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LOMBARD ODIER
INVESTMENT MANAGERS

Investing in the Climate Transition

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USD 5.5 trillion investment will be required annually over the next decade to generate sustainable economic growth, and to align with the Paris Agreement and UN SDGs

p.10

At a glance

- Increasing physical manifestations of an already damaged climate draw stark attention to the **scale, scope and urgency of a climate transition**.
- At current pathways, temperatures are on track to rise as much as 3°C this century.
- To maintain temperature rises well below 2°C, we need to **reduce carbon emissions 50% by 2030** and to net-zero by 2050.
- This transition could have a **positive impact on economic growth** and could boost global GDP up to 5% by 2050.
- **Annual investment needs to almost double to USD 5.5 trillion this decade** and rise to USD 7.2 trillion in the 2030s to remain below a 2°C increase. Capital must be reallocated to both decarbonise and adapt to a carbon-damaged world.
- This creates **significant investment opportunities across multiple sectors**. It is vital to focus on carbon-reduction solution providers, but also transition candidates from hard-to-abate, but economically-vital, industries. Companies working to adapt to climate damage should also receive consideration.
- **Market forces are overtaking the pace of policymakers** and creating a positive feedback loop. This powerful combination of investors, consumers and technological innovation is reducing decarbonisation costs. This in turn forces policy to accelerate and gives greater transparency on climate change materiality.
- **Four key revolutions** underpin the climate transition: the Energy, Transport, Industrial and Food and Land Use Revolutions. These sectors are critical for future economic growth, but remain carbon-intensive.
- Focusing on **unadjusted carbon footprinting can be misleading** and inconsistent with a net-zero economy. At Lombard Odier we embrace carbon-intensive companies that avoid or capture carbon in other parts of the supply chain.

The world is already decarbonising – but needs to accelerate. Market forces are now in the driving seat of the transition. We have as little as seven years before we use up the world's remaining carbon budget.

Please read important information at the end of this document.

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1. Foreword

Increasing physical manifestations of an already damaged climate draw stark attention to the scale, scope and urgency of a climate transition. This transition is already underway and is creating transition-related risks and opportunities across sectors that stand to accelerate abruptly.

The unprecedented scale of investment required for the climate transition may also enhance economic growth prospects. Achieving the goals of the Paris Agreement requires that we maintain the global temperature rise well below 2°C above pre-industrial levels (and pursue efforts to limit the temperature increase to 1.5°C), even as the population continues to rapidly grow and urbanise. Keeping pace with these requirements will require a shift in the allocation of existing resources and additional incremental investment. Close to USD 100 trillion cumulatively[1] will be required over the next fifteen years across all sectors to keep pace with this economic and environmental transition. Additionally, the OECD estimates that combining economic reforms with ambitious climate policies could boost GDP an average 2-3% per year by 2050 across the G20,[2] or 4.7% accounting for the positive impacts of avoiding damage from climate change. This will require a doubling of investment in infrastructure to meet the demands of economic and population growth over the next decade, and also a shift in investment flows to more climate-compatible infrastructure, aligned with a 2°C world.

Adapting to a warmer climate, and mitigating the risk of catastrophic environmental damage will require a monumental, concerted effort from all sectors, including those where emissions are harder-to-abate, but which remain essential to generating economic growth.

Meeting the goals of the Paris Agreement will require significant additional investment to prepare legacy carbon-intensive sectors like transport, energy, agriculture and industry for survival in an increasingly carbon-constrained world. We believe indiscriminate exclusion of these sectors to reduce a portfolio's carbon footprint fails to capture the scientific, social, economic and financial necessity of pursuing environmental improvements in these critical sectors and is therefore unlikely to achieve investors' financial objectives in the long-term. Addressing the needs of a net-zero economy means fundamentally addressing these hard-to-abate sectors.

> *"The Lombard Odier Climate Transition Strategy is designed to offer investors a comprehensive framework to invest in companies across all sectors that are well positioned to generate growth as the transition to a climate-damaged and carbon-constrained economy continues to accelerate."*
>
> Hubert Keller, CEO, Lombard Odier Investment Managers & Managing Partner, Lombard Odier Group.

[1] Lombard Odier estimates and forecasts based on data under the sustainable development scenario of the IEA World Energy Outlook (2019) and Oxford Economics Global Infrastructure Outlook (2017).

[2] OECD Investing in Climate, Investing in Growth (2017). Accessed here https://read.oecd-ilibrary.org/economics/investing-in-climate-investing-in-growth_9789264273528-en#page10.

Without this, the transition to a net-zero economy cannot be achieved.

Even so, the transition to a low-carbon and climate-resilient economy has already begun. The transition is driven by several powerful and self-reinforcing dynamics. While current global policies fall well short of delivering net-zero by 2050, many national policies are aligned, or at least at preliminary levels of discussion, to embrace this goal. Regions are also taking the lead, with the EU unveiling its Green Deal[3] at the end of 2019, which commits it to becoming the world's first climate-neutral continent by 2050. Even where a small handful of governments may lag behind, a wave of sub-national cities and businesses are aligning their targets with net-zero.

Meanwhile, market forces are overtaking policy as a key driver of transition as innovation and increasing economies of scale rapidly change economic realities. Economics are now in the driving seat of the transition, powered through a catalytic positive feedback loop of cost declines and technological innovation. Consumer preferences are changing, channelling spending power towards more sustainable brands, food choices and lifestyles, and raising reputational risks for those who do not toe the line.

Investors, who have trillions of dollars at stake in the climate transition, are also pushing companies to adopt strategies aligned with both a carbon-constrained and climate-damaged world. For instance, in 2019, the International Accounting Standards Board (IASB)[4] joined a long list of over 60 official sector authorities, central banks and regulators to weigh in on climate-related financial risks,[5] stating that climate risks are material for many companies' reported assets and liabilities, and therefore for future corporate profits, thus highlighting the necessity of quantifying and disclosing these risks.

In combination, these forces create a significant growth opportunity for companies across multiple sectors that embrace the transition, either by providing solutions to adapt to a climate-damaged and carbon-constrained world, or by re-positioning themselves to generate competitive advantage.

Those at the forefront of the climate transition are likely to grow their market share and outperform poorly positioned peers. Those that bury their heads and fail to adapt are likely to find themselves starved of customers, capital and talent, and face existential threat.

Hubert Keller
CEO Lombard Odier Investment Managers
& Managing Partner Lombard Odier Group

[3] https://ec.europa.eu/commission/presscorner/detail/en/fs_19_6714.

[4] International Accounting Standards Board: Accessed here https://cdn.ifrs.org/-/media/feature/news/2019/november/in-brief-climate-change-nick-anderson.pdf?la=en.

[5] See for instance the Central Banks and Supervisors Network for Greening the Financial System (NGFS) which has grown from eight founding members to 54 members and 12 observers.

2. Executive summary

There is an urgent need for greater climate action…
Current levels and trends in global greenhouse gas (GHG) emissions are far in excess of the pathways envisioned by the Paris Agreement and could force temperatures to rise by more than 3°C this century.[6] We are already seeing physical manifestations of climate change globally with a doubling in extreme weather events (flooding, hurricanes and wildfires) since 1980. The Intergovernmental Panel on Climate Change (IPCC) has estimated the economic damage from even a 1.5°C change would amount to as much as USD 54 trillion (USD 69 trillion if temperatures reach 2°C).[7] More extreme temperature ranges would increase this figure further still, with economic damage likely to exceed USD 1 trillion per year by 2050,[8] adding an urgent financial and economic incentive to climate action.

…but it may have a positive impact on economic growth
There is an urgent need for decoupling between economic growth and carbon damage. But we believe this will enhance, rather than detract, from economic growth. A landmark OECD report delivered to the G20, *Investing in Climate, Investing in Growth*,[9] states that there need not be a trade-off: combining climate change and pro-growth measures, and in some countries a judicious recycling of carbon tax revenues, can lead to long-term inclusive growth as part of a "decisive transition" to decarbonisation. The analysis shows that well-managed structural reforms and proactive fiscal policies can more than outweigh the negative growth impact of ambitious climate policies.

Investing in climate can boost GDP by up to 5%
The same OECD report shows that bringing together the growth and climate agendas, rather than treating climate as a separate issue, could add 1% to average economic output in G20 countries by 2021 and lift 2050 output by up to 2.8%. If the economic benefits of avoiding climate change impacts such as coastal flooding or storm damage are factored in, the net increase to 2050 GDP would be nearly 5%.[10]

We need to see a significant growth in investment and shift in capital allocation
We estimate that to meet a 2°C scenario (2DS) infrastructure investment will need to increase to USD 5.5 trillion per year over the period to 2030, and to USD 7.2 trillion per year over the period from 2030 to 2040. Not only does investment need to almost double from historical trends just to keep up with economic growth and stated policies but it needs to step up almost 90% by 2030 to achieve the requirements of a sustainable development scenario. The allocation of capital will also need to shift substantially towards renewables, energy efficiency improvements and associated infrastructure.[11]

The world must transition to a net-zero economy by 2050 (with a 50% reduction required by 2030)…

As global warming is related not to the annual level of GHG emissions but to the accumulation of GHGs in our atmosphere, net emissions must eventually be reduced to zero to stabilise temperature levels. To meet the highest ambition of the Paris Agreement (1.5°C), such a point would need to be reached by the middle of this century for CO_2 emissions and by the 2060s for total GHG emissions.[12]

…this requires a concerted effort across all sectors of the economy
Reaching net-zero requires significant efforts to cut energy demand via deep efficiencies and increased uptake of well-publicised solutions such as renewable energy and electric mobility. But we must also focus on harder-to-abate industrial sectors which are vital to the delivery of global economic growth over the next decades. Land use will also play a vital role in the transition, given the necessity for land to provide an increasing carbon sink to mitigate those process-related emissions which will be impossible to fully abate.

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6 See the figure 6 in section 3.1.

7 IPCC (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Chapter 3: Impacts of 1.5°C of Global Warming on Natural and Human Systems. Accessed at https://www.ipcc.ch/sr15/chapter/spm/.

8 Lombard Odier analysis based on Watson and Le Quéré (2018); Aon Benfield (2019). https://tyndall.ac.uk/sites/default/files/implications_of_global_warming_of_1.5_and_2_degrees_-_final_report_1_0.pdf and https://www.aon.com/global-weather-catastrophe-natural-disasters-costs-climate-change-2019-annual-report/index.html.

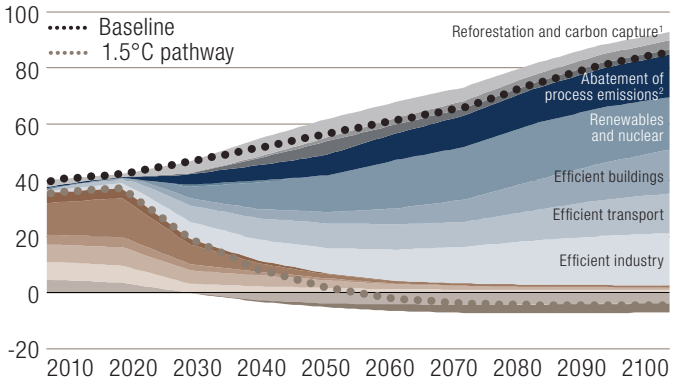
9 OECD (2017). Accessed at https://read.oecd-ilibrary.org/economics/investing-in-climate-investing-in-growth_9789264273528-en#page1.

10 Idem.

11 Declaration on ESG by the European Association of Public Sector Pension Institutions (EAPSPI), 2019 http://portal.versorgungskammer.de/portal/page/portal/eapspi/en/news/declaration_onepagers.pdf. The European Association of Public Sector Pension Institutions (EAPSPI) has emphasized that stable ecosystems, human well-being and an inclusive society are necessary preconditions to a well-functioning economy and, hence, to the financial returns on investments in the long term. EAPSPI (2019), accessed at 2019 http://portal.versorgungskammer.de/portal/page/portal/eapspi/en/news/declaration_onepagers.pdf.

12 See footnote 2.

FIG. 1 NECESSARY TRANSITIONS TO ACHIEVE THE NET-ZERO ECONOMY (Gt CO_2)



Source: Lombard Odier analysis. [1] Agriculture, forestry and land use change (AFOLU); [2] Industry emission not related to energy, such as emissions from cement manufacturing.

Adaptation to climate change is an integral part of the transition

Even in a best-case scenario, communities and businesses around the world will face profound changes in their operational environment and way of life as climate-damage manifests. Early investment in adaptation is estimated to offer a cost-benefit ratio of one-to-four, avoiding far worse damage later on. Initiatives by the IPCC, the EU, and the World Bank are among some of the frameworks that recognise investments aimed at improving resilience and adaptation must stand on an equal footing to actions aimed at constraining emissions.

National policies are beginning to embrace the goal to reach net-zero by 2050

By the end of 2019, 77 countries had announced plans to reduce their emissions to net-zero by 2050, or earlier.[13] While most of these policies remain at preliminary levels of discussion, pressure is growing for other countries to follow suit and formalise their commitments. Even where governments lag behind (as in the US), subnational entities and alliances are emerging to drive the transition[14] based on the increasingly favourable economic and business considerations of low-carbon development, even where political leadership may be shirking its responsibility.

Market forces are overtaking the pace set by policymakers

Regardless of lingering support in some jurisdictions for fossil fuels, the economics of low-carbon technologies such as wind and solar energy, energy storage, and electric vehicles are improving exponentially, through the power of their experience curves (i.e., the more experience a business has in producing a particular product, the lower its cost becomes). Forecasts suggest that as of 2020, wind and solar power will be more cost-effective than 35-45% of the world's coal industry, with investment inevitably shifting to greener alternatives[15] on the basis of unsubsidised economic advantage. Technological advances, aided by greater connectivity and the Internet of Things (IoT), have enabled significant innovation across sectors, which, when combined with greater economies of scale, are catapulting the low-carbon transition forwards.

Consumers are beginning to demand more sustainable products

Consumer surveys report a growing preference for brands with sustainable credentials and, vice versa, a willingness to boycott those that do not. Addressing sustainability challenges can therefore provide a company with an additional unique selling proposition (USP) and help to mitigate reputational risks. Scandals in the fast fashion industry over its environmental footprint, human trafficking and labour conditions provide a ready example of the brand damage that lack of attention to these risks may pose.

Investors have trillions of dollars at stake in the climate transition

Investors are increasingly realising that climate change is material to the performance of companies. For the first time, environmental concerns dominated the top five long-term global risks for business leaders, investors and policy-makers surveyed in the World Economic Forum's annual report, published in 2020.[16] Of these five risks, climate action failure was named as the risk with the greatest potential impact on the global economy.

As investors realise the materiality of climate change, policy is enabling better transparency on company fitness during the net-zero transition

The Bank of England has warned that as much as USD 20 trillion in assets may be at risk of becoming "stranded" as a result of climate change.[17] Thus regulators are embarking on a strategy to enforce more transparency on the materiality of climate change to future company performance. The Bank of England and numerous other central banks will start to stress test domestic financial institutions to quantify their exposures to climate-related risks.

[13] United Nations (2019). Accessed here: https://www.un.org/sg/en/content/sg/statement/2019-09-23/secretary-generals-remarks-closing-of-climate-action-summit-delivered.

[14] US states, cities and businesses representing nearly 70% of US GDP have joined America's Pledge on Climate Change to align with the Paris Agreement.

[15] Based on estimates by IRENA, forecasting that by 2020, auction prices of solar and wind power will fall below the marginal operating cost of 700 GW and 900 GW, respectively, of the world's operational coal capacity, corresponding to 35%-45% of the coal industry's current capacity. IRENA (2018). Renewable power generation costs in 2018. Accessed at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf.

[16] World Economic Forum (2020) Global Risks Report 2019. Accessed at https://www.weforum.org/reports/the-global-risks-report-2019.

[17] The Guardian (17 April 2019). *Mark Carney tells global banks they cannot ignore climate change dangers*. Accessed at https://www.theguardian.com/environment/2019/apr/17/mark-carney-tells-global-banks-they-cannot-ignore-climate-change-dangers.

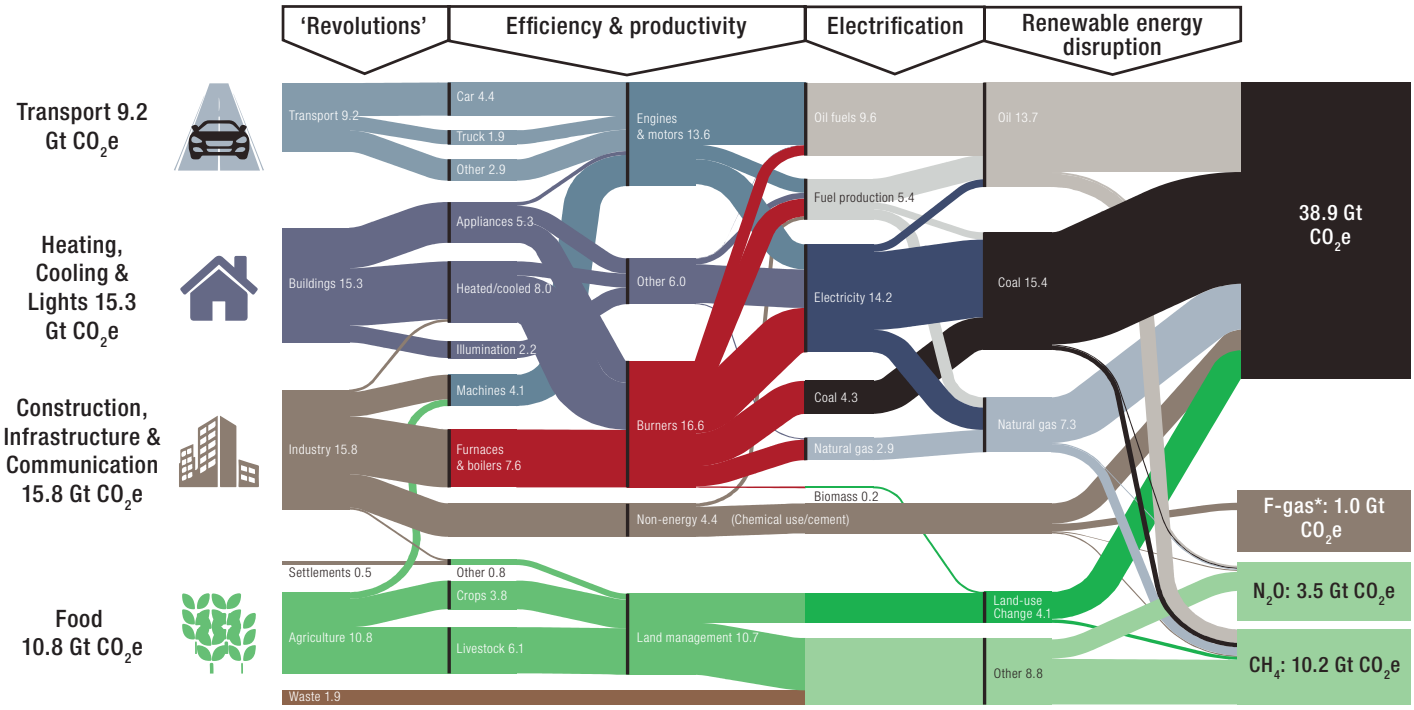
The Network for Greening the Financial System (NGFS) published *A call for action*[18] in 2019 highlighting the financial risks associated with climate change and the importance of ensuring resilience to these risks within the financial system. As at December 2019, over 930 organisations, representing a combined market capitalisation of USD 11 trillion had joined the Financial Stability Board's Task Force on Climate-Related Financial Disclosures (TCFD).[19] Likewise, the EU's Green Deal proposes to enshrine in law the necessity for all sectors of the economy to transition to net-zero emissions by 2050, with the EU Taxonomy aiming to provide a clear framework within which to structure this action.

Positive feedback loop

The powerful combination of policy, investor pressure, consumer pressure and market forces provides a positive feedback loop, which in turn provides more potent incentive to companies to commit to net-zero targets. This poses a substantial and systemic risk to many legacy companies in the oil, gas, utility and industrial sectors. It can also present opportunities for investors to identify new entrants and incumbent businesses which are quickest to adapt their business models to mitigate risks and embrace solutions. A majority of investors now recognise climate change as a material risk – but also believe the transition will provide profound investment opportunities.

Decarbonisation affects all industries: Emissions are deeply entangled with every sector of the economy for the simple reason that we have built our entire industrial and economic model on the convenience and energy density of fossil fuels. The climate transition requires that economic activity rapidly shifts away from this key input, a challenge akin to unpicking a massive knot over several decades. Due to the complex nature of the flow of global emissions and the need to understand the entire emission value chain from Scope 1 to Scope 2, we believe it is vital to focus on decarbonisation across all industries. Scope 3 emissions, or "value chain emissions" are those generated at the upstream or downstream of an organisation and outside of their own direct operations. But these emissions cannot be ignored and often represent the largest source of GHGs, as can be seen by the Sankey flow diagram below:

FIG. 2 THE COMPLEX GLOBAL FLOW OF GHG EMISSIONS



Source: Lombard Odier analysis. Resource efficiency collection, Leonardo DiCaprio Foundation, (2014). *Fluorescent Gas.

[18] Network for Greening the Financial System, Accessed at https://www.banque-france.fr/sites/default/files/media/2019/04/17/ngfs_first_comprehensive_report_-_17042019_0.pdf.

[19] Task Force on Climate-Related Financial Disclosures (2019). *TCFD Supporters*. Accessed at https://www.fsb-tcfd.org/supporters-landing/.

Four revolutions are at the heart of the necessary climate transition.
Coupled with many smaller revolutions in individual industries, these represent necessary ingredients for the shift to a net-zero economy:

1. **The energy revolution requires reform of the full supply chain:** To achieve net-zero emissions, changes are required across demand, supply and the distribution of energy. Energy efficiency is absolutely key to ensuring a net-zero target can reduce primary energy demand by nearly a third compared to reference scenarios. On the supply side, improvements in the economics of renewable energy are fundamental to a shift in the energy mix. Meanwhile, investment in distribution infrastructure is a necessary prerequisite to the electrification of transport and home heating. Also with respect to distribution, hydrogen may play an enabling role, allowing for the use of renewable energy to produce hydrogen gas, suitable for storage and transportation of this power over long distances.
2. **The transport revolution will require more than just electrification:** While electric vehicles are quickly becoming the poster-child of the climate transition, electrification is most suited to short-haul, personal vehicles. Abatement costs of long-haul transport, including shipping and air traffic, are substantially higher. Hydrogen, carbon capture, synfuels and biofuels are likely to be beneficiaries of the transport revolution. In addition, however, behavioural changes – whether driven by consumer consciousness or promoted through government regulation – will prove essential to drive a modal shift in transportation. Railways, buses, and micro-mobility options can reduce the carbon footprint of a journey by over 90%.[20]
3. **An industrial sustainability revolution may be costly, but will generate competitive advantage:** Industrial sectors such as steel, cement and chemicals are major contributors of emissions, but equally essential for global economic growth. Emissions in these industries are hard to abate, owing to the long life of industrial assets, the need for high operating temperatures, and the role of inherent process emissions. Carbon capture can reduce net emissions, as can manufacturing techniques aimed at "dematerialisation" and efficiency, while the use of recycled materials in the circular economy can radically reduce energy requirements. Such innovations may be costly today, but ultimately they provide competitive advantage in markets where downstream customers will place increasingly stringent environmental demands on the products that they source.
4. **A revolution in food and land use can turn this sector into a net-negative carbon sink:** As the Earth's soil holds three times more carbon than the atmosphere, changes in land use are of vital importance to the world's carbon budget.[21] Reversing trends in deforestation and the destruction of natural ecosystems can increase the ecosystem's function as a carbon sink. Better farm management can also boost yields while reducing resource footprints and the use of fertilisers. This in turn helps to reduce carbon footprints and land degradation. Together with other adaptation activities, this may also improve resilience to the risks of climate change and dangers to crop yields from rising temperatures. Demand-side changes, particularly targeting food waste and dietary changes, must accompany these supply-side intervention. In unison, these actions may mitigate 15 Gt CO_2e in GHG emissions per year, exceeding the total emissions of the agriculture, forestry and other land uses (AFOLU) sector as a whole.[22]

The Lombard Odier Climate Transition Strategy targets low carbon and carbon-intensive sectors alike
It is clear that a transition to the net-zero economy cannot be achieved solely through investments in renewable energy, electric vehicles, or other "clean tech" solutions. Additional investments and process innovations in carbon-intensive but essential heavy industry are necessary, and require specialised solutions that provide competitive advantage to transitioning industries, and a market opportunity to the providers of these solutions. With investments needing to stretch as high as USD 7.2 trillion per annum over the next fifteen years in infrastructure compatible with both economic growth and net-zero climate policies, this presents close to a USD 100 trillion infrastructure opportunity, as well as potential for a 4.7% boost to average annual GDP growth globally.[23]

Traditional "carbon footprinting" is not a useful tool to assess the opportunity arising from the need to decarbonise or adapt to climate change
It is very easy to construct portfolios with a low carbon footprint, by excluding the most carbon-intensive and selecting stocks from less-intensive subindustries, within each major sector. While effective in reducing carbon footprint indicators, this approach can provide a false sense of security and is inconsistent with the realities demanded by the climate transition as it excludes many of the most vital sectors for economic growth, where a transition is most urgent and essential, and reduces the contribution of such a strategy to the climate transition.

[20] See figures in section 7.3.
[21] EthicalCorp. (2019). Turning Agriculture from Climate Culprit to Carbon Sink. *Hilssdon, M.* Accessed at: http://www.ethicalcorp.com/turning-agriculture-climate-culprit-carbon-sink.
[22] Roe et al (2019). Contribution of the land sector to a 1.5°C world. In Nature (Vol. 9, pp. 817-828). Accessed at https://www.nature.com/articles/s41558-019-0591-9.epdf.
[23] See footnote 2.

The Lombard Odier Climate Transition Strategy purposefully includes many of the economically critical but carbon intensive industries of relevance to the climate crisis. We target the leaders within these industries who we view as best positioned to set themselves on pathways consistent with the scientific requirements of the Paris Agreement, and will therefore stand to gain market share and outperform their more poorly positioned peers in an increasingly carbon-constrained world. We see wide ranging opportunities from precision farming as a means to reduce carbon, to mass transportation as a means to avoid carbon, and regenerative agriculture as a means to capture carbon, amongst many others.

Our strategy targets both opportunities arising from a carbon-constrained and a climate-damaged world

In line with international frameworks, including the Paris Agreement and the emerging EU Taxonomy, the Lombard Odier Climate Transition Strategy regards activities that serve to adapt to a climate-damaged world as an intrinsic part of the climate transition. Improving resilience through strengthening infrastructure, monitoring risks through meteorological tools, and managing impact through re-insurance activities are all examples of activities that provide a competitive advantage to companies at risk, as well as an investable opportunity among the providers of these solutions.

Focus box: The transition to the "CLIC Economy"

At Lombard Odier, we believe that the transition to decarbonisation and the net-zero economy forms part of a larger economic transformation.

Today, we believe our economy is wildly out of control. As discussed in this paper, our present system has a severe impact on our natural environment and climate change. It is one where economic growth comes hand-in-hand with unpriced negative externalities. In addition, our economy is enormously wasteful. We extract nearly 97 billion tonnes of material from the planet every year,[24] equivalent to over 265 *thousand* times the weight of the Empire State Building. A small fraction of this material is recycled. Meanwhile, even the products that we produce from this material sit idle much of the time. Passenger cars, for instance, sit unused 92% of the time.[25] And on top of all this, increasing inequalities are leaving large swathes of the population behind. The bottom half of all adults in the world collectively own less than 1% of global wealth.[26]

We call this **W**asteful, **I**dle, **L**opsided and **D**irty economy the **WILD** economy, and it is completely unsustainable. To ensure the continued viability of our society, we believe we must fundamentally rethink the way we live, produce and act. To do this, we must *decouple* our economic growth from its underlying, adverse environmental footprint, and ensure our economy delivers broad and inclusive benefits for all stakeholders in society.

