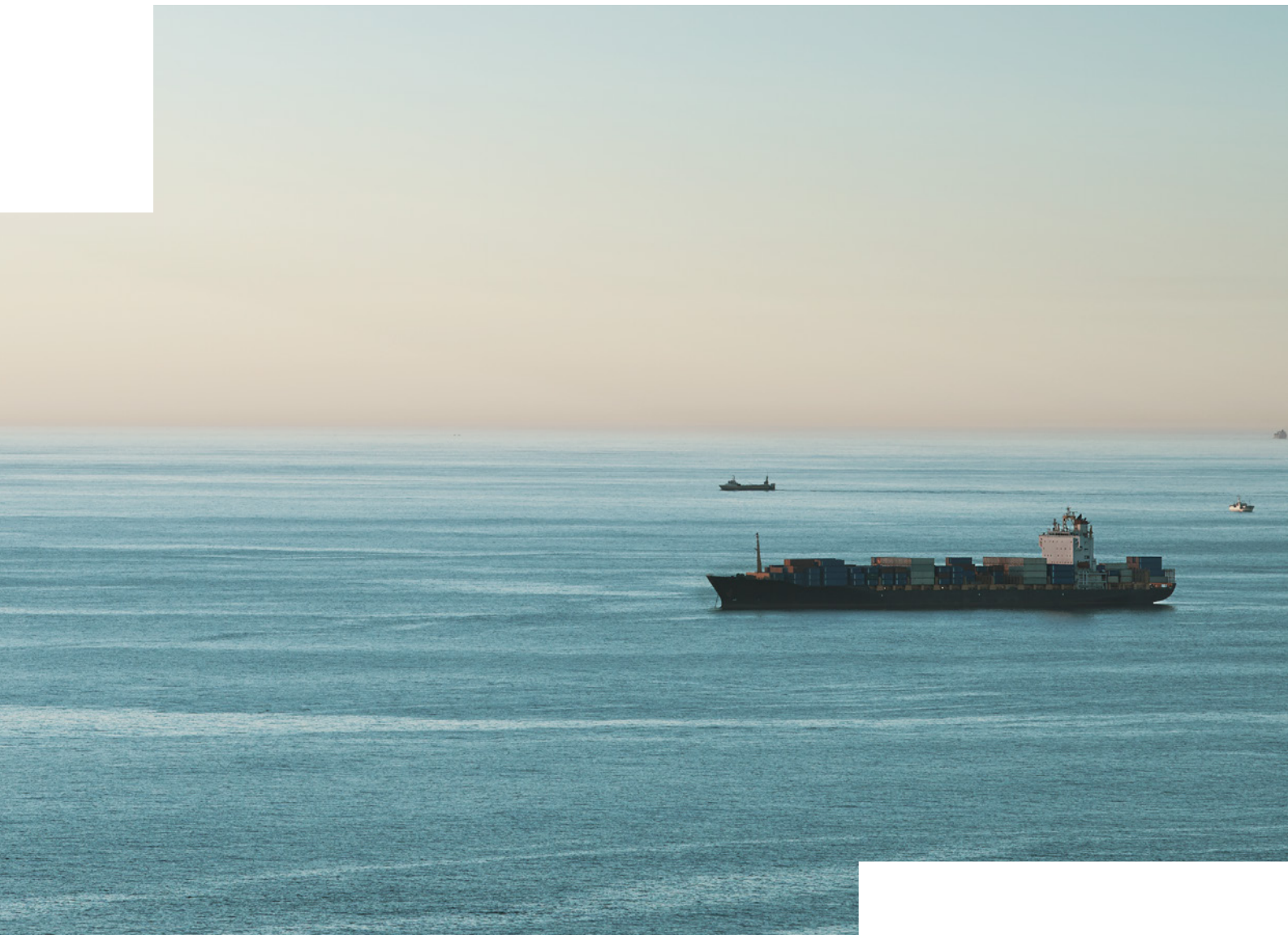


January 2020

Research Institute

Climate change: The energy transition





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Choose change

Around the world, people are discussing climate change and the next steps that we all must take to preserve our planet for generations to come.

In mid-November, a forum organized by the Credit Suisse Research Institute (CSRI) brought together a dozen renowned specialists to speak directly to members of Credit Suisse's top management and share their knowledge regarding climate change and the energy transition.

