circular carbon economy

08

Enabling policies.

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Information Note

This report has been prepared as part of the Guide to the Circular Carbon Economy (CCE) series compiled by the King Abdullah Petroleum Studies and Research Centre (KAPSARC), in the context of the Saudi Arabia Presidency of the G20 in 2020. The report focuses on the importance of enabling policies that are essential to support a rapid global transition towards net-zero GHG emissions. Drawing on OECD's cross-sectoral and interdisciplinary expertise, the report has a particular focus on the enabling framework for moving towards increased circularity in the carbon cycle related to energy production and use. This includes, but is not limited to, the particular policy challenges relating to rapidly scaling up Carbon Capture Utilisation and Storage (CCUS) across industry and power generation.

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Key Messages

- **Achieving net-zero greenhouse gas (GHG) emissions globally will be essential to achieve global climate change objectives.** This will require a holistic, whole-of-economy approach to policy-making, addressing the full range of sectors that both influence emissions and are affected by adverse environmental impacts resulting from climate change. Governments will need to draw on the full array of policy tools available, as well as new policy approaches that are still to be tried and tested.

- **The circular carbon economy (CCE) represents one important part of this holistic approach towards achieving net-zero GHG emissions, and covers several key dimensions of the challenge.** At the same time, it is important to recognise that the CCE does not cover the full spectrum of what is required for net-zero GHG emissions, such as reduction of GHGs not related to energy production and use. The CCE is also distinct from broader interpretations of circular economy, most of which focus on circularity of material use and wider resource efficiency.

Enabling policies across the different dimensions of CCE

- **While the CCE concept is characterised by a wide array of different technology options and approaches employed to achieve climate goals, it is important to maintain a strong focus on reducing emissions in the near-term.** Components of the CCE include not only reducing energy-related CO_2 emissions but also "recycling" CO_2 (such as through bioenergy), reusing it (such as through industrial CO_2 use) and removing CO_2 from the atmosphere through capture and storage of CO_2, including direct capture of CO_2 from the air. Not all technologies required for these "four Rs" of the CCE are yet commercially available. A supportive policy environment will be essential to achieve a rapid transition to a more circular carbon economy, including through better pricing of emissions and through innovation.

- **While each component of the CCE requires specific supportive policy measures, the basis for decarbonisation is set by enabling policies that are common to all four "Rs" of the CCE.** Key cross-cutting elements of this enabling framework include: the importance of a long-term strategy and cross-government alignment to maximise the effectiveness of energy and climate policies; coherent energy pricing (through carbon pricing and removing fossil-fuel subsidies); alignment of financial incentives; a supportive innovation framework beyond funding of basic Research and Development (R&D); and greater transparency on financial climate risks and carbon accounting.

- **International co-operation is an important prerequisite for development of the circular carbon economy.** Ongoing co-operation through the multilateral climate process, including the Paris Agreement and its cycle of increasingly ambitious Nationally Determined Contributions, is important to build trust internationally and among domestic constituents. The success of CCE also depends on international co-operation at other levels, well beyond multilateral environmental agreements. This ranges from international standards for key technologies and facilitation of cross-border trade of low-carbon goods, including transport of CO_2 as part of Carbon Capture, Utilisation and Storage (CCUS). For new technologies, processes and business models to become economically viable for the CCE, access to international markets is important to achieve economies of scale and to ensure widespread international diffusion of technologies.

- **Orienting climate policies around people's well-being can help to accelerate a cost-effective energy transition by creating two-way alignment between climate and other policy objectives.** On one hand, this means ensuring that policies unrelated to climate change should not directly or indirectly undermine mitigation objectives (such as tax codes favouring emissions-intensive investments or behaviours). On the other hand, climate policies need to also contribute to other societal well-being objectives, such as cleaner air and better public health. Focusing on well-being in this way makes the benefits of climate policy more tangible in the near-term, helping to garner social and political support.

- **The emissions reduction component of CCE requires a wide of array of both specific and less specific policy interventions, many of which are widely known with good implementation experience across countries.** These notably include policies to improve energy efficiency throughout the energy chain, ranging from domestic and industrial end-uses (buildings, vehicles, industry) to energy transformation (efficiency of power generation and refining). Key energy-efficiency policies relevant to CCE are well-known, including regulations, standards and financing incentives. Policies to support electricity from renewable sources and other forms of renewable energy are also in widespread use and have evolved rapidly in recent years. These include auction-based tariff-setting for renewables; reforming electricity markets and incentives for demand response for better integration of renewables; and incentives for renewable heat and transport fuels. Fuel switching, in particular incentives for electrification of end-uses, is also an important component, again ranging from transport to industry to building services.

- **The re-use, re-cycle and remove components of CCE will rely on policies more specific to the network of interconnecting processes that make up the CCE.** In particular, value chains related to CCUS are complex and require particular incentive and financing policies over and above carbon pricing. While more expensive than other abatement options in the near-term, CCUS is essential for long-term decarbonisation. Careful policy design is therefore needed to ensure that a robust revenue stream can be identified from carbon capture, and that this revenue incentive is passed transparently along the value chain (from industrial energy user, to CO_2 transporter, to storage operator or CO_2 "user"). This is true whether the CO_2 is ultimately "used" or "stored". A carbon price is necessary, but will alone unlikely generate sufficient incentive in most cases, meaning that additional, CCUS-specific incentives are needed.

Financing and investment for CCE, with a focus on carbon capture and storage

- **Finance and investment is central to a successful transition to net-zero emissions, and governments have an essential role to play in reorienting the financial system to better value longer-term benefits.** The financing challenge includes both scaling up investment in low-carbon technologies and systems and reallocating capital away from carbon-intensive sectors. Current governance of the financial sector creates incentives for short-termism, so that more distant (but ultimately vital) benefits of resilient, low-carbon investments are not sufficiently valued on financial markets. Increased transparency and reporting is needed on climate-related risk assessments – both physical risks and transition risks –to allow investors to correctly price risks and opportunities.

- **Financing CCUS, a core element of the remove component of CCE, throws up particular policy challenges.** Carbon capture projects tend to be large, capital-intensive projects with high perceived risks and in some regions local political and social opposition. These factors combine to push up financing costs. In addition to creating specific CCUS incentives, governments can act to improve financing conditions for CCS, for example through short-term guarantees during the construction phase, through public-private partnerships, use of blended finance mechanisms, and through international collaboration and sharing of experience in financing and creating markets for CCUS. The creation of carbon capture industry clusters, for example through locational incentives or easier permitting, are also important to exploit economies of scale.

- **Perceptions of longer-term business and financial risk are changing fast, with implications for the viability of CCUS business models.** More and more firms are setting ambitious long-term targets related to climate change, including in the oil and gas sector (with some companies recently committing to phase-down the carbon intensity of their products, as well as their own operations). Firms who do not act to reduce their CO_2 intensity could face higher financing costs or even difficulties obtaining finance should more banks and investors apply negative lists or screens within their Environmental, Social and Governance (ESG) integration practices. In the finance sector, there is increasing awareness of the technological and value-chain risks relating to investment holdings. As a result, financial firms are starting to develop expertise and tools such as scenario stress-testing to better evaluate such risks. As expertise in the sector develops, the business case for CCUS could improve due to investors looking for new technology solutions that can balance the risks in their portfolios.

Accelerating technology and business model innovation

- **Accelerated innovation of technologies, processes and business models will be essential for successful transition to net-zero emissions. However, there are signs of a slow-down in low-carbon innovation in recent years.** Even before COVID-19, low-carbon innovation was declining across many domains (as measured by patents), and public R&D spending was stagnant in many regions. This is in stark contrast with what is required to tackle the intensifying climate challenge. In addition to innovation needed for deepening and cheapening emissions reductions, the CCE approach in particular requires technological innovation across the CCUS value chain, and business-model innovation to better value and monetise stored or used CO_2.

- **Governments can play several roles to both "push" and "pull" new technological solutions through the innovation chain.** The underlying policy framework, including carbon pricing and a strong investment environment, are important prerequisites for innovation as well as for deployment of more mature technologies. Public funding of R&D remains a core "push" role for governments to drive innovation, though the design of R&D subsidies is crucial to ensure their effectiveness. Governments can also play an important role to help promising innovations into early commercialization and to avoid the so-called "valley of death". On the "pull" side, public procurement can be an effective tool to create markets for low-carbon materials with a knock-on effect on innovation, including potentially for CCUS.

Applying a COVID-19 lens to policy-making

- **It is essential that all CCE policy and investment discussions are seen in the light of the economic crisis caused by COVID-19, and the recovery policies being put forward by governments.** It is too soon to understand the full implications of the current crisis, but key emerging elements relevant to CCE include:

    - **Financial stress in the private sector,** with a tendency to avoid investment and expenditure perceived as non-essential or discretionary, which may include environmental measures. The IEA recently projected unprecedented falls in energy-sector investment for 2020. Pre-crisis, the energy sector already faced a USD 350bn investment gap relative to the needs of a Paris-aligned scenario.

    - **Implications of low and volatile fossil-fuel energy prices:** in the short-term, low fossil-fuel prices naturally disfavour energy-efficiency and favour fossil-fuel-related investments and behavioural choices, in particular at the consumer end. Over a longer period, low and volatile prices also place financial stress on fossil-fuel firms, slowing down capital investment in fossil-fuel supply and even leading to bankruptcy. On the other hand, low energy prices also can create political opportunities for fossil-fuel subsidy reform, both for consumer subsidies (helping to reorient incentives towards technologies needed for "reduce") and production (changing the investment case at the supply end).

    - **Regaining public support for climate change policies by focusing on inclusiveness and well-being:** with millions of jobs lost and consumer confidence crashing, the need to ensure public and political support for climate change policies has never been more important. Making sure climate policies are progressive and not impacting the most vulnerable parts of society is critical. Adopting full-cost accounting and mainstreaming well-being outcomes into the decision making process on climate policy is also central.

    - **Building Back Better: opportunities to accelerate CCE through stimulus packages.** Governments are preparing large stimulus packages aiming to restart the economy and bolster employment as quickly as possible. In many countries, there is support for orienting the fiscal spending involved in such packages towards sustainable measures aligned with the transition to a CCE. However, so far these measures have often been outweighed by larger support to emissions-intensive sectors, or roll-back of environmental regulations. In many cases, targeting stimulus spending to sustainable investments can deliver strong fiscal multipliers and employment opportunities – i.e. they have strong positive knock-on effects for the broader economy and can be justified on purely economic grounds, in addition to their clear near- and long-term benefits for society.