The end goal of this transformation is an economy that is **C**ircular, **L**ean, **I**nclusive and **C**lean. We call this the CLIC economy. The **CLIC** economy leverages efficient production and consumption and the sharing economy, reducing the wasteful accumulation of idle assets. By focusing on the re-use, repair, re-manufacturing and eventual re-recycling of products, the CLIC economy reduces the dependence on ever greater extraction of mineral resources and recognizes the substantial value of the materials and components that comprise the products we so readily discard today.

Lombard Odier's vision for the transformation from the WILD to the CLIC economy is the subject of a forthcoming white paper entitled *The CLIC economy - Circular, Lean, Inclusive and Clean: A recipe for decoupled growth*.

[24] Estimate of 97 gigatonnes is a 2019 estimate by Lombard Odier, projected from data up until 2017 from IRP. Global Resources Outlook 2019: Natural Resources for the Future We Want. A Report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya (2019) Oberle, B; Bringezu, S; Hatfield-Dodds, S; Hellweg, S; Schandl, H and Clement, J. Accessed at: https://www.resourcepanel.org/reports/global-resources-outlook.

[25] Ellen Macarthur Foundation (2015). Towards a Circular Economy: Business Rationale for an Accelerated Transition. Accessed at: https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf.

[26] Credit Suisse (2019). The Global wealth report 2019. Accessed at https://www.credit-suisse.com/about-us/en/reports-research/global-wealth-report.html.

FIG. 3 THE TRANSFORMATION FROM THE WILD TO THE CLIC ECONOMY

Source: Lombard Odier analysis 2020 based on [1] Ellen MacArthur Foundation; [2] FAO; [3] Circularity Gap Report; [4] Credit Suisse; 106.3Gt based on Lombard Odier estimate of extraction of raw materials in 2019 plus recycled materials.

3. The Climate Transition

At the dawn of the 2020s, we can look back over the last decade to consider what has been achieved, and examine the challenges that will need to be tackled by 2030.

The science of climate change and the severe impacts of a warming world today are clear and present realities. However, the level of governmental ambition and policy response falls woefully short of the concerted action needed to constrain carbon whilst also adapting to the level of environmental damage already upon us and ahead of us as we continue to breach the Earth's planetary boundaries.

This presents clear investment opportunities for carbon reduction solution providers and significant opportunities for traditionally harder-to-abate sectors in terms of increased investment. In a landmark report on behalf of the G20, the OECD (and IEA, NEA and ITF) calculated that up to USD 6.9 trillion per annum to 2030 will be needed for the low-carbon and climate-resilient transition. We have updated these estimates and find that USD 5.5 trillion[27] of investment will be needed annually over the next decade; and USD 7.2 trillion per annum from 2031 onwards, to prepare these sectors for both economic growth and to meet the objectives of the Paris Agreement and Sustainable Development Goals (UN SDGs). Over the next decade, this will require a 45% incremental investment versus the 2014-2018 average, and a c.90% increase by 2031 as shown in Figure 4.

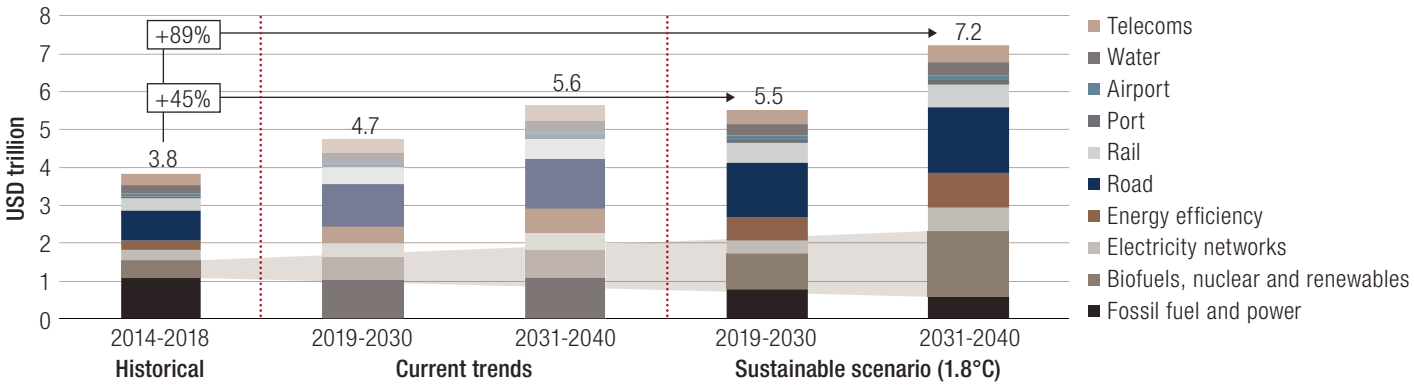
At Lombard Odier we remain convinced that efforts to limit the global temperature increase to 1.5°C above pre-industrial levels, in line with the Paris Agreement, are essential not only from an environmental point of view, but from an economic and financial one as well. Investing in the climate transition offers profound financial opportunities and the prospects of competitive advantage to investors, seeking opportunities in an economy that is driven by low-carbon growth, and is resilient, future-proof and attuned to the changing expectations of policy-makers, consumers, and financial markets.

We believe the acceleration in climate-related action from both regulators and consumers - whether that be via carbon pricing, highly-publicised protest movements, or increased pressure on companies and auditors to quantify and disclose climate risks - will drive increased opportunities for those companies positioned to thrive in a carbon-constrained world. This acceleration (and repricing) also has the potential to occur abruptly in a "Climate Minsky Moment." At the same time, we recognize that no matter how accelerated this action becomes, climate damage of some degree will undoubtedly occur globally. In our view, this offers opportunities for those companies positioned to increase climate-resilience, monitor risks and manage impact, and it is important to focus on these adaptation companies as much as low-carbon solution providers.

In recent years, a number of cleantech and low-carbon funds have emerged that invest in poster-child technologies such as renewable energy and electric vehicles, or in low-impact sectors that offer the allure of guilt-free investment. Few of these funds, however, encapsulate the full extent of the climate transition required across all sectors, especially the hard-to-abate, carbon-intensive industries, such as steel, cement, and chemicals.

The Lombard Odier Climate Transition Strategy seeks to fill this gap, representing an investment philosophy that is aligned with a transition to a net-zero economy. This philosophy is in line with the latest recommendations across science, industry and policy, and is underscored by the EU Sustainable Finance Action Plan through the impending EU regulations on Taxonomy and Benchmarks.[28]

FIG. 4 ANNUAL GLOBAL INVESTMENT NEEDS TO INCREASE 45% OVER THE NEXT DECADE



Source: Lombard Odier estimates and forecasts; based on IEA (2019), Oxford Economics (2017) and OECD (2017).

[27] Lombard Odier estimates and forecasts based on data of the OECD report Investing in Climate, Investing in Growth (2017), the IEA World Energy Outlook (2019) and Oxford Economics Global Infrastructure Outlook (2017).

[28] European Commission (undated). Green Finance. Accessed at https://ec.europa.eu/info/business-economy-euro/banking-and-finance/green-finance_en.

We recognise that the future economy will still require many of the aforementioned hard-to-abate industries – but that they will have to transform and transition. Indeed, addressing climate change requires that we continue to invest in these industries so that they are able to invest in their own transformation, and so we, as investors, can continue to exert our considerable influence on the speed and scale of their transition.

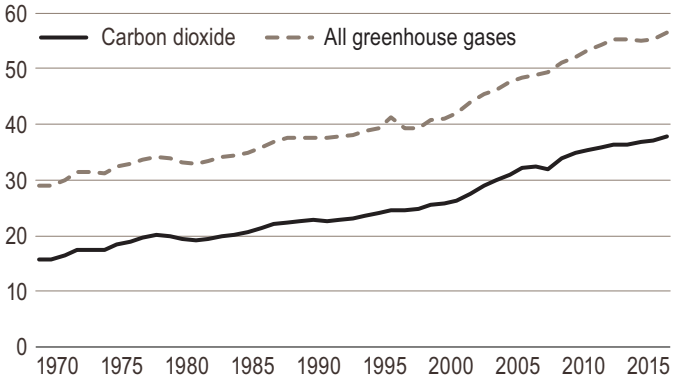
As such, when defining the universe of potential investment opportunities for our Climate Transition Strategy we do not shy away from these sectors, as many others do. Instead, we set out to identify those players that can drive the transition and grow from it, due to an ability to thrive in a climate-constrained world. And we also focus on companies able to adapt to the climate-damage that is to come.

Many companies stand to benefit from the significant increase in investment in infrastructure not only to keep pace with global economic growth and population changes but also to shift existing infrastructure to become more climate-compatible. We believe the companies leading this transition will not only fulfil an important social role, but will ultimately be better positioned for future top-line revenue growth and outperformance.

3.1. The need for change

In 2018, total emissions of GHGs, including from land-use change, increased yet again by 1.3% to 55.3 Gt CO_2e (37.5 Gt CO_2 from carbon dioxide).[29]

FIG. 5 GLOBAL EMISSIONS (GT CO_2E)

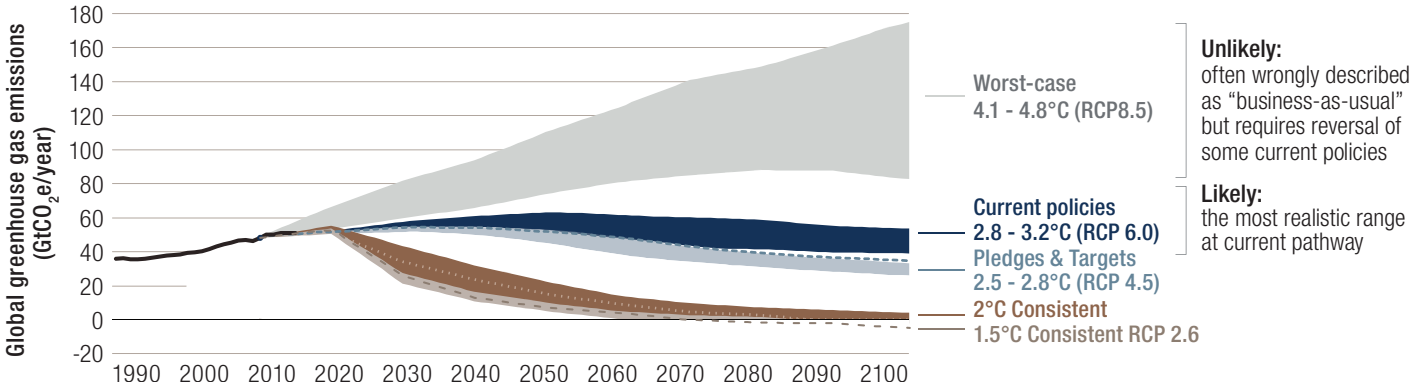


Source: Lombard Odier analysis based on EDGAR (2019), Global Carbon Budget (2019).[30]

To provide a reasonable chance of limiting global warming to 1.5°C, as per the highest ambition of the Paris Agreement, GHGs would need to fall to 25 Gt CO_2e by 2030, representing a 55% decrease from 2018 levels.[31]

Current policies, however, fall well short of this ambition. Estimates for the likely level of global emissions based on our current pathway range from 58-64 Gt CO_2e by 2030.[32] Such a trajectory could see temperatures rise by more than 3°C Figure 6) – a calamitous level that would far exceed any level considered safe and risks the irreversible collapse of the environmental systems upon which the global economy depends.

FIG. 6 WARMING PROJECTIONS – EMISSIONS AND EXPECTED WARMING BASED ON PLEDGES AND CURRENT POLICIES



Source: Lombard Odier analysis, adapted from IPCC Fifth Assessment Report (2014).[33]

[29] UN Environment Programme (2019). *Emissions Gap Report 2019*. Accessed at https://www.unenvironment.org/resources/emissions-gap-report-2019.

[30] International Institute for Applied Systems Analysis (2018). SSP Database (Shared Economic Pathways) – Version 2.0. Accessed at https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=10; *baseline scenario refers to reference case for the SSP 2 (middle of the road) pathway; best-case refers to reference case for the SSP 1 (Sustainability) pathway; worst-case refers to reference case for the SSP 5 (fossil-fueled development) pathway.

[31] Idem.

[32] Idem.

[33] The IPCC uses scenarios called pathways to explore possible changes in future energy use, GHGs, and temperatures. The Representative Concentration Pathways (RCP) were published in the 5th Assessment Report in 2014 and are due to be revised in 2022 in the Sixth Assessment Report and updated to new pathways (SSPs – Shared Socioeconomic Pathways). The previous RCPs are commonly misused, with RCP 8.5 frequently reported as "business-as-usual" For a deeper discussion of RCP8.5 see Carbon Brief, 2019 Explainer: The high-emission "RCP8.5" global warming scenario. Accessed here: https://www.carbonbrief.org/explainer-the-high-emissions-rcp8-5-global-warming-scenario. Current policies are much more aligned with lower temperature trajectories, albeit still misaligned with the requirements of the Paris Agreement.

3.2. The urgency for a net-zero transition

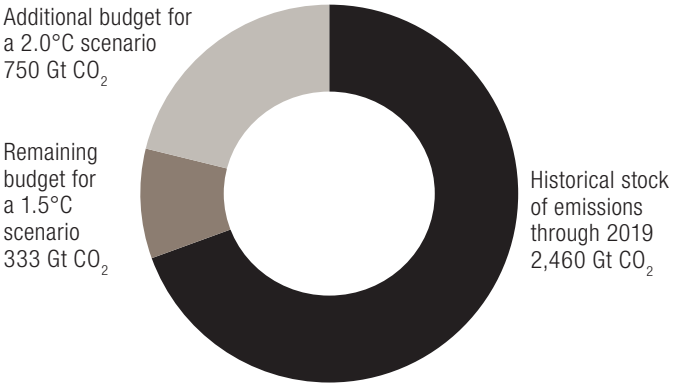
Climate change is correlated less with the level of annual emissions, and more to the stock of GHGs that has accumulated in our atmosphere. Halting global warming therefore necessarily means transitioning to an economy with net-zero emissions, where any remaining, unavoidable emissions are offset through carbon capture from either land use change, bio-energy with carbon capture and storage (BECCS), or artificial solutions such as carbon dioxide removal (CDR) and other negative emission technologies (NETs).

The longer that such a net-zero economy is delayed, the higher atmospheric concentrations of GHGs and resultant temperature anomalies will become. We have already exhausted a cumulative 2,400 Gt CO_2 to date,[34] and the IPCC estimates that we have a remaining carbon budget of 333 Gt[35] to achieve a 66% probability of achieving a 1.5°C scenario. The United Nations estimates that this requires an annual reduction of 7.6%.[36] If this is not achieved, our remaining carbon budget will be exhausted in 7-25 years under a 1.5-2°C scenario. To ensure a reasonable chance of limiting global warming to a level close to 1.5°C, the IPCC has concluded that a net-zero economy must be achieved around the middle of this century.[37]

This goal, however, requires a level of policy and industry ambition well in excess of current commitments. Even in regions such as the EU, where emissions are already falling, emissions would need to fall four times faster than current trends over the period to 2050. In other regions (such as China), where emissions have continued to rise, the challenge is greater still.

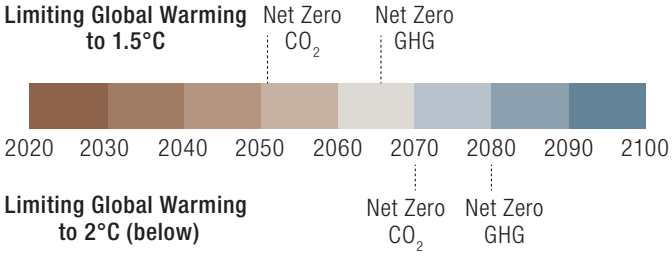
It is important to clarify the difference between net-zero carbon and net-zero GHG emissions. To limit global warming to 1.5°C, the IPCC estimates that the world needs to reach net-zero carbon by mid-century but net-zero GHG emissions will not be required until a decade later. In a 2°C scenario, net-zero carbon emissions need to be achieved by 2070-2080 with a further decade lag for GHGs:

FIG. 7 MAXIMUM, CUMULATIVE CO_2 EMISSIONS TO MAINTAIN TEMPERATURE TARGETS



Source: Lombard Odier analysis, based on Emissions Gap Report (2019), IPCC (2019); includes estimated emissions for 2018 and 2019.

FIG. 8 TIMELINE TO NET-ZERO (CO_2 AND GHG) UNDER 1.5°C AND 2°C SCENARIOS



Source: Lombard Odier.

[34] IPCC (2019) 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories estimates historical emissions up to the beginning of 2011 at 1,640 to 2,420 Gt CO_2. Figure cited is based on the middle of this range and adjusted for estimated emissions over the years 2011-2019. Accessed here: https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/.

[35] IPCC (2019) cites a remaining carbon budget of 420 Gt CO_2 as at 1 January 2018. Figure cited has been adjusted for estimated emissions over the years 2018-2019.

[36] UN Environment Programme (2019): Emissions Gap Report 2019. Accessed at https://www.unenvironment.org/resources/emissions-gap-report-2019.

[37] Idem.

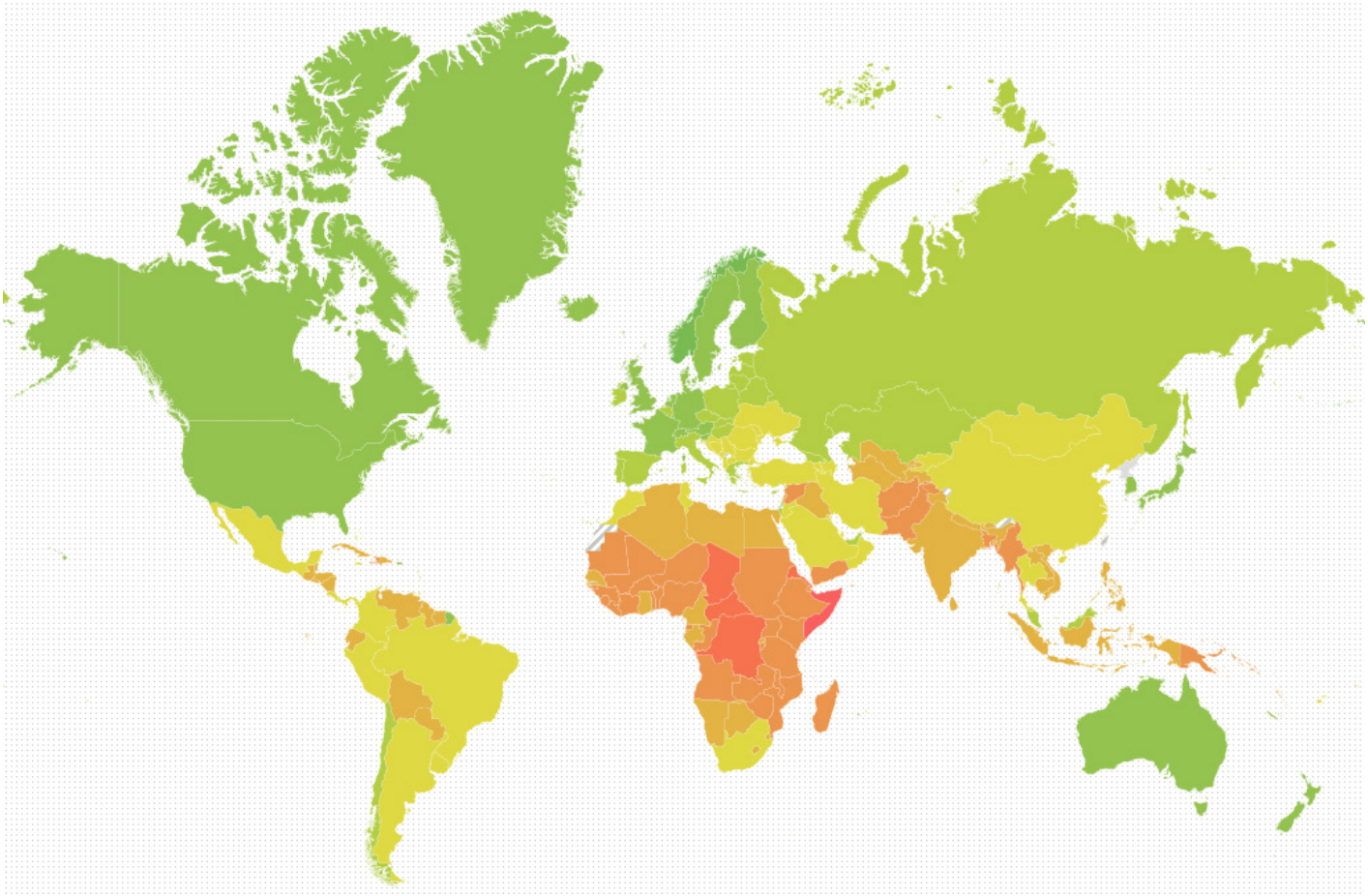
3.3. A climate-damaged world

Even as we seek to promote more concerted action to mitigate climate change through the net-zero economy, even under best-case scenarios, current and future generations will face profound environmental and climatological changes and damage that will pose a severe challenge to communities worldwide.

While some countries may be more exposed than others (see Figure 9), the challenge is a global one. Over 90% of the world's cities, where much of the world's wealth and economic activity is located, are located on coast lines.[38] Cities are therefore particularly exposed to increased risk of flooding, from sea level rise and extreme weather events, while rural areas and food production may suffer from increased periods of drought, rainfall, and changes to crop yields and agricultural productivity.

Recognising these inevitable realities, climate change requires both companies that can perform in a carbon-constrained world as well as those able to contend with the inevitable climate damage to come, to improve resilience and preparedness, and reduce vulnerabilities. International frameworks have placed adaptation activities (i.e. activities that can adapt to existing and future climate damage) on an equal footing with mitigation activities (i.e. activities that can continue to thrive in a carbon-constrained world). The United Nations Environmental Programme (UNEP) has estimated as much as USD 500 billion will be required globally for adaptation activities per year.[39] However, to date, only 5% of climate change investment is currently spent on adaptation efforts.[40]

FIG. 9 ND-GAIN INDEX OF VULNERABILITY AND READINESS TO THE EFFECTS OF CLIMATE CHANGE



Source: Notre Dame Global Adaptation Initiative, used with permission. Version adjusted for GDP.

[38] C40 (2019). Why Cities? Accessed at https://www.c40.org/why_cities.

[39] United Nations (2016). *UNEP report: Cost of adapting to climate change could hit USD 500 billion per year by 2050*. Accessed at https://www.un.org/sustainabledevelopment/blog/2016/05/unep-report-cost-of-adapting-to-climate-change-could-hit-500b-per-year-by-2050/.

[40] Buchner, Barbara et al. (2019). *Global Landscape of Climate Finance 2019*. Climate Policy Initiative. Accessed at https://climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2019/.

Focus box: international recognition of the need for adaptation activities

Following years of awareness-raising, most attention related to climate change historically remained centered on mitigation, and activities that are either already low carbon or can survive a carbon-constrained world. However, increasingly the need for action on adaptation, as an acknowledgement that physical manifestations of climate-damage will without doubt continue to occur, has now been enshrined in a number of international frameworks and initiatives.

- The 2015 Paris Agreement outlines the need for mitigation (article 4) and adaptation (article 7). As part of the agreement, it established a Global Goal for Adaptation (GGA), with the aim of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change."[41]
- The World Bank has launched an action plan on climate change adaptation and resilience, under which direct adaptation finance will ramp up to USD 50 billion over the period from 2021 to 2025.[42] Through this plan, the World Bank Group has stated that it is making adaptation and resilience a key priority that will elevate to an equal footing with climate mitigation actions.
- The EU has progressively increased its emphasis on adaptation activities. In 2013, the EU Commission first adopted a strategy on adaptation, aiming to improve preparedness and resilience. Under the new EU Taxonomy for sustainable finance, agreed in 2019, adaptation is recognised as an eligible activity in the same vein as actions aimed at mitigating climate change.[43]

In light of these frameworks, adaptation and mitigation activities should not be considered mutually exclusive, but as complementary and – as the technical working group for the EU taxonomy observes – may overlap.

The market for adaptation activities is likely to grow. Between them, the members of the G20 countries have planned some USD 60 to 70 trillion in infrastructure spending over the period to 2030.[44] Meanwhile, ongoing urbanisation means around 60% of the urban environment that will host the world's population by 2050 is yet to be constructed.[45] So not only is there a need to increase investment in infrastructure to keep pace with global economic and population growth but also for existing infrastructure to transition to lower carbon intensity and greater resilience to climate damage. Investments in climate resilience may increase upfront costs (estimates vary from 3%[46] to 10%[47]), but serve to avoid much greater future damage,[48] see Figure 4.

In the US, an oft-cited 2005 study concluded that every dollar spent on resilience and preparedness in the US decreased costs to society by an average of four dollars.[49] In 2018, a follow-up study found emergency management programmes and improved building controls produced benefits of four to six dollars for every dollar invested.[50]

In 2019, the Global Commission on Adaptation estimated USD 1.8 trillion investment in five key areas of adaptation globally over the period from 2020 to 2030 would accrue benefits and avoided damages of USD 7.1 trillion, a cost-benefit ratio of nearly four-to-one.[51] In agriculture, the same commission estimated investments in the range of USD 250-500 per hectare increase resilience and boost routine production, increasing yields of crops such as cereal by as much as 70-140%.[52]

Even today, estimates over the years 2010-2018 suggest that median annual losses due to weather events reached USD 215 billion, up from USD 115 billion in the previous decade. In terms of losses, 2017 and 2018 were the costliest back-to-back years in history, with total damages from weather events averaging to USD 327 billion each year.[53]

[41] United Nations Framework Convention on Climate Change (2015). Paris Agreement. Accessed at https://sustainabledevelopment.un.org/frameworks/parisagreement.

[42] World Bank (Sep 10, 2019). It's Time to #AdaptOurWorld. Accessed at https://www.worldbank.org/en/news/feature/2019/09/10/its-time-to-adaptourworld.

[43] EU Technical Expert Group on Sustainable Finance (2019). Taxonomy Technical Report. Accessed at https://ec.europa.eu/info/sites/info/files/business_economy_euro/banking_and_finance/documents/190618-sustainable-finance-teg-report-taxonomy_en.pdf.

[44] Foundation Earth (2015). Regarding: G20 Plans for Infrastructure Finance. Accessed at http://www.fdnearth.org/files/2012/11/G20.final_.pdf.

[45] IRP (2013). Scaled-Up Investments in Sustainable Cities Crucial for Resource Efficiency and poverty Eradication. Accessed at https://www.resourcepanel.org/sites/default/files/documents/document/media/city_level_decoupling_pressrelease_english.pdf.

[46] Global Commission on Adaptation (2019). *Adapt Now: A Global Call for Leadership on Climate Resilience*. Accessed at https://cdn.gca.org/assets/2019-09/GlobalCommission_Report_FINAL.pdf.

[47] OECD 2017, *Investing in Climate, Investing in growth*. Accessed at http://www.oecd.org/environment/investing-in-climate-investing-in-growth-9789264273528-en.htm.

[48] Global Commission on Adaptation (2019). *Adapt Now: A Global Call for Leadership on Climate Resilience*. Accessed at https://cdn.gca.org/assets/2019-09/GlobalCommission_Report_FINAL.pdf.

[49] Multihazard Mitigation Council (2005). *NATURAL HAZARD MITIGATION SAVES: An Independent Study to Assess the Future Savings from Mitigation Activities*. Accessed at (https://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/MMC/hms_vol2_ch1-7.pdf.