The CSRI holds such forums on an annual basis as we believe it is important to debate and understand the topics that are transforming our world. As we sat together at our Zurich headquarters at the most recent forum, the messages we heard about climate change were thought provoking and insightful in terms of humanity's shared future. This is why – for the first time – we have decided to publish a report highlighting some of the key issues discussed.

To state it simply: difficult and daunting decisions lie ahead. There are no easy answers when it comes to climate change, and figuring out the right way to proceed will require significant amounts of capital, along with co-operation, innovative thinking, flexibility, and a healthy dose of caution. Our world is intricately interlinked today, and actions in one area will have consequences in another – at times for the better, at other times for the worse.

This presents a challenge for all companies including Credit Suisse. Our approach to climate change consists of three pillars: managing the risks that arise from climate change; mobilizing funds for the transition to a low-carbon and climate resilient world; and reducing the carbon footprint of our own operations.

The first – and perhaps most important part of our strategy – is to help our clients across different sectors transition to a low carbon world. This includes performing an initial assessment of the key risk attributes for each sector, including reputational risk, sensitivity to carbon pricing, demand at risk, and regulations in the pipeline.

We also have an important role to play in helping our clients manage and fund the ongoing energy transition in a reasonable timeframe. Many companies are beginning to consider the long-term business risks that come with climate change, and how to deploy future capital against this backdrop. Initiatives grouped within the second pillar include impact and responsible/sustainable investing, renewable energy finance, and green bonds and loans. In terms of the third pillar, we are increasing the share of renewable energy within our operations, while decreasing CO₂ emissions and eliminating single-use plastics.

“A new type of thinking is essential if mankind is to survive and move to higher levels,” Albert Einstein once said. When it comes to climate change, there is no undoing or redoing. We need to start envisioning and enabling a more sustainable way forward together. Today.

Urs Rohner

Chairman of the Board of Directors
Credit Suisse Group AG

The energy transition

Climate change is forcing companies to abandon, adapt and transform their mode of business – and do so faster than ever before. One area undergoing considerable transformation is energy, which will require much change ahead and presents significant risk as well as opportunity for all actors involved.



Interest in sustainable investments is expanding significantly as individual investors, large pension funds and shareholder activists respond to climate change and other pressing global issues.

The United Nations' Principles for Responsible Investment (PRI) network, for example, was launched in 2006 and now spans more than 2,600 institutional investors worldwide with USD 89 trillion in assets under management (AuM)ⁱ. The signatories believe that environmental, social and corporate governance (ESG) issues can positively impact investment performance and have committed to incorporating the PRIⁱⁱ.

More recently, investors joined forces to launch the Climate Action 100+ initiative in 2017, which targets the world's "largest corporate greenhouse gas emitters" to rein in emissions, as well as strengthen governance and climate-related financial disclosuresⁱⁱⁱ. The group now includes more than 370 investors with more than USD 35 trillion in AuM.

There are two main arguments driving such investments: the first is to make a positive impact while generating returns; the second is to help safeguard investment portfolios against climate-related business and legal risks.

The latter is of particular concern for institutional investors, who believe some companies have been slow to analyze and acknowledge climate-related risks. A September 2019 report from BNY Mellon Investment Management found that 93% of institutional investors who participated in the study see climate change as an investment risk that has not yet been priced in by all the major financial markets worldwide^{iv}. In other words, they believe there is much more progress to be made on this front.

No industry will be spared from climate change; companies will need to abandon, adapt and transform their mode of business – and do so faster than ever before. One area undergoing considerable transformation is energy, which was the focus of a recent Credit Suisse Research Institute (CSRI) forum that brought together sector specialists and climate change experts to discuss and debate the energy transition.

The evolving energy transition poses many challenges, but offers opportunities as well. In the following pages, we provide a detailed summary of the key points emerging from the CSRI forum. The most important message is one that can be applied to all sectors: the vast extent of climate change and complexity of the required energy transition will require close cooperation between climate specialists and economists, governments and policymakers, businesses and private individuals, as well as consumers and investors.

Environmental and economic challenges

Economy 1 vs. climate 0

So far, the world has been slow out of the starting gates. Humanity is far off track in terms of limiting global warming to 1.5°C above pre-industrial levels, the lower end of the 1.5°C to “well below” 2°C threshold targeted under the 2015 Paris climate agreement.