01

Introduction

Introduction

The human and economic consequences of the COVID-19 pandemic have captured the world's attention, but the immense global challenge of climate change has not receded. Left unchecked, climate change and other global environmental emergencies, such as air pollution and biodiversity loss, are likely to cause economic and social impacts greater than those triggered by the current health crisis. Governments therefore have an opportunity to ensure that economic recovery policies and stimulus packages are aligned with rapid decarbonisation of the economy. Such policies can be good for short-term economic recovery and jobs, while also reducing the risks of damage from climate change in the coming years and decades (OECD, 2020a ,b; IEA, 2020a).

The goal of reaching net-zero greenhouse gas emissions has increasingly become the focus of energy transition scenarios in recent years. This has been a key focus of recent work of the IPCC, in particular in the context of limiting global warming to 1.5°C (IPCC, 2018) and is also embodied in the Paris Agreement through the language of a "balance of emissions and sinks"[1] in the second half of the century (UNFCCC, 2015).

Many different scenarios, strategies and approaches have been developed to depict how the world can shift from current trajectories towards net-zero in the appropriate time-frame. These approaches differ across key characteristics such as how quickly energy demand growth stabilises and reverses; how much renewable and nuclear energy grows in the system; how quickly CCUS is deployed to existing or new fossil-fuel installations and how quickly (and how much) CO_2 can be removed permanently from the atmosphere. Removing CO_2 becomes increasingly important where slower emissions reductions lead to an "overshoot" of GHG concentrations. In such scenarios, considerable CO_2 removal is necessary to subsequently reduce GHG concentrations and limit global warming. In the case of liming warming to 1.5°C, these differences of approach are highlighted by four representative pathways characterised by the IPCC (IPCC, 2018).

[1] Net-zero emissions, carbon neutrality, "balance of emissions and sinks" are terms that are often used interchangeably, referring to achieving net-zero GHG emissions either by balancing remaining emissions with carbon dioxide removal technologies or simply eliminating carbon emissions altogether. Within specific perimeters, such as a company or a country, net-zero is sometimes also interpreted to include the use of "offsetting" residual emissions through the acquisition of offsets corresponding to emissions reductions outside of the parameter (e.g. in another country).

The Circular Carbon Economy (CCE) stands out from other approaches to achieve climate goals because of its strong focus on approaches beyond reducing emissions. The CCE embodies 4 "Rs" – Reduce, Reuse, Recycle and Remove. The "reduce" component is nevertheless essential to achieving climate goals cost-effectively, and it should remain a key priority.

However, the CCE approach recognises the importance of the "net" in net-zero, and the need for a wide number of technology approaches to achieve the overall outcome, including different ways of removing CO_2 from the atmosphere. Despite differences, almost all scenarios achieving net-zero have some residual emissions that need to be compensated for by carbon dioxide removal. CO_2 can be captured directly from industrial processes and points of combustion, but it can also be captured directly from the air with "direct air capture" technologies. In addition, land can also be managed in such a way that it can become a net natural sink for atmospheric carbon. Natural sinks, bio-energy CCS and direct air capture can close the loop on emissions elsewhere that may be too difficult or too expensive to capture directly, such as aviation emissions.

Afforestation, reforestation and other means of enhancing land-based carbon stocks can achieve part of this removal through biological sequestration, meaning there is an important role for "nature-based solutions" in tackling the climate challenge, provided that biological sequestration will not be reversed through future land-use change. However, achieving net-zero while only relying on biological sequestration requires extremely steep reductions in energy demand – surpassing even those caused by the lock-down measures taken to contain the COVID-19 pandemic – as well as a very rapid transition to zero-carbon energy.[2]

Most scenarios therefore rely on a combination of rapid energy demand reduction through higher energy-efficiency, an accelerated transition to low-carbon energy and an increasingly significant contribution of CO_2 removal through CCUS. Scenarios rely to differing degrees on capturing CO_2 directly from the air (DAC) and combining CCUS with bioenergy (BECCS).

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[2] As depicted in the P1 pathway described in the IPCC's report on limiting global warming to 1.5°C (IPCC, 2018).

Whatever the approach followed, strong and aligned enabling policies are essential to underpin the development and deployment of the technology, infrastructure and business models required to stand a chance of achieving the climate goals embodied in the Paris Agreement. Isolated sector-specific policies are not sufficient to achieve the transformation required; a concerted effort on policy alignment is necessary across sectors. This alignment is all the more necessary in a time of economic crisis and recovery, but also presents a key opportunity to rekindle economic growth in a way that can deliver on climate change objectives.

This report begins with a brief overview of how the concept of the "circular carbon economy" relates to the broader context of both the transition to net-zero GHG emissions and the notion of circular economy. The focus of the CCE is primarily on CO_2 emissions relating to energy production and use, as outlined in the introduction to the circular carbon economy (KAPSARC, 2020). However, the OECD's framing of the transition towards a circular economy, as well as towards net-zero GHG emissions, is broader. In the next two sections, the underlying policy framework required to accelerate the transition to a decarbonised energy system is presented, highlighting elements that are common with other approaches and those that are particular to CCE. The final two chapters examine in more detail two specific policy areas of critical importance for the transition towards a more circular carbon economy: investment and financing, and innovation.

02

Policy context for the Circular Carbon Economy

Policy context for the Circular Carbon Economy

Much of the needed policy framework to achieve a circular carbon economy is similar to other approaches for rapidly reducing energy-related CO_2 emissions. In other words, the "Reduce" component of the CCE remains an essential pillar and the policy framework required is therefore consistent with most other emissions reduction approaches. It is likely that the majority of emissions reductions in the CCE come from established emissions mitigation areas such as increased energy-efficiency, more use of renewable energy and electrification of end-uses. A significant focus should therefore be maintained on the policy framework needed to accelerate the technologies, investment and behaviours needed to reduce emissions as quickly and as early as possible, as covered in the next section.

Nevertheless, there are some key particularities of the circular carbon economy that influence the discussion of enabling policies. These include the scope of what is covered relative to broader climate change objectives and circular economy concepts, and the policy and technology outcomes required to ensure that different elements of the circular carbon economy advance in parallel.

Two aspects of scope are important when considering how CCE fits in the broader policy landscape. The first aspect concerns the scope of circularity. The CCE concept primarily embodies a move towards circularity within the cycle of CO_2 emissions from energy, by combining ways of preventing CO_2 from energy use from reaching the atmosphere with techniques to remove it. While this draws on and bears some overlap with the wider circular economy principles, the OECD's view of "circular economy" is much broader.

There is no single, generally accepted, definition of the term "circular economy", but most interpretations have at their core the concept of decoupling natural resource extraction and use from economic output, thereby increasing resource efficiency, and of creating value-chains whereby waste products become inputs for other processes. This goes much beyond energy production, and covers changes in the way materials are extracted, used, shared, repurposed and recycled across the economy. To increase resource-efficiency and reap the potential benefits of a circular economy, governments will need to shift away from the linear economy and instead mainstream circularity and resource-efficiency across the entire economy. The policies needed to stimulate these broader changes in material flows are not covered here.

The second aspect relating to CCE scope is the perimeter of GHG emissions and other climate forcers covered. The achievement of net-zero GHG emissions goes well beyond the energy system. Other greenhouse gases and climate forcers, whether related to energy or not, will be critically important for achieving net-zero emissions and in many instances require different policies not covered in this report. One example concerns reduction of ozone-depleting substances that are also powerful greenhouse gases, such as hydrofluorocarbons (HFCs). In this context, more rapid adoption of the Kigali Amendment to the Montreal Protocol would be an important step for reducing GHG reductions through better management of HFCs. This is however not linked to energy use, and therefore not obviously captured within the CCE.

The emissions of other sectors outside the energy sector are also important. Non-energy emissions from agriculture, for example, account for 11% of global GHG emissions currently. Improving the sustainability of the global food system more broadly also has an important role to play in reducing emissions. While land-use is an important component of improving circularity in energy-related CO_2 emissions in the CCE, for example though the enhancement of natural sinks (such as forests), the GHG implications of land-use change are much broader. The policies shaping the way land is used, planned, managed and restored – beyond carbon sinks – will also be critical to achieving a net-zero GHG economy. These broader land-based policies are also not covered in this report.

In terms of the policies required for circular carbon economy, two distinguishing features of the energy system embodied in the circular carbon economy system have a strong bearing on the policy context required. One is the expanded role for the "3Rs beyond Reduce". This necessarily includes a significant role for carbon capture, utilisation and storage (CCUS), alongside other energy-related technologies. Although progress on CCUS has been slow, most energy transition scenarios see several important roles for CCUS on the road towards a net-zero world. One area is for the so-called "hard to abate" sectors that are lacking in prospects for technologies to reduce emissions quickly. For example, CCUS is likely to be an important tool to reduce emissions in heavy industry sectors, which together emit around 36% of global energy-related CO2 emissions. CCUS is also likely to be an important component for efforts to remove CO_2 from the atmosphere in order to allow residual emissions to continue in other "hard to abate sectors", such as aviation. This would involve combining CCUS with direct-air capture or bio-energy (BECCS).

The other distinguishing feature of CCE is the emphasis on pursuing the 4 Rs simultaneously, with the very wide array of technologies and approaches represented therein. This has implications for enabling policies because it implies the need not only to retain a strong focus on delivery emissions reductions now, but to also consider inter-temporal factors such as how to accelerate innovation and deployment of key technologies related to CO_2 removal and storage.

03

Overview of enabling policies for the Circular Carbon Economy

Overview of enabling policies for the Circular Carbon Economy

This section addresses the underlying policy framework needed to move towards a circular carbon economy. Although the four Rs of CCE each have specific characteristics requiring particular incentive structures and regulation – covered in detail in the other reports in the CCE guide – there is also significant common ground in terms of the general policy environment needed to achieve the transition of energy production and use towards the interrelated components of CCE.