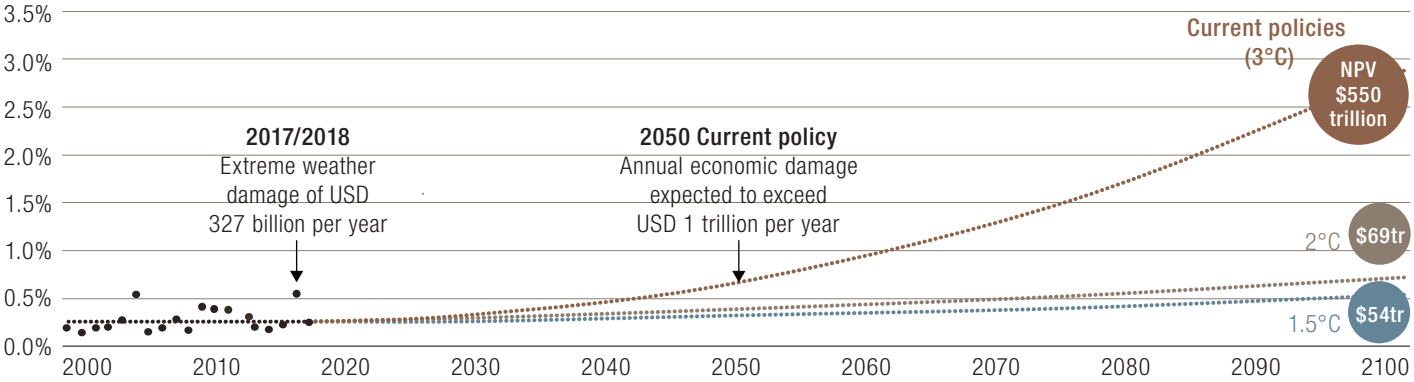
[50] National Institute of Building Sciences (2018). National Institute of Building Sciences Issues New Report on the Value of Mitigation. Accessed at https://www.nibs.org/news/381874/National-Institute-of-Building-Sciences-Issues-New-Report-on-the-Value-of-Mitigation.htm.

[51] Global Commission on Adaptation (2019). *Adapt Now: A Global Call for Leadership on Climate Resilience*. Accessed at https://cdn.gca.org/assets/2019-09/GlobalCommission_Report_FINAL.pdf.

[52] Idem.

[53] AON (2018). Weather, Climate & Catastrophic Insight. Accessed at http://thoughtleadership.aonbenfield.com/Documents/20190122-ab-if-annual-weather-climate-report-2018.pdf.

FIG. 10 ECONOMIC DAMAGE FROM CLIMATE CHANGE (% OF WORLD GDP) IS EXPECTED TO INCREASE DRAMATICALLY, EVEN IN A 1.5°C SCENARIO



Source: Lombard Odier analysis based on Watson and Le Quéré (2018); Aon Benfield (2019).

Climate change will exacerbate these effects. In economic terms, the IPCC estimates the combined effects from a 1.5°C increase would be expected to result in economic damage with a Net Present Value (NPV) of USD 54 trillion.[54] Such damage includes the results of physical risks from flooding and extreme weather events, as well as the cost of discontinued and displaced economic activities. Under a 2°C scenario, the IPCC expects a rise in sea levels of up to one meter this century, possibly putting at risk as many as 145 million people living at near-sea level. Economic costs in this scenario would increase to USD 69 trillion.[55]

The effects of higher temperatures are progressively more difficult to model, placing our ecosystem in dangerous unknown territory. According to some research, however, estimated losses in a 3°C scenario could reach a NPV of USD 550 trillion.[56] This scale of estimated losses underscores the strong economic incentive for the world to avoid such scenarios at all costs.

Given this context, we believe that any investment product aligned with the climate transition must take into account companies able to adapt to climate-damage, as well as those able to operate in a carbon-constrained world. The Lombard Odier Climate Transition Strategy therefore explicitly includes exposure to companies which are adapting to a climate-damaged world and increasing resilience to physical risks, as well as monitoring those risks and managing their impact.

For a further discussion on the economic implications of climate change, see focus box “Making sense of the numbers” at the end of this report.

[54] IPCC (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Chapter 3: Impacts of 1.5°C of Global Warming on Natural and Human Systems. Accessed at https://www.ipcc.ch/sr15/chapter/spm/

[55] Idem.

[56] Kompas, Tom; Pham, Van Ha and Tuong Nhu Che (2018). *The Effects of Climate Change on GDP by Country and the Global Economic Gains From Complying With the Paris Climate Accord.* In Earth's Future (Vol. 6, Issue 8), pp. 1153-1173.

4. Drivers of change: market forces

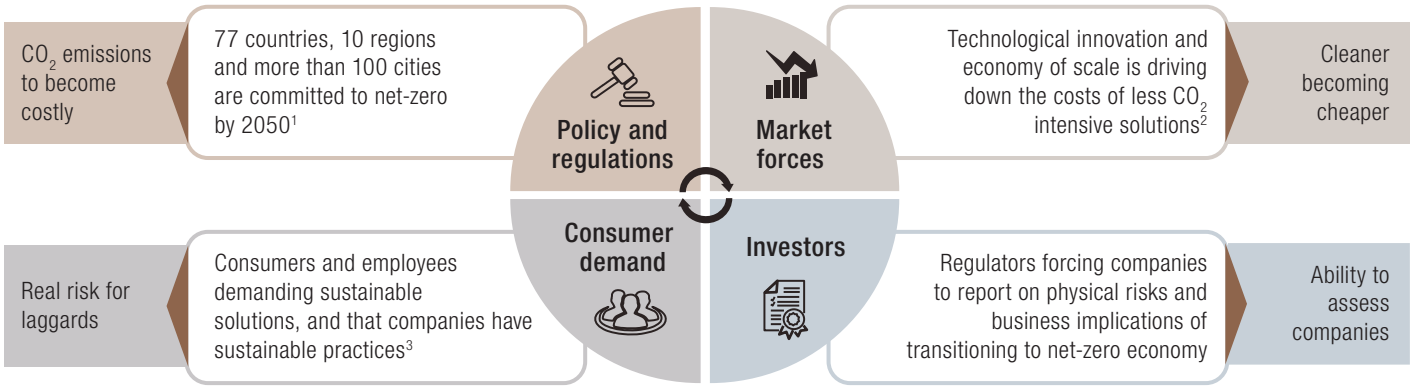
The Climate Transition is well underway. Policy ambition has been slow in the making, and even where governments have made strong commitments, details on implementation in the form of national action plans still lag behind. However, the transition is being driven by more than just policy. Technological advances, consumer demand and investor pressure are all now forcing change. Combined, these market forces provide a growth opportunity for those companies that are embracing the transition and are re-positioning themselves on a pathway to net-zero, while those that shun their responsibility may see themselves starved of capital, talent and consumer demand.

The last decade has provided three essential ingredients that will accelerate and fuel a climate transition: market forces, consumer awareness and investor pressure. These combine to provide a powerful positive feedback loop to support accelerated policy demands:

4.1. Policy environment

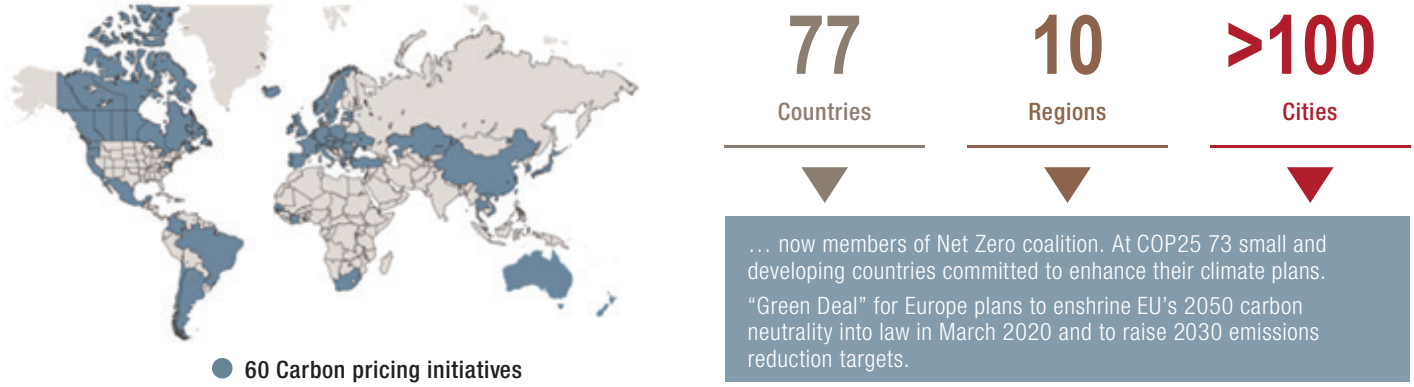
Legal frameworks and policy directives represent perhaps the most specific, measurable indicator of positive change, and determine the minimum standards of achievement with respect to environmental practices. From the original 1992 Earth Summit in Rio de Janeiro, to the landmark 2015 Paris Agreement, policy makers have sought to come to grips with the science and political and economic implications of climate change. These initiatives have succeeded in establishing a scientific basis against which to measure progress on climate action. However, national commitments to turn identified risk-mitigating pathways into reality have generally lagged behind this scientific ambition, with the COP 25 in Madrid a case in point – which has proven to be an exercise in frustration for environmental activists and the business community alike.

FIG. 11 POWERFUL FORCES ARE DRIVING THE CLIMATE TRANSITION: A POSITIVE FEEDBACK LOOP



Source: Lombard Odier. For illustrative purposes only. [1] World Bank Group, State and Trends of Carbon Pricing, June 2019. [2] UN PRI report, September 2019. [3] BloombergNEF 2019, Morning Consult National Tracking Poll #171203.

FIG. 12 COUNTRIES, REGIONS AND CITIES COMMITTED TO DECARBONISATION AND PUTTING A PRICE ON POLLUTION



Source: World Bank Group, State and Trends of Carbon Pricing, June 2019. *Note: Carbon pricing initiatives include ETS (Emissions Trading System), carbon tax implemented, scheduled or under consideration. The authors recognize that other classifications are possible.*

Notwithstanding the lack of dynamic progress, as Figure 12 shows, a growing number of countries have embarked on unilateral or regional initiatives to reduce GHG emissions, committing their economies to net-zero emissions, over varying timelines. To date, these commitments account for a minority share of global emissions, with major nations such as the US, China, India and Japan having climate policies in place, but yet to commit to a similar ambitious goal. Critically, non-state actors, including cities and businesses, have stepped up powerfully to align with the Paris Agreement – such as America's Pledge[57] and "We Are Still In" coalition in the US, which represents nearly 70% of US GDP, founded following the US announcement of its planned withdrawal from the Paris Agreement in 2017.[58]

Whereas national policy targets often still lack clear definition and detail on implementation, one particularly potent tool at the disposal of policymakers is the use of carbon pricing. Putting a price on carbon internalises the negative externality of climate damage, and has the effect of reducing emissions by increasing the price of carbon-based energy, so decreasing demand for it. Carbon prices encourage emitters to find and use economical ways of cutting emissions, and strong commitment to carbon pricing is well understood to create certainty for investors that it pays to invest in low-carbon technologies. For instance, the introduction of carbon price support in the UK electricity sector was accompanied by a 58% decrease in carbon emissions between 2012-2016.[59]

Whether implemented explicitly as a tax or through emissions trading, or implicitly through taxes on energy or the removal of fossil fuel subsidies, carbon pricing mechanisms provide a straightforward and quintessentially textbook economic mechanism to incentivise the reduction of emissions in the economy.

A recent report by the OECD[60] finds that today's carbon prices – while slowly rising – are still too low to have a significant impact on curbing climate change. The report shows that the carbon pricing gap – which compares actual carbon prices and real climate costs, estimated in the OECD economies at EUR 30/tonne CO_2 – was 76.5% in 2018. This figure has fallen from 83% in 2012 but is still insufficient and at the current pace of decline, will see carbon prices meeting real costs only by 2095. This highlights the urgency of pricing carbon correctly in order to align with a net-zero pathway and also demonstrates the order of magnitude of change in carbon prices if governments move to correct the market failure. The report finds that the gap is highest for industry at 91% (and lowest for road transport at 21% due to taxes on transport fuels). The high gap for industry is unsurprising given the hard-to-abate nature of the sector but brings into focus the necessity of finding decarbonisation solutions for a sector so vital to economic security.

At present, the global average price of carbon stands at only USD 2 per tonne. In comparison, the IPCC has suggested that carbon prices should rise to USD 40-80 per tonne by 2020, to USD 50-100 per tonne by 2030, and eventually reach USD 125-140 per tonne by 2040.[61] An OECD report[62] found carbon pricing gaps ranging from as low as 27% in Switzerland to above 90% in some emerging economies. France, India, Korea, Mexico and the United Kingdom substantially reduced their carbon pricing gaps between 2012 and 2015 and other countries have since instigated new carbon pricing initiatives, such as China's emissions trading scheme and renewed carbon pricing efforts in Canada and France.

A carbon border adjustment tax has been proposed as part of Europe's Green Deal to bring the continent to climate-neutrality by 2050. These moves should further reduce the carbon pricing gap but the rate of change needs to accelerate dramatically, especially as the same OECD analysis found that countries with a low carbon pricing gap also tend to be less carbon intensive.[63]

Additionally, it is important to consider the social cost of carbon (SCC), or the measure of economic damage caused by each extra tonne of GHGs produced. This cost includes non-market impacts on both the environment, economic and human health. It helps policymakers evaluate whether an action designed to cut carbon is economically viable using cost-benefit calculations. However, there is extreme uncertainty around SCC estimates, with estimates ranging as high as USD 1,500 per tonne of CO_2e,[64] due to high sensitivity to underlying assumptions including discount rate, and uncertainty on the scale of potential economic and non-economic impact of climate change. The cost is expected to rise over time as the overall level of emissions change and latest studies have concluded that the median cost could be USD 417/tCO_2, with costs highest in India, China, Saudi Arabia and the US.[65]

[57] https://www.americaspledgeonclimate.com/.

[58] We Are Still In (2017). *"We Are Still In" Declaration*. Accessed at https://www.wearestillin.com/we-are-still-declaration.

[59] OECD (2018) *Few Countries are pricing carbon high enough to meet climate targets*. Accessed at: https://www.oecd.org/tax/tax-policy/few-countries-are-pricing-carbon-high-enough-to-meet-climate-targets.htm.

[60] OECD (2018) *Effective Carbon Rates 2018: Pricing Carbon Emissions Through Taxes and Emissions Trading*. Accessed at: https://www.oecd.org/tax/tax-policy/effective-carbon-rates-2018-brochure.pdf.

[61] Edenhofer, O.; Pichs-Madruga, R.; Sokona, Y.; Farahani, E.; Kadner, S.; Seybothm, K.; Adler, A.; Baum, I.; Bruner, S.; Eickmeier, P.; et al. Climate change 2014: Mitigation of Climate Change; Contribution of Working Group III to the Fifth Assessment. Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK, 2014.

[62] Footnote 59.

[63] Footnote 59.

[64] I *Yohe, G.W.; et al. (2007).* "*Executive summary*." *In M.L. Parry; et al. (eds.).* Accessed at: https://web.archive.org/web/20100502173108/http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch20s20-es.html.

[65] Ricke et all, 2018: *Country Level Cost of Carbon*, 24 September 2018. Accessed at https://www.nature.com/articles/s41558-018-0282-y.

4.2. Market forces

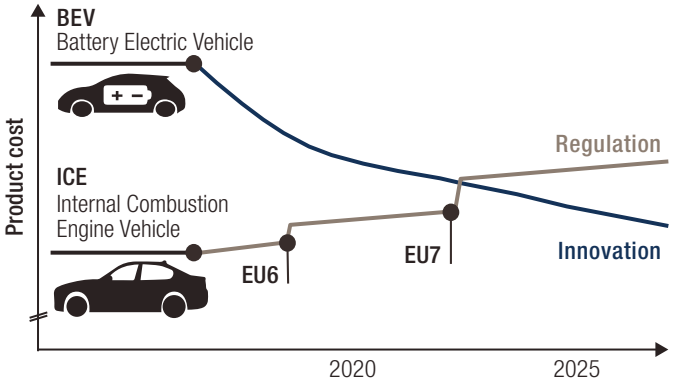
Regulation has played an important catalytic role in driving decarbonisation and creating a market for low-carbon solutions, and, as discussed, we believe that the level of regulatory ambition stands ready to increase. But in in this paper, we show how market forces are now in the driving seat of the transition. We see four key systemic changes as required to drive the climate transition: the Energy, Transport, Industrial, and Food and Land Use Revolutions. A common thread running through these is that the adoption of more sustainable practices and modes of production makes sense not only from an environmental perspective, but also from an economic one. Technological innovation and market forces in low-carbon infrastructure solutions are snatching the reins away from government policies. Economics are now in the driving seat of the transition, with a powerful positive feedback loop of cost declines and increasingly compelling economics.

Data is at the heart of technological innovation, aided by greater connectivity and the Internet of Things (IoT). Data is transforming industries and services and enabling innovations ranging from precision farming, to intelligent buildings, smart grids, smart cars and Industry 4.0. As a result of these technological innovations, costs for decarbonisation solutions across multiple sectors are falling.

We have seen this clearly in the automotive sector where economies of scale have driven down battery costs, thus enabling car manufacturers to more profitably make the electric vehicles needed to comply with regulatory targets, whilst at the same time technological advances in battery cell chemistry have enabled less reliance on artisanal cobalt,[66] longer range batteries and improvements in the environmental credentials of the overall battery lifecycle.[67]

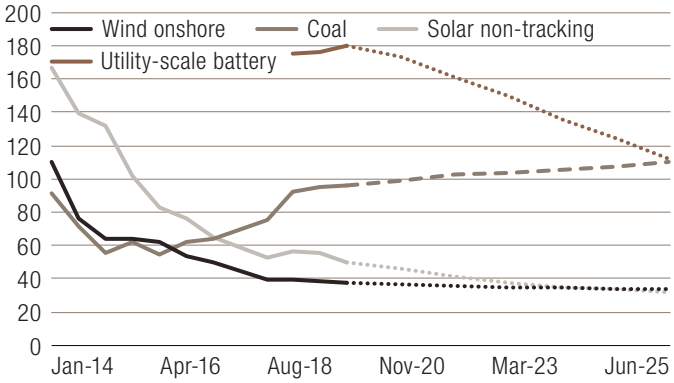
Figure 14 below demonstrates the underlying market forces at work in the power sector. As renewable technologies become more mature and attract greater investment, costs of clean energy are driven down inexorably. Over a period of 10 years, efficiency of common solar cells has increased from 12% to 17% with further innovations under development.[68] Costs of onshore wind in the US have fallen by 66% in real terms since 2014, while prices of solar power have dropped by 70% over the same period.[69] Lifetime costs of storage using lithium-ion technology is expected to fall by 28% over the next five years.[70] IRENA forecasts that by 2020, auction prices of solar and wind power will fall below the marginal operating cost of 700 GW and 900 GW, respectively, of the world's operational coal capacity, corresponding to 35%-45% of the coal industry's current capacity.[71] BNEF forecasts that the world record for low-cost onshore wind and solar will be below USD 10/MWh by 2030.[72]

FIG. 13 MARKET FORCES ARE COMBINING TO DRIVE DOWN BATTERY COSTS AND INCREASE UPTAKE OF EVS



Source: Volkswagen.

FIG. 14 TRENDS IN LEVELISED COST OF ELECTRICITY IN THE US (USD/MWH, 2018 REAL TERMS)



Source: Lombard Odier analysis based on Bloomberg New Energy Finance.

[66] For a more detailed discussion on ethical sourcing of cobalt and the car industry's focus on the full battery supply chain see https://www.unpri.org/social-issues/how-investors-can-promote-responsible-cobalt-sourcing-practices/2975.article; https://www.bmwgroup.com/en/company/bmw-group-news/artikel/conflict-resource-cobalt.html; https://www.benchmarkminerals.com/bmw-announces-it-will-buy-cobalt-directly-from-australia-and-morocco/ and https://asia.nikkei.com/Business/Markets/Commodities/Milestone-reached-in-the-recycle-of-cobalt-from-spent-EV-batteries.

[67] There are multiple debates about the environmental footprint of electric vehicles through the entire value chain (including a focus on sourcing of minerals, the "greenness" of the power supplied to charge the vehicles, and the afterlife of the vehicles and components). Current emissions regulations for car focus solely on tailpipe emissions and omit the regulation of full lifecycle emissions. For further detail see: https://www.forbes.com/sites/jamesellsmoor/2019/05/20/are-electric-vehicles-really-better-for-the-environment/#da3560976d24; https://www.bmwblog.com/2019/08/01/bmw-rare-earths/;

[68] Fraunhofer ISE (2019). Photovoltaics report. Accessed at https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf.

[69] Bloomberg New Energy Finance (2019). Lifetime Costs of Energy. Accessed at https://www.bnef.com/core/lcoe?tab=Forecast%20LCOE.

[70] Lazard (2018). Lazard's Levelized Cost of Storage Analysis – version 4.0. Accessed at https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf.

[71] IRENA (2018). Renewable power generation costs in 2018. Accessed at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf.

[72] BNEF (December 2019): *Peak Emissions Are Closer Than You Think and Here's Why. Accessed at https://about.bnef.com/blog/peak-emissions-are-closer-than-you-think-and-heres-why/.*

In the US, the coal industry received an apparent boost with the election of President Trump, who used the plight of the coal industry as a major justification for the US' announced withdrawal from the Paris Agreement. Despite this high-level support, however, US coal consumption declined by c.16% in 2019,[73] falling to a 42-year low.[74] Over the course of the year, eight major coal companies filed for bankruptcy in the country,[75] and Moody's downgraded the sector to a negative outlook.[76]

Carbon capture, utilisation and storage (CCUS) supports cleaner manufacturing, while the use of scrap metal and improved recycling can radically improve efficiency. The use of computer-aided design, the use of composites, 3d-printed mesh materials and other advanced materials, and the transition to smart factories that improve efficiency through real-time process and inventory management and artificial intelligence all serve to reduce footprints. Transforming production processes in this manner depends on engineering innovation and upfront investment, but ultimately serves to reduce energy requirements and emissions and thus boost production efficiency.

4.3. Consumer demand

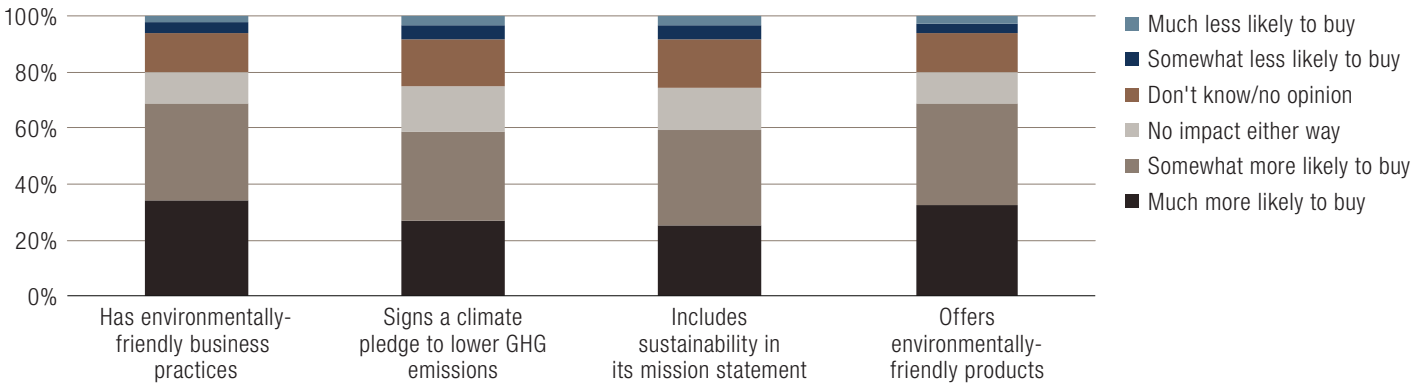
In an age of social media, advocacy campaigns and investigative media, company performance on sustainability is a matter of public record. As public awareness on climate change has entered the mainstream, with the emergence of large protest movements across the world, company reputation has become increasingly reliant on environmental credentials.

Studies suggest that consumers attach greater weight to companies that "walk-the-walk," rather than merely "talk-the-talk." In a US poll conducted by Morning Consult, around 59% of consumers expressed environmental pledges made by the company or a mission statement acknowledging the importance of sustainability would positively affect their decision to buy from the company.[77] The figure increases to 69% for those companies demonstrating good business practices or offering environmentally-friendly products.[78]

Academic studies have found consumer purchasing behaviour is indeed affected by perceptions of sustainability,[79] demonstrating that consumer intent translates into tangible market effects. A study by Nielsen of 1,300 brands across 13 markets found that brands with a demonstrated commitment to sustainability enjoyed sales growth 3% higher than those without it.[80] The same study found two thirds of consumers are now willing to pay more for brands that deliver a positive impact.

As standards and expectations are raised, ensuring companies do not fall behind is critical to protecting reputation. While managers will keep a close eye on their bottom line in their decision of where they intend to position their brand, where companies get sustainability wrong, the damage to branding

FIG. 15 US CONSUMER RESPONSES REGARDING IMPORTANCE OF ENVIRONMENTAL PRACTICES



Source: Morning Consult National Tracking Poll #171203.

[73] S&P Global (2020) *Declining gas prices drive drops in US coal production and demand in 2020: Platts Analytics*. Accessed at: https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/012320-declining-gas-prices-drive-drops-in-us-coal-production-and-demand-in-2020-platts-analytics.

[74] Egan, Matt (10 October 2019). *Trump's push to save coal is failing. Coal demand to plunge to 42-year low*. CNN. Accessed at https://edition.cnn.com/2019/10/10/business/coal-power-trump/index.html.

[75] Johnson, Keith (30 October 2019). Trump Can't Save Coal Country. Foreign Policy. Accessed at https://foreignpolicy.com/2019/10/30/trump-save-coal-country-murray-bankruptcy-gas/.

[76] Institute for Energy Economics and Financial Analysis (2019). Moody's downgrades U.S. coal sector, expects "substantial" decline in demand. Accessed at https://ieefa.org/moodys-downgrades-u-s-coal-sector-expects-substantial-decline-in-demand/.

[77] Morning Consult (2017). *National Tracking Poll #171203*. Accessed at https://www.politico.com/f/?id=00000160-4b8c-d2ac-a1f2-fbfcbf000002.

[78] Idem.

[79] Veit, Claire et al (2018). The Impact of Sustainable Sourcing on Customer Perceptions: Association by Guilt from Scandals in Local vs. Offshore Sourcing Countries. Sustainability (Vol. 10). Accessed at https://www.mdpi.com/2071-1050/10/7/2519/pdf.

[80] Nielsen (2015). *He Sustainability Imperative*. Accessed at https://www.nielsen.com/eu/en/insights/report/2015/the-sustainability-imperative-2/.

(and shareholder value) can be considerable. A study by Cone Communications found 90% of consumers would boycott companies engaging in irresponsible or deceptive business practices.[81] In the fast fashion industry, changes in consumer attitudes to the industry's environmental footprint and exposure to issues of poor working conditions and human trafficking are emerging as a material risk. Sustainable tourism, sustainable fashion and sustainable food have already become trending consumer industries, boosted by growing consumer awareness of climate change, and present many opportunities for companies that target these sustainable products.

A study by McKinsey found on average 51% of the value of the top companies targeting consumer products depends on expected growth trends which are liable to be put at risk by changes in emissions, air pollution, water shortages and other sustainability challenges.[82] The ultimate beneficiaries on one end of the investment value chain – the pensioners, retail investors and insurance policy holders – are increasingly demanding double or triple bottom line solutions, or the three P's (People, Planet and Profit). This pressure is feeding through to asset owners and managers, and ultimately, companies.

4.4. Investor pressure

Even where executives fail to see the urgency of the climate transition, investors are increasingly calling on the companies they invest in to do better. To investors, climate change may represent both a systemic risk, requiring mitigating strategies, and an opportunity for lucrative investments in green technologies, requiring a re-alignment to these growth markets.