At first glance, a few tenths of a degree may not seem like much. For the environment and humanity, however, it could have a tremendous impact. It could mean the difference between a further 70%-90% decline in coral reefs vs. an almost complete extinction, according to a report from the Intergovernmental Panel on Climate Change (IPCC), a UN organization. Risks from droughts and heavy precipitation would be higher at 2°C, while the mean rise in global sea levels would be between 26 cm to 77 cm by 2100 if warming is limited to 1.5°C, around 10 cm lower than with 2°C, according to the IPCC’s assessment.

“Policymakers should not hesitate to act, says former UN Climate Chief Christiana Figueres*. “Climate change is at the same time the biggest challenge – and the best opportunity for our generation.”

Increasing support from financial regulators and central bankers

When we look back in a few years, we may see 2019 as a tipping point. Leading central bankers – a group that normally sticks to the intricacies of monetary policy – have transformed into environmental emissaries who are leading calls for change. In an open letter in April 2019, Mark Carney, the Governor of the Bank of England, and François Villeroy de Galhau, Governor of the Banque de France, called on central banks, supervisors, and financial institutions to “continue to raise the bar to address these climate-related risks and to “green” the financial system^v.” Businesses that fail to do so could face a collapse in asset prices or bankruptcy, Carney has warned^{vi}.

We are already starting to see the dialogue concerning climate risks give rise to real-life implications. In November 2019, Martin Flodén, Deputy Governor of Sweden’s central bank, revealed that the Riksbank would reject issuers “who have a large climate footprint.” In light of the new investment policy, the Riksbank sold bonds issued by the Canadian province of Alberta, as well the Australian states of Queensland and Western Australia in 2019, citing their high levels of greenhouse gas emissions^{vii}.

In Switzerland, the Swiss National Bank and the Swiss Financial Market Supervisory Authority (FINMA) have joined the Network for Greening

*Speakers at the Credit Suisse Research Institute’s Energy Transition Forum in November 2019.

Global warming climate risk scenarios

1.5°C

2.0°C

100%

Increase in the number of the global population exposed to **flood risk**

170%

Every
100 years

Ice-free summers
in the **Arctic Ocean**

Every
10 years

Decline in ocean productivity substantially lower at 1.5°C than at 2°C

70-90%

Loss of the world's
coral reefs

> 99%



Lower economic growth at 2°C than at 1.5°C particularly in developing countries

Lower yields and nutritional content of maize, rice, and wheat in sub-Saharan Africa, Southeast Asia, Central and South America



13.8%

Percentage of the world population exposed to **"severe heat waves"** at least once every five years

36.9%

6% of insects

18% of insects

8 % of plants

Lose over half of their climatically **determined range**

16 % of plants

4% of vertebrates

8% of vertebrates

Source IPCC Special Report on 1.5°C global warming (2018)

the Financial System (NFGS), an initiative founded by eight central banks and supervisors in 2017 that now counts 51 members. European Central Bank (ECB) President Christine Lagarde unveiled plans in November 2019 to consider how to address sustainability concerns within the ECB's monetary policy framework at an upcoming review^{viii}.

An article that appeared in the International Monetary Fund's Finance & Development publication in December 2019, based on a conversation between Lagarde and natural historian David Attenborough, said that "we must treat the natural world as we would the economic world – protecting natural capital so that it can continue to provide benefits well into the future^{ix}."

Threat multiplier

Increasingly numerous and severe changes to our natural world could push 122 million more people into extreme poverty by 2030, according to a 2016 World Bank Policy Research Working Paper^x. Growing numbers of people around the world also face food and water insecurity, which could lead to instability both within and across borders.

Oil-producing countries face their own unique challenges not too far in the future as lower demand and prices for fossil fuels could leave them with fewer funds to deal with the fallout from climate change. In the Middle East, fossil fuel exports account for a quarter of the region's gross domestic product (GDP). Oil-producing countries are for now counting on growing energy consumption in Asia to secure markets and vital income, and are therefore holding back prioritizing investments in the energy transition, according to Emile Hokayem, Senior Fellow for Middle East Security at the International Institute for Strategic Studies (IISS)^{*}.

At the same time, the Middle East's exposure to climate change, including water and food security as well as threats to low-lying port infrastructure is high, according to IISS.

People are already struggling with the fallout from climate change and environmental degradation today across the globe, including displacement as a result of increasingly violent hurricanes, cyclones and forest fires. In and around the city of Basra, Iraq, once known as the Venice of the Middle East, the water source for the population of 4 million is no longer fit for consumption due to pollution. Agricultural production in Iraq and Syria has suffered from severe droughts. Several Middle Eastern coastal cities, such as Alexandria, are threatened by rising seas.