The analysis considers three lenses for how enabling policies and regulatory conditions can be most supportive of the CCE over the medium to long term:

- How the current economic context should influence thinking on enabling policies for CCE, in particular the economic crisis caused by the COVID-19 pandemic, and the large fiscal stimulus packages being prepared to counter it;
- How policies specific to each area of CCE – as covered in other reports in this guide – can be supported by cross-cutting enabling policy conditions, such as combining strong, clear policy packages relating to the energy sector with a concerted effort to ensure alignment of the broader policy framework across policy domains;
- How underlying enabling policies can support the inter-temporal nature of CCE – for example, the need to drive innovation and deployment of technologies that are not yet fully commercial, such as for CO_2 removal and storage.

Policies in the wake of COVID-19

The policy environment for CCE has to be seen in the light of the economic crisis triggered by the containment measures put in place to control the COVID-19 pandemic. The crisis has affected almost all sectors of the global economy, and the resulting financial stress and soaring unemployment has important implications for the investment needs and operational and behaviour changes needed to shift towards a pathway coherent with CCE. The immediate effects may appear detrimental for action on climate change. Financial stress in the private sector, with sharply restricted availability of investment capital, is likely to lead to reduced investment and expenditure in areas perceived as non-essential or discretionary; and this may include environmental measures. More broadly, there has been a refocusing of policy attention (and public opinion) towards combating the immediate health crisis rather than focusing on the slightly longer-term threat of climate change and other pending environmental emergencies, such as air pollution and biodiversity loss.

Nevertheless, there are opportunities for governments to use their response to this economic crisis to create a sustainable recovery, in the spirit of "building back better" (OECD, 2020a ,b). Many countries have issued or are preparing large stimulus packages aiming to restart the economy and increase employment as quickly as possible. In a number of countries, there is growing support for orienting the fiscal spending involved in such packages towards sustainable measures aligned with the transition to a CCE. In many cases, such measures also present strong fiscal multipliers and employment opportunities – i.e. they are have strong positive knock-on effects for the broader economy and so can be justified on purely economic grounds, in addition to their clear near- and long-term benefits for society (Coalition of Finance Ministers, 2020). Several analyses point to the potential for sustainable recovery policies to not only improve environmental performance, but also to be important drivers of employment and contributing to a return to economic growth (e.g. IEA, 2020a).

Responses to the global financial crisis in 2008 provide some lessons, as investments in energy efficiency in particular were shown to support both economic recovery, job creation, energy security and climate change goals (Agrawala et al., 2020). The 2020 crisis is different in many ways, being more profound and wide-ranging than the 2008 crisis that stemmed from the financial sector. More positively, the technology and political context is also different: clean-energy costs have fallen dramatically, and climate change has become a frontline political issue in many countries.

By September 2020 the stimulus packages already announced presented a mixed picture. While many countries have allocated significant proportions to support low-carbon technologies, including those needed for the CCE, in general this spending is far outweighed by support to emissions-intensive sectors (OECD, 2020b). According to one index, 14 out of 17 countries surveyed have proposed stimulus packages whereby the "green" elements are outweighed by environmentally damaging flows (Vivid Economics, 2020). Time is of the essence; for the low-carbon transition to stand a higher chance of success, supportive measures need to be part of the initial wave of stimulus spending and investment. Government debt levels are likely to increase due to the stimulus packages, which could greatly limit availability of public funding to respond to the climate crisis in future.

Winning over public opinion is a key prerequisite for sustainable recovery efforts (and climate change policies more generally) to gain support politically. It is important to emphasise how the positive benefits of such policies can outweigh potential increases to the cost of living, as well as identifying and addressing potential trade-offs relating to energy affordability, competitiveness and jobs. A systematic approach to placing people's well-being at the centre of decision-making is an important additional factor. This relies on full-cost accounting, meaning taking into account traditionally non-monetary benefits such as reduced health costs, avoided clean-up of the environment, lower energy bills for those in affordable housing, etc. Such an approach makes sustainability efforts more appealing (OECD, 2019).

For the energy-related investments required for the CCE, the implications of persistently low and volatile fossil-fuel energy prices need to be considered. Low prices naturally disfavour energy-efficiency and favour fossil-fuel related investments and behavioural choices, in particular at the consumer end. At the same time, low and volatile prices also place financial stress on fossil-fuel firms, slowing down capital investment in fossil-fuel supply and even leading to bankruptcy. Low prices also can create political opportunities for fossil-fuel subsidy reform, both for consumer subsidies (helping to reorient incentives towards technologies needed for "reduce") and production (changing the investment balance at the supply end).

International co-operation

Delivering the CCE will require strong international co-operation on many fronts. This comes through strongly in the individual reports covering specific components of the CCE. At the heart of this is ongoing co-operation through the multilateral climate process, including continued support for the Paris Agreement and its cycle of increasingly ambitious Nationally Determined Contributions. Clear, transparent commitments from all countries, delivered in the same timeframe and focusing on the same time horizon are essential for building trust among governments, and for convincing private actors subject to ambitiouous policy that their own government is not "going it alone".

Other multinational processes are also important to support the CCE and to ensure that it contributes to overall sustainability improvements beyond reducing GHG emissions. Examples include tracking achievement of the Sustainable Development Goals under the UN 2030 agenda; the Convention on Biological Diversity (including 2030 targets to be agreed at COP15 in 2021, an important corollary to the role of bioenergy and biological sinks in the CCE); and the World Trade Organization (in particular its evolving case law relating to climate policies with trade).

The success of CCE also depends on international co-operation at other levels. This ranges from common standards on energy-efficiency, agreements for cross-border trade of electricity (to support more rapid integration of variable renewables such as wind and solar) and of CO_2 to support CCUS in countries without sufficient CO_2 storage potential within their borders. Reducing barriers to trade in low-carbon goods, as well as essential intermediate goods, is another important area where increased international co-operation would be beneficial. For new technologies, processes and business models to become economically viable for the CCE, access to international markets is important to ensure the needed economies of scale (see Section 5).

Long-term framework: essential to guide near-term policies and regulations

Establishing credible long-term targets and strategies is an important prerequisite for ensuring that individual policy measures are sufficiently long-term and robust. Especially when inscribed into domestic law, such long-term perspectives act to improve trust internationally as well as sending a clear signal to all stakeholders – national and local governments; industry; financiers; and the general public – that the direction of travel towards decarbonisation is clear and unequivocal. In this way, long-term strategies can heavily influence nearer-term targets and the setting of policies to achieve them, despite pertaining to relatively far-off objectives.

A long-term perspective also allows for infrastructure planning to help provide investor certainty, for example through pipelines of projects and to identify and avoid potential “lock-in” of future emissions through long-lived infrastructure (OECD, 2018a). In this way, a long-term perspective is particularly relevant in the context of the CCE. The substantial volumes of CO_2 capture, use and storage required for the CCE can be brought into sharper focus by a long-term vision that shows not only the necessity of scaling up CCUS for the longer-term but also the need to start now.

Coherent energy pricing

Ensuring that the price of energy paid by end-users increasingly reflects its true environmental cost is fundamental, though not by itself sufficient, to achieve a transition towards a circular carbon economy for energy-related CO_2 emissions. Several of the other specific reports in the CCE Guide highlight this. Key components of more coherent energy pricing include different forms of carbon pricing and reform of inefficient fossil-fuel subsidies to both consumers and producers.

Robust carbon pricing policies are an important pillar of making energy prices aligned with low-carbon objectives. Carbon pricing mechanisms can be direct taxes, trading systems or hybrid approaches. The number of explicit carbon pricing schemes is rising around the world, but in general prices remain lower than those implied by modelling of low-carbon scenarios (World Bank, 2020). Additionally, it is important to consider the incidence of carbon prices alongside other taxes or levies applied to the same fuels, which are not explicitly labelled carbon prices, but which have the same economic effect. Measured in this way, the “effective carbon rates” among 42 major economies are found to be low: 70% of CO_2 emissions are completely un-priced, and a very small proportion have a price of €30 or more, a low benchmark for ambitious action on climate (OECD, 2018b).

Whatever the type of measure, carbon-pricing policies ideally need to create stable and rising prices for an increasingly large proportion of emitting sectors. To be successful, pricing mechanisms also need to be introduced in ways that ensure support of key constituencies, both for covered sectors and for public opinion more broadly. The use of temporary transition measures, as well as measures to ensure that energy cost increases do not much affect the most vulnerable communities, are important.

In an ideal world, carbon prices would be applied universally across countries in order to create the most cost-effective incentive to reduce emissions, given that GHG emissions have a global impact regardless of where they are released. Commensurate prices internationally would avoid concerns about international competitiveness of firms highly exposed both to energy costs and international trade competition. A universal international carbon price is clearly not realistic in the medium term. As levels of ambition on climate change – including those reflected in carbon prices – appear set to become increasingly divergent internationally, in particular in the wake of the COVID-19 crisis, some countries are considering complementing carbon prices with measures to address competitiveness concerns from impacted industries.

One potential policy tool is to apply some form of border tariff to imports that aims to ensure that domestic producers are not disadvantaged relative to imports in terms of carbon costs. Although these border carbon adjustments have been discussed for many years, the debate was reignited in 2019 by the European Commission's proposal to implement a border carbon adjustment should differences in ambition remain internationally (EU, 2019). While attractive in theory, border carbon adjustments need to be designed with caution, to be sure that they are consistent with international trade rules, feasible to implement technically, and designed to spur greater ambition internationally rather than risking aggravating international tensions (Prag, 2020).

Coherence of the wider energy-pricing environment is equally important. For example, subsidies to fossil fuel production or consumption can effectively act to negate the effects of a carbon price. Reform of inefficient fossil-fuel subsidies, that encourage wasteful consumption, is an important complementary measure to carbon pricing. Periods of low fossil-fuel prices can provide an opportunity to implement reforms, provided that they are carried out in a progressive manner, i.e. with protections for the most vulnerable to ensure that subsidy reform does not further contribute to inequalities.

Even when combined with subsidy reform, carbon pricing alone is not sufficient to achieve the transformational changes required. In some cases, mature technologies that, even with current energy prices unsupported by a carbon price, offer clear economic advantages to individuals or users are not adopted due to non-price barriers. A classic example is energy-efficiency investments, where even opportunities with short payback periods are not adopted due to institutional inertia, aversion to supply investment capital, lack of awareness, etc. In these cases, additional, specific incentives and regulations are required, as described in other reports in this guide.