There has been a strong growth in sustainability-focused investing in the last few years. In 2018, total assets under professional management invested according to responsible investment strategies exceeded USD 30 trillion for the first time.[83] By 2020, we see total assets invested according to responsible investment strategies exceeding USD 40 trillion.[84] Likewise, on the fixed income side, issuance of sustainable debt surged 78% to USD 465 billion in 2019[85] and for the first time surpassed USD 1 trillion cumulatively. Based on our analysis of the prospects for sustainable debt issuance, we expect issuance to grow to USD 560-620 billion in 2020 and USD 720-810 billion in 2021.[86]

However, we believe the majority of sustainable investing still needs to transition to a more forward-looking, judgemental approach in order to fully account for both the risks and opportunities on the table as companies transition towards net-zero. A large proportion of sustainability-related investment focuses solely on simplistic negative exclusions screening or over-reliance on basic ESG metrics which lack consistency, focus excessively on business practices (and not business models) and fail to sufficiently capture risks or forward looking opportunities. Of the USD 30 trillion invested sustainably in 2018, only USD 0.4 – USD 1 trillion focused on sustainability as a core conviction.[87]

However, investor activism is on the rise. One clear example is that 454 shareholder resolutions related to environmental, social and sustainability concerns were filed with US companies in 2019.[88] With a growing awareness of the need to better quantify risks and opportunities associated with climate change, we expect investors to increasingly focus on assessing company fitness for the transition to net-zero.

Investors are now realising that climate change is material to the performance of companies, as a result of the revaluation of assets, emerging liabilities, risks to revenues, and changing cost structures. Moody's, for instance, has stated that 11 sectors with USD 2.2 trillion in rated debt already face elevated environmental risk exposure, with a further 22 sectors with USD 10.1 trillion in rated debt facing moderate risks.[89] Similarly, Standard & Poor's found 717 ratings between 2015-2017 where environment and climate risks were a material factor to the analysis and 106 of these led to a rating action, 56% to ratings downgrades (predominantly on issuers in the oil, gas and power industries).[90]

The Bank of England (BoE) has warned that as much as USD 20 trillion of assets could be at risk of becoming "stranded" in the climate transition.[91] The BoE is therefore calling on all UK financial institutions to stress-test and quantify physical and transition risks

[81] Cone (2015). 2015 Cone Communications/Ebiquity Global CSR Study. https://www.conecomm.com/research-blog/2015-cone-communications-ebiquity-global-csr-study.

[82] McKinsey (2016). Starting at the source: Sustainability in supply chains. Accessed at https://www.mckinsey.com/business-functions/sustainability/our-insights/starting-at-the-source-sustainability-in-supply-chains.

[83] Global Sustainable Investment Alliance (2019). Global Sustainable Investment Review 2018. Accessed at http://www.gsi-alliance.org/wp-content/uploads/2019/03/GSIR_Review2018.3.28.pdf.

[84] Lombard Odier forecasts.

[85] Bloomberg New Energy Finance (2020). Accessed at: https://about.bnef.com/blog/sustainable-debt-joins-the-trillion-dollar-club/.

[86] Lombard Odier forecasts.

[87] See footnote 82.

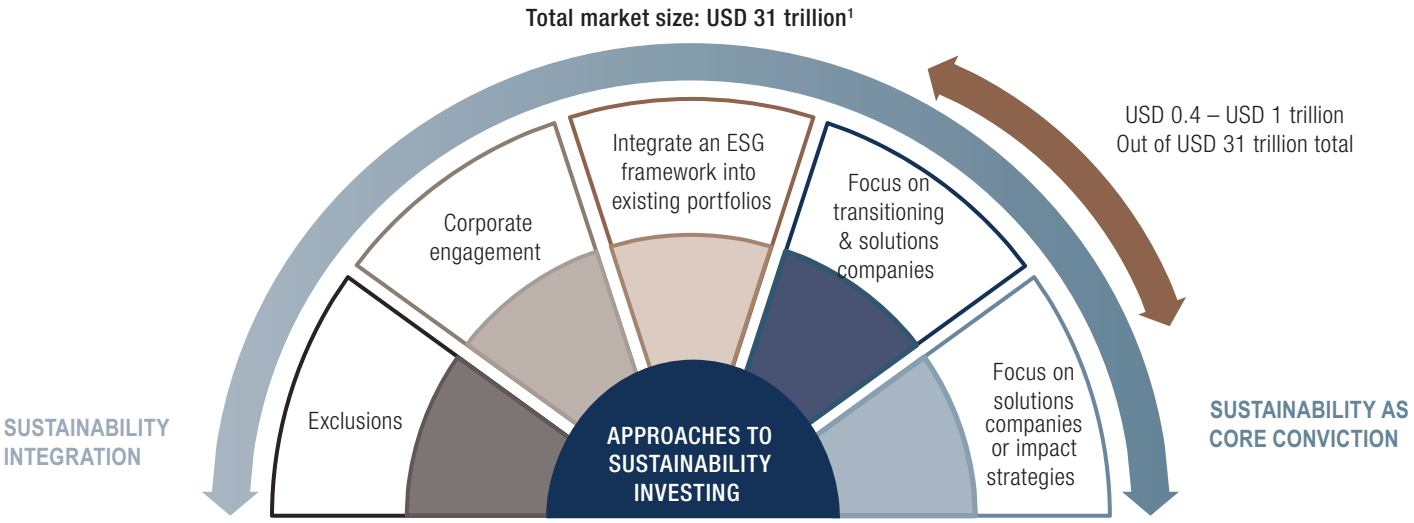
[88] Sustainable Investments Institute (2019). Fact Sheet: Social & Environmental Shareholder Proposals at U.S. Companies. Accessed at https://siinstitute.org/special_report.cgi?id=80.

[89] Moody's (2018). Eleven sectors with USD 2.2 trillion in rated debt have elevated credit exposure to environmental risks, says Moody's. Accessed at https://www.moodys.com/research/Moodys-Eleven-sectors-with-22-trillion-of-debt-have-elevated--PR_389299.

[90] S&P Global Ratings (2017) *How Environment And Climate Risks and Opportunities Factor Into Global Corporate Ratings – An Update*. Accessed at https://www.spratings.com/documents/20184/1634005/How+Environmental+And+Climate+Risks+And+Opportunities+Factor+Into+Global+Corporate+Ratings+-+An+Update/5119c3fa-7901-4da2-bc90-9ad6e1836801.

[91] The Guardian (17 April 2019). *Mark Carney tells global banks they cannot ignore climate change dangers*. Accessed at https://www.theguardian.com/environment/2019/apr/17/mark-carney-tells-global-banks-they-cannot-ignore-climate-change-dangers.

FIG. 16 THE LANDSCAPE FOR SUSTAINABLE INVESTING IS EVOLVING AND EXPANDING



Source: Lombard Odier (adapted from Global Sustainable Investment Review 2018); [1] Note that owing to overlap between the various approaches listed, the totals do not sum to the USD 31 trillion in total sustainable investments; [2] includes screening solely based on negative exclusions as well as best-in class screening; [3] Approaches featuring full ESG integration assumed to include corporate engagement.

associated with different climate scenarios by 2021. In 2019 a practice paper by IASB[92] concluded that climate change risk may be material for many companies and impact corporate profits and should therefore be disclosed and quantified.

To investors, climate change is therefore a clear and present challenge, and they are increasingly vocal in their demands for corporate strategies to reflect this reality. As at December 2019, 930 organisations have joined the Financial Stability Board's Task Force on Climate-Related Financial Disclosures (TCFD), requiring increased transparency on climate risks[93] (see below).

Given the scale of these risks, policymakers have in turn grown increasingly concerned about the risks that climate change, and needed adaptations, could cause for the stability of our financial systems. A number of initiatives have emerged aiming both to identify existing risks, and rally the financial industry to the investment requirements of the climate transition:

- The **Task Force on Climate-related Financial Disclosures** (TCFD) was set up by the Financial Stability Board and G20 in 2015 to make recommendations on integrating climate-related risks into risk disclosures of companies, banks and investors. The TCFD made its first recommendations in 2017, encouraging companies to include disclosure on the governance, strategy, risk management and metrics used to assess the financial significance of climate change.
- The **Network for Greening the Financial System** (NGFS) was founded in 2017, and aimed to help strengthen the global response to the goals of the Paris agreement, with a particular focus on the role of the financial system in managing risks and mobilising capital. The NGFS made its first recommendations in 2019, with the recommendations in the report ranging from integrating sustainability factors into central banks' portfolio management, to policy actions that may support the transition, through disclosure requirements and classifications systems such as the EU taxonomy (described below). While the US has been notably absent from the network, other members (such as the People's Bank of China) have been active and engaged, with the next two years likely to reveal the extent to which national authorities are willing to adopt the recommendations.
- In September 2019 the UNEP Finance Initiative launched the **Principles for Responsible Banking**. The principles commit signatories to align with the Sustainable Development Goals and the Paris Agreement to take into account societal needs. Applying to the whole institution, members commit to measurable targets and disclosure requirements. First reports and self-assessments are due 18 months from signing, with full implementation expected after four years – with the first reports therefore expected towards the beginning of 2021.[94]

[92] See footnote 3.

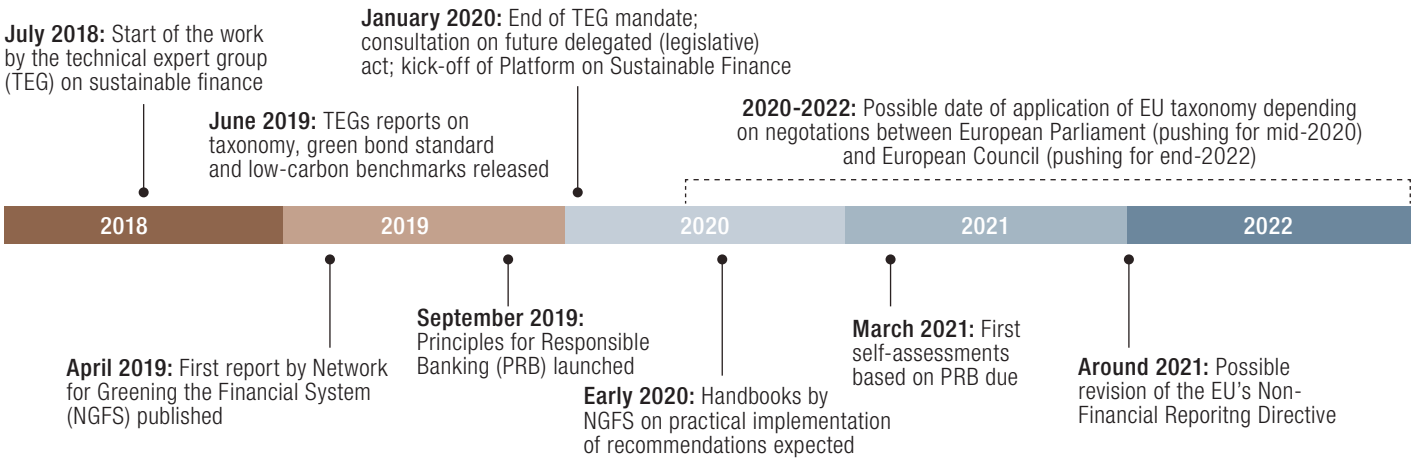
[93] Task Force on Climate-Related Financial Disclosures (2019). TCFD Supporters. Accessed at https://www.fsb-tcfd.org/supporters-landing/.

[94] UNEP Finance Initiative (2019). Principles for Responsible Banking: Key Steps to be Implemented by Signatories. Accessed at https://www.unepfi.org/wordpress/wp-content/uploads/2019/07/Key-Steps-to-be-Implemented-by-Signatories.pdf.

- Standing out among these in breadth and scope is the **EU Commission's action plan on sustainable finance**, originally published in 2018, comprising four main elements:[95] The establishment of a common taxonomy intended to classify sustainable activities, the development of an EU standard for green bonds, the introduction of two benchmarks related to decarbonisation and Paris-alignment, and the promotion of transparency in financial services through disclosure requirements on ESG integration. The EU taxonomy was approved in December 2019 and is likely to be of particular importance to the finance industry in Europe, and is detailed in the focus box in this section.

The combined effect of increased investor awareness and policy makers forcing companies to disclose climate-change materiality is creating a powerful, positive feedback loop. Investors are demanding better company disclosure, which will in turn enable better financial decision-making. The integration of climate risks into new accounting practices, credit risks, disclosure requirements (TCFD), stress tests, and the financial taxonomy is aiding this process. In combination with rising consumer pressure and technology as a further enabler, investors are becoming better able to make enhanced financial decisions related to climate change materiality, and help mobilise capital for the net-zero economy.

FIG. 17 TIMELINE OF REGULATORY AND VOLUNTARY INITIATIVES RELATED TO CLIMATE-RELATED FINANCIAL RISKS AND DISCLOSURES



Source: Lombard Odier.

Focus box: The EU's Sustainable Finance Taxonomy

Increasingly, financial regulations are putting pressure on investors to integrate sustainability into their investment processes and to prevent "green washing." One of these initiatives is the EU's Sustainable Finance Taxonomy which was approved by the EU Parliament and EU Council and EU Commission in December 2019.

The Taxonomy aims to help provide a common language for investors, issuers and policymakers to ensure investments are meeting robust environmental standards and are consistent with high-level policy commitments, such as the Paris Agreement. It provides a green list of activities and products to which financial market participants in EU Member States will be required to adhere in order to label their products "environmentally sustainable." All financial products being offered in the EU will have to disclose their alignment with the Taxonomy. All investors and companies must be reporting in line with the climate element of the Taxonomy by December 2021.

The Taxonomy sets performance thresholds (referred to as "technical screening criteria") for economic activities which:

- Make a substantive contribution to environmental objectives
- Avoid **significant harm** to other EU environmental objectives (pollution, waste & circular economy, water, biodiversity).

The Taxonomy includes activities contributing to both climate change **mitigation** and climate change **adaptation**. It also includes activities that are currently carbon intensive (like iron and steel manufacturing) but transitioning to a lower carbon environment. The aim is to support the transition from carbon-intensive to net-zero in order to incentivise the harder-to-abate sectors to make a more substantial contribution to climate change mitigation. The Taxonomy is explicit about the importance of including these more carbon intensive sectors.

[95] European Commission (undated). Green finance. Accessed at https://ec.europa.eu/info/business-economy-euro/banking-and-finance/green-finance_en.

The three levels of activities the Taxonomy includes are:

TYPE OF ACTIVITY	EXAMPLES
Activities that are already **low-carbon** (i.e. compatible with a 2050 net-zero carbon economy)	· Zero emission transport · Near to zero electricity generation · Afforestation
Transition activities (which contribute to a transition to a net-zero economy by 2050 but are not currently operating at that level)	· Building renovation · Electricity generation <100kg CO_2/kWh · Cars <50g CO_2/km
Enabling activities (that support the decarbonisation of other activities)	· The use of steel for train tracks · Manufacture of wind turbines · Installation of efficient boilers in buildings

There are stringent criteria within the EU Taxonomy for "Transition activities" but they are clearly included within the "sustainability" definition. There is room for high emitting activities but either with required trajectories to achieve net carbon neutrality by 2050 and/or from the top 10% performers' level of the EU-ETS Benchmark in a given sector.

The Taxonomy highlights seven eligible sectors (Agriculture and forestry, Manufacturing, Electricity, gas, steam and air conditioning supply, Water, sewerage, waste and remediation, Transport, ICT and Buildings. It also lays out 67 granular activities within those sectors that are viewed as making a significant contribution to climate change mitigation.

In addition to the Taxonomy, in December 2019 the Technical Expert Group of the EU published its handbook of climate transition benchmarks, Paris-aligned benchmarks and ESG disclosures. This Handbook lays out the recommendations for index portfolios (but we also believe these are relevant for specific asset management portfolios) to report alignments with the Paris agreement. The Handbook, similarly to the Taxonomy, **highlights that high-polluting sectors can (and should) be included in sustainable portfolios**. The Handbook also argues that an equity index which has a very low GHG intensity and does not include any high climate impact sectors is arguably not contributing to the energy transition.

We concur that it is vital to select the best performing companies within high-emitting sectors, in order to encourage further decarbonisation of the hardest-to-abate segments of the market. The Lombard Odier Climate Transition Strategy therefore seeks to align itself with the over-arching concepts of the EU Taxonomy.

5. Decarbonisation: a challenge affecting multiple industries

Achieving a net-zero economy depends on concerted action *across all industries*. Traditionally the focus of decarbonisation has rested on the energy sector and efforts to transition from fossil fuel intensity to zero-carbon primary energy supply. We will discuss routes to improve energy productivity in section 6 as well as the need to transition to lower carbon power systems. However, it is important to understand the complexity of the world's flow of GHG emissions (see Figure 18) and the importance of decarbonising energy-consuming sectors as well as primary energy supply.

A large proportion of end state carbon emissions are generated from carbon-intensive sectors such as transport, buildings, iron & steel, cement and chemicals. These industries are a mainstay of our economy and are essential as a driver of growth, providing the materials upon which our societies are built, and yet emissions in these industries are difficult to abate. The need for high operating temperatures, unavoidable process emissions that result from physical and chemical reactions and the sunk costs of legacy assets represent difficult obstacles that increase the cost of reducing emissions.

Emissions are deeply entangled with every sector of the economy for the simple reason that we have built our entire industrial and economic model on the convenience and energy density of fossil fuels. The climate transition requires that economic activity rapidly shifts away from this key input, a challenge akin to unpicking a massive knot over several decades. Due to the complex nature of the flow of global emissions and the need to understand the entire emission value chain from Scope 1 to Scope 2, we believe it is vital to focus on decarbonisation across all industries. Scope 3 emissions, or "value chain emissions" are those generated at the upstream or downstream of an organisation and outside of their own direct operations. These emissions cannot be ignored and often represent the largest source of GHGs, as can be seen by the Sankey flow diagram at Figure 18 below.

Society's reliance on fossil fuels is responsible for the majority of global GHG emissions. Coal, oil and gas have fuelled most economic development for decades; they have influenced everything from the design of our homes, transport and cities to the way we produce food and manufacture goods. For instance, the use of natural gas to generate electricity in combined-cycle gas turbines influenced the liberalisation and design of electricity markets in some OECD countries in the 1990s. Similarly, today's urban planning and transport choices are marked by our reliance on petrol or diesel cars. The same observation applies to GHG-intensive inputs in agriculture and industry. Unravelling this will require a deep understanding of the policy signals driving it and an unwavering commitment to change.[96]

Since policy frameworks and economic interests were historically geared towards fossil fuels and carbon-intensive activities. Inadvertently or not, this creates a misalignment between existing policy and climate objectives, hindering low- carbon investment and consumption choices. However, many countries and regions are now tackling this reality directly and beginning the process of unravelling this complex web. This unravelling, from the removal of fossil fuels subsidies by finance ministries to macroprudential interventions by central banks, is occurring gradually but – like a sneeze – can build slowly before the full explosion.

Even sectors which may not at first glance appear to have a direct exposure to climate change, could still need urgently to transition their business models. For instance, a company in the consumer staples sector might not appear energy-intense but may still have to invest to ensure a switch to net-zero carbon transportation for its goods and services, or look further down its supply chain to understand its suppliers' agricultural processes, as well as analyse its upstream waste footprint. Similarly, a blue chip technology stock, still needs to focus on its Scope 3 emissions across the entire value chain,[97] even if its own direct carbon footprint is low. Decarbonisation thus touches all stocks and sectors, given the current energy-intensity of the world's economy.

5.1. Net-zero urgency for hard-to-abate industries

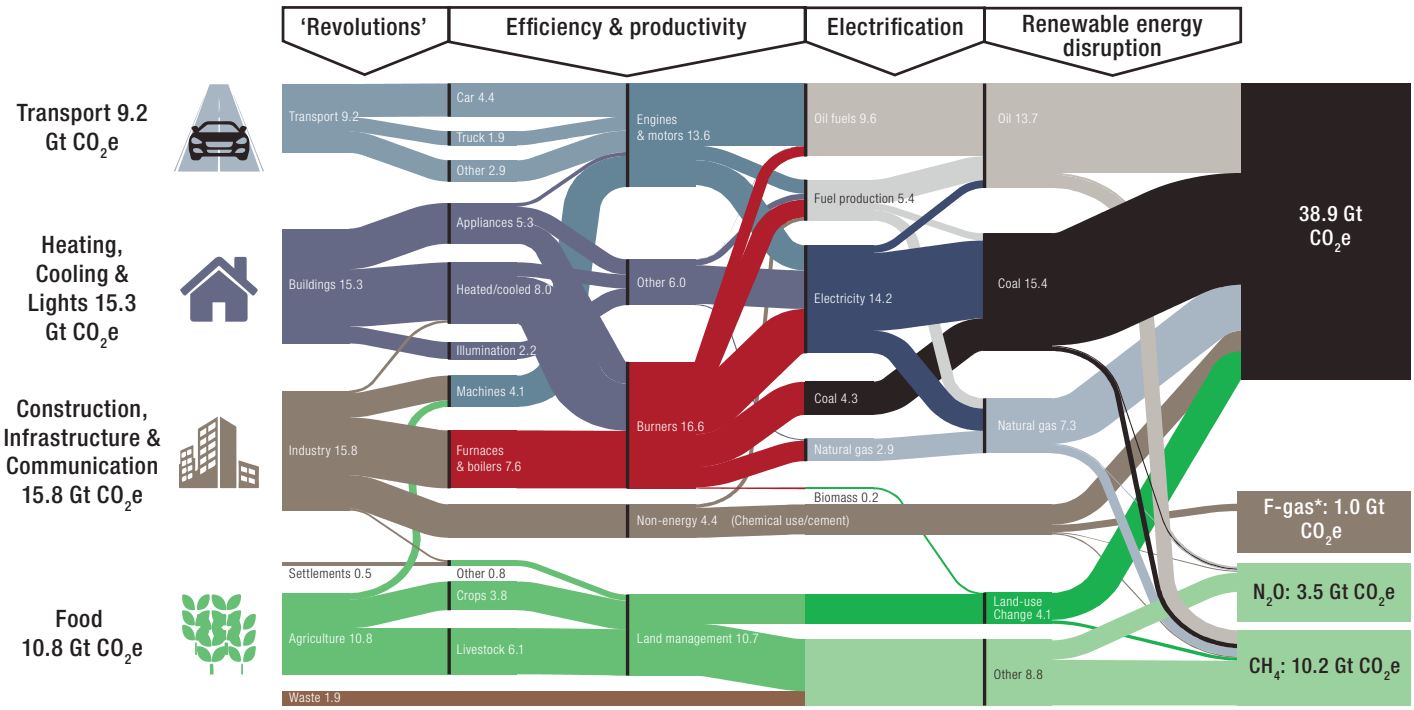
We highlighted in section 3.2 the necessity of focusing both on CO_2 reduction but also on total GHG reduction in order to align to a net-zero world. It is important to highlight that decarbonisation must be a key focus across industries, but, in order to achieve net-zero ambitions, a reduction in total GHG emissions will also be required. Energy demand remains a key primary source of carbon emissions, requiring revolutions across multiple supply chains, including power, transport, buildings and heavy industry, which we will discuss in detail in the proceeding sections.

Land use must also be emphasised as a key provider of negative carbon emissions. Land will help to mitigate emissions still produced by other sectors. However, this must be achieved with

[96] OECD/IEA/NEA/ITF (2015), Aligning Policies for a Low-carbon Economy, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264233294-en.

[97] CNBC, 22 January 2020: *How Microsoft's new carbon-negative plan will test the idea of a climate economy*. Accessed at: https://www.cnbc.com/2020/01/22/how-microsofts-carbon-negative-plan-will-test-the-climate-economy.html.

FIG. 18 GLOBAL FLOW OF GHG EMISSIONS



Source: Lombard Odier analysis. Resource efficiency collection, Leonardo DiCaprio Foundation, (2014). *Fluorescent Gas.

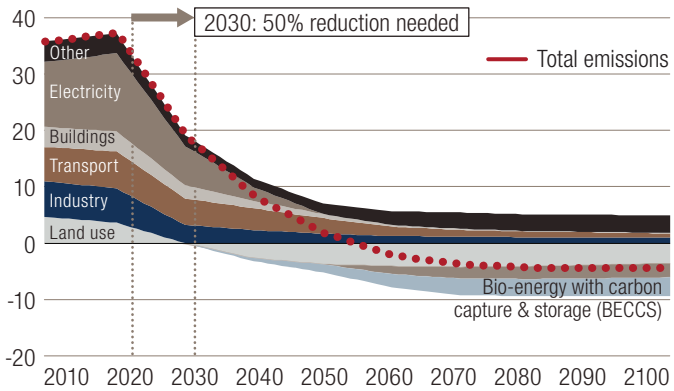
the complementary aim of reducing other GHG emissions, such as methane, from agricultural processes.

The Sankey chart above (Figure 18), highlights that while food generation accounts for 20% of total GHG emissions, it only accounts for c11% of carbon emissions. This is because the sector is methane (CH_4) and nitrous oxide (N_2O) intensive and accounts for 44% and 81% of total CO_2e emissions of these gases respectively. Therefore, unless production and processing efficiencies can been achieved in this sector, total contributions to GHG emissions will rise significantly.[98]

The urgency of the reduction will be exacerbated as the demand for food continues to rise, driven by economic development and population growth. Without a heavy focus on providing a net-zero pathway for land applications' methane and nitrous oxide emissions (particularly given the industry's importance in acting as a carbon-sink to mitigate other hard-to-abate industries), global targets will not be achieved. These conflicting aims must also be achieved with minimum disruption to the bio-diversity of the ecosystem.

Land use applications are a helpful source of mitigation for carbon in other sectors but a report from the Energy Transition Commission (ETC)[99] concludes that reaching net-zero CO_2 emissions will require the energy and industrial system reach net-zero emissions in themselves – i.e. without permanently relying on the purchase of land use offsets. Figure 19 below shows the pathway required by these sectors to align to a 1.5°C world and the urgent need to decarbonise over the next decade. The figure highlights the importance of land-use (via bio-energy and BECCS as a carbon sink.

FIG. 19 PATHWAY TO THE NET-ZERO ECONOMY AND NET-NEGATIVE ECONOMY (1.5°C)

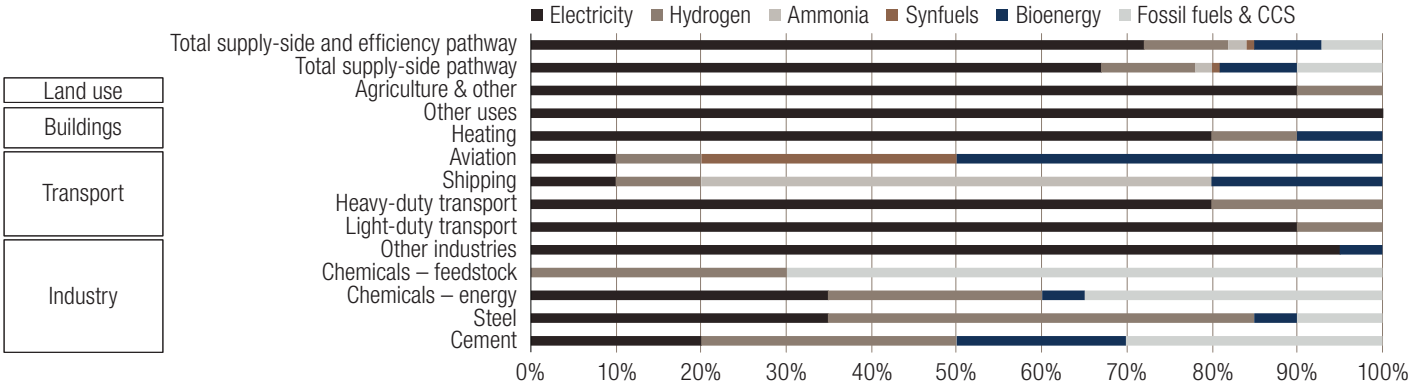


Source: IPCC Special Report: Global Warming of 1.5°C.

[98] IPCC (2019) *Special Report On Climate Change and Land* Accessed at https://www.ipcc.ch/srccl/chapter/summary-for-policymakers/.

[99] ETC (2018) – *Mission Possible: Reaching Net-Zero Carbon Emissions From Harder-to-Abate Sectors by Mid-Century*. Accessed here: https://www.ineteconomics.org/uploads/general/ETC_MissionPossible_FullReport.pdf.

FIG. 20 ESTIMATED FINAL ENERGY MIX (%) IN A ZERO-CARBON ECONOMY (2050) – ELECTRICITY ALONE CANNOT DECARBONISE HARD-TO-ABATE INDUSTRIES



Source: Energy Transitions Commission Mission Possible 2018.

