalised because the benefits accrue every year. If we take a 5% discount rate that implies a capitalisation factor of 20, which gives a total opportunity of $1.2 trillion.

If we include avoiding the costs of global warming and ambient air pollution from fossil fuels (at least $50 per MWh), the Gigafall would reach $6 trillion.

“ The vast rewards of renewable energy will be reaped by society as a whole.”

Critically, these vast rewards will be reaped by society as a whole. This is in contrast to the beneficiaries of fossil fuel discovery and exploitation, who are the owners of resources and governments.

The information contained above is for illustrative purposes only.

Addressing the Counterarguments

Below we answer some counterarguments that have been made to the rise of renewables. While these challenges will slow progress and often make it challenging, they can be overcome:

System Costs These are additional costs to bring renewables into an electrical system to cope with their intermittency. At low levels of penetration of variable renewables, system costs are minimal, with the International Energy Agency, for example, forecasting a US system cost of solar in 2017 of zero and in 2040 of just $5 per MWh*. As penetration rises, so system costs rise, but at the same time, technological innovations tend to reduce system costs, and falling renewable prices have so far been far larger than rising system costs.

Lack of Space There are parts of the world where space is limited but for most locations this is not an issue. Approximately 1% of the world's land will be needed to support global energy demand and this figure is likely to fall as future energy supply becomes more efficient.

Limited Grid Capacity It is fair to note that grid capacity is too small for a renewable system. And the answer to this is of course to expand and strengthen grid capacity. There is precedent — the entire global electricity infrastructure was built over a century and is subject to continual improvements. This will also be the case for the transition to renewables.

* Projected characteristics are based upon estimates and reflect subjective judgments and assumptions. There can be no assurance that developments will transpire as forecasted and that the estimates are accurate.

Lack of Minerals Shortages of minerals such as rare earth metals, lithium and cobalt are often cited as an impediment to renewables adoption. However, the real issue is not a lack of total reserves in the earth's crust, but a lack of capacity to extract it. This then leads to a typical mining cycle of rising prices, more supply and (as we have already seen) falling prices as new capacity exceeds demand.

Regulation Renewables are a zero marginal cost energy source, and some have suggested that it is not possible for them to grow in systems designed for the marginal economics of fossil fuels. We argue that regulators will adapt codes and systems to accommodate the new technology, particularly as the gap between leaders and laggards opens up and pressure to act in the interests of the public mounts.

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* AUM reflects approximately $43.72 billion USD (as of December 31, 2019), with respect to which State Street Global Advisors Funds Distributors, LLC (SSGA FD) serves as marketing agent; SSGA FD and State Street Global Advisors are affiliated.

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