On its own, carbon pricing is also unlikely to provide sufficient incentive for the innovation and deployment of new technologies essential to deliver a rapid transition towards net-zero emissions. This is particularly true for the CCE, where additional policies are needed not only for innovation of new technologies but also to improve the financing profile for technically proven, but not yet widely deployed, approaches such as CCUS (see Section 4).

In summary, coherent prices need to be accompanied by a range of supporting measures and reforms. One element of this is ensuring that other, non-climate, policies are aligned with climate objectives and not counteracting the effects of carbon pricing and other climate policies. This alignment issue is covered in the following sub-section.

Policy alignment for more effective action on climate

A strong enabling framework for CCE goes well beyond policies specifically related to climate change. In 2015, the OECD first highlighted that for ambitious climate goals to be achieved cost-effectively and with strong political support, alignment of broader policies well beyond the climate sphere is important (OECD/IEA/NEA/ITF, 2015). Climate policies are implemented on top of many existing policies, regulations and incentive structures. If other policies implicitly or explicitly counteract the objectives of climate policies, the low-carbon transition will be slowed down. More recently, the concept has been extended to encompass "two-way" alignment of climate policies: to win political and public support, climate policies themselves need to be well aligned with society's social and well-being objectives (OECD, 2019). Both components of alignment are likely to matter for the CCE.

The first component of alignment aims at overcoming the incumbent advantages of emissions-intensive technologies and investments in our economies. To achieve the substantial emissions reductions required for a trajectory towards net-zero, climate policy alone is not enough; policy alignment is required across fiscal, financial, legal, trade and other domains. For CCE policies to be successful, governments need to ensure that policies unrelated to climate change are not directly or indirectly counteracting the effects of climate policy. As countries develop long-term economic packages to respond to the current COVID-19 crisis, ensuring that this alignment supports any green stimulus measures will be important to ensure their success. Key examples of policy alignment challenges include the following (though many more exist and have been documented across sectors):

- **Aspects of the general tax code that favour carbon intensive behaviours and investments.** For example, implementation of a carbon price to influence personal and business behaviour will not be effective if tax breaks or other incentives in the general tax code encourage more emissions-intensive behaviour (one example is a strong income tax incentive for company cars with unlimited free usage). In this light, fiscal reforms brought in to combat the COVID-19 economic crisis need to be assessed for their potential perverse incentives if they act to encourage emissions-intensive investments or behaviour.

- **Urban planning that favours low-density sprawl and car-intensive travel.** Climate policies such as carbon pricing can be ineffective – and quickly unpopular – if people and businesses do not have viable low-carbon alternatives available to them. A key example is in city design. Low-density sprawling neighbourhoods with insufficient public transport naturally favour personal car transport; any carbon costs added to transport fuel in these cases will therefore penalise people who have limited alternative options. Reforming urban planning to encourage compact neighbourhoods supported by public transport and active transport modes (such as cycling) can help to remove this misalignment over the medium term (OECD, 2019).

- **Trade barriers on low-carbon goods or intermediate products.** Trade barriers, such as tariffs or non-tariff-barriers such as local-content requirements, have persisted on some key low-carbon goods (such as solar photovoltaic equipment) and intermediate goods essential to the completion of final goods. To accelerate the low-carbon transition internationally, it is ultimately in most countries' interests to remove these barriers and facilitate the diffusion of key low-carbon technologies internationally.

The other dimension of two-way alignment is to design climate policy so that it clearly also contributes to other societal well-being objectives, such as cleaner air and better public health. Adopting this well-being approach helps to make benefits of climate policy more tangible in the near-term, garnering public support for more ambitious climate policy while improving the investment case of low-carbon alternatives relative to less costly (in private terms) but emissions-intensive capital investments (OECD, 2019). Air pollution is a particularly salient example. The health effects of air pollution have become a major policy priority in many countries, covering both developed and developing countries (as globally up to 7 million premature deaths per year are linked to indoor and outdoor air pollution). With some important exceptions (such as implicit or explicit promotion of diesel vehicles), actions to tackle climate change are also beneficial for reducing air pollution, and vice versa. Exploiting the synergies between climate action and reduced health impacts from air pollution can therefore be a strong argument for "aligning" climate policies with broader well-being goals.

In addition, as societies begin to take stock of the implications of the COVID-19 pandemic, an increased focus on public health, societal well-being and overall economic and social resilience may also increase the importance of highlighting the key health benefits of most climate polices.

Integrating policies specific to the four Rs

For each of the four Rs making up CCE, the individual reports making up the CCE Guide have recommended specific incentive measures and regulations, and these are not reproduced in detail here. The "reduce" component of CCE remains crucial for decarbonisation and should be the first priority even when taking a CCE approach. A wide of array both specific and less specific policy interventions are needed to support "reduce", many of which are widely known with good experience of implementation across countries. However, the underlying enabling policy framework is crucial to not only support the successful implementation of these specific policies, but also manage interactions and potential synergies and trade-offs between areas.

One key area for "reduce" concerns policies to improve energy efficiency throughout the energy chain. This includes efficiency of domestic and industrial end-uses (buildings, vehicles, industrial processes) as well as efficiency of energy transformation processes (efficiency of power generation and refining). Key energy-efficiency policies for CCE are well-known, including regulations, standards and specific financing models tailored to the cash-flow characteristics of energy-efficiency investments. The barriers to adoption are also well-known and policies can be designed to overcome these non-price barriers to create investment and behaviour changes that a carbon price alone would be unlikely to deliver.

At the same time, renewable electricity and other forms of renewable energy are also an essential pillar of the "reduce" component, with key supporting policies including auction-based price-setting for renewables; reforming electricity markets for better integration of renewables; and incentives for renewable heat and transport fuels. Yet in some cases, policies supporting renewables and those targeting energy-efficiency can act in competition against one another, so the enabling policy framework needs to take a holistic view to ensure that the overall effect is the most effective in delivering durable emissions reductions.

A key nexus of the "recycle" and "remove" components is bioenergy and its relationship with natural sinks of CO_2 such as forestry and other land-uses. Bioenergy can play many roles in the energy system, ranging from solid biomass for power generation (which can be combined with CCS to remove CO_2 from the atmosphere), biomass for heat generation (in industry and buildings) or through many different forms of liquid biofuels for transport.

Policies to drive use of bioenergy to displace fossil fuels are generally similar to other "reduce" policies, but with some key particularities. One concerns air pollution. Some forms of biomass combustion can create significant local air pollution unless regulations or incentives for flue gas cleaning are present, as is the case for fossil-fuel combustion. The second concerns sustainability of biomass production. While each molecule of CO_2 released during biomass combustion is equal to a molecule removed from the atmosphere during the growth phase – the "recycle" notion of the CCE – other sources of CO_2 or other GHGs can be released as a result of biomass production. Sustainability safeguards and standards are therefore important to ensure that bio-energy and CO_2 removal are not counterproductive either for climate change or for broader environmental implications, including for biodiversity loss (e.g. through monoculture plantations, indirect land-use change leading to deforestation; emissions related to processing and international transport of bioenergy feed-stocks).

Finally, the challenge to develop CCUS at scale – an essential pillar of the remove component of CCE – comes with its own set of policy challenges. Unlike most other components of CCE, CCUS has no direct commercial driver other than the value of preventing emissions from reaching the atmosphere. It is therefore more dependent on regulation and policy-driven incentives than, for example, renewable energy (which can be sold) or energy efficiency (which creates monetary savings through lower consumption). Additionally, the diverse actors and complex value chains required to achieve CCUS at scale present particular challenges for financing, as discussed in more detail in the next section.

Further, policy measures for some applications of CCUS also need to consider interactions with existing policies not only for CO_2 emissions control, but also local air pollutants such as sulphur dioxide (SO_2) and oxides of nitrogen (NO_x). Post-combustion capture of CO_2 from fossil-fuel-fired power plants, whereby CO_2 is stripped from flue-gases following fuel combustion, requires flue gas that is already clear of SO_2 and NO_x (USEA, 2010). In many regions, this is facilitated by pre-existing air pollution regulations or incentives, meaning that most plants have flue gas scrubbers already fitted. However, in countries where such regulations do not exist or are poorly enforced, they can be an important enabling policy for post-combustion CO_2 capture. More generally, policies to reduce air pollutants have strong synergies with climate change policies, and bring strong health and environmental benefits.

04

Finance and investment policies for CCE, with a focus on CCUS

Finance and investment policies for CCE, with a focus on CCUS

This section addresses financing and investment policies needed to bring forward the investment in the infrastructure and technology transformations necessary to shift onto low-emission, climate-resilient energy pathways that draw on all four Rs as defined by the CCE. Finance and investment is clearly central to a successful transition towards net-zero emissions economies. The challenge includes both scaling up investment in low-carbon technologies and systems and reallocating capital away from carbon-intensive sectors. In the CCE, the additional emphasis on removing CO_2 from the atmosphere requires higher deployment of CCUS than many other low-carbon transition concepts. This section therefore concludes with a section highlighting measures specific to financing CCUS, central to achieving a circular carbon economy.

Energy investment trends and opportunities to align economic recovery programs with clean energy goals

Current clean energy investment trends fall short of where they need to be to meet the Sustainable Development Goals. Over the last 5 years, clean energy investments have remained relatively stable at just over USD 600 billion per year. A doubling is required in the level of clean energy investments by the late 2020s if the world is to be on a sustainable pathway.