5.2. Technically feasible to decarbonise hard-to-abate industry

Cost-effective solutions are starting to become apparent for the decarbonisation of electricity and electric vehicle adoption will increasingly decarbonise short-distance transport. However, it is also important to address the "harder-to-abate" sectors, including heavy-industry, heavy-duty/long-distance transportation and building heating. Without a focus on decarbonising these sectors, it will be impossible to achieve net-zero by mid-century.

The ETC Mission Possible[100] report concludes that it is both technically and economically possible to decarbonise each harder-to-abate sector at an affordable cost to consumers and to the overall economy if key innovations are deployed, zero carbon energy supply is increased and policy obstacles are removed to ensure a "just transition" for all.

With a step up in investment focused on hard-to-abate industries, the ETC argues that energy and industrial systems can reach net-zero by 2050 in developed economies and 2060 in developing economies (see Figure 20). We concur and believe that while the transition will be challenging, it will also deliver major economic opportunities, drive technological innovation and resource productivity improvements which will benefit the industrial cost base, and therefore deliver environmental benefits.

As we will discuss in the following section on the key sustainability revolutions, we believe it is vital to step up investment in innovative decarbonisation technologies such as hydrogen, biomass and carbon capture, because energy efficiency improvements and electrification are not enough by themselves to reach net-zero in all industries. Technological innovations have greatly reduced costs for renewable energy. Further cost reductions will enable the power sector to keep pace in a sustainable manner with the incremental electricity demand enforced by the decarbonisation of transportation, buildings and heavy industry. But electrification must be deployed in combination with other technology innovations, such as hydrogen, biochemistry, biomaterials and carbon capture.

5.3. Economic growth depends on carbon-intensive sectors

Energy, transport, buildings and industry are a mainstay of our economy and are essential as a driver of growth, providing the materials upon which our societies are built. As we have discussed, emissions in these industries are difficult to abate. However, we believe that economic growth is dependent on the harder-to-abate sectors. We are also convinced that solutions to decarbonise these sectors, as well as those aimed at adapting infrastructure for an increasingly climate-damaged world will offer investment opportunities.

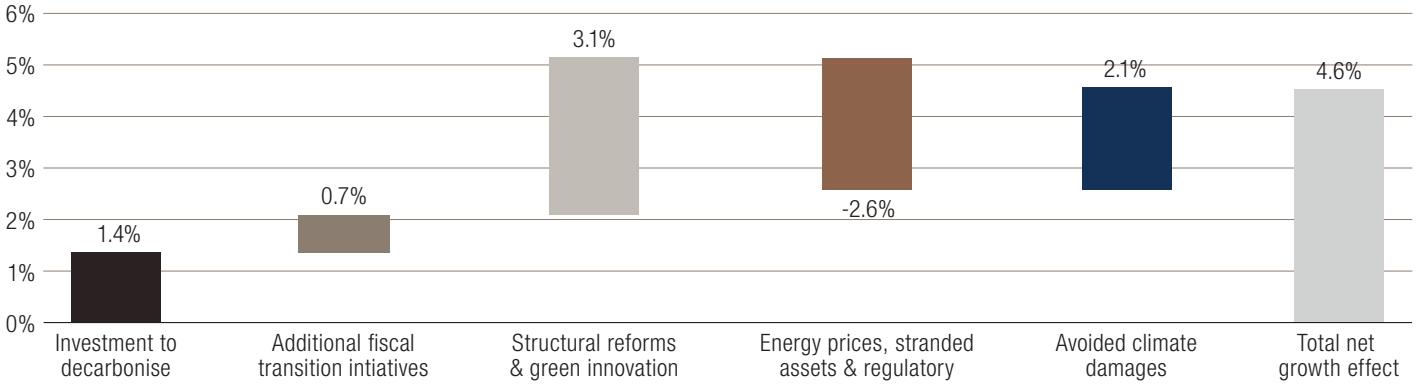
The Energy Transitions Commission[101] estimates the EU requires a further annual USD 0.9 trillion in spending (0.6% of GDP) over the next thirty years in industrial, power and building infrastructure to achieve net-zero targets but that this investment will generate 2.4% global savings. On our estimates,[102] global infrastructure

[100] Idem.

[101] Financing net zero: investment opportunities and financing challenges, 2 December 2019.

[102] Based on power and energy spending based on stated policy and sustainable development scenarios of the IEA World Energy Outlook (2019). Transport, water and telecoms spending is based on current trend and investment requirements to meet sustainable development goals from Oxford Economics Global Infrastructure Outlook (2019).

FIG. 21 GDP GROWTH OPPORTUNITY FOR THE G20 BY 2050 FROM CLIMATE PREPAREDNESS (66% PROBABILITY OF ACHIEVING 2°C). % COMPARED TO BASELINE



Source: OECD (2017) Investing in climate, investing in growth. Note: total net growth effect would be 4.7% for a 50% probability of achieving 2 degree scenario.

spending will need to increase from the current annual rate of USD 3.8 trillion to USD 4.7 trillion over the next decade to keep pace with global economic growth trends and stated policies on the environment. But to meet sustainable development goals aligned with a 1.8°C scenario, investment would need to increase 45% to USD 5.5 trillion per annum over the next decade and by c.90% in the 2030's to USD 7.2 trillion annually. This, in our view, presents an almost USD 100 trillion investment opportunity over the next fifteen years.

Another way of thinking about the importance of decarbonizing these hard-to-abate, carbon-intensive sectors, is in terms of the GDP growth opportunity presented by climate preparedness (see Figure 21). Without decarbonisation, these sectors may continue to present substantial global economic growth opportunities but the flip side would be a devastating increase in climate damage (see Figure 10).

However, with sufficient investment to decarbonise these industries and improve supply side energy efficiency, even factoring in the cost of "stranded assets,"[103] we see sustainable pathways presenting a 4.6% growth opportunity to the global economy by 2050.

It is important to emphasise that economic growth is dependent on all sectors and that while hard-to-abate industries may have the greatest urgency and require the highest investment, all sectors with Scope 3 emissions exposure have a responsibility to decarbonise. It is vital for companies to fully understand their entire value chain of energy and emissions consumption and transparently disclose this. Investors must also try to untangle the web of emissions that are entwined at every level of the economy in order to fully understand the risks and opportunities that the climate transition offers.

Policy frameworks better aligned to climate objectives (and less geared to fossil fuels and carbon-intensive activities) may follow. But to date policy has been poorly aligned with climate action. Investors must therefore take the reins and act decisively to support greener, more inclusive and resilient growth. This can be via investment in pro-growth infrastructure, in a more diversified energy supply, in low-carbon innovation, in more sustainable land use, in more sustainable urban mobility, in increased manufacturing circularity and in adaption activities.

Only by untangling the web of emissions can investment opportunities be identified. For instance, the decarbonisation of transport may pose risks to traditional transport mode, but the transition to a more sustainable mobility may equally present multiple opportunities for adjacent services and sectors. As we will discuss in section 7, by taking away space from the car and preventing induced demand for travel, smarter cities can reinvent urban space. This can offer significant investment potential not just for transport but also for infrastructure, real estate, leisure and retail. Transport is just one example of the way in which energy entangles all sectors and where only via complex analysis can we disentangle the global web to uncover the hidden opportunities in adjacent industries.

[103] Mark Carney of the Bank of England has estimated "stranded assets" as a USD 20 trillion threat to the global economy. Accessed at: https://www.theguardian.com/environment/2019/oct/13/firms-ignoring-climate-crisis-bankrupt-mark-carney-bank-england-governor.

6. The Energy Revolution

At a global level, the energy sector accounts for as much as 68% of all manmade GHG emissions, including emissions in downstream sectors.[104] As a result, climate change policies and efforts to limit global warming to well-below 2°C are critically dependent on the decarbonisation of our energy system. Given the scale of the energy sector and the extent of change required, it is no exaggeration to speak of the need for an energy revolution. Such a revolution affects every aspect of the energy supply chain, from energy efficiency on the demand side, to renewable energy on the supply side, and investment in infrastructure, charging capability, and hydrogen on the distribution side. While the task ahead is clear, the challenge – and investment required – is vast.

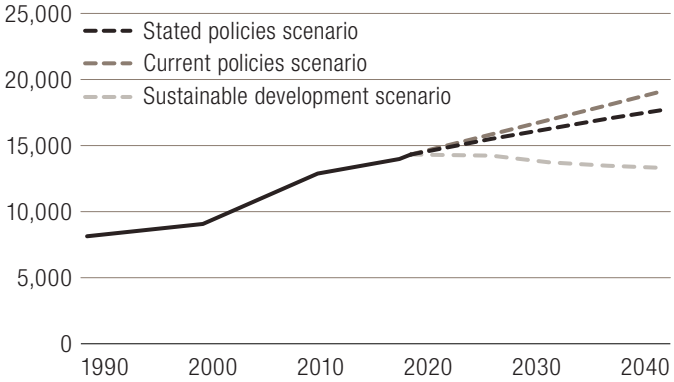
6.1. Trends in energy demand

After decades of growth in GHG emissions, it was therefore welcome news when from 2014 to 2016 emissions from the combustion of fuels appeared to stabilise. Although emissions need to fall, rather than merely stabilise, this initial success appeared to be a step along the right path. In 2017 and 2018, however, progress reversed with emissions from energy reaching an all-time high, increasing 1.7% in 2018.[105]

The root of the problem lies in the ongoing strength of energy demand, which has outpaced increases in the generation of renewable energy. In 2018 energy demand increased by 2.3%,[106] twice the average rate of growth since 2010. While the world economy's relatively strong performance drove much of this increase, heatwaves and cold spells also boosted demand for heating and cooling. In this manner, climate change results in a vicious cycle, exacerbating volatility in weather patterns, which in turn contributes to higher emissions from energy use that further accelerates global warming.

The IEA estimates that based on stated policies as of 2019, energy demand will continue to increase to 2040, albeit at a slightly diminishing rate, averaging 1% per year over the period.[107] At this rate, total primary energy demand will reach 17.7 Btoe,[108] up 24% from 2018 (see Figure 22). By comparison, a sustainable development scenario would require a decrease of 7% over the same period, paired with a radical change in the composition of energy supply.

FIG. 22 HISTORICAL PRIMARY ENERGY DEMAND AND SCENARIOS TO 2040 (MTOE)



Source: International Energy Agency (2019), World Energy Outlook 2019.

Reducing energy demand requires investment in energy efficiency, across all industries. With buildings accounting for around 30% of global energy demand,[109] green construction practices are a primary priority. Retrofitting existing buildings, for instance, can reduce energy requirements by 50-90%.[110] In transport, which accounts for 17% of energy demand,[111] energy efficiency may be improved by encouraging a shift to more efficient modes of transport, such as rail (see chapter 7). In industry, responsible for a further 30% of energy demand,[112] lean manufacturing (see chapter 8) and increased reliance on recycling are necessary interventions.

Investment into carbon reduction solutions in the energy efficiency space will need to more than double in the next two decades, from the level of spending in 2014-2018 under a current stated policies scenario. Under a Sustainable Development Scenario, aligned to the Paris Agreement, spending would need to increase 3.5 times.

Solutions promoting energy efficiency are an important area of investable opportunities. Even simple technologies such as LED light bulbs are estimated to have decreased global emissions by

[104] Center for Climate and Energy Solutions (2019). Global Manmade GHG Emissions by Sector, 2013. Accessed at https://www.c2es.org/content/international-emissions/.

[105] International Energy Agency (2019). Global Energy & CO_2 Status Report 2019. Accessed at https://www.iea.org/reports/global-energy-and-co2-status-report-2019/emissions.

[106] International Energy Agency (2019). Global energy demand rose by 2.3% in 2018, its fastest pace in the last decade. Accessed at https://www.iea.org/news/global-energy-demand-rose-by-23-in-2018-its-fastest-pace-in-the-last-decade.

[107] International Energy Agency (2019). World Energy Outlook 2019). Available at https://www.iea.org/reports/world-energy-outlook-2019.

[108] Billion tonnes of oil equivalent.

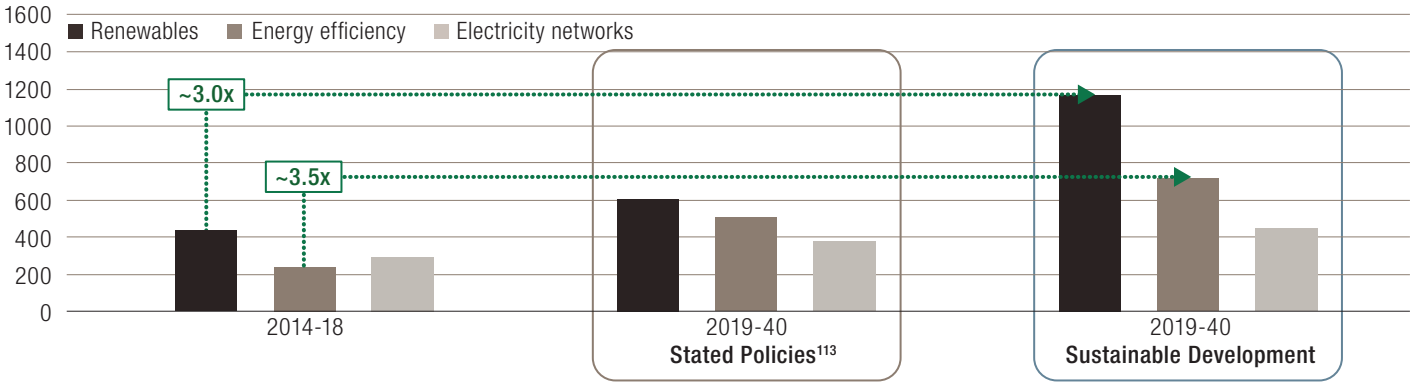
[109] Idem.

[110] Global Environment Facility (undated). Energy Efficiency. Accessed at https://www.thegef.org/topics/energy-efficiency.

[111] International Energy Agency (2019). World Energy Outlook 2019). Available at https://www.iea.org/reports/world-energy-outlook-2019.

[112] Idem.

FIG. 23 FUTURE ENERGY INVESTMENT REQUIRED TO REACH A NET-ZERO WORLD (USD BILLION PER YEAR)



Source: International Energy Agency (2019), World Energy Outlook 2019.

1.5% in 2017.[114] By offering energy savings, such technologies reduce environmental footprints as well as operating costs, which supports the rapid uptake of this type of innovation.

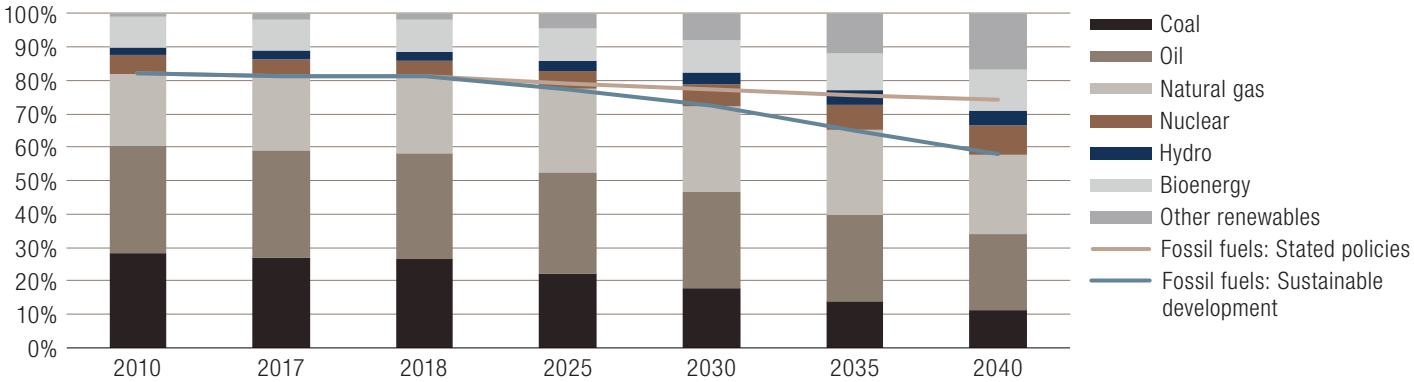
6.2. Trends in energy supply and distribution

On the supply side an acceleration in investment in renewable energy is required. Climate models suggest the remaining carbon budget that would allow us to keep global warming below a 2°C scenario is limited to 1,080 $GtCO_2$, and only 333 $GtCO_2$ for a 1.5°C scenario.[115] At present levels of emissions, these latter figures amount to only 7-11 years of emissions.

Further expansion of energy from fossil fuels would exhaust this budget at an accelerating rate. Nonetheless, in 2018, 70% of the increase in energy demand was met by fossil fuels.[116] While electricity generation from renewables now accounts for 26% of global power output and is growing at double-digits[117] (BNEF's NEO model forecasts wind and solar reaching 39% penetration by 2040 and 48% by 2050),[118] such increases are growing from a low base and lag behind the increase in energy demand, with fossil fuels making up the remainder.

As shown in Figure 24, to ensure alignment with the Paris Agreement, fossil fuels must be phased out at an accelerating pace. Although these energy sources are likely to continue to account for a majority share by 2040, they must be much-reduced compared to current levels, and the levels that stated policies are likely to drive.

FIG. 24 REQUIRED PHASE-OUT OF FOSSIL FUELS IN SUSTAINABLE DEVELOPMENT SCENARIO (% OF ENERGY SUPPLY)



Source: International Energy Agency (2019), World Energy Outlook 2019.

[113] Stated policies scenario reflect the impact existing policies would have in the future. The Sustainable Development Goals (2015) are the United Nations 17 targets promoting peace and prosperity.

[114] HIS (2017). LEDs Took Half a Billion Tons of Carbon Dioxide From the Sky in 2017, IHS Markit Says. Accessed at https://news.ihsmarkit.com/prviewer/release_only/slug/energy-leds-took-half-billion-tons-carbon-dioxide-sky-2017-ihs-markit-says.

[115] International Panel on Climate Change (2019). Table 2.2 in Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. Accessed at https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_Chapter2_Low_Res.pdf.

[116] International Energy Agency (2019). Global energy demand rose by 2.3% in 2018, its fastest pace in the last decade. Accessed at https://www.iea.org/news/global-energy-demand-rose-by-23-in-2018-its-fastest-pace-in-the-last-decade.

[117] International Energy Agency (2019). Renewables. Accessed at https://www.iea.org/fuels-and-technologies/renewables.

[118] BNEF (December 2019): *Peak Emissions Are Closer Than You Think and Here's Why. Accessed at https://about.bnef.com/blog/peak-emissions-are-closer-than-you-think-and-heres-why/.*

Consequently, to ensure that the goal of the Paris Agreement to limit global warming to a level well below 2.0°C, investment in renewable energy must continue to accelerate. According to IRENA, investment in renewable energy must be scaled up at a rate six times faster than has been the case up until 2018.[119]

Market forces, however, are likely to represent a major driver of such growth in investment. As discussed in section 4 costs of wind and solar energy are rapidly decreasing, and are already at a point where levelised (lifetime) costs of energy from these renewable sources is below that of coal in the US, and increasingly below much of the coal electricity generating capacity worldwide (see section 4.2).

A number of enabling technologies will prove essential for the energy revolution to achieve its full potential. First, battery energy storage systems can radically improve the economics of renewable energy installations, with costs of such systems already rapidly falling. Second, power grids and distribution networks must be upgraded, particularly if transitions to electric mobility and the phase-out of residential gas heating is to be supported. Third, as we discuss in section 7.2, hydrogen is likely to play a key role by enabling the conversion of renewable electricity into low carbon gas, thereby enabling storage and transportation of this power over long distances.

6.3. The energy investment landscape

As per Figure 4. above, we estimate a total of close to USD 100 trillion of capital will be required over the next 15 years (or USD 5.5 trillion per annum 2019-2030 and USD 7.2 trillion per annum from 2031) for investments in transport, water and sanitation, renewable energy, energy efficiency, power grids, energy storage, and other enabling technologies.[120]

The world will require USD 0.9 trillion incremental investment per annum over the next decade to keep up with economic growth and current stated environmental policies. However, to achieve a sustainable development scenario of 1.8°C this figure would need to rise to an incremental USD 1.7 trillion (USD 3.4 trillion from 2031 onwards), or a step up of 45% and 89% respectively (see Figure 23). This leaves a substantial funding gap. Cost savings related to these investments, however, are expected to exceed these additional costs by a factor of five-to-one, creating an attractive role for the finance community in channelling capital towards these technologies.

[119] OECD (2017) Investing in climate, investing in growth. Accessed here http://www.oecd.org/environment/investing-in-climate-investing-in-growth-9789264273528-en.htm.

[120] Idem.

7. The Transport Revolution

Transportation is a carbon-intensive sector and accounts for around 17% of global GHG emissions[121] or around 8 Gt CO_2 in 2018 (see Figure 25).[122] Road vehicles emit 6 Gt CO_2 annually, nearly three-quarters of all transport-related CO_2 emissions. Transport, and in particular personal transportation, has therefore been at the forefront of policymakers,' consumers' and investors' minds when considering the climate transition. With the advent of electric vehicles, aided by technological advances in battery technology and economies of scale on cost, emissions from short-haul, road transport have become much easier-to-abate. The next key area of focus, however, will have to be heavy and long-distance transport, such as trucking, aviation and shipping, which are harder-to-abate and where electrification alone will not provide the solution.

CO_2 emissions from transport have continued to rise, albeit at a decelerating annual growth rate of 0.6% in 2018 (versus 1.6% annual growth over the last decade).[123] The latest report from the Transition Pathway Initiative (TPI) found only 35% of transport companies are aligned with even the least-ambitious Paris-aligned benchmarks and less than one-fifth have reduction plans aligned with a path to keep global warming at 2°C or below.[124]

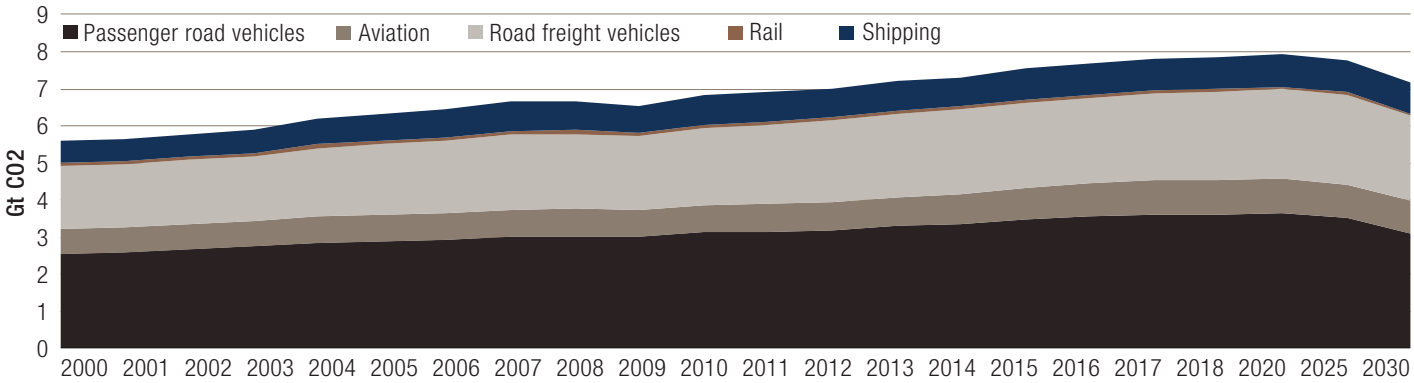
Regulation is, however, having a disruptive impact on traditional transportation modes and demand. Short-haul transport emissions are already heavily regulated at international, national and local levels, with fleet average CO_2 targets, zero emissions zones, congestion charging, diesel bans and parking restrictions already in full force in many regions. Shifting consumer preferences are an additional driver of change, such as in the case of environmental consciousness about the effects of long-distance travel (e.g. "flight shaming").

Over the next decade and beyond, we expect these trends to intensify. Driven by these changes, we also expect a clear divergence between winners and losers as transportation and future mobility trends transition to low (and increasingly zero) carbon intensity. In addition, we expect the policy focus to broaden from short-haul personal vehicles to encompass commercial vehicles and harder-to-abate long-haul transportation sectors (aviation and shipping), as a result of net-zero transport regulation.

7.1. Electrification as a key enabler

For the transport sector to meet projected mobility and freight demand while reversing CO_2 emissions in line even with the least ambitious pledges of the Paris Agreement, energy efficiency measures will have to intensify significantly. With the advent of electric vehicles, the regulatory landscape is rapidly evolving, including initiatives aimed at phasing out traditional internal combustion engine (ICE) vehicles enforced at both national and subnational governmental levels.

FIG. 25 TRANSPORT SECTOR CO_2 EMISSIONS BY MODE



Source: IEA, Transport Tracking report 2019. NB total CO_2 emissions from transport were 8Gt CO_2 in 2018. Total GHG emissions totalled 9.2Gt CO_2e.

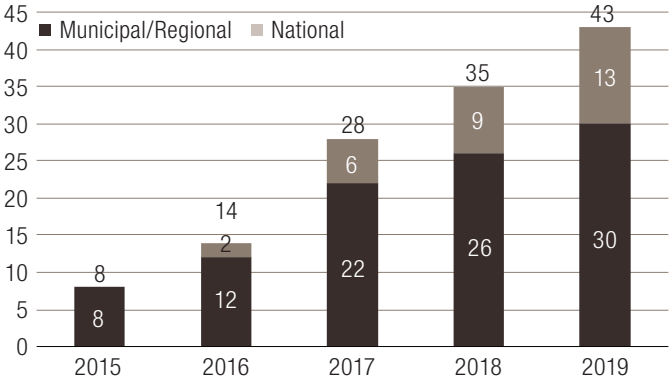
[121] See Figure 1.

[122] International Energy Agency (2019). Tracking Transport. Accessed at https://www.iea.org/reports/tracking-transport-2019.

[123] Idem.

[124] Transition Pathway Initiative: Management Quality and Carbon Performance of Transport Companies: December 2019. Accessed at https://www.transitionpathwayinitiative.org/tpi/publications/29?type=NewsArticle.

FIG. 26 NUMBER OF GOVERNMENTS/LOCAL AUTHORITIES THAT HAVE ANNOUNCED PLANS TO PHASE OUT ICE VEHICLE SALES



Source: BNEF, Government sources.

To date, most transport regulations continue to focus on tailpipe emissions as the main lever of change. Simplistically, electric vehicles provide the solution due to their zero-emission nature. However, tailpipe emissions (CO_2 and NOx) and thus air quality improvement is only one of the many sustainability challenges facing the transport sector and its supply chain. As policymakers become more attuned to the needs of the climate transition, we expect the next transition could be towards policies focused on full life-cycle vehicle emissions, requiring increased attention to upstream supply chains and manufacturing efficiencies.

In order to assess the investment opportunity for electric vehicles, we believe it will become increasingly important to focus on full lifecycle emissions, thus also capturing the energy-intensity of the raw material extraction, battery and vehicle manufacture and the power source used to charge the electric vehicles (from well-to-wheel), as well as the after-life of the components.[125]

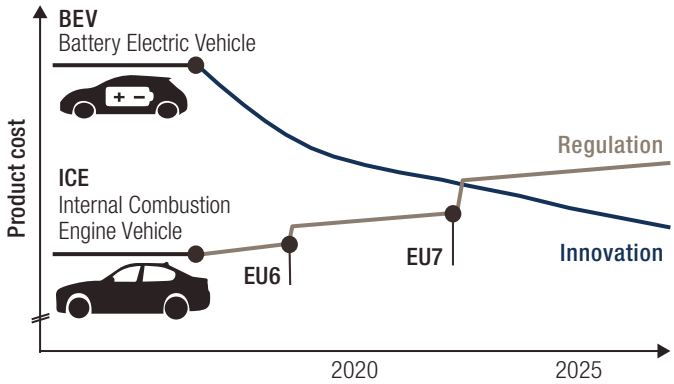
There are already clear winners along the automotive supply chain who focus on solutions to decarbonise and improve the sustainability of the lifecycle of electric vehicles. Solutions range from improvements in battery cell chemistry to reduce the reliance on cobalt[126] and rare earth metals, battery recycling,[127] vehicle-to-grid (V2G), renewable material sourcing, wind-energy powered production,[128] etc. Automakers need to position themselves as transitioning businesses. The best positioned auto makers will be those that transition fastest to become net-zero mobility service providers and those that look beyond tailpipe emissions to full lifecycle sustainability.