"Climate change is a threat multiplier," says Hokayem. "These issues are not yet creating conflict in the Middle East, but they do exacerbate existing problems. As time goes by, however, climate change may well become a primary driver of instability and conflict in the region."

Destination zero

Confronted with a sobering outlook and potential implications for future generations, the public is ramping up pressure on policy makers to take action, though the degree of pressure varies across countries. The advent of the school strikes for the climate is perhaps the best-known example as they have spread worldwide. This attention to climate change helped Green parties increase their share of the vote and achieve their strongest result to date in the Swiss federal elections during the autumn of 2019.

The target pursued is net-zero emissions of carbon dioxide (CO₂) – the biggest contributor to anthropogenic (human-caused) greenhouse gases. The dilemma is that achieving so-called carbon neutrality will require nothing short of an economic and industrial revolution in a compressed timeframe. "Limiting warming to 1.5°C is possible within the laws of chemistry and physics, but doing so would require unprecedented changes," according to the IPCC.

Such an objective will not be easy to achieve. The United Nations Environment Programme (UNEP) recently stated that global emissions must decline by 7.6% on an annual basis between 2020 to 2030 to meet the 1.5°C objective, and by 2.7% annually to reach the 2°C goal^{xi}.

In order to achieve the 2°C goal, the world would need to transition to a completely decarbonized energy system within the next 30 to 40 years, according to Nicolas Gruber, Professor of Environmental Physics at ETH Zurich^{*}. "All sectors would have to become net zero by 2050," says Gruber. "It is our generation's challenge to climb down."

The present reality looks different: greenhouse gas emissions rose 1.5% on an annual basis over the past decade^{xii}. Furthermore, on current trends hydrocarbons (natural gas, coal and oil) look set to retain a 60%-70% share of the world's energy consumption up to 2050, according to Nick Butler, Visiting Professor at King's College in London^{*}. "There is no collapse of the oil market, and coal is entrenched in China and India," says Butler.

Plan of action

The International Energy Agency (IEA) modeled in a Sustainable Development Scenario (SDS) what it would take to keep global warming below 1.8°C. The SDS models a 2070 timeframe to achieve net-zero emissions, projecting that global CO₂ emissions would drop to less than 10 billion tonnes by 2050 from 33 billion tonnes in 2018^{xiii}.

Reductions in CO₂ would come from two main areas: a greater share of renewables in the global fuel mix, accounting for more than 65% of worldwide electricity generation by 2040 (with a role for nuclear energy, as well as carbon capture, utilization and storage); and increased energy efficiency across the board, for example in buildings, industrial processes and transportation, according to the IEA.

The world still has many challenges ahead in order to achieve the energy transition, including managing the financial implications for companies as well as taxpayers, producing renewable energy at competitive costs, solving energy storage difficulties, and creating new battery recycling infrastructure.

Another obstacle is that demand for energy is set to rise – not fall – in coming decades, fueled by an increase in the global population to 9.7 billion by 2050 from 7.7 billion currently, according to UN estimates, as well as rising standards of living, which have historically correlated closely with rising energy demand.

Even if the world succeeds in achieving net-zero carbon emissions, temperatures on Earth will remain above pre-industrial levels for centuries to come, according to Gruber of ETH Zurich. Generations far into the future will still be dealing with the consequences of global warming and climate change.



The growth dilemma

Much of the growth in energy demand will come from emerging markets (EM) as those economies continue to expand, lifting more people out of poverty and increasing demand for electricity. “The world’s economic center of gravity is moving one degree eastward every nine months,” says Butler of King’s College. “Growth in energy since 2000 reflects the success of China and India in drawing people out of poverty. This is set to continue.”

But sustainable economic growth remains a considerable challenge for developed markets (DM) as well. Just five of the G20 countries, which account for 78% of greenhouse gas emissions, have adopted a zero-emissions timeline, UNEP says.

Energy transitions of the past include wood to coal in the late 19th century and coal to oil in the 20th century, according to a 2019 research paper from Chatham House: *The Geopolitical Implications of Future Oil Demand*^{xiv}, which predicts that the current energy transition could happen faster than many expect.

Clearly, engaging the power of markets to promote the energy transition would be the optimal approach, with a global carbon-trading scheme the most effective course of action. The 2019 UN Climate Change Conference in Madrid failed to achieve a consensus on dealing with carbon emissions, but according to Figueres, hopes are that the world will eventually adopt a carbon-trading scheme on a broader scale. Regional schemes such as the one operating in the European Union are a start, but even there CO₂ prices remain too low to substantially accelerate the energy transition.