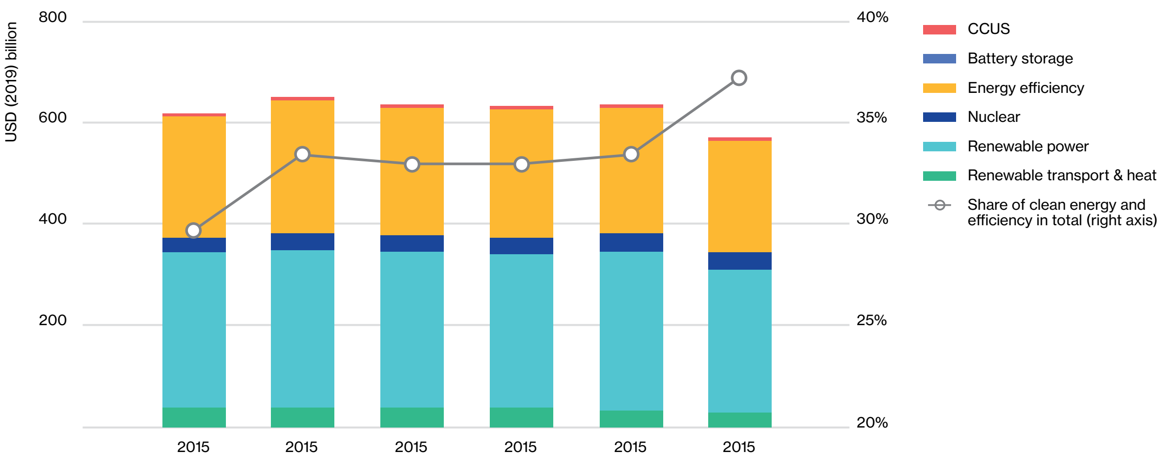

Figure 1. Global investment in clean energy and energy efficiency and share in total investment
Historical data up to 2018; estimates for 2019 and projection for 2020
Note: CCUS = Carbon capture, utilisation and storage
Source. IEA, 2020b

The COVID-19 pandemic and disruptions in the global economy caused by the lockdown has triggered the most severe economic recession in nearly a century and is causing tremendous damage to people's health, jobs and well-being. The OECD's Economic Outlook in June 2020 applied two scenarios – one in which a second wave of infections leads to a second lock down later in the year and one in which another major outbreak is avoided with the global economy projected to decline by 7.6% or 6% in 2020 (OECD, 2020c). The IEA projects that energy investments in 2020 are expected to fall by about 20%, as a result of the COVID-19 pandemic and disruptions caused by the lockdown and economic recession (IEA, 2020b).

Constrained budgets and cuts to capital expenditure plans could slow down the pace of the transition as governments, companies and households delay investment spending and hold on to existing assets for longer. The rate at which newer more efficient technologies are brought on line will determine the speed of the clean energy transition.

However, the fossil-fuel sector will see the largest reduction according to the IEA, with investments expected to decline by about 30% in 2020. The share of clean-energy investments are expected to hold up much better than fossil fuels, with the share of clean-energy supply and efficiency investments rising to a projected 37% in 2020, having been steady at about 33% over the last 4 years. This is however partly explained by the drop off in fossil-fuel investments.

While investments in renewables have so far proved to be more resilient to the crisis than fossil fuels, the outlook for energy efficiency remains challenging as consumers and industry delay investments (IEA, 2020c). The current low fossil-fuel prices also make the economic case for efficiency less attractive with payback periods rising and both individuals and firms preferring to hold on to cash reserves given the uncertain economic outlook. In this context, it is all the more important that governments take advantage of the stimulus programmes under development to ensure that efforts to support economic recovery through fiscal spending are aligned with clean energy goals, as discussed in section 3 above.

Reset the financial system in line with long-term climate risks and opportunities

While the framework policies described in the previous chapter are fundamental to change the financial incentives and make low-carbon energy sources more competitive, governments can take a range of other measures targeted at reorienting the financial system towards a longer-term approach essential for the CCE. Current governance of the financial sector creates incentives for short-termism. Increased transparency is needed on climate related risk assessments and reporting to allow investors to correctly price risks and opportunities.

To encourage investment practices that align with long-term low-carbon goals, governments can adopt requirements for disclosure of climate-related financial risks and opportunities for investors and other measures to avoid short-termism. Inadequate disclosure can lead to a mispricing of risk and capital. Financial supervisory authorities need to better access and manage climate-related risks that could have adverse impacts on the financial stability of the system in the short and long term, including the risk of climate risks conflating other stability risks such as that resulting from COVID-19.

There is growing recognition within the finance system that the failure to align investment flows with a well-below 2°C pathway creates risks for the financial system. Initiatives such as the Financial Suitability Board's Task Force on Climate-related Financial Disclosure (TCFD) and the G20's Sustainable Finance Study Group and Sustainable Insurance Forum (SIF) among many others are working towards building awareness and developing tools that can be used to better evaluate long-term climate risks and help investors integrate sustainability within their investment strategies. The TCFD has developed a voluntary set of consistent climate-related financial disclosures for use by companies in providing information to investors, lenders, insurers and other stakeholders. TCFD has so far been supported by financial regulators from Australia, Belgium, France, Hong Kong, Japan, the Netherlands, Singapore, South Africa, Sweden and the United Kingdom (TCFD, 2019).

In addition to increased requirements for climate related disclosure, the TCFD also encourages investors to integrate scenario-based climate risk management (scenario stress tests), both for physical climate risks and for transition risks, for which the latter in particular can help to influence investment strategies in favour of CCE. Such tools can highlight risks of stranded assets and shift investors towards more resilient low-carbon energy infrastructure.

In addition to adopting consistent reporting frameworks, financial regulators should encourage institutional investors to integrate ESG factors into their investment governance. This requires the adoption of ESG evaluations into investment policy and its use in informing asset allocation decisions and securities valuation models. Only a few countries today have adopted financial regulation that requires the integration of ESG factors into investment decisions, although others are considering adopting this policy. However, there is mounting evidence that ESG indices to date have not led to significant performance enhancements on the environmental side (OECD, forthcoming), and that improvements are needed to better highlight firms that are making significant strides towards investments aligned with a net-zero trajectory.

To support an accelerated transition of the financial sector towards sustainable investing, countries can develop a sustainable finance taxonomy that provides a common definition of which investments are considered environmentally sustainable. This can address concerns around green washing and false claims of climate compatibility. Such taxonomies should facilitate a transition to a low-carbon economy that is consistent with long-term climate goals and help investors avoid investments in stranded assets or lock-in of carbon intensive infrastructure.

Support the development of innovative financial instruments targeting low-carbon infrastructure investments

For an enabling framework to accelerate the deployment of new technologies essential for CCE (as well as incentivising mature low-carbon technologies), it must also address the unique financing needs of early stage companies that have moved beyond the public support provided for development and demonstration phase. As clean energy technologies enter the deployment phase, the financing needs of companies rise sharply as production scales. Firms will need to lower financing costs by accessing more debt financing and lowering the portion of equity capital that require higher returns.

This shift towards higher shares of debt financing can be enabled through a variety of innovative financing instruments and measures that can help to offset a variety of risks and facilitate private investment. Such measures include a variety of risk-mitigant instruments such as direct loans, co-investment, loan guarantees and cornerstone stakes; and transaction enablers such as warehousing and blended finance.[3]

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[3] Further details can be found in Rottgers, Tandon and Kaminker, 2018.

The development of public-private partnerships tailored to specific elements of CCE (e.g for CCUS, see below) can be effective, in particular where societal benefits require public financing to be blended with private sources of capital to address certain risks and lower overall project costs. In addition, the use of strategic public procurement can help to create early demand in new markets (and help drive innovation) to lower technology costs and facilitate technology deployment and commercial adoption (see section 5).

Dedicated public financial institutions (PFIs) such as green investment banks – or green "windows" inside existing public financial institutions – can help to finance and create early markets for less mature clean energy technologies or where project scale and high transaction costs are limiting access to affordable finance. These institutions can play an important role in helping to develop and expand clean energy project pipelines as part of their mandates (OECD, 2016). More generally, PFIs often hold a mandate to provide long-term financing aligned with policy objectives and independent of market cycles. Due to state-backing, PFIs are able to leverage capital at below-market rates for targeted investments. In many instances these institutions aim to mobilise private sector investment and innovation finance (Röttgers & Youngman, 2020). These characteristics and objectives of PFIs align well with the goal of overcoming barriers to private investment in low-carbon infrastructure. Some PFIs already have an explicit mandate and authority to invest in green infrastructure – often with established guidelines on which technologies or markets to address (Cochran et al., 2014).

Mobilising more private sector finance for clean energy investments, particularly from institutional capital, will require the availability of suitable financing instruments that can meet the scale and liquidity requirements of large investors such as pension funds, insurance companies and sovereign wealth funds. Together such investors hold approximately USD 74 trillion in financial assets (BCG 2019). Green bonds are a particularly attractive instrument for institutional investors to gain exposure to clean energy investments and in just under a decade have exhibited a promising market growth rising from just USD 3bn in 2011 to USD 258 bn in 2019 (Climate Bonds Initiative, 2020). In addition to issuing sovereign green bonds, governments can support green bond issuances from corporates and sub-regional governments by putting in place frameworks that help to lower the listing and issuance costs and through reporting and disclosure requirements that help investors integrate climate change and sustainability evaluations of bonds more broadly.

There is also a need to develop innovative financing models targeted at smaller clean energy projects that are also an important component of CCE. Governments and other development partners can help aggregate and standardise projects, this can help reduce transaction costs by simplifying project evaluation and due diligence.

Digital technologies are influencing financial markets and transforming how corporations and individuals are raising capital and investing. Blockchain and digital ledger technologies can shift centralised models of traditional finance institutions to one that, like the energy system, becomes more decentralised and interconnected. Digitalisation of both the energy and finance sectors can create new opportunities for innovative financing options to emerge. This includes the digitisation of green bonds that can lower transaction costs as well as access retail investors (such as Indonesia's retail green sukuk in 2019). Another example is the growth of models for aggregation of smaller energy efficiency and renewable energy projects into larger tranches, the aggregation of smaller investors via "robo-advisors", and the provision of online platforms for matchmaking between project developers and investors.[4] The use of blockchain technologies can also help investors better evaluate clean-energy project risk and return profiles by providing near-real time performance data.

Rethink development finance to mobilise commercial capital for the clean energy transition

Developing countries and emerging economies face a significant investment gap in delivering the 2030 Agenda and Paris Agreement, estimated in the range of USD 3.5-4.5 trillion per year between 2015 and 2030, even before the COVID-19 crisis struck. Mobilising investment in new, clean infrastructure, particularly energy, will be key to ensuring countries shift to low-carbon pathways.