The car industry is one of the sectors where policy has advanced fastest, and is now forcing car makers to sell a larger number of electric vehicles than consumers are ready to buy. Despite the growing availability of electric vehicles, consumer expectations (including range-anxiety) will remain a critical challenge for the electric vehicle industry to overcome. Charging infrastructure is improving, albeit the roll-out and density of such networks has thus far remained uneven, often hampered by unclear policies and the lack of national action plans.

However, as electric vehicle battery cell costs fall and upfront investments in electric architectures peak, we believe personal transport electrification can provide near-term investable opportunities. The businesses fastest to react to this transition, with dedicated platforms for battery electric vehicles (BEVs) and a clear vision across the supply chain for sustainable material sourcing, will be best able to capture the electric opportunity. We see a tipping point in the mid-2020's when BEVs are as profitable to produce as ICEs and when battery chemistry improvements reduce consumer-range-anxiety.

Despite regulatory pressure and technological innovation, most third party forecasters assume only a gradual transition to electric vehicles. Sales of ICEs are expected to peak early this decade and then start to decline. Even the most ambitious third party forecasters estimate sales of ICE vehicles will continue to remain in the tens of millions through to 2040 and beyond.[129] But this

FIG. 27 MARKET FORCES ARE COMBINING TO DRIVE DOWN BATTERY COSTS AND INCREASE UPTAKE OF EVS



Source: Volkswagen, 2018.

[125] For a more detailed discussion on electric vehicle environmental credentials, see: https://www.forbes.com/sites/jamesellsmoor/2019/05/20/are-electric-vehicles-really-better-for-the-environment/#da3560976d24;

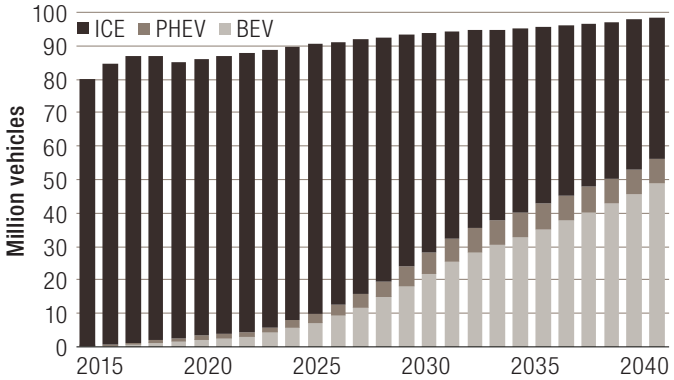
[126] Cobalt is often controversially sourced from the DRC, a high risk area and where 20% of the country's cobalt is extracted by artisanal mines, where serious, systemic human rights violations are commonplace, including child labour. For further detail see footnote 65.

[127] As an example see Groupe *Renault and EEM create first "smart island" in Porto Santo*. Accessed at: https://media.group.renault.com/global/en-gb/groupe-renault/media/pressreleases/21204577/le-groupe-renault-et-eem-creent-la-premiere-ile-intelligente-a-porto-santo.

[128] https://www.bmw.cc/en/all-models/bmw-i/i3/2016/sustainability.html.

[129] Bloomberg New Energy Finance (2019).

FIG. 28 GLOBAL PASSENGER VEHICLE SALES BY DRIVETRAIN



Source: Bloomberg New Energy Finance (2019).

potentially fails to capture the binary nature of the tipping point that when BEVs are as profitable to produce as ICEs, global automakers will stop producing combustion engine vehicles. Even were this the case, and ICE sales were to fall to zero over the next two decades, given the substantial lifetime of most vehicles, the vehicle fleet of combustion engine vehicles would remain high. It is clear that faster uptake of electric vehicles than currently forecast will be essential to meet the demands of the net-zero economy on the time horizon necessary.

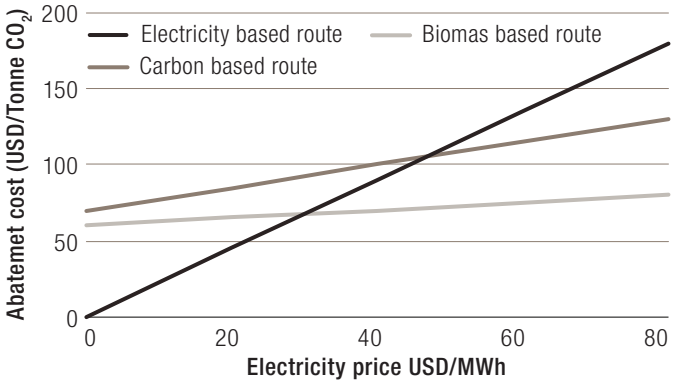
7.2. Long-haul transport as the next regulatory frontier

Whereas passenger vehicles account for approximately half of all transport-related emissions (see Figure 25), long-haul transport accounts for the remainder, split between road and rail freight, aviation, and shipping. As opposed to short-haul and light vehicle travel, long-haul travel is comparatively hard-to-decarbonise via electrification, primarily owing to current limits on battery weight and capacity. Consequently, abatement costs of long-haul transport are substantially higher, and targets to reduce emissions therefore pose a substantial financial challenge to companies operating in these industries.

For these harder-to-abate, long-haul transportation sectors, once the low-hanging fruit of logistical and operational efficiencies are exhausted, we expect companies to face disruption as significant as that currently experienced by the automotive sector. We expect regulatory pressure to drive higher investment into less carbon-intense biofuels or "synfuels,"[130] with biomass and hydrogen likely to be among the key beneficiaries. We expect the use of sustainable fuels to increase rapidly from a low base – sustainable aviation fuel today accounts for just 0.1% of the overall market[131] but we expect its availability to increase over the next few years. Those companies that do not shy away from this disruption and invest in potential solutions to decarbonise transportation, will be best placed to deliver value for investors.

We also believe carbon capture may grow in importance, albeit with a tipping point in terms of CO_2 abatement cost for electrification (battery electric or fuel-cell electric), biomass and carbon capture depending heavily on electricity price:

FIG. 29 ELECTRICITY VERSUS CCS COST ABATEMENT FOR LONG-HAUL TRANSPORTATION (HEAVY-DUTY ROAD, AVIATION AND SHIPPING)



Source: McKinsey 2018, Decarbonization of the industrial sectors: the next frontier.[132]

[130] Synthetic fuels produced from coal, natural gas or biomass feedstocks through chemical conversion. In this scenario we are focusing on the "green" or renewable sources for the Synfuel.

[131] International Energy Agency (2019). Are aviation biofuels ready for take off? Accessed at https://www.iea.org/commentaries/are-aviation-biofuels-ready-for-take-off.

[132] Accessed at https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/how%20industry%20can%20move%20toward%20a%20low%20carbon%20future/decarbonization-of-industrial-sectors-the-next-frontier.ashx.

Focus box: the rise of the hydrogen economy

We see an increased role for hydrogen as a key enabler for the decreased dependence on harder-to-abate fossil fuels in the energy system. We expect hydrogen to play a key role in decarbonising the building, chemicals, power and long-distance transportation sectors.

Current hydrogen production is largely "grey" as it is produced from fossil fuels (mainly methane from natural gas), although in some cases the CO_2 is captured, utilised and stored (CCUS) and thus classes as "blue" hydrogen. To occupy a significant role in the climate transition, however, "green" hydrogen generated through electrolysis using renewable energy needs to become the norm.

Given recent declines in the levelised costs of wind and solar, the feasibility of using green hydrogen as an energy carrier and feedstock and also to store renewable electricity has gained momentum. BNEF estimates that green hydrogen will start to be cost-competitive with "brown" hydrogen by 2030, and that by 2050 it will have a clear advantage.[133] The Hydrogen Council expects hydrogen to cover at least 18% of final global energy demand by 2050 and the FCH JU[134] estimates hydrogen and its infrastructure can provide EUR 130 billion of annual revenue by 2030 and around 560 Mt of CO_2 abatement by 2050. Were carbon prices to reach USD 100/tonne, BNEF estimates green hydrogen could have an addressable market of nearly 30% of global emissions.

Currently, hydrogen costs levels are too high for most commercial applications. However, given increased regulatory and social pressure to decarbonise the energy system we see this shifting drastically over the next decade. As a first step, hydrogen can be blended into much of the existing gas grid without need for major upgrades. Over time, energy suppliers may be able to convert grids to run on pure hydrogen. Hydrogen's role in "sector coupling" will also be important as it enables conversion of renewable electricity into low carbon gas, enabling storage and transportation of this power over long distances.

We expect to see a significant ramp-up in new electrolyser capacity over the next decade, but believe clean hydrogen will still remain a low single digit percentage of overall hydrogen production by 2030, given current costs. Through these initial applications, however, we expect economies of scale to drive down electrolyser costs, creating a significant opportunity for hydrogen to be used to decarbonise many of the hard-to-abate sectors.

In the steel, refining and chemicals sectors, as processing costs decline, hydrogen can be utilised to both reduce CO_2 emissions and, in some instances, provide a carbon sink. These sectors already use hydrogen as a key component for industrial processes, such as refineries eliminating sulphur from diesel fuel and the production of ammonia for fertilisers. If this hydrogen were converted from "grey" to "green," it could enable the decarbonisation of some of the most carbon-intense industries.

7.3. Modal shifts and increased shared mobility options

While electrification is a necessary step in the process of decarbonising the transport sector, further efforts are needed to ensure the compatibility of long-distance transportation with a net-zero world.

First, managing demand for travel to reduce frequency and distance travelled will be important, and is the focus – for instance – of proposed taxes on air transportation. Second, encouraging a modal shift to more efficient transportation solutions such as rail, micro mobility (electric two and three-wheelers) and micro-transit vehicles will be essential and require a further legislative and policy push. As Figure 30 and Figure 31 below show, a transition to these forms of transport may reduce energy intensity per passenger-kilometre by a factor of four.

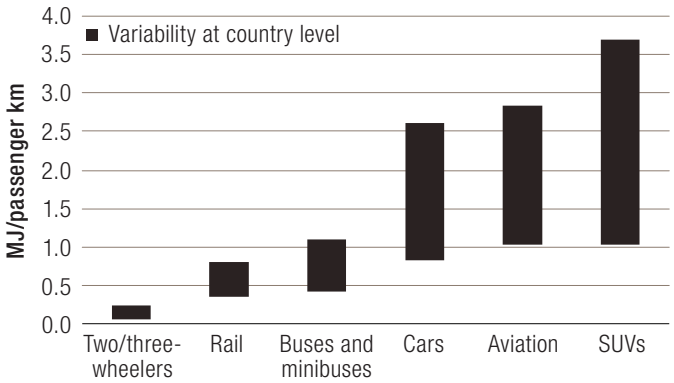
Globally, 60% of all journeys are shorter than 5 miles in length (see Figure 32), and yet currently 70% of those journeys are taken by car in developed markets.[135] A modal shift for such short-distance trips presents multiple investment opportunities. Many cities have already seen a rapid expansion in availability of alternative transport modes, with the advent of ridehail, car-sharing, and micromobility (electric scooters, mopeds, rickshaws, micro-cars etc.), as well as increased investment in public transport infrastructure.

[133] BNEF (December 2019): *Peak Emissions Are Closer Than You Think and Here's Why. Accessed at https://about.bnef.com/blog/peak-emissions-are-closer-than-you-think-and-heres-why/.*

[134] FCH JU (11 February 2019). The Fuel Cells and Hydrogen Joint Undertaking: "Hydrogen Roadmap Europe: A sustainable pathway for the European Energy Transition". Accessed at https://www.fch.europa.eu/news/hydrogen-roadmap-europe-sustainable-pathway-european-energy-transition.

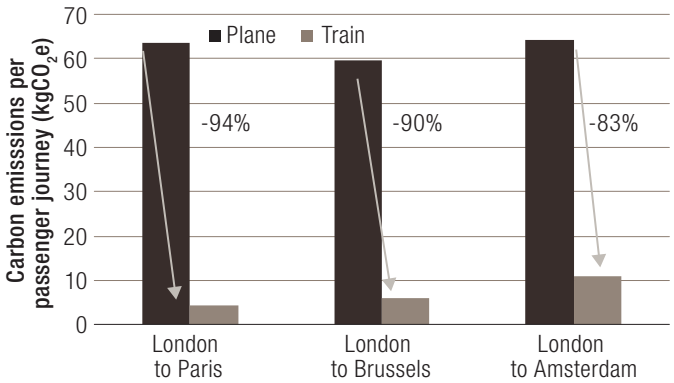
[135] Based on data from the 2017 US National Household Transport Survey and national statistics.

FIG. 30 ENERGY INTENSITY BY TRANSPORT MODE



Source: IEA, Transport Tracking report 2019.

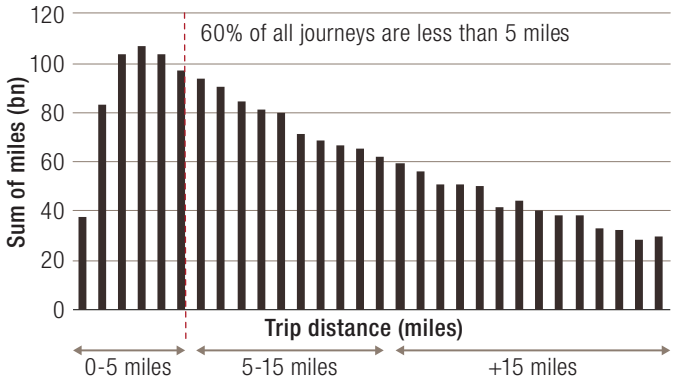
FIG. 31 EMISSIONS PER PASSENGER ON SELECTED ROUTES SERVED BY EUROSTAR



Source: Eurostar Tread Lightly Report 2019.

With speed, ease and affordability on their side, we expect to see a strong growth in micro-vehicle usage, albeit with an evolution in micro-vehicle form factors towards safer, more versatile and more weather-proof options. We believe many cities will encourage these new, smaller modes of transport,[136] in combination with micro-transit (on-demand mini-buses) as a means of easing congestion, improving air quality, making transportation options more equitably available and easing pressure on space. As shared mobility options continue to proliferate and with autonomous vehicle technologies advancing, we expect many sectors adjacent to the transport sector to benefit from space taken away from the car and diverted to green infrastructure, buildings and public spaces.

FIG. 32 AVERAGE TRIP DISTANCE: MICROMOBILITY OPTIONS BETTER SUITED TO URBAN DEMANDS



Source: Lombard Odier, National Household Transportation Survey (NHTS) 2017, National transportation statistics.

Air passenger demand, meanwhile, is growing at more than 4% a year,[137] but a modal shift is already starting to occur. The ABTA Travel Trends 2019 reported that 45% of travelers now believe the sustainability of their travel provider is important when booking a holiday (versus just 24% in 2014).[138] In the EU, many countries are evaluating aviation taxes to make air travel more expensive than more energy-efficient transportation. Germany's parliament has voted on a climate package including a tax cut aimed at reducing train ticket prices by around 10%.[139] In Sweden, the "flight-shaming" (flygskam) movement has started to impact passenger numbers.

As long-haul regulation increases and consumer sentiment shifts towards more environmental options, we expect opportunities for companies in sectors at the more efficient end of the mass transportation spectrum to multiply.

[136] As an example, the UK is consulting on plans to encourage electric scooters on roads: Accessed at: https://www.thetimes.co.uk/article/e-scooters-to-get-green-light-on-uk-s-roads-cz2vxhm6b and New York Governor, Andrew Cuomo, is pushing to legalise e-bikes and e-scooters by 1 April 2020. Accessed here: https://gothamist.com/news/cuomo-pledges-push-legislature-legalize-e-bikes-and-e-scooters-next-week, 23 January 2020.

[137] IATA (2019). Healthy Passenger Demand Continues in 2018 with Another Record Load Factor. Accessed at https://www.iata.org/en/pressroom/pr/2019-02-07-01/.

[138] ABTA (2019). Travel Trends 2019. Accessed at https://www.abta.com/news/abta-launches-travel-trends-report-2019.

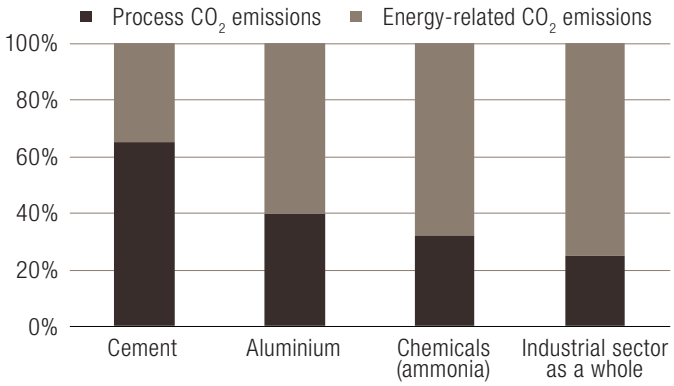
[139] Associated Press (20 December 2019). Germany OKs cheaper train tickets in plan to lower emissions. Accessed at https://apnews.com/10d75f073858cf6e891f6c3af801bc2d.

8. The Industrial Revolution

Industry is the third largest consumer of energy after buildings and transport, and a major source of emissions. However, whereas buildings and transport might be considered sectors with a relatively low cost of abatement (with the exception of long-haul transport and building heating), industrial sectors have generally been considered harder to abate. While some industries have low footprints, industries focused on the production of steel, cement, chemicals and other key materials account for a large share of emissions that are comparatively difficult, and costly to avoid.

Nonetheless, a number of strategies and solutions may be identified that can support companies in their shift to a net-zero economy, creating energy and cost savings along the way for those that embrace the transition.

FIG. 33 CO_2 EMISSIONS FOR SELECTED SECTORS BY TYPE OF EMISSIONS (%)



Source: International Energy Agency (2019).

8.1. Clean manufacturing

After the energy sector, the manufacturing industry is the largest source of GHG emissions, accounting for around 19% of emissions in the EU,[140] as well as being a primary source of industrial waste. The production of cement and various non-metallic minerals (4% in the EU), the production of basic metals such as aluminium and steel (4%) and chemical production (3%) are each significant contributors.[141] Owing to the larger heavy industry elsewhere in the world, the weight of these industries in terms of their share of global emissions is larger still, with industrial production as a whole accounting for 30% of worldwide emissions.[142]

Based on current trends, emissions from the industrial sector would account for 45% of allowable emissions in a Paris-aligned scenario over the period to 2060, with emissions from the sector eventually exceeding our total annual carbon budget.[143] Reducing emissions in the sector is therefore essential to meeting climate goals, although such reductions are generally more difficult to achieve in this sector than in other industries, such as energy or construction.

As shown in Figure 33 below, industrial emissions may be split between energy-related emissions, and process-emissions, resulting from the chemical or physical reactions inherent to the production process. Energy-related emissions, both to provide electricity and to support the high operating temperatures that many plants require, may be reduced by switching to alternative fuels, although plant modifications can be expensive. Process emissions, meanwhile, account for around 28% of industrial emissions, but for up to 65% in some difficult-to-abate industries, such as cement.[144]

Nonetheless, a number of mitigation strategies are available to reduce emissions. Aside from the transition to alternative fuels and feedstocks, the IEA estimates that modernising technologies to improve energy efficiency, better use of materials (including recycled materials), and related greentech may reduce emissions by roughly 46% over the coming decades.[145]

Of particular importance to the industrial sector is the deployment of carbon capture, utilisation and storage (CCUS) technologies. Considered one of the most cost-effective solutions available to reduce emissions, the technology can also be retrofitted to existing plants, which is of particular relevance given the 50+ year lifespan of most industrial plants. CCUS plants are estimated by the IEA have the potential to account for 24% of total emission reductions over the period to 2060, accounting for the capture of 28 $GtCO_2$, and reducing overall emissions in the sector by a further 14%.[146]

However, it is important to understand that even on a net-zero pathway, there will still be unabateable emissions from industry, which will need to be mitigated by negative emissions from land and BECCS (see Figure 19). Electrification, hydrogen and bioenergy

[140] Eurostat (2019). Air emissions accounts by NACE Rev. 2 activity. Accessed at https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_ainah_r2&lang=en.

[141] Idem.

[142] SeeThe *Lombard Odier Climate Transition Strategy targets low carbon and carbon-intensive sectors alike*:

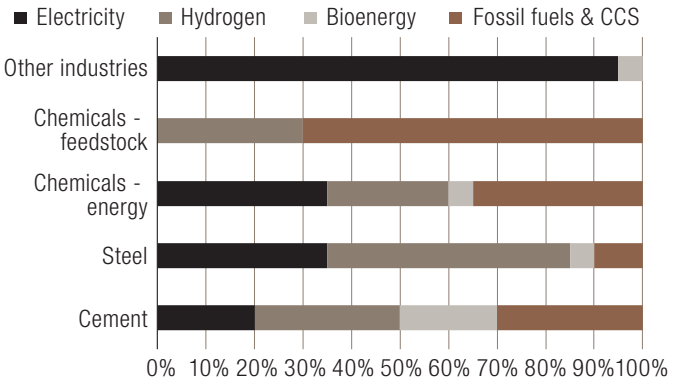
[143] International Energy Agency (2019). Transforming Industry through CCUS. Accessed at https://www.iea.org/reports/transforming-industry-through-ccus.

[144] Idem.

[145] Idem.

[146] Idem.

FIG. 34 INDUSTRIAL SOLUTIONS REQUIRED TO REACH NET-ZERO CARBON ECONOMY BY 2050 (%)

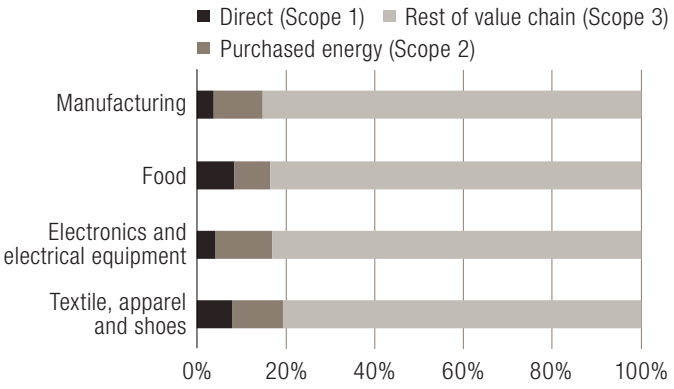


Source: ETC: Mission Possible.

usage will need to accelerate to abate as many of the energy-related emissions as possible, but there will remain residual process emissions, particularly in the chemicals and cement sectors.

Reducing emissions also requires a comprehensive, supply chain approach, given that on average, emissions in a company's supply chain outweigh those of its own operations by a factor of four.[147] In Figure 35, a breakdown in emissions is shown for selected sectors, distinguishing between direct emissions to the factory gate (Scope 1), emissions related to energy requirements (Scope 2) and the upstream and downstream emissions linked to supply chain and the end-product lifecycle (Scope 3).

FIG. 35 DIRECT AND SUPPLY CHAIN GREENHOUSE EMISSIONS BY SECTOR (% OF TOTAL EMISSIONS)



Source: Adapted from McKinsey & Company (2016), based on Carnegie Mellon University, CDP, GreenBiz.[148]

As the statistics in the figure show, the relevance of Scope 3 emissions underline the importance of supply chain transparency, and the need to pursue reductions on-site, as well as among suppliers. The CDP Supply Chain project – one initiative geared to such efforts – reports that engagement by members responsible for USD 3.3 trillion in annual procurement has contributed to 633Mt in reported CO_2 reductions, associated with USD 19.3 billion in annual savings.[149] Ultimately, therefore, such activities do not merely improve environmental performance, but increase the competitiveness, image, and growth prospects of the industry.

8.2. Lean manufacturing

Lean manufacturing may be summarised as the concept of doing more with less. Applied to manufacturing, this encapsulates both the production process – through increased efficiency of resources and capital assets – as well as the product itself – through lightweighting, computerised design, or products-as-a-service.

Digitalisation is a key enabler of leaner forms of manufacturing. Following previous revolutions resulting from the invention of steam, the assembly line, and computing, current trends towards the digitalisation of value chains, products and business models is now often referred to as *Industry 4.0*. Driven by the advent of artificial intelligence, cloud computing, and big data analytics, a range of new applications is making manufacturing leaner and more efficient, with smaller environmental footprints:

- **3D printing and computerised design will drive dematerialisation.** In the aerospace industry, less than 10% of the weight of materials purchased makes it onto the final airplane, with the remainder machined away during manufacturing.[150] Additive manufacturing (including 3D printing) is one technology that increases efficiency, building up its products layer by layer, minimising waste. New designs may be capable of reducing the weight of some components in the aerospace and other industries by half,[151] reducing environmental footprints, as well as offering radical cost savings. Prices of some of the resins used in 3D printing have fallen by 80% over the past three years, with an increased range of materials and components capable of being printed.[152]
- **Predictive maintenance will help equipment last longer.** Unplanned downtime represents a significant cost to manufacturers – estimated at USD 50 billion annually. Equipment failure is the primary cause of such downtime,

[147] CDP (2018). Closing the Gap: Scaling up sustainable supply chains. Accessed at https://www.cdp.net/en/research/global-reports/global-supply-chain-report-2018.

[148] McKinsey & Company (2016). Starting at the Source: Sustainability in Supply Chains. *Bove, A-T and Swartz, S.* Accessed at https://www.mckinsey.com/business-functions/sustainability/our-insights/starting-at-the-source-sustainability-in-supply-chains.

[149] Carbon Disclosure Project (2019). Global Supply Chain Report 2019. Accessed at https://www.cdp.net/en/research/global-reports/global-supply-chain-report-2019.

[150] DigitalAlloys (2019). Comparison of Additive Manufacturing & CNC Machining. Accessed at https://www.digitalalloys.com/blog/comparison-additive-manufacturing-cnc-machining/.

[151] Bloomberg NEF (2019). 2H 2019 Advanced Materials Market Outlook.

[152] Bloomberg NEF (2019). 3D Printing Materials Overview: Costs and Capabilities.

responsible for 42% of this figure.[153] In smart factories, data on past and current performance on equipment can help predict when equipment is likely to break. In a study of the pulp and paper industry, these technologies have been found to contribute to a 66% productivity gain among staff and 20-30% improvement in process efficiency.[154]

- **The Internet of Things improves supply chain waste.** Real-time tracing of materials, inventories and supply lines provides streamlining opportunities. Business investment now accounts for 50% of spending on connected devices in the Internet of Things, with 54% of projects motivated by cost savings.[155] Radio-frequency identification (RFID) systems can replace paper logs to track an item's position in a warehouse, and feed into just-in-time ordering and delivery systems to ensure that inventories are neither larger than necessary, nor below minimum levels, reducing waste.

8.3. Circular manufacturing

Today, our economy remains incredibly wasteful. We extract nearly 97 billion tonnes[157] of material from the planet every year, equivalent to over half the weight of Mount Everest. More than half of this material ends its life in emissions, air pollution and untraceable waste.[158] Of the remaining amount, half again goes to the accumulation of ever greater stocks of material goods – much of which sit idle, and unused.[159] And at the end of the chain we produce more than 2 billion tonnes of waste per year,[160] or 270 kilos per person, including a large share in the form of unrecycled plastics.

Recycling rates remain low and are highly uneven between sectors. In the automotive industry, 95% of vehicles and 75% of automotive materials are profitably recycled, and steel enjoys a high recycling rate of around 86%.[161] By contrast, current recycling

Focus box: Lean manufacturing in the automotive industry

The automotive industry has been one of the pioneers of lean manufacturing. Japanese automaker Toyota[156] was one of the first in the industry to develop the idea of organising its manufacturing and logistics into a defined system known as the Toyota Production System (TPS), focused on "just-in-time" production, a precursor of both "lean manufacturing" and modularity.