Transforming investing

As the transition takes hold, the consequences for the global economy and investors could be dramatic. Indeed, Figueres suggests that the “fastest economic transition in history” could occur in the 2020s^{xv}. Overall, the financial sector will need to help bring about a “massive reallocation of capital” in order to address climate-related challenges, according to Carney and Villeroy de Galhau^{xvi}.

New rules and regulations, evolving prices, and technological innovation will require investors, whether private or institutional, to carefully calibrate risks. Yet there are interesting investment opportunities as well. Legacy fossil-fuel companies will need to transition to renewable energy, while environment-friendly start-ups will grow into mature companies that may eventually join the ranks of listed companies on domestic and international exchanges.



Growth in energy since 2000 reflects the success of China and India in drawing people out of poverty.

Nick Butler

Visiting Professor at
King’s College in London

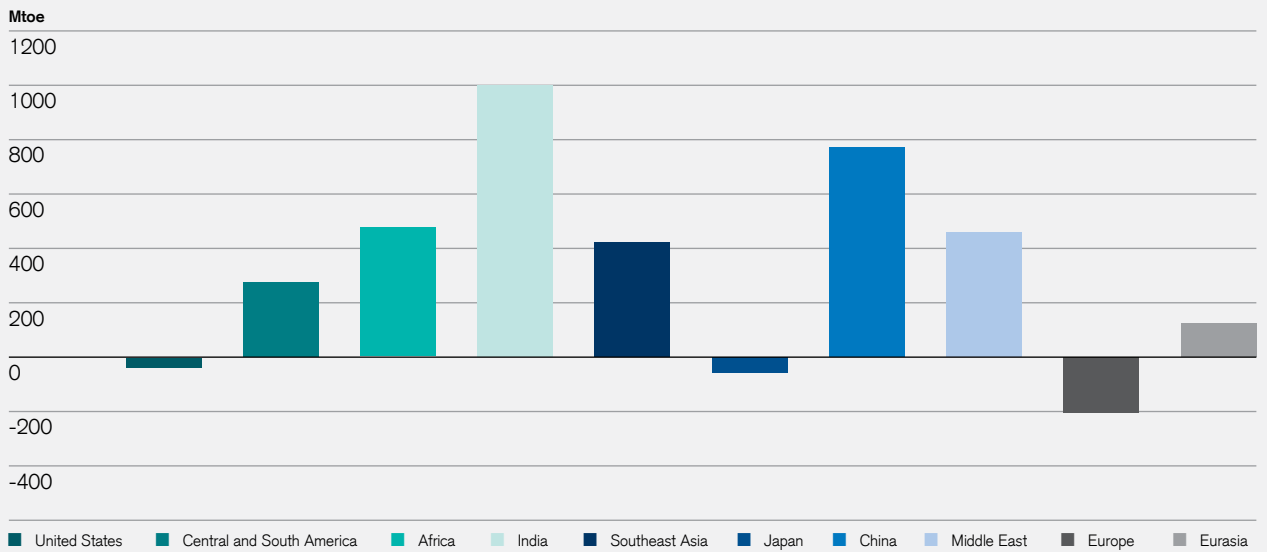
“We believe we can play a material role in helping to finance and advise those companies that are committed to making the sustainable transition and it is critical that we support the high carbon-emitting industries in particular along this journey,” says Marisa Drew, Chief Executive Officer of the Impact Advisory and Finance Department at Credit Suisse*. “Given the urgency of addressing the health of our planet, we believe that sustainability and impact will become a far deeper and broader investment theme underpinning all asset classes and will be increasingly more inclusive for all types of investors and issuers.”

“When we can offer enough choice to meet all investors’ requirements – for small as well as institutional-scale investors who aspire to construct well-diversified sustainable portfolios, we will truly see these markets go mainstream,” says Drew.

Within private equity, there is already “much to work with” in terms of sustainable investments, according to Leslie Harwell, a Managing Partner at Alante Capital*, which focuses on investing in the transformation of the textile and clothing industry. Consumer industries, in particular, are a prime environment for impact investing as new technologies help drive supply chain efficiencies and support new models of consumption, like rental and resale, Harwell says.