Development banks (multilateral, bilateral and national) have a critical role to play in infrastructure finance, particularly in developing countries. These publicly owned financial institutions have a specific development mandate and can leverage capital markets via their strong credit ratings and the backing of their shareholder governments to provide financing (OECD/WB/UNEP, 2018). There is a need to strengthen development bank mandates to support the delivery of transformative strategies to decarbonise the energy sector. Incentive structures in development banks need to integrate sustainability outcomes alongside financial targets.

The use of concessional finance by development banks is an important enabler for creating new markets for clean energy technologies. These funds should be used strategically and focus on projects and programmes that have the largest potential to support clean energy transition goals in a country. They should also make way for more investment at less concessional terms to help scale or address early market risks to provide demonstrational impacts.

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[4] The OECD and IEA held a webinar to explore the opportunities for fintech to mobilise clean energy finance with materials available here.

Development banks can also use a blended finance instrument that uses development finance to mobilise commercial support for development projects including for clean energy projects. A variety of risk mitigation instruments (highlighted above) are used to mobilise commercial finance for clean energy projects which otherwise would not reach financial close.[5]

International organisations such as the OECD can also help to support major economies align their clean energy finance and investment frameworks to mobilise private finance. Overall, there is no shortage of capital available globally for investments. However, finance and investment in clean energy projects in emerging economies remains hampered by misalignments in climate and energy policies and in electricity markets. The OECD's Clean Energy Finance and Investment Mobilisation (CEFIM) programme aims to strengthen domestic enabling conditions to attract finance and investment in clean energy.[6]

Enabling conditions and business models for CCUS finance and investments

Given the importance of CCUS for the circular carbon economy concept, this section provides a special focus on financing mechanisms and other targeted policies to support investments in CCUS technologies. CCUS is not a single technology. It involves a complex interaction of several technologies, actors and types of firms, leading to particular financing needs.

Specific supporting policies for CCUS, beyond carbon pricing and the enabling policies described in previous chapter, are necessary for a number of reasons

While CCUS is essential for full decarbonisation of the economy, in most cases the cost of capturing and using or storing a tonne of CO_2 is higher than more immediate abatement options, meaning that current carbon pricing systems will not be sufficient to support CCUS. CCUS projects also tend to be large, capital intensive projects with high-perceived risks, both of which push up financing costs. The ability of firms to access financing for such projects could prove to be particularly challenging without either direct government support or regulation which allows firms to monetize the value of investing in CCUS technology.

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[5] Additional details on the use of blended finance can be found in the OECD Blended Finance Principles.
[6] Further information on the OECD CEFIM Programme is available here.

An additional factor is the complexity of CCUS value-chains, with several different actors and business types meaning that some actors carry significant "cross-value-chain" revenue risk (as they are dependent on other actors further up the chain). Coordination across different CCUS actors is important to ensure that the transport and storage infrastructure is available when capture technologies have been installed. Achieving the necessary scale to justify investments in transport and storage will also be a prerequisite to being able to finance these projects as well as those for carbon capture, leading to a potential chicken and egg situation. These project development risks can be partially offset with clear commitments from governments on the role CCUS will play in a CCE, as well as direct intervention in certain parts of the supply chain such as CO_2 storage, which could prove particularly difficult to finance privately.

CCUS can also face political and social opposition that is highly location-specific and can act as a further barrier to attracting finance for CCUS projects, as it increases the political and social risk for investors. Government programmes to inform communities and the public on the importance and role of CCUS technologies in the clean energy transition and meeting sustainability goals can help to overcome such challenges.

CCUS-specific market creation policies to promote attractive risk-return ratios

In the CCE, the value generated by CCUS comes from the CO_2 captured and then used or stored. Complex value-chains of CCUS projects make revenue generation and revenue pass-through uncertain for different actors in the chain. Policy and regulation is thus essential to support the development of different business models to help facilitate finance and investment along the CCUS value chain, and to facilitate a cluster approach to advance development and investment in projects.

CCUS incentive policies tend to focus on the capture end of the value chain, whereby they help to supplement carbon pricing to provide reliable revenues per tonne of CO_2 captured (or "not emitted"). These incentives can be usefully combined; for example, the "stacking" of incentives such as 45Q tax credits in the US combined with low-carbon fuel standard and/or cap-and-trade in California has helped to improve the business case for CCUS projects.

To accelerate the roll-out of end-to-end CCUS projects it will be important to improve the financing profile of CCUS components across the value chain. This can be aided by introducing specific policies that incentivise or allow for revenue creation from CO_2 usage and storage directly, in order to reduce reliance on revenue being passed along the value chain. On the storage side, one possibility is to create tradable credits for CO_2 permanently stored, which would be additional to existing trading systems that implicitly credit CO_2 captured (Zakkour and Heidug, 2019). On the usage side, incentives will be needed that are distinct from those that support financing of CO_2 storage investments.

Different actors in CCUS have different business needs, and these differences need to be reflected in how incentives apply and can be stacked. For example, industry-sector emitters have different liabilities and interests to the oil and gas companies who may be suited to transport and storage (they do not have direct carbon liability from operations, but business interest in CCUS may stem from reputational reasons). While specific incentives for different types of actor may be necessary, the government still has an important role to play in creating the conditions that bring together these different business models into a functioning, scalable business model – this is explored in the next section.

The need for government involvement in CCUS beyond policy and regulation

While setting the right policy and regulatory environment of CCUS is a priority for governments, a variety of challenges remain which could warrant further government involvement to advance and develop CCUS projects. Without government involvement to develop certain parts of the CCUS supply chain, and to ensure the conditions within countries (and even across borders) are conducive to working value chains coming together, advancement will likely remain below the levels required by the CCE (and by most ambitious decarbonisation scenarios).

Regional governments can help to create or attract "clusters" of industry capture by providing locational incentives or to facilitate permitting. The creation of clusters will help to exploit economies of scale at the capture and transport end of the value chain. Engagement with regional governments will also be needed in developing CO_2 storage facilities to help improve public awareness and acceptance of projects that if not addressed early could lead to future financing risks.

There is also a need to clarify the role of government for long-term liability of storage in the unlikely event of a physical CO_2 leak. CO_2 storage facilities may also need to be operated under regulated monopoly arrangements either under full or partial public ownership arrangements depending on the industry structure in each country and the interest of the private sector to develop the necessary supply chains.

Other potential forms of government support include short-term guarantees during the construction phase or revenue guarantees for financing transport infrastructure during the creation of clusters to help reach the necessary scale and help prove business models. Public-private partnership models could also be a solution to support risk sharing of large-scale demonstration projects as well as for the development and operation of CO_2 storage sites.

International collaboration and sharing of experience in financing and creating markets for CCUS can also help to accelerate deployment and advance commercialization across key markets. The CEM CCUS Finance Initiative in an example where international collaboration efforts are focused on providing practical solutions to overcome the unique financing challenges of CCUS projects (see box below). The recognition of the Initiative of the key role that CCUS will need to play in meeting international climate goals, as well as their commitment to working with governments and industry to identify solutions to overcome the finance and investment challenges, are signals that under the right frameworks finance for CCUS projects can be mobilised.

Box 1. CEM CCUS Initiative - Key Financing Principles for CCUS

The Finance Sector Lead Group for CCUS, established under the auspices of the Clean Energy Ministerial (CEM) CCUS Initiative, brings together banks and other finance sector organisations to explore the barriers to large-scale investment in CCUS, including how to establish a revenue stream from CCUS projects.

A set of "Key Financing Principles for CCUS" were prepared in close consultation with public and private financial sector organisations, through a series of meetings held under Chatham House Rule between January-July 2020. The development process for the Principles engaged several Multilateral Development Banks, major international private banks, regional and national finance institutions, institutional investors, other investment firms and advisers.

The summary below provides a listing of the Key Financing Principles for CCUS:

1. Industry, governments and the financial sector should communicate the importance of CCUS.

2. Government policies should establish a revenue stream for CCUS to facilitate private sector investment.

3. The financial sector, industry and governments should work together to facilitate CCUS investment and help mitigate the risks of CCUS deployment.

4. Industry, the financial sector and governments should work together to establish a pipeline of CCUS projects.

5. The financial sector should ensure CCUS is part of their climate change strategies and is eligible for sustainable finance.

6. The financial sector should strive to accelerate the development of novel financing approaches to CCUS.

7. Governments should consider CCUS as part of their Nationally Determined Contributions (NDC) under the Paris Agreement.

8. Governments should utilize existing development and climate institutions to advance CCUS in developing countries.

9. Governments should consider CCUS investment as a means of creating and preserving sustainable jobs and providing a low-carbon stimulus to the economy.

10. Industry, governments and the financial sector should consider CCUS investment as a means of driving innovation and supporting broader industrial development.

Source: CCUS Initiative website, 2020.

Reputational and risk issues that could create new incentives for CO_2-intensive sectors to integrate CCUS into their clean energy investment strategies

Industry-led sustainability initiatives within the financial sector (such as IIGCC, UNPRI and TCFD among many others) are increasing. These have helped to spur new financial regulation around climate risk disclosures and integration of ESG principles into investment policies. Together, these factors may lead to conditions where companies operating in CO_2-intensive sectors will face increasing pressure from the investment and finance community to invest in CCUS as part of their ordinary business practices.

Awareness within the financial sector of the technological and value-chain risks within their investment holdings has been growing and the sector is starting to develop expertise and tools such as scenario stress-testing to better evaluate such risks. As expertise in the sector develops the business case for CCUS could also rise among investors looking to new technology solutions that can balance these risks. Further, the growing trend among asset owners and asset managers as well as firms to address reputational risk and how they manage climate change and sustainability issues within their funds and business practices could fuel the trend towards more activist investors that take a more active role in influencing the strategic direction of the firms they own. This could provide a boost to investor interest in CCUS investment opportunities and potentially increase the availability of finance for CCUS projects.

Additionally, as national and corporate low-carbon targets become increasingly ambitious and binding, firms who do not act to reduce their CO_2 intensity could face higher financing costs or even difficulties obtaining finance should more banks and investors apply negative lists or screens within their ESG integration practices. Increasingly, companies are setting climate change objectives that include the carbon intensity of the products they sell, in addition to the direct emissions of their operations (i.e. extending to Scope 3 emissions). This trend could also have implications for financing energy supply and demand related infrastructure that could benefit CCUS development.