Toyota's now well-known manufacturing system was first popularised in a book in the 1990's by three MIT academics called The *Machine That Changed the World*, and led many other manufacturers to emulate the strategy, which remains in practice today around the world.

The principle of the indispensability of people and their importance were heavily emphasised by Toyota. Three main pillars run through the TPS, all of which remain relevant today:

1. Just-in-time, i.e., making what is needed, only when it is needed and only in the amount that is needed in order to eliminate as much waste as possible
2. Jidoka, i.e., automation with a human touch, with a focus on stopping to fix problems immediately in order to ensure the highest quality right from the start.
3. Kaizen – continual improvement and always striving for innovation and evolution

The system highlighted seven types of "muda" or waste: transport, inventory, motion, waiting, overproduction, overprocessing and defects and sought to eliminate as many of these as possible. These concepts have been copied by many industrial manufacturers over the years to ensure minimal production glitches and downtime, as well as maximum flexibility and best quality.

In industrial businesses with high fixed costs, manufacturing in a leaner way is vital to ensure maximum profitability, as well as minimising environmental footprints.

[153] Emerson and Wall Street Journal (2019). Unlocking Performance: How Manufacturers Achieve Top Quartile Performance. Accessed at https://partners.wsj.com/emerson/unlocking-performance/how-manufacturers-can-achieve-top-quartile-performance/.

[154] Idem.

[155] TechJury (2019). Internet of Things Statistics 2019 [The Rise Of IoT]. *Petrov, C.* Accessed at https://techjury.net/stats-about/internet-of-things-statistics/

[156] Any reference to a specific company or security does not constitute a recommendation to buy, sell, hold or directly invest in the company or securities.

[157] Estimate of 97 gigatonnes is a 2019 estimate by Lombard Odier, projected from data up until 2017 from IRP. Global Resources Outlook 2019: Natural Resources for the Future We Want. A Report of the International Resource Panel. United Nations Environment Programme. Nairobi, Kenya (2019) Oberle, B; Bringezu, S; Hatfield-Dodds, S; Hellweg, S; Schandl, H and Clement, J. Accessed at: https://www.resourcepanel.org/reports/global-resources-outlook.

[158] Circle Economy (2019). The Circularity Gap Report: Closing the Circularity Gap in a 9% World. *De Wit, M; Verstraeten-Jochemsen, J; Hoogzaad, J and Kubbinga, B.* Accessed at: https://docs.wixstatic.com/ugd/ad6e59_ba1e4d16c64f44fa94fbd8708eae8e34.pdf.

[159] Idem.

[160] The World Bank (2019). Solid Waste Management. Accessed at https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management.

[161] Steel Recycling Institute (2017). Steel is the World's Most Recycled Material. Accessed at: https://www.steelsustainability.org/recycling.

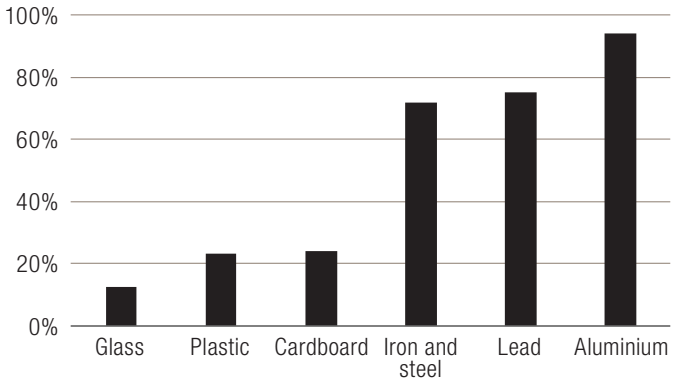
rates of plastic are only 14-18%.[162] Across all materials, only 43% re-enters the economy through water treatment, composting, land application, recycling and other forms of recoveries.

Whereas recycling is a vital component of any circular strategy, the circular economy highlights the importance of repair, re-use, re-manufacturing and recycling. Recycling a product – stripping it down into its component materials – should be deemed only a last resort, where the product itself has fully exhausted its useful economic life. In the EU, for instance, new legislation will come into force in 2021 giving consumers a "right to repair," requiring manufacturers to make products longer-lasting and easier to repair, for instance through modular designs.

When products do eventually reach the end of their life, increased attention must be paid to waste and recycling processes. The value of materials contained in electronic waste alone is estimated at nearly USD 63 billion, which will increase as the electronics industry continues to expand.[163] Automakers such as Volkswagen and BYD are investing in battery recycling plants, to improve their environmental footprint, and reduce their exposure to raw materials.[164] As raw material prices are more volatile today than at any point during the previous century,[165] such recycling not only decreases environmental footprints, but also serves to mitigate supply chain risks.

Overall, circular business models may avoid USD 4.5 trillion in lost economic growth by 2030, and as much as USD 25 trillion by 2050.[166] Meanwhile, recycling materials can drive substantial efficiency savings. While glass recycling reduces energy requirements by around 10-15%, this increases to 72% for iron and steel and as much as 94% for aluminium.[167] The circular economy therefore constitutes an essential component of the climate transition – albeit one requiring re-design of products, production processes, consumption and disposal.

FIG. 36 ENERGY SAVINGS FROM RECYCLING OF SELECTED MATERIALS (%)



Source: American Geosciences Institute,[168] Pappu (2007),[169] Foodlum (2019).[170]

[162] OECD (2018), "Improving Plastics Management: Trends, policy responses, and the role of international co-operation and trade", *OECD Environment Policy Papers*, No. 12, OECD Publishing, Paris. Accessed at: https://www.oecd-ilibrary.org/docserver/c5f7c448-en.pdf?expires=1570011172&id=id&accname=guest&checksum=BDDFA318EEC655CD36AD72E81FE4D9D2.

[163] BloombergNEF (2019). Dell eyes USD 63 billion E-Waste Recycling Opportunity: Q&A. *Collins, B.* Accessed at https://about.bnef.com/blog/dell-eyes-63-billion-e-waste-recycling-opportunity-qa/.

[164] Any reference to a specific company or security does not constitute a recommendation to buy, sell, hold or directly invest in the company or securities.

[165] McKinsey (2011). Resource revolution: Meeting the world's energy, materials, food, and water needs. *Dobbs, R; Oppenheim, J; Thompson, F; Brinkman, M and Zornes, M.* Accessed at https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Resource%20revolution/MGI_Resource_revolution_full_report.ashx.

[166] Accenture (2015). The Circular Economy Could Unlock USD 4.5 trillion of Economic Growth, Finds New Book by Accenture. Accessed at https://newsroom.accenture.com/news/the-circular-economy-could-unlock-4-5-trillion-of-economic-growth-finds-new-book-by-accenture.htm.

[167] American Geosciences Institute. How does recycling save energy? Accessed at https://www.americangeosciences.org/critical-issues/faq/how-does-recycling-save-energy.

[168] Accessed at https://www.americangeosciences.org/critical-issues/faq/how-does-recycling-save-energy.

[169] As cited by David et al (2019). Recover, Recycle and Reuse: An Efficient Way to Reduce the Waste. Engineering Research and Development (Vol. 9, Issue 3), pp. 31-42.

[170] Foodlum (2019). Which Reusable Water Bottle is Most Sustainable? Accessed at https://www.foodlum.com.au/blogs/news/which-reusable-water-bottle-is-most-sustainable.

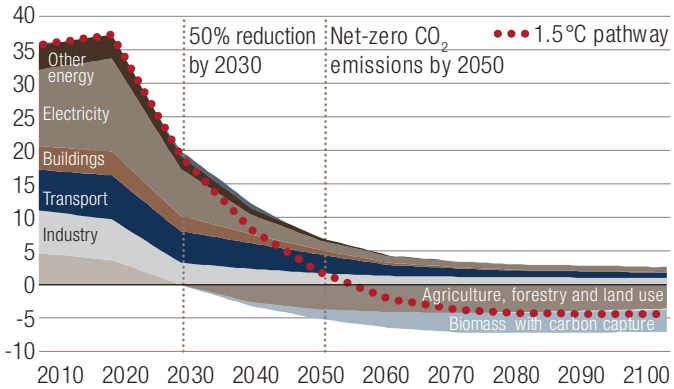
9. The Food and Land Use Revolution

Land applications, including agriculture and forestry, account for around 20% of GHG emissions (see Figure 1). Albeit only accounting for 11% of CO_2 emissions, these industries account for 44% of methane, and 81% of nitrous oxide emissions, radically increasing total contributions to GHG emissions.[171] Feeding a growing population is placing ever-increasing demand on the food industry but vast resources are wasted in both the production and consumption of food.

However, different forms of land use also act as a major carbon depository. Forests, grasslands and savannahs, in particular, act as a major carbon sink. Deforestation and the conversion of ever greater areas of land to agricultural use annually contributes some 5Gt CO_2 in emissions (see Figure 37). Reversing this trend is essential to mitigating climate change. Active afforestation, reforestation, forest management, and agroforestry may eventually ensure a net negative contribution from such land use changes to global GHG emissions. Such net-negative contributions are essential to offset unavoidable emissions from hard-to-abate industries and secure the transition to a net-zero economy.

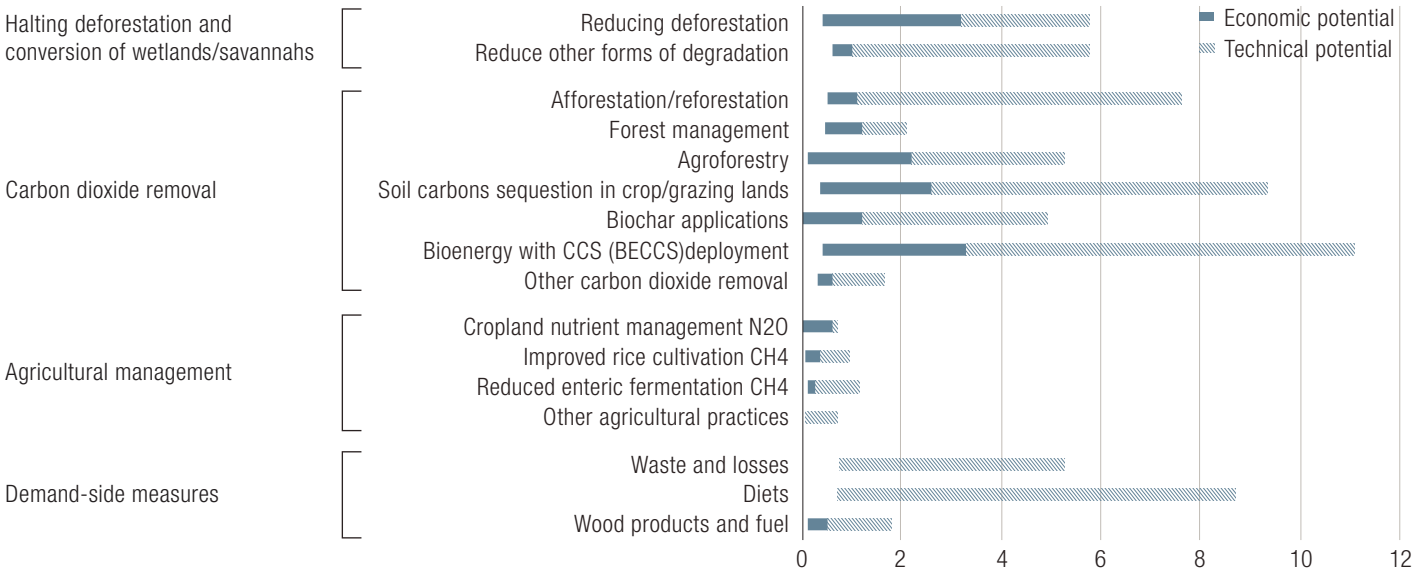
Figure 38 below provides a summary overview detailing the mitigation potential of land-related activities. These include changes to land use and the active removal of carbon dioxide may reduce global emissions by a combined total of 1-12 Gt CO_2e per year (section 9.1). Improved agricultural practices, may further reduce emissions by 0-3 Gt CO_2e per year (section 9.2). On the demand-side, meanwhile, actions to address food waste as well as dietary changes, such as a reduction in the consumption of meat, can add a further 2-14 Gt CO_2e per year in mitigation potential (section 9.3).

FIG. 37 LAND USE NEEDS TO REACH NET-ZERO BY 2030 (GT CO_2)



Source: IPCC Special Report: Global Warming of 1.5°C; S1 Marker Scenario.

FIG. 38 LAND-BASED MITIGATION POTENTIAL IN 2020-2050 (GT CO_2e PER YEAR)



Source: Adapted from Roe et al (2019).[172]

[171] IPCC (2019) *Special Report On Climate Change and Land* Accessed at https://www.ipcc.ch/srccl/chapter/summary-for-policymakers/.

[172] Roe et al (2019). Contribution of the land sector to a 1.5 °C world. In Nature (Vol. 9, pp. 817-828). Accessed at https://www.nature.com/articles/s41558-019-0591-9.epdf.

Taken together, Roe et al. estimate that the cumulative set of land-related interventions that could be implemented in an economic and sustainable manner could, in theory, reduce global emissions by up to 15 Gt CO_2e per year by 2050, compared to current emissions from the sector of circa 11 Gt CO_2e. Land therefore needs to become a net-negative sector, making it of fundamental importance to the net-zero economy.[173]

9.1. Regenerative land use

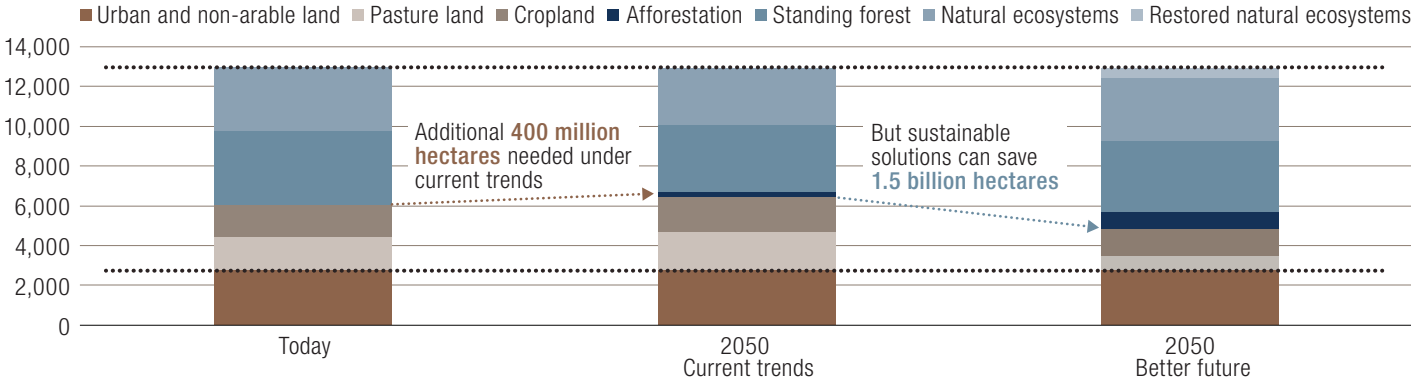
Overall, the Earth's soil holds three times more carbon than the atmosphere.[174] Since the 19th century, increased land use has resulted in a loss of an estimated two-thirds of all carbon stores from soils and live vegetation. Globally across sectors we currently emit around 11.5 Gt of carbon (or 42 Gt CO_2) per year. Of this, around 5.1 Gt of carbon (18.8 Gt CO_2) enters our atmosphere each year. Meanwhile, our soils contain an estimated 15 Gt of carbon – three times as much as enters the atmosphere each year.[175] Increasing the carbon content of these soils by just 0.4% per year, which is the goal of the 4p1000 initiative, would absorb 22 Gt CO_2 per year, thus offsetting the CO_2 that enters our atmosphere.[176] This demonstrates why sustainability in agriculture and land management are essential objectives in the management of climate change.

According to the Food and Land Use Coalition, 10 key transformations to food and land use could result in cost savings of USD 5.7 trillion per year and new opportunities worth USD 4.5 trillion per year by 2030.[177] These interventions include actions to restore essential ecosystems and increase the regenerative capacity of agricultural activities, but also include interventions aimed at improving efficiency, yields, reducing food waste, and changing diets (discussed in sections 9.2 and 9.3). The combined effect of these transformations is not only to generate new opportunities for growth, but to ensure a fundamental redistribution in the use of land, favouring the restoration of natural forests.

Figure 39 shows that in the Better Futures scenario described above, the amount of agricultural land used to feed the world's populations could *fall* by 1.2 billion hectares, even while feeding a growing population. Freeing up such land makes possible the implementation of afforestation, reforestation and other restoration activities and help capture the vast quantities of carbon that would need to be extracted from the atmosphere to maintain us on a path to meet the targets of the Paris Agreement.

Companies must help drive this transition. Food companies, for instance, ought to be encouraged to commit to the support of regenerative agriculture in their supply chains, adopting an approach that prioritises biodiversity, soil enrichment and the restoration of natural ecosystem services. Similarly, companies in the wood, pulp and paper industry may play a key role by putting in place appropriate forest management approaches and contributing to carbon capture. Companies engaged in these and other restorative activities may achieve a net negative footprint. In a world of increased consumer awareness and higher carbon pricing, that translates directly into competitive advantage.

FIG. 39 TOTAL SURFACE LAND USE BY 2050 UNDER CURRENT TRENDS AND A "BETTER FUTURES" SCENARIO (MILLION HECTARES)



Source: Adapted from Food and Land Use Coalition (2019).[178]

[173] Idem.

[174] EthicalCorp. (2019). Turning Agriculture from Climate Culprit to Carbon Sink. *Hilssdon, M.* Accessed at: http://www.ethicalcorp.com/urning-agriculture-climate-culprit-carbon-sink.

[175] Sustainable Food Trust (2015). Soil degradation: a major threat to humanity. Accessed at: http://www.fao.org/fsnforum/sites/default/files/discussions/contributions/Soil-degradation-Final-final_0.pdf.

[176] 4p1000 (2018). The "4 per 1000" Initiative. Accessed at https://www.4p1000.org.

[177] CarbonBrief (2018). The impacts of climate change at 1.5C, 2c and beyond. Accessed at https://interactive.carbonbrief.org/impacts-climate-change-one-point-five-degrees-two-degrees/?utm_source=web&utm_campaign=Redirect.

[178] Food and Land Use Coalition (2019). Growing Better: Ten Critical transitions to Transform Food and Land Use. Accessed at https://www.foodandlandusecoalition.org/wp-content/uploads/2019/09/FOLU-GrowingBetter-GlobalReport.pdf.

9.2. Improving yields and efficiency

Previous agricultural revolutions achieved dramatic increases in productivity, but at the cost of increased land degradation, water use, and other inputs. Land degradation, for instance, is accelerating, and rising demand for food is expected to lead to an increase in demand for water from the agricultural sector. Agriculture currently accounts for ca. 70% of global fresh-water use[179] and usage is set to rise from 7,130 trillion litres in 2000 to 13,500 trillion litres by 2050.[180] Meanwhile, the use of fertilisers and manure account for as much as 4% of global GHG emissions.

Precision farming is one of the solutions that aims to reduce such footprints, aiming to achieve more, with less. Live data gathered from satellites, drones and sensors is used to assess plant and soil status, after which automated equipment delivers the optimal amount of resources. In controlled studies, these techniques reduced water consumption by 10-15%,[181] while nitrogen use could be reduced by 27% without affecting yield. Growing at 14% per year, the sector is forecast to represent a USD 10 billion dollar industry by 2024,[182] amidst lively competition between innovative start-ups for market share and investment.

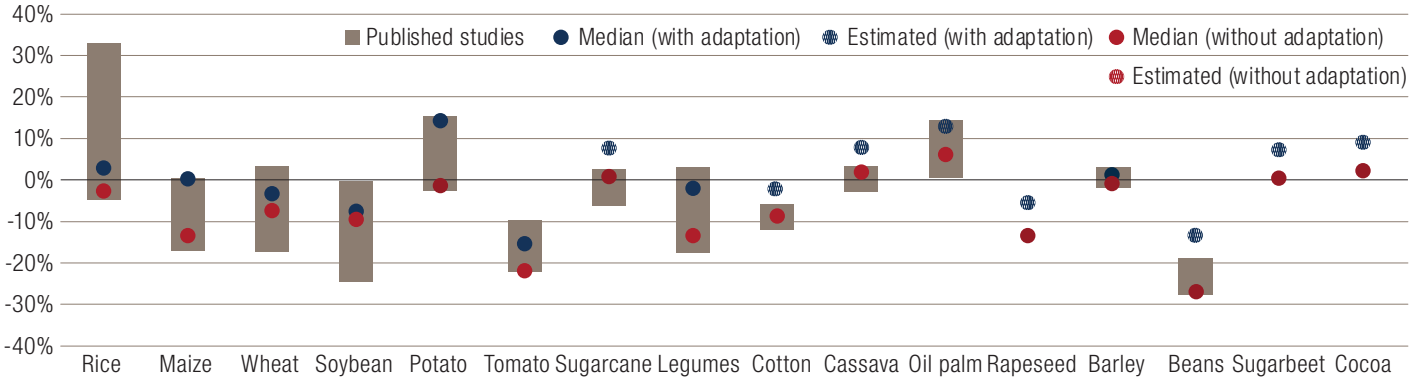
Such yield monitoring and optimisation is not only a tool aimed at mitigation, but may also contribute to adaptation to climate change. In the event of a 2°C temperature increase, crop yields of many staple foods are expected to decline, with the smallest farms most at risk. Without adaptation, some crop yields may decline by up to 30%, in turn putting the world's food production, food prices, and poverty targets at risk.[183] On the other hand, the Global Commission on Adaptation has estimated that adaptation efforts aimed at improving dryland crop production offers a benefit-cost ratio to over five-to-one, and net economic benefits of USD 700 billion to 2030.[184] The use of alternative, climate and flood-resistant crops is one key intervention – optimising yields and minimising resource footprints through yield monitoring and precision farming are another.

9.3. Challenges from farm to fork

Reforming our food and land use systems requires action across the entire supply chain, including in distribution, and consumption, with the need to address food waste and dietary choices emerging as key challenges.

Globally, for instance, food waste amounts to over 1.3 billion tonnes of food per year and has been estimated to account for 4.4 $GtCO_2e$ in GHG emissions, placing food waste at a similar order of scale as cars as a contributor to the climate crisis.[185] As shown in Figure 41, much of this food waste occurs past the farm gate during processing, retail and end consumption, requiring behavioural changes as well as industrial solutions. New packaging materials, for instance, may extend food life and thereby reduce waste. In Europe, the European Commission has committed to halving per capita food waste at the retail and consumer level by 2030, providing a regulatory incentive to the further development of such solutions.[186]

FIG. 40 EXPECTED CHANGES IN AGRICULTURAL CROP YIELDS IN 2°C SCENARIO, BEFORE AND AFTER ADAPTATION (%)



Source: Lombard Odier analysis, based on a review of academic studies of selected crops as published by Agriculture Impacts (http://ag-impacts.org).

[179] IPCC (2019) *Special Report On Climate Change and Land* Accessed at https://www.ipcc.ch/srccl/chapter/summary-for-policymakers/.

[180] National Geographic (2018). 75% of Earth's Land Areas Are Degraded. *Leahy, S.* Accessed at https://www.nationalgeographic.com/news/2018/03/ipbes-land-degradation-environmental-damage-report-spd/.

[181] American Journal of Experimental Agriculture (2013). Precision Farming for Small Agriculture Farm: Indian Scenario. Mandal, S and Maity, A. Accessed at https://pdfs.semanticscholar.org/b4bc/ef002514223d05d22e89ad0eeb37dcd85609.pdf.

[182] Markets Insider (2018). Precision Farming Market to see a CAGR of over 14% to 2024. Accessed at https://markets.businessinsider.com/news/stocks/precision-farming-market-to-see-a-cagr-of-over-14percent-to-2024-1001606538.

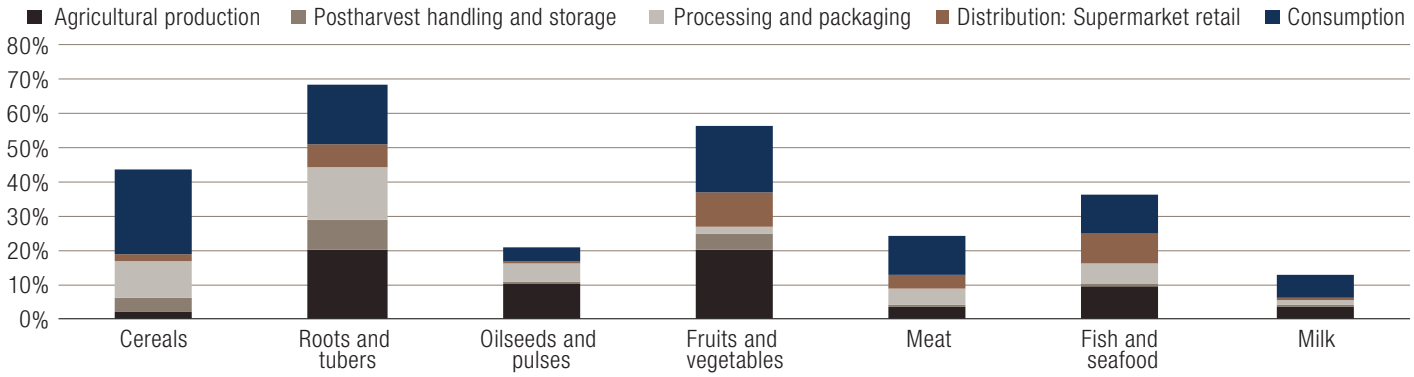
[183] Global Commission on Adaptation (2019). *Adapt Now : A Global Call for Leadership on Climate Resilience.* Accessed at https://cdn.gca.org/assets/2019-09/GlobalCommission_Report_FINAL.pdf

[184] Idem.

[185] FAO (2011). *Global Food Losses and Food Waste.* Accessed at http://www.fao.org/3/a-i2697e.pdf; Food and Agricultural Organization (2011). Food wastage footprint & climate change. Accessed at http://www.fao.org/3/a-bb144e.pdf.

[186] Commission (2018). *EU actions against food waste. Accessed at* https://ec.europa.eu/food/safety/food_waste/eu_actions_en.

FIG. 41 EUROPE: FOOD WASTE OF SELECTED PRODUCT GROUPS BY VALUE CHAIN STAGE (%)



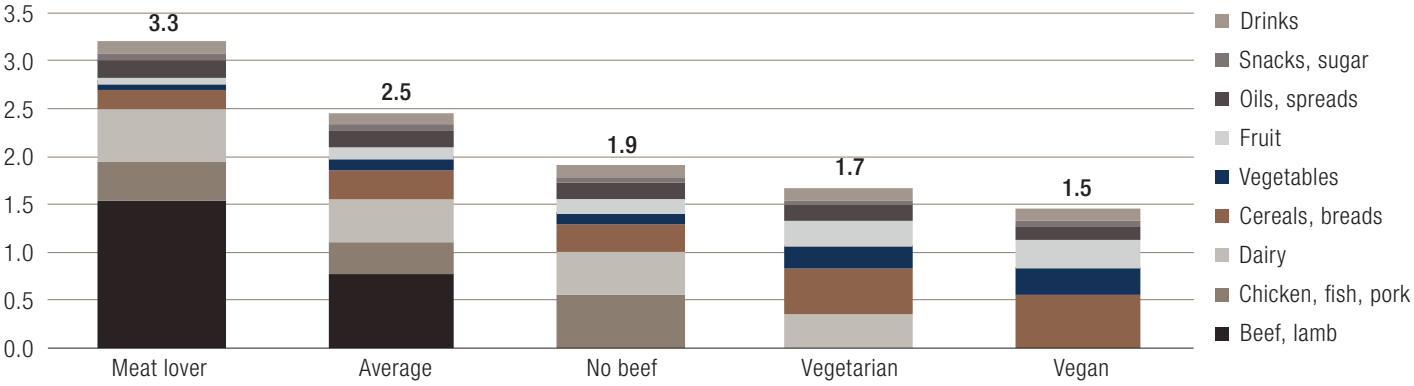
Source: Adapted from FAO.[187]

Nonetheless, these interventions are unlikely to be sufficient to meet the goals of the Paris Agreement and the net-zero economy without parallel changes in consumer behaviour as regards food choices. Meat consumption, in particular, accounts for a disproportionate share of a typical diet's carbon footprint (see Figure 42), even after accounting for the relatively higher portion of waste associated with fruits, vegetables, roots and cereals, making a transition to a more vegetables-based diet an important sustainability objective.