Harwell acknowledges that determining the impact tends to be more “straightforward” for early-stage, private investors as they can target specific companies offering exact solutions that

Change in primary energy demand in selected countries 2016-2040



Source "Change in primary energy demand in selected countries, 2016-2040", IEA, Paris <https://www.iea.org/data-and-statistics/charts/change-in-primary-energy-demand-in-selected-countries-2016-2040>

can be used across an industry, as opposed to a large multinational trying to implement sustainable practices across the organization, covering everything from sourcing and the supply chain to employment and sales/return practices.

Another issue that investors must navigate is so-called "greenwashing": a lack of a universally adopted set of standards and definitions for what is green, coupled with marketing campaigns highlighting climate-friendly initiatives, can make some companies appear more sustainable on the surface than further inspection would warrant. "In terms of sustainability disclosure and metrics, people tend to report what they are good at, but not what they are not so good at", says Drew. "Until we have comparable data being disclosed by companies across industries, investors will have to determine if the reported information a company chooses to disclose is enough to meet their objectives to invest sustainably. Today, how 'green' an investment really is may very well have to rest in the eye of the beholder."

“
We believe we can play a material role in helping to finance and advise those companies that are committed to making the sustainable transition.

Marisa Drew

Chief Executive Officer of the Impact Advisory and Finance Department at Credit Suisse

Challenges and opportunities in a renewable energy world

Time to move

While engaging high-level market forces would be the most effective means to promote climate mitigation, additional approaches will be needed. In particular, regulation and mitigation initiatives which engender new technology are key. Governments must, for example, design smart incentive schemes to encourage the transition to a new, more sustainable fuel mix.

Divestment strategies may also have a role to play, but the impacts may be less effective than desired. If companies write down their “stranded assets,” and sell them to a buyer at a fraction of their replacement value, this may paradoxically end up lowering the bar for entering the carbon business. “In nearly all cases, the high carbon assets offloaded by Western public corporations continue to operate given their positive cash margins,” explains Laszlo Varro, Chief Economist at the IEA*.

Incentives for renewable energies could be a more viable option. In light of recent technological progress, policy design and infrastructure operation are more important than actual subsidies. Indeed, Varro worries more about underinvestment in renewables – than about overinvestment in oil and gas.

Carbon countdown

Higher prices for carbon are, however, a key to incentivize the switch to renewables. The levelized cost of electricity (LCOE) for wind, solar and storage has consistently declined since 2010 and is expected to continue to do so through 2040. In many regions on an LCOE basis, the construction of new renewables plants is already cheaper than conventional fuel-based plants, even without subsidies, according to Credit Suisse Investment Banking.

This is not yet the case for coal-fueled power plants, however. An average carbon tax of USD 30 per ton and USD 20 per ton would make new wind and utility-scale solar plants, respectively, cost competitive with existing coal power plants in various countries around the world, according to Credit Suisse Investment Banking. In countries with more sunshine, such as India and the Middle East, solar is already competitive with coal-based plants on an LCOE level – even with no additional carbon tax.

Such incentives are not without hurdles, however, in particular concerns that an ill-designed carbon tax could broaden inequality – currently at a 50-year high in the USA^{xvii} – as such a tax would push up energy prices and disproportionately impact those in lower income brackets, both in DM as well as EM. This could lead to unrest: the gilets jaunes movement in France has its origins in protests over higher fuel prices. Redistribution schemes for the revenues from carbon taxes might offer a solution to this issue.



The extra proceeds from carbon taxes could be used to fund infrastructure projects or healthcare, or lower income taxes, according to the Organisation for Economic Co-Operation and Development (OECD)^{xviii}. Phoebe Koundouri, a Professor of Economics and Econometrics at the Athens University of Economics and Business*, says that ambitious carbon pricing is often correlated with high political trust and low levels of corruption. If trust is low, the revenue from carbon pricing should be recycled using a transparent strategy that bolsters trust in order to increase its acceptance, according to Koundouri.

When designing revenue-recycling mechanisms, behavioral insights and the political context should be taken into consideration, Koundouri says. Additionally, possible spillover effects from carbon pricing within research & development should be addressed with targeted instruments, while public interventions, such as investments in the electricity and transport sectors, are necessary to transform existing infrastructure, according to Koundouri.

For now, some 70% of energy-related CO₂ emissions are not taxed worldwide, the OECD says^{xix}. And when fossil fuels are taxed, the logic is at times unclear. As the OECD notes, taxes on coal are zero or near zero in many countries, while, taxes on natural gas, a cleaner fuel, are higher.