Finally, government procurement policies could help to support market creation by putting in place preferential demand for carbon “utilisation”, e.g. products featuring recycled carbon or for low carbon materials. Encouraging the adoption of industry standards that promote or even integrate CO_2 intensity targets for CO_2 intensive industries could support the development of CCUS business models in hard to abate sectors.

05

Accelerating innovation and diffusion of new technologies

Accelerating innovation and diffusion of new technologies

Technological progress is critical for the economic transformation required to address climate change. The speed with which innovations move from the lab to demonstration to large-scale deployment will have a large impact on the cost and likelihood of achieving climate change goals (OECD/WB/UNEP, 2018). Technological innovation on its own is not enough; innovation of business models is also necessary, including for CCUS. The integration of new digital technologies not directly related to energy can also become an important factor. For example, developing carbon accounting methods using block chain technology, can be a means to improve transparency on the real carbon content of goods and services.

In addition to innovation needed for deepening and cheapening emissions reductions, the CCE approach in particular requires technological innovation for CO_2 capture, storage and use, and business model innovation to better value and monetise stored or used CO_2. Innovation needs are particular important to reduce costs of CO_2 capture technologies – including direct-air capture – as well as novel means of CO_2 utilisation to increase the potential market size for CO_2 that is used sustainably rather than stored.

This chapter first examines current trends in innovation related to the circular carbon economy, before highlighting key policy opportunities for accelerating innovation and diffusion of new technologies, at different stages of technology development. Enabling policies are important to ensure not only commercialisation of new technologies and business models at scale, but also their diffusion internationally.

Innovation trends for CCE

A surprising trend of the last decade is that the rate of low-carbon innovation – as measured by global patent applications for a group of climate-change mitigation technologies – appears to have peaked in the first part of the decade before tailing off (Figure 2). This is surprising as it coincides with a period of rapidly arising awareness on climate change globally, as well as fast and unexpected cost reductions for some key technologies important for climate mitigation (in particular solar PV). The trend is also disconcerting, given the rapidly accelerating urgency of the climate change challenge, and the pressing need for technological innovation if the world is to meet the goals of the Paris Agreement and avoid the worst impacts of climate change.

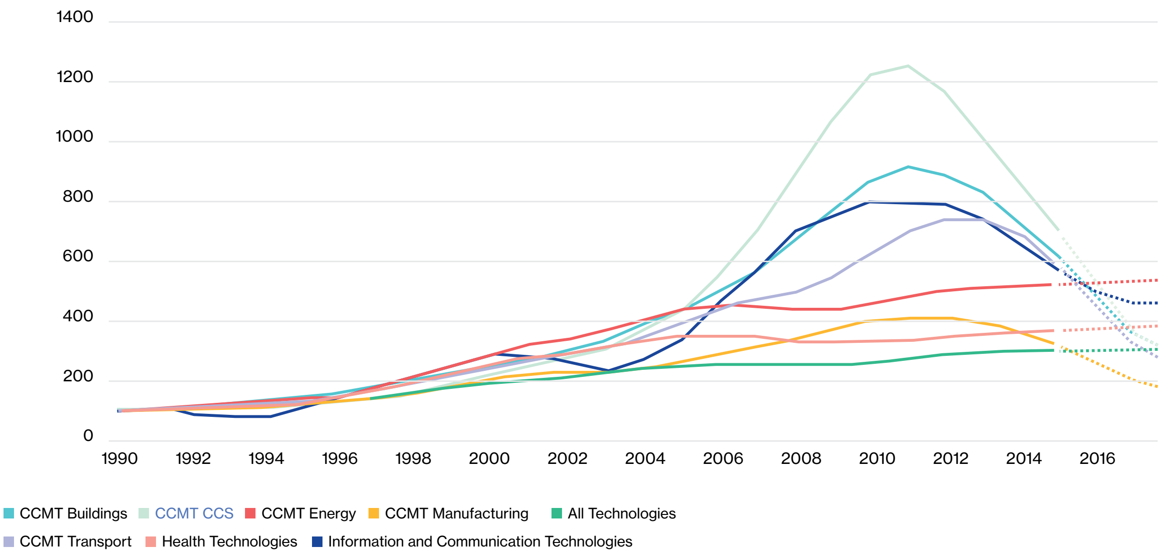

Figure 2. Global patent applications for climate change mitigation technologies, 1990-2015 (projections to 2018)

Note: Patent data extracted from EPO World Patent Statistical Database (PATSTAT) by OECD and IEA (2019)

CCMT = Climate Change Mitigation Technologies.

Source. Visualisation by IEA (2019)

One possible reason for the slow-down in patent activity is a reduction in public-sector research and development spending on energy in the middle of the decade (Figure 3). Nevertheless, the global trend since then has been rising, at least up until early 2020. This trend is however far from universal, and concerns mostly the People's Republic of China, and to a lesser extent the US. Most other regions have seen stable or declining levels of public sector R&D. Estimating the gap between current funding levels and what would be required to accelerate the low-carbon transition is challenging; nevertheless there is a broad consensus that public investment in low-emission R&D would have to at least double to reach the goals of the Paris Agreement (Dechezleprêtre et al., 2016).

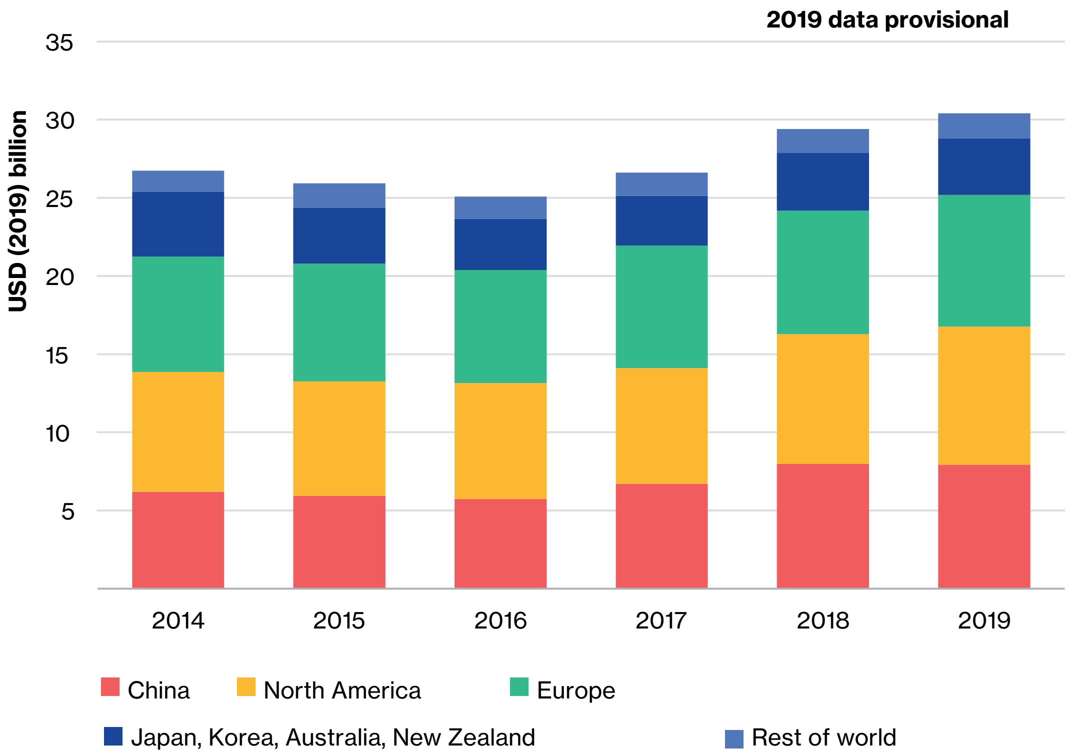

Figure 3. Spending on energy R&D by national governments
Source. IEA, 2020b

Beyond public sector R&D funding, the private sector has several critical roles to play in bringing forward innovation. While estimates of private sector energy-related R&D show a growing trend since 2010, the sectoral split is quite revealing (Figure 4). A key driver of growth has been the automotive sector, in part due to a ramping up of capabilities for electric mobility. However other key sectors, such as oil and gas and electricity have seen stable or decreasing R&D spending. In general, the energy sector spends a lower proportion of revenue on innovation than many other sectors, despite the sector being on the cusp of a major policy- and environment-driven transformation.

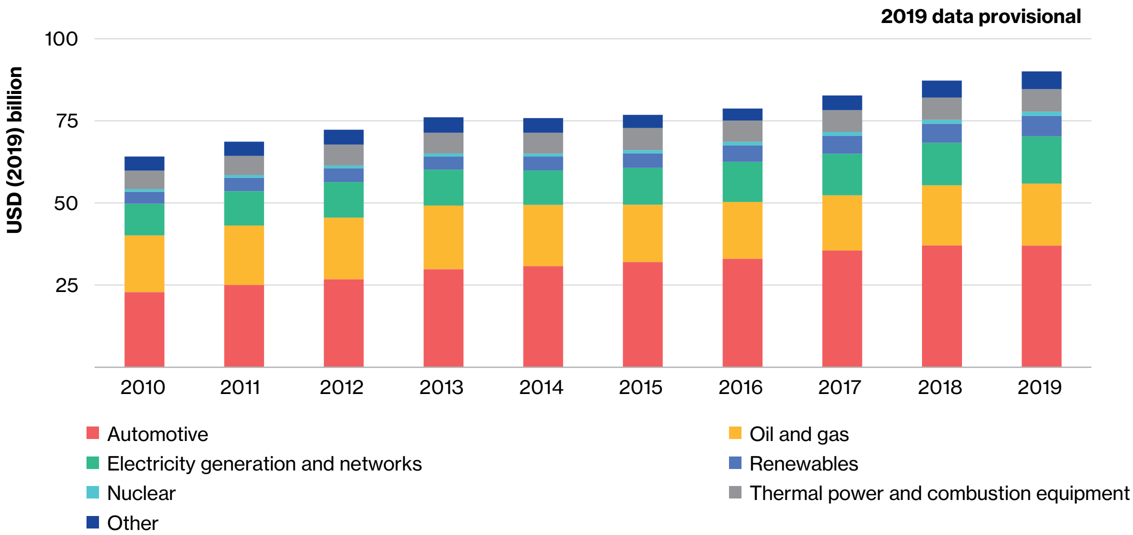

Figure 4. Spending on private sector energy-related R&D by key sectors
Source. IEA, 2020b

It is too soon to tell what impact the COVID-19 crisis will have on R&D spending, and to what extent fiscal spending from stimulus packages will counter a drop off in private-sector spending. Although the context was different, public spending on R&D was relatively robust in the years following the great financial crisis in 2007-8, at least in developed countries where R&D budgets benefited from stimulus packages. In the private sector, the picture was fairly mixed across sectors and firms; while R&D spending generally fell across the board in the aftermath of the crisis, it recovered at different speeds, with renewables firms bouncing back faster and the oil and gas sector taking several years for energy R&D spending to return to pre-crisis levels (IEA, 2020b).