While accounting for just 18% of calories, the meat and dairy industries account for 80% of all farmland used and meat consumption has also been linked to increased rates of cancer, heart disease and overall mortality.[188] Trends to a more vegetarian diet may therefore be supported not only by moves towards decarbonising the global economy, but more directly by consumer demand for healthier alternatives. Having named veganism a top consumer trend in 2018, food delivery service Just Eat reported a 94% increase in orders for "healthy" food in 2018.[189] In the US, self-reported veganism has increased 600% in just three years, a trend mirrored in other Western markets.[190]

The emergence of plant-based (and, to a lesser-extent, insect-based) alternatives to meat may provide a further impetus to such dietary changes, increasing the range of consumer choice and offering a product similar in taste and experience at a much-reduced environmental cost. While limited barriers of entry are a cause of concern to investors, with consumer demand growing and new market entrants rapidly emerging, dietary changes are likely to be a key trend of this decade.

FIG. 42 FOOTPRINTS BY TYPE OF DIET (T CO_2e PER PERSON PER YEAR)



Source: Shrink that Footprint.[191]

[187] FAO (2011). *Global Food Losses and Food Waste.* Accessed at http://www.fao.org/3/a-i2697e.pdf.

[188] PLOS One (2016). Health-motivated taxes on red and processed meat. A modelling study on optimal tax levels and associated health impacts. *Springmann, M; Mason-D'Croz, D; Robinson, S; Wiebe, K; Godfray, C; Rayner, M and Scarborough, P.* Accessed at https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0204139

[189] Independent (2019). Veganism trend set to grow in popularity in 2018, according to Just Eat. Accessed at https://www.independent.ie/life/food-drink/veganism-trend-set-to-grow-in-popularity-in-2018-according-to-just-eat-36443713.html.

[190] Global Data (2017). Top Trends in prepared Foods 2017. Accessed at https://www.reportbuyer.com/product/4959853/top-trends-in-prepared-foods-2017-exploring-trends-in-meat-fish-and-seafood-pasta-noodles-and-rice-prepared-meals-savory-deli-food-soup-and-meat-substitutes.html.

[191] Shrink that Footprint (2013). *The carbon foodprint [sic] of 5 diets compared.* Accessed at http://shrinkthatfootprint.com/food-carbon-footprint-diet/comment-page-1#comments

10. Lombard Odier Climate Transition Strategy

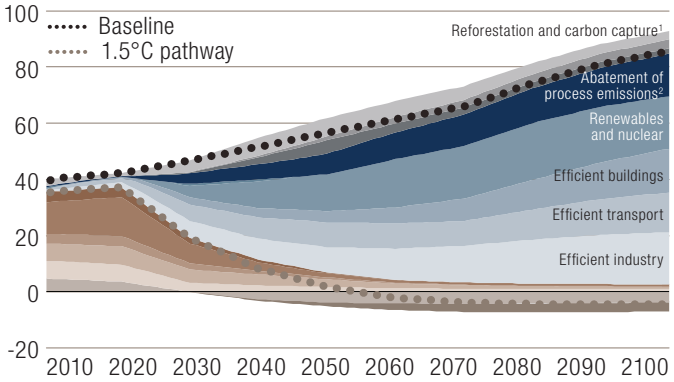
The Lombard Odier Climate Transition Strategy is designed to capture the massive investment opportunities associated with the need to transition to a net-zero economy, aligned with the Paris Agreement. In so doing, it attempts to fill a crucial gap in the market that existing cleantech and low-carbon strategies have not yet filled, by also including hard-to-abate industries along with industries where solutions are more readily available. In addition, it seeks to give appropriate attention to activities focused on adapting to a climate-damaged world, alongside activities intended to mitigate carbon intensity in a carbon-constrained world.

Developing an investment product that addresses the challenges outlined in this paper requires a thoughtful, thorough approach, which this chapter seeks to outline.

10.1. The need for cross-sectoral ambition

As shown in Figure 43 below, the transition to renewable energy and greener forms of mobility are essential adjustments, but are not sufficient. While opportunities in this space have received much of the limelight, a net-zero economy cannot be achieved without concurrent transitions in harder-to-abate industries.

FIG. 43 EU: NECESSARY ADJUSTMENTS FOR THE NET-ZERO ECONOMY BY TYPE OF SECTOR (MT CO_2e)



Source: IPCC Special Report: Global Warming of 1.5°C; [1] Agriculture, forestry and land use change (AFOLU); [2] Industry emission not related to energy, such as emissions from cement manufacturing.

The Lombard Odier Climate Transition Strategy therefore pursues alignment with a net-zero emissions economy by assessing the pathways to a deep and extensive decarbonisation across all *sectors*.

Strategies focused on solution providers, such as a pure players in the electric vehicle, wind energy or solar energy industries, capture part of this transition. They fail, however, to capture the important and difficult evolution required among these climate-intensive, transitioning industries. The Lombard Odier Climate Transition strategy, on the other hand, seeks to include such industries, where measurable performance targets can be identified.

Agriculture is one such industry, where emissions cannot be fully eradicated. In fact, in the net-zero economy envisioned by a roadmap tool developed by ClimateWorks/CTI, agriculture would account for 48% of positive emissions in the EU by 2050, up from 12% today, even if emissions in this sector were to half over this period.[192] This highlights the need for concerted action in the sector, and the importance of emerging solutions, including regenerative agriculture, the development of plant-based substitutes for meats, and precision farming.

The steel, cement and chemical industries also each account for substantial shares of GHG emissions, through their usage of electricity, the burning of fossil fuels to support high operating temperatures, and difficult-to-abate process emissions. We believe that the products of these industries will remain essential to our economy, but must be produced in a cleaner fashion.

The steel industry, accounting for 4-7%[193] of global emissions, offers a case in point. Transition pathways suggest that the industry must reduce its emissions by as much as 70%.[194] One strategy to achieve this is moving from blast oxygen furnaces (BOFs) to electric arc furnaces (EAF) that increase efficiency by around 64%[195] and rely on scrap metal, leveraging steel's notable recyclability and growing secondary supply. Driven by demands for less-intensive forms of steel by downstream markets seeking to reduce supply chain emissions, producers of EAF steel are

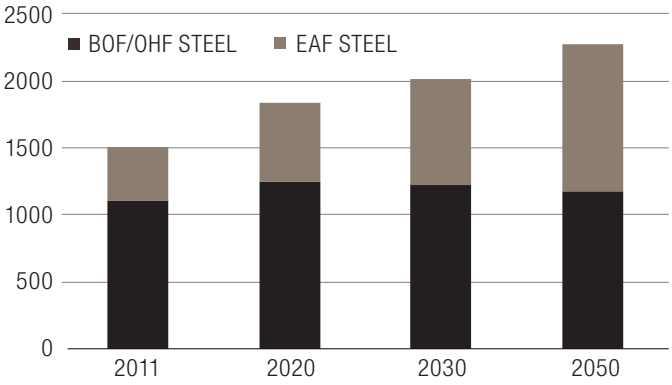
[191] Shared Effort scenario from the ClimateWorks/CTI 2050 Roadmap Tool. The creation of scenarios using the ClimateWorks/CTI 2050 Roadmap Tool, that has been developed by Climact sa/nv and the European Climate Foundation, does not imply endorsement of those scenarios by either Climact nor the ECF, nor endorsement of any conclusions based on those scenarios.

[192] European Commission. Energy Efficiency and CO_2 Reduction in the Iron and Steel Industry. Accessed at https://setis.ec.europa.eu/system/files/Technology_Information_Sheet_Energy_Efficiency_and_CO2_Reduction_in_the_Iron_and_Steel_Industry.pdf.

[193] Shared Effort scenario from the ClimateWorks/CTI 2050 Roadmap Tool, see footnote 191 above. Full abatement of emissions in this sector and other hard-to-abate sectors, including in agriculture and manufacturing, is unlikely to be feasible, and would instead be offset by either land use change, bio-energy with carbon capture and storage (BECCS), or artificial solutions such as carbon dioxide removal (CDR) and other negative emission technologies (NETs).

[194] Morgan Stanley (2017). Transitioning to energy efficient steel.

FIG. 44 FORECAST PRODUCTION OF CRUDE STEEL IN A 2°C SCENARIO (MT)



Source: International Energy Agency, as cited by Morgan Stanley Research (2017), Transitioning to energy efficient steel.

expected to see a growing competitive advantage as they are likely to be less impacted by increased carbon constraints and therefore gain market share within overall steel production, at the expense of producers reliant on steel produced at BOFs.

In chapter 8, we discussed other strategies and opportunities available to manufacturing sectors to survive in the net-zero economy. Generally speaking, the costs faced by these hard-to-abate industries in reducing emissions are higher than those in other industries. However, at the same time, as the example from the steel industry seeks to illustrate, those companies that succeed in this transition will face an important competitive advantage. Late adopters may face increased abatement costs, while non-adopters may be denied access from vital markets entirely and see opportunity for growth evaporate and even have their assets turned into stranded assets.[196]

10.2. The paradox of carbon footprints

In the pursuit of a cleaner, climate-neutral economy, it may be tempting to favour those stocks characterised by a low carbon footprint. Given the growing interest in such stocks, carbon footprinting has become a growing business among information and data providers, and is a common metric against which funds and indices are compared.

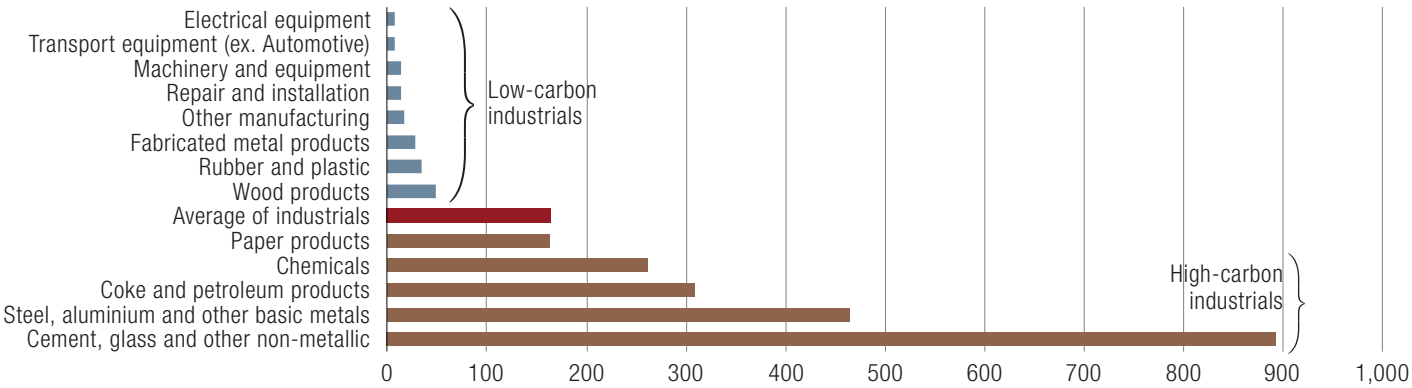
Carbon footprints can offer a useful benchmark for comparing companies within the same industry, or for tracking the progress of environmental improvements within a single company. However, they act as a potential pitfall when used indiscriminately.

Figure 45 provides an insight as to the reasons why. The figure shows the relative carbon intensity (calculated as the tonnes of GHG emissions per million Euros of output) for selected industries in the EU. Under a NACE classification (widely used in the EU) each of these industries would be considered to fall in the broader "manufacturing" category, while under a GICS classification (developed by MSCI and S&P), these industries would fall under "industrials" or "materials."

Given the stark differences in the relative carbon intensity of the various industries, it is easy to see how a "low carbon" portfolio may be constructed, including only the "best" industrials.

In the EU, the 5 highest-carbon industries shown in Figure 45 account for around 40% of the total turnover, but for 93% of the emissions. As shown in the example below, excluding these sectors results in a radical improvement in the carbon footprint of a hypothetical portfolio, and might be marketed as offering an opportunity to invest in best-in-class industrials, at least from a carbon footprint perspective.

FIG. 45 EU: INTENSITY OF EMISSION IN SELECTED INDUSTRIAL INDUSTRIES (T CO_2e PER MILLION EUROS REVENUE)



Source: Lombard Odier calculations based on Eurostat (2019).

[196] See commentary on the IASB practice note on the materiality of climate-related risks and stranded assets evaluation in section 2 and 4.4 of the paper.

TABLE 1 ILLUSTRATIVE EXAMPLE OF A LOW-CARBON VERSUS INCLUSIVE PORTFOLIO

		COMPANY 1	COMPANY 2	COMPANY 3
		ELECTRICAL EQUIPMENT	RUBBER AND PLASTIC	BASIC METALS
Carbon intensity	t CO_2e/Meuro	8	35	465
Turnover	Meuro	6,620	6,600	7,400
Total emissions	t CO_2e	51,637	228,676	3,444,407
Low-carbon portfolio				
Weighting	%	50%	50%	0%
Weighted carbon intensity	t CO_2e/Meuro		**21**	
Total abatement potential	t CO_2e	140,156		
Portfolio that includes difficult-to-abate sectors				
Weighting	%	33%	33%	33%
Weighted carbon intensity	t CO_2e/Meuro		**168**	
Total abatement potential	t CO_2e		**1,229,158**	

Source: Lombard Odier.

However, while such a low-carbon strategy offers an easy means of decreasing a portfolio's carbon footprint, it is not aligned to the needs of the net-zero economy. In the net-zero economy, we believe paper, chemicals, basic metals, cement, glass and other non-metallic minerals will still be required and only the products of the coke and petroleum industry may partially be substituted.[197] The simple exclusion of these sectors, therefore, fails to capture the necessity of pursuing environmental improvements in these hard-to-abate industries.

The Lombard Odier Climate Transition Strategy does not exclude such industries and, instead, aims to identify companies that either offer specific solutions or are positioned within transitioning industries, where decarbonisation is both an environmental necessity and a source of competitive advantage.

10.3. Three approaches to climate change

Based on the analysis in sections 10.1 and 10.2 three different types of strategies related to climate change can be identified:[198]

- First, *greentech or cleantech* strategies generally focus on "pure player" solution providers, such as emerging players in the electric vehicle industry, energy storage or the battery supply chain, manufacturers of wind turbines, of solar panels, developers of renewable energy projects, or of various other industry-specific solutions aimed at constraining emissions – such as precision farming or developers of substitutes to meat proteins. Greentech or cleantech strategies generally do not, however, include carbon-intensive, but economically critical, *transitioning* industries, even though efficiency, material, design and process improvements available to these industries are a necessary component of the climate transition.
- Second, *low carbon* strategies that advertise their low carbon footprint will generally outperform on this metric. However, the use of the carbon footprinting criterion may lead to the exclusion of subindustries with a high, current footprint, but vital to both a carbon transition and to the future economy. Moreover, while this strategy offers a low carbon footprint, it offers more limited abatement potential, given the low baseline level and absolute size of emissions represented.
- Third, the *Lombard Odier Climate Transition Strategy* seeks to take a more holistic view and includes solution providers as well as transitioning industries, including any sector where action on climate change is a necessary step on the pathway to the net-zero economy; where such climate action is deemed possible on the basis of existing solutions and strategies; and where such action offers perceived competitive advantages to companies that are leading the way. As a result of the inclusion of transitioning industries, some of which have a high environmental footprint today which requires urgent remediation, the carbon footprint of the Lombard Odier Climate Transition Strategy is therefore understandably and deliberately expected to be higher than those of other cleantech or low carbon strategies, indices and benchmarks. In so doing, however, it seeks to prioritise abatement potential, and the pursuit of alignment with net-zero pathways.

[197] Even the substitution of petroleum products would only be a partial substitution. While the use of petroleum as a fuel may be replaced by renewable forms of energy, the plastics industry will continue to require petroleum. While plastics themselves are becoming more controversial, we believe plastics will continue to represent an important material that offers environmental benefits over many competing materials, albeit necessitating rationalisation of design, as well as improved waste management and recycling.

[198] This classification is intended to be illustrative only of three broad classes of investment philosophies as identified by Lombard Odier. It is not presumed to offer an exhaustive overview of all the various investment products available in the market today and has been intentionally simplified.

These three investment philosophies may be summarised graphically as per Figure 46.

The Lombard Odier Climate Transition strategy is thereby designed to align with the requirements of the net-zero economy. It targets the ingredients, solutions, ambitions, and pathways necessary to pursue the ambition of the Paris Agreement to limit global warming to 1.5°C.

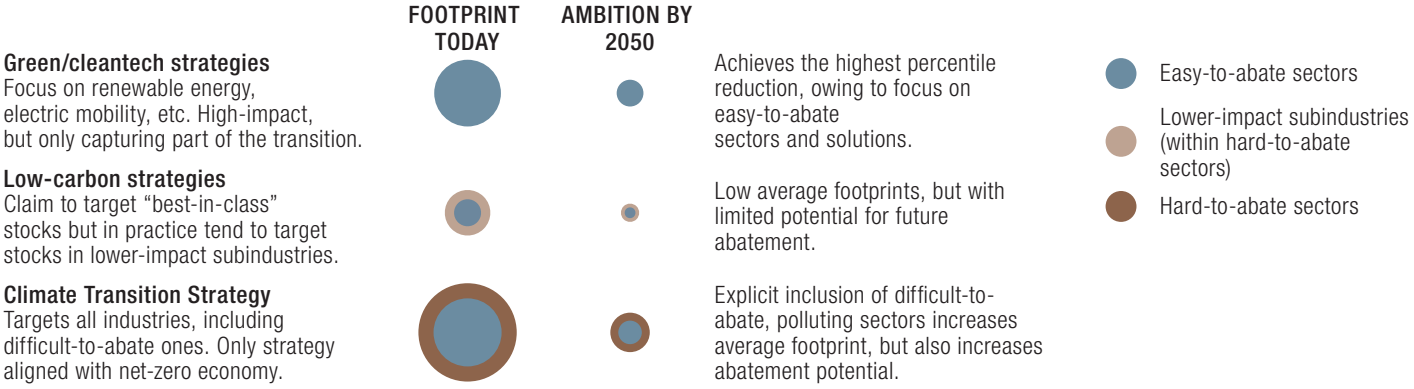
10.4. Addressing the two sides of climate change

As discussed in section 3.3, an international consensus has emerged as to the importance of adaptation activities aimed at improving preparedness and resilience and reducing vulnerability to the effects of climate damage. Indeed, initiatives such as the Paris Agreement and action plans by the World Bank and the EU now recognise that mitigation and adaptation activities should be placed on equal footing.

At the same time, studies discussed in this section have found that early investment in adaptation may avoid damage at a cost-benefit ratio of four-to-one, further supporting the importance of these activities from an economic and investment perspective.

The Lombard Odier Climate Transition strategy seeks to align itself with these initiatives, and hence includes investable opportunities in a carbon-constrained environment, alongside its focus on climate-damage adaptation.

FIG. 46 ILLUSTRATION OF THE CONCEPTUAL, RELATIVE CARBON INTENSITY AND ABATEMENT POTENTIAL OF CLEANTECH, LOW-CARBON AND LO'S CLIMATE TRANSITION STRATEGY



Source: Lombard Odier.

FIG. 47 SCHEMATIC OVERVIEW OF TYPES OF ACTIVITIES WITHIN THE SCOPE OF THE LOMBARD ODIER CLIMATE TRANSITION STRATEGY

CARBON-CONSTRAINED WORLD		CARBON-DAMAGED WORLD
SOLUTION PROVIDERS	TRANSITION CANDIDATES	ADAPTATION OPPORTUNITIES
Carbon **reduction**	Carbon-intensive **industries**	Increasing **resilience**
Carbon **avoidance**	Carbon-intensive **transportation**	Monitoring **risks**
Carbon **capture**	Carbon-intensive **building**	Managing **impact**
Growth opportunities	Competitive advantage	Growth opportunities

Source: Lombard Odier.

With respect to increasing resilience, our strategy explores opportunities related to the strengthening of civil infrastructure as well as urban planning and preparedness. Activities in this space may range from the placing of underground power lines, to the development of hard (concrete) and soft (green) flood defences, and the improvement of water and waste management systems. Civil engineering firms that offer consulting, design and construction services, are the primary companies involved in these activities.

With respect to monitoring risks and managing impact, a more diverse group of companies has also been identified as part of our Climate Transition Strategy. Activities within these themes, for instance, include services that monitor meteorological risks, the provision of early warning systems and risk management software. In the financial sphere, companies offering risk rating services, green finance, and (re-)insurance candidates are also of immediate relevance. In a world where climate change consequences are already manifesting (such as the devastating wildfires in Australia), being able to insure and diffuse these risks is an opportunity for insurers (and re-insurers) as long as risk can be properly priced.

Through these additions, the Lombard Odier Climate Transition Strategy gives specific, investable shape to international action plans calling for increasing funding of adaptation activities. In so doing, it aligns itself with the Paris Agreement in a way that simpler methodologies based merely on carbon footprints do not.

11. Conclusions

The world today faces no greater crisis than our changing climate and environment. Although it is difficult to quantify the value of our world's ecosystem, the profound climatic and ecological changes likely to result from even small increases in average temperatures will be immeasurably disruptive and create risks at a local, company, industry, community as well as a systemic level across the global economy. There is nowhere for investors to hide from the long-term financial implications of climate change.

While elected policymakers have a primary responsibility to define the pathways for the climate transition, and are increasingly understanding that climate action can lead to better economic growth prospects, market forces are increasingly emerging as the driving force. Improving economics of renewable energy technologies, the evolving demands of environmentally-conscious consumers, and the expectations of savvy investors with an acute awareness of inevitable risks are at the root of a reallocation of capital and resources to those industry leaders capable of effecting a positive change.

The Lombard Odier Climate Transition Strategy is intended to fill a critical gap by making available a concrete means of investing in the decarbonising economy and the transition to a net-zero economy. At present, green/cleantech funds may offer exposure to highly-publicised technologies in renewable energy or electric mobility, and low-carbon funds may cherry-pick exposure to selected subindustries with a smaller emissions footprint. Neither of these types of strategies, however, are well aligned to the type of a transition that is required – a revolution that requires a fundamental rethink of business practices and business models across all sectors.

By seeking to invest in both the solution providers as well as the carbon-intensive, transitioning industries they serve, the Lombard Odier Climate Transition Strategy may have a footprint that may end up being comparatively higher than a reference index but for "good" reasons. We believe the companies selected will bring strong solutions to climate issues enabling carbon reduction at other steps of the value chain and that we will therefore be investing in "carbon well spent." The transformation of our economy cannot be accomplished without tackling the challenges faced by hard-to-abate industries, such as steel, cement and chemicals, head-on. The Lombard Odier Climate Transition Strategy embraces that challenge, and sets out to identify the leaders in each industry that may achieve this goal.

Notwithstanding the efforts that may limit the extent of global warming, climate change will bring inevitable change to our environment. Communities, businesses and economies are at risk of severe economic damage, expected to reach as much as USD 54 to 69 trillion even in a 1.5°C and 2°C scenario respectively.[199] The IPCC, the EU and the World Bank have called for early climate-damage adaptation activities to be placed on equal footing with carbon-constraining activities. The Lombard Odier Climate Transition Strategy gives concrete shape to this call, by explicitly including within its investment universe those companies that we believe offer opportunities to adapt to and monitor climate damage.

Despite the challenges ahead, the climate transition highlights the need for a broader sustainability revolution. As the examples on the energy, transport, industrial and land use sectors explored in this note demonstrate, the revolutions in these sectors create opportunities even as they address emerging risks.

At Lombard Odier we believe that the Sustainability Revolution is the single largest investment opportunity of our lifetime – and the Climate Transition is an essential part of it.

[199] IPCC (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global GHG emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Chapter 3: Impacts of 1.5°C of Global Warming on Natural and Human Systems. Accessed at https://www.ipcc.ch/sr15/chapter/spm/.

Focus box: Making sense of the numbers

When it comes to the economic implications of climate change, the numbers involved can be eye-watering, ranging into the billions and trillions of dollars.

Throughout this report, a variety of figures are cited to illustrate the argument in this paper for the central need for a radical increase in our efforts to support the mitigation of climate change in a carbon-constrained world, and the need for adaptation to climate change in a carbon-damaged world. As different sources rely on separate definition and approaches and cover different periods, we provide below a summary of a selection of some of the key figures cited in this report, to explain how they relate:

- In 2017 and 2018, the economic damage resulting from extreme weather events amounted to an average of USD 327 billion per year (USD 438 billion in 2017 and 215 billion in 2018), compared to median losses of USD 115 billion per year in the decade up to 2010.[200] This figure exceeds the *insured* losses for these years, and includes the effects of physical damage, disruption in production, lost sales, and supply chain effects.
- UNEP estimates that the costs of adaptation to increase resilience to physical risks of climate change will increase to USD 140 to 300 billion per year by 2030, and may reach USD 280 to 500 billion per year by 2050. This represents an *annual* cost aimed at *reducing* the adverse effects of climate change, including improving resilience to physical risks, and adaptation to changing climatic conditions in agriculture and other sectors.[201]
- Similarly, the Global Commission on Adaptation has estimated that USD 1.8 trillion in investment over the period 2020 to 2030 in such adaptation actions would accrue benefits of USD 7.1 trillion, at a benefit-to-cost ratio of nearly four-to-one.[202] The USD 1.8 trillion figure is a *cumulative* investment figure over the decade ahead, while the USD 7.1 trillion figure relates to *avoided damage* that are prevented as a result of such investment. These figures are not exhaustive, however, and do not cover all forms of climate adaptation. The infrastructure figure, for instance, relates primarily to spending in low and middle-income countries.
- The G20 countries are estimated to have planned USD 60 to 70 trillion in infrastructure spending over the period from 2015 to 2030.[203] This is a cumulative figure that relates to total expected investment spending, including all forms of infrastructure, and not specifically related to climate change. This infrastructure, however, must be made *resilient* to climate change. Increasing resilience of vulnerable infrastructure may increase costs by 3-10%,[204] but as not all infrastructural projects may be deemed vulnerable, this increase in cost may not apply to the complete USD 60-70 trillion figure.
- The *aggregate* cost of climate change comprises expected losses from physical risks such as flooding, as well as adverse health and productivity effects from heat stress, drought and pollution, and indirect impact on economic demand. The cumulative cost of these effects is estimated to reduce global GDP by 0.28% in a 1.5°C scenario, 0.46% in a 2°C scenario, and as much as 2.62% under current policies (modelled as a 3.66°C increase in global warming). The net present value of these annual losses amount to USD 54 trillion, USD 69 trillion and USD 550 trillion in these three scenarios respectively.[205]

[200] AON (2018). Weather, Climate & Catastrophic Insight. Accessed at http://thoughtleadership.aonbenfield.com/Documents/20190122-ab-if-annual-weather-climate-report-2018.pdf.

[201] UN (2016). UNEP report: Cost of adapting to climate change could hit USD 500 billion per year by 2050. Accessed at https://www.un.org/sustainabledevelopment/blog/2016/05/unep-report-cost-of-adapting-to-climate-change-could-hit-500b-per-year-by-2050/.

[202] Watson and Le Quéré (2018). The implications of global warming of 1.5°C and 2°C. Accessed at https://tyndall.ac.uk/sites/default/files/implications_of_global_warming_of_1.5_and_2_degrees_-_final_report_1_0.pdf.

[203] Foundation Earth (2015). Regarding: G20 Plans for Infrastructure Finance. Accessed at http://www.fdnearth.org/files/2012/11/G20.final_.pdf.

[204] Global Commission on Adaptation (2019). Adapt Now : A Global Call for Leadership on Climate Resilience. Accessed at https://cdn.gca.org/assets/2019-09/GlobalCommission_Report_FINAL.pdf.

[205] Watson and Le Quéré (2018).

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