Policies and regulations are in the making to incentivize the required transitions, enable transparency and document progress. By 2018, 135 countries had adopted power regulatory policies, 70 had transport regulatory policies, 44 countries had carbon pricing policies and 20 had adopted heating and cooling regulatory policies, according to the Renewables 2019 Global Status Report^{xx}. Furthermore, the European Union has issued non-binding guidelines for climate-related reporting, while China has mandated that all listed companies disclose environmental information by 2020^{xxi}. The USA has an ESG Disclosure Simplification Act pending before Congress. Overall, the IEA says that the energy transition lies in the hands of governments around the world, who will drive more than 70% of global energy investments^{xxii}.

For many businesses, the impact of current and future policy-driven changes is yet to come.

“This energy transition will be expensive; it is not a case of simple substitution but of complementarities, of integrating new, renewable sources of energy,” says Christof Rühl, Senior Fellow, Harvard Kennedy School.*

Behind the curve

Shipping is one example of an industry lagging behind the zero emissions curve. It also happens to be an “enormous contributor” to CO₂ emissions, with the global shipping fleet transporting 90% of world trade, according to Greg Atkinson, Chief Technology Officer at Eco Marine Power*.

Shipping companies tend to be reluctant to introduce new, climate-friendly technologies, according to Atkinson. He says there are currently few incentives to do so: companies are focused on the bottom line and do not want to make costly investments, and it is difficult to find crews who are familiar with these new technologies. One area that shipping companies have heavily invested in are exhaust scrubbers, but questions have been raised about how clean or green this technology really is. Open-loop scrubbers, for example, use saltwater to remove sulphur from exhaust systems and then dump it back into the sea.

“It’s not a big step forward,” Atkinson says, referring to the scrubbers. “We don’t think the solution is to transfer pollution from one environment to another.” He rather suggests a viable, sustainable solution could be to power ships with a mix of solar power and sails (10%-15%) with hydrogen fuel cells for the rest. There are many other outstanding questions in terms of how the shipping industry can address climate change: are there too many ships; is the “right” cargo being transported; should ship designs be radically changed; and is shipping adequately regulated, according to Atkinson.

Power in progress

While renewable energy has become an important part of the world’s power mix, it remains a work in progress and must scale up quickly and efficiently to meet rising demand for energy. During the next three decades, about USD 9.4 trillion will be invested in solar and wind power, according to Bloomberg^{xxiii}.

One of the main points in favor of solar PV, which converts sunlight into energy, is its adaptability as the panels can be used for small spaces (homes, businesses, even fish farms), though they are most effective in larger power plants. Yet this technology does have limitations: the amount of sun – and energy – captured depends greatly on the region, as well as the time of day and year^{xxiv}.

Wind turbines have their own shortcomings in that they are not suitable for every location. The average annual wind speed must be at least 9 to 13 miles per hour for small and utility-scale turbines, respectively, according to the US Energy Information Administration^{xxv}.

In terms of environmental drawbacks, wind farms require large tracks of land, including service roads, and they can be a hazard to birds and bats^{xxvi}.

For now, hydropower remains the largest and most mature source of renewable energy. However, the IEA warns that increasing investment costs are making it a less attractive option in markets such as China and Brazil^{xxvii}.

Unclear for nuclear

The need to shift toward a zero emissions world has once again shone a spotlight on nuclear energy. Besides hydropower, nuclear has the lowest CO₂ emissions, according to Professor Dr. Andreas Pautz at the Swiss Federal Institute of Technology*. Another clear advantage is that nuclear power has a high availability (nuclear plants are capable of producing full power for more than 90% of the year), fits seamlessly into today’s grid structure, and can be built up quickly in terms of capacity. This has been demonstrated by the 290 TWh/y increase in nuclear production in France between 1980-1996 compared with a 38 TWh/y increase in solar production in Germany between 2000-2016, according to Pautz.

However, some developed countries have decided to phase out nuclear power in recent years due to public concerns about nuclear waste disposal and safety in particular. Nevertheless, maintaining a functional nuclear workforce remains a critical issue due to continued plant life (e.g. nuclear plants in Switzerland have another 25 years of operation) and the necessity of dealing with nuclear legacies, for example the decommissioning of nuclear power plants or long-term storage of spent nuclear fuel.

In contrast, Russia and China are expanding their new nuclear built program and are starting to export their technologies into developing countries. Ample investment opportunities remain in nuclear, Pautz says, pointing to the retrofitting and upgrading of safety systems for current nuclear plants in view of extended lifetimes, the development of small modular reactors for flexible deployment in remote locations and more volatile grids, as well as advanced reactors for enhanced sustainability of nuclear fuels.