As part of their response measures for the economic recession in 2007-08, many governments provided support to clean technology development (Agrawala et al., 2020; Pollitt, 2011). Several of these measures concerned CCUS projects and so are relevant for the CCE. For example, the United States and the EU provided USD 4.8 billion support to carbon capture and storage (CCS) projects (Agrawala et al., 2020). Ex-ante studies were optimistic about the economic and job impacts of these projects – as well as their emissions reduction benefits. For example, Houser et al. (2009) estimated that USD 1 billion spending on CCS demonstration projects under the United States stimulus scheme would generate 28 500 jobs in the initial year, reduce CO_2 emissions by 342 kt annually, and save USD 225 million per year in energy costs up to 2020.

However, ex-post analysis suggests that public support to CCUS projects following the 2007-08 crisis ran into several difficulties (Agrawala et al., 2020). These experiences provide lessons for current stimulus efforts and for CCE innovation policy. The EU allocated up to EUR 1 billion to support six CCUS projects, but by 2018 only one project was operating at a pilot level, despite EUR 424 million of the support fund having been disbursed. In the US, USD 3.4 billion was allocated to CCUS (covering research and design, commercial demonstration, implementation, and education). However, USD 1.3 billion that had been allocated to four CCUS projects was returned to the US Treasury because the projects could not advance within the time-limit of the funding. One reason that this funding support was not more successful was the lack of other enabling policies, such as robust carbon prices (covered below). However, the experience also highlights the challenges for businesses seeking to invest in innovative technologies and processes with high capital outlays, even when public subsidy is available.

Enabling policies to accelerate innovation for the CCE

There are several ways that governments can create an enabling environment to accelerate low-carbon innovation. Well-designed policies for innovation need to consider the range of barriers that hold back innovation in these sectors in the first place. In theory there are two main market failures explaining why firms in general underinvest in low-carbon innovations (Jaffe et al., 2005). One is the pollution externality, and is due to the impacts of pollution being unpriced or undervalued in the marketplace. The result is less incentive to pursue innovation for pollution reduction technologies, the same market failure that leads to under investment in mature low-carbon technology. The other market failure is the knowledge externality, meaning that innovators are often not rewarded for all the benefits of their inventions, in part because of the public good nature of environmental improvements.

In practice, there are many more market failures and barriers that hold back low-carbon innovation. These include, for example, information asymmetries which hinder learning-by-doing; imperfections and short-termism in capital markets that lead to lower financing of R&D in general; inertia of existing and incumbent technologies through lock-in and path dependence; imperfect competition in energy markets that may lead to more innovative firms being squeezed out of the market; regulatory barriers preventing adoption of new technologies; and restrictive trade policies.

In the context of this wide range of potential barriers, governments' role in innovation goes well beyond funding R&D, though this remains a key aspect. Enabling policies are key to an effective innovation environment, even if they are not explicitly aimed at accelerating innovation.

One underlying policy important to innovation is carbon pricing. Carbon pricing and other low-carbon incentive policies have an important role to play in driving innovation in addition to their more widely known role of encouraging less carbon intensive investment and operational decisions by covered entities (covered in section 3 above). For example, there is evidence that the EU Emissions Trading System has triggered more innovation in firms covered by the scheme relative to similar firms not covered by the carbon price (Calel & Dechezleprêtre, 2016). This effect was apparent even when carbon prices were relatively low. More generally, carbon pricing not only helps bend innovation towards more environmentally benign ends, but also allows achieving such outcomes at lower levels of public spending. In fact, public support for R&D would no doubt need to be significantly scaled up in the absence of carbon pricing in order to achieve a given level of innovation output.

Carbon pricing can also support innovation through the use of revenue raised through emissions trading or carbon taxes. In the EU, low-carbon innovation has long been an objective of using revenue raised through the sale of permits in the EU ETS. This was done initially through the setting aside of permits, the sale of which was used to fund innovative technologies (the known as the NER300). More recently, a dedicated Innovation Fund began in 2020, also funded by revenue from the sale of emissions permits in the EU ETS.

Another element of the enabling framework for innovation concerns the underlying investment environment. There is evidence that the quality of more general investment conditions are an important factor for innovation as well as deployment of low-carbon energy assets. For example, the overall ease of doing business, investment policies regulating registering property, and competition policy significantly affect investment flows in renewable energy projects as well as innovation activity for renewable energy technologies (Ang, Röttgers and Burli, 2017). This dependence of deployment and development on the broader investment policies suggests that policy makers need to strengthen the investment environment with regards to renewable energy, and align it with climate mitigation policies.

Of course, policies more specific to different parts of the innovation chain are also important. These can be broadly categorized as supply- and demand-side policies. Supply-side policies are those that aim to "push" innovation through funding research and supporting development and early-stage deployment of new technologies, processes and business models. Demand-side policies are those that aim to "pull" through new technologies by creating markets and demand for final or intermediate products for those innovations.

On the supply side, scaling up public RD&D funding remains an important priority. Research is the foundation of future innovation, but tends to be under-supplied by the private sector due to the market failures described above, as well as the long time horizon and uncertainties about future commercial viability. Public research through government research institutes and laboratories has an important role to play in linking basic and applied research. This goes beyond technological development, and is also important for identifying socioeconomic and behavioural triggers that could help deliver systemic changes in favour of the low-carbon transition, including through better acceptance of new technologies and habits (OECD/WB/UNEP, 2018). Public sector RD&D also goes beyond individual governments; international co-operation on R&D can be critical to bring forward new technologies faster, as can well designed public and private collaborations within countries. To ensure that co-operation is successful, care must be taken to balance different mandates and restrictions, and clearly define and co-ordinate management and responsibilities (OECD, 2014).

Governments can also help to drive increased R&D from private firms and universities through direct funding in the form of loans and grants, or through proven fiscal incentives, such as tax credits. Substantial research has explored the effects of different designs of public R&D subsidies. Empirical evidence shows that while effectiveness of R&D subsidies has been mixed and depends on design of the programmes, there are examples of R&D tax credit schemes that had statistically and economically significant effects on both R&D and patenting (Dechezleprêtre et al., 2016). For instance, over the 2006-11 period, aggregate business R&D in the United Kingdom would have been around 10% lower in the absence of the a relief scheme.

More generally, subsidies are likely to be more effective if they focus on energy technologies that operate "upstream" (not at the consumer level) and have a strong public good component (Agrawala et al., 2020). In the context of the CCE, it is also important that R&D subsidies for fossil-fuel research are aligned with long-term goals such as net-zero emissions, in order to switch the emphasis towards CCUS technologies and others compatible with those long-term targets (OECD, 2018).

Another important role for governments in the innovation chain is to improve the conditions for promising innovations as they move to early-stage commercialisation, in order to avoid the so-called "valley of death". Innovative energy investments with high capital investment and long construction times – such as many CCUS projects – face particular severe financing challenges due to the increased technology and project risk.

Governments can help bridge the valley of death in several ways. There are several examples of successful public and private incubators (e.g. Israel's Incubators Centre for Technological Initiative) and accelerators (e.g. Start-Up Chile). Public money can also be used to directly fund riskier long-term projects that promise large social benefits, but whose risk profile is initially too high to attract private capital. Low-interest loans, loan guarantees, tax incentives and quasi-equity financing can be deployed to reduce investment risk and attract private sector finance. Additionally, governments can more specifically support researchers with funding, technical assistance and support for market readiness for new energy technologies, such as the example of the US Department of Energy's Advanced Research Project Agency (OECD/WB/UNEP, 2018).

On the demand side of the innovation policy equation, there are also several important policy levers for governments. Several of the enabling policies specific to the "reduction" component of CCE (discussed above) are also important as tools to create the demand for innovative technologies and processes, even though their primary effect is to support deployment of more mature technologies: these include technology deployment incentives and performance standards. National and subnational public procurement policies can also be designed to create market pull for innovative technologies needed for the CCE. India's UJALA programme to deploy LED lighting is one example of how government procurement has helped to quickly lower technology costs and revolutionise India's lighting market. Further, by introducing climate-related criteria in procurement decisions, public procurement can bring low-emission solutions to market and trigger industrial and business model innovation through the creation of lead markets (Baron, 2017). If these criteria are designed to apply to core construction materials such as cement and steel, this can have knock-on effects up the supply chain. Given the importance of CCUS as a tool to decarbonise cement and steel production, public procurement standards can in this way also help to improve the business case for CCUS projects.

Lastly, to have lasting global effects as part of the transition towards net-zero emissions, new low-carbon technologies need to be rapidly diffused globally. Evidence suggests that strong environmental policies act to accelerate technology diffusion by creating international markets. However, barriers to trade and foreign direct investment are particularly important for accelerating diffusion of low-carbon technologies. This includes both explicit trade tariffs – which still exist in several countries for low-carbon final and intermediate goods, as well as non-tariff barriers and barriers to trade in services. The latter matters because deployment of climate mitigation and adaptation technologies often depends on specialised services, often imported from other countries. The extent and effectiveness of technology diffusion are determined not only by markets, but also by the absorptive capacity of recipient countries. This points to the importance of investing in capacity building, education and technical extension services to help enhance the ability of the public and private sectors in developing countries to more quickly adopt new technologies and behaviours. While emerging economies are better integrated into international technology markets, less developed countries remain largely excluded due to their general isolation and lack of absorptive capacity (Glachant and Dechezleprêtre, 2017).

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