“ The CO₂ can be stored underground in suitable geological structures, such as porous rocks that have hosted water for millions of years.

Marco Mazzotti
Professor at ETH Zurich



CO₂ magic

Mitigation strategies, such as Carbon Dioxide Capture and Storage (CCS), will also play a crucial role as reaching the Paris agreement target will require avoiding emissions from point sources, e.g. power plants and industrial plants, and generating so-called negative emissions, i.e. removing CO₂ that is already in the atmosphere. The former is based on post-combustion capture, used for decades in the chemical industry, which prevents CO₂ emissions from entering the atmosphere by capturing and storing CO₂ in geological formations, e.g. an aquifer. The latter is also possible through direct air capture followed by storage, though it is about 10 times more expensive than post-combustion capture, according to Marco Mazzotti, a Professor at ETH Zurich*.

"The CO₂ can be stored underground in suitable geological structures, such as porous rocks that have hosted water for millions of years," says Mazzotti.

Considering the extent of current carbon emissions, a lot of CO₂ will need to be buried underground^{xxviii}. "To give a sense of scale, that means by 2030 humanity needs to be compressing, transporting, and burying an amount of CO₂, by volume that is two to four times the amount of fluids that the global oil and gas industry deals with today," the news website Vox explained in a 2019 report.

An alternative approach is to transform that "waste" CO₂ into new, carbon-based products, including synthetic fuels, (by combining CO₂ captured from the atmosphere with hydrogen generated via electrolysis of water), chemicals, and building materials, according to the IEA^{xxix}. The point here being that the production of these new products would not release more carbon emissions. Unfortunately, any of these requires significant energy to produce. Mazzotti believes that hydrogen fuel, i.e. a carbon-free synthetic fuel, will be a key element of the future energy system, as the energy penalty is lower than for carbon-based fuels.

Fit fuel

Biofuels also have a key role to play in reducing the world's carbon footprint, including in the shipping industry. Biofuels are made from organic matter and can be blended with fossil fuels or used alone^{xxx}. The challenge for biofuels is in affordability due to the low price of fossil fuels.

In the evolving energy sector with many new competitors and technologies, oil & gas companies face a difficult balancing act. They must invest in low carbon alternative sources of fuel (which yield lower returns) to stay relevant while maintaining their core, and higher yielding, legacy oil & gas businesses to finance dividend payments to shareholders, according to Butler of King's College.

Along with technological innovation, nature has its own solutions to help address the carbon crisis created by humanity. There are about 3 trillion trees on earth, according to Tom Crowther, a Professor at ETH Zurich*. These ecosystems store some 600 Gigatonnes (GT) of carbon, and Crowther sees the potential to store up to 200 GT more of carbon through a global restoration effort, which, if done at current best-in-class costs of USD 0.30 a tree, could cost as little as USD 300 billion.

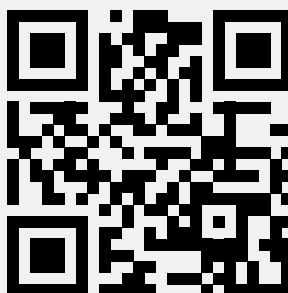
Prepare for change

Investors are used to dealing with uncertainties, be it geopolitics, technological innovation or economic developments. Returns are never a given, which is why a disciplined investment process is key to ensure that risks are accounted for, opportunities are spotted, and biases are overcome. Climate change presents a blind spot and significant risk for many investors.

Although scientists have issued warnings about the climate for decades now (the first global climate conference was held in 1979 in Geneva), businesses and governments, consumers and investors have largely ignored the threat and stayed on the high carbon path. This is no longer a viable approach. There will be much change ahead – perhaps the greatest period of transformation that humanity will ever experience – and this presents significant risk as well as opportunity for all actors involved. The energy transition has begun – let's join forces to make it succeed.

We would like to thank all the experts quoted in this report.

For information on Credit Suisse's principles and approach to climate protection, see our Statement on Climate Change at:



credit-suisse.com/klima

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Publisher

Nannette Hechler-Fayd'herbe
Oliver Adler

Editor

Catherine McLean Trachsler

Contributors

Jens Zimmermann

Editorial support

Christa Jenni

Project management

Camilla Damm Leuzinger
Claudia Biri

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